THE CLAY RESOURCES AND THE CERAMIC INDUSTRY OF CALIFORNIA

BY
WALDEMAR FENN DIETRICH

BULLETIN No. 99

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PHOTO No 1. Russ Building, San Francisco, faced with architectural terra cotta manufactured at the Lincoln plant of Gladding, McBean & Co. (Photo supplied through the courtesy of the company.)

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
FRED G. STEVENOT, Director

DIVISION OF MINES AND MINING
FERRY BUILDING, SAN FRANCISCO

LLOYD L. ROOT — State Mineralogist

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The Clay Resources and the Ceramic Industry of California

By
WALDEMAR FENN DIETRICH
Associate Professor of Mining Engineering, Stanford University

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LETTER OF TRANSMITTAL.

To His Excellency, HON. C. C. YOUNG,
Governor of the State of California.

SIR: I have the honor to herewith transmit Bulletin No. 99 of the State Division of Mines and Mining on the Clay Resources of California.

This work deals in detail with one of California's nonmetallic mineral industries which is annually growing in importance and value. Ceramic plants are being established in increasing numbers, existing plants are being enlarged, and a wide variety of products is being put on the market. Our natural deposits of clays in this state form the basis upon which these industries are founded.

This bulletin is the result of over two years' field and laboratory investigations conducted by Mr. W. F. Dietrich, associate professor of mining engineering at Stanford University; the work being handled on a cooperative basis between the University and this Division. Acknowledgement is here made of the courtesy and cooperation of Mr. Theodore J. Hoover, Dean of the School of Engineering of Stanford University.

Respectfully submitted.

LLOYD L. ROOT,
State Mineralogist.

Chapter I.

INTRODUCTION.

The scope of this report is confined to a study of the raw materials and manufacturing practice of that part of the ceramic industry of California which involves the manufacture of products which "are molded in the aqueous plastic condition and which derive their strength from the partial fusion (vitrification) of silicates at high temperatures."[1] This restriction excludes glass, enameled metals, cements, limes, plasters, and most abrasives, which in modern parlance are broadly considered to belong to the field of ceramics.

The report includes a brief technical description of most of the clay-working plants and known clay deposits in California, together with the results of laboratory tests of the important clays of the state.. The principal emphasis is upon the economic and technologic phases of the clay-working industry of California, rather than upon its geologic aspects.

The field work was done in the summers of 1925 and 1926, and the total time in the field was five months. In a state having 155,652 square miles of land area, it was obviously impossible in the period of the field examination to make detailed investigations of all known clay deposits, or to search for new deposits not already known to the ceramic industry, the Mining Bureau, or to local inhabitants in the possible clay areas. Hence the principal value of this report lies in the fact that it is a record of progress of the clay industry and presents for the first time standard test data on the known clays as a basis of comparison for new clays that may be discovered in the future. The uses of many of the clays that were tested are very well known from plant experience, so that it should not be difficult for the intelligent plant operator to correlate the test data with the results of commercial practice, not only for the clays now in use in his plant, but for other clays that have been tested.

The search for high-grade clays on the Pacific coast has received new impetus in recent years on account of the phenomenal increase in population in the region and the consequent increased demand for structural and decorative clay products. There seems little doubt that this is but the beginning of one of the greatest periods of expansion that the world has ever seen. If this view of the future is correct, California is destined to become one of the great ceramic centers of the United States. That new clay deposits will be discovered is almost a foregone conclusion. Thus far, only the obvious deposits have been found, and only those that can be cheaply mined, and that can be used without beneficiation, have been exploited. The geologic column of California is practically complete, and there remain many thousands of square miles of land that have never been thoroughly prospected for clays. Prospectors and local residents away from existing clay producing regions are on the whole unfamiliar with the nature of clays, but it is certain that their knowledge will improve by contact with trained men who are on the lookout for new discoveries. It is true that the abundance of cheaply recoverable terra cotta and fire clays has

[1] Wilson, Hewitt, Ceramics, p. 2, McGraw-Hill Book Co., 1927.

heretofore hindered the development of new resources, but with the rapid acquisition of the best of these deposits by single manufacturing interests, and with the increasing demand for new types of clays, either to displace those varieties now being imported from outside of the state, or to make improved products, the incentive to clay prospecting will be entirely adequate.

METHODS OF INVESTIGATION.

The field work on the clay deposits consisted of a visit to each property to obtain clay samples and to prepare a description of the development and mining operations, the thickness of the clay and overburden and other features of possible interest. Most of the samples were taken from exposed surfaces, and due precautions were taken to secure samples that were representative of the workable beds of clay. In a few places, samples were taken from bins or storage piles, if these seemed more suitable for securing representative samples than the clay banks. In some instances, samples were submitted by the clay producers themselves as being representative of their deposits. A number of core drill samples were obtained from the Ione district, through the courtesy of S. E. Kieffer.

The plant descriptions were nearly all prepared by the author after an inspection of the plant. Many of these descriptions were submitted to the plant executive for approval before publication. A few descriptions were prepared by members of the organization concerned.

Descriptions of a number of plants that were started subsequent to the field investigation or that were overlooked by the author, were prepared by Messrs. Laizure, Logan, or Tucker, district engineers, Division of Mines and Mining.

The test work was done in the ceramic laboratory of the Department of Mining and Metallurgy at Stanford University by methods described in Chapter IV.

PREVIOUS WORK.

The clays and clay industries of California were described in two earlier reports[1] of this Bureau. These reports include descriptions of known deposits and of the operating plants, but contain very few data on the ceramic properties of the clays.

Most of the county reports of the Bureau contain descriptions of clay deposits and clay-working plants that were prepared by members of the State Mineralogist's staff. In a number of cases these descriptions are sufficiently up to date to permit their use in the present report, and are reprinted here for the sake of completeness and continuity, as the county reports are scattered through a number of volumes of the State Mineralogist's reports.

An important article[2] on the Alberhill clays by the late J. H. Hill, then president of the Alberhill Coal and Clay Company, was published by the Bureau in 1923.

[1] Structural and Industrial Materials of California: Cal. State Min. Bur., Bulletin 38, part III, pp. 190–259, 1906.
The Clay Industry in California: Cal. State Min. Bur., Prel. Report No. 7, 102 pages, 1920.

[2] Hill, J. H., Clay deposits of the Alberhill Coal and Clay Company: State Mineralogist's Report XIX, pp. 185–210, 1923.

The ceramic properties and chemical analyses of certain clays from the Alberhill district have been given by Burchfiel.[1]

The clay mining and preparation plant of the Clay Corporation of California, at Lincoln, has been described by C. N. Schuette.[2]

All of the foregoing references were freely used in the preparation of this bulletin, even at the cost of repetition, as it was desired to bring together in one volume all of the available information on the clay resources of the state.

ACKNOWLEDGMENTS.

In a work of this nature it is impossible to give individual acknowledgment to all those who contributed to it. The writer wishes to express his appreciation of the courtesies that were extended to him by many persons connected with the ceramic industry of California. Their cooperation in making this bulletin possible is especially noteworthy in view of the fact that, on the whole, the ceramic industry today remains as one of the few mineral industries that extensively uses secret processes and secret formulae.

Prof. Hewitt Wilson of the University of Washington rendered invaluable assistance in outlining the methods of clay testing and in making many valuable suggestions and criticisms.

Mr. John T. Roberts, president of the Stockton Fire Brick Company, generously contributed equipment and refractories to the ceramic laboratory in which the test work was done, and was ever ready to give valuable advice and information during the progress of the work.

Mr. L. M. Richard, consulting economic geologist for Gladding, McBean and Company, was especially helpful in the field in the Alberhill-Corona district, and contributed many ideas concerning the organization of the report.

Several graduate students in metallurgy or ceramics at Stanford University contributed to various phases of the investigation, especially in the laboratory. Among these should be mentioned V. J. Minner, C. W. Briggs, H. J. O'Carroll, D. R. Irving and R. E. Paine.

Acknowledgment is also due to Messrs. Walter W. Bradley, W. Burling Tucker and C. A. Logan of the Division of Mines and Mining for assistance in compiling data, and for many helpful suggestions regarding the conduct of the work. In addition, Messrs. Tucker, Logan, and C. McK. Laizure supplied a number of descriptions of deposits or plants not visited by the author, acknowledgments of which are made in the text.

GENERAL REFERENCES.

Little space has been devoted in this report to the origin of clay, its chemical and physical properties, or to clay-working processes in general. Such information has usually been included in clay reports from other states, but there seems little justification for its inclusion here, in view of the fact that there are now a number of excellent texts for those who desire such information. A few of the more important works are listed below:

[1] Burchfiel, B. M., Refractory clays of the Alberhill, California, deposits: Jour. Amer. Cer. Soc., Vol. 6, pp. 1167–1175, 1923.

[2] Schuette, C. N., Engineering principles applied to the exploitation of a clay deposit: Eng. & Min. Jour.-Press, Vol. 121, p. 964, June 12, 1926.

Wilson, Hewitt, "Ceramics." McGraw-Hill Book Co., New York, 1927. An excellent text on clay technology, covering the chemical and physical properties of clays. Not suitable for readers who have no knowledge of chemistry or physics.

Andrews, A. I., "Ceramic Tests and Calculations." John Wiley and Sons, 1928. An elementary text on the methods of clay testing, and on the calculations relative to glazes, bodies, enamels and glasses.

Searle, A. B., "The Chemistry and Physics of Clays and Other Ceramic Materials." Ernest Benn, Ltd., London, 1924. A valuable reference work of scientific conceptions and data on clays. Particularly useful to research workers.

Ries, Heinrich, "Clays, Their Occurrence, Properties and Uses," 3d Edition. John Wiley and Sons, 1927. The standard work on the geology and origin of clays, with sufficient information on properties and uses to serve as an elementary text. Perhaps the best general work for the layman.

"Clay Products Cyclopedia and Equipment Catalog." Issued annually by Industrial Publications, Inc., Chicago, Illinois. A useful reference, of particular value as a dictionary of ceramic nomenclature and for the descriptions and illustrations of ceramic equipment.

Chapter II.

SUMMARY OF THE CERAMIC INDUSTRY OF CALIFORNIA.

INTRODUCTION.

For the benefit of those who may be unfamiliar with clay-working processes, a brief summary of clay technology is given.

Definition of clay: "Clays are the weathered products of the silicate rocks, containing sufficient hydrous silicate of alumina in the softened condition to produce a plastic or semiplastic mass when tempered with water."[1] Clays may be classified into many types. In this report a classification is used that is based upon physical properties and uses. The details of this classification are given in Chapter IV.

Definitions of a few of the more general terms used in clay momenclature are given below:[2]

Kaolin is amorphous hydrated aluminum silicate, corresponding to the formula of $Al_2O_3.2SiO_2.2H_2O$ and is the most important constituent of china clay. The term is widely used in commercial practice to include china clay and rock high in china clay.

China clay is the commercial variety of kaolin. It may occur naturally in deposits of sufficient purity, but is more often prepared by the purification of natural deposits. It burns white, and has high refractoriness, but the plasticity is generally poor.

Ball clays are white or light-cream-burning clays of high plasticity and bonding power that vitrify to dense impervious bodies at comparatively low temperatures.

Fireclays are those clays that withstand high temperatures, particularly those that do not fuse at temperatures below 1605° C. (2921° F., cone 27). They are used in the manufacture of fire brick or other refractories and are often used for architectural terra cotta, wall tile, etc.

Face brick clays may be divided into one of three groups. (1) Red-burning clay; (2) white-burning clay; (3) buff-burning clay. The color, plasticity, shrinkage, and vitrification must fall within certain general limits, dependent upon the type of brick to be manufactured.

Common brick clays vary widely in their composition and properties. They are usually high in fluxes and in most cases are red-burning. They should mold easily and develop hardness and strength at as low a firing temperature as possible without seriously warping or cracking.

Slip clays are fine grained, and contain a high proportion of fluxes. They should melt at a low temperature (preferably below 1200° C., cone 5) to a greenish or brown glass to form a natural glaze.

Clay preparation: With the exception of some of the heavy structural products, it is seldom possible to find a single raw material that

[1] Wilson, Hewitt, Ceramics, p. 7.
[2] See Wilson, *op. cit.*, pp. 28–39, and Clay Products Cyclopedia, 1926, pp. 94–96, for further details.

possesses the desired plastic, drying and firing characteristics for making a given ceramic product. It is usually necessary, therefore, to blend several clays and nonplastics in order to control the properties of the finished product. For example, clays having different percentages of iron may be blended to secure the desired color; highly plastic clays may be blended with those having poor plasticity in order to control shrinkage and porosity; feldspar may be added as a flux to lower the temperature of vitrification; crushed quartz or crushed calcined clay may be used as a "grog" to produce a skeleton structure that is bonded by the clay, giving greater strength and less tendency to warp than if clay alone were used.

After deciding upon the proportions of the various raw materials, some of them are ground separately and others are ground after mixing, either by dry or wet methods. Ball mills and grinding pans are the principal types of machinery used for fine grinding. At some point in the process, all the materials are mixed together, the proper amount of water is added, and the mass is subjected to a thorough mixing, with or without additional grinding. For the manufacture of many types of ware, the plastic mass is allowed to age in humidified rooms or under wet sacking for a period of 24 hours to one month, in order to secure uniform distribution of the water and to develop maximum plasticity.

Manufacturing processes: After the clay is properly prepared, the three essential steps in the manufacture of a ceramic product of the type under consideration are shaping, drying and firing. A fourth process that is applied to certain types of ware is glazing.

Shaping: The shaping of clay wares may be done while the clay is in one of the four different degrees of plasticity: (1) Dry pressing of pulverized mixtures to which has been added just enough water to bind the mass together when subjected to pressure in hydraulic, cam, or screw presses. This process is principally used for shaping floor and wall tile, especially the hard vitrified tile used in bath-room floors, and to some extent it is used in common brick and face brick manufacture. (2) Stiff-mud shaping, in which sufficient water is added to the clay to permit the mass to flow through a die without rupture. A column of clay is pushed through a hollow die by a plunger or screw or the clay may be pressed into a steel mold by a plunger. This is the usual process for making common brick, face brick, fire brick, and roofing tile, and is the only method in use for shaping hollow tile, sewer pipe, drain tile, and electrical conduit. (3) Soft-mud shaping, in which almost enough water is added to cause stickiness. This consistency is used for the hand pressing of terra cotta and tile in plaster molds, for the shaping of pottery and stoneware on pottery wheels or in molds, for the hand molding of roofing tile over paper covered wooden molds, or for the hand or mechanical pressing of common brick or face brick. (4) Casting, in which the finely-ground mixture is suspended in water so that the resultant "slip" may be poured into plaster molds. The plaster absorbs water from the slip, gradually precipitating the solids against the inner walls of the mold. When the walls are thick enough, the surplus slip is poured from the mold, the object is left in the mold until stiff enough to stand its own weight, then the mold is stripped off and the shape allowed to dry. Casting is the cheapest method of producing pottery on a large scale, and is the principal method in use for shaping sanitary porcelain.

Drying: The drying of clay wares may be done under sheds in the open, in specially heated rooms, or in specially designed humidity dryers in which the three factors of time, temperature and humidity are under close control. The type of drying will depend upon the characteristics of the clay used and upon the shape and size of the ware to be dried. As clay shrinks during drying, it is important that the drying be controlled in such a way as to avoid undue strains which might cause cracks in the dried ware, or lines of weakness which would result in cracks during the subsequent firing operation.

Firing: The proper firing of ceramic ware is perhaps the most important part of the process, and many types of kilns are available for the purpose. The essential conditions to be met by a ceramic kiln are control of the time-temperature cycle and uniformity of heat distribution. In some cases, kiln gases can not be allowed to come in contact with the ware, so that muffle kilns are necessary, or else the ware is enclosed in fireclay receptacles known as "saggers." Most kilns now in use are of the periodic type, but there is a growing tendency to use continuous kilns in which the ware is set on trucks which move through a tunnel that is fired near its mid-point. Firing temperatures range from 895° C. (1643° F.) for soft-burned common brick to 1350° C. (2462° F.) for hard porcelain and fire brick. A few special products are fired as high as 1640° C. (2984° F.).[1]

Glazing: Glazing may be done by dipping, spraying, or painting a water suspension of the glaze ingredients on the ware either before firing, or after a preliminary (biscuit) firing. In some cases where complicated polychrome decorations are used, several firings are necessary before the piece is finished. Salt glazing is another method, wherein common salt is vaporized in the kiln during firing, the sodium of the salt reacting with the clay body to form a fusible compound.

CLAY DEPOSITS OF CALIFORNIA.

In practically all of the low altitude areas of California there is an abundance of common clay and shale suitable for the manufacture of common brick and hollow building tile. By reason of the low unit value of these products, the raw material must be cheaply mined, and will not stand transportation charges from points very distant from the brick yards, which are situated near the centers of consumption. In the San Joaquin and Sacramento valleys, it has been difficult to find good bodies of clay with sufficient plasticity for the manufacture of the best quality of building brick, and some of the plants in this area have been forced to ship plastic clay from different points to mix with the local materials. In the San Francisco Bay district and in Los Angeles County, the two important centers of consumption, there are ample common clay resources. The same is true of the smaller valleys in the Coast Range and in the foothills of the Sierra Nevada.

In the mountainous portions of the state, in the desert regions, and in the volcanic area of the northeastern counties, it is difficult to find

[1] Pyrometric cones are extensively used in the ceramic industry as temperature indicators. See table No. 9 in Chapter IV.

suitable common brick clays, but as these areas will probably never be thickly populated, such brick as are needed can be shipped in from more distant points.

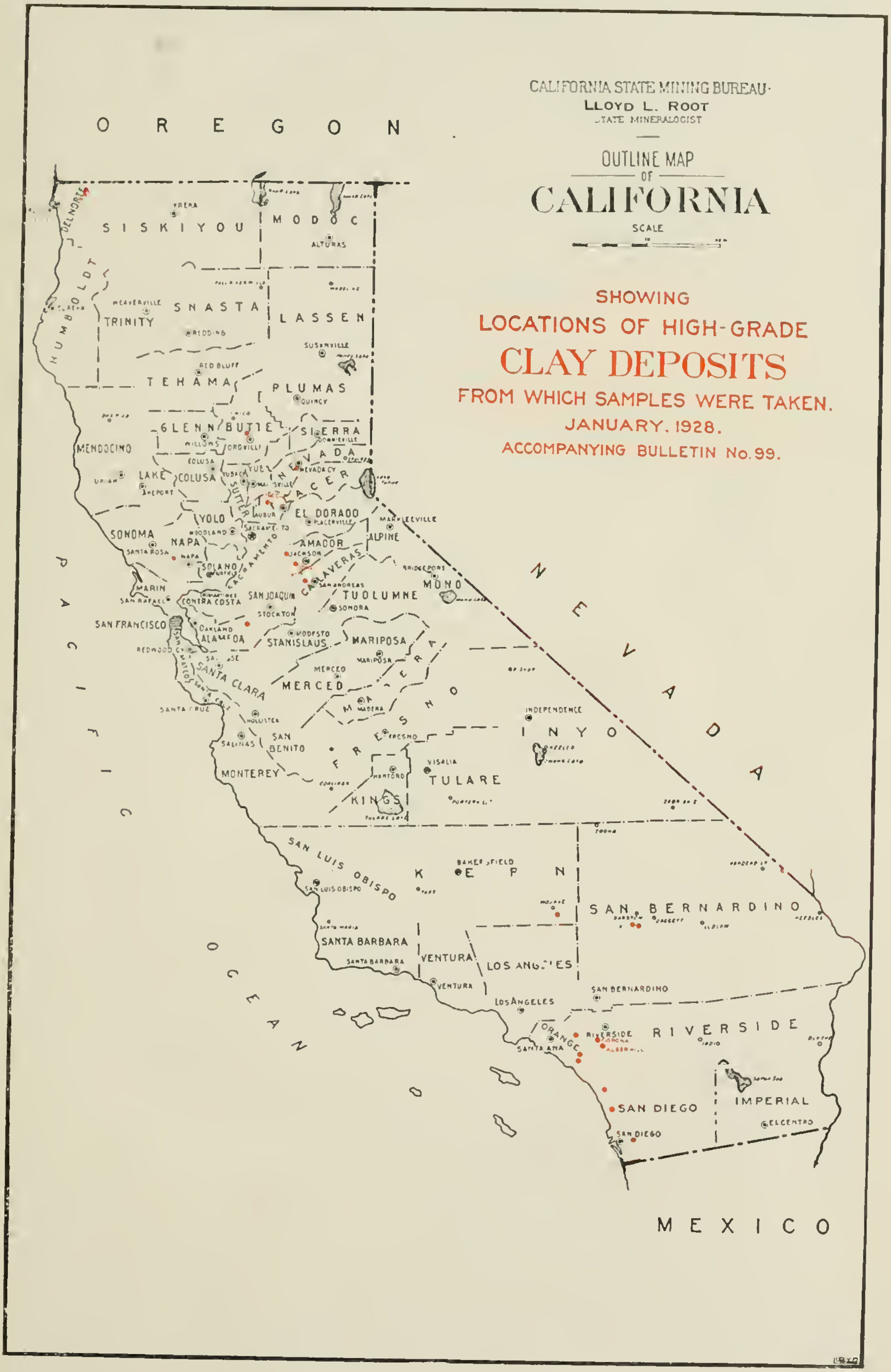
The demand for paving brick has never been great enough to lead to an intensive search for red-burning shales of the type used elsewhere in the United States for paving brick manufacture. A few such shales are known, and one or two deposits are being worked, but, for the most part, the demand for paving brick, sewer pipe, conduit pipe, and other red-burned vitrified products has been met by a blending of various clays, with or without grog. Three deposits are of special interest in this connection: the Natoma clay (see samples No. 210 and 212), which consists of fine gold-dredge tailings deposited in settling basins; the Goat Ranch shale (see sample No. 282), an Upper Cretaceous shale in Santa Ana Canyon; and the Santa Margarita shale (see samples No. 216 and 217), from an undeveloped deposit along the Southern Pacific Railroad near Santa Margarita.

The general distribution of the high-grade clays of California is shown on Plate I.

The high-grade clays of the state are found mainly in deposits of Eocene age, although there is one important area of Pleistocene clay, and the importance of certain beds in the Upper Chico (Cretaceous) is just receiving recognition. Approximately 90 per cent of the high-grade clays of the state are now being mined from one of three areas: the Alberhill-Corona district in Riverside County; the Ione district in Amador County; and the Lincoln district in Placer County. The age of the clays in all three districts is Eocene, and the deposits were formed by sedimentation in inland seas, with or without subsequent alteration.

The Alberhill-Corona clays occur in an area in the Temescal Valley some twelve miles long and two miles wide. In many places the clay beds are three to four hundred feet thick. The clays were laid down in Eocene time in an arm of the sea. The region is characterized by a discontinuity of structure that arose from folding, faulting, and erosion subsequent to clay deposition, and by extreme local variations in the individual clay beds caused by variations in the conditions of sedimentation. A wide variety of red, pink, and buff-burning plastic clays and a good range of plastic and semi-plastic fireclays are produced in the district. The colored clays are used for face brick, roofing tile and red earthenware, and as an ingredient of sewer pipe, electrical conduit and other mixes. The buff-burning clays, generally refractory, are used for architectural terra cotta, stoneware, decorative tile, pottery, etc. The refractory clays are used for fire brick and other refractory shapes. A few selected varieties are sufficiently free from coloring compounds to permit their restricted use in white-burned products. The typical clays are characterized by excellent plasticity, low or medium dry strength, low or medium drying and firing shrinkage, and open fired texture. A few varieties are found that possess high dry strength and high shrinkage, and that vitrify completely within commercial firing ranges, but these are the exception rather than the rule. The proportion of sand in the clays varies widely from almost pure sand to pure clay, resulting in a wide range of commercial varieties.

The Ione clays and sands occur in a belt about twelve miles long and one-half to one mile wide. The total thickness of clay is not known,


CALIFORNIA STATE MINING BUREAU
LLOYD L. ROOT
STATE MINERALOGIST
OUTLINE MAP
OF
CALIFORNIA
SCALE
SHOWING
LOCATIONS OF HIGH-GRADE
CLAY DEPOSITS
FROM WHICH SAMPLES WERE TAKEN.
JANUARY, 1928.
ACCOMPANYING BULLETIN No. 99.
OREGON
NEVADA
MEXICO
PACIFIC OCEAN
DEL NORTE
SISKIYOU
MODOC
ALTURAS
HUMBOLDT
TRINITY
SHASTA
LASSEN
SUSANVILLE
TEHAMA
PLUMAS
QUINCY
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
LAKE
COLUSA
YOLO
EL DORADO
ALPINE
SONOMA
NAPA
SOLANO
AMADOR
CALAVERAS
MONO
MARIN
CONTRA COSTA
SAN JOAQUIN
STOCKTON
TUOLUMNE
SONORA
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SANTA CLARA
MERCED
MADERA
FRESNO
INYO
INDEPENDENCE
SAN BENITO
MONTEREY
TULARE
VISALIA
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
SANTA ANA
RIVERSIDE
SAN DIEGO
IMPERIAL

but in a number of places a thickness of over 100 feet has been demonstrated. The beds are more continuous, and have less local variations in the character of the material, than is the case at Alberhill. The area is important for its high-grade fireclay and fire-sand. Some plastic pink- and buff-burning clays are also produced for use in terra cotta, stoneware and pottery manufacture. The fireclays are the most refractory that have thus far been found in the state, but are characterized by low dry strength and high firing shrinkage, with a strong tendency to crack when fired. The fire-sands are composed of quartz-mica sand with from 10 to 25 per cent of clay, and are important as a nonplastic ingredient of fire brick mixtures, to diminish the shrinkage and the tendency to crack. Future developments in this area are expected to greatly extend the known dimensions of the clay beds, and to disclose other varieties of clay not now accessible.

The Lincoln clays lie in an isolated remnant of the Ione formation (Eocene), protected by a lava capping. The beds underlie a low hill adjoining the town of Lincoln. The clay is continuous over an area of about four square miles, to a depth of approximately 100 feet below the lava capping. The Lincoln clay is an excellent buff-burning plastic fireclay that is especially valuable in the manufacture of architectural terra cotta, faience tile, fire brick, and other products. There are also beds of pink-burning clays that are used in sewer pipe, roofing tile and face brick mixtures. The Lincoln clays have excellent plasticity, medium dry and fired strength, a long vitrification range, and, although the shrinkage is high, the clay can stand rapid firing without cracking.

Some other clay producing areas of lesser importance are: (1) The Cardiff-Carlsbad area in San Diego County, containing excellent fireclays, some of which are closely similar to the famous Gros-Almerode fireclays of Germany; (2) The Santa Margarita Rancho deposit, near San Juan Capistrano, San Diego County, containing important deposits of highly aluminous fireclay; (3) The Hunter Ranch deposit, near El Toro, Orange County, where there is an excellent fireclay, associated with a bed of kaolin and sand from which a high-grade kaolin can be recovered; (4) The Goat Ranch deposit, in Santa Ana Canyon, Orange County, an Upper Chico (Cretaceous) deposit of flint fireclay.

California is especially favored with resources of nonplastic ceramic materials. At Campo, San Diego County, is a large deposit of excellent feldspar, and many other feldspar deposits are known in southern California. Silica is available in many forms in California and near the border in Nevada. A large deposit of quartzite has been found in the desert south of Barstow, from which silica brick is being made. Talc, used in some floor-tile bodies, is available from a number of sources. The most extensive deposits of andalusite and cyanite in the United States occur in California. These minerals are of increasing importance in the manufacture of high-grade refractories.

The most important ceramic materials that are thus far lacking in California are ball and china clays equal in purity and uniformity to those from the deposits of England or from the eastern United States. A clay possessing the properties of a mixture of the two varieties has been found in San Bernardino County, and a good china clay has been found in Nevada, but thus far production has been small, and most of the ball and china clay requirements of the California industry are met by importation from the eastern states or from England. One of the factors that has hindered the establishment of a local clay washing industry to produce china clay is the low price of Belgian glass sand at Pacific coast ports, making it unprofitable to market the quartz sand which would be a by-product of kaolin washing. Since the yield of kaolin would be but 20 to 30 per cent from the known deposits in California, the importance of a satisfactory market for the sand is apparent.

While a few small deposits of bone clay have been found in southern California, highly aluminous clay is relatively scarce, and no commercial deposits of diaspore, bauxite or gibbsite[1] have been discovered in California.

MINING METHODS.

Most of the clay deposits of California are mined by open pit methods, and with the exception of most of the common clay deposits, hand methods predominate. Where a production of the order of one car (50 tons) per day or more is needed mechanical methods are in general use, if topographic features are favorable, and if no hand sorting of the clay is necessary.

Drilling and blasting are necessary at many of the deposits. The holes are usually drilled with hand augers, and blasted with light charges of low-power explosives. As a rule, a nearly vertical bank is carried, and the height of the bank corresponds to the thickness of the bed being mined. Stripping of overburden, if any, is carried out in advance of mining, on a separate bench.

The hand methods in use involve pick and shovel loading into auto trucks, wagons, mine cars, wheelbarrows, or loading chutes, depending on local conditions.

The mechanical methods include horse-drawn scrapers, power-driven drag scrapers, and power shovels of various types actuated by gasoline or electricity. The scrapers usually load directly into hoppers, from which the clay is drawn off into auto trucks, industrial railway cars, or onto belt or bucket conveyors. The shovels load into auto trucks, or into industrial or standard railway cars.

Most of the underground mining is done by the room and pillar method, from a tunnel entry, with only such auxiliary timber support as is necessary to support localized blocks of loose ground. While pillars are robbed as much as is practicable, from 20 to 35 per cent of the clay must be left in the pillars to support the workings.

Transportation from the pit to the plant or railroad siding is done at many properties in the original vehicle in which the clay is loaded. At other properties a loading platform or chute is placed as near the pit as possible, and the clay is transferred to cars on an industrial railroad or into auto trucks.

Most of the clay mining in the state is done on contract, especially at smaller properties. To one familiar with metal mining, the methods in use at many of the properties seem needlessly crude and wasteful of human energy, but the short working season, seldom longer than from

[1] These three minerals are types of aluminum hydroxide. Diaspore contains 12–14 per cent of water and has a formula approximating to $Al_2O_3.H_2O$. Bauxite contains 20–24 per cent of water and corresponds to $Al_2O_3.2H_2O$. Gibbsite contains 27–35 per cent of water and corresponds to $Al_2O_3.3H_2O$. See Searle "The Chemistry and Physics of Clays," p. 339. The bauxites are used in the manufacture of metallic aluminum, and are valuable for the manufacture of a superior type of fire brick (diaspore brick) that is more refractory than ordinary fireclay brick. These brick are used, among other purposes, for lining the clinkering zone of cement kilns.

May to October, the comparatively small scale of operation, the fluctuation of demand, the irregularity and small size of some of the deposits, the necessity of hand sorting in a number of cases, and the fact that many of the deposits are mined under a royalty lease, all must be given due consideration before any valid criticisms can be made.

Clay mining costs for open pit work range from 10¢ to 25¢ per ton for scraper or shovel loading, to 20¢ to 50¢ per ton for hand loading. Hand sorting may double the cost of hand loading. Transportation to the pit mouth, or to a bin within a few hundred yards of the pit, may add from 5¢ to 25¢ per ton. Incidentals may total from 5¢ to 25¢, making the total direct cost vary between the approximate limits of 20¢ and $1.50 per ton. In addition, many of the properties are several miles from a railroad or plant and must stand a transportation cost that may be in excess of $1 per ton. The longest auto truck haul noted was 15 miles, and there are a number of deposits where the haul is from three to eight miles from the pit to a railroad or plant. Where a royalty is paid, the charge is usually from 10¢ to 25¢ per ton.

Underground mining costs are naturally higher than open pit costs, but the direct cost of mining and loading, including hand sorting, is seldom in excess of $1 per ton. Haulage and transportation costs must be added.

As an indirect indication of costs, the selling prices of a number of clays may be cited: The price of Alberhill clay f.o.b. gondola cars at Alberhill ranges from $1 per ton for the cheaper grades that occur in large deposits and that are cheaply mined by mechanical methods, to $5.50 per ton for the rarer varieties that are hand sorted and may be mined by underground methods. The price of Lincoln clay, mined by a power shovel from a large pit, is nominally $1.75 per ton, f.o.b. Lincoln.

CERAMIC PLANTS.

A check list of the clay-working plants of California, with the products made in each, is given in Table 1. It will be noted that the majority of the plants in the state are in or near the two major centers of population and industry, the Los Angeles area, and the San Francisco Bay district. However, common brick and hollow-tile plants are well distributed among the lesser centers of population, and there are a number of important manufacturers of high-grade ceramic products whose plants are at some distance from the larger centers. Some of the plants in the latter group have been built adjacent to clay pits in order to secure close coordination between the clay quarrying and the manufacturing plant. Since freight rates on finished products are higher than on raw materials, it is advantageous to locate the plant near the geographical center of consumption of finished ware.

The check list also reveals the wide diversity of the California industry and shows that nearly all of the ceramic products now in use are manufactured in one or more California plants. The important exceptions are magnesia brick, chrome brick and chemical porcelain and stoneware. Magnesia brick were made for a short time during the World War, when foreign supplies were unavailable, and earlier attempts were made by various companies, but the business is uneconomic under normal conditions.

TABLE No. 1. CHECK LIST OF CERAMIC PLANTS IN CALIFORNIA, AND PRODUCTS MANUFACTURED.

County	Name of Plant	Described on page	Products Manufactured: Structural Ceramics												Refractories			Pottery and Miscellany								
			Common brick	Paving brick	Face brick	Sewer pipe	Drain tile	Hollow block	Terra cotta	Conduits	Roofing tile	Flue lining and chimney pipe	Floor and terrace tile	Wall and fire place tile	Fire clay brick	Silica brick	Special refractories	Tableware	Kitchenware	Art or garden pottery	Sanitary ware	Stoneware	Flower pots, ollas, etc.	Electrical insulators	Porcel in specialties	Cast iron enameling
Alameda	California Bisque Doll Co.	38																		x						
	California Faience Co.	39																		x						
	California Pottery Co.	39				x					x	x	x	x						x		x				
	N. Clark & Sons	40				x			x			x			x											
	W. S. Dickey Plant No. 18 (Livermore)	40			x							x			x											
	W. S. Dickey Plant (Niles)	40		x				x																		
	Electrical Porcelain Works	40																						x		
	Hidecker Tile Co.	41									x															
	Kraft Tile Co.	41												x												
	Miller's Oakland Art Pottery	41				x	x					x														
	M. & S. Tile Co.	41									x															
	Muresque Tiles, Inc.	42												x												
	Remillard Brick Co.	42	x																							
	Tech. Porcelain & China Ware Co.	42																						x		
	Walrich Pottery	45												x						x						
	Westinghouse High Voltage Insulator Co.	45																						x		
	Woolenius Tiles	49												x												
Amador	Ione Fire Brick Co.	60													x											
Butte	Lund Clay Plant	65	x																							
	Table Mt. Clay Products Co.	65			x																					
Contra Costa	California Art Tile Co.	72												x												
	Mastercraft Tile & Roofing Co.	73																								
	Port Costa Brick Works	73	x					x																		
	Richmond Pressed Brick Co.	74	x	x	x								x		x											
	Standard Sanitary Manufacturing Co.	75																			x					x
Fresno	Craycroft Brick Co.	78	x		x			x																		
	Pioneer Brick & Tile Co.	78	x																							

Humboldt	J. D. Thompson Brick Co.	81	x				x	x																		
Imperial	Simons Brick Co.	86	x																							
Kern	Bakersfield Sandstone Brick Co.	89	x																							
	Kern County Brick Co.	89	x																							
Los Angeles	Acme Brick Co.	94	x																							
	Alhambra Kilns, Inc.	94									x		x													
	American China Co.	94												x												
	American Encaustic Tiling Co.	95											x	x												
	American Refractories Co.	96													x		x									
	Angulo Tile Plant	97									x															
	Atlas Fire Brick Co.	97													x											
	Batchelder-Wilson Tile Co.	97							x				x	x												
	J. A. Bauer Pottery Co.	98																	x			x	x			
	California Brick & Tile Co.	98	x																							
	California Clay Products Co.	99											x	x												
	City Brick Co.	100	x																							
	Claycraft Potteries, Inc.	100												x												
	H. F. Coors Co., Inc.	100																							x	
	Davidson Brick Co.	100	x																							
	Empire China Co.	101																x								
	Emsco Refractories Co.	101													x	x										
	Gladding, McBean & Co. (3 plants)	101	x		x	x		x	x		x	x	x	x												
	Globe Tile & Porcelain Works	103											x													
	H. & H. Tile Co.	103											x													
	Italian Terra Cotta Co.	103																		x						
	K. & M. Pottery	104																				x	x			
	K. & K. Brick Co.	104	x																							
	[1]La Cal Tile Co.	104																								
	Linderman and Decker Co.	104									x															
	Long Beach Brick Co.	105	x																							
	Los Angeles Brick Co. (3 plants)	105	x					x																		
	Malibu Potteries	107												x												
	Mission Brick Co.	107	x																							
	Mission China Co.	109																x								
	Pacific Clay Products Co. (3 plants)	109			x	x	x			x		x			x							x	x			
	Pomona Brick Co.	116	x																							
	Pomona Tile Manufacturing Co.	117											x	x												
	Poxon Pottery	117																x								
	St. Louis Fire Brick & Clay Co.	118													x											
	Santa Monica Brick Co.	118	x		x						x		x													
	Simons Brick Co. (3 plants)	119	x								x															
	[2]Standard Brick Co. (2 plants)	120	x																							
	Torrance Brick Co. (2 plants)	120	x		x			x																		
	Tudor Art Tile Co.	121												x												
	Vitrefrax Co.	121															x									
	Washington Iron Works	122																								x
	Western Brick Co.	122	x																							
	Whiting-Mead Co.	123																		x	x					x

TABLE No. 1. CHECK LIST OF CERAMIC PLANTS IN CALIFORNIA, AND PRODUCTS MANUFACTURED—Continued.

County	Name of Plant	Described on page	Products Manufactured: Structural Ceramics: Common brick	Paving brick	Face brick	Sewer pipe	Drain tile	Hollow block	Terra cotta	Conduits	Roofing tile	Flue lining and chimney pipe	Floor and terrace tile	Wall and fire place tile	Refractories: Fire clay brick	Silica brick	Special refractories	Pottery and Miscellany: Tableware	Kitchenware	Art or garden pottery	Sanitary ware	Stoneware	Flower pots, ollas, etc.	Electrical insulators	Porcelain specialties	Cast iron enameling
Marin	McNear Brick Co.	124	x																							
Merced	California Pottery Co.	128					x	x			x															
Monterey	Arca Roofing Tile Plant	130									x															
	Monterey Mission Tile Co.	131									x		x													
Orange[3]	Brea Clay Products Co.	140	x																							
	Garber Brick & Tile Co.	141	x								x		x													
	La Bolsa Tile Co.	142	x		x		x	x																		
	Olive Roofing Tile Co.	144									x															
Placer	Gladding, McBean & Co.	151			x	x			x		x	x			x					x						
Riverside	Gladding, McBean & Co.	171			x			x			x				x											
	Los Angeles Brick Co.	174			x										x											
	Hancock's Brick Yard	181	x																							
	Prado Tile Co.	181									x									x						
Sacramento	Cannon and Company	183			x			x							x											
	Muddox Pottery	186				x						x														
	Panama Pottery	187																		x		x	x			
	Sacramento Brick Co.	188	x																							
	Valley Brick Co.	189	x																							
San Diego	National Brick Co.	203	x																							
	Old Mission Tile Co.	203									x															
	San Diego Brick & Tile Co.	203	x					x																		
	Union Brick Co.	234	x																							
	Vitrified Products Co.	235			x			x			x		x													
San Francisco	Jalanivich and Olsen	207																		x						
	Tara's Porcelain Laboratory	207																							x	

San Joaquin	San Joaquin Brick Co.	208	x																						
	Stockton Brick & Tile Co.	208	x					x																	
	[1]Stockton Fire Brick Co.	209												x											
San Luis Obispo	San Luis Brick Works	213	x					x			x														
San Mateo	West Coast Porcelain Manufacturers	215																		x	x				
Santa Barbara	Angulo Tile Co. (2 plants)	218									x		x												
	Maengenberg & Whitiker	218	x				x	x																	
Santa Clara	Garden City Pottery Co.	219																				x	x		
	Kartschoke Clay Products Co.	220				x					(x)	x													
	Platts Premier Porcelain, Inc.	220																			x				
	Remillard Brick Co.	221	x																						
	San Jose Brick & Tile Co.	221	x																						
	San Jose Tile Co.	221											x	x											
	S. & S. Tile Co.	231											x	x											
Tehama	O'Connor Bros. Brickyard	231	x																						
Tulare	S. P. Brick & Tile Co.	232	x					x																	
Ventura	Anderson and Hardison	234	x																						
	Peoples Lumber Company	234	x		x		x	x			x														
Yuba	Marysville Brick Co.	236	x																						

[1] Detailed information lacking as to products made.
[2] Also make sewer brick.
[3] The Orange County Brick and Tile Company, manufacturers of sand-lime brick is described on page 141
[4] Also manufactures diatomaceous insulating brick and shapes.

MANUFACTURING METHODS IN CALIFORNIA PLANTS.

Common brick: In California, one common brick plant uses the dry-press process, and the other plants are nearly equally divided between the soft-mud and the stiff-mud process. Nearly all of the plants use drying sheds in the open, but some use drying racks in an enclosed and heated building, and a few use waste-heat or separately-fired tunnel driers. Field kilns are preferred in southern California, where there is little rainfall throughout the year, and continuous kilns of the Hoffman type are preferred in northern California. Oil is the usual fuel for the field kilns, although natural gas is used at some plants which are located near the oil fields. At some plants, gas is used during the water-smoking period and oil for the balance of the firing cycle. The continuous kilns are fired with coal. Firing temperatures range from cone 08 to cone 1 (950° to 1160° C.).

No mechanical hacking, setting or loading machines are in use in California. So far as could be ascertained, none of these devices have been given a trial in the state. It would seem that even though such machines in their present form may not be entirely satisfactory, the hope of saving from 25 to 40 man-shifts per 100,000 brick would be a sufficient inducement to encourage the development of automatic brick-handling machines, especially in the larger plants.

Hollow block: All hollow block are shaped in auger machines. Some of the plants making hollow block are also making common brick and both products are subjected to the same drying and firing treatment. Waste-heat or separately-fired tunnel driers are in use at a number of plants. Field kilns are widely used, but several plants use Hoffman kilns, one uses a Haigh kiln, and a few use use round down-draft kilns. Firing temperatures are usually between cone 04 and cone 3 (1060° to 1170° C.).

Face brick: Most of the face brick of California is shaped by the stiff-mud process. Much of it is repressed. The dry-press method is used at a few important plants. Drying is usually done in waste-heat tunnel driers, and round down-draft kilns are used at all plants for firing.[1] The firing temperatures usually approximate cone 02 to cone 5 (1125° to 1205° C.).

Sewer pipe: All sewer pipe is made in presses which are usually operated by electric power. Drying is done on drier floors which are usually heated by steam or waste heat from the kilns. Round down-draft kilns are used for firing and the firing temperatures range from cone 02 to cone 5 (1125° to 1205° C.). The dry strength of some of the sewer pipe mixes in use in California is too low to permit setting to the full height of the kilns, so that the capacity per kiln is not so great as at most of the eastern plants where stronger clays are available.

Drain tile: There is little demand for drain tile in California and it is only made in a few plants, where it is shaped by auger machines, dried on heated drying floors and fired in round down-draft kilns.

Terra cotta: Architectural terra cotta is an important product in California. A particularly fine example of its use is shown on the

[1] The wide range of colors demanded by modern architectural design is secured by varying the body mixture and by the normal differences of temperature at different parts of the kilns.

frontispiece, Photo No. 1, which is a view of the Russ Building, in San Francisco. The typical body in use in California consists of a siliceous plastic fireclay mixed with an equal weight of nonplastics, such as quartz sand and grog made by regrinding rejected terra cotta from the plant. This produces a body having an absorption of about 15 per cent, when fired to cone 4 to 6 (1190° to 1230° C.). The mixing, pugging and aging of the body mix is highly important, and due precautions are taken at all plants to ensure uniformity of the plastic mix that is sent to the pressers. All shapes are made by hand pressing in plaster molds. After drying to leather hardness, the molds are stripped and the pieces are finished by hand, after which they are dried and sprayed with glaze. A few Carrier humidity driers are used in California in place of the usual method of drying on heated floors. In California, the ware is fired to cones 4 to 6 (1190° to 1230° C.) in round down-draft kilns.

A considerable quantity of garden pottery is made in California, either as an auxiliary product in the terra cotta plants or in smaller plants making a specialty of this class of ware. The body mix and manufacturing methods are similar to those used for making terra cotta.

Conduits: Electrical conduits are shaped by auger machines, using a mix similar to that used for sewer pipe. In California, they are usually dried in waste-heat tunnel driers. Round down-draft kilns are used at all plants.

Roofing tile: Roofing tile is popular in California on account of the prevalence of Spanish architecture. Hand-made or hand-finished machine tile is in considerable demand for the better class of homes, and machine-made tile is widely used on homes, apartment houses, hotels, schools and even on office and public buildings. Most of the hand-made roofing tile plants are small and have little equipment. Drying is done under sheds or in a barn, and firing is done in simple rectangular or vertical kilns, most of which are up-draft. There are a number of large plants making machine-made tile with an auger machine. Many of these use waste-heat tunnel driers. Beehive kilns are in general use at these plants, but one plant uses a tunnel kiln. Firing temperatures approximate cones 06 to 02 (1015° to 1125° C.). Several plants produce a hand-finished machine tile and finish the upper surface by hand before drying is complete. Such tile has nearly the same appearance as hand-made tile when laid on the roof, but is considerably cheaper. Present-day architectural design calls for a wide range of colors in roofing tile, as in face brick. With machine tile, the color range is secured by varying the proportions of buff- and pink-burning clays that are used with the red-burning clay body, and by sorting the different colors produced in different parts of the kiln. In the manufacture of hand-made tile, the mix is seldom varied in a given plant, but the color variations are obtained by normal variations in firing temperature in different parts of the kiln. In fact, the kilns are so small and so simple in design that it would not be possible to secure a uniform burn of the entire kiln. Individual tile usually show a considerable color difference between opposite sides or ends of the tile. This feature, together with the irregularity of outline, largely accounts for the artistic value of hand-made tile when applied to moderately small roofs. It should be noted, however, that hand-made tile can not be relied upon to make a water-proof roof, on account of high porosity and cracks in many of the tile. They are often laid over machine tile.

Flue lining: Many of the fire brick and architectural terra cotta plants in California and some of the sewer pipe and roofing tile plants make flue lining to supply the trade within their marketing territory. A siliceous refractory mix is used, similar to that used in architectural terra cotta or in low or medium-duty fire brick. Round shapes are made in a sewer pipe press, and square shapes are made in an auger machine or by hand pressing. Waste-heat tunnel driers or humidity driers are sometimes used, but a common method of drying is on floors in heated rooms.

Floor tile: There are a number of important plants in California that make vitrified floor tile by the dry-press process. English or Florida kaolin and English, Kentucky, or Tennessee ball clay are usually used in white tile, together with California or Arizona feldspar and California or Nevada silica, although Illinois silica or Belgian sand is used at times in place of California silica. Some plants have introduced California talc into white vitrified tile bodies with considerable success. Colored tile are made by substituting colored clays or by adding coloring compounds in the proper proportions. Power-driven presses are gaining in favor at the larger plants for the shapes and sizes most commonly used, but hand-presses are preferred at the smaller plants, and are used at all plants for special, or infrequently used, shapes. Specially designed tunnel kilns are in successful operation at one or two plants.

There has been a good market in California for rough-textured colored floor tile, and a number of small plants have been built to satisfy the demand. Most of these use a red-burning clay, or a mixture of buff- and red-burning clays, with grog or siliceous sand. Hand molding in plaster molds is extensively practiced, but competition has led to the use of tile augers in many plants. If desired, an undulating surface can be imparted to machine-made tile by hand treatment before drying. Oil stains are frequently applied after firing to modify the surface color or lustre of the tile. The active demand for this class of ware in recent years has stimulated artistic development, and the product from nearly every plant possesses an individuality of design, texture, and color. In a few plants, however, slavish copying of successful designs from other plants was noted.

Wall and fireplace tile: The artistic development of California decorative tile is an outstanding contribution to ceramic art in the United States. There is perhaps no other region in the world today that produces such a wide diversity of wall and fireplace tile, or that is so well prepared to create new designs for private homes, hotels, stores and office buildings. Several factors have contributed to this condition, among which are the following: (1) An abundance of suitable clays, cheap fuel and power, and low-unit labor costs which make it possible to produce certain types of tile so cheaply that they not only find an important local market, but can also be shipped to eastern points on a competitive basis. (2) An active state-wide building program that is based upon the necessity of providing for many new industries each year and for new homes for the thousands of people who annually enter the state from the east and middle west to become permanent residents of California. (3) The prevailing prosperity and resultant high standards of living which are more apparent on the Pacific Coast than in any other section of the United States. (4) The diversity of architectural design arising in part from the foregoing factors, and in part from the natural environment of California, where climatic conditions favor out-of-door life throughout the year, and where comparatively low land values in most residential districts make it possible for a home builder to acquire sufficient land to avoid the necessity for a cramped architectural style such as must be used in more congested centers of population. The dominant motive of California architecture is Spanish-American, the keynote of which is to be found in the missions that were established under Spanish rule in the latter part of the eighteenth and the first part of the nineteenth centuries. Suggested by this beginning the Spanish-Moorish, Mexican-Aztec, and Pueblo Indian styles have been extensively used. Those desiring a relief from these types, yet desiring to build in keeping with their local surroundings, have often chosen Italian designs. Still others, desiring destinctive effects, and sensing the possible over-development of Latin types in many districts, have used New England colonial, southern colonial, English, Norman, and other types, many of which are hybrids or are indistinguishable as formal styles.

Refractories: The manufacture of fire brick in California has now progressed to the point where practically all of the local demand for fireclay brick and special shapes is met by California products. Several manufacturers are making a fireclay brick with calcined clay grog that gives as good or better service as the best grades that are produced elsewhere in the United States. The demand for medium or low-duty fire brick is usually met by a quartz-grogged fireclay product. One manufacturer is developing a flint fireclay brick. Another manufacturer has been marketing a silica brick for the past two or three years. Mullite refractories are being manufactured at a plant in Los Angeles, using cyanite from a large deposit in the Imperial Valley desert. No commercial deposits of bauxite or diaspore have yet been discovered, so that the state is still dependent on eastern products where a diaspore brick is needed, as in linings for the hot zone of cement kilns. However, sufficient quantities of bone clay have been found on several properties in southern California to permit its use as calcined grog and as a portion of the plastic content in the manufacture of high-alumina brick.

The methods of manufacturing refractory ware in California follow the usual practices employed elsewhere. Most plants are equipped with auger machines for shaping the standard shapes. The better grades of brick are repressed. Some hand-molded standard brick are made, and are repressed in hand-operated presses. Special shapes are made by hand-molding. Drying is usually done in waste-heat tunnel driers, although a few humidity driers are in use, especially for the shapes that are difficult to dry. Round down-draft kilns are generally used for firing, and the firing temperature for most of the fireclay brick produced in the state is cone 11 (1325° C.). One of the most notable developments is the use of a tunnel kiln by the Vitrefrax company for firing mullite brick at cone 29 (1640° C.).

Tableware: Plain and decorated semi-vitreous table and hotel ware is made at a number of plants in California. Thus far, these plants have used imported clays, in conjunction with feldspar and silica from local sources. One plant, the Empire China Company, expects to go into production in the spring of 1928 on vitreous ware, using a California feldspar and silica and a Nevada china clay, together with a certain amount of Florida clay.[1] The manufacturing methods follow well-established practice.

Kitchen ware and stoneware: A number of potteries in California are manufacturing kitchen ware and stoneware. In most cases, all materials used in the body mix are obtained from local sources of supply. Slip clays for glazing have thus far been imported from other states. The usual manufacturing practices are followed.

Art pottery: There are a few small potteries devoted to the production of distinctive lines of art pottery. As the type of body and the plant practice is different at each of these, the reader is referred to the check list, figure 1, and to the plant descriptions in Chapter III for further details.

Red earthenware: The local demand for flower pots, ollas, earthenware household utensils and other red earthenware products is met by a number of plants, some of which specialize in one or more of these products.

Sanitary ware: A complete line of sanitary porcelain, with the exception of bath tubs, is made at three plants in California by the casting process, using imported clays, California or Illinois silica, and California feldspar. All three plants are equipped with tunnel kilns for both the biscuit and glost firing. Biscuit firing is usually at cone 11 (1325°C.), and the glost firing is at cone 6 (1230° C.). Three metal enameling plants are devoted to the manufacture of enameled cast-iron sanitary ware. Semi-porcelain plumbing accessories are made at three smaller plants. One of these uses a body made entirely from California raw materials.

Electrical insulators: The manufacture of high-tension electrical insulators probably presents one of the most difficult ceramic problems of modern industry. The industry is represented in California by one plant, that of the Westinghouse Electric and Manufacturing Company, at Emeryville (c.v., p. 45). California feldspar is the only local material used in the body mix. Semi-porcelain electrical accessories are being made at three small plants in California.

Thermal insulators: Although accurate statistics are unavailable for publication, the bulk of the diatomaceous earth insulating brick output of the United States, if not of the world, is produced in California. The Celite Products Company at Lompoc, and the Stockton Fire Brick Company at Stockton are the only producers at present. The production of sawn natural blocks of diatomaceous earth, at one time of importance, is now relatively small compared to the production of molded (hand or auger-machine) and fired shapes.

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[1] Personal communication from G. Ray Boggs, December 8, 1927.

STATISTICS.

BRICK AND HOLLOW TILE.

The brick and hollow tile statistics compiled by the State Division of Mines and Mining include all classes of brick. The detailed figures of production and value for 1926, by counties and by class of ware, are given in Table 2. This is a companion to Table 6, referred to later under pottery clay, in which the segregated figures for other clay products are given.

Table 3 gives statistics for the common brick industry of California, by years from 1896 to 1926 inclusive. The annual value of the common brick production is plotted to a ratio scale on Plate II. For comparative purposes, Plate II also includes the curves for the average unit value of common brick per thousand, and the gross annual value and the average unit value per barrel for cement during the same period. The rapid growth of the cement industry relative to that of the common brick industry is of special interest, as is also the comparative trend of prices in the two industries. The trend of cement prices reflects the economies of steady technical and mechanical progress in the cement industry, and the increasing size of plant units. The trend of common brick prices closely parallels the fluctuations in commodity prices and labor wages, as modified by fluctuations in the unit cost of fuel, as a high percentage of the cost of making common brick arises from labor and fuel costs, and there have been no important technical or mechanical improvements in brick manufacture during the period under review. The influence of the San Francisco earthquake of 1906 is strikingly shown by the decline of the common brick production and the continued rise of the cement production after a slight recession following the financial panic of 1907.

POTTERY CLAY.

The term 'pottery clay' as used in State Mining Bureau reports refers to all clay other than that used in the manufacture of common brick and hollow tile.[1] The production of pottery clay in California in 1926 is given in Table 4, and the production by years, from 1887 to 1926, inclusive, is given in Table 5. The production of pottery clay products in California during 1926 is given in Table 6.

[1] For a further elaboration of this definition see Cal. State Min. Bur. Bulletin No. 97, p. 94, 1926, or other annual statistical reports by the Bureau.

TABLE No. 2.

Brick and Hollow Tile Production for 1926, by Counties.

(From Bulletin No. 100, p. 70, 1927.)

County	Common		Fire		Glazed, pressed, fancy, vitrified, paving		Hollow building tile or blocks		Total value
	Amount M	Value	Amount M	Value	Amount M	Value	Tons	Value	
Alameda					3,692	$178,222	35,330	$356,242	$534,464
Butte	273	$4,316							4,316
Fresno	5,117	76,731	*		*		*		76,731
Kern	4,591	55,140							55,140
Los Angeles	219,473	1,913,573	[a]7,079	$480,316	[b]11,774	560,178	21,471	192,408	3,146,475
Orange	6,272	72,489							72,489
Riverside	*		9,017	398,735	3,731	134,175	*		532,910
Sacramento	12,850	178,900	*		*		*		178,900
San Diego	10,291	124,424	*		*		*		124,424
San Joaquin	6,269	106,942	*				*		106,942
Santa Barbara	430	6,785					406	10,291	17,076
Santa Clara	18,222	197,782							197,782
Alameda, Amador, Contra Costa, Humboldt, Imperial, Marin, Merced, Riverside, San Luis Obispo, Tehama, Tulare*	44,876	494,515							494,515
Alameda, Amador, Contra Costa, Fresno, Merced, Placer, Sacramento, San Diego, San Joaquin*			13,285	705,002					705,002
Contra Costa, Fresno, Placer, Sacramento, San Diego*					10,806	466,010			466,010
Contra Costa, Fresno, Merced, Placer, Riverside, Sacramento, San Diego, San Joaquin, San Luis Obispo, Tulare*							33,125	312,948	312,948
Totals	328,664	$3,231,597	29,381	$1,584,053	30,003	$1,338,585	90,332	$871,889	$7,026,124

*Combined to conceal output of a single operato rin each.
[a] Includes special silica brick.
[b] Includes Ferguson sewer liners.

Av. value per M
$6.11
5.74
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6.18
5.83
6.44
7.14
7.35
7,18
6.90
7.05
7.32
6.74
6.33
6.05
6.08
6.28
5.75
6.13
6.12
6.56
7.14
9.43
12.18
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14.21
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13.03
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Brick and Hollow Tile Production for 1926, by Counties.

(From Bulletin No. 100, p. 70, 1927.)

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	Amount M	Value	Amount M	Value	Amount M	Value	Tons	Value	
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Butte	273	$4,316							4,316
Fresno	5,117	76,731	*		*		*		76,731
Kern	4,591	55,140							55,140
Los Angeles	219,473	1,913,573	[a]7,079	$480,316	[b]11,774	560,178	21,471	192,408	3,146,475
Orange	6,272	72,489							72,489
Riverside	*		9,017	398,735	3,731	134,175	*		532,910
Sacramento	12,850	178,900	*		*		*		178,900
San Diego	10,291	124,424	*		*		*		124,424
San Joaquin	6,269	106,942	*				*		106,942
Santa Barbara	430	6,785					406	10,291	17,076
Santa Clara	18,222	197,782							197,782
Alameda, Amador, Contra Costa, Humboldt, Imperial, Marin, Merced, Riverside, San Luis Obispo, Tehama, Tulare*	44,876	494,515							494,515
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Totals	328,664	$3,231,597	29,381	$1,584,053	30,003	$1,338,585	90,332	$871,889	$7,026,124

*Combined to conceal output of a single operato rin each.
[a] Includes special silica brick.
[b] Includes Ferguson sewer liners.

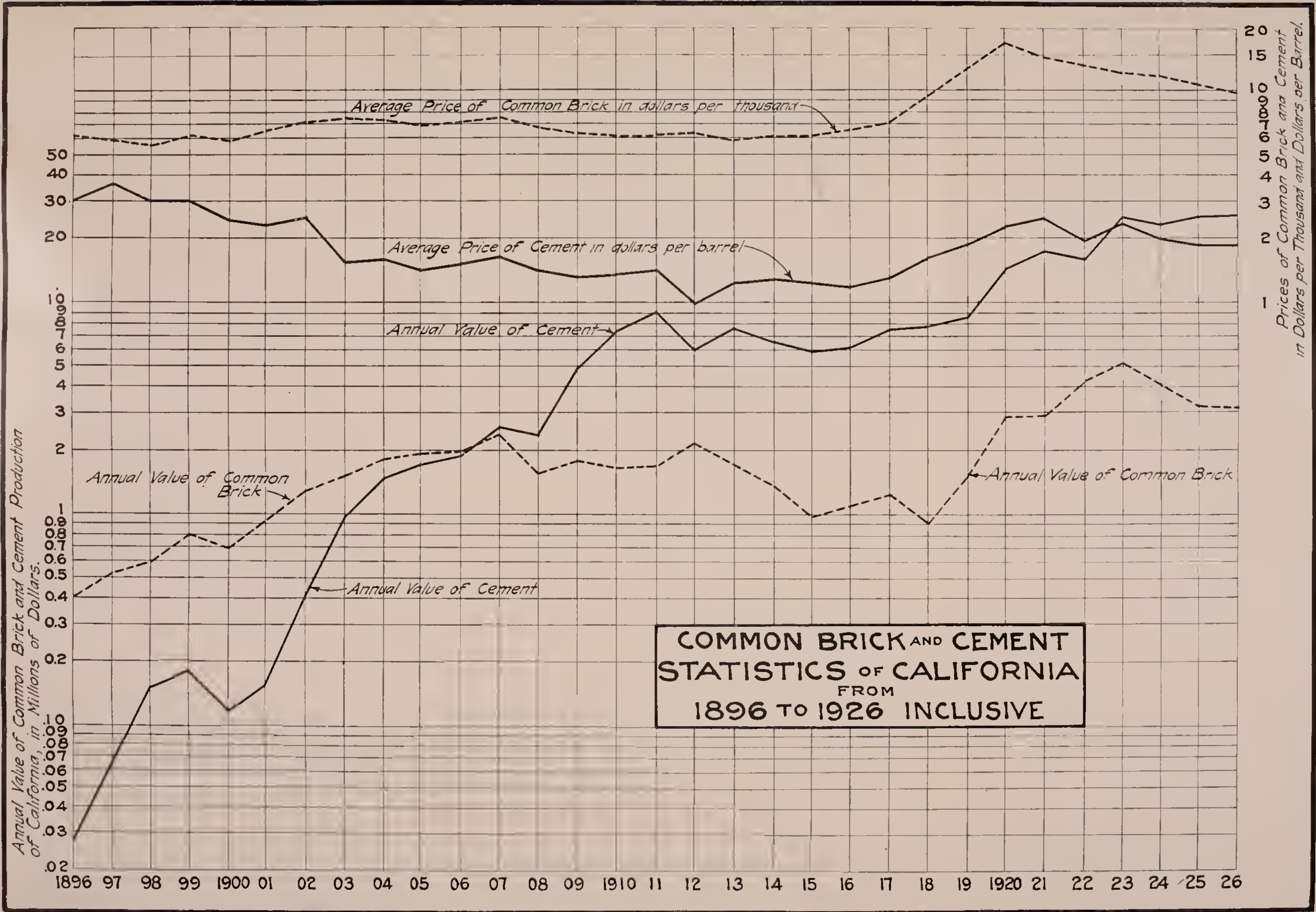

COMMON BRICK AND CEMENT STATISTICS OF CALIFORNIA FROM 1896 TO 1926 INCLUSIVE
Average Price of Common Brick in dollars per thousand
Average Price of Cement in dollars per barrel
Annual Value of Cement
Annual Value of Common Brick
Annual Value of Common Brick and Cement Production of California, in Millions of Dollars.
Prices of Common Brick and Cement in Dollars per Thousand and Dollars per Barrel.
1896 97 98 99 1900 01 02 03 04 05 06 07 08 09 1910 11 12 13 14 15 16 17 18 19 1920 21 22 23 24 25 26

TABLE No. 2.

Brick and Hollow Tile Production for 1926, by Counties.

(From Bulletin No. 100, p. 70, 1927.)

			Glazed, pressed,	Hollow building	

TABLE No. 3.

Common Brick Production of California, by Years.*

Year	Production M	Value	Av. value per M
1896	74,240	$391,567	$6.11
1897	88,890	509,955	5.74
1898	108,076	598,823	5.54
1899	129,512	800,210	6.18
1900	119,906	698,583	5.83
1901	146,522	943,250	6.44
1902	181,040	1,291,941	7.14
1903	217,715	1,600,882	7.35
1904	256,898	1,843,936	7.18
1905	284,205	1,961,909	6.90
1906	278,780	1,962,866	7.05
1907	339,439	2,483,062	7.32
1908	236,383	1,593,814	6.74
1909	276,396	1,749,209	6.33
1910	280,265	1,694,312	6.05
1911	282,199	1,716,442	6.08
1912	349,797	2,198,303	6.28
1913	295,729	1,699,426	5.75
1914	221,243	1,356,885	6.13
1915	160,452	981,888	6.12
1916	168,826	1,107,940	6.56
1917	169,015	1,207,765	7.14
1918	96,732	912,205	9.43
1919	126,892	1,545,558	12.18
1920	163,782	2,823,304	17.24
1921	202,417	2,880,124	14.21
1922	323,625	4,363,629	13.48
1923	397,754	5,194,527	13.03
1924	335,203	4,124,385	12.30
1925	297,449	3,317,766	11.12
1926	328,664	3,231,597	9.82

* Data prior to 1920 from U. S. Geol. Surv. Min. Res., since 1920 from Cal. State Min. Bureau reports.

TABLE No. 4.

Production of Pottery Clay in California in 1926.

(From State Div. Mines and Mg. Bulletin No. 100, p. 97, 1927.)

County	Tons	Value	Used in the manufacture of
Alameda	5,870	$7,183	Drain, faience, flood, quarry and roofing tile, sewer pipe.
Amador	97,768	135,767	Architectural terra cotta, fire clay products, chimney and sewer pipe, refractories, drain, floor and roofing tile, and various.
Contra Costa	7,675	5,688	Architectural terra cotta, sewer pipe, faience and drain tile.
Los Angeles	[a]86,767	99,076	Architectural terra cotta, conduit, red earthenware, refractories, drain, faience, floor and roofing tile, chimney and sewer pipe, and oil well mudding.
Monterey	491	1,164	Floor and roofing tile.
Orange	13,150	38,989	Conduit pipe and stoneware, refractories, drain and roofing tile, and various.
Placer	104,250	147,241	Architectural terra cotta, chimney, sewer and conduit pipe, drain,, floor and roofing tile, sanitary ware, red earthenware, and various.
Riverside	58,528	178,383	Conduit and sewer pipe, red earthenware, refractories, roofing tile, and various.
Sacramento	1,548	2,310	Crushed brick, faience tile, et al.
San Bernardino	[b]2,268	10,605	Porcelain.
San Diego	[cd]30,187	58,269	Therapeutic clay, sewer pipe, faience, floor and roofing tile, and various.
Santa Barbara	1,100	1,700	Drain, floor and roofing tile.
Ventura	[a]373,000	93,250	Oil-well drilling mud.
Butte, Calaveras, Humboldt, Merced, San Luis Obispo, Santa Clara, Sonoma[b]*	18,859	26,884	Earthenware, porcelain, chimney and sewer pipe, drain and roofing tile.
Totals	801,461	$806,509	

* Combined to conceal output of a single operator in each.
[a] Includes clay and shale for oil-well drilling mud.
[b] Includes kaolin.
[c] Includes 'Cornwall' stone.
[d] Includes therapeutic clay.

TABLE No. 5

Pottery Clay Production of California, by Years.

(From State Div. Mines and Mg. Bulletin No. 100, p. 98, 1927.)

Year	Tons	Value	Year	Tons	Value
1887	75,000	$37,500	1907	160,385	$254,454
1888	75,000	37,500	1908	208,042	325,147
1889	75,000	37,500	1909	299,424	465,647
1890	100,000	50,000	1910	249,028	324,099
1891	100,000	50,000	1911	224,756	252,759
1892	100,000	50,000	1912	199,605	215,683
1893	24,856	67,284	1913	231,179	261,273
1894	28,475	35,073	1914	179,948	167,552
1895	37,660	39,685	1915	157,866	133,724
1896	41,907	62,900	1916	134,636	146,538
1897	24,592	30,290	1917	166,298	154,602
1898	28,947	33,747	1918	112,423	166,788
1899	40,600	42,700	1919	135,708	245,019
1900	59,636	60,956	1920	203,997	440,689
1901	55,679	39,144	1921	225,120	362,172
1902	67,933	74,163	1922	277,232	473,184
1903	90,972	99,907	1923	376,863	697,841
1904	84,149	81,952	1924	417,928	651,857
1905	133,805	130,146	1925	537,587	674,376
1906	167,267	162,283	1926	801,461	806,509
Totals				6,710,784	$8,442,643

TABLE No. 6.

Value of Pottery Clay Products Made in California During 1926.

(From State Div. Mines and Mg. Bulletin No. 100, p. 97, 1927.)

Product	Number of producers	Tons	Value
Architectural terra cotta	5	15,954	$2,361,524
Chimney pipe, terra cotta and flue lining	10	13,207	461,786
Drain tile	12	7,178	113,168
Roofing tile	24	73,984	1,917,415
Sewer pipe	10	100,689	2,910,567
Chinaware and semi-vitreous tableware	3	------	627,516
Sanitary ware	6	------	1,894,705
Red earthenware	6	------	198,308
Stoneware and chemical stoneware	6	------	434,772
Floor, faience, mantel, glazed and hand-made tile	27	------	2,867,772
Miscellaneous art pottery, bisque ware, brick dust, calcined clay, ceramic, mosaic wall tiles, conduit, conduit pipe, fire clay products, crushed brick and tile, garden furniture and pottery, high temperature cement, porcelain, gas radiants, and backs, cast stone, ground clay, fire clay and grog, broken tile and various	23	------	837,670
			$14,625,203

TOTAL ANNUAL VALUE OF CLAY PRODUCTS IN CALIFORNIA COMPARED TO THE TOTAL FOR THE UNITED STATES.

The figures of the annual value of clay products, and the number of producers reporting are given in Table 7, for California and for the entire United States during the period from 1896 to 1926, inclusive. The ranking of California among the states, and the production of California as a percentage of the total United States production are also shown in the table. The production figures are plotted on a ratio scale on Plate III. Both the California and the United States curves may be conveniently divided into four time periods: (1) From 1896 to 1907, a period of rapid growth, during which the United States production increased at an average of 8.7 per cent per year, whereas the California production increased at an average of 21.3 per cent per year. (2) From 1907 to 1915, a period of depression following the financial panic of 1907, the effect of which was exaggerated in its influence on the common brick and hollow tile industry of California by the San Francisco earthquake of April, 1906. During this period the average annual production of clay products in the United States remained nearly stationary, while that of California showed an average annual decrease of 5.7 per cent. A contributing factor to this condition, both in California and in the United States at large, was the rapid increase in the use of reinforced concrete, especially in the construction of large buildings in the major cities. (3) From 1915 to 1923, a period of rapid expansion and rising prices, but with a retardation of growth in 1917 and 1918 in the production of certain ceramic branches, such as architectural terra cotta, which were classed as nonessential and were unable to secure sufficient fuel or labor for maximum production, and a further period of retardation in 1921, following the post-war deflation that gained momentum in 1920. The latter effect is not noticed in the ceramic production of California. The average annual increase in the value of ceramic products in the United States during the eight year period was 12.7 per cent compared to 24.6 per cent for California. (4) From 1923 to 1926. The period is too short to permit accurate interpretation of trend, but a slowing down is apparent, both in California and in the United States at large.

The average annual rate of growth of the value of ceramic products in the United States for the entire period of 30 years from 1896 to 1926 was 6.0 per cent, compared to 12.3 per cent for California.

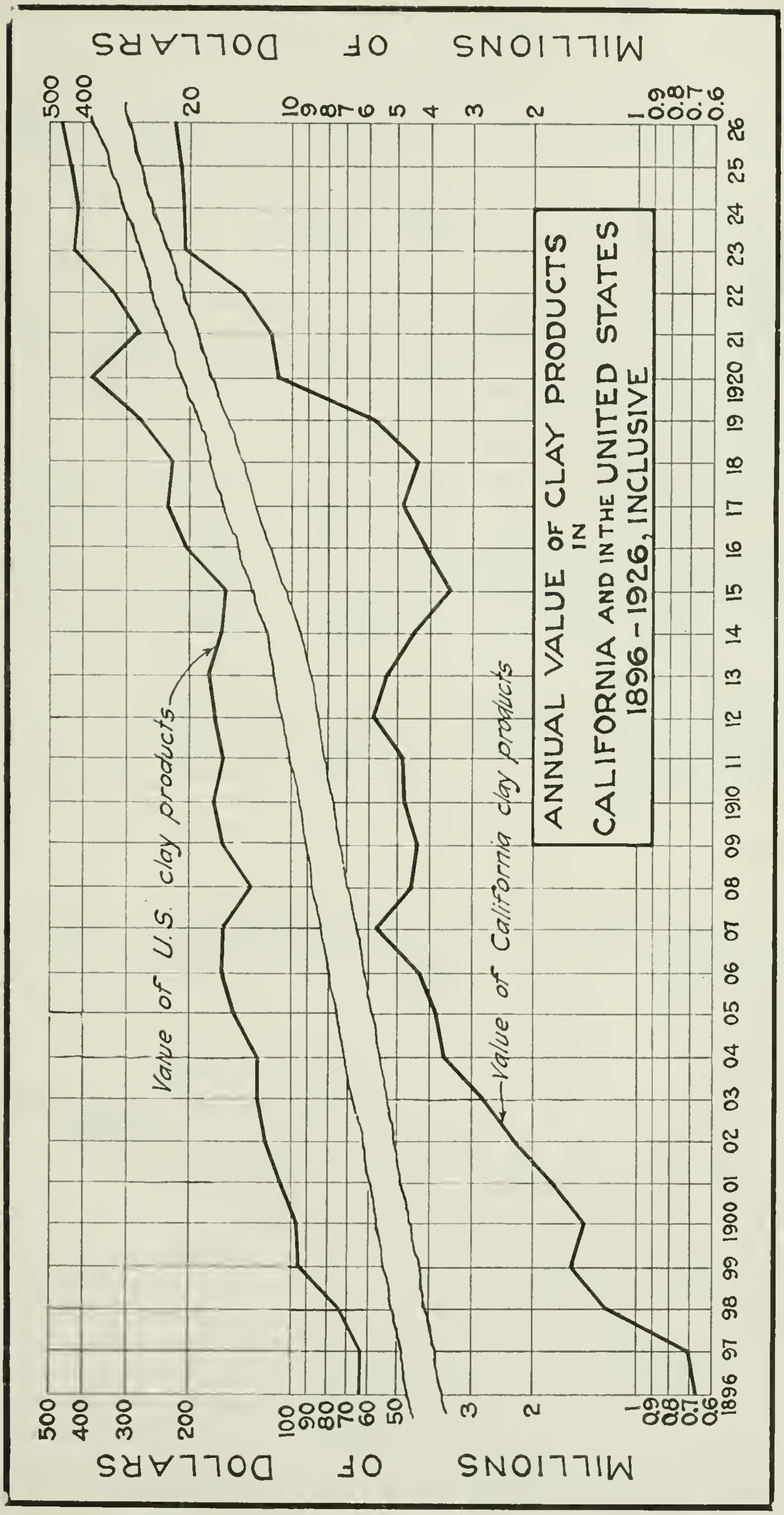
TABLE No. 7.

California and Total United States Production of Ceramic Products from 1896 to 1926.*

	California				United States	
Years	Value	No. of producers	Rank among states	% of total U. S. value	Value	Number of producers
1896	$680,207	91	21	1.08	$63,110,408	6293
1897	703,410	92	21	1.13	62,359,991	5424
1898	1,263,734	77	12	1.70	74,487,680	5971
1899	1,587,518	79	12	1.66	95,797,370	6962
1900	1,375,998	72	14	1.43	96,212,345	6375
1901	1,769,155	92	11	1.61	110,211,587	6421
1902	2,253,096	89	11	1.84	122,169,531	6045
1903	2,831,543	105	9	2.16	131,062,421	6034
1904	3,624,734	121	8	2.77	131,023,248	6108
1905	3,865,147	122	8	2.58	149,697,188	5925
1906	4,364,230	113	8	2.71	161,032,722	5857
1907	5,740,537	118	8	3.61	158,942,369	5536
1908	4,523,745	119	8	3.40	133,197,762	5328
1909	4,437,165	99	9	2.67	166,321,213	5068
1910	4,842,391	107	9	2.85	170,115,974	4915
1911	4,915,866	92	8	3.03	162,236,181	4628
1912	5,912,450	91	8	3.42	172,811,275	4284
1913	5,344,958	91	9	2.95	181,289,132	4065
1914	4,461,661	84	10	2.70	164,986,983	3860
1915	3,599,375	83	10	2.21	163,120,232	3636
1916	4,163,426	79	10	2.01	207,260,091	3412
1917	4,826,125	74	11	2.10	232,512,773	3153
1918	4,329,220	68	11	2.00	221,884,651	2783
1919	5,834,648	66	10	2.10	275,346,378	2776
1920	10,946,423	65	9	2.9	373,670,102	2716
1921	11,172,491	63	8	4.1	270,738,536	2449
1922	14,689,830	62	6	4.6	321,494,403	2098
1923	20,833,053	86	6	4.9	424,582,628	2441
1924	20,994,732	86	6	5.0	415,779,378	2353
1925	21,324,844	99	6	5.0	423,446,917	2417
1926	21,651,327	95	–	4.6	459,049,470	2391

* From U. S. Geol. Survey prior to 1920. Since 1920 from U. S. Bur. Mines, Min. Res.

PLATE III


ANNUAL VALUE OF CLAY PRODUCTS IN CALIFORNIA AND IN THE UNITED STATES
1896 - 1926, INCLUSIVE
Value of U.S. clay products
Value of California clay products
MILLIONS OF DOLLARS
MILLIONS OF DOLLARS

Chapter III.

CLAY DEPOSITS AND CERAMIC PLANTS BY COUNTIES.

ALAMEDA COUNTY.

General Features.

Alameda County is on the eastern shore of San Francisco Bay and has a land area of 732 square miles, 500 of which are rich agricultural bottom lands devoted to farming and fruit growing. The principal cities are Oakland, Alameda and Berkeley. The population of the county is 344,177 (1920 census).

The county is traversed in a northwesterly and southeasterly direction by several mountain ranges, which together form the eastern group of the Coast Range mountains. These ranges become rugged and reach higher altitudes in the southeastern portion of the county, their continuation into Santa Clara County culminating in the Mount Hamilton range. The mountains consist largely of metamorphic sandstones, jaspers and serpentines of the Franciscan formation, together with sandstones and shales of Cretaceous and Tertiary age.

The mineral resources of Alameda County include asbestos, brick, chromite, clay, coal, limestone, magnesite, manganese, potash, pyrite, salt, soapstone, and crushed rock, sand and gravel. The principal commercial mineral products in the order of their relative importance are: miscellaneous stone, salt, brick and hollow tile.

Clay Resources.

There are excellent deposits of common clay suitable for the manufacture of common brick, hollow tile, and roofing tile at various places in the county, and a number of plants for manufacturing these products are in operation. The best and most extensive common clay deposits occur in the Livermore and Niles valleys.

High-grade clays were at one time mined near Tesla, on the eastern edge of the county, but there is no present production.

On account of favorable manufacturing and marketing conditions, a number of important ceramic plants have been established in the county, especially in Oakland, Alameda, Berkeley, Niles and Livermore, and a wide diversity of ceramic ware is produced.

California Bisque Doll Company. Mrs. H. T. Epperson, manager. Office and plant at 1175 San Pablo Avenue, Berkeley. Formerly the *California China Company.* This plant was built in 1906 for the manufacture of bisque doll heads, but there was no commercial output until 1919. It is said to be the only plant in the United States producing bisque doll heads on a commercial scale. A number of other ceramic products are made, such as salt and pepper shakers, art vases and bowls, and novelties. California raw materials are used whenever possible. The use of Clark and Marsh kaolin from near Calistoga (samples No. 190–192, pp. 261, 280) is of special interest. The clays are prepared by small scale apparatus, and most of the shapes are made by casting.

Firing is done in saggers in a small up-draft kiln, fired to cone 12 for biscuit ware, and to cone 7 to 9 for the glost firing.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 35 (California China Company).

California Faience Company (formerly *The Tile Shop*). C. R. Thomas and W. B. Bragdon, owners and operators, 1335 Hearst Avenue, Berkeley. At this plant, glazed art pottery, art tile, and inserts are made from a red-burning body, the composition of which varies from time to time, depending upon the clays that are available. Shale is purchased from the Richmond Pressed Brick Co. (sample No. 119, p. 325), and clay is sometimes obtained from the Angel Ranch deposit near Eureka (sample No. 181, p. 336).

The clays are prepared by ball-milling, and are pugged by hand. Most of the art pottery is shapped by casting, and the tile and decorative inserts are made by hand pressing in plaster molds. A gas-fired pie-baking oven is used to finish the drying, after air-drying is completed in the shop.

Two kilns are in use. One is a Calkins kiln, and the other is a round down-draft kiln, 13-ft. in diameter and 10-ft. high, with a continuous bag-wall extending nearly to the crown. The biscuit and glaze firing are done together, the kilns being set so that the ware to be biscuited receives the greater heat. Cone 04 is brought down in the biscuit zone of the kilns.

The company has been successful in establishing a small, but high-class market for its ware, and a considerable part of its output is shipped to Eastern points. Special orders are taken for ornamental garden and fountain pieces, as well as for pottery and tile.

Two or three men are employed in addition to the owners.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 37.

California Pottery Company. F. A. Costello, president; J. F. Creegan, secretary. Plant, 2265 East Twelfth Street, Oakland. (The company also operates a plant at Merced, see page 128.) This company was established in 1872. The products made at this factory are vitrified sewer pipe, chimney pipe, flue lining, garden pottery, lead pots for the paint industry, wall and floor tile (faience), roof tile, and stoneware. The clays used are Lincoln No. 1–6 (sample No. 146, p. 303), Ione sand (Shepard) (sample No. 128, p. 261), Valley Springs clay (samples No. 202–204, pp. 299, 337), a surface clay from Niles, similar to that used by the Niles plant of the W. S. Dickey Clay Manufacturing Co. (sample No. 265, p. 343), and some Nigger Hill clay from Calaveras County (sample No. 236, p. 263).

The sewer pipe, chimney pipe, flue lining and garden pottery and tile mixtures are prepared by dry-pan grinding, followed by wet-pan pugging. Sewer pipe is made in the usual presses. Chimney pipe, flue lining, and roofing tile are also made in a sewer-pipe press. Some of the roofing tile are hand finished, giving the appearance of hand-made tile. Floor tile, wall tile, and garden pottery are hand molded. Single-fire glazes are used.

The clay mixture for stoneware is prepared by blunging, filter pressing and pugging, followed by ageing for a suitable period. Most of the stoneware is jiggered.

Drying is done in a steam rack for the tile and stoneware, and other ware is dried on floors heated with waste heat from the kilns.

Eight round down-draft kilns are used, fired with oil, atomized with steam. Two or three are 30-ft., four are 28-ft. and two are 25-ft. in diameter. Stoneware is fired to cone 8 (2400° F. on pyrometer) and other ware is fired to 2100° F. The average firing time is four days, making the total cycle 8 to 9 days per kiln. Sixty men are employed.

In 1927, this company purchased the property formerly operated by the California Pressed Brick Company, and the plant was overhauled and newly equipped for the manufacture of brick and tile.[1]

Bibl: Cal. State Min. Bur., Bull. No. 38, p. 202; Prel. Rept. No. 7, p. 36.

N. Clark and Sons. A. V. Clark, president and general manager; G. D. Clark, secretary. Main office at 112–116 Natoma Street, San Francisco. Plant at Pacific Avenue and Fourth Street, Alameda. This plant has been in operation since 1889. The principal products are architectural terra cotta, sewer pipe, fire brick and face brick.

The company owns or controls deposits of all raw materials used in the body mixes at the plant. Sand and clay from Ione (see under Amador County) and a calcareous shale from a deposit at Walnut Creek (see under Contra Costa County) are the principal materials used.

The fire brick and face brick are made by the stiff-mud process, without repressing. Sewer pipe and terra cotta are made by the usual processes. Sixteen oil-fired round down-draft and muffle kilns are in use.

Part of the plant was destroyed by fire in July, 1917, but was rebuilt in 1919. Another fire occurred on September 16, 1927, which caused a shut-down during reconstruction.

Bibl: State Min. Bur. Bull. 38, p. 202; Prel. Rept. 7, p. 36.

W. S. Dickey Clay Manufacturing Company: N. A. Dickey, manager. Office, 604 Mission Street, San Francisco. Plant No. 18 is one mile west of Niles, and was formerly known as the California Brick Company. Hollow tile and paving brick are manufactured. A Haigh continuous kiln is used for firing. Plant No. 19 is at Livermore, and was formerly known as the Livermore Firebrick Works. Fire brick, fireclay refractories, face brick and sewer brick are manufactured.

The management refused permission to publish data on the two plants, and as much of the data previously published by the Bureau is obsolete, there is no need for repeating it here.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 35 (California Brick Company), and p. 37 (Livermore Firebrick Works).

Electrical Porcelain Works. Levi S. Baker, proprietor; Joseph Baker and Chas. Ball, officials. Office and plant at 2414–16 Sixth Street, Berkeley. Electrical porcelain insulating products are manufactured, using English china and ball clays, Florida kaolin, San Diego County feldspar and silica, and Ione and Lincoln fireclays. The ware is shaped by dry pressing, throwing, turning, machine-pressing, or casting, according to the nature of the shapes to be made. Two oil-fired

[1] Clay-Worker, July, 1927, p. 36.

kilns are used. One is 14 feet in diameter, and the other is 8 by 8 feet square.

Hidecker Tile Company. G. C. Hidecker, manager. The plant is at Twenty-fourth and Union streets, Oakland, and manufactures roofing tile only. Local clay from excavations in Oakland and vicinity is mixed with Lincoln clay (sample No. 147, p. 303) and Natoma clay (samples No. 210 and 212, p. 337). A Williams hammer pulverizer is used to disintegrate the clay, which is then screened through an 8-mesh screen, passed to a pug-mill, and finally to an auger machine, which is equipped with a hand-operated wire-cutter. The tile are dried on pallets in the open air.

Two up-draft oil-fired kilns are used. The larger of these holds 25,000 eighteen-inch tile, and the smaller holds 12,000 tile. The water smoking is done with wood-shavings and requires 24 hours. This is followed by four days firing with oil, to a finishing temperature ranging from 875° to 980° C. Eight to ten men are employed during the operating season of five to eight months.

Kraft Tile Company. A. Clay Myers, president; J. L. Kraft, C. H. Kraft, E. Ridgeway, and H. E. Leash, directors and officers. General office, 55 New Montgomery Street, San Francisco. Plant at Pabrico, two miles west of Niles.

This plant was built in 1926 to manufacture high-fired faience tile, using Lincoln fireclay and Ione sand. Augers are used for shaping the tile. Hot-air driers of the dehydrator type are used for drying. After drying, the tile are carefully trimmed to size in a special machine before applying the glazes. This produces a finished tile that falls within closer limits of size than is customary in most plants. The product is fired in round down-draft kilns. The output of the plant in July, 1927, was 1000 square feet of tile daily.

Miller's Oakland Art Pottery. Mrs. Isabelle Miller Burress, owner. Albert Van Cleve, manager, 2237 East Twelfth Street, Oakland. Sewer pipe, patent chimney pipe, flue lining, and drain tile are made at this plant. Yarn and Harvey clays (samples No. 124 and 133, pp. 298, 302) from M. J. Bacon, Ione, are used, together with excavation debris from Oakland and vicinity.

The clays are prepared in dry and wet pans, and the ware is shaped in steam presses. Drying is done on the floors of the building, without special provision for heating by waste kiln gases.

The firing equipment consists of five oil-fired round down-draft kilns, the largest of which are 22-ft. in diameter and hold 35 tons of ware. The firing schedule varies from 48 to 72 hours, depending on the ware, and the finishing temperature averages 2000° F. (1093° C.) with a maximum of 2100° F. (1149° C.).

Twenty-five men are employed.

Bibl: Cal. State Min. Bur., Bull. No. 38, p. 204 (Oakland Art Pottery).

M & S Tile Company. Owned by F. J. Thomas, G. L. Smith and J. M. Bettencourt. The plant is near the Oakland-Niles highway at Decoto. This plant was established in February, 1926, for the manufacture of hand-made roofing tile. A local surface clay (sample No.

264, p. 343) is used. The clay is similar to that used in the W. S. Dickey Company's hollow tile plant at Niles (sample No. 265, p. 343).

The clay is mined with the aid of a team and scraper. A small power-driven pug-mill prepares the clay for hand-molding. Drying is done on pallets under a shed. A rectangular oil-fired down-draft kiln, having a capacity of 5700 roofing tile, is used for firing. The firing schedule occupies 55 to 60 hours, and the finishing temperature is cone 06 (1005° C.).

Five men were employed at the time of visit, in September, 1926.

Muresque Tiles, Inc. Wm. F. Muir, president and manager; Chas. Orpin, secretary; 1001 Twenty-second Avenue, Oakland. This is a small plant for making hand-pressed floor, wall and mantel tile, and decorative inserts. Lincoln and Ione clays are used, which produce a buff or cream body. Matt glazes are used, which are buffed on a wheel after firing, producing effects similar to the well-known Batchelder tile, made in Los Angeles (see page 97). An oil-fired muffle kiln is used. No further details would be furnished by the company.

Remillard Brick Company. C. Remillard, president; R. C. Giroux, secretary. Office, 332 Phelan Building, San Francisco. The plant is one and one-half miles northeast of Pleasanton, on the main line of the Southern Pacific Railroad. The plant was established in 1889 and has been operated continuously since then. Common red brick are manufactured.

The clay deposit consists of a sandy loam, 25 feet thick, and is mined from a pit one-quarter mile from the plant by a drag-line scraper operated by an electric hoist. The clay is loaded into cars and hauled by motor to the plant. The soft-mud process is used. The brick are dried under sheds in the yard, and are fired in two 16-compartment Hoffman kilns, of 20,000 daily capacity each. Fifty men are employed during the season.

Bibl: Cal. State Min. Bur. Repts. XII, p. 381; XIII, p. 613; Bull. 38, p. 242; and Prel. Rept. No. 7, p. 37.

Technical Porcelain and China Ware Company. J. Pagliero, owner. Office and plant 420 Kains Avenue, Albany, via Berkeley. This is a small plant manufacturing porcelain bath-room fixtures by the casting process from a mixture of California clays. One square up-draft kiln is used for both biscuit and glost firing. Four men are employed.

Tesla: The coal and clay deposits of Eocene (Tejon) age in Corral Hollow, near Telsa, and extending for a short distance eastward into San Joaquin County, have been known since 1862. These deposits have been worked at various times in the past, notably during the period from 1897 to 1907. The coal was inferior in quality, and was costly to extract on account of steep dip and swelling ground. As late as 1919 an attempt was made to reopen the coal mine, at which time the property was purchased by the Beckman-Linden Engineering Corporation of San Francisco, and considerable sums of money were expended on equipment and development before it was clearly demonstrated that commercial success could not be expected under prevailing conditions. The principal activities in the past have centered around the Tesla

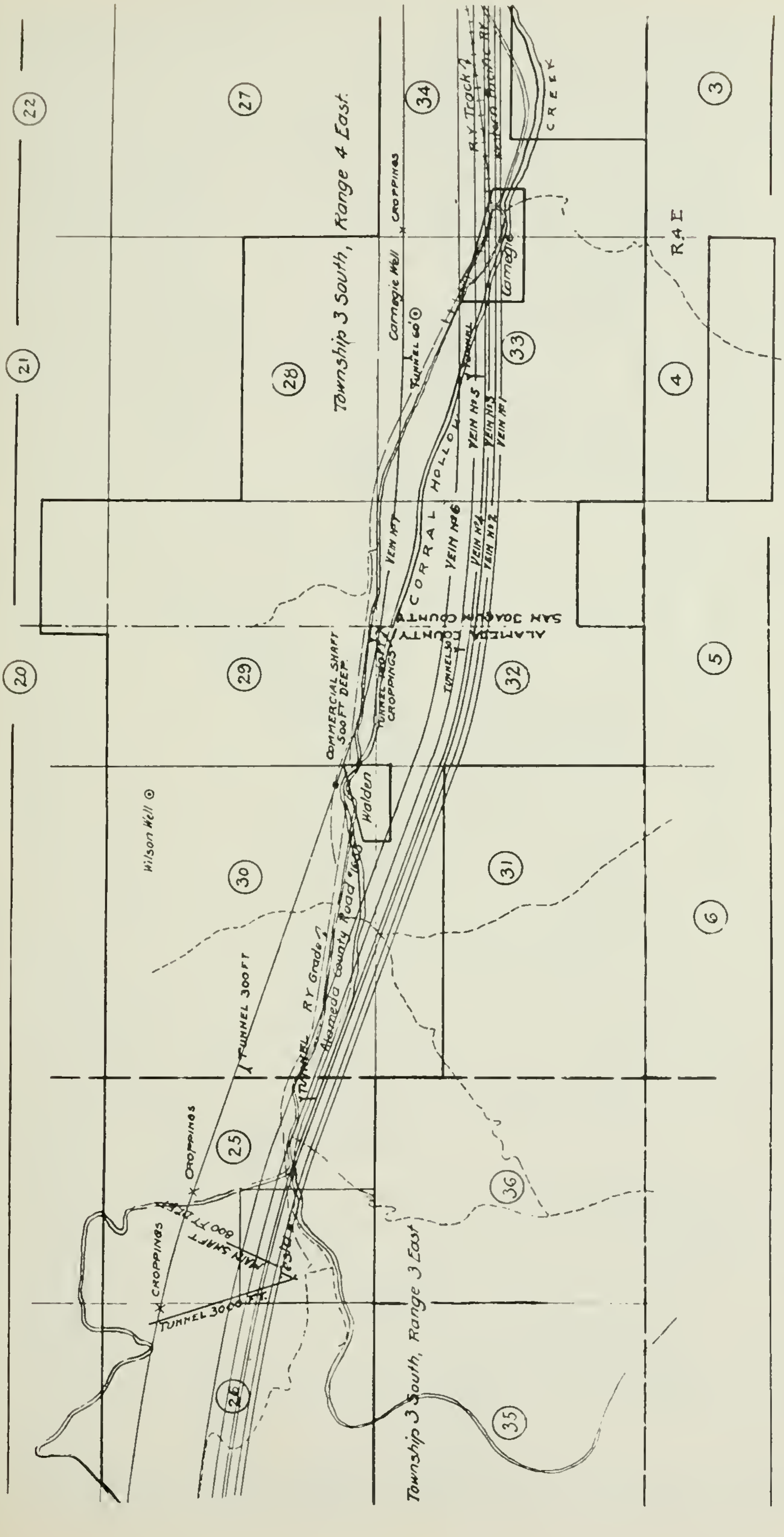


PLATE IV. Map of Tesla district, Alameda County. (Map by Beckman and Linden Engineering Corporation, October, 1919.)

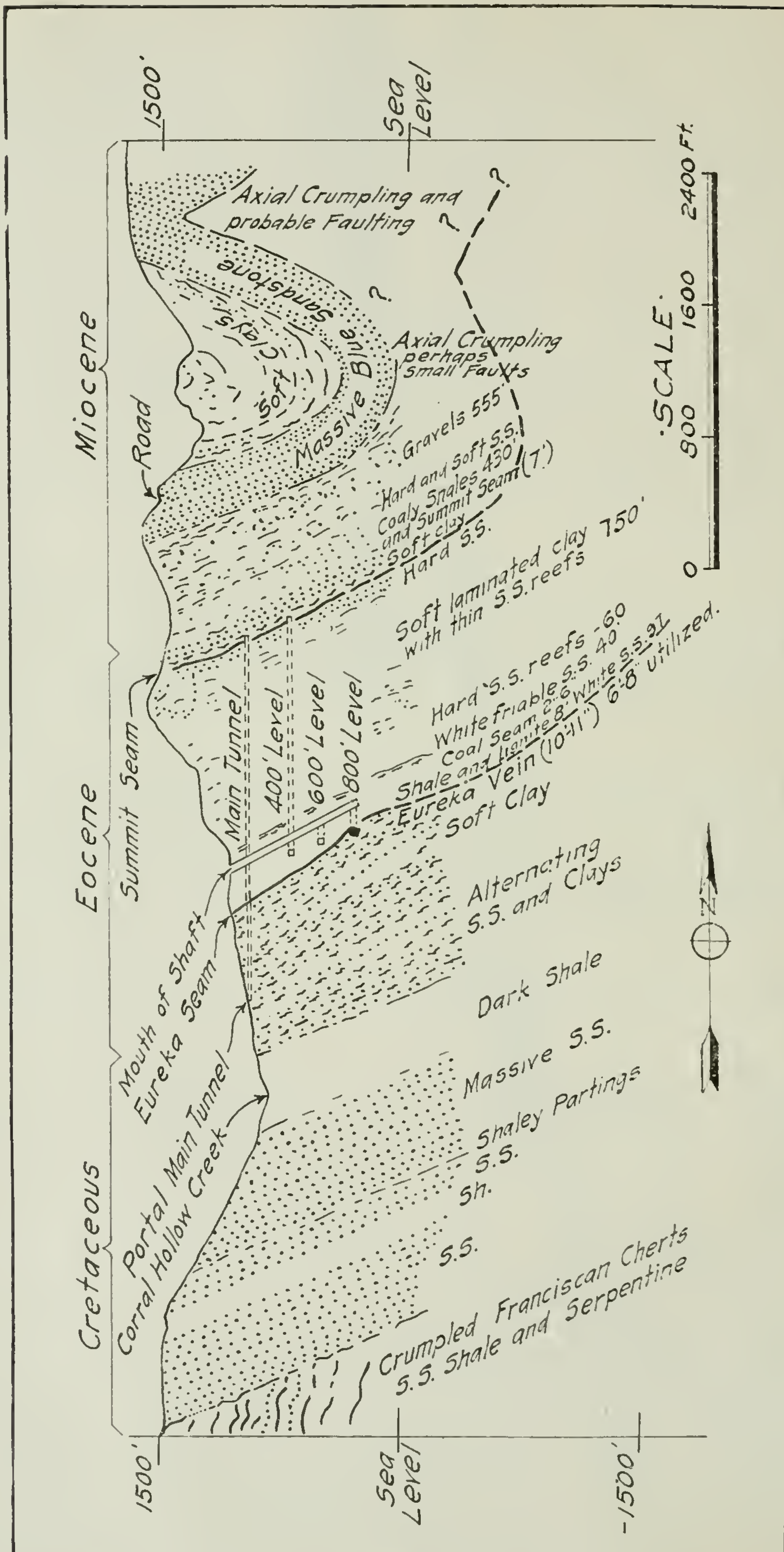


PLATE V. Geologic section through main Tesla shaft. Details generalized. (Map by Beckman and Linden Engineering Corporation, October, 1919.)

mine, in the SE½ of Sec. 26, T. 3 S., R. 3 E., M. D. M., which followed what is known as the Eureka coal seam to a depth of 800 feet. Some work was also done on the Summit seam. See Plate IV for a surface map of the district, and Plate V for a geologic cross-section. In developing the coal deposits, extensive beds of clay were found. The clays were of various grades, ranging from high-grade plastic fireclay to red-burning sewer pipe and paving-brick clays and shales. Considerable quantities of high-grade quartz sand were also discovered. Two clay-working plants were established in the district, using clays that were obtained from the coal mine, and from tunnels and open-cuts nearby. The Carnegie Brick and Pottery Company produced sewer pipe in an 8-kiln plant in the S½ of Sec. 30, T. 3 S., R. 4 E., M. D. M., two miles east of Tesla, and also had a 45-kiln plant for producing fire brick, face brick, and terra cotta at Carnegie, four miles east of Tesla. These operations were discontinued in 1912, some years after the cessation of coal mining operations, as it was not possible to obtain an adequate supply of suitable clays from the workings near the surface after the coal mine was abandoned.

The district must still be considered as an important potential source of high-grade fireclays, as there seems little doubt that extensive prospecting would demonstrate the presence of many millions of tons of fireclay that would be equal, if not better, in quality to any refractory clays now being mined in California. There is little justification at present, however, for attempting to rejuvenate clay mining in the district, as the fireclay deposits at Ione, Amador County, and at Lincoln, Placer County, are adequate in quality and quantity for present needs, and are cheaply mined, mainly from surface workings, whereas underground mining under difficult conditions would be necessary if extensive operations were to be carried on at Tesla.

RYAN RANCH DEPOSIT: Owned by Wm. Ryan, Livermore. In 1926 and 1927 a small open pit (see photo No. 2) was excavated on an outcrop of fireclay alongside the Livermore-Tesla road in the NW¼ of Sec. 26, T. 3 S., R. 3 E., M. D. M. The workings exposed a bed of white plastic clay 6 to 8 feet thick, underlain by white sandstone, and overlain by lignitic shale. The strike of the beds is nearly east-west, and the dip is about 65° north. Sample No. 259 was taken, and the test results on page 263 show it to be an exceptionally good grade of fireclay, that burns nearly white. The deposit is apparently a small remnant of Eocene enclosed in Miocene rocks, and there is little evidence of the continuity of the Eocene at this point.

Walrich Pottery. J. A. Wall, owner, 1285 Hearst Avenue, Berkeley. Art ware, porcelain specialties, decorative and mantel tile are made at this plant from a white semi-porcelain body, composed of Illinois silica, California (Campo) feldspar, English china and English ball clay. Translucent glazes are used, in a wide range of colors.

Most of the shapes are cast, although a few are hand pressed. A Calkins kiln, 20 in. by 36 in. by 20 in., heated with oil, is used for firing the ware. The biscuit ware is fired at cone 4, and the glost firing is at cone 1.

Westinghouse Electric and Manufacturing Company. J. W. Ryan, manager; G. M. Whisler, assistant manager; 6121 Green Street, Emeryville. This is a branch factory of the parent organization of Pennsylvania. It is devoted exclusively to the manufacture of high-voltage porcelain insulators and is the only plant of its kind in California. The raw materials used are Campo (California) feldspar, Ottawa (Illi-

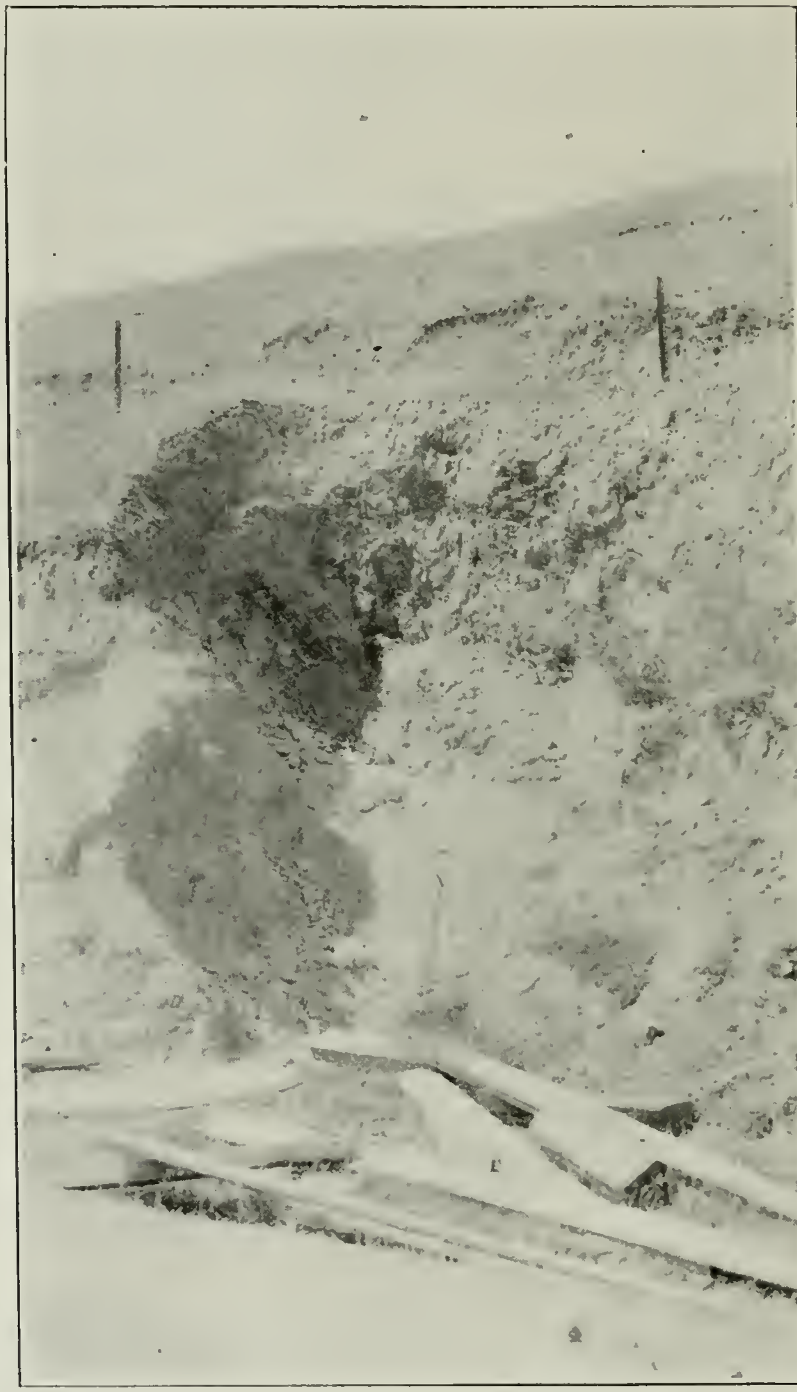


PHOTO No. 2. Ryan Ranch clay deposit, near Tesla, Alameda County. (Sample No. 259.)

nois) flint, Kentucky ball clay, Georgia china clay, Ione and Lincoln (California) sagger clays.

The feldspar and flint are ground in a ball mill for two hours after which they are mixed with the blunged clays. From the blunger the slip flows successively through an agitator, 200 mesh screens, magnetic separator, agitator and then is pumped into a filter press where the

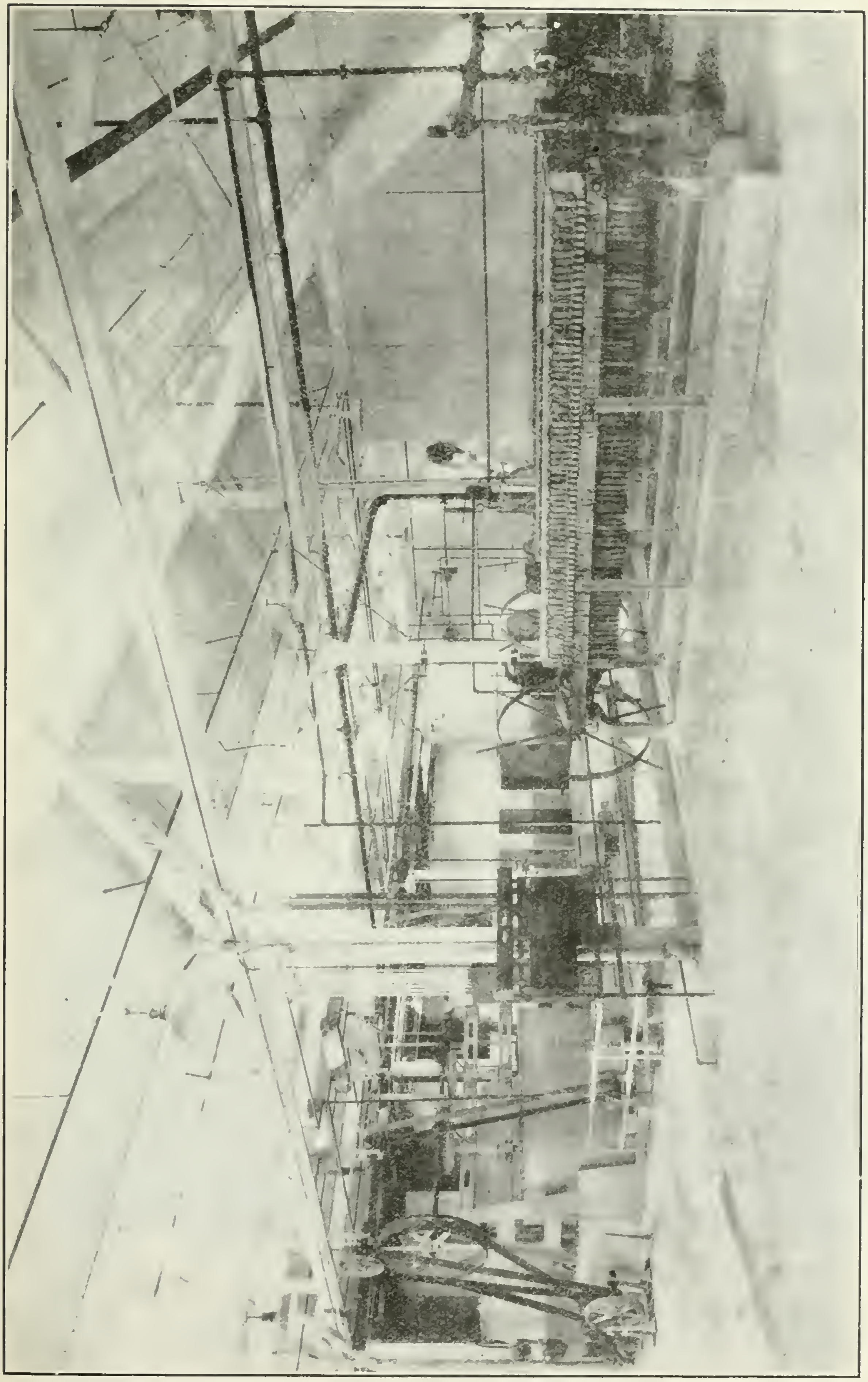


Photo No. 3. Filter-Press Room. Westinghouse Electric and Manufacturing Co., Emeryville, Alameda County.

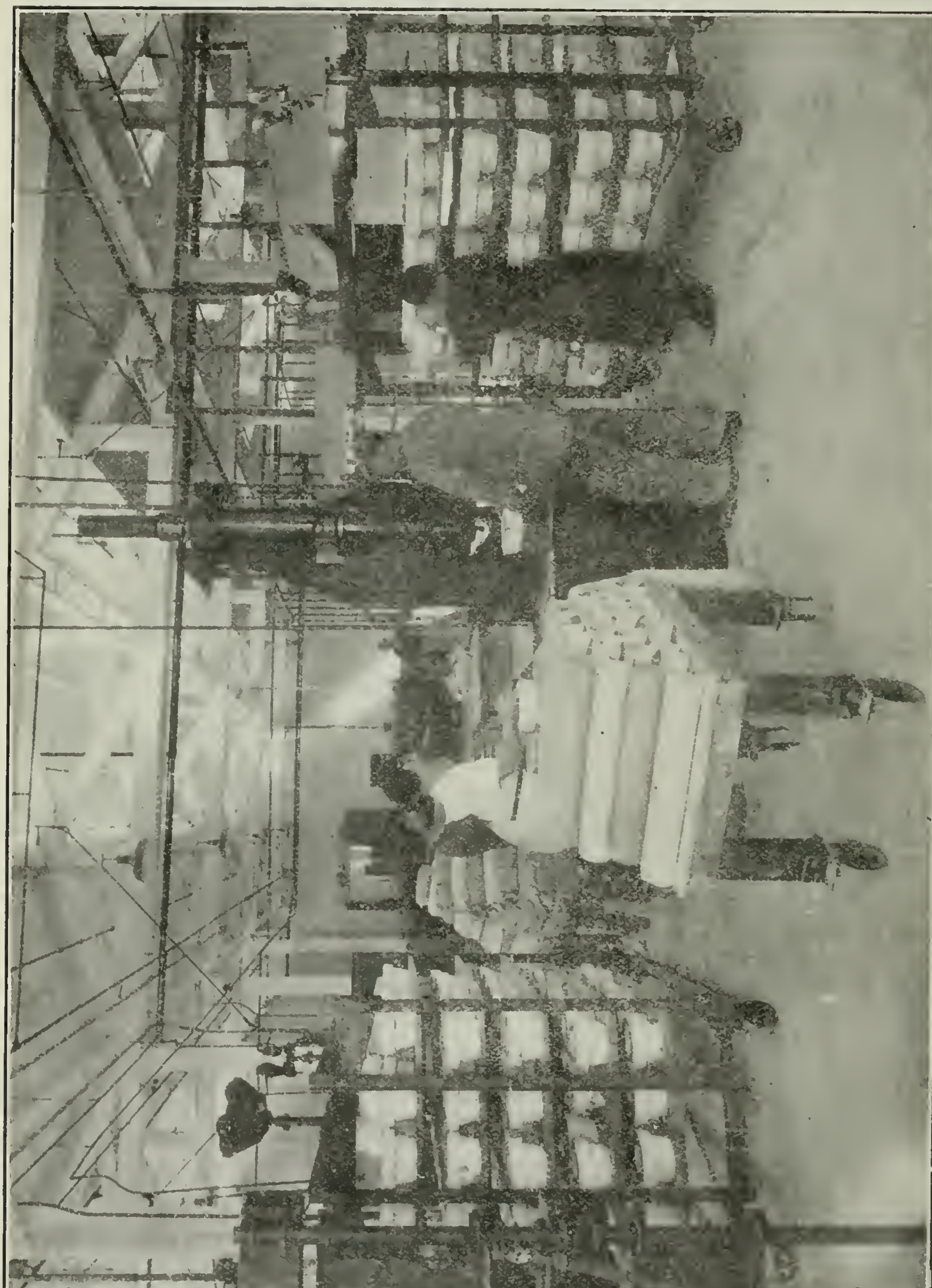


PHOTO No. 4. Hot-Pressing Room. Westinghouse Electric and Manufacturing Co., Emeryville, Alameda County.

excess water is removed. The filter press cakes are pugged and then stored in concrete cellars for about three weeks. The filter press room is shown on photo No. 3.

Before using, the clay is again pugged to the best size for the insulator being made. The pugs of clay are cut to correct length and shaped roughly by hand prior to placing in the plaster of paris mold which gives it the outer shape. The inside shape is made by the modern hot press method. A portion of the hot press room is shown on photo No. 4.

From the hot press, the mold and insulator go through a continuous-mold release dryer after which the insulator is easily removed from the mold. The next operation is trimming the surface next to the mold to include tie wire grooves, and improve the surface condition of the insulator.

Trimming is followed by the final drying in a tunnel-type humidity dryer which operates on a 60-hour schedule. After drying, an Albany slip glaze is applied and the insulators are ready for firing. Special colors can also be supplied for indicating phase, voltage, etc. These are white, blue, green, chocolate, black, etc.

For firing the insulators are placed in saggers which in turn are placed in one of four draft kilns. Each kiln is 16 feet in diameter and 12 feet high to the crown and the average burn is 800,000 cubic inches of ware. The firing is done with gas for the first few hours after which oil is used for the 60 hr. period. The temperature is controlled by means of recording pyrometers and pyrometric cones. The finishing temperature is cone 10 down (approximately 1260 degrees C.). The cooling period is about three days.

An average of sixty-five men are employed in this plant.

Woolenius Tiles. C. A. Elsenius, owner and manager, 1631 Woolsey Street, Berkeley. This is a small plant engaged in the manufacture of decorative tile, inserts, and mantel pieces, using a fireclay body made from Lincoln clay (sample No. 146, p. 303) and Shepard (Ione) sand (sample No. 128, p. 261). The clays are pulverized to 50-mesh, pugged, and regular shapes are made in a tile auger. Special designs are hand pressed. A thin matt glaze is fired on with the body, and is afterwards partly removed by buffing on a wheel. A rectangular down-draft kiln, heated with oil, is used for firing. The finishing temperature is from cone 5 to cone 7.

One or two men are employed besides the owner.

Bibl (Clay Resources of Alameda County): State Mineralogist's Repts. X, p. 91; XII, p. 39; XIII, p. 51; XIV, p. 607. Cal. State Min. Bur. Bulletin No. 38, pp. 202, 204–206, and 227; Prel. Rept. No. 7, pp. 35–37, 94. U. S. G. S. 22d Ann. Rept., Pt. III, pp. 501–504.

AMADOR COUNTY.

General Features.

Amador County lies to the east of the Sacramento Valley and extends from the lower foothills to the summit of the Sierra Nevada. It traverses the center of the famous Mother Lode gold belt, and is similar to El Dorado, Calaveras, Tuolumne and Mariposa counties in climate, physiography, geology and natural resources. Amador is the smallest county of the group, and contains 601 square miles. The population is about 8000. Gold and clay mining and stock raising are the principal industries. The county is well provided with good roads, connecting the principal towns with each other, and with the Sacramento Valley. A branch of the Southern Pacific Railroad extends from Galt to Ione, where it connects with the Amador Central, running to Martel and serving the gold mines in the vicinity of Jackson and Sutter Creek, the principal towns in the county. There is timber suitable for underground mining in the mountains. Electric power is supplied to most of the towns in the county by the Pacific Gas and Electric Company, and water is supplied by this company to the Mother Lode section of the county.

The geology and mineral resources of the county have recently been summarized by Logan:[1]

"White clay forms a conspicuous part of the Ione (Tertiary) beds, which extend across the entire west side of the county from north to south. This and other colored clays nearby form the basis of an important industry, supplying potteries in various parts of the state.

"Also associated with the Ione beds and usually within 100 feet or less of the surface, near Carbondale, Ione, Buena Vista and Lancha Plana, occur numerous deposits of brown lignite. This was mined at several places until a few years ago. . . .

"Farther east, alternating beds of Mariposa (Jurassic) black slate, amphibolite schist, serpentine and Calaveras (Carboniferous) rocks extend northwest, parallel to the axis of the mountain range of which they form the flank. In the amiphbolite schist numerous copper mines and prospects occur, but are all idle now. Chromite occurs in the serpentine, and many small lenses of limestone in the Carboniferous rocks. These formations begin about a mile east of Ione and extend for seven miles eastward, where the Mother Lode mines occur, in another belt of black Mariposa slate. This slate enters the county at Middle Bar bridge on Mokelumne River, running thence northwest through and beyond the county. With an average width of about one-half mile, and in many of the mine workings narrowing to only a few hundred feet, this slate belt and the immediately adjoining and at times intercalated areas of altered igneous rocks contain all the important gold quartz mines of the county.

"To the east of the Mother Lode the rocks are nearly all of Carboniferous age for a distance of ten miles, until an elevation of about 3000 feet is reached, where the granodiorite forming the core of the mountains appears. At Oleta in the northern part of the county and at Volcano much placer gold has been produced. A series of detached gravel bodies covered by rhyolite and andesite extends across the county between these two old camps. The gravel in this region represents remnants of Tertiary river deposits. In the western part of the county, near Ione, are accumulations of delta and shore gravel, deposited when the inland sea or gulf had its shores in that vicinity, during the time of the Ione disposition, which was at the same time as the formation of prevolcanic channels in the rivers of the Sierra Nevada. In places where it has been reconcentrated by later streams some of it has been rich enough to mine profitably. There are also beds of white and red sandstone in the Ione formations, which have been worked in the past. Marble occurs two miles east of Plymouth and eight miles east of Sutter Creek, enclosed in the Calaveras formation. Besides the numerous small bodies of limestone, there are two especially large areas, one at Volcano and one four miles northwest of that town. Asbestos, talc, ocher and low-grade iron ores also occur."

Clay Resources.[2]

The Ione-Carbondale district is noted for its high-grade fire clays and fire sands. Associated with the high-grade clays and sands are a number of important red-burning plastic clays. A fire brick plant has been in operation near Ione for many years. An experimental clay washing plant was operated a number of years ago on the N. Clark and Sons property near Carbondale (see Plate VI), and another washing plant was operated near Ione by the Philadelphia Quartz Company. Both of these operations were abandoned prior to 1921, but in February, 1927, a new plant was erected on the Carlile property by E. E. Tremain, lessee.

[1] Logan, C. A., Amador County; State Mineralogist's Report XXIII, p. 132, April, 1927.

[2] The report by Logan, *op. cit.*, was freely drawn upon in the preparation of this summary.

county of the group, and contains 601 square miles. The population is about 8000. Gold and clay mining and stock raising are the principal industries. The county is well provided with good roads, connecting the principal towns with each other, and with the Sacramento Valley. A branch of the Southern Pacific Railroad extends from Galt to Ione, where it connects with the Amador Central, running to Martel and serving the gold mines in the vicinity of Jackson and Sutter Creek, the principal towns in the county. There is timber suitable for underground mining in the mountains. Electric power is supplied to most of the towns in the county by the Pacific Gas and Electric Company, and water is supplied by this company to the Mother Lode section of the county.

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"White clay forms a conspicuous part of the Ione (Tertiary) beds, which extend across the entire west side of the county from north to south. This and other colored clays nearby form the basis of an important industry, supplying potteries in various parts of the state.

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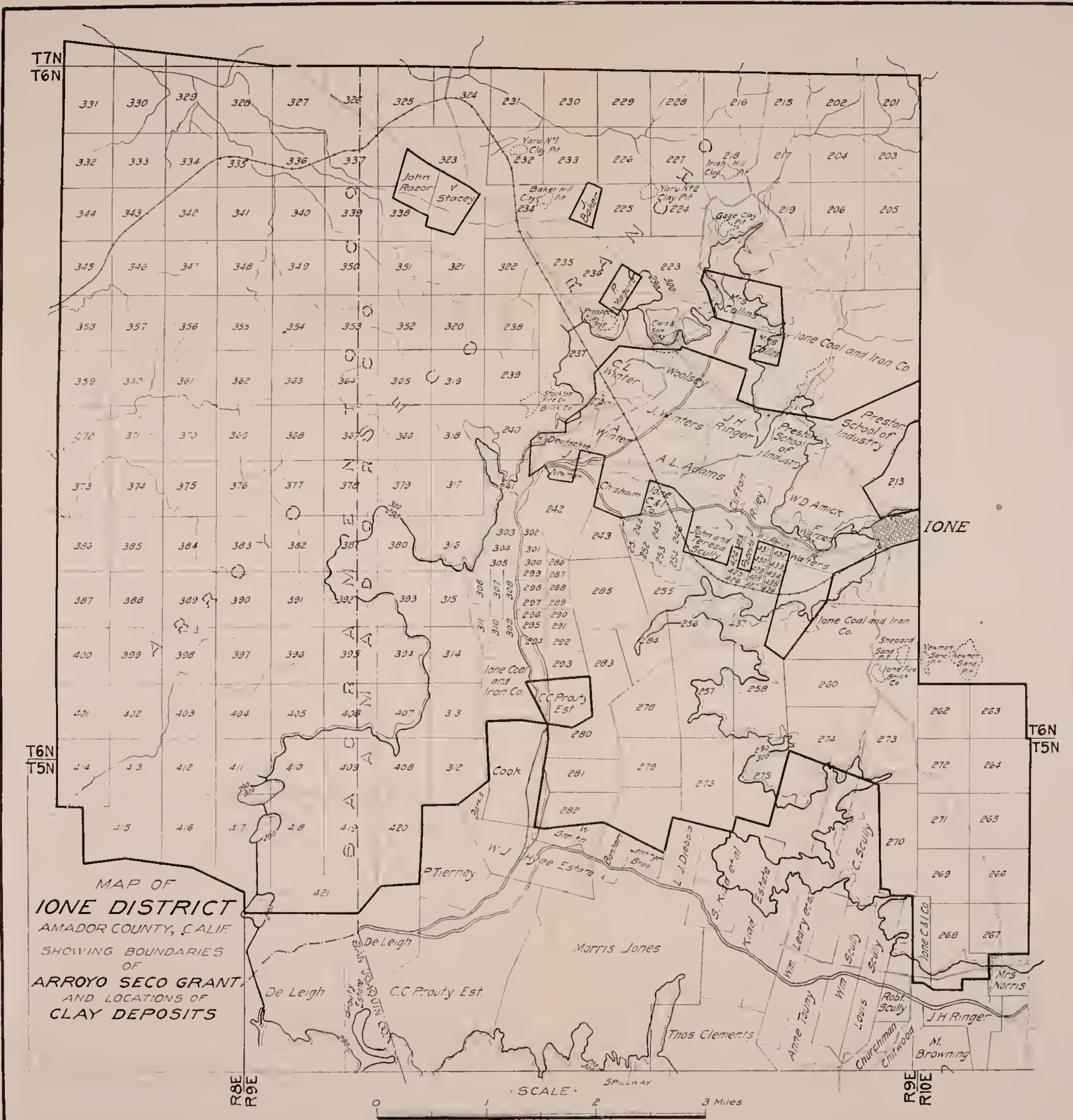

PLATE VI. Property map of Ione district. (By courtesy of S. E. Kieffer.)

54979—facing page 50

Enough information has been obtained from these various washing operations to demonstrate the fact that it is possible to produce a quartz sand suitable for the manufacture of glass and sodium silicate, and for use as "flint" in porcelain bodies. The kaolin content of the sands is seldom in excess of 25%, and generally contains enough iron oxide to cause it to fire to a light-cream color, although in places it is sufficiently pure to fire to a satisfactory white color for use in white-ware bodies. Several factors adversely affect the establishment of a financially-sound washing operation in the district, among which may be mentioned the comparatively high freight rate to producing centers, the low cost of Belgian sand, which is delivered to California ports at a price of about $5 per ton, the low content of high-grade kaolin in most of the sands, and the fact that few important plants now using English or Florida kaolin would be willing to change to the use of local material unless assured of an ample supply of uniformly high-grade kaolin over a long period of years.

A new use for Ione sand is in making white cement. One large company has recently bought a sand property, and it is anticipated that others will follow.

The clays occur as a part of the Ione formation and are distributed over a length of 12 miles and a width of 4½ miles in the county, with extensions into Sacramento County on the northwest and into Calaveras County on the southeast. In most places the clays are covered by an overburden of soil, sand, tuff, volcanic breccia, and sandstone, varying from a few inches to a maximum of 20 feet over most of the deposits now being worked. The clay beds have a slight westerly dip. Lignite coal, interbedded with clay, is found at depths of 40 to 125 feet. The clay beds are not continuous, and the extreme limits of the probable boundaries of the deposits have not been determined, but enough mining and drill prospecting has been done to demonstrate the fact that there is an ample supply of clay for many years.

The contemporary theory of the origin of the clays has been well summarized by Logan.[1]

"The white clay apparently came from the rhyolite ash flows, which have been found directly over the older series of gold-bearing gravel channels in the Sierra Nevada. Probably a long enough period of erosion ensued after these initial ash outbursts to permit the carrying of the finer sized and lighter particles down the streams into the shore waters of the inland sea which then filled the Sacramento and San Joaquin valleys. Before the white ash was covered and preserved by later flows of darker colored breccia and ash, a large part of it was thus swept away.

"That the clay is of rhyolitic origin, possibly mixed with the quartz sand from those mysterious earlier rivers whose remaining sections now show such a remarkable amount of quartz cobbles, with scarcely any other rock, is substantiated by the analyses. The sandy clay carries about 70% silica, 20% alumina, 1.25% iron oxides, 0.3% CaO, and 0.2% MgO. Other samples where the percentage of silica is less, contain 32% to 34% dry weight of alumina. The amount of calcium is typically low and it is erratically distributed, sometimes as gypsum seams. As the percentage of iron increases the clay becomes mottled red and yellow, but the usual color is white, cream or light blue."

Arroyo Seco Grant.

Introduction.

The greater part of the Ione clay deposits lie within the boundaries of the Rancho Arroyo Seco, which was formerly owned by the McKissick Cattle Company, who leased many of the clay deposits to Bacon & Bacon (see *post*) and other operators in the district. In 1926 the grant was purchased by S. E. Kieffer, 57 Post Street, San Francisco,

[1] *Op. cit.*, p. 135.

who then leased the clay properties to G. A. Starkweather. Mr. Starkweather is operating some of the properties, but has subleased a number of them to various operators. A map of the grant, and of the surrounding property, showing the location of the principal clay deposits, is shown on plate VI.

Core Drilling.

During the seasons of 1925 and 1926, a large amount of core drilling was done in the Ione district under the direction of Mr. S. E. Kieffer, consulting engineer. Many of these holes penetrated the sand, clay and coal beds to depths of 150 feet or more. Through the courtesy of Mr. Kieffer, a number of core-drill clay samples were obtained for testing. The location of the holes from which these samples were taken is shown on the map, plate VI, and the approximate depth of the samples from the surface, as well as the approximate thickness of each formation, are given in table No. 8.

TABLE NO. 8.

Description of Core Drill Samples from Ione District.

Sample No.	Drill hole No.	Location of hole	Depth of top of sample from surface, feet	Thickness of formation, feet	General character of material
239	--	NE. cor Lot 254	37	25	Fire sand
240	--	E. side Lot 237	--	100(?)	Plastic fireclay
243	47	Lot 336	230	16	Sandy clay, poor quality
244	54	Lot 324	13	19	Plastic fireclay
245	55-1	Lot 237	32	41	Plastic fireclay
247	55-2	Lot 237	73	18	Plastic fireclay
246	55-3	Lot 237	93	16	Plastic fireclay
248	56-1	Lot 237	4	24	Plastic fireclay
249	56-2	Lot 237	44	36	Plastic fireclay
250	56-3	Lot 237	80	30	Plastic fireclay
251	57-1	Lot 237	3	9	Plastic red-burning
252	57-2	Lot 237	12	10	Plastic fireclay
253	57-3	Lot 237	22	20	Pl. fireclay, nearly white
254	57-4	Lot 237	42	26	Buff plastic fireclay
255	57-5	Lot 237	68	46	Red plastic, cone 26
256	60	Lot 255	(near bottom)	—	Red plastic, cone 19-20
257	62	Lot 255	66	6	Pl. fireclay, nearly white
258	61	Lot 255	75(?)	10(?)	Buff plastic fireclay

It is not possible from the data available to establish continuity of the various beds of clay and sand represented by the core drill samples, but the presence of large reserves of high-grade clays is well demonstrated. Most of these clays, however, can not be mined under present conditions while large deposits of good material are still available for open-pit mining.

Active Deposits.

Gage Pit. The Gage pit, leased and operated by G. A. Starkweather, is in Lot 224 of the Arroyo Seco grant, two miles east of Lignite siding on the Southern Pacific Railroad northeast of Ione. The clay is dazzling white in color, slightly plastic, and has a talcy feel. It has been used by the West Coast Calcimine Co. The pit at the time of visit, in August, 1925, was 100 feet wide at the face, which had advanced 120 feet from the approach. The exposed clay bank was 12 feet thick. Mr. Bacon stated that the total average thickness of this clay is 16 feet. The clay is capped by less than three feet of volcanic breccia.

A view of this pit, looking eastward, is shown on photo No. 5. Sample No. 125 was taken for test, the results of which are given on page 273. The usual annual production is 600 tons, all mined and loaded by hand and hauled in auto trucks to Lignite.

Jones Butte Deposit. The Jones Butte clay mine, sub-leased from Mr. Starkweather and operated by the Stockton Fire Brick Co., is in Lot 240 of the Arroyo Seco grant, on the western slope of Jones Butte, also known to local inhabitants as Deutschke Hill. The mine is 1.5 miles by road from Edgar siding, on the Southern Pacific Railroad, two miles northwest from Ione.

A geological study of the deposit was made by C. N. Schuette, at one time in the employ of the Stockton company as a geologist and

PHOTO No. 5. Gage clay pit, near Lignite, looking eastward. (Sample No. 125.)

engineer. The successive formations, from the top of the hill downward, are lava, tuff, gravel, clay, and lateritic iron. The clay bed is lens shaped in the north-south section of the hill, and wedge shaped in the east-west section, thinning toward the east. The clay in the mining area covered by operations in August, 1925, was 8 to 10 feet thick and there was an additional 2-foot bed of extremely 'fat' or 'unctuous' clay in the roof. The floor has a general pitch toward the south, and mining is complicated by the presence of sharp rolls in the floor in places. The floor is generally red lateritic iron, but in places this is covered by a variable thickness of yellow plastic clay.

The mine is worked entirely by underground methods. The general plan, modified by local irregularities, is to run drifts in a general easterly direction on a slightly ascending grade on approximately 20-foot centers. The drifts are as small as is consistent with efficient driving and tramming, usually five by seven feet. Upon reaching the limit of the block to be mined, or the limit of workable thickness, the retreat is made by slabbing to the roof and slicing a five cut from each side of the drift, leaving a pillar approximately 5 feet in width to support the rooms while the retreat is in progress. The minimum extraction of clay in the minable area is thus 75% of the total. Where the roof is strong enough, the extraction can be increased by further pillar robbing.

At the working faces, mine cars are loaded by hand shoveling, and are trammed by hand for a minimum distance of 400 feet to a bin near the portal of the tunnel. From here the clay is drawn off into an auto truck for transportation to the car-loading bin at Edgar.

The mine is normally operated on a production schedule of four cars (total 200 tons) per week for a period of four months, or somewhat in excess of 3000 tons of clay per year. The number of men employed, including a foreman and a truck driver, is five.

Three samples were taken. No. 120 is the main 'Edwin' clay. The test results, page 272, indicate that it is one of the best plastic fire-

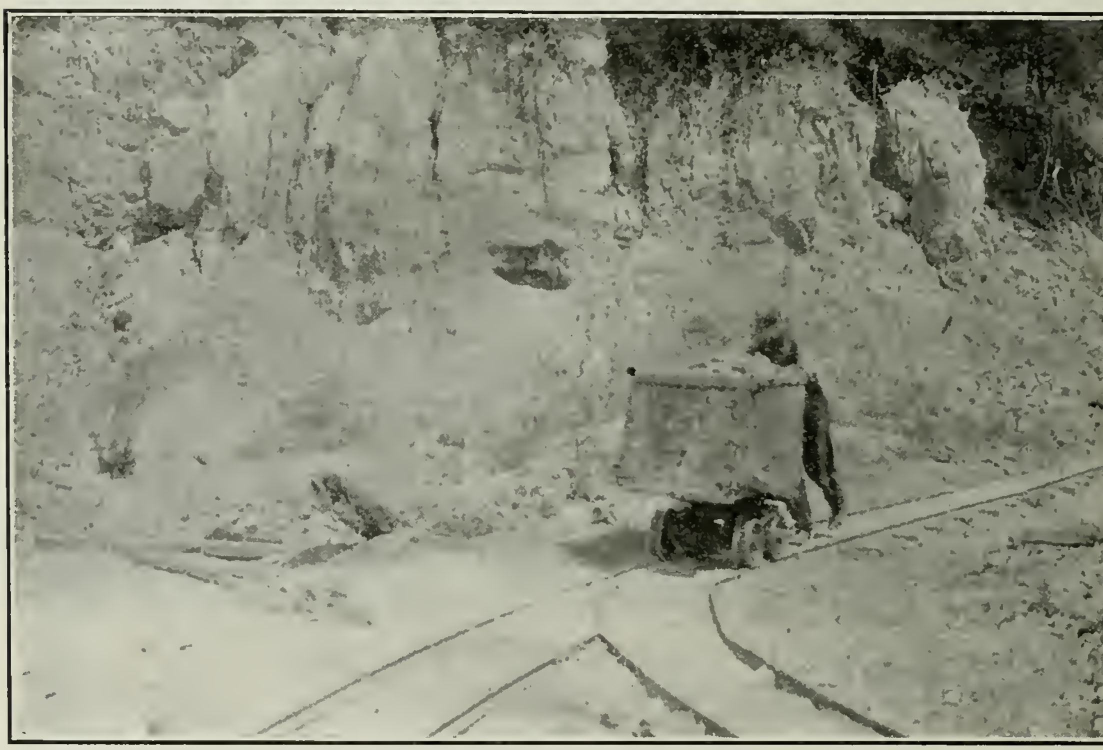

PHOTO NO. 6. Jones Butte Mine, Arroyo Seco Rancho, facing eastward toward portal of tunnel. (Samples No. 120, 121 and 122.)

clays in California, but shows the high shrinkage and fire cracking typical of the Ione clays. Sample No. 121 is the 'unctuous' clay occurring in the roof of the mine. It was taken, and the test work done (see page 302), as a matter of general interest, although the known thickness of the bed is insufficient for commercial production. Sample No. 122 is the 'Laterite,' which has no present commercial value, but is considered of sufficient interest to warrant a record of its properties, which is given on page 328.

A view of the property near the portal of the tunnel is shown on photo No. 6.

Shepard Pit (leased by G. A. Starkweather). The Shepard sand pit is ¾ mile from Ione at Shepard spur on the Amador Central Railroad. The eastern boundary of the property adjoins the western boundary of the Newman sand pit. A view of the pit is shown on photo No. 8, from which the extent of open pit mining and the present method of underground mining by pillar and room can be seen. The sand has an average thickness of 16 feet. The capping of volcanic breccia

PHOTO No. 7. Barber or Shepard sand pit one mile east of Ione.

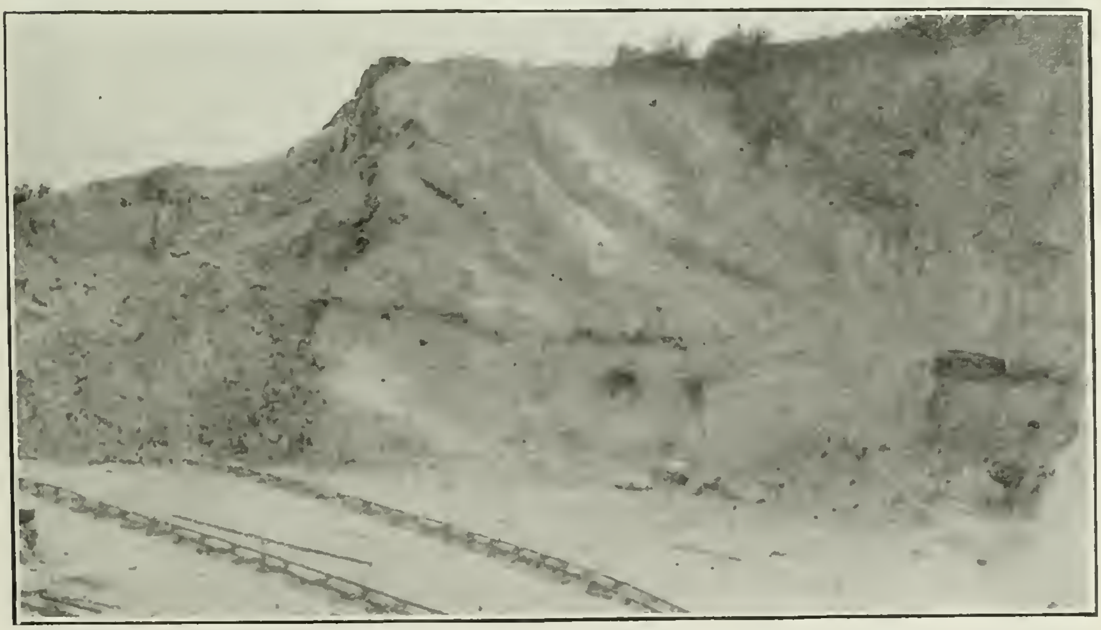

PHOTO No. 8. Sand pit subleased by the Ione Fire Brick Co. (Sample No. 140.)

is sufficiently strong so that rooms can be driven into the deposit nearly to the full height of the sand bed, and wide enough to permit the entrance of auto trucks to the loading face. Round pillars of sand are left at approximately 25 foot intersections, to support the back. The sand has been mined in this fashion over a considerable area. See photo No. 7.

Sample No. 128 was taken for test, the results of which are given on page 261. The sand is fine grained, nearly white, and contains enough clay to develop slight plasticity and bonding power. It is widely used by fire brick and terra cotta manufacturers as a fine grog. The normal output from the Shepard pit is 15,000 tons per year. At the present rate of mining, the reserve of sand in sight is sufficient for many years, although mining costs will be higher as mining proceeds farther from the openings into the rooms.

Photo No. 8 shows a nearby sand pit, subleased by the Ione Fire Brick Co., from which sample No. 140 was taken. See page 280.

Yaru Deposit. The Yaru clay pit, leased and operated by G. A. Starkweather, is located on lot 232 of the Arroyo Seco grant, 100 yards north of a siding at Lignite on the Southern Pacific Railroad, four miles northwest of Ione.

Photo No. 9 is a view of this pit. The overburden is less than three

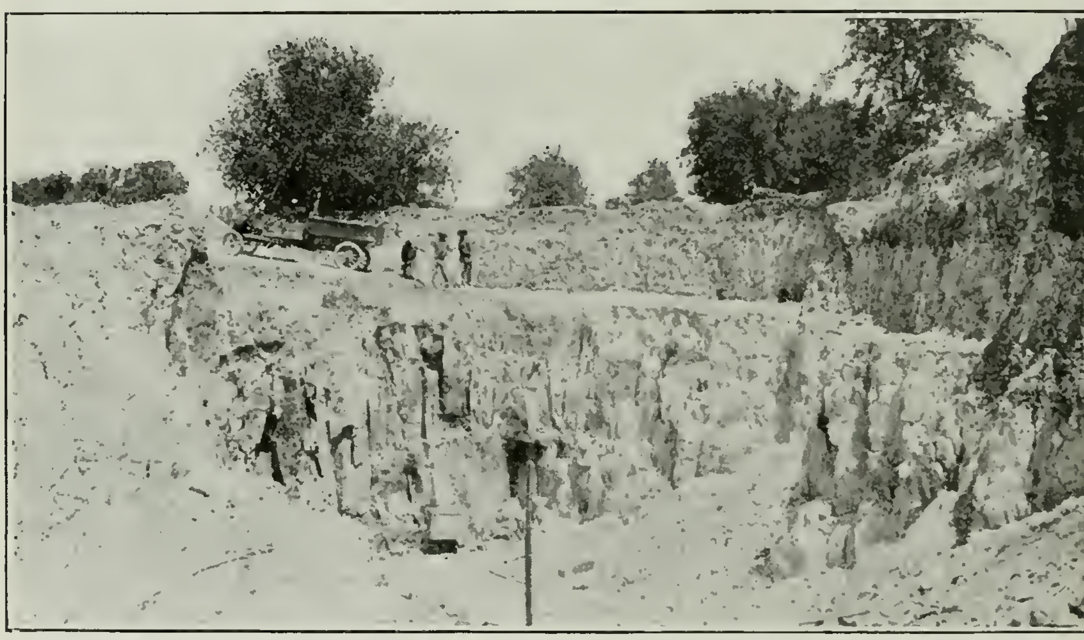

PHOTO No. 9. Yaru clay pit, Ione. (Samples No. 123, 124.)

feet in thickness. The upper bed (sample No. 123, p. 335), clearly shown in the photograph, is designated Yaru No. 2. It is a yellowish and blue-gray plastic fire clay 6 feet thick. The lower bed (sample No. 124, p. 302), is known as Yaru No. 1, and is somewhat lighter in color, but contains yellowish streaks along fracture planes, and occasional nodules of iron-stained sand. A car hoist is used to elevate the clay from the bottom of the pit to a hopper on the surface where it is dumped into a truck for the short haul to the railroad siding. The thickness of Yaru No. 1 exposed by mining operations is 25 to 30 feet. Borings in this clay are said to indicate a total thickness of 90 feet, but streaks of sand are encountered in places.

Total shipments of Yaru No. 1 and No. 2 are normally 4000 tons per year.

Miscellaneous Operations.

Bacon & Bacon. Mark J. Bacon, manager, Ione. This firm is engaged in a general clay-mining business, working some properties for the owners under contract and also shipping to numerous consumers from pits which they own or lease. Twenty-five men, two steam shovels and six trucks are employed during the operating season from early in April to the end of the dry season.

Two of the properties owned by Bacon and Bacon are here described, the Bacon Red (Lane mottled) and the Chocolate pits.

Bacon Red: This is on an 80-acre tract, comprising the NW¼ of Sec. 32, T. 6 N., R. 10 E., M. D. M., near the intersection of the Jackson highway and the Amador Central Railroad, 1.8 miles southeast of Ione. The clay is a fine-grained plastic, red-white mottled clay (sample No. 127, p. 335), and is quite characteristic of the region. It is mined from an open pit, 150 feet long at the face. In 1925 the pit had advanced 60 feet in from the starting point, and the exposed clay bank was 15 feet high, covered by shallow overburden of loose gravel. The overburden will gradually increase as the clay is followed into the hill, but the maximum thickness of overburden will probably not be excessive, as the hill is low, and has a gentle slope. The clay is evidently not bottomed by the floor of the pit, and it is stated that the total thickness of clay, as determined by boring, is nearly 40 feet.

The normal production from this pit is 1000 tons per year, all mined by hand. There is no siding at the pit, the clay being hauled in trucks to one of the loading platforms maintained by Mr. Bacon.

Chocolate Pit: The chocolate pit is 3 miles north of Carbondale. Two varieties of clay are mined from this pit. The upper bed, 4 to 5 feet thick, is a chocolate-colored plastic clay (sample No. 137, p. 266) of special value in the manufacture of saggers. This is underlain by the Bacon bottom (sample No. 138, p. 280), a 4–5 foot bed of white-burning plastic clay occasionally used in sanitary ware bodies. The overburden is less than four feet thick, so that these clays can readily be quarried.

The production from this pit has been small, mainly on account of the length of haul compared to other varieties that have nearly the same properties. About 500 tons of chocolate and 100 tons of Bacon bottom are mined each year. The pit was 150 ft. long, and 40 ft. wide at the time of the visit in July, 1925.

Carlile Clay and Sand Deposit.[1] Mrs. Sarah E. Carlile, Ione, owner; E. E. Tremain, Buena Vista, via R. F. D., Ione, lessee. The property contains 60 acres on W½ NW¼ Sec. 8, T. 5 N., R. 10 E., M. D. M., four miles from Ione and 2.8 miles by road to the nearest railroad spur. The property was not worked prior to 1927.

In February, 1927, a plant was being erected to wash the sand and clay. A bed of white sandy clay, overlain by two to seven feet of brown clay, had been stripped over an area about 80 feet square. According to present plans, the clay will be dug by drag-line scraper. The washing and settling plant comprises several hundred feet of sluices with sand traps and eight large clay-settling tanks. The sand is expected to settle out on the way through the sluices and traps, leaving the clay in suspension, free from grit, to pass to the settling tanks, from which it will be drawn, after which it will be filtered and dried.

[1] Entire description by C. A. Logan, *op. cit.*, p. 136, who visited the property in 1927, after construction work had been started.

The estimated capacity is 10 tons a day. The sand is not at present being considered for marketing.

The author visited the property in 1926 before construction work had been started, and took a sample, No. 208, from a shallow open pit. The test results are on page 262.

N. Clark and Sons (see under Alameda County) own two important pits in the Ione district, the Clark sand pit and the Dosch clay pit.

CLARK SAND PIT: The Clark sand pit, owned by N. Clark and Sons of San Francisco and Alameda, is an 80-acre property in the SW¼ of Sec. 28, T. 7 N., R. 9 E., 1.8 miles by road northeast of Carbondale, and 0.8 miles northeast of the Harvey clay pit. The sand bed is 25 to 40 feet thick, and is overlain by a variable thickness of volcanic breccia. Most of the sand not requiring stripping has been removed by open pit methods, the pit covering more than an acre. Present mining is by the room and pillar method, similar to that used at the Shepard and Newman pits. The extent of the workings, size of rooms and pillars, and general plan is nearly the same as in the Shepard pit.

Some years ago an experimental washing plant was built near this pit, to study the economic possibilities of washing the sand to produce a high-grade clay and a white sand as separate products. The experiments were abandoned for various reasons, among them the lack of sufficient water, and the lack of profitable market for the sand.

Sample No. 134 was taken for testing, the results of which are given on page 261. These should be compared with the results on samples No. 128, 129, and 140.

The normal production of Clark sand is 5000 to 7000 tons. It is loaded by hand into trucks and hauled to Carbondale.

DOSCH PIT: The Dosch clay pit is in Lot 222 of the Arroyo Seco grant, near the Ione-Sacramento highway at a point three miles northwest of Ione, and one mile from Clarksona siding on the Amador branch of the Southern Pacific Railroad. The Dosch clay is the best known of the Ione clays, and production from this pit is considerably greater than from any other plastic clay deposit in the district.

Two varieties of clay are differentiated. The Dosch stripping, sample No. 135 (see p. 312), includes the upper beds that are more or less contaminated by surface infiltration of water carrying iron salts. The thickness varies, but is usually less than 10 feet. This clay is useful as an ingredient of sewer-pipe mixes. The Dosch clay, sample No. 136 (see p. 302), underlies this to a maximum thickness of 80 feet. It is a plastic fireclay, used for terra cotta, pottery, and stoneware. At the time of visit in 1925 and 1926, the pit was about an acre in extent, and the height of the face was 40 feet. Mining is by steam shovel, loading into 5-ton trucks. Four trucks are in service to haul the clay from the pit to Clarksona, where it is stored in a large covered warehouse, and loaded into railroad cars as needed for shipment. A supply of clay is thus available during the winter months, when mining is stopped.

The production is 4000 tons of Dosch stripping and 10,000 to 12,000 tons of the underlying Dosch clay per year.

W. S. Dickey Clay Manufacturing Company. The Fancher pit, under lease to the W. S. Dickey company, is on the northerly slope of Jackson Valley, one mile west of Buena Vista, 3.75 miles air line S. 3° E. from Ione, or 5.6 miles by road south of Wallon siding, on the Amador Central Railroad.

Photo No. 10-A is a view of this pit, taken on August 8, 1925. The stripping of loose sandy and gravelly soil attains a maximum thickness of 20 feet in the present pit, but will gradually increase as mining operations advance northward. Two varieties of clay are differentiated. The upper bed (sample No. 141), six to ten feet thick, is a yellowish fireclay, containing occasional iron stained boulders. This is underlain by at least 15 feet of hard blue-gray plastic clay (sample No. 142), which at the time of visit was not in use. The results of tests on these varieties are given on page 280.

The method of mining previous to 1927 is clearly illustrated in the photograph. Hand picking and light blasting was used to loosen the clay from the bank, where it was picked up by a tractor-drawn scraper, dragged up an incline, and dumped into a hopper over the tunnel,

PHOTO No. 10-A. Fancher clay pit, Jackson Valley, near Ione, leased by W. S. Dickey Clay Mfg. Co., facing northwest. (In 1925.) (Samples No. 141 and 142.)

from which it was delivered to an auto truck. A one-ton Ford truck is used for hauling the clay to Wallon siding. Beginning in 1927, the thickness of overburden has been such that the mining method was changed to tunneling.

Eckland Property. Mrs. C. Eckland, 1743 N. Hunter Street, Stockton, owner. This property consists of 80 acres, lying to the south of the Ione-Jackson highway at the point where it crosses the railroad, 1.5 miles east of Ione. The property is at present (1927) idle, but was at one time worked by Mr. Dennison of Ione. Yellow, pink, and red-mottled plastic clays are exposed in the walls of the abandoned pit, from which sample No. 213 was taken (see page 299). Wm. Haverstick of Ione supplied a sample (No. 209, p. 263) of white sandy clay from a 16-foot drill hole on the southwestern portion of the property. Almost the entire property is covered with an overburden of volcanic breccia, and insufficient prospecting has been done to determine the extent and character of the underlying clay beds.

Ione Fire Brick Co., J. T. Roberts, president and general manager, 12 Russ Building, San Francisco; Wm. Brown, superintendent at Ione. The Ione Fire Brick Co., a subsidiary of the Stockton Fire Brick Company, is located about two miles southeast of the town of Ione, on a spur track of the Amador Central Railroad. Machine-made fire brick are made, using a mixture of Lincoln clay, now secured from the pit of the Clay Corporation of California at Lincoln (sample No. 280, p. 305), and Ione clay, sand (sample No. 140, p. 280), and grog from pits near the plant.

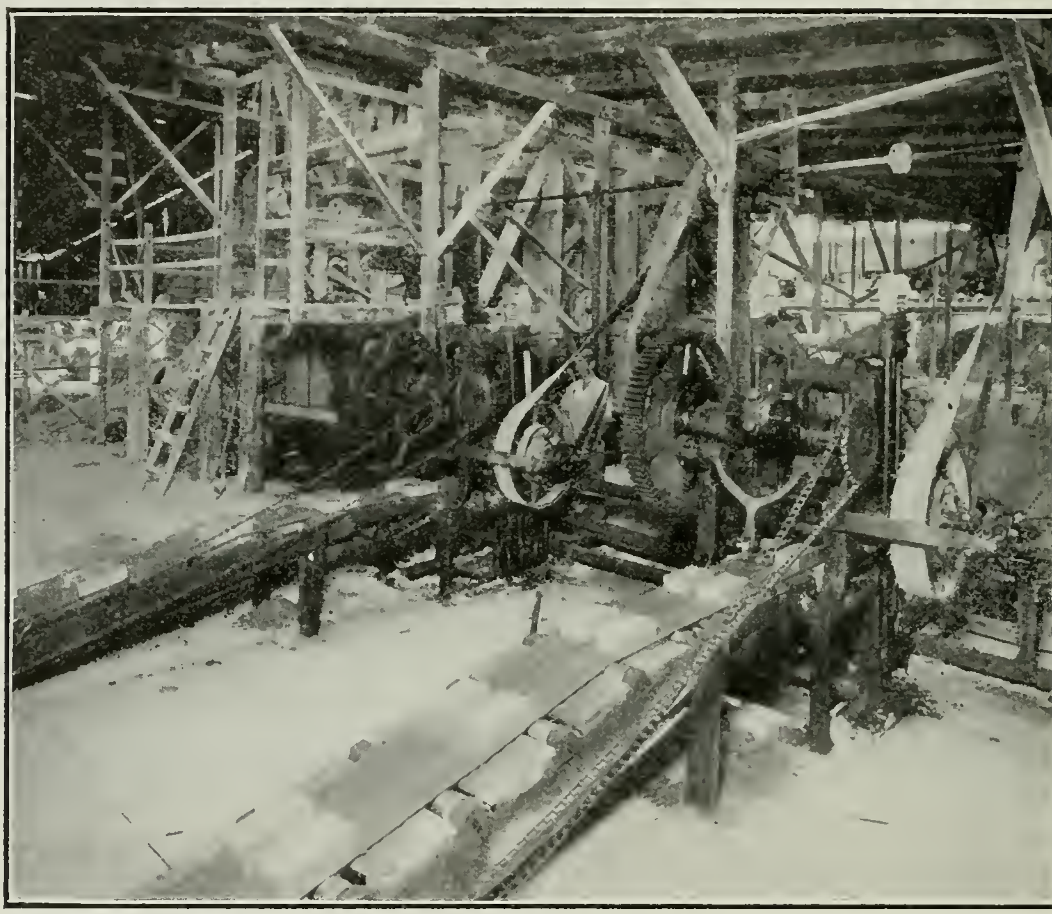

PHOTO NO. 10-B. Brick machinery in plant of Ione Fire Brick Company. (Photo by courtesy of the company.)

The mixture is prepared in a dry pan and pug mill, shaped in an auger machine, wire cut (side), and repressed. Drying is accomplished in air under sheds and in the open. Only such standard shapes as can be made on the auger machine are manufactured at this plant, there being no hand molding. Photo No. 10-B is an interior view of the plant, showing an auger machine and two represses, with off-bearing conveyors.

The firing equipment consists of five oil-fired round down-draft kilns, having a total capacity of 11,000 brick per day. The auger machine capacity is 20,000 brick per day, which makes it possible to prepare a surplus for storage to be fired during the winter months, when clay mining can not be economically carried on.

GROG: Grog for use in the plant of the Ione Fire Brick Company is mined from a small pit adjoining the Bacon red clay pit. A six to twelve foot bank is exposed, over a length of 100 feet. The material consists mainly of partly-rounded quartz gravel, most of which is under two inches in diameter. The interstices are partly filled with fine sand, with a small amount of clay. Iron staining is a prominent macroscopic feature, but the total iron content is not too high to permit the production of second-grade fire brick when used as the sole grog constituent.

SAND: The sand pit of the Ione Fire Brick Company is near the grog pit and is shown on photo No. 10-C.

May E. Newman Estate. Main office, 980 Bush Street, San Francisco. The pit is on a 150-acre property in Secs. 20, 30, and 31, T. 6 N., R. 10 E., M. D. M., on the Amador Central Railroad, one mile southwest from Ione, and less than a half mile northeast from the plant of the Ione Fire Brick Co.

The bulk of the output from this property up to date has been Ione sand, but plastic red clay beds have been found, and a small amount has been shipped. The main sand pit abuts the railroad tracks on its eastern boundary. The sand occurs in two separate beds each 10 to 15 feet thick and separated by a bed of carbonaceous sand from 6 to 30 feet thick. Volcanic breccia of variable thickness overlies the deposit. Open-pit mining was used at first, but practically all of the sand not covered by volcanic breccia has by this time been removed, and present mining is by underground methods, using the room and pillar method.

The general plan of mining, whenever a systematic lay-out is possible, is to drive rooms in the bottom of the upper bed approximately 10 by 10 feet in cross-section on 25 foot centers to the limit of the block of ground being mined, usually about 250 feet, then retreat by excavating to the roof, and by cutting across to adjacent rooms, finally reducing the pillars to approximately six feet in diameter. The sand is loaded by hand into small cars, which are dumped into a loading chute at the entrance of the mine. The loading chute delivers to mine cars which are in turn hauled up an incline and out of the pit by a car hoist, finally delivering the sand to a loading bin on the railroad siding.

Some of the lower sand bed has been mined and shipped from places where it has been exposed by open-pit mining. The present underground method does not leave the mine in a satisfactory condition for the recovery of the lower bed in the future, unless the capping of volcanic breccia can be utilized as grog, and the bed of carbonaceous sand is stripped. Seven or eight men are employed during the dry months, when an average of 9 cars per week is shipped. The annual output varies with demand, and is normally in excess of 6000 tons.

Since the above was written, the property was visited in 1927 by Mr. Logan, from whose report[1] the following additional notes are taken:

"The old pits, operated for years south of the track, have been worked up to the property line. A new pit has recently been started on the north side of the track. In vertical section, so far as opened, it shows from top to bottom 25 feet of overburden 10 feet of red mottled clay, and 15 feet of white sand. The red mottled clay now being shipped for testing (April 13) is said to carry a little more sand than the Bacon mottled clay. Nine men were employed on that date. Clay is mined by hand in an open pit and hauled in a small truck to the railroad cars, a few hundred feet away. It is thought this clay will prove suitable for tile. The white sand is stated to run 71% silica. If regular production starts, drifts will be run to avoid handling the overburden."

[1] State Mineralogist's Rep. XXIII, p. 141.

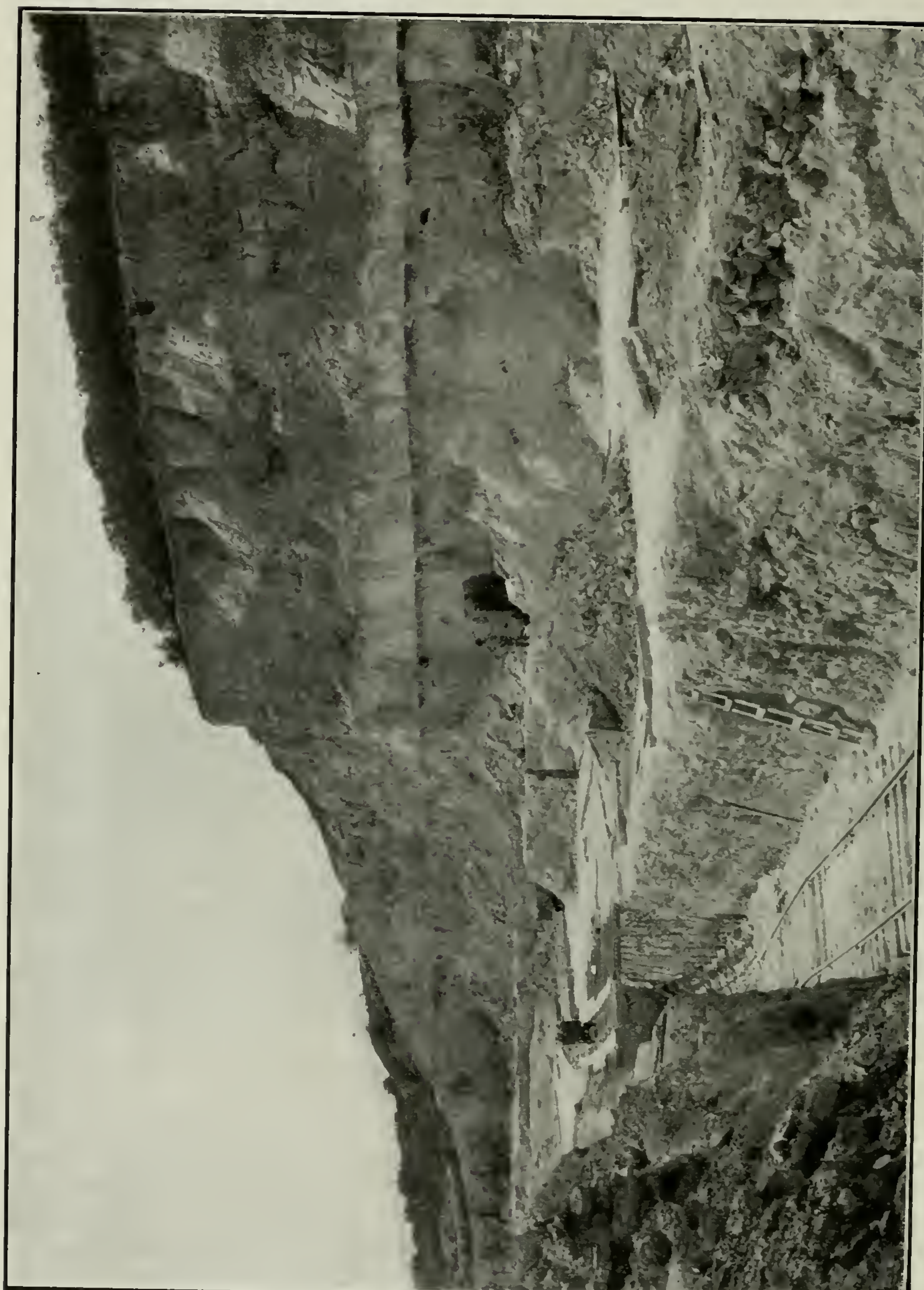

PHOTO No. 10-C. Sand pit of the Ione Fire Brick Company. (Photo by courtesy of the company.)

Three samples were taken from this property. No. 129 is sand from the upper sand bed, taken from the underground workings at the working face when visited on August 8, 1925. The test results are given on page 261. Sample No. 130 is representative of the carbonaceous sand, and was taken with the object of studying possible uses. The test results, page 290, on the untreated sand were unfavorable, and is unlikely that beneficiation, even if proved possible, would be of commercial importance in the immediate future. Sample No. 131 is from the deposit of red clay from the new pit, and is seen (p. 329) to be quite similar in its properties to the Bacon red (sample No. 127, p. 335).

Yosemite Portland Cement Company.[1] Main office, Pacific Building, San Francisco. This is known as the Harvey pit and is part of over 100 acres of land recently purchased from Fred Harvey. The pit is just east of the old Harvey coal mine, and one mile north of Carbondale. The land is in Secs. 32, 33 et al., T. 7 N., R. 9 E., M. D. M.

Bluish fireclay occurs with an overburden of from two to three feet of soil in which are found concretionary boulders of red iron oxide. The pit was formerly operated by hand methods, but in 1927 a plow and scraper, drawn by a tractor, were used for removing the overburden, and the clay was mined by a small steam shovel. The pit is now about 12 feet deep, and it is stated that borings have indicated a depth of 65 feet of clay, over an extensive area. Auto trucks are used to deliver the clay to the railroad.

The clay contains about 32% alumina, dry basis, and is used in the manufacture of white cement. It is also a useful sewer pipe and terra cotta clay.

Sample No. 133 was taken for test. The results are given on page 298.

Changes Since Former Reports.

The following important changes have occurred in the Amador County clay industry since the publication of Preliminary Report 7, and the Nineteenth Report of the State Mineralogist:

Amador Kaolin Company. Extinct.

W. D. Amick Property (formerly operated by the Philadelphia Quartz Co.). A white sand deposit containing from 20% to 30% of kaolin. A washing plant was built and operated during the World War. Now dismantled and idle.

McKissick Cattle Company. Former owner of Rancho Arroyo Seco, now owned by S. E. Kieffer and leased by G. A. Starkweather, as noted, *ante.*

Newman Clay Company. Now May E. Newman Estate.

Philadelphia Quartz Company. No longer operating in the county

Bibl. of Ione district: Cal. State Min. Bur. Report XIV, pp. 5–11; XXIII, pp. 134–144. Bull. No. 38, p. 206. Prel. Rept. No. 7, p. 38.

[1] Logan, C. A., *op. cit.*, p. 138. (Under Pacific Portland Cement Company, Consolidated.)

BUTTE COUNTY.

General Features.

Butte County is in the north-central portion of the state, largely between the Sacramento and Feather rivers. Its western half is in the Sacramento River basin and its eastern half is in the foothills of the Sierra Nevada Mountains. The area of the county is 1722 square miles and its population is 30,030 (1920 census).

Among the mineral resources of the county are asbestos, barytes, chromite, gems, gold, limestone, marble, mineral water, platinum group, silver, and miscellaneous stone. The following are produced commercially at present: gold, miscellaneous stone, platinum, silver, mineral water, brick, copper, gems (diamonds), lead, natural gas, and soapstone.

Clay Resources.

Deposits of high-grade clay have been reported from numerous localities in Butte County, especially within a radius of 12 miles from Oroville, the county seat, but only one of these has been developed. Common brick clays are plentiful at many places in the valley region east of the Sacramento River, and northwest of the Feather River, and in some of the Neocene River channels at higher elevation.

Beginning at a point two miles north of Oroville, and extending northward for nearly eight miles to Pentz and Cherokee, the Ione formation has been traced.[1] The geologic history of this region has been summarized by Lindgren as follows:

"(1) Deposition of Chico formation (Upper Cretaceous); (2) epoch of erosion; (3) accumulation of lowest gold-bearing gravels (Eocene?); (4) deposition of Ione formation, underlying Table Mountain; (5) eruption of basalt of Table Mountain; (6) formation of high volcanic gravels of Table Mountain; (7) epoch of erosion; (8) deposition of tuff and lower gravels (late Pliocene) of Oroville; (9) epoch of erosion; (10) deposition of bench gravels of Oroville (Quaternary); (11) epoch of erosion; (12) deposition of present stream gravels. The epoch of erosion (item 7 above) following the formation of the high volcanic gravels in many places removed a part of the Ione formation and basalt before the deposition of tuff. The Ione formation itself was laid down on a very uneven surface."

As a result of the foregoing geologic history, it is possible that many of the occurrences of high-grade clay that have been reported are small and irregular, although in most localities thorough prospecting by drilling will be necessary in order to determine the size, shape, and quality of the deposit, as very little information can be gleaned by surface examination. So far as known, the only property in the Ione formation that has been well prospected is that of the Table Mountain Clay Products Co. near Wick, where a sufficient quantity of good clay was found to warrant the erection of a plant.

A number of localities south and southeast of Oroville were investigated, and samples were taken of some of the typical materials of possible ceramic utility. Some of these proved to be derivatives of the rhyolitic and andesitic flows, with little or no ceramic value. The nature of such deposits is discussed more fully in the descriptions of deposits in Nevada and Placer counties.

Some clay from settling-ponds left by the dredges that formerly operated near Oroville has been mined and shipped to various ceramic plants, especially to the Gladding, McBean & Co., plant at Lincoln,

[1] Lindgren, Waldemar, The Tertiary Gravels of the Sierra Nevada of California: Prof. Paper 73, U. S. Geol. Survey, p. 86, and Plate XV, 1911.

Placer County, but the new enterprise of the Natoma Clay Co., at Natoma, Sacramento County (see page 186), will doubtless render such operations unprofitable in Oroville.

One common brick plant near Palermo supplies the needs of this region for common building brick.

The *Lund Brick Yard* is on the Nelson E. Lund ranch, 3.6 miles by road east of the Palermo-Honcut road from a point 4.4 miles southeast of Palermo, a total of 13.7 miles by road southeast from Oroville. At the time of visit, on August 24, 1925, the first successful burn of common red brick had been completed. Mr. Lund expects to manufacture ruffled face brick if the local demand warrants.

The clay is mined by hand methods from a deposit of clay and silt that comprises the upper part of a Tertiary river channel deposit, parts of which were formerly hydraulicked for gold. Three distinct variations of sand-gravel-clay beds are exposed in the pit. The upper bed is from one to three feet thick, and consists of fine-grained red-colored plastic clay, with little sand and few pebbles. The middle bed contains more sand, and some fine gravel, and is from three to four feet thick. The lower bed, of unknown thickness, is too sandy to work alone, and contains considerable fine gravel, and some larger boulders. Each of these beds was sampled separately, under the sample numbers 178–, 1, 2, and 3, respectively, from the top down. The middle bed gives the best results for brick-making and the top bed is characterized by high shrinkage and danger of cracking during drying and firing. A reasonably uniform product can be obtained by including a sufficient proportion of the sandier bottom bed to offset the high shrinkage of the top bed, but on account of extreme and sudden variations in the character and thickness of each of the beds, this may be difficult unless a method of bedding and reclaiming is used in the plant. See page 325 for the results of test.

The plant is equipped with a bucket elevator for delivering the material from the pit to a roll crusher. This is followed by double pugging, and an auger machine of 20,000 brick daily capacity. Power is supplied by steam from an oil-fired boiler. The clay is worked in a softer state than is commonly used with auger machines. Drying is done under sheds. Care must be taken to avoid exposure of the brick to sun and hot wind during drying, as serious drying cracks may develop.

An oil-fired kiln is used for firing. Steam is used for atomizing the oil. In the 10-ft. by 20-ft. kiln in use at the time of visit, the firing required seven days, and the kiln cooled in four to five days.

The plant is operated as needed to supply the local demand.

Table Mountain Clay Products Co. L. F. Riley, president; H. M. Gamble, superintendent. Home address, Oroville. This company has acquired and developed a clay deposit in the SW¼ of Sec. 22, T. 20 N., R. 3 E., M. D. M., and at the time of visit on August 24, 1925, were constructing a plant for the manufacture of face brick, hollow tile, and roof tile. The plant lies 0.4 mile west of the Oroville-Pentz highway, from a point 5.9 miles by road northwest from the center of Oroville.

The property was prospected by means of auger holes, most of which varied from 14 to 22 feet deep. Clay was found under a large portion of the property, underlying a variable amount of basaltic capping. None of the holes penetrated to the bottom of the clay beds, and it is claimed that one hole was drilled to a depth of 72 feet without encountering a change of formation.

The overburden covering a large portion of the area is only 6 inches to 2 feet in thickness, and mining operations will at first be confined to this ground. Mining is done with horse scrapers, delivering the clay to belt conveyors which are extended as the pit advances.

The clay is crushed in rolls, mixed in a pug-mill, and the products are shaped on an auger-machine having a capacity of 40,000 brick per day. A dry pan may later be added ahead of the pug-mill. Drying is done under sheds in the open air. The kilns are fired with oil.

Sample No. 175 was taken for test, the results of which are on page 304.

Undeveloped Deposits.

Two samples were taken from alongside the Oroville-Quincy road. No. 176 (see page 325) is a decomposed igneous rock, considerably kaolinized, and badly iron-stained, from an exposure 4.3 miles by road southeast from the center of Oroville, in Sec. 13, T. 19 N., R. 4 E., M. D. M. The sample probably contains more iron oxide than would be found in the body of the deposit. The size of the deposit could not be estimated, but the occurrence is such as to indicate a good tonnage. The material is suitable for the manufacture of red brick. Another sample, No. 177 (see page 336), was taken from a road cut, 2.9 miles from the center of Oroville. It is high in volcanic ash, but contains enough alluvial clay and silt to make it usable to a limited extent in the manufacture of red brick, if mixed with a more plastic clay. The extent of the deposit was indeterminate.

An unsuccessful attempt was made to secure recent information regarding the deposits mentioned in previous reports of the Bureau.[1] All of these reports were made previous to 1906, and in the limited time available for the present investigation, it was impossible to find anyone in the various localities mentioned who had any knowledge of the existence of clay deposits, or who were able to give information regarding the former owners of these deposits. For the sake of completeness, these reported occurrences are listed hereunder, with such notations that seem of interest at the present.

Bohannon Ranch, Yankee Hill. Sec. 4, T. 21 N., R. 5 E., M. D. M. "Large body of plastic yellow clay, tenacious and refractory." This lies in the Big Bend of the Feather River, probably at an elevation of over 1000 feet above the bottom of the canyon. If of economic value, clay could be delivered by pack-train or tramway to the Western Pacific railroad, a distance of probably two miles. The result of inquiry among residents of Yankee Hill did not warrant an attempt to find the property. The mere fact that it was described as "yellow," and that it is in such an isolated region preclude the possibility of economic utilization for many years to come.

Biggs. (Max Brooks and Mr. Reed, reported owners). Sec. 19 and 30, T. 18 N., R. 3 E., "Light brown and white, brittle clay, about

[1] Cal. State Min. Bur. Prel. Rept. No. 7, p. 43, which summarizes the data given in Bulletin No. 38, p. 211.

one-half mile wide." This is now included in the Butte County Farms. Mr. H. H. Grimes, the manager, kindly undertook an inquiry among old-time residents and employees in the vicinity, and reported that nothing was known of such a deposit, and that the previous report may have referred to a wide belt of hard-pan that comes close to the alluvial surface of the ground over portions of the property.

Coal Cañon. Sec. 12, T. 20 N., R. 3 E., "A stratum of clay in a coal mine." This probably refers to an abandoned and inaccessible coal mine in the Ione formation underlying Table Mountain. The property is 2.5 miles northeast of the plant of the Table Mountain Clay Products Co.

Durbin Ranch. SW¼ Sec. 13, T. 21 N., R. 3 E., "Large deposit of refractory clay, with low plasticity. Total depth 100 ft." Also, "* * * a deposit of light-colored clay, more plastic than above in NE¼, Sec. 13." This would lie one mile north of Pentz. A reconnaissance of this section was made, without finding any material of value. Most of the section is covered with Tuscan tuff. The Ione formation outcrops to the south, and disappears under the Tuscan tuff.

Garden Ranch. SW¼ Sec. 22, T. 19 N., R. 3 E., 3 miles southeast of Oroville. "Extensive deposits exposed in road building." No material of value could be found on this area.

Snow Ranch, Lovelocks. SW¼ Sec. 31, T. 24 N., R. 4 E., "Light-colored clays of medium plasticity." A reconnaissance of this locality was made, and nothing of interest was found. Some partly kaolinized diabase (?) occurs in places, but is badly contaminated with iron. The region is too inaccessible to be of economic importance as a producer of any but the finest grades of clay.

CALAVERAS COUNTY.

General Features.[1]

Calaveras County lies on the west slope of the Sierra Nevada Mountains, the elevation ranging from 400 feet above sea level, where it joins San Joaquin County on the west, to 8000 feet where the eastern boundary rests on the summits of the Sierras adjoining Alpine County. Bounded on the north by Amador County and on the south by Tuolumne, it shares with them the advantage of a climate where snow seldom falls and practically never lies below 2500 feet elevation, and where mining may be carried on throughout the year under ideal weather conditions.

Water, power, and timber resources are plentiful. Several railroad branches connect the main towns with points in the San Joaquin Valley. Most points in the county at elevations under 2500 feet can be reached by automobile during the greater part of the year.

The principal mineral products of the county are gold and copper. Other minerals that have been produced are silver, produced as a by-product of gold and copper mining, limestone, mineral paint, clay, mineral water, asbestos, rock crystal (quartz), chromite, and miscellaneous stone.

[1] From Logan, C. A., Calaveras County: State Mineralogist's Report XXI, p. 135, 1925.

Geology.

The geology of the county is similar to that of Amador County and others in the Mother Lode belt. The Ione formation (Eocene) is found at numerous places, but is not so extensively developed, nor so well preserved as in Amador County. The following is a portion of the geological summary of the county as given by Logan:[1]

"The Neocene shore-line, as indicated by the Ione formation, covered the county from Lancha Plana through Valley Spring to Jenny Lind, and southward to Milton. The most westerly of the lode mining districts are the Hog Mountain-Gopher Range copper mining district, where copper ores occur in diabase and allied rocks, near the southwest corner of the county, and the Campo Seco copper district, where similar ores occur in amphibolite schist. In a depression called Salt Spring Valley, between the older crystalline rocks of Gopher Ridge and Bear Mountains, lies a belt of black Mariposa slate with interbedded lenses of amphibolite, with important copper deposits, which conform in strike with the direction of schistosity of the enclosing rocks. The Mother Lode belt of black Mariposa slate enters the county at Middle Bar, but aside from the Gwin Mine, which had reached a depth of 2850 feet before it was closed several years ago, little deep mining has been done in this district, though numerous quartz mines have been opened to depths of less than 1000 feet. There are many prominent veins in the granodiorite area of Mokelumne Hill, but the main belt passes southeast, a line of fissuring having passed into the amphibolite schist, in which rock were found the deep mines of Angels Camp and Carson Hill.

"The East Belt is a general name given to the gold-quartz mining districts in the great body of Calaveras (Carboniferous) rocks, lying east of the younger Mother Lode slate and east of the amphibolite schists accompanying the Mariposa slate. The Calaveras rocks are chiefly hard blocky siliceous and micaceous schists, quartzite, curly black slates and accompanying intrusive dikes, usually of basic character."

Clay Resources.

Various clay deposits in the Ione formation near Valley Springs and Helisma have been operated in the past. Some work has been done recently on a deposit of kaolinized talc schist in the Calaveras (?) formation.

The *California Pottery Co.*, of Oakland and Merced, own two deposits in Calaveras County, one at Nigger Hill, and the other at Valley Springs. Henry Ward of Valley Springs is superintendent.

NIGGER HILL: Near Nigger Hill, about three miles north of Valley Springs, a good deposit of white-burning kaolinized sericite schist has been discovered. A tunnel has been driven for 250 feet. The kaolinized zone is from 15 to 25 feet thick. The material has low plasticity, but is of use as a filler in white tile bodies.

Sample No. 236 (p. 263) was taken at the face of the tunnel, and Sample No. 237 (p. 263) was taken at the portal.

VALLEY SPRINGS CLAY PIT: This pit is ¼ mile northwest from Valley Springs on a spur track from the Valley Springs branch of the Southern Pacific Railroad. The property comprises 17 acres. Fireclay from the Ione formation is mined from an open pit, shown in photo No. 11. Two distinct varieties of clay are mined and shipped to the Merced plant of the company. One of these is classed as 'pink mottled,' (sample No. 202, p. 337), and the other is 'yellow' (sample No. 203, p. 337). The two varieties are somewhat intermingled, but can be separated by hand as mined. In the southern end of the pit, northward to the break in the face shown in the photo, the pink mottled predominates, and in the northern end of the pit, the yellow variety is more important. Some yellow sandy streaks traverse the clay, and in places small quantities of white clay are found.

[1] *Op. cit.*, p. 140.

The floor of the pit is approximately 200 ft. square, and the face varies from 10 to 30 feet high. The clay is loosened by hand drilling and light blasting, and is loaded by hand shoveling into wheelbarrows, which are dumped into a hopper. An inclined belt conveyor transports the clay from the hopper to a railroad car.

In a test pit five feet deep, just east of the track, pink mottled clay is exposed. Fifty feet farther east another test-pit was sunk, with the aid of a windlass, to a depth of 25 feet. Both pink-mottled and yellow clay were found to the bottom of the shaft. From the debris surrounding the collar of the test-pit it was estimated that the pink-mottled variety comprised about one-third of the material excavated. A third 25-ft. test pit was dug 100 feet north of the second one, and similar material was encountered, in addition to a bluish-white plastic clay, not entirely free from limonitic stains (sample No. 204, p. 299). This

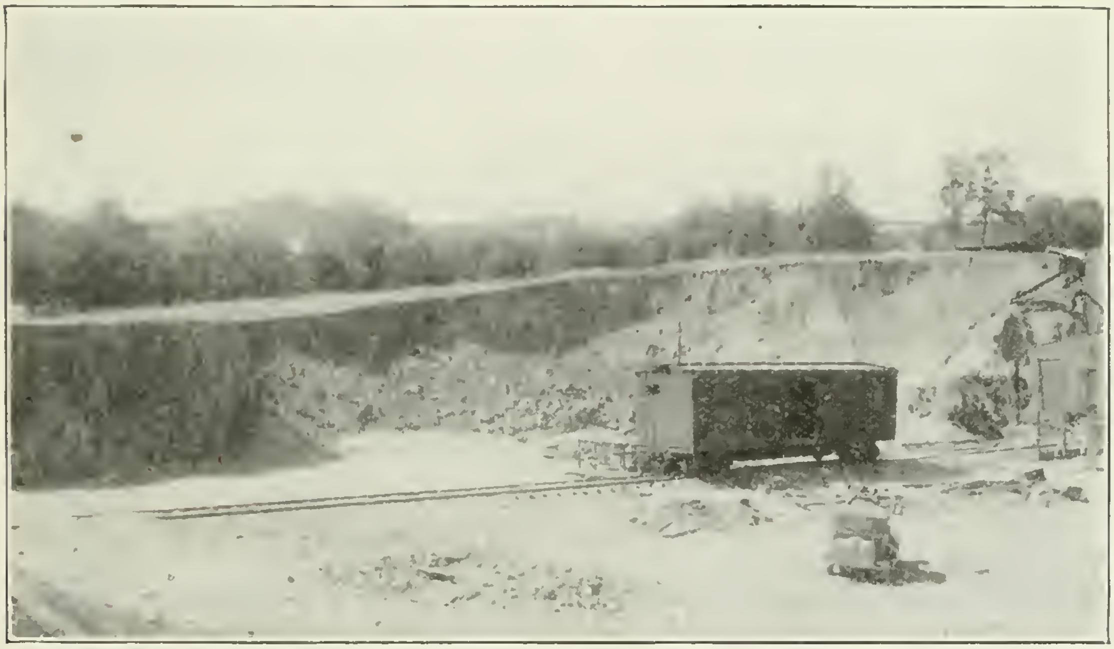

PHOTO No. 11. Valley Springs clay pit (California Pottery Co.), facing west. The track runs S. 25° E. The 5-ft. test-pit appears in the center foreground. (Samples No. 202–204.)

test-pit was bottomed in a yellowish sandy bed. From the evidence on the dump, the bluish-white variety of clay predominates at this point.

It is evident that the total thickness of useful clay is in excess of 50 feet, and the structural and topographic features are such as to warrant the expectation that these beds underlie an area of many acres.

Three men are employed during the operating season. In 1925, nearly 200 cars were shipped, at the rate of approximately four cars per week.

Helisma Fireclay Deposit. One-quarter mile north of Helisma (formerly Burson) station on the Valley Springs branch of the Southern Pacific Railroad is an abandoned fireclay pit formerly controlled by W. A. Houts, 202 Balboa Building, San Francisco. The present ownership of the property was not determined. The deposit is in the Ione formation. The total thickness of clay exposed in the pit varies from 8 to 15 ft. The upper part of the clay bed is a bluish-white clay with good plasticity, and the lower part is a greenish-white clay, with less plasticity. Both varieties of clay are traversed by thin limonitic seams a foot or more apart.

The main pit is 150 ft. long, 50 ft. wide and from 8 to 15 feet deep. The overburden, of volcanic breccia, increases from a few inches at the lower edge of the pit to 10 ft. at the upper edge. Two hundred feet to the west is a smaller pit 80 ft. long by 30 ft. wide, and a maximum of 10 ft. deep. The clay is similar to that in the larger pit, but contains more iron, and is more sandy.

The clay was formerly worked by hand loading into cars which were hauled up a gentle incline to a loading chute overlooking a railroad siding. All equipment has been removed from the property.

The probable extent of the clay bed beyond the existing exposures could not be determined without boring, on account of the overburden. Structural features are favorable to a continuance of the clay under the low hill on which the pit is located, but the overburden covering the top of the hill may be 20 ft. or more in thickness.

Sample No. 201, page 305, includes both types of clay from the main pit.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 43.

Penn Mining Co. During the operation of the copper smelter at Campo Seco, a kaolinized sericite schist overlying the copper beds was used in the smelter as a refractory. Since the smelter was closed down this material has not been utilized. The locality was visited on September 22, 1926, and a sample was taken from the abandoned open cut from which it was formerly obtained. The sample is No. 238 and the tests demonstrate that the plasticity and strength are low, and that the content of fluxes is high, causing fusion to begin at cone 9 (1285° C.). See page 316.

Bibl: State Min. Bur. Bull. 38, p. 211; Prel. Rept. 7, p. 43.

Texas Mining Company. J. P. Hoskinson, Valley Springs. This is an undeveloped property about two miles north of Valley Springs. Small exposures of sandy fireclay belonging to the Ione formation have been found, and some prospecting has also been done on an outcrop of kaolinized sericite schist of Calaveras (?) (Carboniferous) age. Sample No. 233 was taken of the fireclay, but was not tested, as the quality was obviously poor, and the continuity of the deposit is doubtful. Sample No. 234 and 235 were taken from two different exposures of the kaolinized schist. The test results of No. 235 are given on page 263. It is a white-burning refractory material of low plasticity, that would be useful as a filler in white ceramic bodies. No. 234 was not tested, as it is similar to No. 235.

COLUSA COUNTY.

General Features.

Colusa County lies on the west side of the Sacramento Valley. The west side of the county is in the foothills of the Coast Range, and the east side is in the basin of the Sacramento Valley. The area of the county is 1140 square miles, and the population is 9920 (1920 census). Colusa is the county seat and principal town.

The mineral resources of Colusa County are largely undeveloped. Occurrences of coal, chromite, copper, gypsum, manganese, mineral water, pyrite, quicksilver, sandstone, miscellaneous stone, sulphur, and in some places, gold and silver, are known. Of these, the only commercial production is of mineral water, sandstone, and miscellaneous stone.

Clay Resources.

Common clays suitable for the manufacture of brick are abundant, but there is at present no local industry. A brick yard was at one time operated at Colusa by George Smith.

Bibl: State Mineralogist's Rept. VIII, p. 159; State Min. Bur. Bull. 38, p. 242; Prel. Rept. 7, p. 44.

CONTRA COSTA COUNTY.

General Features.[1]

Contra Costa is one of the East Bay counties and is bounded on the west and north by the waters of San Francisco, San Pablo and Suisun bays and San Joaquin River. San Joaquin County is on the east and Alameda County is on the south.

The area of the county is 714 square miles, about half of which is under cultivation. The population in 1920 was 53,889. Its industrial and shipping activities are extensive. The county has approximately 70 miles of deep water-front on which are located nine port cities in which have been established many chemical and industrial works. Agriculture, stock raising, and to a lesser extent, mining, contribute to the prosperity of the county.

Topographically, Contra Costa County is distinguished by containing the most prominent landmark in the central coast counties, Mt. Diablo, which rises to an elevation of 3849 feet above sea level. This peak is in the eastern part of the two main ridges of the Coast Range Mountains, which strike northwesterly across the county. The western ridge lies close to the coast. Its crest is more regular but its highest peaks are less than 2000 feet in elevation. The western flank slopes gently toward San Francisco Bay. Between the eastern and western ridges lies San Ramon Valley, drained by San Ramon Creek, which flows northward into Walnut Creek and hence into Suisun Bay. Marsh Creek rises on the eastern slope of Mt. Diablo and flows northeasterly into the San Joaquin River. These are the two principal streams in the county. The northeastern corner of the county is included in the delta area of San Joaquin Valley and is elevated only slightly above sea level.

Geology.

That portion of the Coast Range within Contra Costa County has been studied by the Department of Geology and Paleontology of the University of California, and the southeastern portion has been mapped by Lawson.[2]

A nearly complete section of the Coast Range formations from the Franciscan to the recent are exposed within the county, but as the area is one of many faults, no single formation is continuous over a large

[1] From Laizure, C. McK., Contra Costa County: State Mineralogist's Rept. XXIII, p. 2, 1927.
[2] Lawson, A. C., San Francisco Folio, No. 193, U. S. Geol. Survey.

area. The most abundant strata are sandstones and shales of Cretaceous and Tertiary age.

Contra Costa County is lacking in deposits of valuable metals, but its structural materials are important natural resources on account of their easy accessibility and proximity to the cities surrounding San Francisco Bay. Its coal deposits are of potential value. The most important minerals now produced are: cement, miscellaneous stone (crushed rock, sand, and gravel), and brick. Clay, limestone, mineral water, and foundry sand are also on the commercial list. Other mineral resources include asbestos, coal, copper, diatomaceous earth, manganese, and quicksilver.

Clay Resources.

Alluvial clay and silt are not abundant in those parts of the county that are favorably situated with respect to manufacturing and marketing conditions. However, there is an abundance of Tertiary clay shale

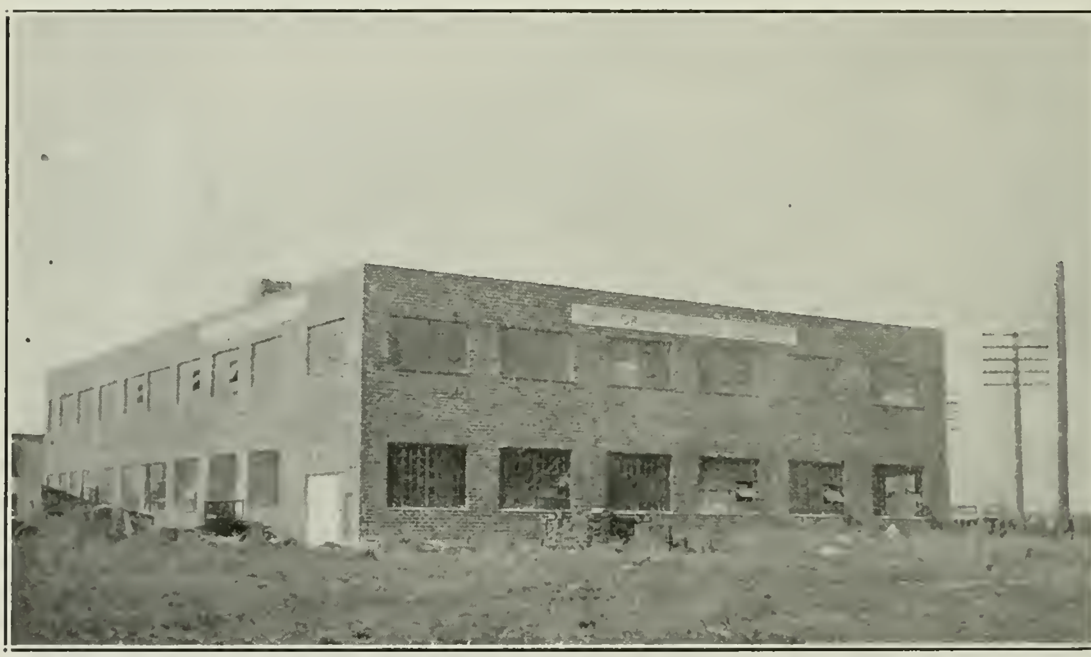

PHOTO No. 12. California Art Tile Co. plant, Richmond, Contra Costa County. (From State Mineralogist's Report XXIII, p. 7, 1927.)

in several of the formations that are widespread throughout the area, and a number of brick and hollow-tile plants have been established at various places.

No deposits of high-grade clays have thus far been discovered in the county, but on account of favorable manufacturing and marketing conditions, a number of important ceramic plants have been established in or near Richmond, and a wide diversity of ceramic ware is produced.

California Art Tile Company. J. W. Hislop, president; L. J. Hislop, secretary; W. A. Hislop, chemist; and C. E. Cummings, superintendent. Address, Box 1116, Richmond. This plant is at Twenty-seventh and Maine streets, Richmond, and was built in 1926 to replace a smaller plant that had been established in 1922. Decorative wall and mantel tile are made from a buff-burning fireclay body, and terra cotta glazes. Lincoln clay and Ione sand are used for the body. A view of the plant is shown on Photo No. 12.

The body mix is prepared by grinding in a 10-ft. dry pan, followed by a pug-mill. A tile auger with a patented cutter is used for making the regular shapes, and special shapes are hand pressed. Drying is done in a room heated by kiln gases. The glazes are applied by spraying before firing. Saggers are made at the plant in a sagger press.

The kiln equipment consists of three 30-ft. and one 24-ft. oil-fired, round down-draft kilns. The tile are fired to cone 8 to 10 in four days. The cooling time is also four days.

Forty men are employed at the plant. The rated output of the plant is 40,000 sq. ft. of tile per month.

Bibl: State Mineralogist's Report XXIII, p. 7, 1927.

N. Clark and Sons. At Oxley siding, on the Southern Pacific Railroad, ½ mile north of Walnut Creek, is a shale pit owned by N. Clark and Sons, 116 Natoma Street, San Francisco. The material is a thin-bedded, soft, nearly white, calcareous shale of Tertiary age (Miocene?), overlain unconformably by sand and gravel. It is used as a component of terra cotta and other mixtures in the company's plant in Alameda.

The deposit is worked by an open cut along a face that is approximately 200 feet long. At the southern end of the pit, the shale bank is 70 to 80 feet high above the floor of the pit, but the contact between the shale and the overlying gravel and sand dips toward the north, so that the shale disappears at the northern end of the pit. The shale is broken by hand drilling and blasting, and is delivered to a loading platform either by wheelbarrows or by horse-drawn scraper. A storage shed is provided for the winter supply when mining is stopped. Sample No. 200 was taken for testing, the results of which are on page 342.

Mr. Faber of Walnut Creek is mining under contract, and two or three men are employed during the operating season. About two cars per week are shipped.

Bibl: Cal. State Mining Bur. Prel. Rept. No. 7, pp. 44–46; State Mineralogist's Reports XVII, p. 49, and XXIII, p. 13.

Mastercraft Tile and Roofing Company. (Entire description by Laizure, *op. cit.*, p. 7.) C. V. and F. A. Mero, owners. Office, No. 1 Twentieth Street, Richmond. Cement roofing tile has been manufactured by this company for the past four years at its Richmond plant. During the past year (1926) hand-molded clay roofing tile has been added to their line. The clay tile plant is on San Pablo Canyon road, near San Pablo, but the clay is obtained near Richmond. Firing is done in a rectangular down-draft kiln using oil for fuel. Six men are employed.

Port Costa Brick Co. C. B. Berg, president; W. S. Hoyt, secretary; B. F. Ferrario, plant superintendent. General offices, 808 Sharon Building, San Francisco. The plant is located three-quarters of a mile east of Port Costa, at the edge of Carquinez Straits. The products are common brick and hollow tile.

A bank of interbedded bluish shale and red clay of Cretaceous (?) age is mined by a 1½-yard electric shovel in a large open cut 1000 feet from the plant. The clay is transported to the plant in 5¾-yard hopper-bottom side-dump cars, hauled by a gasoline tractor fitted with flanged wheels, or by an electric third-rail locomotive. The local material is used alone for the manufacture of brick, but is mixed with one part of Lincoln No. 8 (sample No. 148, p. 336) clay for each two parts of local clay for the manufacture of hollow tile. The Lincoln clay is necessary to secure sufficient die lubrication to prevent lamination and rupture to the clay as it passes from the auger machine. A sample of the local clay was taken for testing. See sample No. 199, page 326.

The clays are prepared by grinding in two No. 3 Williams pulverizers and three 9-ft. American dry pans. Revolving screens are used to remove rock inclusions. The pulverized clay is elevated to bins from which it is fed to the auger machines. A special Giant auger machine is used for brick, and an American No. 290 auger is used for tile. The brick auger is equipped with a Freese cutter, and the tile auger has a Chambers No. 5C rotary tile cutter.

In the summer, some ware is dried in air under sheds. The drier yard has a capacity of 1,000,000 brick, and drying is completed in 12 to 14 days. This method is not used in the winter, when all ware is dried in a 22-tunnel oil-fired drier. The drier has a capacity of 400 cars of 500 brick each, or 200,000 brick, and the drying period varies from four to six days. The dryer heat is supplied by an oil furnace, using Ray burners. Two 25-hp., 66-in. fans, one of which is used as a pressure fan and the other as an exhaust, force the heated air through the drier.

Firing is done in eleven field kilns and a Hoffman continuous kiln. The Hoffman kiln has 22 chambers, and has a total capacity of 400,000 brick. The monthly output of the kiln varies from 1,000,000 to 1,250,000 brick, which corresponds to a firing cycle of 15 to 18 days, of which time 85 to 100 hours is occupied by firing, following the water-smoking period. Petroleum coke or coal screenings are used for fuel. As a rule, the Hoffman kiln is set to a height of three or four feet from the bottom with brick, and then filled with hollow tile.

Both hollow tile and brick are fired in the field kilns. The local clay is tender during the water-smoking period, and coal firing is used during this stage, followed by oil during the actual firing period. The oil is atomized with steam, which is generated in a 125-hp., horizontal fire-tube boiler, equipped with a Johnson rotary oil burner.

The usual firing temperatures are between 1600 and 1750° F., for brick and 1850° F. for hollow tile.

The plant is operated by electric power from the lines of the Great Western Power Co. There is a connected load of about 900 horsepower, but only 400 is used at present. Fifty to sixty men are employed.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 45; State Mineralogist's Reports XVII, p. 50, and XXIII, p. 8.

Richmond Pressed Brick Company. (Described by Laizure,[1] supplemented by notes by the author.) The plant was erected by the Los Angeles Pressed Brick Company, but it became an independent company, affiliated with the United Materials Company, in 1921. S. W. Smith, president; W. S. Hoyt, secretary; F. M. Irving, plant superintendent. Home office, Sharon Building, San Francisco. The plant is at Point Richmond, near the Santa Fe-San Francisco ferry terminal, and is served by a spur track of the Santa Fe Railroad. See Photo

[1] Laizure, C. McK., Contra Costa County, State Mineralogist's Rept. XXIII, p. 8, 1927.

No. 13. The output includes pressed brick, fire brick, face brick, paving brick and red floor tile.

For the buff and other light-colored brick a portion of the raw materials used include clay and sand shipped in from Ione and Lincoln, as well as some sand from Antioch. Clay shale from the pit adjoining the plant is used for making dark-red brick. As the bank is high, the material, after blasting, drops largely by gravity to a loading bin. From here it is trammed a short distance in cars to the plant.

Fire brick and most grades of face brick are made by the stiff-mud process. Dry pans and a pug-mill are used to prepare the clay for the auger machine, which has a capacity of 100,000 brick per day. All of the fire brick, and certain grades of face brick are repressed before passing to the waste-heat tunnel driers. A specialty of the plant is red pressed brick, which is shaped by dry pressing, following dry-pan preparation of the clays.

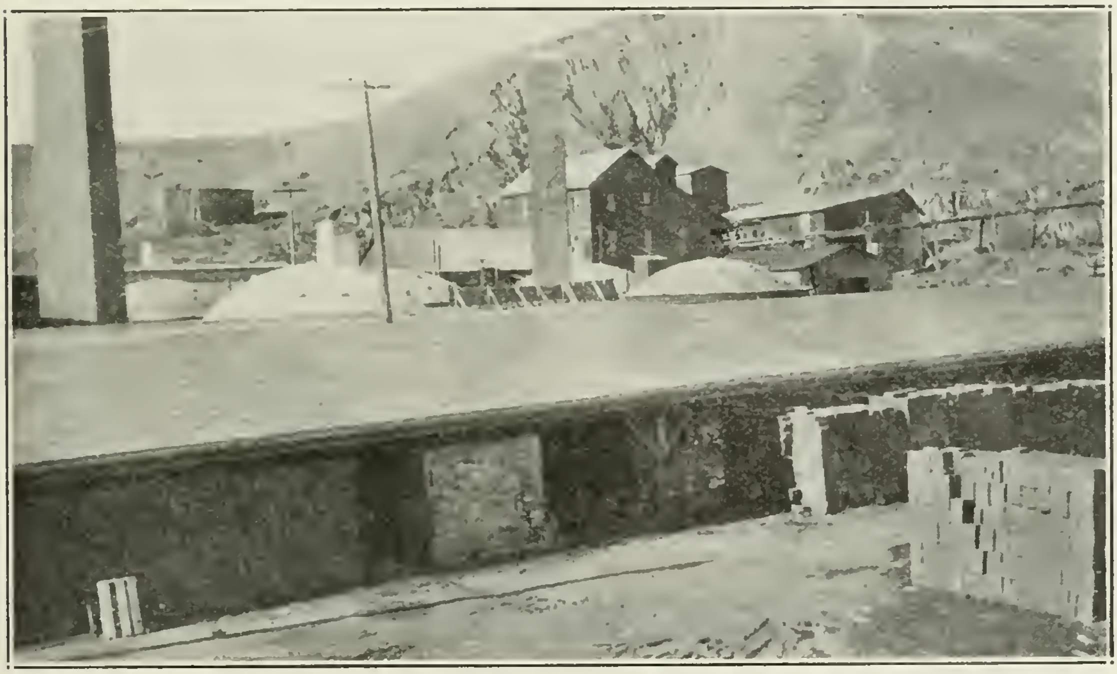

PHOTO No. 13. Richmond Pressed Brick Co. plant, with clay pit in background, Richmond, Contra Costa County. (Sample No. 119.) (From State Mineralogist's Report XXIII, p. 8, 1927.)

The firing equipment consists of six 36-ft. round down-draft kilns, using oil, atomized by compressed air. The red-burned ware is fired for nine days to finishing temperatures corresponding to cones 09 to 07 (930° to 975° C.), and the buff face brick and fire brick are fired to cones 7 to 9 (1210° to 1250° C.) in seven days. The kilns are equipped with pyrometers.

Electric power is used to operate the plant. Fifty-five men are employed. See sample No. 119, page 325.

Standard Sanitary Manufacturing Company. The Standard Sanitary Manufacturing Company of Pittsburgh, Pennsylvania, purchased the plants of the Pacific Sanitary Manufacturing Company in 1926, and have since constructed a new sanitary porcelain plant, known as Pacific Pottery, to replace two smaller plants formerly operated by the Pacific company. The Standard company is also continuing the operation of the enameling plant, now known as the Pacific Enamel Works, formerly owned by the Pacific company. These plants are in Richmond and San Pablo. F. A. Kales, Box W, Richmond, is general manager.

The two plants manufacture a complete line of porcelain and enameled sanitary ware, except porcelain bath tubs. Both plants are modern in every respect, and are designed for economy of production and close control of manufacturing methods to ensure uniformity of quality. Two tunnel kilns were installed in the new porcelain plant.

It is against the policy of the company to permit publication of details regarding the plant equipment and operation.

Bibl: State Min. Bur. Prel. Rept. 7, p. 44, 1920.

Extinct Companies.

Among the former brick companies that have ceased operations in the county are:

Mt. Diablo Pottery and Paving Brick Co.
Carquinez Brick and Tile Co.
Coast Firebrick Co.
Holland Sandstone Brick Co.
Diamond Brick Co.
Golden Gate Sandstone Brick Co.
Richmond Brick Co.
Gerlack Brick Co.

DEL NORTE COUNTY.

General Features.

Del Norte County, in the northwest corner of the state, is without rail connections, and is dependent upon light-draft vessels docking at Crescent City, auto stages, trucks, wagon and pack trains for transportation. Lumbering is the principal industry. Under such conditions, and with a population of less than 3000 (1920 census), the demand for clay products is so small that practically no clay industry has been developed, and no deposits of high-grade clay have yet been found that will warrant mining and shipment to outside points.

The geology and the physiographic features of the county have been well summarized by Laizure:[1]

"A low costal plain, three to five miles in width, extends from the vicinity of Smith River to a point a few miles south of Crescent City. East of and surrounding this area of Quaternary formations and extending from the Oregon line through Del Norte and south into Humboldt is a belt of Franciscan rocks, mainly sandstones and shales. The eastern boundary of this belt crosses Smith River just west of South Fork, and its contact with the succeeding zone of metamorphic and eruptive rocks marks the line between the Coast Range and the Klamath Mountains. This succeeding zone of metamorphics also extends through the county from north to south, widening out toward the north, where its width is about 15 miles. It is composed mainly of serpentine with unaltered masses of peridotite and many inclusions of 'diorite,' more or less altered. This belt is mineralized and most of the deposits of gold, copper, chromite, and platinum are associated with it. Between here and the eastern boundary there is another narrow belt made up largely of Franciscan schist and slate, intruded by deep-seated igneous and volcanic rocks. Serpentine again predominates along the boundary and extends over into western Siskiyou County."

Clay Resources.

Deposits of common clay suitable for brick manufacture occur at several points within a short distance of Crescent City, especially in

[1] Laizure, C. McK., Del Norte County: State Mineralogist's Report XXI, p. 282, July, 1925.

Elk Valley and along the Smith River. A small brick yard, with a wood-fired kiln, was at one time operated by Benjamin Howland, who used clay from the Musick property, in Elk Valley, 4.8 miles from Crescent City.[1] There is said to be a deposit of good pottery clay in Elk Valley,[2] but this could not be verified in the course of the present investigation.

Musick Property. This property lies 0.3 mile north of the Elk Valley road, from a point 4.5 miles from the center of Crescent City. The pit, now abandoned, is 25 feet in diameter, and three to four feet deep. A layer of black soil, less than one foot deep, overlies a yellow plastic clay, of unknown thickness and lateral extent.

Sample No. 180 was taken from this deposit. The test results are on page 326.

FRESNO COUNTY.

General Features.[3]

Fresno is one of the southern counties of the San Joaquin Valley. Madera and Merced counties are on the north, Mono and Inyo on the east, Tulare and Kings on the south, and San Benito, Monterey and San Luis Obispo on the west. The area of the county is 5977 square miles, or nearly three times that of the State of Delaware. The population is 128,779 (1920 census). The San Joaquin River separates Fresno from Madera County, and the eastern boundary runs along the summit of the Sierra Nevada Mountains. Along this line are numerous peaks exceeding 13,000 feet in elevation above sea level.

Adequate transportation is provided throughout the populous section of the county by two railroads—the Southern Pacific and the Santa Fe—each of which has many branches to important points. Power and water facilities are well provided for mining, industrial, and agricultural purposes.

The principal wealth of the county is in agricultural products, and the greater part of that portion of the county lying in the San Joaquin Valley is under cultivation. The most important mineral product is petroleum, the bulk of which is produced from the Coalinga field, and is responsible for placing Fresno County sixth in importance as a mineral producer among the counties of California. Miscellaneous stone is of secondary importance. Other commercial products are natural gas, granite, brick and hollow tile, gold and silver, and mineral water. Comparatively little mineral development has been done in the mountainous portion of the county, but occurrences of many useful minerals other than those noted above are known, among which are asbestos, barytes, chromite, copper, gems, graphite, gypsum, limestone, magnesite, marble, quicksilver, and tungsten.

Clay Resources.

No commercial deposits of high-grade clays have been discovered in the county. The alluvial silts of the San Joaquin Valley have been utilized for many years for the manufacture of common brick and hollow tile. There is, however, a scarcity of common clay of suitable plasticity for this purpose, and it has often been necessary to ship in

[1] State Mineralogist's Report XIV, p. 379, 1913-14.
[2] *Idem.*
[3] See State Mineralogist's Rept. XIV, pp. 429-432, 1914.

small quantities of this material to the brick yards from distant points. Two brick plants are at present (1927) in operation, one of which makes hollow tile and face brick in addition to common brick.

Craycroft-Herold Brick Co. F. J. Craycroft, president, 407 Griffith-McKnight Building, Fresno; Wm. Turner, vice president and superintendent. The plant is located at Crayold siding three miles west of Fresno. The products are common brick, ruffled and plain face brick, and hollow tile.

Some of the clay used in the plant is from a superficial valley deposit of plastic clay 6 miles south of Merced. The deposit is mined to a depth of 14 feet, and one car (50 tons) per day is used to mix with a local clay from a pit near the plant. The local clay is mined to a depth of five feet with a horse scraper. It is a valley silt, with insufficient plasticity to be used alone.

The plant is equipped with a 9-ft. dry pan and revolving screen for preparing the tile mixture, and a No. 4 Williams pulverizer for the brick mixture. The ground mixture is elevated to bins from which it is fed to the pug-mills by automatic feeders. An American No. 2 auger is used for tile, and an American No. 4 auger with a Freese cutter shapes the brick. Drying is generally under sheds, as under the prevailing conditions the waste heat drier with which the plant is equipped has insufficient capacity, and operating costs are higher than open-air drying. In the summer, when the atmosphere is hot and dry, the ware is dried in about seven days.

The face brick are fired in three 38-ft. round down-draft kilns. Common brick and hollow tile are fired in field kilns, having a capacity of 950,000 common brick each. The fuel is oil, atomized with steam. The firing period is 7 days, to a temperature of 1900° F., followed by 7 days cooling. Pyrometers are used to control the temperature of the down-draft kilns.

The capacity of the plant is 56,000 brick and 6,000 hollow tile per day. Electric power is used throughout the plant.

Bibl: State Mineralogist's Report XIV, pp. 433–434; Bull. 38, p. 242.

Pioneer Brick and Tile Company. T. W. Hasty, president and manager; Arthur Bentley, superintendent. Address P. O. Box 614, Fresno. The plant is at California and Peach avenues, south of Fresno. Common red brick is the only product.

A local valley clay is used, and it is mined to a depth of five feet with a Bay City gasoline shovel. Hardpan underlies the clay. The clay is delivered to a Potts disintegrator, from which it is carried by a belt conveyer to a pug-mill, followed by a Bonnett auger, equipped with a Freese cutter. The brick are dried in sheds, requiring from seven to ten days. Three open kilns are in use, fired with oil, atomized with steam. The kilns have a capacity of 1,060,000 brick each. The firing period is 5½ to 6 days, to a maximum temperature of 1550 to 1600° F., and cooling requires 4 to 5 days. One and one-half barrels of oil are used per thousand brick.

The capacity of the plant is 40,000 brick per day. Electric power is used for all machinery.

GLENN COUNTY.

General Features.

Glenn County lies on the west side of Sacramento Valley, north of Colusa, and south of Tehama. Its area is 1259 square miles, and the population is 11,853 (1920 census). Willows is the principal town. The western portion of the county is in the foothills of the Coast Range, and the eastern portion is in the basin of Sacramento Valley. In the foothills, deposits of chromite, copper, manganese, sandstone, and soapstone have been found. The only commercial mineral production in recent years is of sand and gravel.

Clay Deposits.

Brick clays are abundant, especially in T. 19 and 22, R. 3 W., M. D. M. The clays are chiefly sandy loam. No brick have been made since about 1895, but several yards were operated near Willows previous to that time.

Bibl: State Min. Bur. Bull. 38, p. 243.

HUMBOLDT COUNTY.

General Features.

Humboldt County, of which Eureka is the county seat and principal town, is on the north coast, between Del Norte and Mendocino counties. Although the harbor facilities at Eureka are excellent, the progress of the county was slow completed through to Eureka from the south.

The greater part of the country is rugged and mountainous. The ridges and spurs of the Coast Range traverse the county in a northwesterly direction, roughly paralleling the coast line. The coastal plain is narrow and along the greater part of the coast line is practically nonexistent.

The area of the county is 1259 square miles and its population is 11,853 (1920 census).

Geology.

The geology of the county has been summarized by Laizure[1] as follows:

"Sedimentary formations extend from the Mendocino County line north along the coast to a point about five miles north of Arcata. They cover a strip about 12 miles wide at the south end. Where the belt crosses the Humboldt Base Line, the formations have a width of 30 miles, gradually running out to a point at the north. In the southern part the rocks consist of massive marine sandstones, with some shale and limestone beds, all of Cretaceous age. The northern part is composed of clay shales and sandstone of Tertiary age, with small areas of Quaternary sands, gravels and clays, notably along the lower reaches of Eel River. The eastern boundary of these sediments runs a little west of north. The contact on the east and covering all the southeastern portion of the county, and extending northwest to Rocky Point above Trinidad there is a belt of Franciscan sandstone, chert, and serpentine, about 12 miles in width. A long, narrow strip of Cretaceous shales, with lenses of sandstone three to four miles wide, borders the Franciscan on the east. It enters the county on the southeast at Humboldt Base Line, trends northwest and passes out at Stone Lagoon, near Orick.

"All that portion of the county lying north and east of this belt is composed of Jurassic, Paleozoic, and pre-Cambrian metamorphic and intrusive rocks, including limestones, schists, slates, extensive masses of serpentine, diorite and other crystalline rocks. Most of the gold and copper deposits occur in this area."

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[1] Laizure, C. McK., Humboldt County: State Mineralogist's Report XXI, p. 295, July, 1925.

Clay Resources.

Common clay suitable for the manufacture of red-burning structural ware occurs in sufficient quantity for the needs of the county in the Quaternary sediments along the coastal plain and main streams. Some of the Tertiary formations also contain common clay of good quality. Four brick yards have been operated in the county at various times in the past, one at Fortuna, formerly owned by J. D. Thompson,[1] and three in Eureka, known as the Humboldt Clay Manufacturing Co., the Tracy Brickyard, and the Eureka Brick and Tile Co. Of these, only the last remains in operation, under the name of the Thompson Brick Co.

Pottery clay has been reported in various localities, but none of these have yet proved to be of economic importance. A salmon and pink-burning clay suitable for making earthernware pottery by the casting process has been found on the Angel Ranch, 18 miles from Arcata, and a few tons per year are used in the ceramic art department of the Humboldt State Teachers College. No white-burning clays nor fire clays have been reported from the county. None of the localities were visited where 'pottery' clays have been reported, as the known quality of the clay was not sufficient to be of economic value when the length of haul to possible points of use was considered.

Angel Ranch Clay. Through the courtesy of Mr. R. H. Jenkins of the Humboldt State Teachers College at Arcata, who has worked with a number of Humboldt County clays, a sample of pink or buff-burning pottery clay from the Angel Ranch was secured. The Angel Ranch is near Hungry Hollow, on the county road to Hoopaw, and the deposit is about 18 miles from Arcata, over a fair road. On account of the fact that the clay is not of sufficiently high quality to warrant commercial exploitation from a deposit at such a distance from cheap transportation, the locality was not visited, and little information was obtained regarding the extent of the deposit. See sample No. 181, page 336.

Freshwater Slough Deposit. South of Freshwater Slough, near the northeast corner of Sec. 36, T. 5 N., R. 1 W., H. M. is an exposure of grayish white plastic clay in a road cut. The clay exposure is two feet thick and 60 feet long, overlain by yellowish sandy soil, from three to ten feet thick. Boring or test-pitting would be necessary in order to determine the extent of the deposit. The material is suitable for the manufacture of common brick or hollow tile, as shown by the test results, sample No. 184, page 342.

Loofbourrow Deposit. On the property of Dr. T. L. Loofbourrow, First National Bank Building, Eureka, four miles south of Eureka, and one-quarter mile east of the highway is a deposit of fine-grained, excessively plastic clay with a bluish-gray color when dry. The age of the clay is thought to be Miocene. The clay has been prospected by two narrow open cuts, and by numerous hand-auger holes. One of the cuts is 50 feet long and the other, near by, is 12 feet long. They expose the top of the clay bed, which underlies from 10 to 15 feet of surface gravel and yellowish clay. It is stated that the auger holes

[1] State Mineralogist's Report XIV, p. 392, 1913–14.

demonstrated that the clay has an average thickness of 22 feet over four or five acres. See sample No. 185, page 342.

Bibl: State Mineralogist's Report XXI, p. 302, July, 1925.

W. A. Preston Property. "A bed of high-grade clay is found on the W. A. Preston holdings. Some of this has been used by R. H. Jenkins, of the Humboldt State Teachers College at Arcata, in the production of pottery and for experimental purposes."[1]

The Preston holdings (W. A. Preston, Box 387, Arcata) comprise 160 acres of patented land, the NE¼ of Sec. 28, T. 6 N., R. 1 E., H. M., adjoining the townsite of Arcata. Mr. Jenkins reports[2] that the deposit is not of sufficiently good quality to warrant exploitation at the present time.

Strong's Station. Mr. Malcolm B. Kildale, geologist, submitted a sample of bluish-gray plastic clay from near Strong's Station, on the Van Duzen River. This was tested under sample No. 211. See page 342. The deposit is stated to be extensive, but it is too far from the market to be of value, as it is only suitable for the manufacture of common brick.

Sunny Avenue (Eureka) *Deposit.* On Sunny Avenue, one block south of Myrtle Avenue, in north Eureka, is an exposure of gray plastic clay that is typical of the sedimentary deposits of the vicinity. The exposure of clay that was sampled is two feet thick, lying beneath a thin covering of sandy soil. The full thickness of the clay bed could not be determined from the exposures, but it is reasonable to expect a minimum of ten feet over an area of several acres, and it is likely that commercial deposits of similar material could be found in many places near Eureka or Arcata, if needed. The clay is suitable for the manufacture of red brick and building tile, as shown by the test results, sample No. 183, page 326.

Thompson Brick Company. J. D. Thompson, president and owner, Myrtle and Harrison streets, Eureka. This company was formerly known as the *Eureka Brick and Tile Co.* The property is on Eureka Slough, 1.5 miles from Eureka, and covers 6.18 acres. There is a wharf at the plant. Common brick, drain tile and hollow building tile are made from surface clay that occurs on the property. The drain tile is made in sizes from 3-in. to 12-in. diameter.

The clay is mined from an open pit with a Fordson tractor and a Fresno scraper. The pit has a maximum depth of 12 ft., but good clay is known to extend to greater depths. The clay bed is made up of irregular streaks of yellow, gray and black clay, with a varying proportion of sand. It is generally too plastic to be successfully used alone, and is mixed in the plant with a maximum of 15% of sand. The clay is dumped from the scraper into a hopper and from there it is elevated to the head of the plant in cars drawn by a cable hoist. Sample No. 182 was taken from the deposit. See page 326.

In the plant, the clay is passed through a disintegrator, followed by a pug-mill and a Brevan auger machine equipped with a wire-cutter. The brick or tile are air-dried under sheds. In the cool, moist atmos-

[1]State Mineralogist's Report XXI, p. 302, 1925.
[2] Private communication, August, 1926.

phere of the locality, drying often requires a period of four weeks, and is seldom completed in less than two weeks.

Firing is done in a 30-ft. round down-draft kiln, which has a capacity of 75,000 brick or the equivalent volume of tile. The water smoking is done with wood, for a period of 75 hours. The burn is finished with oil, atomized with steam, requiring 75 hours additional. The finishing temperature is 1850° F.

The machinery is operated by steam power, generated in oil-fired boilers. From five to eight men are employed during the season. The capacity of the plant is 1,000,000 brick or its equivalent per year, and the output is usually about half that amount. The selling price of brick, f.o.b. yard, is $20 to $22 per thousand. Photo No. 14 is a view of the plant.

Bibl: State Mineralogist's Report XXI, p. 301, 1925; Prel. Rept. No 7, p. 46, 1920.

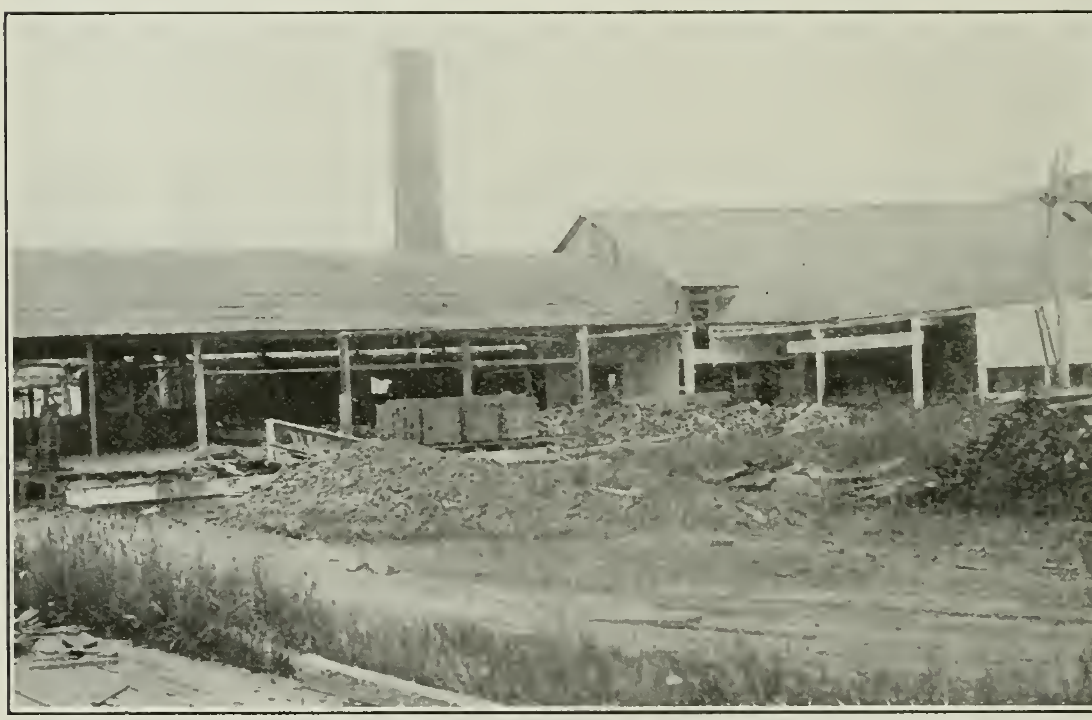

PHOTO NO. 14. Plant of Thompson Brick Co., Eureka, Cal.
(Photo by C. McK. Laizure, State Mineralogist's Rept. XXI, p. 301.)

Weatherby Ranch Deposit. "There is a deposit of clay of unknown extent on property of the Hanify Lumber Company, four miles south of Elk River, under lease to Clarence Weatherby, Eel River, via Eureka. The strata exposed in a cut on a ridge through the property show clay underlain with two feet of fine volcanic ash. Underneath the ash is six feet of yellow clay, then two feet of lignite coal, with clay again below the coal. Some production of volcanic ash has been made, but the coal and clay have not been developed. The Hanify Lumber Company's railroad runs within ¼ mile of the deposit."[1]

[1] State Mineralogist's Report XXI, p. 302, 1925.

IMPERIAL COUNTY.

(By W. Burling Tucker, Mining Engineer.)[1]

General Features.

The principal industries of Imperial County are agriculture, stock raising and dairying. Its mineral resources are varied and extensive and the rapid and continued growth of the towns of Imperial Valley and the manufacturing industries of the Pacific coast have led to the development of deposits of structural and industrial materials throughout the county.

Imperial County is bounded on the east by the state of Arizona, north by Riverside County, west by San Diego County and south by Mexico. Its area is 4089 square miles, with a population of 43,383 (1920 census). The county is served by two railroads, the Southern Pacific and the San Diego and Arizona, each of which has several branches to important points. Two main paved highways afford easy access to the county from the north. The highway between San Diego and El Centro forms part of the coast route from Los Angeles to Imperial Valley, Yuma and Phoenix. The other route from Los Angeles is over the Valley Boulevard by way of Beaumont and Banning to Brawley and El Centro. The Blythe-Glamis route to Yuma and Imperial Valley is one of the main desert roads, which enters the county from the northeast at Palo Verde and runs southwest to Glamis, from which point the road follows the railroad north to Niland.

Physiography.

The most important feature of Imperial County is the broad and nearly level expanse of the Colorado River delta, which separates the Gulf of California from the Salton Basin and is known as Imperial Valley. The Salton Sea region is one of the interesting topographical features of the county. Diagonally across the region, from southeast to northwest, it extends as a great trough whose lowest point is nearly 300 feet below sea level. On the west side of this deep trough rise the Peninsular Mountains, whose culminating points are 10,000 feet above sea level. On the east side is a desert containing irregular ranges and undrained basins ranging in altitude from a few hundred feet to 5000 feet or more.

The eastern border of the territory is formed by the Colorado River, whose waters flow through a low valley and finally spread out over a huge delta as they enter the Gulf of California.

The surface of the central portion of the Salton Basin is very even and nearly flat; about its borders are alluvial slopes. In a number of places rocky masses protrude above the even surface of the basin as rocky islands project out of the sea. Such island-like features are formed by Borego, Superstition and Carrizo mountains, the Cargo Muchacho Mountains, Pilot Knob and a number of volcanic buttes 100 to 200 feet high south of Salton Sea.

The Sand Hills constitute an important feature of the physiography of Salton Basin. The sand hills east of Imperial Valley constitute the largest belt of dunes in this region and also one of the largest in the United States. They extend southeastward from the vicitity of Amos

[1] State Mineralogist's Report XXII, pp. 248–285, 1926. Such portions of this report were used, with a few slight alterations, as have a bearing on the clay resources of the county.

and terminate a few miles beyond the Mexican boundary, being about 40 miles in length and from two to six miles in width. The crests of some of the dunes rise in places 200 to 300 feet above the land on either side.

Another interesting feature of the Salton Basin is the old beach line which lies 40 to 50 feet above sea level and encircles Imperial Valley, the Salton Sea and part of Coachella Valley south of Indio.

Geology.

The most useful references on the geology of the region are Blake's original description of the Salton Basin,[1] and Mendenhall's papers on Coachella Valley and Carrizo Creek,[2] Fairbanks' report,[3] and U. S. Geol. Survey Water Supply Paper No. 497, 'The Salton Sea Region, California,' by John S. Brown. In the following notes on the geology of Imperial County excerpts are taken from the last-named paper:

According to most geologists who have worked in this region, the oldest rocks are probably of pre-Cambrian age. The pre-Cambrian rocks occur mainly in the desert mountains in the region between the Salton Basin and the Colorado River. They are commonly flanked by Tertiary or later sediments about the mountain borders and in large areas they are covered or intruded by Tertiary volcanic rocks. The rocks that can most certainly be referred to as the oldest series consist of granite and granitic gneiss. In this series probably belong the granite and schist that compose most of the Cargo Muchaco Range and the granite, slate, and schist that form the basements of the Picacho Hills and the eastern part of the Chocolate Mountains. On the western border of the desert in Carrizo Mountain, and on the top of Fish Mountain in the Carrizo Creek region, are beds of marble and some schist and sandstone which have been referred by Mendenhall and Fairbanks to the Paleozoic, with suggestion that they may be Carboniferous. Marble schist and gneiss of undetermined age in the Santa Rosa Mountains may belong to the same series of rocks as the Carrizo Mountain district.

Tertiary Sedimentary Deposits.

Sedimentary beds, believed to be of Tertiary age, occupy extensive areas along the southwest and northeast sides of the Salton Basin and presumably underlie practically the entire basin. The largest and best-known exposures southwest of Salton Sea are in Carrizo Creek Valley, around Yuba Well, south of the Santa Rosa Mountains and northeast of Superstition Mountain and Borego Mountain, and on the north side of Fish Mountain. The Tertiary beds consist of soft, poorly consolidated conglomerates, sand and clay containing in places a large amount of gypsum and some other saline materials. Part of the Tertiary beds in the region are marine and part terrestrial.

Tertiary and Quaternary Volcanic Rocks.

The volcanic rocks of this area are probably mostly Tertiary; some of them are Quaternary. They occur as flows interbedded with sedimentary beds in the Carrizo region, around Superstition Mountain, and in Iris Pass. The lavas are most prominent in the Chocolate and Palo

[1] Blake, W. P., Pacific Railroad Reports, Vol. V, 1853.

[2] Mendenhall, W. C., Ground waters of the Indio Region, Calif., with a sketch of the Colorado Desert: U. S. Geol. Surv., Water Supply Paper No. 225, 1909.

[3] Fairbanks, Harold W., Geology of San Diego, Orange and San Bernardino Counties: State Mineralogist's Report XI, pp. 76–120, 1892.

Verde mountains. The Palo Verde Mountains are entirely volcanic, being chiefly a mass of andesitic or rhyolitic flows. The Chocolate Mountains, from one end to the other, exhibit a great mixture of andesitic and rhyolitic flows with possibly syenite and trachyte in the west end.

The only volcanic material of unquestionably Quaternary age in this region is found in the vicinity of the mud volcanoes southeast of Salton Sea, where three or four small buttes of black obsidian protrude through the Quaternary silt.

Quaternary Deposits.

The Quaternary deposits immediately underlie nearly all the lowlands and have the largest areal extent of all the rock formations. They underlie the larger part of the Salton Basin and practically all of the Colorado River Valley. The valley fill consists of sand, gravel and clay washed down from the hills and mountains.

Mineral Resources.

Imperial County ranks as the forty-sixth county in the state's mineral production. It contains deposits of clay, copper, cyanite, gold, gems, gypsum, lead, manganese, marble, mineral paint, pumice, salt, silver, sodium, strontium, sulphur and talc, largely undeveloped.

Clay Resources.

Imperial County contains extensive deposits of river silt that has been used for the manufacture of common brick and tile.

Extensive exposures of Tertiary clays are found on the west margin of Imperial Valley toward Carrizo Creek. These clays are many miles in extent and of great thickness, but have not been prospected sufficiently to determine their value for commercial purposes. On these Tertiary clay deposits a number of locations have been made by the Columbia Cement Company, of Los Angeles, and the American Portland Cement Company, of San Diego. Of special interest to the ceramic industry is the extensive deposit of cyanite at Ogilby.

During the development of the towns of Imperial Valley, a number of local brickyards have been established and operated for a short time. The Simons Brick Company, described below, is the only operator in the county at present.

Full Moon Clay Deposit. The deposit is located on the southwestern slope of the Chocolate range of mountains, in T. 10 S., R. 16 E., S. B. B. and M., eight miles north of Iris siding on the Southern Pacific Railroad.

Holdings comprise five claims known as the Full Moon group. Owner, J. Thebo, of La Mesa, California.

The clay is a white talcose clay, showing a high alumina content. The development consists of a number of open cuts along the surface outcrop. Analysis of clay made by A. J. Forget, of Los Angeles:

Silica (SiO_2)	27.93%
Alumina (Al_2O_3)	42.33%
Iron (Fe_2O_3)	1.92%
Lime (CaO)	0.53%
Soda	0.70%
Water (combined)	12.44%
Moisture	0.74%
Sulphur anhydride (SO_3)	13.39%
	100.00%

Simons Brick Company. Walter R. Simons, president. Main office, 125 West Third Street, Los Angeles. This company is the only manufacturer of brick and tile in the valley at the present writing and only operates the plant at intervals to supply the local demand. The brick plant is located about one mile southeast of El Centro.

The clay used is local silt of the valley, which is very fine and sticky. This deposit continues unchanged to a depth of 1500 feet as shown by local borings, but varies slightly in texture and the proportion of sand present, the variations in composition occurring every three or four feet. This variation enables the brick maker to mingle layers of different qualities and form a brick mixture of suitable character.

The material from the clay pit is delivered by scrapers to the hopper, from which it goes to a belt conveyor, and is elevated to a set of rolls. The material from rolls is elevated by bucket elevator to a screen. The through size from the screen goes to two stiff-mud brick machines. The brick and tile go to drying sheds, then are oil fired in open-field kilns.

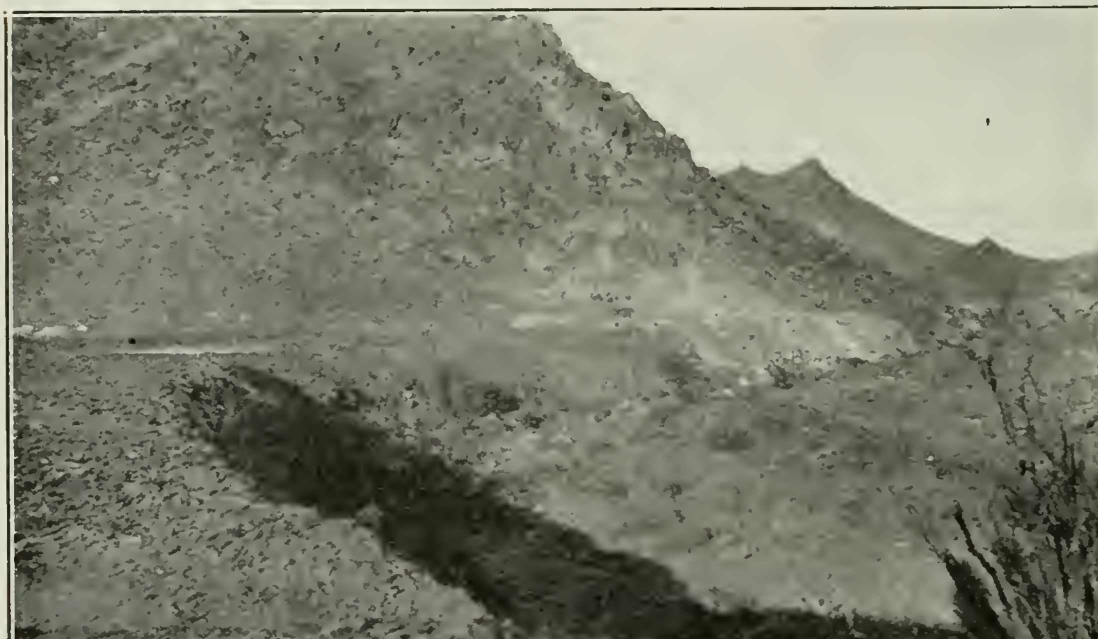

PHOTO NO. 15. Vitrefrax cyanite deposit, Cargo Muchacho Range, near Ogilby, Imperial County. Photo by W. B. Tucker; State Mineralogist Rep. XXII, p. 270.

CYANITE AND DUMORTIERITE.

Cyanite ($Al_2O_3.SiO_2$) and dumortierite ($8Al_2O_3.B_2O_3.6SiO_2.H_2O$) are both aluminum silicates but with slightly different physical characteristics. Cyanite is an aluminum silicate of the same chemical composition as andalusite and sillimanite, but crystallizing in the triclinic system; occurs usually in long-bladed crystals rarely terminated; hardness, 5–7.25; gravity, 3.56–3.67; color, blue.

An extensive deposit of cyanite occurs near Ogilby, which is being developed by the Vitrefrax Company, of Los Angeles.

Dumortierite is a basic silicate of aluminum, with boron, but crystallizing in the orthorhombic system. It occurs usually in small prisms; color, blue, dark blue and violet-red; hardness, 7; gravity, 3.22–3.45.

Dark blue boulders of dumortierite have been found in the washes in the Picacho district about 25 miles from Ogilby. These metamorphic minerals are found in the schists and gneisses.

Ogilby Cyanite Deposits. The deposits of cyanite occur near the base of hills on the western slope of the Cargo Muchacho range of mountains, three miles northeast of Ogilby. Elevation 500 feet. Holdings comprise ten claims known as the Drifted Snow and Blue Bird groups, 200 acres. Owner, Vitrefrax Company, 5100 Pacific Boulevard, Los Angeles.

The first discovery of cyanite was made in a low, rounded hill one-eighth mile wide by one-half mile long, and probably consists of 25 per cent cyanite in a matrix of quartz. One-quarter of a mile farther east, a prominent vein of cyanite outcrops for one-half mile in length, at the foot of the Cargo Muchacho range. The vein, which occurs in a mica schist, is nearly vertical and varies from 10 to 200 feet in width. Open cuts and tunnels have been made along the deposit for a distance of over 500 feet along the strike. The most extensive showing has been found on the north end of the deposit. Here it outcrops for over 200 feet in width. Quartz is the gangue mineral, while small amounts of black tourmaline occur throughout the vein material. On the south end of the deposit, both walls of the vein have a selvage of talc.

Eight to ten men are employed in getting out material for shipment to the company's plant at Los Angeles, where it is being used in the manufacture of high-grade refractories.

INYO COUNTY.

(By W. Burling Tucker.)[1]

General Features.

Inyo County lies on the eastern border of the state, north of San Bernardino County. It is the second largest county in the state, with an area of 10,019 square miles. The population is but 7031 (1920 census). Within the borders of the county are both the highest point and the lowest point in the United States. Mount Whitney has an elevation of 14,501 feet, and Salt Flat, in Death Valley, is 280 feet below sea level.

In recent years the county has become more accessible with the construction of several automobile highways which supplement the railway lines that already served important points.

Geology.

The general geology of the county has been described in detail in Report XV of the State Mineralogist, pp. 45 to 60, and a geologic map accompanies that report. Granitic rocks form the backbone of the principal mountain ranges. Paleozoic and Mesozoic metamorphic formations, principally crystalline limestones, quartzites, and schists are prominent in the eastern part of the county. These have been intruded by porphyry and diorite, and there have been numerous flows of rhyolite, andesite, and basalt. Tertiary sediments were deposited in the Death Valley region, and saline deposits formed from the evaporation of sea waters.

In the higher mountainous sections are found many vein-forming minerals, and in the lake beds of Death Valley saline deposits exist. The mineral resources include andalusite, antimony, asbestos, barytes,

[1] Inyo County, State Mineralogist's Report XXII, pp. 453–530, 1926. Portions of this article were abstracted for use in the present report.

borates, copper, dolomite, gems, gypsum, lead, marble, montmorillonite ('bentonite,' 'shoshonite' and 'amargosite'), soda, sulphur, talc, tungsten, and zinc. The principal products are lead, soda, borates, bentonite, and silver.

Clay Resources.

Extensive beds of Tertiary clay occur along the Amargosa River in the vicinity of Shoshone and Tecopa. These beds vary in thickness from 6 to 20 feet and in different localities are covered with an overburden of volcanic ash and gravel wash.

Fairbanks Clay Deposit. R. J. Fairbanks, owner, Shoshone.. The property is situated one mile southeast of Shoshone, on the west side of the Amargosa River. The holdings comprise 160 acres. Elevation 1600 feet.

The beds of clay trend north and south and are 6 to 8 feet thick, overlain by 4 to 6 feet of volcanic ash. The clay is green in color and quite plastic.

The Pacific Minerals and Chemical Company and Gladding, McBean and Company, of San Francisco and Los Angeles, also own deposits of clay located between Shoshone and Zabriskie.

KERN COUNTY.

General Features.[1]

Kern is the southernmost county in the San Joaquin Valley, and takes in the southern portion of the Sierra Nevada Mountains, includes a portion of the Coast Range in its western end, and to the south and east of the Sierras it encloses a large section of the Mojave Desert. The total area of the county is 8100 square miles. It is the third largest county in the state, and is bounded on the north by Tulare, Kings and Inyo, on the south by Los Angeles and Ventura, on the east by San Bernardino, and on the west by San Luis Obispo. It is characterized by greater variety and contrasts of topography, geology, climate, and resources than any other California county.

The northern part of the county is well provided with water and power for industrial, agricultural and mining purposes. In the southern part of the county, on the Mojave Desert, water is relatively scarce, but power can be secured for all important purposes from the lines of the Southern California Edison Company, now one of the largest power systems in the world. Transportation facilities are provided to important points in the county by the Southern Pacific and Santa Fe railroads, supplemented by a system of state and county highways.

The principal mineral product is petroleum, the production of which maintained for many years the supremacy of Kern County among all counties of California in the value of its mineral output. Kern was surpassed by both Los Angeles and Orange counties in 1923, but by Los Angeles only since then, for which petroleum also is responsible.

Among the commercial mineral products of the county, in addition to petroleum, are natural gas, borates, cement, brick and clay, gold and silver, salt, miscellaneous stone, and antimony. Other minerals that have been discovered or that have been worked in the past are: asphalt,

[1] State Mineralogist's Report XIV, pp. 471–475, 1914.

copper, fuller's earth, gems, gypsum, iron, lead, limestone, magnesite, marble, mineral paint, potash, soapstone, soda, sulphur, and tungsten.

Clay Resources.

The alluvial silt of the San Joaquin Valley, in the vicinity of Bakersfield, has been in use for many years for the manufacture of common brick. As is the case in Fresno County, deposits of plastic common clay are scarce. The local silts have barely enough plasticity to permit the manufacture of a satisfactory grade of common brick by the soft-mud process. Two brick plants are in operation in Bakersfield.

A deposit of high-grade clay at Rosamond, near Mojave, has attracted attention for many years. It is possible that more extensive prospecting in the desert region will disclose other deposits of high-grade clays.

Bakersfield Rock and Gravel Company. A. H. Kaspe and W. J. Walters. It is reported [1] that this company was developing clay lands in 1927, in connection with its sand and gravel business. A conveyor system, storage bins, and loading equipment were to be installed, at a cost of $18,000. Further details are lacking at the time of going to press.

Bakersfield Sandstone Brick Company. James Curran, manager. Office and plant at 501 Sonora Street, Bakersfield. The company owns 40 acres of land.

Common red brick are manufactured from an alluvial silt which is mined to a depth of ten to twelve feet with a clam-shell excavator. The soft-mud process is used. The plant is equipped with a pug-mill and a Martin press. Drying is done on steel trucks, either in the open, or under sheds. As the plant is only operated during the dry season, drying is usually completed in seven days. Firing is done in field kilns, which are started with gas and finished with oil, atomized with steam. Thermo-electric pyrometers are used for recording temperatures. At the fire-holes, the finishing temperature is 2100° F., two feet above the arch it is 1840° F., and two feet below the top it is 1750° F.

The capacity of the plant is 40,000 brick a day, and 14 men are employed during the operating season.

Bibl: State Mineralogist's Rept. XIV, p. 477; and Prel. Rept. No. 7, p. 48.

Kern County Brick Co. Owned by King Lumber Co., Elmer King, president, Bakersfield. This property comprises 12 acres in Sec. 21, T. 29 S., R. 28 E., M. D. M., on the eastern outskirts of Bakersfield. The deposit is a sandy loam 25 feet thick, and has been used for the production of common brick since about 1900. The soft mud process is used, the equipment consisting of a disintegrator, pug-mill, and 6 mold press. Cable haulage is used to transport the brick from the presses to the drying sheds. Firing is done in oil-fired field kilns. The capacity of the plant is 37,000 brick per day, the annual production depending upon local demand. Ten men are employed.

Titus Clay Deposit. H. E. Titus of Rosamond owns two placer claims totaling 40 acres, comprising the NW¼ of the SE¼ of Sec. 11, T. 9 N., R. 13 W., S. B. M., covering a deposit of pottery clay of good

[1] Clay-Worker, May, 1927, p. 486.

quality. The distance by road from Rosamond is 4.8 miles in a direction slightly north of due west. The clay has been developed by an open pit, and by a 200-foot tunnel, now inaccessible.

The clay is enclosed in felsite porphyry, and is apparently a local alteration and decomposition in place, of a phase of this rock. Inclusions of porphyry in various stages of alteration are intermingled with the clay. The deposit has no definite stratification, but appears to lie in a nearly flat bed, overlain by a red-colored porphyry capping.

The known dimensions of the deposit is 300 feet wide, 700 feet long, and 50 feet deep, with unknown possibilities for extension in any of these dimensions. The property was formerly known as the Hamilton deposit. At various times during a period of over 10 years, clay has been mined from an open pit, and shipped to ceramic plants in the Los Angeles district, notably the Los Angeles Pottery Company and the Pacific Sewer Pipe Company both of which are now non-existent under their original names or ownership, and more recently to the Tropico plant of Gladding, McBean & Co. The clay has been used in stoneware and sewer-pipe mixtures, and a commercial test run has been made for terra cotta mixtures. It is likely that the property will eventually be acquired by one of the manufacturing companies, although at present development work has not progressed far enough to permit a prediction as to the probable tonnage and quality that can be expected beyond the known limits of present knowledge. Sample No. 114 was taken from this deposit, and the test results are given on page 312.

W. S. Webb of Rosamond owns a property one mile west of the Titus claims, on what is a supposed extension of the same clay bed. This property was not visited.

Merry Widow Mine. Mrs. Mary Y. Smith of Rosamond is the principal owner of the Merry Widow mine comprising two lode claims in the SW¼ of Sec. 8, T. 9 N., R. 12 W., S. B. M., 2.8 miles by road north of Rosamond, of which 1.6 miles is on the highway to Mojave. This is in the Rosamond gold mining district, now idle, but at one time a small producer of gold from narrow veins in granite porphyry and slate. Two samples were taken from an 800-foot tunnel on the Merry Widow property. One of these, No. 115, is footwall gouge from a drift on a vein encountered at a point 200 feet from the portal of the tunnel. The gouge is over five feet in thickness, and lies at an angle of 45 to 50°, dipping south. About 40 feet of this material, measured along the strike of the vein, is exposed in the drift. The test results, page 349, show that the clay has little value for ceramic purposes, on account of poor plasticity, red color, high shrinkage, fire splitting, and low fusion point.

The other sample, No. 116, was taken of the decomposed rock that occurs near the portal of the tunnel. It is evidently an altered granite porphyry. Test results, page 349, were even less favorable than those obtained on sample No. 115.

KINGS COUNTY.

General Features.

Kings County is in the south-central portion of the state, south of Fresno County. Its area is 1559 square miles, and the population is 22,031 (1920 census). The principal town is Hanford. The western edge of the county is in the foothills of the Coast Range. The rest of the county is in the basin of the San Joaquin Valley.

The mineral resources of the county are practically undeveloped. Deposits of fuller's earth, gypsum, mineral paint, natural gas, and quicksilver have been noted. The commercial production is almost negligible.

Clay Resources.

Common brick clays are reasonably abundant in the vicinity of Hanford and elsewhere in the county. Two former brickyards, the Clinker Brick Company and Trewhitt Brickyard, both near Hanford, were abandoned prior to 1911.

Bibl: State Mineralogist's Rept. XIV, p. 527, 1913–14; State Min. Bur. Bull. 38, p. 243; Prel. Rept. 7, p. 49.

LAKE COUNTY.

General Features.

Lake is one of the counties north of San Francisco Bay. It is bounded on the north by Mendocino and Glenn counties, on the east by Glenn, Colusa and Yolo, on the south by Napa, and on the west by Sonoma and Mendocino. It has an area of 1328 square miles, and its population is 5542 (1920 census).

The outstanding physiographic feature of the county is Clear Lake, which has been a prominent resort area for many years. Clear Lake is surrounded by rolling hills in which are many interesting geological features. The prevailing rocks in the county are the Franciscan (Jurassic) serpentines and slates and Tertiary volcanics. There is a small area of Pliocene, and an area of Quaternary near Clear Lake, besides some undifferentiated Tertiary formations at the southern extremity of Clear Lake.[1]

Mineral production in the past has been comparatively small, and has been largely confined to quicksilver and mineral water. Some of the leading minerals found in this section, in part as yet undeveloped, are borax, clay, copper, gems, gold, gypsum, mineral water, quicksilver, silver, and sulphur.

The entire county is but sparsely settled, and is without rail connections. Besides the production of minerals, the population is engaged in farming, stock raising, and the operation of summer resorts at the numerous mineral springs in the county, and on the shores of Clear Lake.

Clay Resources.

The county was visited by the author in September, 1925, and attempts were made to examine clay occurrences that had been reported previously by the Bureau,[2] in which had been mentioned a line of kaolin deposits near the Mount Sam Quicksilver Mine, and undeveloped deposits at Glenbrook, Kelseyville, Soda Bay, and Sulphur Bank. Inquiry was made among local inhabitants, and a number of localities were visited, but no evidence of these deposits could be discovered. As

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[1] Smith, J. P., The geologic formations of California: Cal. State Min. Bur. Bull. 72, and geologic map.

[2] Bull. 38, p. 361. Rept. IX, p. 303; XIV, 204. Prel. Rept. 7, p. 49.

time was not available for prospecting, the search was abandoned. It is obvious that only a deposit of exceptionally high-grade clay would have commercial value in this region, on account of the cost of transportation to market, and while the possibility that such a deposit may be found can not be entirely eliminated, it is unlikely.

Common brick clay is not abundant in this region, but there is little likelihood that a brick yard will ever be established on account of lack of market. A few samples of common clays were taken from deposits near Kelseyville, but only one of these, No. 188, was tested. This is a clay shale from an undeveloped exposure 1.4 miles southeast of Kelseyville on the Lower Lake road. The test results are on page 336.

LASSEN COUNTY.

General Features.

Lassen County is in the northeast portion of the state, south of Modoc, which is the northeasternmost county. Its area is 4531 square miles, and the population is 8507 (1920 census). It is a succession of mountain ranges and high-altitude plateaus, and is only partly developed. Almost the entire area of the county is covered with Tertiary and Quaternary lavas. In the valleys and around the shores of lakes are Quaternary sediments. Occurrences of copper, gems, gypsum, gold, silver, and sulphur are known. There is a small annual production of gold, silver and miscellaneous stone.

Clay Resources.

The county was not visited in the course of the present investigation. It is obvious that only clays having exceptional unit value could be commercially produced in the region. A deposit of clay is reported on the Anderson Ranch, at Hayden Hill, owned by H. P. Anderson, but details are lacking. Hayden Hill is a gold mining district. It is possible that kaolinization of some of the rhyolite tuffs, especially those high in alumina, that are known to occur in this district, may have resulted in the development of high-grade clays.

In Preliminary Report 7, p. 49 (1920), the following notes are given:

"J. E. Pardee, Susanville. Common brick clay. No recent production.

"A. E. Buehler, Susanville. Formerly operated a clay deposit, but no recent production."

No recent data are available.

LOS ANGELES COUNTY.[1]

General Features.

Los Angeles County is bounded on the north by Kern County, on the east by San Bernardino County, on the south by Orange County, and on the west by Ventura County and the Pacific Ocean.

The ocean shore line extends for about ninety miles. The county comprises 4067 square miles, a large part of which is mountainous. The population, according to the 1920 census, is 936,438.

The chief topographic features of the county are the mountain ranges, the valleys, and the great Los Angeles Plain which stretches

[1] Tucker, W. B., Los Angeles County, State Mineralogist's Report XXIII, p. 287, *et seq.* No data on the ceramic industry are given in this reference, but Mr. Tucker's general description of the county was freely drawn upon.

from the foothills to the sea. The highest peaks of the mountains are in the San Gabriel Range, in the northeastern part of the county, and are over 10,000 feet high. Other ranges in the county are the Santa Susana and Santa Monica. The San Gabriel Range is chiefly formed of crystalline rocks, with its central axis consisting of granite, with gneisses and schists on its flanks. The Santa Susana and Santa Monica ranges are chiefly formed of Tertiary sedimentary rocks.

There is only a small production of metals in Los Angeles County, its principal mineral wealth being in structural and industrial materials, petroleum, and natural gas. Since 1923, Los Angeles County has led all other counties of the state in the value of its mineral production, largely due to its petroleum production.

Among its mineral resources may be noted asphalt, barytes, borax, brick, clay, copper, diatomite, fuller's earth, gems, gold, gypsum, lead, limestone, marble, mineral paint, mineral water, natural gas, petroleum, glass sand, sandstone, serpentine, silver, soapstone, miscellaneous stone, and zinc.

Clay Resources.

Los Angeles county is especially fortunate in that there is an ample supply of common clay and shale for the manufacture of heavy structural ware, such as common brick, hollow tile, roofing tile, sewer pipe, etc. Close to the metropolitan area of the city of Los Angeles are numerous deposits of shale and loam that have been in use for many years for the manufacture of these products. Property values have increased to such an extent in recent years that many of these deposits have been sold for business or industrial purposes, but there are still a number of plants in operation within a radius of one mile from the business center of the city. In the outskirts of the city, on almost every side, within a radius of 20 miles from the downtown section, are numerous clay and shale deposits that are being utilized by the ceramic industry. Perhaps the most important of these deposits is in Santa Monica, where a number of brick yards have been established, and from which clay is mined for use in other plants of the county. The Santa Monica clay is not only suitable for the manufacture of common brick, but is extensively used in hollow tile, roofing tile, sewer pipe, electric conduit, face brick, and other structural ware bodies.

No high-grade clays are produced in the county. It is claimed that high-grade clays occur on the Malibu Ranch, north of Santa Monica (see under Malibu Pottery), but these have not been extensively prospected, and at this writing little information was available as to the extent and character of these clays.

On account of extremely favorable industrial conditions in the Los Angeles district, with a combination of cheap power, fuel and labor, adequate spur track facilities, equable climate, and an extensive market arising from the rapid growth of the region, there are a large number of ceramic plants in the county, and practically every commercial type of ceramic ware is being manufactured in one or more plants. The high-grade clays needed by the industry are largely obtained from the Alberhill-Corona deposits in Riverside County and from deposits in Orange and San Diego counties. The freight rate on clays from the Alberhill district is about $0.90 per ton, in carload lots, and the costs of mining are relatively low, so that most grades of clay from Alberhill can be delivered in Los Angeles at a cost of $2 to $6 per ton. Some Lincoln and Ione clays, from Placer and Amador counties, respectively, are shipped into Los Angeles for use in the manufacture of terra cotta, floor tile, stoneware, and pottery. English china and ball clay, and clays from Florida and Kentucky are also imported for the manufacture of whiteware and tile, at a cost of $14 to $25 per ton, delivered. Southern California abounds in deposits of feldspar and silica, especially in San Diego and Riverside counties, so that these materials may be secured by the local industry at comparatively moderate cost.

Descriptions of individual clay deposits and ceramic plants follow. The field work was done during the summers of 1925 and 1926, and the industry has been growing and changing rapidly, so that it is obviously impossible to present the latest information on all plants. Attempts were made by correspondence to bring all material up to date as of November, 1927, but in many cases no replies had been received at this writing. Mr. Tucker, of the Mining Division, rendered valuable service in obtaining data on a number of plants in November and December, 1927.

Acme Brick Company.[1] Thos. Kelley, president; R. L. Worthington, secretary. Office and plant in Santa Monica. The company owns 20 acres of land and manufactures common brick only. The deposit consists of 20 to 30 feet of red and yellow clay, overlain by two feet of soil. The clay is mined in an open pit by a gasoline shovel, which loads into 3-ton side dump cars. The cars are hoisted up an incline to a hopper at the plant.

The soft-mud process is used. The clay is ground in a dry pan, elevated by a bucket elevator to a ¼-inch impact screen, pugged in two pug-mills in series, and finally passes to the brick press, which has a capacity of 60,000 brick per day. The oversize from the screen is returned to the dry pan for regrinding.

Conveyors are used to transport the brick to and from the drier, which is heated by steam from two 150-h.p. oil-fired boilers. Drying is completed in from 24 to 36 hours.

Six oil-fired field kilns are in use, having a capacity of 600,000 brick each.

The plant operates throughout the year. Forty men are employed, and 135 h.p. of electric power are installed.

Alhambra Kilns, Inc. E. H. Ockerman, Alhambra. The company now operates two plants, one at Alhambra and the other at Santa Monica. The site of the Alhambra plant was visited by the author shortly after construction was started, in September, 1926. A request for recent information was addressed to the company on November 11, 1927, but no reply had been received at this writing. It is known that hand-made roofing tile and patio floor tile are being made.

American China Company. W. N. Reeves, owner, 2304 East Fifty-second Street, Los Angeles. This company specializes in single-burn, glazed tile, ready-set for soda fountains, fire places, etc. A portion of the tile used is made at the plant from Alberhill clays, principally E–101 and SH–4 (samples No. 11, p. 257, and 273, p. 273), and also

[1] Data supplied by W. B. Tucker, district mining engineer, December, 1927.

some clay from the Emsco pit near Corona. The balance of the tile is purchased from the California Clay Products Company.

The ware is burned for 24 hours in a gas-fired kiln having a capacity of 400 square feet of tile. The output of the plant varies with the demand up to 75,000 sq. ft. per year.

American Encaustic Tiling Co., Ltd. Frank A. Philo, general manager, Crawford Massey and Mr. Schreiber, ceramists. Los Angeles plant at 2030 East Fifty-second Street; Hermosa Beach plant at 700 Fifteenth Street. The Los Angeles plant was built by the West Coast Tile Company and purchased in 1919 by the American Encaustic Tiling Co., Ltd., a nationally known manufacturer of ceramic floor, wall, and decorative faience tile, with plants at Zanesville, Ohio, and Maurer, N. J., and with head offices at 16 East Forty-first Street, New York City. The Hermosa Beach plant was purchased by the company from the Prouty-line Products Company in 1925.

The company markets a complete line of vitrified and semi-vitrified glazed and unglazed floor, wall, and decorative faience tile. Both the Los Angeles and Hermosa Beach plants manufacture a large variety of colors in glazed, unglazed, and decorative tiles.

With such a diversity of products, it is natural that the raw materials in use at the plant cover a wide range. It has been found that in order to minimize plant difficulties, and to secure a uniformly high-grade product, it is necessary to use a good quality of English china clay, Florida kaolin, English and Kentucky ball clays, in practically all of the white or nearly-white burning mixtures, rather than to attempt to rely upon California materials. However, some of the clays used at the Los Angeles plant, and all of the clays used at the Hermosa Beach plant, are obtained in the State of California. Quartz and feldspar are obtained mainly from the large deposits owned by the company in Riverside County. The company also owns a deposit of 'Cornish Stone' (Sample No. 58), at Dehesa, San Diego County, which is used as an ingredient of a hard, white, vitrified tile, known under the trade name of "Kaospar."

The Los Angeles plant covers about 3½ acres and the Hermosa Beach plant about 2½ acres. Both plants are completely equipped, well arranged, and efficiently operated. At the Los Angeles plant all of the materials entering the plant are ground in mills suited to each material, and particular care is exercised to avoid contamination with iron. This necessitates the use of wood or porcelain liners in the pebble mills for grinding to pass 140-mesh screen. Imported Danish flint pebbles are used as local pebbles have proved to be lacking in hardness. After grinding, the mixtures are prepared by adding the proper amount of each material to double blungers. The 'pulp' is then treated in filter presses, dried in gas-heated dryers to about 10% moisture, broken through 20-mesh screen, tempered with sufficient moisture to insure the proper consistency for dry pressing, and stored in bins until ready for use.

Most of the tiles are formed by dry pressing, using either power-driven or hand-operated presses, depending upon the quantity of each size and color required as well as the shape of the tile.

At the Los Angeles plant the bodies are fired in 12 gas-heated beehive kilns, approximately 20 feet in diameter by 12 feet high. The firing schedule requires four to five days heating, and three to four days cooling, the maximum temperature corresponding to cone 11 (1285° C.). Upon the completion of this firing, the tiles that are to be glazed are transferred by truck to the glazing room which is in a separate building a short distance from the biscuit kilns. After applying the glaze mixture, the tiles are re-fired in a Harrop tunnel kiln which is approximately 250 feet long, 8 feet wide, and 8 feet high. The glost cycle occupies about 54 hours, reaching a maximum temperature corresponding to cone 01 (1110° C.). At the Hermosa Beach plant both the biscuit ware and the glazed ware are fired in five specially-designed tunnel kilns, the firing temperature being about the same as that used at the Los Angeles plant.

All temperatures are controlled by the use of a pyrometer, either of the intermittent or continuous recording type.

Each plant is equipped with a machine shop for making all ordinary repairs, and for making the dies used in the presses. A complete experimental laboratory, equipped with ball mill, mixing pans, blunger, filter press, etc., in charge of an experienced ceramic engineer, is maintained at each plant for the purpose of studying bodies and glazes, and to aid in the solution of operating difficulties.

Both plants together employ approximately 600 persons.

All tiles sold by the American Encaustic Tiling Co., Ltd., are made by them in their own plants in the United States of America.

Bibl: State Min. Bur. Prel. Rept. No. 7, p. 62 (West Coast Tile Co.).

American Refractories Company. F. E. Keeler, president; Earl McClintock, vice president; G. Ray Boggs, general manager and secretary-treasurer. Office and plant at 3232 Alosta Street, Los Angeles.

This company is engaged in the manufacture of fire brick for flue linings, kilns and boiler settings, and silica glass-tank blocks. One of the specialties is the manufacture of radiant stove backs.

The company controls the Hunter Ranch clay deposit in Orange County (samples 63 and 64), and purchases other clays from the Alberhill district.

The clays as received at the plant are stock piled, from which they are fed by wheelbarrows in the proportions desired for the various mixes to an 8-ft. dry pan. The dry pan product is elevated to a screen, which delivers oversize to the dry pan for regrinding, and undersize to a double-shaft and a single-shaft pug-mill in series. From the pug-mills, the plastic mix is fed to an American auger machine. All machine-made brick are repressed in a Raymond press. Some grades of brick, particularly the 'Arc' brand, are made by hand molding, and all special shapes and glass-tank blocks are hand molded.

After shaping, the ware is transferred on hand trucks to a waste-heat drying floor. Drying usually requires about three days.

The radiant stove backs are made by dry pressing, and are fired in two down-draft rectangular kilns, 7-ft. by 9-ft. and 6-ft. by 8-ft. in size. Brick and other shapes are fired in four 28-ft. round down-draft kilns. Natural gas is used for all firing. The round kilns are fired to cone 13 (1350° C.) in ten days and are cooled by the aid of exhaust fans in six days. Allowing five days for drawing and setting, the complete cycle requires 21 days.

The capacity of the plant is 15,000 standard 9-in. brick a day, or its equivalent in other ware. Twenty-five men are employed.

Angulo Tile Company. Plant No. 2; R. F. Angulo and Sons, owners. This company has two plants engaged in the manufacture of hand-made Mission roof and terrace tile. Plant No. 2 is at Reseda, Los Angeles County, and Plant No. 1 is in Santa Barbara (see under Santa Barbara County). The Reseda plant is the larger operation. Clay is obtained from a surface deposit adjoining the plant. A tile machine has recently (November, 1927) been added to the equipment. The company has a U. S. patent on a special method of making hand-made roofing tile. The plant is equipped with three kilns, fired with gas and oil.

Atlas Fire Brick Company. M. I. Power, president; C. J. Walters, vice president; Stuart Findley, secretary; Clifford Tillotson, manager. Office and plant at Boyle and Slauson avenues, Los Angeles.

This company specializes in the manufacture of silica brick and high-grade fireclay brick. In addition to standard straight fire brick and silica-brick shapes, the company is prepared to make all key and arch shapes, glass-tank blocks, and special shapes.

The raw materials in use include the Emsco white plastic fireclay (sample No. 70, p. 272) from Riverside County, German fireclay (sample No. 56, p. 297) and ganister from the company's deposit near Hicks, San Bernardino County. From 6000 to 12,000 tons of clay and 3000 to 4000 tons of ganister are used each year.

The mixtures are prepared by dry-pan grinding, followed by pugging. All clay brick mixtures are repugged, and then aged in a moist room for a period approximating two weeks. The silica brick are all hand molded. Special care must be taken with the large glass-tank blocks, to ensure thorough tamping during molding. Fire brick are made by either the dry press or wet process, the latter being by hand molding, followed by repressing.

All shapes are air dried, then fired in gas-fired round down-draft kilns. Fire brick are fired to cone 12 (1310° C.) and to cone 14 (1390° C.); glass-tank refractories to cone 12; and silica brick up to cone 18 (1485° C.). Seven kilns are in operation, and 40 men are employed.

Batchelder-Wilson Co. E. A. Batchelder and L. H. Wilson, owners. Office and plant at 2633 Artesian Street, Los Angeles. This company, formerly known as the Batchelder Tile Company, specializes in decorative tile for homes, and their artistic products have become well-known throughout the region west of the Rocky Mountains. The principal products are facing and paving tile for interior decorating. Some architectural terra cotta is produced for entrance ways and interiors.

The clays used are Hill blue (sample No. 9, p. 287), extra select main tunnel (sample No. 18, p. 321) and some pink mottled (sample No. 7, p. 328), supplied by the Alberhill Coal and Clay Company in Riverside County; Lincoln No. 1–6 (sample No. 146, p. 303), from the Lincoln Clay Products Company in Placer County; Bacon red (sample No. 127, p. 335), and Harvey (sample No. 133, p. 298), from Ione, Amador County, and a small quantity of Santa Monica clay (represented by sample No. 61, p. 341). Some bentonite from a deposit near Amboy, San Bernardino County, is used in the underglazing slip.

Six standard mixtures are used, grading in fired-body color from red to cream. The mixtures are prepared by jaw crushing, roller-mill grinding, and final pug-mill mixing and tempering. The batches are seasoned in moist rooms before pressing, a period of at least two weeks being preferred.

All of the products are hand moulded in plaster molds, which are made in the plant. The drying is in air, followed by automatic drying ovens. The total drying time is about 48 hours. After drying, an underglaze slip is sprayed on, followed by the color decorations, which are painted by hand.

The kiln equipment includes two 7 x 12 foot rectangular kilns, two 20-foot round down-draft kilns, and one 200-foot tunnel kiln, all gas fired. A great variety of colors from the same body and glaze is produced by varying the temperature and atmospheric conditions during firing. Pyrometers and cones are used on all kilns for controlling temperatures.

After firing, some of the tile are buffed on emery wheels to remove a part of the glaze. This is followed by several sprays of raw linseed oil, thus producing a pleasing mottled effect.

Monorail transportation is used throughout the plant.

A small testing laboratory, in charge of a ceramic graduate, is maintained.

J. A. Bauer Pottery Co. W. E. Bachman, president, 415 West Avenue Thirty-three, Los Angeles. This is a four-kiln pottery making a complete line of red flower pots, white stoneware, yellow bowls, crocks, vases, and ollas. Santa Monica clay (sample No. 61, p. 341) is used for flower pots and ollas, while Alberhill and Lincoln clays are used for the light-colored, vitrified stoneware bodies. Approximately 4000 tons of clay are consumed per year.

The clays are spray-washed to remove surface contamination, then pugged. Flower pots and some of the other ware are machine molded. For other products turning ('jiggering') or hand moulding are used. All of the smaller ware is dried in 24 hours, natural gas auxiliary heating being used in the drying room. White, yellow or cream glazes, where used, are applied by dipping before firing. A single firing matures both the body and the glaze.

The four kilns are of the round down-draft type, fired with gas, but equipped to burn oil if necessary or desirable. The red ware is burned to a temperature of 1850° F. in three to four days, and the cream body ware is fired to 2250° F. in about the same time. One of the kilns is ordinarily operating on the light colored body, and is equipped with pyrometric control.

At present this is the only plant in Los Angeles manufacturing flower pots. Not over half of the company's business is in flower pots, but this constitutes the largest single item. In order to permit the full time operation of the plant on a systematized plan, a stock of ware aggregating over $100,000 in value is constantly kept on hand.

Fifty men are employed.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 50.

California Brick and Tile Company.[1] (Formerly the Owens Brick

[1] Data supplied by W. B. Tucker, district mining engineer, December, 1927.

Company.) K. A. Miller, president; H. W. Broughton, secretary. Office and plant at 6159 Kester Street, Van Nuys. The company owns 20 acres of land, and manufactures common brick only.

The deposit consists of red and yellow clay, 20 to 30 feet thick, underlying an overburden of soil from one to two feet thick. The clay is excavated from an open pit by a gasoline shovel, which loads into 3-ton cars. A gasoline motor hauls the cars from the pit and delivers the clay to two hoppers at the plant.

From the hoppers the clay is delivered by two parallel belt conveyors to two dry pans. The product from the pans is elevated by two bucket elevators to two wire screens, which deliver the undersize to a central hopper, and return the oversize to the dry pans. From the hoppers, the clay is fed to a pug-mill, then to an auger machine, equipped with a wire cutter.

From the take-off belt following the wire cutter, the brick are loaded on drier cars. A 16-track tunnel drier is used, which is 120 feet long, 60 feet wide, and 6 feet high, and has a capacity of 75,000 brick per 60 hours. Two Hadfield-Penfield blowers, driven by a 50-h.p. motor, circulate heated air from an oil-fired furnace to the drier.

Six natural-gas-fired field kilns are in use, having a capacity of 750,-000 to 1,000,000 brick each.

Machinery in the plant is driven by a 160-h.p. Western gas engine. The plant operates throughout the year, and 40 men are employed.

California Clay Products Co. Victor Kremer, president. "Victor Kremer Enterprises, Inc.," 315 West Mutual Life Building, 321 West Third Street, Los Angeles. The plant is in South Gate. This factory manufactures an extensive line of glazed wall tile and ceramic floor tile. English china and ball clays are used in the white-burning bodies, but Lincoln clay (sample No. 146, p. 303) from Placer County and Cardiff fire clay (sample No. 36, p. 311) from the company's property in San Diego county are used in the cream, buff and darker-colored bodies.

The finer clays to be used in the manufacture of white bodies and other high grade ware, are prepared by blunging and filter pressing the ground material. Plastic clay mixtures are prepared in pug mills, and are well seasoned before use.

Dry-pressed floor and wall tile are made in hand-operated presses. Floor and wall tile with an undulating surface are produced by hand pressing of pugged clay in plaster molds. The latter are highly prized by architects to secure certain artistic effects, as the undulating surface gives the impression of wear resulting from long use.

Drying is done with hot air, produced by waste heat. The drying time varies from 24 to 36 hours depending upon the size of tile.

Monochrome glazes are applied by hand dipping in the glaze slip. Polychrome work is done with a glaze bulb. Some brush work is done in special cases.

All of the glazed tile are given a double firing. There are three biscuit kilns with a firing cycle of 72 to 90 hours to attain a maximum temperature of 2400° F. Three glost kilns are in use, with a firing cycle of 36 hours to 1800° F. The apparent discrepancy in the capacities of the biscuit and glost kilns is explained by noting that the tile are packed in sand in the biscuit kiln saggers, but must be supported on pins in the glost saggers, hence requiring more space per unit of tile area in the latter case.

Much of the work in the factory, such as applying glazes, removing loose dust from tile after dry pressing, packing and unpacking of saggers, etc., is of such a nature that women employees are used, men being employed only for the heavier duties, such as operating the presses, trucking, kiln setting or drawing, and firing.

City Brick Co. The plant is at 1900 West Manchester Avenue, (Eighty-sixth Street) and Western Street. This company makes common red brick only. The clay in use is a surface deposit of loose sandy loam, with just sufficient bonding power to permit the manufacture of a satisfactory building brick by the soft-mud process. The clay is mined in a shallow pit by horse scrapers, which deliver the material to an incline tram which dumps into a hopper feeding a disintegrator and pug mill, followed by a 6-brick press. The brick are carried to the drying sheds by rope conveyors. The dried brick are fired in gas-fired open kilns. Handling losses are apparently higher than in most plants, on account of the low strength of the brick in the plastic and dry state.

Claycraft Potteries, Inc. Gus Larsen, president; F. H. Roberts, vice president; W. C. Reordan, treasurer; Henry Prussing, secretary. Office and plant at 3101 South Fernando Road, Los Angeles. This company manufactures faience art tile, using an Alberhill clay body that matures at cone 5 (1180° C.) and applying glazes that mature at cone 4 (1050° C.).

The plant is equipped with two 8-ft. wet pans, two tile augers, a sagger press and three tile presses, one of which is power-driven and has a capacity of 900 tile per hour. All fancy pieces are hand-molded in plaster molds.

The ware is dried in three 6-ft. by 7-ft. by 25-ft. tunnel driers. The biscuit firing is done in three 220-ft. round down-draft kilns, gas fired. Three muffle kilns are used for the glost firing.

Twenty-five men are employed.

H. F. Coors Co., Inc., H. F. Coors, manager. P. O. Box 517, Inglewood. This plant is at 419 South Judah Street, Inglewood. It was established in December, 1925, for the manufacture of porcelain plumbing accessories and electrical specialties.

English china clay and Coors ball clay (sample No. 57, p. 264), Campo or Kingman feldspar, and various grades of silica are used in the body mixture, which is prepared by ball-mill grinding.

Some of the ware is dry-pressed, and some is cast. A hot-air drier is used. An 8-foot gas-fired round down-draft kiln is used for both the biscuit and the glost firing. A small muffle kiln is used for decorating, which consists principally of labeling faucet handles.

Davidson Brick Co. Nathan Davidson, owner, 5301 Chicago Avenue, Los Angeles. This is a well-equipped and well-arranged plant for manufacturing common red brick. The clay varies from an adobe to a soft clay shale. Mining operations have exposed a bank 60 to 70 feet high, and 300 feet long. The pit extends into a gently-sloping hillside above the plant. An electric shovel is used for mining and loading into dump cars, which are hauled to the plant by a gasoline locomotive.

Brick are made by the stiff-mud, side-cut process. A rope conveyor is used to deliver the brick to the drying sheds. Oil fired field kilns are used.

A sample (No. 60) of the more shaly variety of clay was taken as representative of the class of material to be expected in this district. The tests (p. 340) indicate that the drying and firing properties of the clay are not greatly different from those of the Santa Monica clay (sample No. 61, p. 341), which is widely used in Los Angeles County as an ingredient of sewer pipe, conduit, flower pot, and olla mixtures.

Empire China Company. Office and plant at Burbank. Mr. Morgan, superintendent. This is a well-equipped plant, containing seven round down-draft kilns that operated for a number of years for the manufacture of semi-porcelain hotel and dinner china. Experiments have been in progress for a number of months on the manufacture of vitreous dinnerware, and the management expects to start production of this ware during the spring of 1928, using a California feldspar and silica, Nevada china clay, and a certain amount of Florida clay.[1]

Emsco Refractories Company. E. M. Smith, president. Office and plant in Southgate, at Manchester Avenue and Atlantic Boulevard. This company was established in 1927, and was not visited by the author, such data as are included here having been supplied by the company. The company manufactures fire brick, silica brick and glass-tank refractories. The clays are obtained from El Toro, Orange County. (Hunter Ranch ?, see samples No. 63, 64 and 268, p. 260), and from the Emsco pit in the Alberhill district, Riverside County. Eight gas-fired kilns are in use.

Gladding, McBean and Company. Southern Division. Atholl McBean, president; Fred B. Ortman, vice president. Los Angeles office at 621 South Hope Street. In 1926 this company merged with the Los Angeles Pressed Brick Company. The Southern Division of the company includes the following plants: the Alberhill (see under Riverside County), Santa Monica and Los Angeles plants, all formerly owned by the Los Angeles Pressed Brick Company; and the Tropico plant. The company also owns the Goat Ranch clay deposit in Orange County (see under Orange County).

LOS ANGELES PLANT. 952 Date Street, Los Angeles. This is the largest of the plants formerly owned by the Los Angeles Pressed Brick Company, and has perhaps the greatest manufacturing resources of the southern California plants of Gladding, McBean and Company. The products made at this plant are terra cotta, face brick, 'quarry' tile, and roofing tile. The plant is in the heart of the Los Angeles commercial district and all clay must be shipped in.

The terra cotta mixtures are the same as those in use at the Tropico plant, described below, and are prepared in the same manner by dry pans and pug-mills, followed by a variable period of seasoning in waste-heat humidifiers.

The face brick mixtures consist of varying proportions of Santa Monica red-burning clay and a number of varieties of Alberhill clay. The face brick production of this plant is the second largest in the

[1] G. Ray Boggs, private communication, December 8, 1927.

Gladding, McBean organization. A wide range of colors and textures are produced.

Quarry tile are hand made from mixes similar to those used for face brick, and are produced in a wide range of red colors. The product is known as 'Palacio' tile.

Practically all of the roofing tile produced by the Southern division and approximately 60% of that manufactured by all of the company's plants is made at the Los Angeles plant. Both machine and hand made tile are produced. The laboratory is constantly experimenting on new glazes and body mixes, and many distinctive effects have been produced.

The plant is well equipped. Practically all labor is performed mechanically and all moving of material is done by motor. There are 25 kilns, divided as follows: thirteen round down-draft kilns, four terra cotta muffle kilns, and eight rectangular mufflle kilns for enamel work.

Santa Monica Plant: Colorado Avenue and Twenty-fifth Street, Santa Monica. Formerly owned by the Los Angeles Pressed Brick Company. The products are roofing tile, hollow tile, flue lining, chimney pipe, quarry tile, and brick.

Most of the clay used is mined at the plant, which also supplies a large quantity of clay for the Los Angeles plant. The property includes 45 acres of clay land. The deposit is similar to that in use by other manufacturers in this area, including the Western Brick Co., the Simons Brick Co., and the Santa Monica Brick Co. On the Gladding, McBean property the clay is from 10 to 36 feet thick, dipping northwestward, and increasing in depth in that direction, presumably underlain by gravel. Sample No. 61 was taken from the stock pile in the plant, and is an index of the type of material mined by this company and others in the district. The test results are on page 341.

All products are made by the stiff-mud process, on auger machines. The quarry tile, known as 'Promenade' tile, is made in a wide variety of red tones, with here and there a purplish to greenish hue.

Twelve round down-draft kilns are operated.

Bibl: Bull. 38, p. 214 (L. A. P. B. Co.), and p. 217 (Western Art Tile Works (now the Tropico plant). Prel. Rept. 7, pp. 53–56 (Los Angeles Pressed Brick Co.), and pp. 56–57 (Pacific Minerals and Chemical Co., now the Tropico plant).

Tropico Plant: Located in Glendale. This plant was started in 1902 as the *Pacific Art Tile Company*, the first factory of its kind west of the Rocky Mountains. After several reorganizations, the plant was eventually acquired by Gladding, McBean & Company and in 1922 the name was changed to its present form. The principal products of the plant are sewer pipe, flue lining, architectural terra cotta, and faience tile.

Sewer Pipe: The sewer pipe mixture contains red-burning common clay from Santa Monica (sample No. 61, p. 341), Emsco red (sample No. 72, p. 328), and one or more other clays from various sources. The clay is prepared by dry pan and pug-mill, shaped in power-driven (steam) presses, dried on slatted floors, and fired in down-draft beehive kilns, fired with gas up to 1100-1300° F., and finished to cone 03, 1980° F., with oil. The smaller pipe is set two lengths high, and requires a firing schedule of 88 to 100 hours. The larger pipe is set three high, and requires a 120-hour firing schedule. The total kiln turnover is 10 to 11 days. Thirty-two kilns are in use for sewer pipe and flue lining, each with a capacity of approximately 40 tons.

Flue Lining: The principal ingredient of the flue lining mixture is the white Emsco clay (sample No. 70, p. 272).

Terra Cotta: The architectural terra cotta output of this plant is not large at present, at least not of the order of magnitude of the output at the Lincoln, Placer County, plant of the company. Essentially the same terra cotta mixtures are used at Tropico as at Lincoln, the Lincoln clay (sample No. 157, p. 304) being shipped to Tropico for the purpose. The terra cotta mixture is prepared by dry pans and pug mills, followed by seasoning in humidified rooms for at least 24 hours before pressing. Six kilns are in use for terra cotta, firing to cone 3 to 5.

Tile: The faience tile is made by dry pressing a buff-burning body similar to the terra cotta mixture, biscuited at cone 4, and glost at cone 05 and 06. The body is mixed and ground in dry pans, and shaped in screw presses, formerly operated by hand, but now entirely supplanted by power driven presses. At the time of visit, July, 1925, 5 bee-hive kilns were in use for tile. The biscuit kilns were operated on the same schedule as the terra cotta kilns, requiring 100–110 hours firing, while the glost kilns operated on a 20-hour firing schedule. The glost kilns use oil exclusively. A small tunnel kiln for tile has since been installed in order to secure more uniform results, and to decrease the time cycle.

Miscellany: This plant is continually progressing, and various improvements and economies are being added from time to time. Mechanical handling of materials is in use wherever it is economic. The present system of handling the ware is on hand trucks, running on tracks, in the shaping and glazing departments. A gasoline tractor is used for kiln-yard haulage. Recording pyrometers with base metal couples are used for temperature control of the kilns.

A laboratory is maintained to aid in the development of terra cotta glazes and bodies.

Bibl: Cal. State Min. Bur. Bull. No. 38, p. 217 (Western Art Tile Works); Prel. Rept. No. 7, p. 56 (Pacific Minerals and Chemical Co.).

Globe Tile and Porcelain Works. P. C. Boving (formerly of the Pomona Tile Company), president and general manager. This plant was established in 1927 for the manufacture of ceramic floor tile. The plant has 15,000 square feet of floor space, and the capacity is 3000 square feet of tile per day.[1]

H & H Tile Company. Ord Hagerman and V. K. Halieman. Represented by C. P. Johnson, Arcade Building, Los Angeles. This company was organized in 1927 with a capitalization of $30,000, to produce ceramic tile.[2] Further details are lacking at this writing.

Italian Terra Cotta Co. W. H. Robinson, owner. Office and plant at 1149 Mission Road, Los Angeles. This is claimed to be the only plant on the Pacific Coast exclusively engaged in the manufacture of sculptured terra cotta garden pieces.

[1] Clay-Worker, November, 1926, p. 390.
[2] Clay-Worker, August, 1927, p. 123.

The bodies are made from Alberhill pink mottled (sample No. 7, p. 328) and hill blue (sample No. 9, p. 287), and some Santa Monica clay (sample No. 61, p. 341), which produce a red body when fired. A slip glaze, light brown in color, is used on some pieces. The clays are prepared by dry-pan grinding followed by a pug-mill. After sufficient seasoning, the pieces are shaped by hand pressing in plaster molds and air dried before firing. A gas-fired round down-draft kiln is used for firing, the heating schedule ranging from 68 to 72 hours.

Many of the models are imported from Spain and Italy. The market for the products is not confined to the Los Angeles district, as the artistic value of the ware has often impressed visitors from other sections of the United States, and many pieces have been shipped to the eastern and middle western states.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 51.

K. & M. Pottery. M. C. Myers, president. Office and plant at 2318 East Fifty-second Street, Los Angeles..

This pottery makes stoneware from Alberhill clays, using the E–101, and the hill blue (sample No. 11, p. 257, and 9, p. 287) varieties. Ollas are also made from the pink-mottled clay from Alberhill (sample No. 7, p. 328).

The stoneware is made by turning and the glaze is applied to the dried ware before firing.

The plant is equipped with three round down-draft gas-fired kilns, 25 feet, 22 feet, and 15 feet in diameter, respectively. The annual wholesale value of the product is nearly $60,000.

Bibl: Cal State Min. Bur. Prel. Rept. No. 7, p. 51.

K and K Brick Company.[1] O. J. Cubach, president; H. D. Simons, secretary. Office, 801 Merchants National Bank Building, Los Angeles. This company owns a 38-acre property in Bishop Canyon, Los Angeles, and manufactures common brick.

The deposit consists of blue and gray plastic shale, 10 to 20 feet thick, underlying from two to five feet of adobe soil and gravel. The clay is mined by hand methods in an open cut, and is transported to the plant in small cars.

The stiff-mud process is used. The plant is equipped with a dry pan, screens, pug-mill, and a Raymond auger machine, with a wire cutter.

The brick are dried in open drying sheds, and are fired in six open field kilns. Both natural gas and oil are used as fuel.

The plant operates throughout the year and 35 men are employed. Power is supplied by a 250-h.p. boiler. The rated capacity of the plant is 75,000 brick per day.

Bibl: State Min. Bur. Prel. Rept. 7, p. 51.

La Cal Tile Company. Val Alden and Kittridge streets, Van Nuys. A recent report[2] states that this company was building a plant on the above site, at a cost of $70,000. Further details are lacking at this writing.

Linderman & Decker Company.[1] Address, Lomita. This is a firm

[1] Data supplied by W. B. Tucker, district mining engineer, November, 1927.
[2] Clay-Worker, March, 1926, p. 207.

of general contractors who own a 10-acre property at Harbor City that is now under lease to Mexicans, who are manufacturing hand-made roofing tile.

The deposit consists of 10 to 15 feet of red clay, overlain by one to to two feet of gravel. Hand methods of mining are used, and the clay is delivered to the tile plant by a horse-drawn dump-cart. The clay is prepared and the tile shaped by hand. Drying is done in the open air. A round gas-fired kiln is used for firing.

Long Beach Brick Company.[1] H. A. Havner, president; H. C. Armstrong, secretary. Office at 154 Elm Street, Long Beach. The company owns a 10-acre property at Harbor City, and manufactures common brick.

The deposit consists of red clay, 10 to 20 feet thick, covered by a maximum of two feet of gravel. The clay is mined by scrapers, and is transported to the plant by belt conveyors and Ford trucks.

The equipment includes a dry pan, elevators, screens, American auger machine, and wire cutter. Drying is done in open-air drying sheds. Rope conveyors are used to transport the brick to and from the drying yard.

Six open field kilns, fired with natural gas, are used. The plant usually operated during ten months of the year, employing 25 men. Electric power is used, the installed capacity being 200 h.p. The rated capacity of the plant is 45,000 brick per 8-hr. day.

Bibl: Cal. State Min. Bur. Prel. Rept. 7, p. 51.

Los Angeles Brick Co. A. A. Conger, president; E. W. Murphy, vice president; Henry Prussing, secretary; Gustav Larsen, director in charge of operations; W. C. Reordan, director in charge of sales. Home office, 1078 Mission Road, Los Angeles.

This company owns and operates three common-brick and hollow-tile yards in the Los Angeles district, and has recently built a plant at Alberhill to manufacture tile, fire brick, and other products (see under Riverside County, p. 174) from clays mined on their own properties, acquired through the purchase of the holdings of the California Clay Manufacturing Company.

The Los Angeles brick yards are the Mission Road plant, at the corner of Mission and Marengo streets, near the County Hospital; the Chavez Cañon plant, in Chavez Cañon, west of Adobe street; and the Seventh Street plant, at East Seventh Street, on the corner of Utah Street.

Mission Road Yard: This property comprises 15 acres. The clay is a surface material from 25 to 30 feet thick, underlain by five or six feet of sand. Common brick only are made at this plant, using the soft-mud, sand-mold process. The brick are air-dried, then fired in open field kilns, using gas as fuel. The average daily capacity of the yard is 80,000 brick. A Hoffman continuous kiln, fired with coal screenings was formerly in use, but has been dismantled. Rope conveyors are used to deliver the brick pallets from the presses to the drying yard.

Chavez Cañon Yard: This is a 26-acre property. The clay is a thin-bedded Puente (Lower Miocene) shale, forming a bank over 100

[1] Data supplied by W. B. Tucker, district mining engineer, November, 1927.

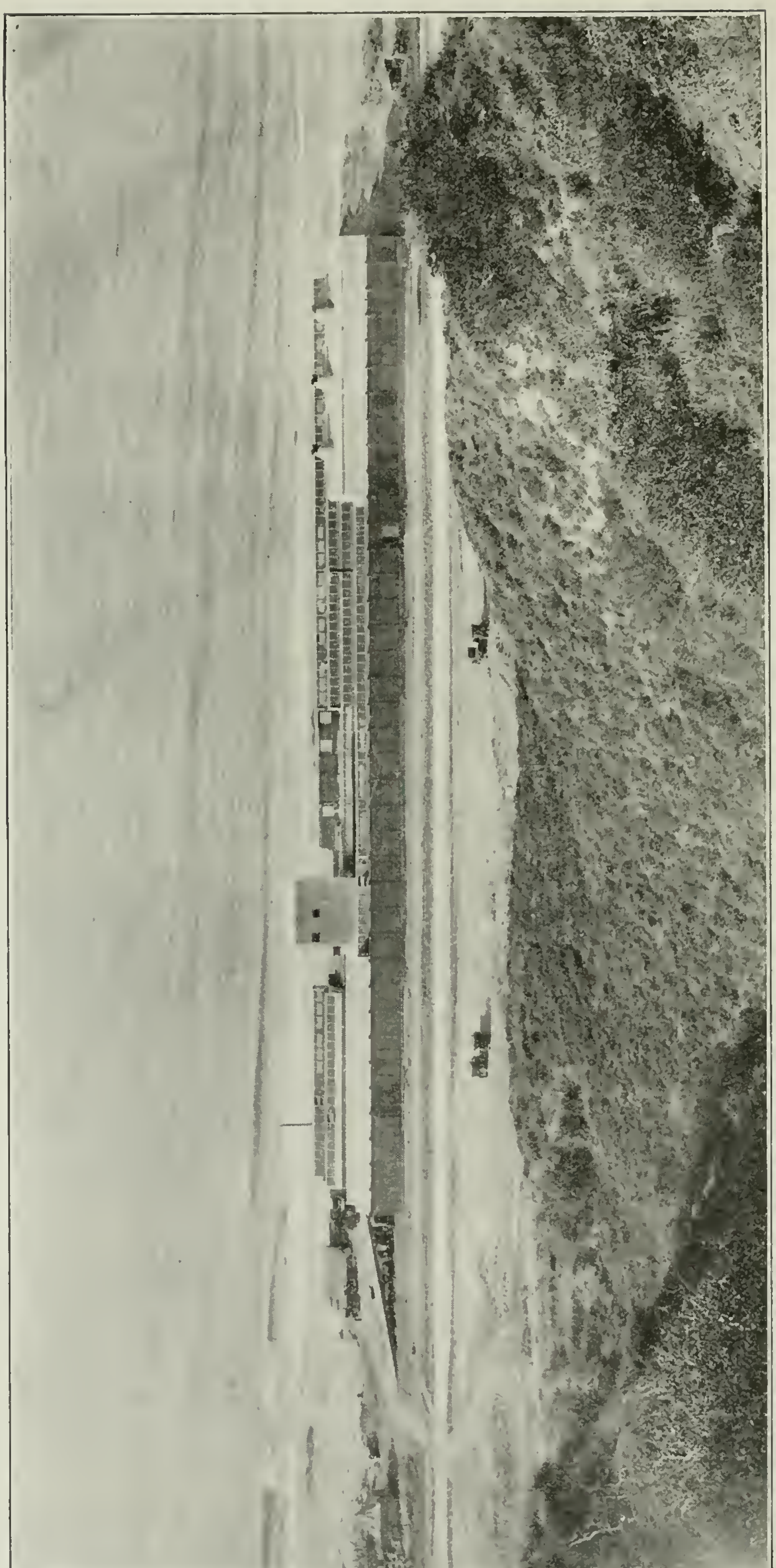

PHOTO No. 16. Malibu Pottery, on the Pacific Ocean, north of Santa Monica. Los Angeles County. (Photo by courtesy of the company.)

feet high, and dipping southward into the hill. The individual beds of shale vary from a very fine-grained plastic clay, to a sand, the different phases being present in such proportions as to make an excellent material for brick and hollow tile. The clay is mined by a team and scraper, dumped into a hopper, delivered to a car, which is hauled up into the plant by an electric hoist. The clay is ground in a dry pan, and fed by belt conveyors to pug-mills and auger machines. The bricks are dried in driers heated with steam from auxiliary boilers. Firing is done in open field kilns, with gas fuel. The capacity of the plant is 80,000 brick and 100 tons of hollow building tile per day.

SEVENTH STREET YARD: This yard is 12 acres in area. The clay belongs to the upper portion of the Boyles Heights Terrace formation. The soft-mud process was used, followed by air drying, and firing in open field kilns. It is probable that this property will be sold, as it has become too valuable for industrial property to warrant its continuance as a brick yard.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 52.

Malibu Potteries. Owned and operated by the Marblehead Land Co.; R. B. Keeler, plant manager, P. O. Box, 518, Santa Monica. The plant is on the Coast highway, north of Santa Monica. The products of the plant are plain and decorated wall tile, made from a terra cotta body. A view of the plant is given on photo No. 16.

A variety of clays are used, including a number of clays from the Malibu Ranch, some Alberhill clays, and English ball clay. The mixes are prepared by grinding in a 4-ft. dry pan, elevating to a bin, screening, and pug-milling, followed by six weeks ageing. Most of the tile are shaped in a Muller tile auger, but some are hand-pressed in plaster molds. Saggers and tile setters are made at the plant, by hand.

A Carrier drier, operating on an 18-hour cycle, is used for drying the tile. The saggers and setters are dried in the open.

Three up-draft kilns are in use. On biscuit firing, 10,000 sq. ft. of tile can be loaded per kiln, and the entire firing cycle takes one week. The finishing temperature is 2300° F., which is reached in 96 hours from the start of firing. On glost firing, each kiln holds 5000 sq. ft. of tile, the finishing temperature is 1600° F., the firing occupies 48 hours, and the entire cycle takes four days. Normally, one kiln is on biscuit firing, one is on glost firing, and the third is used for either, according to conditions. The kilns are fired with oil, atomized by air.

Mission Brick Company.[1] Mrs. A. E. L. Anderson, 755½ Santa Monica Boulevard, Los Angeles, owner. Joseph F. Reutera, manager. Office and plant at 6140 Sepulveda Boulevard, Van Nuys. The product of the plant is common red brick. The property consists of five acres of land, containing a bed of red clay from 5 to 20 feet thick, overlain by from one to two feet of soil. Mining is done in an open pit, using scrapers which are hauled by a Fordson tractor to a hopper which feeds a belt conveyor delivering to a bin at the plant. The soft-mud process is used. The plant is equipped with a pug-mill and a Quaker brick press, which has a capacity of 20,000 brick per day. The brick are dried under sheds, to which they are transported in hand trucks.

[1] Data supplied by W. B. Tucker, district mining engineer, December, 1927.

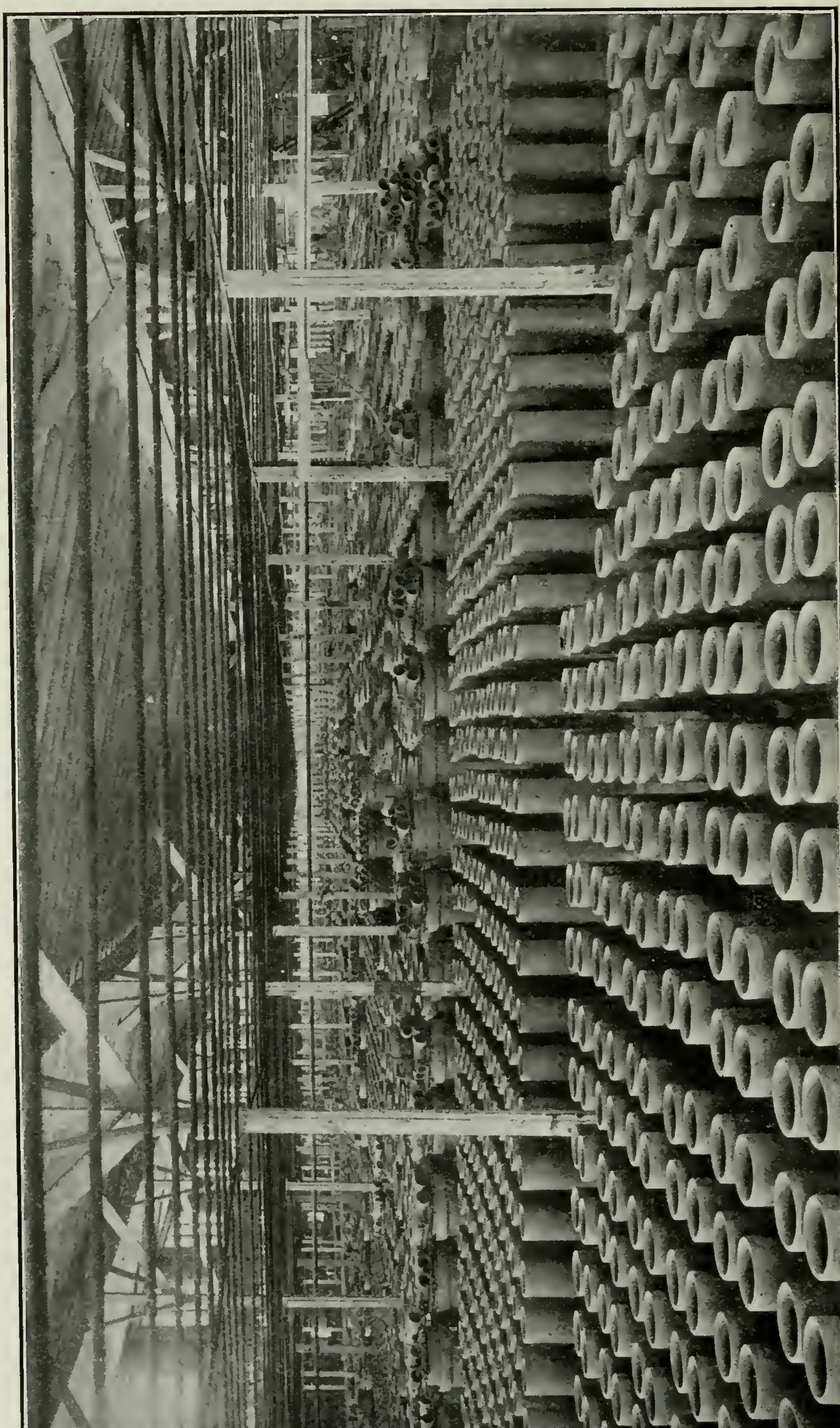

PHOTO No. 17. Drying floor, Los Nietos plant of Pacific Clay Products Company, Los Angeles County.
(Photo by courtesy of the company.)

Two gas-fired field kilns are used, having a capacity of 50,000 bricks each. Electric power is used in the plant, the installed capacity being 60 h.p. Twenty men are employed during the operating season, which is usually four months.

Mission China Company. Victor Kremer, president; Jas. Tiffany, manager. General offices at 321 W. Third Street, Los Angeles. Plant at 652 S. Griffin Avenue. This plant has been manufacturing semi-porcelain hotel and dinner ware for a number of years. The raw materials in use are English china and ball clay, Edgar (Florida) kaolin, and California feldspar and silica.

The body mix is prepared by screening through 150-mesh, blunging, filter-pressing, and pugging. Most of the ware is shaped by jiggering, but casting is used on the more complicated shapes. Steam drivers are used, operating on a 12-hour cycle. Saggers are molded by hand at the plant.

The biscuit ware is fired in two 17-ft. 6-in. up-draft kilns, to a finishing temperature of cone 8 (1225° C.), requiring 55 to 60 hours. The ware is then dipped in glaze, and fired in two 16-ft. glost kilns to cone 5 (1180° C.), in 30 to 35 hours. Two days are required for cooling both types of kilns. The paper transfer process of decorating is used, and the decoration is fired on at cone 016 (735° C.). Two decorating kilns are in use, which are fired in 12 to 14 hours, the entire cycle requiring 30 hours. All kilns are fired with natural gas.

Fifty men and women are employed in the plant. Most of the work is paid by piece rates, which are the same as those established in eastern potteries.

Pacific Clay Products Co.[1] William Lacy, president; Robert Linton, vice president and general manager; W. R. Fawcett, secretary-treasurer; Wm. McClintock, general superintendent. Main office, 1151 South Broadway, Los Angeles. This company owns and operates three factories in Los Angeles district and several clay properties in Riverside and San Diego counties. The present company supersedes the *Pacific Sewer Pipe Company* which was formed some years ago by consolidating several smaller companies situated in Los Angeles, Corona, and Elsinore, these smaller companies having started business around 1880 to 1885.

Clay Properties: The company owns and operates the following clay mines:

Name	Shipping point
Douglass	Alberhill, Riverside County
McKnight	Corona, Riverside County
Wildomar	Wildomar, Riverside County
[1]Hoist Pit	Elsinore, Riverside County
Kelly No. 1	Farr, San Diego County

[1] The company owns a one-half interest in this property.

In addition the company operates under lease several properties in Orange and San Diego counties; also owns and holds in reserve for future operations five additional tracts in Riverside and San Diego counties. The total clay lands owned outright total 625 acres. The bulk of the clays used in the company's plants come from its own mines, although some are purchased from the Alberhill Coal and Clay

[1] Description prepared by the company.

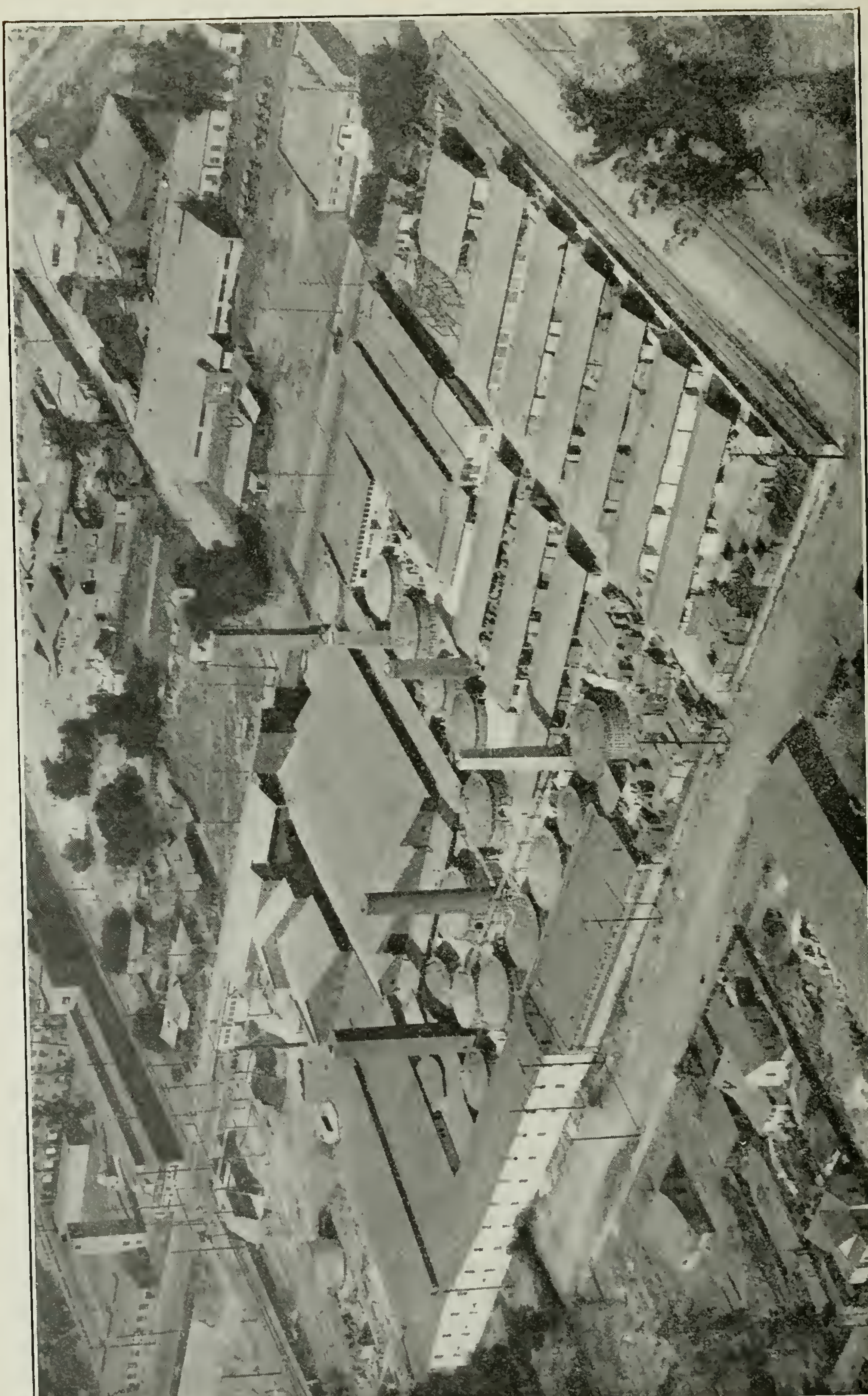

Photo No. 18. Airplane view, Lincoln Heights plant, Pacific Clay Products Co., Los Angeles. (Photo by courtesy of the company.)

Company, the Emsco Clay Company, and the Lincoln Clay Products Company. Many different clays enter into the manufacture of the various products made, which include sewer pipe, electrical conduit, face brick, enameled brick and tile, fire brick and refractory shapes, fireclay, flue lining and gas flues, drain tile, stoneware, earthenware water coolers and other articles.

PLANTS: Three factories are operated at present, viz, the Lincoln Heights plant, Avenue Twenty-six and Humboldt Avenue, Los Angeles; the Slauson plant, Slauson and McKinley avenues, Los Angeles, and the Los Nietos plant on the eastern edge of the Santa Fe Springs oil field. The plants have a combined capacity of over 90,000 tons of clay products per year. A plant at Terra Cotta, near Elsinore, and two plants at Corona were also formerly operated. General views of the Lincoln Heights and the Los Nietos plants are shown on photos No. 18 and 19.

LINCOLN HEIGHTS PLANT: J. L. Davies, superintendent. This factory was built about 1890 and was equipped to manufacture sewer pipe, brick and stoneware. At present it comprises a brick department producing face brick, enamel brick and tile, fire brick and refractory shapes and roofing tile; and a stoneware department making a comprehensive line of grey earthenware, ollas, mixing bowls, etc.

Clays for the stoneware are selected with especial reference to producing a body as dense and impervious as possible; for ollas, or self-cooling water jars, the body should be slightly porous, since the cooling comes from evaporation of water which percolates through the jar to the outer surface. The mixes are finely ground in a Raymond hammer pulverizer, the dust being lifted by a suction fan a height of 10 feet to the pug-mill feeder. The pugged clay is allowed to soak in the 'sweating room' for 24 hours or more, then goes to the jig rooms where there are 9 potters' wheels suitable for making all kinds of turned pottery up to a 12-gallon jar. The ware is dried in steam-heated dryers, then dipped in the proper glaze. Some of the stoneware is given a biscuit firing before glazing, but most of it is made at a single burning, using a slip glaze which matures at the same temperature as the body. The stoneware bodies mature at about cone 8, and are a cream or light yellow color. Saggers made at the plant are used for some of the ware, chiefly for support, but as much ware as possible is open fired. There are 5 kilns 20 to 24 feet diameter used for stoneware.

The brick department equipment consists of 3 dry pans, Hummer screens, 2 pug-mills, 2 auger machines, two 14-brick American cutters, 2 represses, 2 humidity dryers holding 40,000 brick each, an overhead traveling crane with clam shell for clay unloading, 2 electric lift trucks with pallets for handling brick, and 11 kilns 30 feet diameter. The capacity is 40,000 brick per day.

A view of the clay bins and unloading crane is shown on photo No. 20, and a pug-mill, auger machine and cutter is shown on photo No. 21.

The stiff-mud brick—comprising the rough and smooth texture wire cut face brick and re-pressed wire cut fire brick—are dried in the humidity dryers in 42 hours. About 6 days are required for the firing, the finishing temperature being about 2100°. Dry press brick go directly to the kilns without preliminary drying, and are burned to

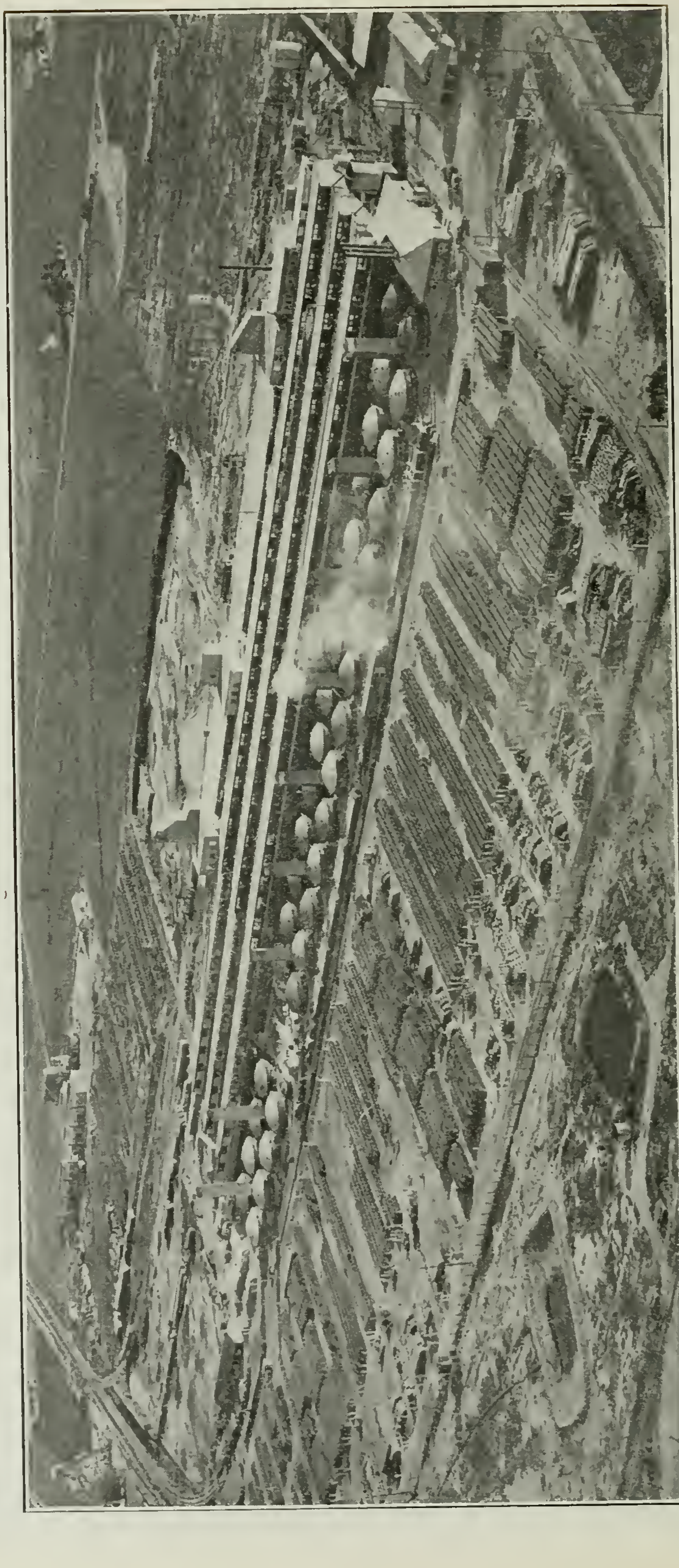

PHOTO NO. 19. Airplane view, Los Nietos plant, Pacific Clay Products Co., Los Angeles County. (Photo by courtesy of the company.)

about 2050°. Enamel brick are made on biscuit, or burned pressed brick, which are coated with enamel slips and burned a second time to mature the glaze.

A variety of very attractive shades of red, tan, grey and other colors is made in the wire-cut brick. Present architectural practice favors combining different shades and colors, following the impressionistic idea, and these combinations are proved very effective in lending distinction to face-brick buildings. The Pacific enamel brick is in wide demand and is shipped to all the Pacific Coast states as well as abroad.

A complete line of fire brick and refractories is also manufactured. Three grades of standard fire-brick are made, with softening points of

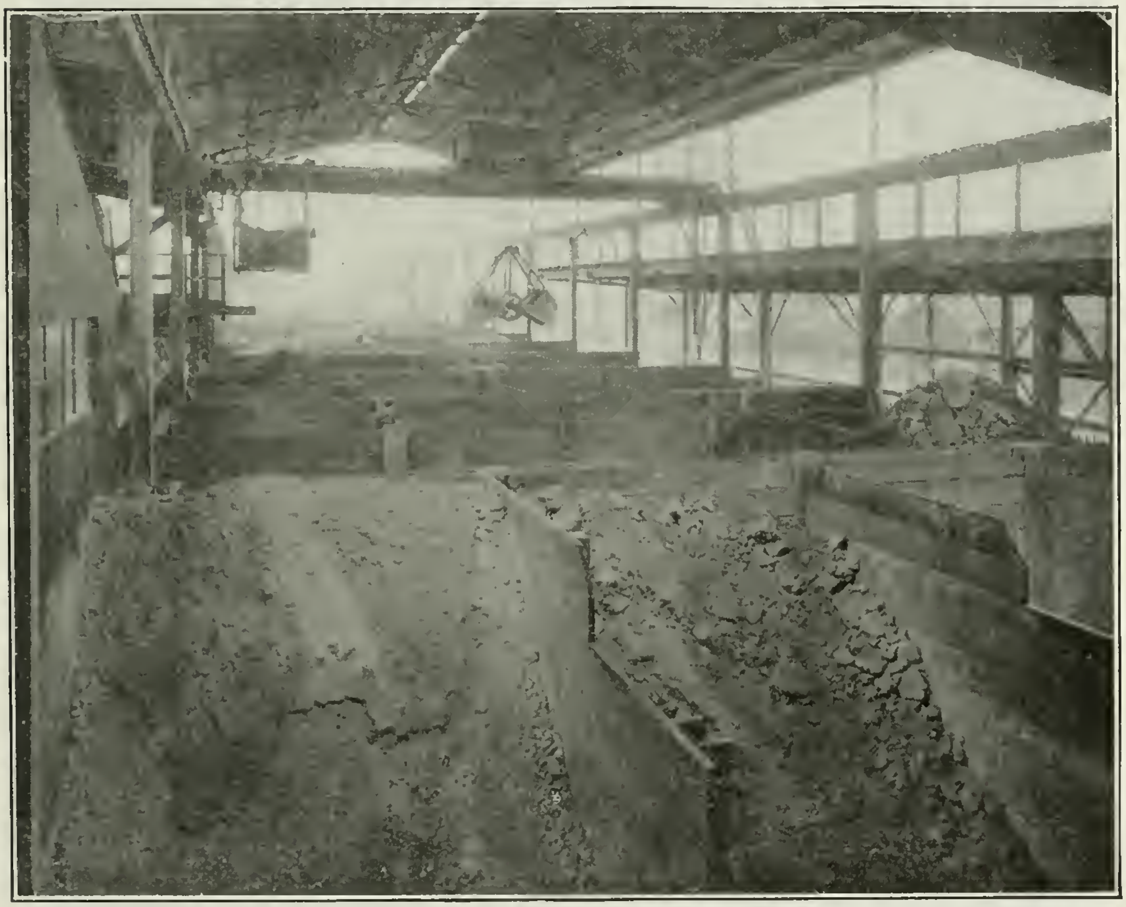

PHOTO No. 20. Clay bins and unloading crane, Lincoln Heights plant, Pacific Clay Products Co., Los Angeles. (Photo by courtesy of the company.)

about 3200° F., 3100° F. and 3000° F., respectively. The highest grade brick is hand molded, the others made on the auger machine and repressed. They are burned to about 2500° F.

Roofing tile are also made, using a combination Hummer machine. They are dried on waste heat drying floors and burned in the brick kilns.

Over 20 different clays are used at this plant, coming from Riverside, Orange, San Diego, Los Angeles, and Placer counties. The plant site comprises over six acres, and lies between main lines of the Santa Fe and Union Pacific railroads, having sidings from each. The plant is equipped to use either natural gas or fuel oil. Machinery is all motor-driven. About 130 men are employed.

The company's laboratories are located at this plant and are fully equipped for chemical and testing work. A high temperature testing kiln capable of heating up to 3400° F., is used for testing fire brick. Routine testing for color and shrinkage is regularly carried on. All kilns are equipped with pyrometers which are used for control in connection with Orton standard cones.

Los Nietos Plant: Cecil V. McClintock, superintendent. The Los Nietos factory is the largest and newest of the plants, and is situated

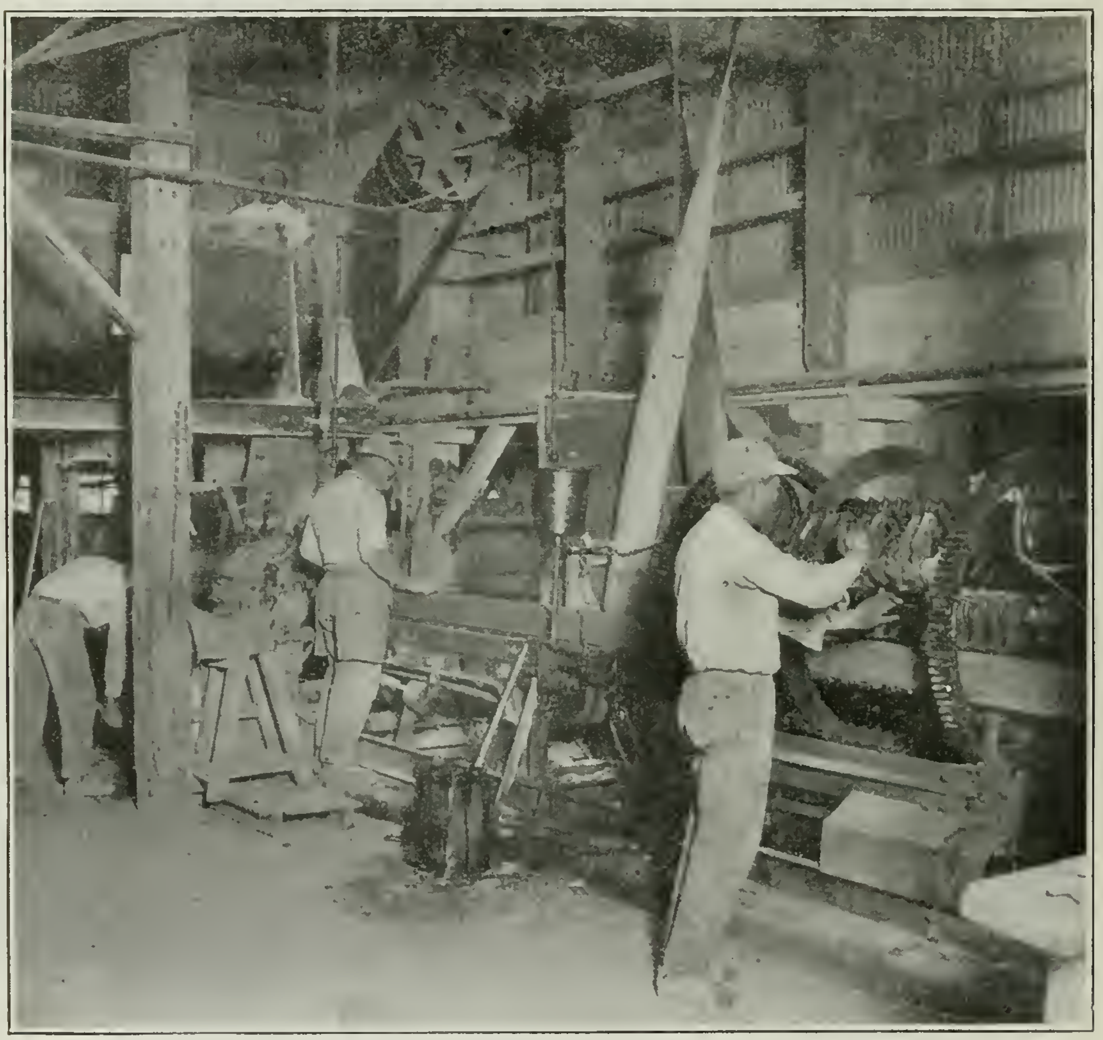

Photo No. 21. Pug-mill, auger machine and cutter, Lincoln Heights plant, Pacific Clay Products Co., Los Angeles. (Photo by courtesy of the company.)

on a 46-acre tract on the edge of the Santa Fe Springs oil field. It is a thoroughly modern, well-arranged plant. Sewer pipe is the principal product, but electric conduit segmental sewer blocks and lining blocks, drain tile and flue lining are also made.

The plant makes sewer pipe, electric conduit, roofing tile, drain tile, flue lining and gas flues. Clays are shipped in from Riverside and San Diego counties and some clay mined on the premises is also used.

The equipment comprises three 9-ft. American dry pans, 2 pulverizers, gravity screens, four 8-ft. American wet pans, one 14-ft. pug-mill, 3 sewer-pipe presses, 1 auger machine, and 36 circular down-draft kilns 30 and 34 feet diameter. Some of the dry and wet pans are shown on photo No. 22, and one of the sewer-pipe presses is shown on photo No. 23. The drying floor is 220 x 920 ft. and is shown on photo No. 17. There is a well-equipped machine shop and testing plant for sewer pipe. Steam is furnished from two 250-h.p. Babcock and Wilcox boilers, with three 150-h.p. tubular boilers as stand-by. Excepting the steam-driven sewer-pipe presses all equipment is driven by electric motors. Natural gas and oil are both used for fuel.

Clays are shipped in from Riverside and San Diego counties and used in connection with red shale mined on the premises. The clay track is elevated above the storage bins so that the clays are dumped

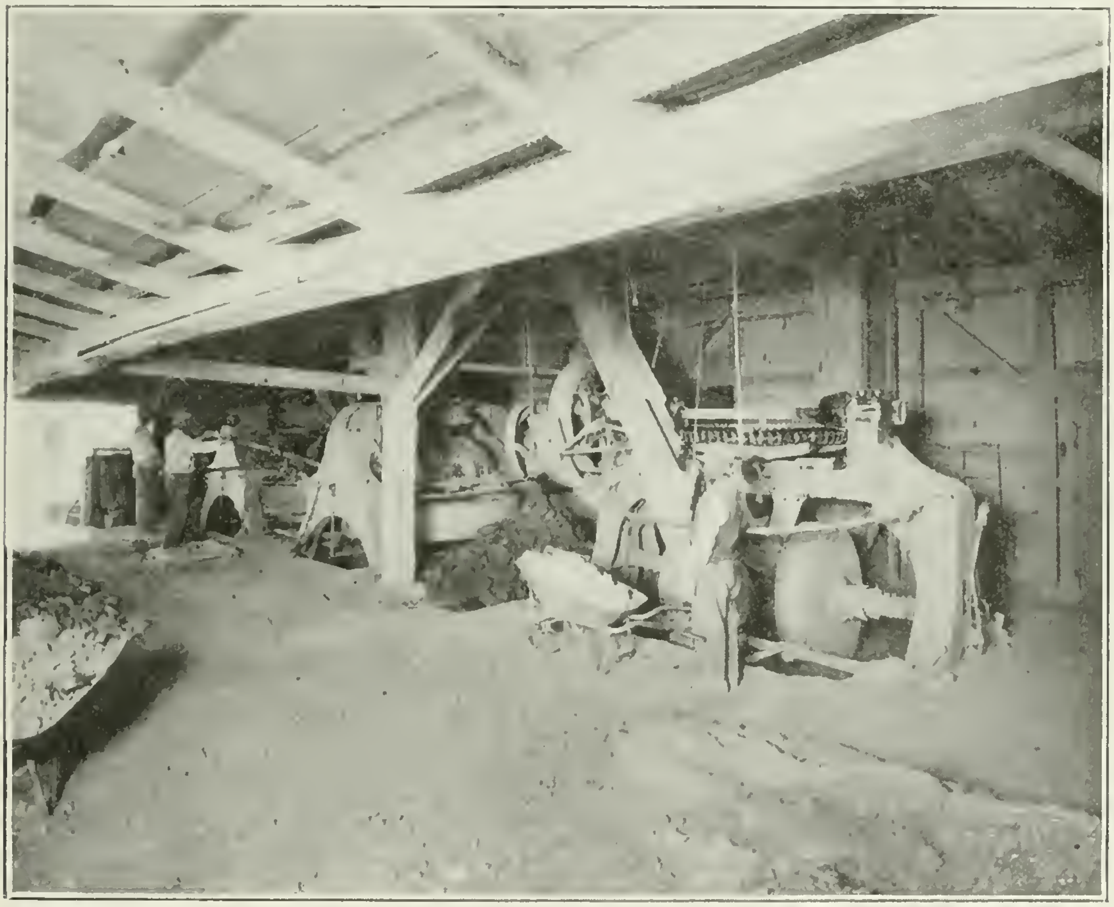

PHOTO No. 22. Dry pans and twin wet pans, Los Nietos plant, Pacific Clay Products Co., Los Angeles County. (Photo by courtesy of the company.)

directly from the cars at minimum cost. Some of them require fine grinding which is done by regrinding the oversize from the screens in pulverizers of the squirrel-cage type.

The drying room is equipped with steam-heating pipes overhead and underneath the floor, affording very satisfactory control. From 2 to 15 days is required to dry the ware, depending upon the size. Firing time varies likewise from 3 to 8 days. The bodies mature at 2100° F. to 2200° F. The salt glazing is done during the last two hours of the firing, *i. e.*, when the kiln is at maximum heat, by throwing a shovelful of salt into each fire-box every fifteen minutes. The salt volatilizes, is carried through and around the hot pipe, and as the vapor comes in contact with the clay the alkali in the salt combines with the silica of the clay to form the glaze on the surface.

All sizes of sewer pipe up to and including 30-inch are made. Segmental blocks for making sewers of larger size are also among the products. The plant employs 150 men.

The plant is served by both Santa Fe and Southern Pacific railroads, having sidings connecting directly with each.

SLAUSON AVENUE PLANT: Roy Lacy, superintendent. The Slauson Avenue plant was built about 1885. It is located on a tract of six acres on McKinley Avenue from Slauson Avenue to Fifty-third Street. It is served by the Santa Fe Railroad, the plant sidings connecting

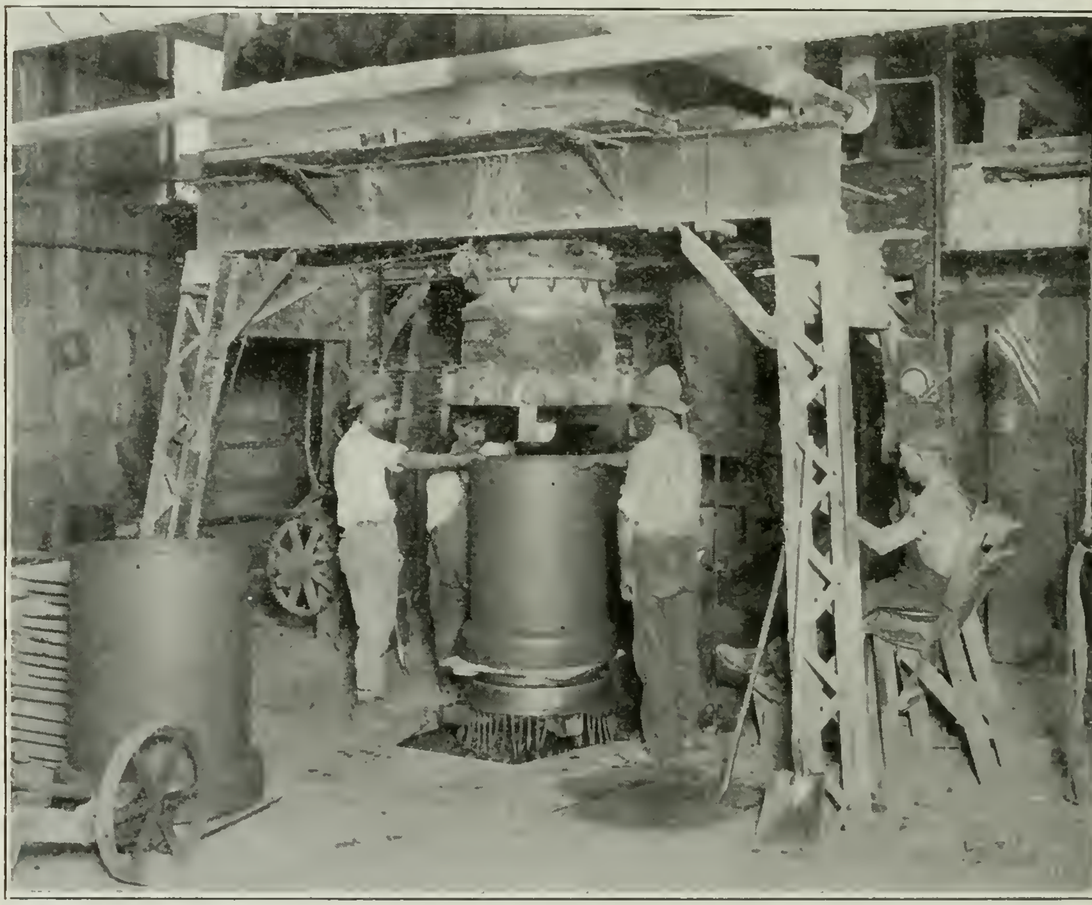

PHOTO NO. 23. Sewer-pipe press, Los Nietos plant, Pacific Clay Products Co., Los Angeles County. (Photo by courtesy of the company.)

with the tracks on Slauson Avenue. Equipment consists of a conveyor unloader for clay, 2 dry pans, pug-mill, double-shaft auger machine, and sewer-pipe press. There are seven 30-foot kilns and one 28-foot.

Pomona Brick Company.[1] E. G. Stahlman, president; H. F. Stahlman, secretary. Address, Pomona. This company owns a 10-acre property on West Ninth Street, Pomona, and manufactures common brick.

The deposit consists of red sandy clay, 8 to 20 feet thick, without overburden. The clay is loaded by a small steam shovel into trucks.

The plant equipment includes a dry pan, screens, pug-mills, and a

[1] Data supplied by W. B. Tucker, district mining engineer, November, 1927.

Potts brick press. The brick are conveyed to a drying yard on rope conveyors. Five field kilns, fired with natural gas, are in use.

The plant operates during about six months of the year, and employs 14 men during that period. About 110 h.p. of steam power are required. The rated capacity of the plant is 30,000 brick per 8-hr. day.

Bibl: Cal. State Min. Bur. Prel. Rept. 7, p. 58.

Pomona Tile Manufacturing Company, Third and Reservoir streets, Pomona. R. J. Schroeder, president and treasurer; C. V. Svendsen, superintendent. This company manufactures ceramic floor and wall tile, using Edgar clay from Florida, English china clay, California and Arizona feldspar, California silica, and some Santa Monica clay where red-burning bodies are required. Alberhill and Lincoln clays are used for saggers.

The tile are shaped in hand-operated dry presses. At the time of visit, July, 1925, two down-draft kilns were in operation, and a third kiln for increasing the capacity by 80% was under construction. Gas is used for fuel, with oil in reserve. The kilns are fired to cone 11.

The plant employs from 40 to 45 employees, mostly women and girls, who do the work of packing and unpacking the saggers, cleaning the tile after firing, and pasting them on paper.

Poxon Pottery. G. J. Poxon, president; Earl Lincoln, foreman. Offices 2300 East Fifty-second Street, Los Angeles. This pottery makes a complete line of plain and decorated table ware. All of the clays used are imported from England. The imports amount to about 1000 tons per year of ball and china clay. Feldspar and silica of the best quality are obtained from various sources in southern California, mainly from Riverside County.

After coarse-crushing to about ¼″ size, the silica and feldspar are mixed in the proper proportion with the clays, and the grinding is finished in a wet pulp. The mix is then passed to filter presses for the removal of excess moisture, and the filter cake is then ready for shaping.

Power-driven wheels are used throughout for all shapes that can be made mechanically. After shaping, the ware is dried for about three hours in gas-heated drying rooms, or for a longer time in the factory atmosphere.

The biscuit firing is done in gas-fired kilns at a temperature of 2300° F., for 70 hours. After cooling, the ware is dipped in the glazing material, and fired for 30 hours at 1800° F.

Some of the decorating is done by the paper-transferring process, while the higher-priced ware is hand-decorated. After decorating, the ware is fired for 12 hours at about 1100° F.

Seven gas-fired kilns are in use. The factory produces about 1500 dozen pieces per day, and employs 70 men and women.

Some ten years ago this plant used California clays, but found that the English clays gave better results. Kaolin from Hart, San Bernardino County, has been used recently, but is said to be too variable. Clay from Amador County has been tested with good results.

In 1926, the company built a new plant at Slauson and Miles avenues, in Vernon. It is understood that both plants will be operated, but further details are lacking at this writing.

St. Louis Fire Brick and Clay Co. Joseph Mesmer, president; A. J. Mesmer, superintendent. Office and plant at 2464 E. Ninth Street, Los Angeles. This company manufactures fire brick. Practically all of the clays in use at present are purchased from various sources, but the company owns a deposit near Corona that has been worked at various times in the past. The principal clays in use are the select main tunnel (sample No. 15, p. 264) and west blue (sample No. 23, p. 277) from Alberhill; the Emsco pink mottled (sample No. 71, p. 278) and the Lincoln, No. 1–6 (sample No. 146, p. 303). Some experiments were made with the Weiss clay from Glen Ellen, Sonoma County (samples No. 194 and 195, p. 262), but difficulties were encountered in securing satisfactory strength.

Both the auger and hand-pressing processes are in use, and the brick are fired in three down-draft bee-hive kilns, and two rectangular kilns, using oil as fuel.

Bibl: Cal. State Min. Bur. Prel. Rept. 7, p. 58.

Santa Monica Brick Company.[1] E. A. Douglas, president; F. M. Taylor, vice president and treasurer. Office and plant at Twenty-third and Michigan streets, Santa Monica. The company owns 10 acres of clay land and manufactures common brick, red face brick, roofing tile, and red floor tile.

The clay is a plastic, red-burning clay, underlying an extensive area from which numerous other manufacturers in the Los Angeles district secure clay for brick, hollow tile, roofing tile, and sewer pipe manufacture. There is no overburden. The deposit is now (1927) being worked by a power shovel against a 45-ft. bank, but the height of the bank may be increased in the future to 75 feet. The clay is transported to the plant in cars operated by an endless cable hoist.

The plant is equipped with a 60-h.p. 24-in. by 24-in. American disintegrator, a 150-h.p. American auger machine, having a rated capacity of 75,000 brick per day, an American automatic brick cutter, a 40-h.p. Fate-Root-Heath roofing-tile auger, having a rated capacity of 10,000 tile per day, and a hand-operated roofing-tile cutter, in addition to the necessary elevating and conveying equipment.

A hot-air tunnel drier is used, which operates on a schedule of 36 hours. Ten up-draft field kilns with permanent walls are used for firing. Both natural gas and steam-atomized oil are used. Normally, four kilns each with a capacity of 500,000, are used for firing brick, five kilns of 15,000 capacity each are used for roofing tile, and one kiln of 1000 sq. ft. capacity is used for floor tile. The brick are water smoked for three days, fired for four days, and allowed to cool for three days. Drawing and setting require about seven days. The finishing temperature at the end of the firing period is approximately cone 07 (975° C., or 1787° F.). The tile are water smoked for one day, fired for three days, and cooled in two days. One day is sufficient for setting and drawing.

The company also makes hand-made Mission roofing tile, which are dried in the open air.

The plant is operated throughout the year, employing 60 men. A total of 350 h.p. of electric power is installed in the plant. The rated

[1] Data supplied through the courtesy of the company.

capacity of the plant is 75,000 brick and 40 squares (100 square feet each) of roofing tile per day.

Simons Brick Co. Walter R. Simons, president; Robt. P. Isitt, vice president; H. B. Howeth, secretary; J. T. Crampton, treasurer. Office at 125 West Third Street, Los Angeles.

Boyle Plant: The Boyle plant of the Simons company occupies a 30-acre property at 1117 South Boyle Avenue, on the east bank of the Los Angeles River, a few blocks south of the Seventh Street yard of the Los Angeles Brick Co. This plant is now engaged in the manufacture of roofing tile exclusively. The clay deposits on the property have been worked out by past operations, at least to such an extent that it is more economical to ship clay to this plant from the company's large pit at Santa Monica. In order to produce the wide variety of colors demanded by the trade of today, varying amounts of Emsco white plastic (sample No. 70, p. 272) and other clays from the Alberhill district are mixed with the Santa Monica material. Most of the ware is red, and the mixture for this product contains 75% Santa Monica clay and 25% of a pink burning fire clay, such as Emsco pink mottled (sample No. 71, p. 278). Light pink, cream, and buff tile are produced by adding up to 90% of a light burning fire clay.

The tile are formed by the stiff-mud process, with Mueller machines. Drying under sheds requires nearly a week. Firing is done in 12 down-draft bee-hive kilns. The lighter-colored tile, containing more refractory clay than the red burned variety, are fired in one compartment of a double rectangular kiln, the dimensions of each compartment being 6 ft. by 20 ft. by 8 ft. A temperature of 2500° F. is required, and the heating period occupies three days. Kiln slabs, for supporting the tile during firing, are made of a mixture high in refractory clays, and are fired in the other compartment of the double rectangular kiln.

Santa Monica Plant: This plant is at Colorado Avenue and Twenty-sixth street, Santa Monica. The property consists of 24 acres. The clay is similar to that on other properties in the same area; see under Gladding, McBean and Company, Santa Monica Brick Company, and others. The soft-mud process is used and the brick are fired in oil-fired field kilns.

Simons Plant: The Simons plant is advertised as being the largest plant in the world exclusively devoted to the manufacture of common brick. It is situated on a 400-acre tract at Simons, on the main line of the Santa Fe Railroad, 1½ miles northeast of Montebello on the Southern Pacific Railroad.

The clay is of excellent quality for the manufacture of common brick, and occurs in a superficial bed averaging 16 to 18 feet in thickness, underlain by fine sand. The clay is mined by steam shovel, and hauled to the plant in 6-yard cars by gasoline locomotives. Sixteen soft-mud pug mills and Potts presses are arranged in units of two machines each at such positions in the yard as to provide ample room for drying sheds placed so as to secure the most economical transportation of the brick from the presses, and to the kilns. The brick are dried in from 7 to 10 days, depending upon the weather, and are fired in gas-fired field kilns. An 18-arch kiln will hold 756,000 brick, and a 30-arch kiln holds

1,250,000. Both sizes are in use, the choice depending on requirements at the time of setting.

The total capacity of the yard is 650,000 brick per day. The company has purchased a townsite, and has built homes for renting at a nominal rate to its 650 employees. Recreational facilities are provided, and every attempt is made to secure a permanent force of satisfied employees.

Standard Brick Co. J. V. Simons, president; R. G. Simons, vice president; H. W. Simons, secretary. Office at 102 Stimson Building, 129 West Third Street, Los Angeles. This company manufactures common red brick, and sewer brick, which are semi-vitrified common brick. Two yards are operated, one at Soto and Lugo streets, on the southern end of Boyle Heights, the other on Eucalyptus Street, in Inglewood.

BOYLE HEIGHTS PLANT: This property covers 8 acres. The material is a clay loam, 15 to 18 feet thick, underlain by sand. A steam shovel is used to mine the clay and load it into dump wagons, which are hauled to the dry pans. The brick are made in Potts soft-mud brick machines, and are dried in air under sheds, requiring from three to four days. Three or four gas-fired field kilns are maintained, depending upon the demand. The brick in the arches are carried to the semi-vitrification point, with less than 10% absorption, are sorted out after firing, and sold as sewer brick. The firing cycle is usually five and one-half days firing, and an equal time cooling. Mr. Welldon is foreman.

INGLEWOOD: At Inglewood the clay is of much the same character as at the Boyle Heights plant, containing lenses of sand and fine gravel, underlain by coarse gravel. The same brick-making process is used here as in the Los Angeles yard. Mr. Paye is foreman.

Bibl: Cal. State Min. Bur. Prel. Rept. No. 7, p. 62.

Torrance Brick Company.[1] T. H. Reed, president; V. T. Pullman, secretary. Office address, Torrance. This company operates two plants.

PLANT NO. 1: This plant is on the Plaza del Almo Boulevard, Torrance, and produces common red brick only. The property comprises 15 acres, consisting of a 30-ft. bed of red and yellow plastic clay, overlain by about one foot of soil. The clay is mined by scrapers, which deliver to a hopper in the plant. From the hopper, the clay is elevated by a bucket elevator to rolls. The roll product is elevated by a bucket elevator to wire screens, which return oversize to the rolls for regrinding and deliver undersize to a pug-mill. The pugged clay passes to an auger machine, equipped with a wire cutter. The capacity of the auger is 60,000 brick per day.

The brick are transported to drying sheds in hand-trucks. Four open field kilns, fired with natural gas, are in use. The kilns have a capacity of 750,000 brick each. The plant operates throughout the year. Electric power is used, the installed capacity being 105 h.p. Thirty men are employed.

PLANT NO. 2. This plant is at Graves Avenue and Jackson Street, Monterey Park. Common brick, hollow tile, and red face brick are

[1] Data supplied by W. B. Tucker, district mining engineer, December, 1927.

produced. The property consists of 20 acres of clay shale, from 20 to 30 feet thick. The capacity of the plant is 60,000 brick per day, or its equivalent in other ware. Electric power is used, the installed capacity being 120 h.p. Forty men are employed.

Tudor Art Tile Company. H. C. Hill, C. J. Biddle, T. P. Cook, and Geo. Skee, owners. Geo. Skee, superintendent. Office address, 1204 Lane Mortgage Building, Los Angeles. Plant at 5848½ Santa Fe Avenue, Los Angeles. This company manufactures faience tile and inserts, using Alberhill clay. All special shapes are hand-molded in plaster molds, and an auger machine is used for standard tile shapes. Two gas-fired kilns are used. One is a rectangular semi-down-draft, 6-ft. by 8-ft. by 6-ft., fired to cone 01 (1145° C.) for biscuiting, and the other is a rectangular muffle glost kiln, 5-ft. by 6½-ft. by 12-ft., fired to cone 02 (1125° C.).

Clay-Worker reports[1] the organization of the *Tudor Potteries, Inc.*, with a capitalization of $50,000, by C. J. Biddle and M. L. Vincent. No further information was available at the time of going to press.

The Vitrefrax Company.[2] Harvey M. Brown, president; Geo. W. Clemson, vice president; C. V. Knemeyer, secretary; Ralph W. Brown, treasurer and general manager; Thomas S. Curtis, director of research. Office and plant at 5100 Pacific Boulevard, Los Angeles.

This company manufactures a broad line of ceramic materials for the porcelain, white-ware, and electrical isulator trade, as well as super refractories in the form of prepared grains, cements and finished raw materials, together with a line of finished refractory brick and shapes for the glass industry.

The company maintains an extensive research and development laboratory for fundamental investigations, as well as a control laboratory for physical and chemical control of its regular products.

In Imperial County, near Ogilby, California, the company owns and operates an immense deposit of cyanite, which forms the principal raw material for its mullite line of refractories and ceramic materials. In addition, the comany has under long contract abundant supplies of aluminum oxide at Marysville, Utah; high alumina clays from the Alberhill and Santa Margarita Ranch deposits; and contract control of what is believed to be the purest magnesium oxide resources in the United States.

The mullite products of the company constitute its most important line. The material is manufactured in several grades, one of which is made especially for the spark-plug industry. The highest grade of mullite products, trade marked 'Durox,' is manufactured by fusing a specially concentrated cyanite of great purity in the electric furnace at a temperature approximating 3000° C., whereby a yield of nearly pure mullite is obtained.

The most important application of the mullite refractory material in its highest state of purity is in the form of glass-house refractories, in which form the company's product is gaining important recognition. Excellent service is being obtained in many commercial installations on the Pacific coast, while an awakening interest in the east has caused

[1] July, 1927, p. 58.
[2] Copy prepared by the company.

orders to be placed by a number of prominent glass manufacturers within the past year.

For the general refractories trade, for use in heavy-duty boiler refractories and the like, a cheaper grade of mullite is manufactured and sold under the trade mark 'California Mullite.' This product readily competes in the eastern market with all other available sources, and has been pronounced after extensive tests to be equal to or the superior of any mullite available from the calcination of sillimanite, andalusite or cyanite.

Illustrations of the plant are shown in photos No. 24 and 25.

Bibl: Curtis, T. S., Super Refractory Manufacture. Ceramic Industry, July, 1926.

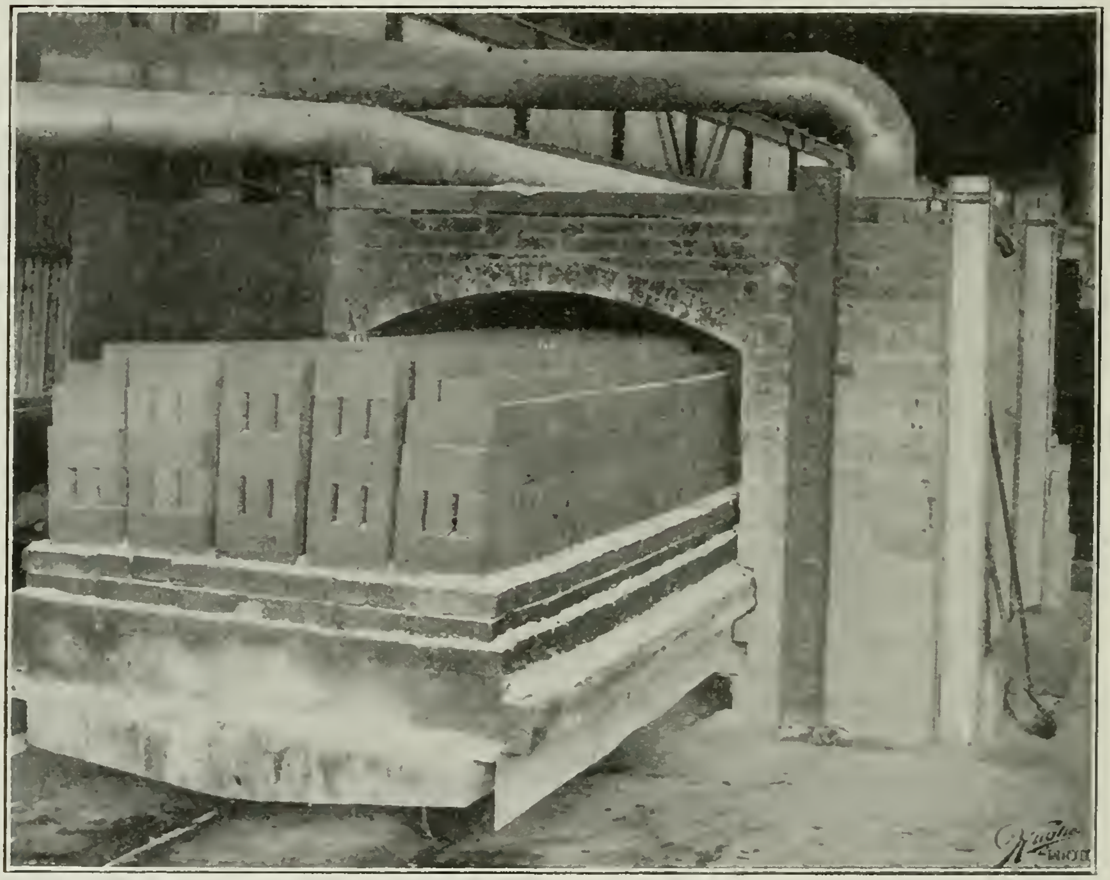

PHOTO NO. 25. California Mullite brick being fired in tunnel kiln at Cone 28, Vitrefrax Co., Los Angeles.

Washington Iron Works. Eighth and Mateo streets, Los Angeles. This company operates a sanitary ware enameling plant. The plant was visited, but in justice to the company no details are published, as other manufacturers of this ware refused publication of data.

Western Brick Co. G. A. Wild, president; J. J. Lagomarsino, superintendent. Office at Room 605, 126 West Third Street, Los Angeles. This company manufactures common red brick only, using local clays. Plant No. 1 is at 1155 Lilac Terrace, on the southern side of Elysian Park. The capacity of this plant is 10,000,000 per year.

Plant No. 2, is at Twenty-sixth and Colorado streets, Santa Monica, covering the same clay formation as that occurring on the property of

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Marin County lies north of San Francisco, the Marin Peninsula and San Francisco Peninsula being separated by the Golden Gate. The

[1] From Laizure, C. McK., Marin County: State Mineralogist's Report XXII, p. 314, 1926.

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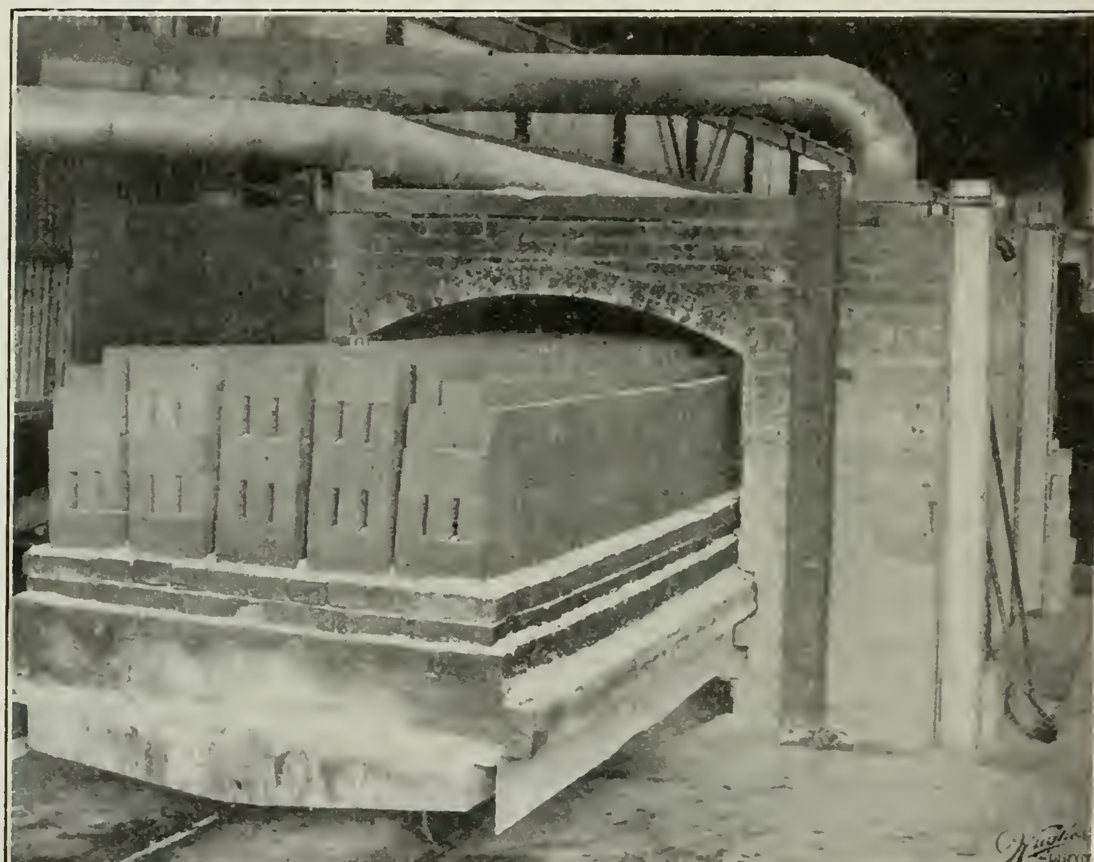

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Photo No. 24. Interior view of plant, Vitrefrax Company, Los Angeles. (Photo by courtesy of the company.)

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the Los Angeles Pressed Brick Company and the Simons Brick Company. This plant has a capacity of 25,000,000 brick per year. Either oil or gas fuel is used for firing in open field kilns, the choice of fuel depending upon relative economy at the time.

Whiting-Mead Company. J. M. Bonner, secretary. Plant and office at 2260 E. Vernon Street, Los Angeles. The Whiting-Mead pottery is one of the largest on the Pacific coast in which sanitary porcelain is manufactured. A small quantity of garden pottery is also produced. The clays used are a white clay from Corona (No. 70, p. 272), hill blue (No. 9, p. 287), and pink mottled (No. 7, p. 328), from the Alberhill Coal and Clay Co., English china and ball clays, Nevada china clay from near Cuprite, in addition to silica and feldspar from San Diego County.

The casting process is used exclusively. The clay slip is piped to all parts of the casting room, which is on the second floor of the plant building. Waste-heat driers are used. The ware is fired in two Harrop tunnel kilns, each 365 feet long, using trucks 5-ft. by 5-ft. by 10-ft. After the biscuit firing in the first kiln, the ware is dipped in glaze, and is glost in the second kiln. The firing cycle in the two kilns is the same, 66 hours, so that the loading and unloading of the kilns can be synchronized. Precious metal thermocouples are used for temperature control in the kilns.

The company also operates a sanitary ware enameling plant on the same site. It is one of three such plants in California, the others being the Washington Iron Works of Los Angeles and the Pacific plant of the Standard Sanitary Manufacturing Company at Richmond.

MADERA COUNTY.

General Features.

Madera County is in the east-central portion of the state, and lies between Merced and Mariposa on the north and Fresno on the south, in a narrow strip, extending from the floor of the San Joaquin Valley on the west to the summit of the Sierra Nevada Mountains on the east. Its area is 2112 square miles, and the population is 12,203 (1920 census). Granite is the principal mineral product. Some miscellaneous stone, gold and silver are also produced. Occurrences of copper, iron, lead, molybdenum, pumice, and building stone are known.

Clay Resources.

Common brick clay is reasonably abundant in the valley section of the county. The Sunset Brick Company (also known as Dyer's Brickyard) operated at Madera for a time, but has been idle since about 1919.

Bibl: State Min. Bur. Bull. 38, p. 249; Prel. Rept. 7, p. 64.

MARIN COUNTY.

General Features.[1]

Marin County lies north of San Francisco, the Marin Peninsula and San Francisco Peninsula being separated by the Golden Gate. The

[1] From Laizure, C. McK., Marin County: State Mineralogist's Report XXII, p. 314, 1926.

Pacific Ocean bounds it on the west, Sonoma County and portions of San Pablo and San Francisco bays surround it on the north and east. The total area of the county is 529 square miles, and the population is 27,342 (1920 census).

The main line of the Northwestern Pacific railroad runs through the eastern side of the county, and a narrow-gauge branch traverses the western portion, passing through Point Reyes and continuing northward into Sonoma County.

Marin County is for the most part rugged and picturesque, the ridges having steep slopes with only a few small flat valleys. The main ridge trends northwesterly, culminating at the south in Mount Tamalpais, which overlooks both bay and ocean from an elevation of 2601 feet. From this main crest the drainage is both to the ocean and bay sides. Other notable topographic features are Tomales, Drakes, Bodega and Bolinas bays on the ocean side and Richardsons Bay on the inland side.

Geology.

The geology of the Marin Peninsula has been described by Lawson [1] and Osmont,[2] to which the reader is referred for a detailed discussion.

Geologically, the county is divided into two areas by the great San Andreas fault, which runs in a northwest direction from Bolinas Bay to Tomales Bay. The country lying east of the fault comprises about three-fourths of the county and is composed almost entirely of Franciscan rocks. These include massive sandstone, chert and intrusive bodies of serpentine and basalt. The Point Reyes Peninsula, which includes that portion of the county lying west of San Andreas fault, is composed mainly of Monterey shale, which is distinctly bituminous in places. Two small areas of volcanic rock are exposed near Inverness and Tomales Point.

The mineralization of the county is diversified, but the deposits that may be classed as economic resources are limited, though important on account of their proximity to the metropolitan bay area. The economic minerals are mainly structural and industrial nonmetallic products. Occurrences have also been noted of asphaltum, petroleum, chromite, coal, jasper, garnets, manganese, mineral water, and natural gas. A little copper ore was at one time shipped, and traces of gold and silver have been found. Salt has been produced.

Clay Resources.

No deposits of high-grade clay have been reported in the county, but there is an adequate supply of clay and shale suitable for the manufacture of red structural ware at numerous places in the county. Common brick and other products have been produced since 1870 and three plants have been in operation at various times in the past. One plant is at present steadily producing, and a second plant is under construction.

McNear Brick Co. E. B. McNear, president and manager; L. B. McNear, superintendent. Main office, 417 Berry Street, San Francisco. Manufacturers of common brick.

The clay pit and brick yard are at tidewater on McNear Point, four miles east of San Rafael. The present pit is 3000 feet from the plant.

[1] Lawson, A. C., San Francisco Folio, No. 193, U. S. Geol. Survey.
[2] Osmont, V. C., Bull. Dept. of Geology, Univ. of Calif., Vol. 4, No. 3.

in a bank of shale, slate, sandstone and clay in the face of a hill, underlain by Franciscan sandstone. The material sometimes requires blasting. It is delivered to a loading hopper by two electrically operated dragline scrapers operating on a 10% slope in favor of the load. The clay bank has the form of an arc of a circle, with a radius of 300 yards, and a center at the loading hopper. The unblasted bank stands at a height of 30 to 60 feet, and has a nearly vertical face. A view of the pit is shown on photo No. 26.

From the loading hopper, the clay is loaded by a chain conveyor into 2.5 cu. yd. side-dump contractor's cars. Trains of four cars each are hauled to the plant by a Baldwin Westinghouse electric trolley locomotive.

At the plant, the clay is fed to two 9-ft., dry-pans, elevated by a bucket elevator and delivered to a pug mill and auger machine, equipped with a wire cutter. Drying is done under sheds, and requires 15 days (average) in summer, and a longer time in winter. Firing is done in

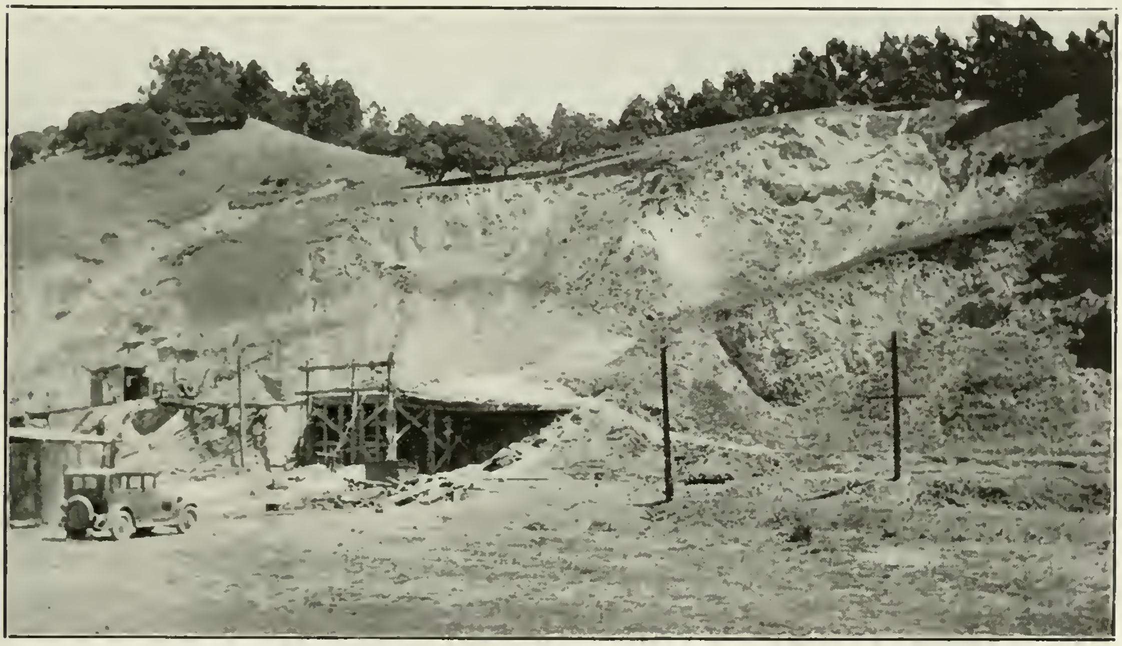


PHOTO No. 26. Clay and shale deposit of McNear Brick Company, showing loading hopper. Marin County. (From State Mineralogist's Report XXII, p. 318, 1927.)

two Hoffman continuous kilns, fired with coal screenings or oil coke. The kiln turnover period is 15 days, and actual firing requires from five to six days. The finishing temperature is 2000° F.

The capacity of the plant is 60,000 common brick per day. From 45 to 50 men are employed.

Sample No. 198 was taken from the dry-pan feed. The superintendent stated that the sample was somewhat leaner than the normal feed to the plant as it had rained the previous night, and only the more sandy clay can be handled when the ground is wet. The test results are on page 329. Occasional seams containing calcite are encountered in the pit. These can be included in the mix if they are well distributed in the feed to the plant.

Bibl: State Mineralogist's Reports VIII, p. 342; XII, p. 382; XIII, p. 615; XIV, p. 244; XXII, p. 317. Bull. No. 38, p. 249. Prel. Rept. No. 7, p. 64.

Louis Sbarbori,[1] 554 Broadway, San Francisco, has recently (1926) leased the Remillard property (see *post*) and was expected to begin the manufacture of floor tile during 1927. No further data are available.

EARLIER REPORTS.

The status of operations or clay deposits noted in previous reports[2] is as follows:

Maillard Ranch. Lagunitas. Now owned by the Lagunitas Development Company, 833 Market Street, San Francisco. "Clay deposit on Spring Creek, about eight miles northwest of San Rafael." The deposit is still undeveloped, and is probably common clay.

Patent Brick Company. Gallinas Station. This plant has been dismantled, and the company is out of business. The Hidecker Tile Co., Twenty-fourth and Union streets, Oakland (see under Alameda County), occasionally crushes some of the old brick from this place for use in the manufacture of roofing tile.

Remillard Brick Company. Greenbrae. "Shale and sandstone, practically inexhaustible." This plant was dismantled about 1911. The company operates plants at Pleasanton, Alameda County, and at San Jose, Santa Clara County (9 v.).

Bibl (On Marin County clay resources): State Mineralogist's Reports V, p. 108; VIII, p. 342; XI, p. 253; XII, pp. 329, 382; XIII, pp. 506, 615; XIV, pp. 244–248; XXII, pp. 317–319. Bull. 38, p. 362; Prel. Rept. 7, p. 64.

MENDOCINO COUNTY.

General Features.

Mendocino County joins Humboldt County on the south and is bounded by the Pacific Ocean on the west. Its area is 3453 square miles, and the population is 24,116 (1920 census). Lying in the Coast Range, the greater part of the county is mountainous and heavily timbered, except in the southeastern portion, through which flows the Russian River. Lumbering is an important industry.

The rocks of the Coast Range within the limits of the county consist mainly of Franciscan (Jurassic), Chico (Upper Cretaceous), and various Tertiary sedimentary and metamorphic formations. The mineral resources are largely undeveloped. Occurrences of asbestos, chromite, coal, copper, graphite, magnesite, and mineral water are known, as well as traces of gold, platinum, and silver. Miscellaneous stone, coal and natural gas are produced in small amounts.

Clay Resources.

Common brick clays are available near the coast at the town of Mendocino, and also at Ukiah. Brickyards were at one time operated in these places, and at Talmage, near Ukiah, but there has been no production in recent years. The brickyard of U. N. Briggs, at Ukiah, has been out of business since 1922. The most recent production of common brick was at the Mendocino State Hospital, at Talmage. See below.

[1] Laizure, *op. cit.*, p. 319.
[2] Especially in Prel. Rept. 7, p. 64.

Mendocino State Hospital. Talmage.[1] A brickyard was operated here for a few years to manufacture brick for use in construction work at the hospital. The clay consisted of a local deposit of gravelly silt, about 10 feet deep, and covering an area of about one-half acre. It was mined with a plow and scraper. The plant is equipped with a disintegrator, conveyor, pug-mill, and auger machine, with a wire cutter. The lack of screening equipment reduced the capacity of the machinery to 8000 brick per day instead of 30,000, on account of gravel in the clay. Firing was done in open field kilns. The production cost of the brick was stated to be $11.50 per thousand. There has been no production since 1924, as it was found that concrete construction is cheaper, with cement at $2.28 per barrel, delivered.

Bibl: State Mineralogist's Rept. XIV, p. 415; State Min. Bur. Prel. Rept. 7, p. 64.

MERCED COUNTY.

General Features.[2]

Merced County is situated near the geographical center of the state. It is bounded on the north by Stanislaus County, on the east by Mariposa, on the south by Madera and Fresno, on the west by Santa Clara and San Benito counties. It has an area of 1995 square miles and supports a population of 24,579 (1920 census). Most of the land is cultivated, and much of it is irrigated, there being extensive irrigation systems covering the valley lands. Merced is essentially an agricultural county.

The greater part of the county lies within the San Joaquin Valley, and is composed of unconsolidated sands, gravels, and clays of Quaternary age. Along the eastern edge of the county there is a narrow belt of Tertiary formations, represented mainly by clays, shale and massive sandstone. On the western side of the county Cretaceous sandstones and shales appear, and as the western boundary of the county, near the summit of the Coast Range, is approached, Franciscan rocks of Jurassic age are exclusively in evidence. These consist mainly of slates, cherts, sandstones, schists, and serpentine.

Both metallic and nonmetallic minerals have been found and produced in Merced County. Among the former are gold, platinum, silver, copper, and a few pounds of lead. Crushed rock, gravel, sand, clay, and clay products are the chief nonmetallics. In addition to these the occurrence of a few other minerals has been noted, such as cinnabar (quicksilver), stibnite (antimony), barite, calcite, diatomaceous earth, magnesite, asbestos, manganese, coal, and soda niter, but for the most part these are entirely undeveloped and probably most of them do not occur in marketable quantities.

Miscellaneous stone, including crushed rock, gravel, and sand, cement, brick and tile, are at the present time the principal mineral products. Structural materials of this nature will contribute almost exclusively to the future mineral output of the county.

Clay Resources.

No commercial deposits of high-grade clay have been found in the county, notwithstanding intensive investigations on the part of the

[1] Information secured through the courtesy of Dr. Donald R. Smith.

[2] From Laizure, C. McK., Merced County: State Mineralogist's Report XXI, p. 173, *et seq.*, 1925.

California Pottery Company and the Yosemite Portland Cement Company. The latter company recently built a cement plant near Merced and conducted an elaborate search for high-alumina clay, low in iron, but were finally forced to import this material from the Ione district.

There are a few remnants of the Ione formation in the foothills of Merced County. These have not been thoroughly prospected, but there seems little reason to hope for commercial clay deposits in them.

Clay suitable for the manufacture of common brick and hollow tile is available in the vicinity of Merced. A brickyard operated in Merced from 1905 to 1910. The clays from various places are now being used by the California Pottery Company (see *post*), the Yosemite Portland Cement Company, and the Craycroft-Herold Brick Company of Fresno. The latter company mines clay from a deposit six miles south of Merced, and ships to its plant in Fresno.

California Pottery Co. F. A. Costello, president. General office, Mills Building, San Francisco. Plant at Merced. The company also operates a plant in Oakland, Alameda County. The Merced plant is in the southern outskirts of Merced, between the state highway and the Southern Pacific railroad. The products of the plant are roofing tile, hollow tile, and some 3-in. to 6-in. drain tile. Red, buff, and pink ruffled face brick were formerly made.

The local clay is mixed with clay from the company's pit near Valley Springs, Calaveras County (samples No. 202–204, pp. 299 and 337), and with red-burning clay from the Natoma Clay Company in Sacramento County (samples No. 210 and 212, p. 337). The local clay is a valley silt, and is mined to a depth of 10 feet with team and scraper from a pit adjoining the plant. It has insufficient bonding strength and plasticity to be used alone, and at least 35% of the Valley Springs clay, or an equivalent amount of Natoma clay must be mixed with it.

The plant is equipped with a 10-ft. Raymond dry pan, one American number 290 auger machine for hollow tile and face brick, one American No. 233 auger for roofing tile, a 20-tunnel American waste-heat drier, and eight 30-ft., oil-fired, steam-atomized, round down-draft kilns. The dryer cycle is 36 hours. When there is insufficient dryer capacity, some ware is dried on the drier floor. Each of the kilns has a capacity of 125 tons of hollow tile, 100 tons of Sierra roofing tile, or 90 tons of Spanish roofing tile. Firing requires 72 hours, to a maximum temperature of cone 4–5 (1170° C.) for buff-colored ware, and to cone 2 (1135° C.) for red-colored ware. Seventy-five per cent of the output of the plant during 1925 was roofing tile. The output of drain tile is very small.

The plant is handicapped by the fact that clay must be brought in from the north, and at the same time, the principal market for the products are to the north.

Forty-three men are employed.

M. Goldman[1] of Merced is the owner of large land holdings in the eastern part of the county, and it has been reported in the past that white clay, suitable for the manufacture of pottery, occurs on this property in the vicinity of Merced Falls. The holdings have not been thoroughly prospected, but the investigations that were made failed in find-

[1] Laizure, C. McK., *op. cit.*, p. 179.

ing any high-grade clay; the material being apparently a silt deposit of indefinite composition, rather than a residual clay.

Clay deposits have been reported from T. 5 S., R. 14 E. Their character and value have not been determined.

Bibl (Merced County clay resources): State Mineralogist's Reports, XIV, p. 605; XXI, pp. 175, 177–179. Bull. 38, pp. 217, 250; Prel. Rept. 7, p. 64.

MONTEREY COUNTY.

General Features.[1]

Monterey is one of the central coast counties, extending from the Pajaro River, which empties into Monterey Bay, south to the sixth Standard Parallel. It is bounded on the north by Santa Cruz County. San Benito, Fresno and Kings counties adjoin it on the east, and San Luis Obispo County bounds it on the south. Its area is 3330 square miles and its population 27,980 (1920 census). The main line of the Southern Pacific railroad, coast division, runs through the county, connecting it with San Francisco and Los Angeles, as also does the state highway, a concrete paved road. Connecting county roads are kept in good condition, and it is only in the more remote mountainous sections that economic transportation becomes a problem. The completion of the proposed road along the coast, connecting Monterey and San Luis Obispo, now open from the north to a point 18 miles beyond Big Sur and from the southern end as far north as Salmon Creek, will open up a large area which has heretofore been accessible only by water or steep trails, and one whose mineral resources are scarcely known.

Among the principal topographic features is the great central Salinas Valley, the largest of the intermountain valleys of the coast region, being about 100 miles long by 6 to 10 miles in width, and lying parallel to the coast. Between the valley and the coast rises the Santa Lucia Mountain Range, which culminates in a number of peaks, some reaching nearly 6000 feet above sea level. Along the eastern side of the valley, and with their crests forming the eastern boundary of the county, are the Gavilan and Diablo ranges. Among the smaller valleys are the San Lorenzo, San Antonio, Cholame, Carmel, and Nacimiento. In each of these the principal axis extends northwesterly, parallel with the general structure of the mountain ranges.

Geology.

The geology of most of Monterey County is described and mapped in Bulletin No. 69 of the State Mining Bureau, 'Petroleum Resources of California,' and the folio accompanying it. It is also shown in lesser detail on the Geological Map of California (1916).

The Santa Lucia Range has a core of granitic rock. This is exposed in Santa Lucia Peak at an elevation of 5967 feet, and throughout the territory between Carmel River and Sur River, either along the coast or in the river cuts. Limestone and gneiss overlie the granite in places, and make up Pico Blanco, Ventana Cone, Marble Peak, Twin Peak, and Cone Peak. Most of the area from Mill Creek southward to Three Peaks and bounded on the northeast by Nacimiento River is made up of Fran-

[1] Laizure, C. McK., Monterey County: State Mineralogist's Report XXI, p. 23, 1925.

ciscan sandstone and shale, with intrusions of serpentine. It is in the region of these serpentine intrusions and the later intrusive acid dikes that the important mineral deposits of the Los Burros district are found. The geology of the Los Burros district has been described in considerable detail by Hill.[1] There is evidence throughout of much faulting, and the precipitous coast follows a fault line. Monterey sandstone and conglomerate flank the mountains on the southwest side of Nacimiento River, and dip towards the valley. Most of the older sediments exposed east of the Nacimiento consist of Monterey shale, which is considerably folded east of Jolon.

Along the coast, resting unconformably on the granite and Franciscan rocks, are raised beach deposits. The settlement of Gorda is located on the most recent of these terraces. This terrace is noticeable in Willow Creek, one-half mile back from its mouth, and also along the coast north of Gorda. These terraces are important in relation to placer gold. It is thought that the placer deposits near Jolon originated in a similar manner.

In the northeastern part of the county, in the Gavilan Range, granite occurs associated with gneisses and schists. In places these rocks contact with massive beds of metamorphosed limestone, and dolomite is commonly associated with them. Feldspathic segregations give rise to commercial deposits of feldspar along the range as far south as the Pinnacles. In the vicinity of the Pinnacles there is a small area where volcanic activity has taken place and extrusive volcanic rocks are in evidence. Farther south Tertiary sandstone and shales predominate. A long, narrow belt of the Franciscan rocks, including slates, sandstones, and much schist and serpentine, extends from Priests Valley southeastward beyond Parkfield. Workable coal beds are exposed in the vicinity of Priests Valley and the principal quicksilver deposits occur in the Franciscan, not far from Parkfield.

The following commercial minerals are of record as occurring in Monterey County: Arsenopyrite, barite, bitumen (asphaltum), calcite (limestone and marble), chromite, cinnabar (quicksilver), clay, coal, copper, diatomaceous earth, dolomite, galena, garnet, gold, graphite, gypsum, magnesite, magnetite, malachite, metacinnabarite, molybdenite, orthoclase (feldspar), psilomelane (manganese), quartz, salt, serpentine (asbestos), and stibnite. Not all of these have been produced in commercial quantities, however, nor is it known that all occur in sufficient quantity to be of value. About ten other species of mineralogical interest only have also been noted.

Clay Resources.

No commercial deposits of high-grade clays have been discovered in the county. Common brick clays are not abundant, but there is little doubt that suitable deposits can be found if needed for local purposes. A clay pit and brickyard were at one time operated on a small scale at the south end of Salinas. The only clay-working operations in the county at present (1927) are two hand-made roofing tile plants, which are described below.

Arca Roofing Tile Plant. Joe Arca of Castroville owns and operates a small hand-made roofing-tile plant one mile east of Castroville on the

[1] Hill, J. M., The Los Burros District, Monterey County, California: U. S. Geol. Survey Bull. No. 735–J, 1923.

Salinas road. The property covers one acre. The clay deposit consists of 18 ft. of yellow plastic clay, underlying one foot or less of black adobe. See sample No. 117, page 324, for test data on the clay. The clay is mined by hand and is fed to a horse-driven pug-mill. After the pugged clay is aged for a few days, the tile are shaped by hand over wooden forms, and are then dried in air under sheds. The clay is excessively plastic, and in the cool moist climate of the region, drying is very slow. The tile are fired in an oil-fired rectangular up-draft kiln.

The capacity of the plant is 500 tile per day, and three or four men are employed.

Mr. Arca reports that good roofing tile clay occurs on the Martin ranch near the Carmel mission. It was used by the Indians in making roofing tile for the Mission. Mr. Arca attempted to establish his plant there but found that the land was too valuable.

Monterey Mission Tile Co. H. L. Watson, president; T. H. Bane, secretary treasurer. The new plant of the Monterey Mission Tile Company is near Seaside, and about two miles north of Del Monte. The property covers three acres. The products are red-burned roof tile, floor tile, and step tile, all of which are hand-made. The clay is mined by hand methods from the Thomas Field ranch on the Laguna Seco grant, at a point 5.5 miles toward Salinas from the junction of the Salinas road and the Santa Cruz road just north of Del Monte. The total haul to the plant is seven miles. The clay is a black adobe, 10 feet deep, covered with 2 feet of sandy soil. Sample No. 214 was taken from the clay in storage at the plant. See page 327.

At the plant, the clay is mixed with approximately 20% of grog consisting of ground rejects from the kiln, pugged in a Patterson vertical pug-mill, and aged for at least three days before molding. A 5-hp. motor drives the grog crusher and the pug mill.

The tile are shaped by hand with Mexican labor, and are dried under sheds. The drying time varies widely with climatic conditions, but usually requires at least two weeks, on account of the cool, humid atmosphere generally prevailing in this region.

The tile are fired in a cylindrical up-draft kiln, 13½ feet in diameter in the lower 6-ft. section, tapering to six feet in diameter in the upper 5-ft. section, and finally tapering to four feet in diameter at the throat. The kiln will hold approximately 600 roofing tile. It is fired with four oil burners, placed in pairs at opposite sides of the kiln. The oil is preheated to 120° F. in electric heaters placed in the pipe line, and is atomized with air from motor-driven blowers. Four base-metal thermocouples, with a multiple recorder, are used to control the firing, in addition to Orton standard cones. The maximum temperatures recorded at the end of firing are 1830° F. on the bottom, and 1470° F. on the top of the kiln. Firing requires 32 to 38 hours.

The product is distinctly different in appearance from machine-made tile, and from most of the hand-made tile produced in the state, on account of the irregular texture and the play of colors to be seen on each individual tile. The owners of the plant were formerly builders in the district, and the tile plant is the outgrowth of a local desire for more artistic effects than could be obtained with the tile previously on the market. Since the tile are made by an expensive process, they are only to be seen on some of the finest residences in Carmel and Pebble Beach.

From 8 to 10 men are employed when the plant is in full operation.

Bibl: State Mineralogist's Report XXI, p. 57, Jan. 1925.

Miscellaneous Deposits.

Echstine Deposit. Mrs. G. P. Echstine, Pleyto. In T. 24 S., R. 8 E., M. D. M. An occurrence of white plastic clay had been reported to the Bureau. The deposit was investigated in September, 1926, and was found to consist of a plastic clay that is grayish white when dry, but darkens considerably when wet, and fires to a red color. The property is difficult of access, and is some 18 miles from the railroad, hence the clay has no possible commercial value.

Heins Lake Deposit. Owner, Martha E. Bardin, Salinas. The bottom of Heins Lake, now dry, situated about two miles southeast of Salinas, is reported to be composed of blue clay. There is about 300 acres in the deposit, and it is said to average four feet in depth.[1] No investigation was made by the author.

Jens Deposit. Chualar. A supposed deposit of clay from which it was reported that several thousand tons had been shipped. An investigation showed that the material is low-grade feldspar.

Bibl (Clay resources of Monterey County): Cal. State Min. Bur. Bull. 38, p. 250; Prel. Rept. 7, p. 65; Rept. XXI, pp. 29 and 57.

NAPA COUNTY.

General Features.

Napa County, with a land area of 783 square miles, runs nearly to a point at both extremities. It is bounded on the east by Solano and Yolo counties and on the west by Lake and Sonoma counties. Its southerly end touches San Francisco Bay. The main drainage system of the county is that of the Napa Valley, which is a rich agricultural section, and is served by a branch line of the Southern Pacific railroad, extending from San Francisco Bay to Calistoga, in the northwestern corner of the county. Mt. St. Helena, a prominent landmark, is in the northwest corner, at the junction with Lake and Sonoma counties.

The principal geological formations in the county, in addition to Recent sediments in the valleys, are Franciscan (Jurassic) slates, sandstones and serpentine, Miocene sandstones and shales, and Tertiary volcanics.[2]

The principal mineral resources include quicksilver, mineral water, miscellaneous stone, and magnesite. Occurrences of diatomite, limestone, copper, iron, chromite, gold, silver, and mineral paint have been noted. A cement plant at one time operated at Napa Junction.

Clay Resources.

Common clays suitable for brick manufacture occur in the Napa Valley. Previous to 1890 there was a plant in operation near Napa,

[1] Laizure, C. McK., *op. cit.*, p. 29.
[2] Smith, J. P., The geological formations of California: Cal. State Min. Bur. Bull. 72, and Geological Map.

where brick and drain tile were made. The cement plant at Napa Junction used local clay in cement manufacture.

An interesting occurrence of kaolin is described at considerable length below, not so much for its present value, which is doubtful in the present state of development, but because of its significance in encouraging further prospecting for commercial deposits in this region.

Clark and Marsh Kaolin Mine. This property, referred to in a previous report[1] as a 'china clay' deposit, owned by W. R. Teale, has been acquired by J. R. Clark and C. L. Marsh of Calistoga. The property includes the following areas: S½, SE¼, Sec. 12, and N½ NE¼, Sec. 13, T. 8 N., R. 7 W., and the S½ SW¼, Sec. 7, NW¼ NW¼, Sec. 18, and the diagonal (NW.–SE.) NE½ NE¼ NW¼ Sec. 18, in T. 8 N., R. 6 W., M. D. M., a total of 300 acres. The principal workings lie near the top of a hill, 3.5 miles by road south of Calistoga. Some road grading is necessary before trucks can be run to the mine.

PHOTO No. 27. Clark and Marsh Kaolin Mine. Main workings, facing west. Note scrub brush over deposit, and timber in left background on other formations. Calistoga, Napa County.

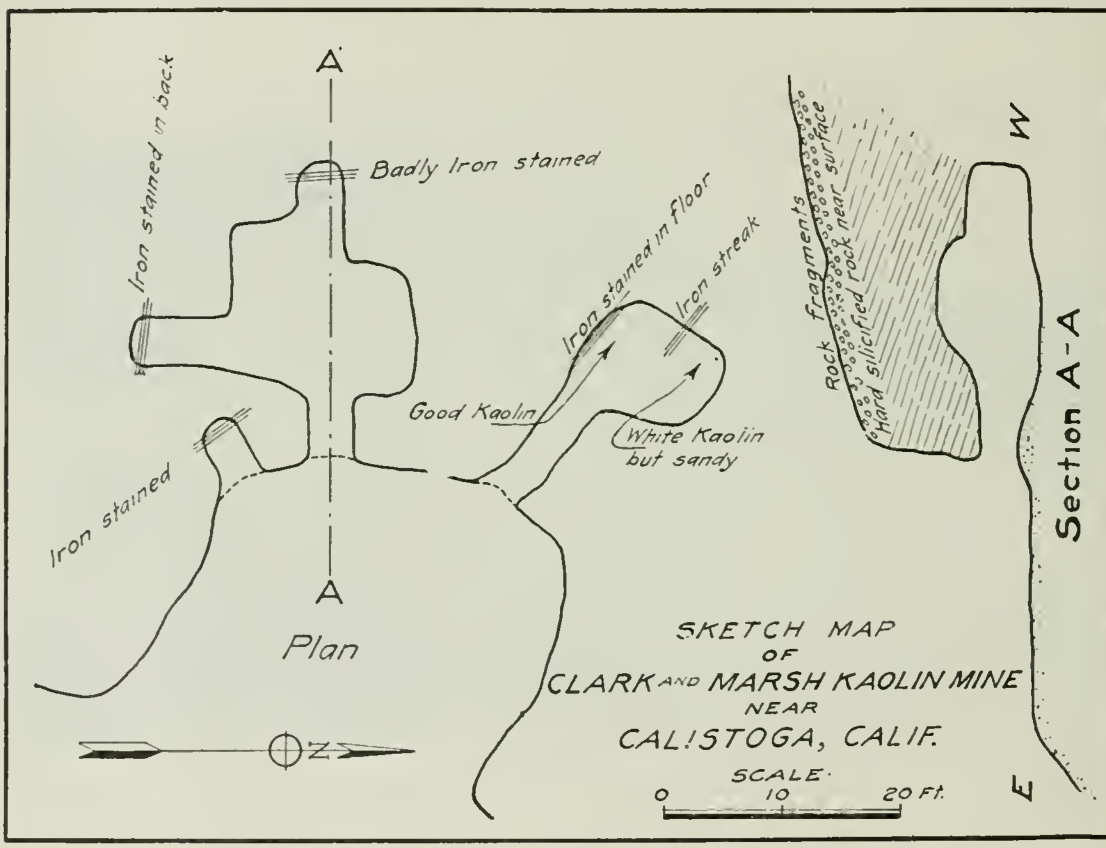
The deposit is a residual kaolin formed by the alteration of a rhyolitic rock that has a wide distribution in the region. This rock forms the crest of certain of the low hills south of Calistoga, and is distinguishable by its white color, and its hardness at the surface, where silicification has taken place. The debris covering the formation is very thin, and is composed of irregular grains and fragments of the silicified rock itself, with only enough soil to support a scattering growth of shrubs, principally manzanita, whereas the soil resulting from the decomposition of most of the other formations in the region is adequate to support a growth of heavy brush and trees. This characteristic is illustrated in photo No. 27, which is a view of the main workings.

Plate VII is a sketch map of the main workings, from which over 200 tons of kaolin have been removed, some of which has been shipped to

[1] Cal. State Min. Bur. Prel. Rept. No. 7, p. 65, 1920.

various clay products manufacturers for testing. An examination of the workings shows that the progress of kaolinization has been very erratic. The hard, silicified zone at the surface is from one to three feet thick. Below this, the kaolin varies from a non-plastic aggregate of partly-altered feldspathic grains, to a fine-grained mass that has fair plasticity. In places, following lines of fracture, the kaolin is heavily stained by iron-bearing minerals, but between these discolored areas, the mass of the material is practically white in color. The most discouraging feature of the workings is that most of the headings end in material that is badly iron-stained. It is estimated that 20% of the material exposed in the underground workings is contaminated with iron. The iron-stained portions are distributed in such a manner as

PLATE VII



to make hand-sorting necessary, rather than selective mining, if the material is to be mined on a commercial scale. The writer believes that the general conditions are sufficiently favorable to warrant more extensive prospecting near these workings, especially at greater depths below the surface.

From a point alongside a road about 1500 ft. north of the main workings, and at an elevation 400 feet below them, is a 72-ft. tunnel, having a direction of S. 75° W. Most of the material encountered in the tunnel is well kaolinized, but the mass of the material is slightly stained with iron. The best kaolin lies near the floor of the tunnel, in that portion between 25 and 50 feet from the portal. Nearer the face, the rock is not so well decomposed, and there is a large proportion of unaltered quartz and feldspar. It is possible that an extensive deposit of kaolin may be found by farther prospecting in this locality. No streaks of heavily iron-stained material were found in the tunnel, as in the workings near the top of the hill.

This deposit of kaolin has attracted considerable attention in the past from various clay products manufacturers, but none have felt warranted in incurring the expense of leasing or purchasing the property, and doing a sufficient amount of prospecting on it to determine the limits of workable material. It is one of the few localities in the state where high-grade residual kaolin has been found, and it is more accessible to marketing centers than the El Cajon Mountain deposit in San Diego County or the deposits at Hart, San Bernardino County, or even the sedimentary deposit on the Hunter Ranch, Orange County.

Sample No. 190 is representative of the average of the white kaolin exposed in the main workings. Sample No. 191 is from the same workings, but was taken from the iron-stained portions of the exposures. Sample No. 192 was taken as representative of the average white kaolin from the lower tunnel. The test results are on pages 261, 280 and 281.

Bibl (Clay resources of Napa County): State Min. Bur. Rept. XIV, p. 262; Prel. Rept. 7, p. 65.

NEVADA COUNTY.

General Features.

Nevada County is 12 to 20 miles wide and 80 miles long, reaching from the Sacramento Valley to the Nevada line. It is bounded on the north by Yuba and Sierra counties, on the east by the state of Nevada, on the south by Placer, and on the west by Yuba County. It contains 974 square miles, and its population is 10,860 (1920 census).

The mineral production of the county is mostly gold and silver. Some chromite, copper, granite, lead, and miscellaneous stone are also produced. Antimony, asbestos, barytes, clay, gems, iron, mineral paint, pyrite, soapstone, and tungsten also occur in the county.

Clay Resources.

Previous publications of the Bureau[1] have reported several clay deposits from the vicinity of Grass Valley, Nevada City and Colfax. Most of the localities mentioned and a few others that have been recently called to the attention of the Bureau were visited, but in no place was found a deposit of high-grade clay that would warrant exploitation under any commercial conditions that are likely to prevail for many years to come, although in a number of localities common brick clay of inferior quality occurs and in at least one locality, on the Sonntag Ranch, near Peardale (sample No. 169), a buff-burning clay with low shrinkage and fair strength was found.

The geology of this region has been described by Lindgren and others.[2] The few deposits of clay-like materials occur in the Tertiary superjacent series of sedimentary rocks and rhyolitic flows, and in many places are closely associated with the Neocene gold-bearing

[1] Prel. Rept. No. 7, p. 65.

[2] Lindgren, Waldemar, The Gold Quartz Veins of Nevada City and Grass Valley, California; Seventeenth Ann. Rept. U. S. Geol. Survey, Part 2, pp.1–262, 1896.

Lindgren, Waldemar, Tertiary Gravels of the Sierra Nevada of California: Prof. Paper 73, U. S. Geol. Survey, pp. 121, 159, 1911.

MacBoyle, Errol, Mines and Mineral Resources of Nevada County: State Mineralogist's Report XVI, Dec., 1918.

gravels. One of the most typical of these occurrences is the altered rhyolitic tuff (sample No. 172) in the Manzanita gravel pit, northeast of Nevada City. This is commonly described as 'pipe clay.' It is nearly white in color in the dry state, has good plasticity, but burns red and has a high drying and firing shrinkage. Other clays sampled in this region probably are variations of the same material, but mixed with varying proportions of decomposed granite and other products of decomposition of the bedrock series. In general, the better grade of clays differ from those found in Placer County from Alta to Gorge (page 158) in that they have a workable plasticity and workable firing properties, whereas all of the volcanic clays of Placer County thus far examined seem to be totally unsuited for ceramic uses.

The only known clay occurrence of possbile commercial interest in the county is that at Pine Hill, described below under Pine Hill Mine, and John Sweet Kaolin Deposit.

Banner Mountain. Sample No. 170: This was taken from near the Banner Mountain road, 1.0 mile east from the intersection with the Nevada City-Colfax road, in or near the NW¼ NE¼, Sec. 30, T. 16 N., R. 9 E., M. D. M. This probably corresponds to the deposit formerly reported under the name of E. M. Taylor.[1] The present owner of the adjoining property is W. E. Parsons, of Grass Valley. No development work has been done, but the deposit can be traced for several hundred feet, and is at least six feet thick, overlain by red andesitic soil. The material is a white clay shale, and the sample probably contains more iron than would be expected in the mass of the deposit, away from surface contamination. The test results are on page 315.

Beaser Ranch, Chicago Park. Sample No. 168: The sample was taken from an undeveloped deposit on the P. M. Beaser Ranch in the S½ S½ SW¼, Sec. 15, T. 15 N., R. 9 E., M. D. M. The clay is exposed along the side of a small creek bed. The extent of the deposit could not be determined, but it is at least two to three feet in thickness, and is overlain by nonplastic rhyolitic tuff. The deposit is within one-half mile of the narrow gage railroad connecting Colfax with Grass Valley. The test results are on page 313.

Manzanita Mine. Sample No. 172: This is a sample of 'pipe clay' from the Manzanita gravel pit, in the NE¼ SW¼, Sec. 6, T. 16 N., R. 9 E., M. D. M., 1.5 miles on the North Bloomfield road from the center of Nevada City. The clay occurs in beds from 3 to 6 ft. thick, interbedded with rhyolitic sandstone beds of approximately the same thickness. The total thickness of rhyolitic clay and interbedded sandstone is approximately 90 feet. This formation is overlain by 150 feet of andesitic tuffaceous breccia, and is underlain by 190 ft. of Neocene gold-bearing gravel, which in turn rests on the granodiorite bedrock. This occurrence and that represented by sample No. 171 probably corresponds to the occurrence previously described as lying in Sec. 6, T. 16 N., R. 9 E., near the Reddik and Odin mines.[2] The test results are on page 342.

North Bloomfield Road. Sample No. 171: This sample was taken from alongside the North Bloomfield Road, 1.8 mile northeast from

[1] Cal. State Min. Bur. Prel. Rept. No. 7, p. 65.
[2] *Op. cit.*

Nevada City, in the W½, Sec. 6, T. 16 N., R. 9 E., M. D. M. The ownership was not determined. Along the upper side of the road at this point is an exposure of moderately plastic, fine-grained clay, nearly white when dry, but greenish when wet. The bed is over 10 ft. thick and can be readily traced for over 300 feet. It is overlain by decomposed andesite. The test results are on page 329.

The *Pine Hill Mine*, now controlled by Ira J. Coe, 462 Mills Building, San Francisco, is on the northern half of Pine Hill in Sec. 13, T. 14 N., R. 7 E., M. D. M., one mile north of Wolf Post Office, and nine miles by road to a proposed railroad siding near Auburn. About two-thirds of this distance is on a paved highway. The property comprises 160 acres, including three patented claims, the Golden Gate, Golden Gate Extension, and Thrasher.

The mine was originally located and developed as a copper and gold prospect.[1]

Several well-defined veins have been found on the property. These contain some gold, silver, and copper, associated with quartz, pyrite, and limonite. The footwall of the principal vein is diabase, and the hanging wall is serpentine. Rhyolite and iron-stained porphyry are found in places. The rocks in the vicinity of the veins have been altered, and considerable kaolin has been formed, some of which is moderately pure. Four samples were taken from various points in the underground workings.

SAMPLE NO. 159: This is a sample of nearly white kaolin that occurs as a gouge in a vein exposed by workings on the west side of Pine Hill, near its crest. At this point, a cross-cut tunnel, 50 feet long, was run to cut the vein. From near the end of the tunnel, a vertical winze, 26 feet deep, was sunk, which was continued as an inclined winze in the vein which has a dip of 31°, S. 35° E. The inclined winze is now filled with water and debris to within 60 feet of the bottom of the vertical winze, so that the total depth of the incline could not be determined. The material included in the sample was from the footwall gouge that is exposed in the incline throughout its accessible length. It was impossible to secure a sample entirely free from iron staining by infiltration from the overlying pyritic quartz, as the workings have been open for many years, and are usually flooded to the floor of the tunnel each winter. It is claimed that auger holes have been drilled into the footwall to a depth of 14 ft. without penetrating the kaolin, and that below the layer of surface contamination, the kaolin is uniformly white in color. It was not possible to verify this statement. No such thickness is exposed in the cross-cut. It is obvious that if the drill-holes had not been drilled at right angles to the dip of the vein, false indications of thickness would have resulted. Further exploration in these workings is necessary before any attempt can be made to predict the quantity and quality of kaolin that may be available. The test results, page 261, are favorable, but not as satisfactory as to color as in sample No. 160.

SAMPLE NO. 160: This is a sample from the lower 10 feet of a 50-ft. vertical shaft near the top of the hill, 200 yards or more east of the

[1] MacBoyle, Errol, Mines and Mineral Resources of Nevada County: State Mineralogist's Report XVI, 1921.

West tunnel. The fired color and other ceramic properties of this material are satisfactory for many high-grade uses, as shown on page 261, and the occurrence of the deposit is such as to warrant the prediction that a commercial tonnage of uniform material would be disclosed by farther development. The material cut by the first 40 ft. of the shaft is similar in physical properties and in mineralogical constitution, but is light pink and yellowish in dry color, showing the presence of a higher proportion of iron oxide.

SAMPLE No. 166: This is a picked sample of white kaolin, occurring as a gouge in a vein cut by a tunnel entering the North side of the hill, at a low level. The gouge is from two to four feet thick, and grades into altered country rock, similar in composition to sample No. 167. The continuity and homogeniety of this occurrence is doubtful. It is unlikely that this occurrence will be of importance, as continuity, homogeneity, and sufficient thickness for economic mining may be lacking. The test results are given on page 316. The fired color is not as good as in sample No. 160, and the fusion point is considerably less.

SAMPLE No. 167: This is a composite sample from a cross-cut branch of the East tunnel. It is typical of the altered country rock of the hill, and occurs in abundance. The test results are given on page 315. It has weak plasticity.

Bibl: State Mineralogist's Report XVI, Nevada County, p. 88.

Sonntag Ranch, Peardale. Sample No. 169: The sample was taken from a drainage ditch on the south side of the You Bet road, 1.8 mile from Peardale station on the narrow gage railroad. The adjoining property to the south is owned by H. E. Sonntag, and is in the NE¼, Sec. 3, T. 15 N., R. 9 E., M. D. M. At this point a bed of white plastic clay crosses the road in an east-west direction, but is difficult to trace because of the overlying andesitic debris, which weathers to a red, plastic soil and obscures the underlying structure. No development work has been done. The clay bed is at least 4 feet thick. The sample was taken by digging a hole about one foot deep in order to avoid contamination from the andesite soil that has been washed over the outcrop, but even with this precaution, the sample contains more iron-bearing minerals than would be found in the mass of the deposit. Mr. Sonntag reports that the same clay was found in a spring on his ranch ½ mile to the west, but this could not be verified. It is not certain whether this deposit, or the one from which sample No. 168 was secured,[1] is the one referred to in previous reports[2] as occurring on the De Golia Ranch. The test results are on page 313.

John Sweet Kaolin Deposit. John Sweet of Wolf owns the south half of Pine Hill, consisting of 120 acres in Sec. 13, T. 14 N., R. 7 E., M. D. M. The same formations as those described under 'Pine Hill Mine' persist on this property, but very little development has been done. A 30-ft. vertical shaft has been sunk on the N½ NE¼ of the section, but this was not accessible at the time of visit in August, 1925. The general appearance of the material in the dump at this shaft

[1] See under Beaser Ranch, *ante*.
[2] Cal. State Min. Bur. Prel. Rept. No. 7, p. 65.

resembles that exposed in the 50-ft. vertical shaft on the Pine Hill property, from which sample No. 160 was taken, and the rather meager evidence available points to the conclusion that the kaolin was formed by the alteration of a diabase. A small sample, No. 158, was taken of the material lying on the dump, but was not tested.

An unsuccessful search was made for the deposits previously described at *Union Hill*, and that in Sec. 29, T. 17 N., R. 9 E., M. D. M.

Bibl (Clay resources of Nevada County): Cal. State Min. Bur. Bull 38, pp. 217–218, 250–251; Prel. Rept. No. 7, pp. 65–66.

ORANGE COUNTY.

General Features.[1]

Orange County is bounded on the east by Riverside County, north by San Bernardino and Los Angeles counties, west by Los Angeles County and the Pacific Ocean, and on the south by San Diego County. It comprises 795 square miles, about three-fifths of this area being valley land and the remaining two-fifths mountainous and foothill land. The population of the county is 61,375 (1920 census).

The Santa Ana Range of mountains is the line between Orange and San Bernardino counties, at the northeast corner of the former county. It is also the dividing line between Orange and San Diego and Riverside counties. This range also sends up a line of foothills westwardly along the seashore nearly half way across the county. All the western portion of the county is included in the Santa Ana Valley. The highest point of land has an elevation of 5675 feet above sea level, and is known as Santa Ana Peak.

The Santa Ana River comes into the county near the northeast corner and continues through it in a northwesterly direction, flowing into Newport Bay. Santiago Creek has its rise in the Santa Ana Range of mountains, and flows in a northerly and westerly direction, emptying into the Santa Ana River about two miles northwest of the city of Santa Ana. Aliso Creek has its rise in the same range, but on the southern slope of the mountains, and runs in a southwesterly direction, flowing into the ocean near Arch Beach, about twenty miles southeast of the mouth of the Santa Ana River. Trabuco, Mission Viejo, and San Juan creeks have their rise on the south side of the Santa Ana Range and come together near the sea, reaching the ocean at 'San Juan-by-the-Sea.' Coyote Creek marks the boundary of the county on the west.

Geology.

The formations of the region consist of a base of granitic and metamorphic rocks overlain by Cretaceous, Tertiary, and Pleistocene sediments.

The main portion of the Santa Ana Mountains is composed of ancient crystalline rocks, mostly slates of Jurassic age; along the western and southern flanks, rocks of Chico age are exposed, which in turn are overlain by small patches of the Eocene. In the Laguna Hills the formations exposed are mainly coarse sandstone of Eocene age. These are overlain along the edges of the hills by beds of sandstone and shale of the Monterey series. In the flat area running from Tustin to El Toro the dia-

[1] Tucker, W. B., Orange County: State Mineralogist's Report XXI, pp. 58–59, 1925.

tomaceous shale of the Monterey series is present, occupying a synclinal trough between the Santa Ana Mountains and the Laguna Hills. This condition continues southeast through the Capistrano district to the San Diego County line.

For detailed geology of Orange County the reader is referred to the reports by Bowers[1] and Fairbanks[2] in two of the earlier State Mineralogist's Reports.

Orange County is among the upper three counties in California in the value of its mineral production, the other two being Los Angeles (first in 1926) and Kern (second in 1926) counties. In all three cases, the principal product is petroleum. Of secondary importance in Orange County are natural gas, miscellaneous stone, clay, brick, gold, silver, copper, lead, and zinc. Besides these substances, occurrences of coal, gypsum, diatomite, sandstone, and tourmaline have been found in Orange County.

Clay Resources.

Low-grade clays for use in making red-burned structural ware are fairly abundant in the county, and plants seeking a location need have no difficulty in finding suitable material.

On the west side of the Santa Ana Range are deposits of high-grade clay that are apparently equal in geological age to the Eocene clays of the Temescal Valley (Alberhill-Corona district) in Riverside County. These deposits have been developed in recent years, and a number of exceptionally good varieties of fireclay are now being produced commercially. An especially interesting occurrence of flint fireclay occurs on the Goat Ranch, in Santa Ana Canyon, in the Upper Chico (Upper Cretaceous) formation.

American Silica Company. G. Ray Boggs, president. Office, Suite 1212 Pacific Mutual Building, Los Angeles. This company controls an important deposit of fireclay on the Hunter and Robinson ranches, 12 miles by road east of the town of El Toro. The Hunter Ranch lies in Sec. 11, T. 6 S., R. 7 W., S. B. M., and the Robinson Ranch is adjoining. At the time the property was visited, in August, 1925, some 1500 tons of clay had been mined from two different openings. Two samples were taken, No. 63 and 64. The test results are on page 260. Since 1925, the property has been extensively developed, and new deposits of valuable fireclays have been discovered, hence a description of the earlier developments is of little value at this time. Through the courtesy of Mr. Boggs, several samples of the clay that was in use in 1926 were secured, both as crude clay, and in mixes that were prepared for the manufacture of fire brick. See samples No. 266, 268 and 270, on pages 292, 260 and 282, respectively.

The clays are probably of Eocene age.

Brea Clay Products Company. C. M. Haaker, president; A. D. Yost, superintendent. Home office, Brea. The plant is on the eastern side of the town of Brea.

Operations commenced in the summer of 1925. Common red brick is manufactured from local surface clay which is mined to a depth of

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[1] Bowers, Stephen, Orange County: State Mineralogist's Report X, pp. 399–409, 1890.

[2] Fairbanks, H. W., Geology of San Diego County; also portions of Orange and San Bernardino counties: State Mineralogist's Report XI, pp. 113–118, 1893.

10 to 12 feet with a steam shovel. A drag-line conveyor delivers the clay to a belt conveyor which feeds a pug-mill and auger machine, equipped with a hand operated side cutter. After drying in the open and under sheds, the brick are fired in open oil-fired field kilns. A semi-Diesel engine is used for operating the plant.

The output at the time of visit in July, 1925, was 60,000 brick per day, and an increase to 80,000 was expected within a short time. The company also expected to produce hollow tile and roofing tile.

Sample No. 65 was taken for testing. See page 322.

Garber Brick and Tile Co. H. Garber, president, Olive. The company controls 6 acres, one-half mile east of Olive, on the Orange County Park road. Common brick, hand-made roofing tile, floor tile, roof dressing and a dust product for molding sand are manufactured.

All of the clay used is mined from a pit on the property. Material is transported from the clay pit by a drag scraper to the plant, where it passes through rolls, is elevated to storage bins. The brick are made by the soft mud process. A pug-mill prepares the clay for the brick press as well as for the tile plant. The brick are conveyed by a cable conveyor to drying racks. After drying, the brick are burned in field kilns, using natural gas as fuel.

Both roof and floor tile are hand molded, air dried under sheds, and fired in two down-draft kilns. The rated output of the plant is 2000 roof tile and 25,000 brick per day. The equipment includes a 30-h.p. boiler, Ingersoll-Rand compressor, Blake type crusher, screens and elevators. From 25 to 30 men are employed.

Bibl: State Mineralogist's Report XXI, p. 65.

Gladding, McBean and Company. Office of Southern Division at 621 South Hope Street, Los Angeles. This company, through its merger with the Los Angeles Pressed Brick Company, now owns the Goat Ranch, noted in previous reports[1] as containing an important deposit of flint fireclay. The location of the property is shown on Plate X, under Riverside County. The property consists of 1700 acres, and lies in an extremely rugged portion of the Santa Ana Mountains, south of Gypsum station on the Santa Fe railroad. The deposit lay idle for many years, but since 1925 considerable development work has been done, which has demonstrated the presence of large deposits of flint fireclay and red-burning shale in the Upper Chico (Upper Cretaceous) formation. A view of one of the fireclay exposures is shown on photo No. 28, and one of the red shale prospect pits is illustrated on photo No. 29.

The flint fireclay, when dry, is gray to black in color, and has a conchoidal fracture. The lighter-colored varieties have very much the appearance of chert, but can easily be scratched with a knife, and when ground with water, develop moderate plasticity.[2] It contains from 34% to 40% of alumina, and is highly refractory. Sample No. 282 was taken for testing, but should not be considered as representative of the deposit, as it is a grab sample from development workings. The results are on page 282. Sample No. 221 (page 330) of similar material,

[1] Prel. Rept. 7, p. 66, and Rept. XXI, p. 66. Listed under "Los Angeles Pressed Brick Company."

[2] In this connection, see Walker, T. C., The Effect of Fine Grinding on an Indurated Clay: Jour. Amer. Cer. Soc., Vol. 10, pp. 449–450, June, 1927.

but of much poorer quality and containing a high percentage of iron, was also tested.

The red-burning shale has been prospected at a number of points on the property. It is of value in the manufacture of red-burned vitri-

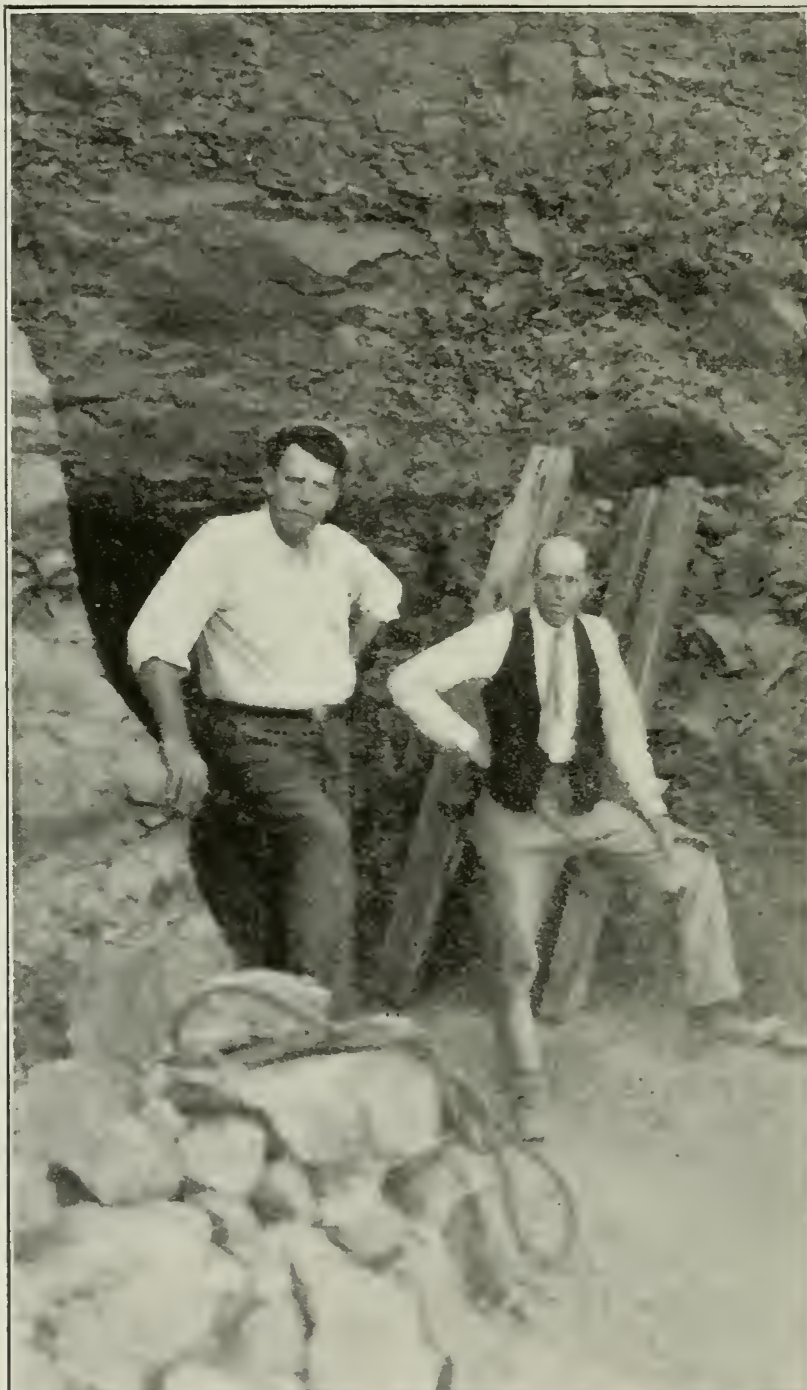

PHOTO No. 28. Flint fire clay at portal of tunnel, Goat Ranch, Gladding, McBean and Company, Orange County. (Sample No. 282.)

fied ware, such as sewer pipe and paving brick. Sample No. 223 (p. 343) was taken and tested.

La Bolsa Tile Company. G. W. Moore, president; A. W. Griffith, secretary and manager; E. R. Bradbury, superintendent. Home office, Huntington Beach. This company has been established for twenty years. The plant and clay pit are two miles north of Huntington Beach at Weibling siding on the Southern Pacific Railway, adjoining the northern edge of the Huntington Beach oil field. The company

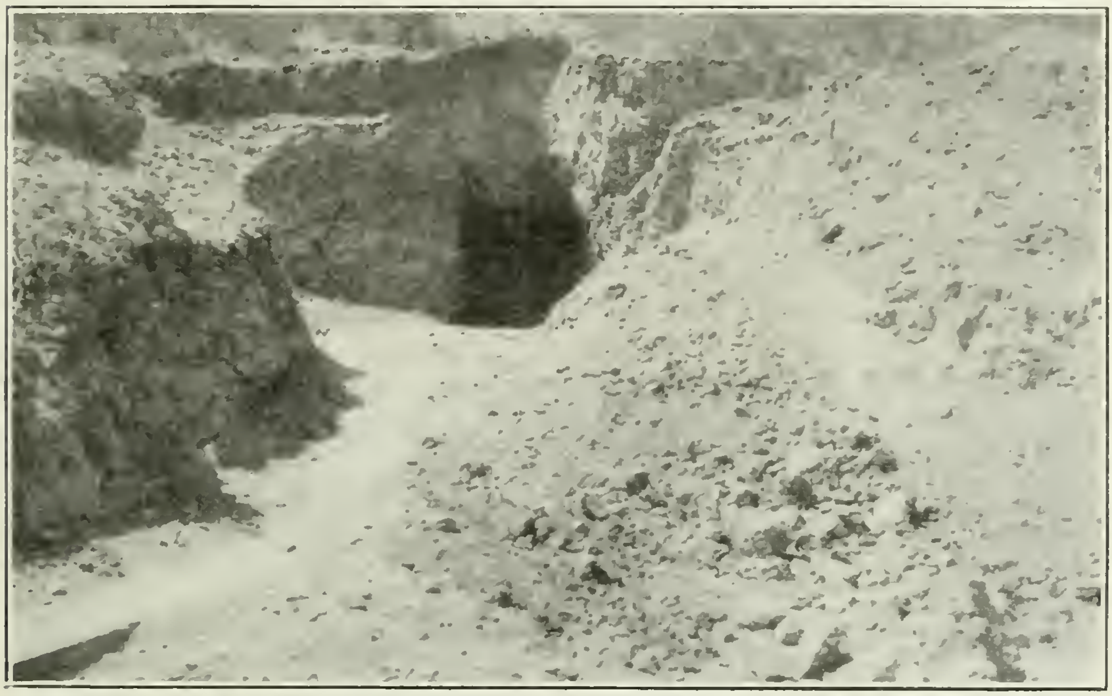

PHOTO NO. 29. M M 2 pit, Goat Ranch, Gladding, McBean and Company, Orange County.

PHOTO NO. 30. Plant of La Bolsa Tile Company, Weibling, Orange County. (From State Mineralogist's Report XXI, p. 65, 1925.)

owns 31 acres in Sec. 35, T. 5 S., R. 11 W., S. B. M. The products are drain tile from 3 to 20 inches in diameter, hollow building blocks, common brick, and more recently, ruffled face brick. Photo No. 30 is a view of the plant.

The clay is mined to a depth of five feet by a Fordson tractor, using a harrow for loosening and a scraper to deliver it to a hopper, which feeds a dry pan. An elevator delivers the ground material to a hopper which feeds a short pug-mill from which the clay passes to an auger machine. The plant is equipped with two auger machines which are used to shape all products except drain tile of 10 inches diameter or larger, for which purpose a vertical steam press is used.

The drying sheds are heated by hot air forced by a blower through flues under the floor. The air is heated either by the exhaust from the kilns or by exhaust steam. The drying sheds have a storage capacity of 60,000 tile. The drying cycle is from 24 to over 60 hours, depending on the size of the ware.

The plant is equipped with three 28-ft. down-draft kilns, with a capacity of 70 to 80 tons of material each, and one 32-ft. kiln, with a capacity of 100 tons. Natural gas is generally used as fuel, but the plant is equipped for oil firing when needed. The firing cycle is 72 to 80 hours to a maximum of 1650° F.

The finished products are dense and hard with a good red color. Ten men are employed.

Bibl: State Mineralogist's Report XXI, p. 66; Prel. Rept. No. 7, p. 66.

Olive Roofing Tile Co. Ramon Flores, owner. This is a small plant near that of the Garber Brick and Tile Company. Hand-made roofing tile is the only product. Surface clay from the property is utilized. One kiln is in use.

The plant is a Mexican operation, and as many as 24 men are employed at times.

Orange County Brick and Tile Company.[1] F. C. Krause, president; Charles Page, secretary; W. J. Carmichael, general manager. The company owns nine acres in Sec. 9, T. 4 S., R. 10 W., within the city limits of Anaheim.

The company is manufacturing building brick, and also produces sand for building purposes. The material used is unconsolidated sand. The sand is mixed with lime and cement in the following proportions: Common brick: lime 7½%, cement 2%. Face brick: lime 10%, cement 5%.

Material from the sand pit is transported by drag-line scraper to a hopper, from which it goes to a bucket elevator, elevated and then passed through a revolving screen. Here it is sized into three different sizes; the over-size and the minus 8-mesh going to storage bins, the fine sand to wet-grinding pan, where it is ground and then elevated to two bins, then sent on to the mixer from which it is fed to two American clay brick rotary presses. One press has a capacity of 8000 brick, the other 17,000 brick. The brick then are loaded on to cars and given 10-hour heat treatment under 125 pounds pressure in two Hardinge cylinder driers. These driers are 80 feet long by 6 feet in diameter. Heat for cylinder driers is furnished by 70-h.p. boiler, oil being used as fuel. The other equipment is driven by electric motors. Ten men are employed.

[1] By W. B. Tucker, *op. cit.*, p. 66. While not a ceramic operation of the type being considered in this report, this description is included here as of general interest, as it is typical of similar operations in various parts of the state.

The Vitrefrax Company (*O'Neill Ranch* Fire Clay Deposit). On the Rancho de Santa Margarita, the greater portion of which is now owned by the Jerome O'Neill family, are several excellent showings of high-grade fireclay, one of which has been leased and developed within the last few years through the efforts of the Vitrefrax Company of Los Angeles. This deposit is 10.2 miles by road east of San Juan Capistrano, in Gabino Cañon, close to the San Diego County line. The material consists of a white and blue-gray fireclay high in alumina, and quite free from iron stains. It is known locally as a bone clay, and in fact corresponds in analysis to that of typical bone clays, but without the distinctive pisolitic structure of the type clays. The fireclay bed is overlain by a thin bed of black carbonaceous plastic clay, which separates it from the overlying loosely consolidated sandstone. Underlying the fireclay is a mottled plastic clay, similar in general appearance to the Alberhill pink-mottled variety. The thickness of the

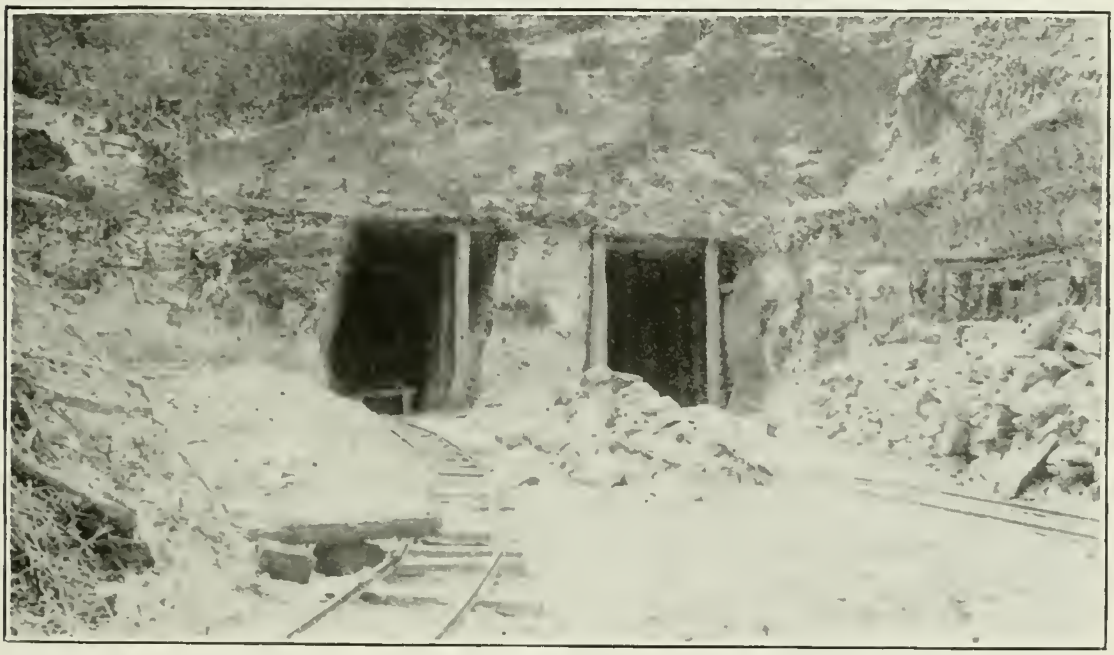

PHOTO No. 31. Vitrefrax Co. Entrance to upper chamber workings, O'Neill Ranch clay deposit, Orange County. (Sample No. 62.)

fireclay, as exposed in the workings, is from 10 to 15 feet. The bed is flat-lying, with a slight westerly dip. A view of the deposit is shown on photo No. 31.

The clay is recovered by chamber mining, using posts where needed to support the overburden. At the time of visit, in July, 1925, an area of 70 by 25 feet had been mined and a 100-foot tunnel had been driven to the west of the chambers, and at a lower level, with the object of providing for gravity loading of small mine cars, by means of a raise to the clay bed. One of these raises had been driven nearly to the roof of the clay, and demonstrated that the total thickness of clay above the tunnel is nearly 20 feet.

At several other localities in the vicinity are exposures of various grades of clay. It is likely that in the future, important clay beds will be developed and mined.

Sample No. 62 was taken for testing. See page 259.

Bibl (Clay resources of Orange County): Repts. XV, 519; XXI, pp. 65–67. Prel. Rept. 7, pp. 66–67.

PLACER COUNTY.

General Features.[1]

Placer County extends from the Sacramento Valley on the west for a distance of 80 miles to the Nevada state line on the eastern slope of the Sierra Nevada, including the larger part of Lake Tahoe. The total area is 1395 square miles. The elevation increases gradually from near sea level on the west to mountain peaks 8000 to 9000 feet high along the summit of the range on the east, then descends to 6225 feet along Lake Tahoe. There is a corresponding variation in climatic conditions. The western part of the county below an elevation of 2500 feet supports most of its industries and nearly all of the population of about 20,000. In this region snow seldom falls below 2000 feet elevation and never lies on the ground below that elevation. The county seat, Auburn, is at an elevation of 1360 feet, and the district from there westward through Newcastle, Penryn, Loomis and Rocklin is the most important deciduous fruit producing area in the state, Newcastle being the leading shipping point. The soil is mainly decomposed granite and granodiorite on the west and amphibolite schist and diabase near Auburn and to the east, until the granodiorite of the high mountains is reached.

The Ogden route of the Southern Pacific system traverses the county from the Sacramento line to the summit of the Sierra Nevada, passing through the principal towns, and the Oregon branch of the same railroad, leaving the main line at Roseville, passes northward through Lincoln, serving the farming and clay working industries there. Two state highways run about parallel to the two lines of railroad, one eastward from Sacramento over the mountains, and the other northward from Roseville along the east side of Sacramento Valley. A third state highway runs north from Auburn to Grass Valley and Nevada City, in Nevada County.

Taking its name from the Spanish, because of the richness of its surface gold placers, the county showed a great diversity of mineral resources at an early date, and was distinctly a mining county until about 1890, when fruit raising began on a large scale for eastern shipment. Lumbering and the summer grazing of cattle in the higher mountains have been less important industries.

Gold has been the principal mineral product of the county, but since 1920 the value of the pottery clay and brick production has exceeded that of the gold production. Since 1922, the value of pottery clay alone has been greater than that of gold. Other mineral products that have been produced commercially in recent years include miscellaneous stone, granite, silica (quartz), chromite and copper. Small tonnages of asbestos, manganese ore, magnesite, mineral paint and soapstone have been shipped at various times, and the limestone production of the county was at one time of importance.

Clay Resources.

A remnant of the Ione formation, containing valuable clay deposits, occurs on the edge of the Sacramento Valley at Lincoln. Since 1875,

[1] Logan, C. A., State Mineralogist's Rept. XXIII, pp. 235–237, 1927.

this area has been a clay producing and clay working center. Present production from the district is between 125,000 and 150,000 tons annually. Other remnants of the Ione formation occur at various places in the county, and clays have been found in other formations, but none of these have led to the discovery of commercial deposits. On account of the fact that the active clay working industry centers about Lincoln, the discussion of the clay resources of the county is divided into two sections: the Lincoln District, and Miscellaneous Deposits.

Lincoln District.

At Lincoln is one of the three most important clay deposits in the state. The deposits underlie a group of low hills that rise to a maximum of 80 feet above the alluvial plain of the Sacramento Valley. The clays are a remnant of the Ione formation which was protected from erosion by a capping of andesite-agglomerate. As shown by C. N. Schuette,[1] and illustrated in the vertical section through a portion of the property of the Clay Corporation of California, plate IX, the upper clay beds have been removed by erosion a short distance beyond the limits of the present lava cap. Since the period of erosion, gravel, sand, and soil from the rivers and flood plains of the Sacramento Valley have raised the floor of the valley to its present level.

In some places the recent deposits abut against the margin of the lava cap, and in other places they lie against the gently-sloping surface of erosion of the upper clay beds, thus affording some exposures of clay which aided in the original discovery and development of the deposits.

The clay beds lie practically horizontal, and are characterized by remarkable uniformity in thickness and quality over large areas. Several different beds can be differentiated and are of sufficient thickness to permit separate mining. The ceramic properties of the clays may be summarized as follows: The drying and firing shrinkage is high, but shrinkage takes place with little danger of cracking. The fusion point lies between cone 28 and cone 33; fired colors range from light buff to light red; knife hardness develops near cone 1; vitrification is well advanced (less than 3% absorption) at cone 13; and fired strengths are good, but with the highly-grogged mixtures necessary to avoid excessive shrinkage, the body strength may not be so high as is desired. The principal uses are for architectural terra cotta, fire brick and stoneware.

Clay Corporation of California. John T. Roberts, president. Home office, Rialto Building, San Francisco. The mining property of the Clay Corporation of California, a subsidiary of the Stockton Fire Brick Company, has recently been described by C. N. Schuette.[2] The description that follows is partly based on Mr. Schuette's article, and partly upon notes made by the writer when the property was visited on August 13, 1925, and again on June 25, 1926.

The property is in Sec. 4 and 9, T. 12 N., R. 6 E., M. D. M. The area is covered by andesite-agglomerate from its southern boundary to

[1] Engineering Principles Applied to Exploitation of a Clay Deposit, Eng. and Min. Jour.-Press, Vol. 121, p. 964, June 12, 1926.
[2] *Op. cit.*

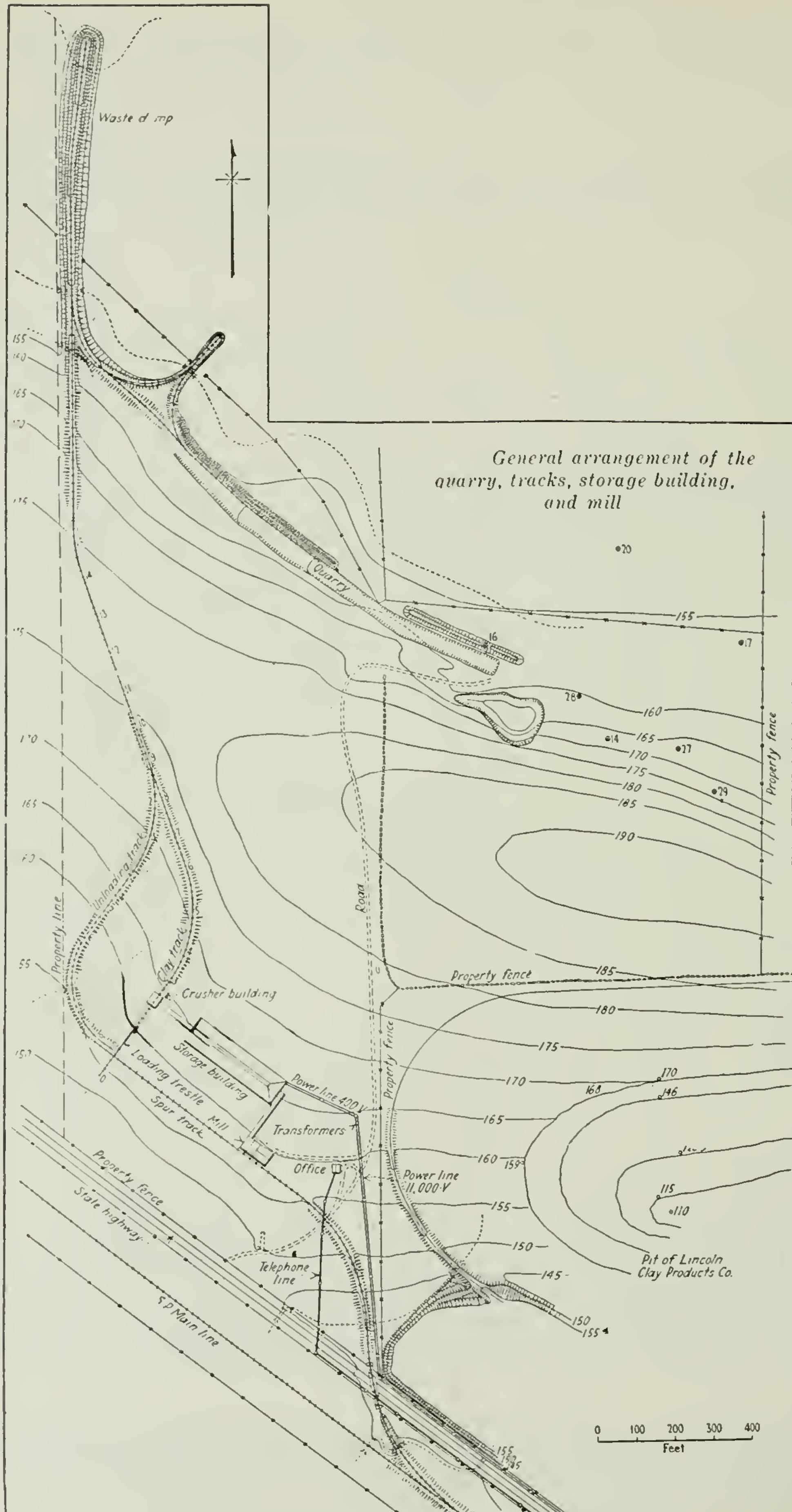

PLATE VIII. General arrangement of quarry and plant of the Clay Corporation of California, Lincoln, Placer County. (Reprinted by permission of Engineering and Mining Journal.)

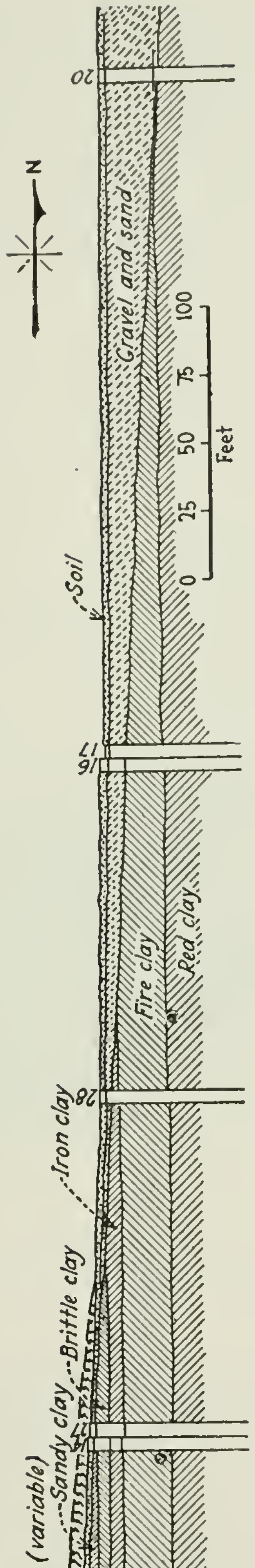

PLATE IX. Vertical section of clay beds on Clay Corporation of California's property, near Lincoln, showing drill holes. (Reprinted by permission of Engineering and Mining Journal.)

a line roughly parallel to and approximately 1600 ft. north of the Lincoln-Marysville highway. Drilling and test pitting shows that all of the clay beds exposed in the adjoining property of the Lincoln Clay Products Co. on the south persist on an even grade, thickness, and character under the area covered by the lava flow, but that they do not persist northward as they had been removed by erosion before the deposition of the valley sediments. This condition is shown in the generalized north-and-south cross-section, plate 9. Over 1,000,000 tons of clay corresponding to the Lincoln Clay Products Co. No. 1–6, have been developed.

The general arrangement of the quarry and plant is shown on plate VIII. Since the stripping is as thick or thicker than the underlying clay, the trackage was laid out to place the waste dump as near the pit as possible. The quarry starts on the north slope of the hill and is carried parallel to the trend of the hill, thus giving a pit face of sufficient

PHOTO No. 32. End-cut during preparation of pit of Clay Corporation of California, at Lincoln, Placer County. (Samples No. 152 and 153.)

length to yield a full season's tonnage at one cut. The pit face is 1700 feet long.

The pit equipment consists of a $\frac{3}{4}$-cu. yd. gasoline shovel, an 8-ton gasoline locomotive, ten 3-yd. rocker dump cars, and two flat cars. Thirty-pound rail and 36-in. track grade is used, with a maximum of 2% grade. Photo No. 32 shows the shovel at work during the preparation of the pit.

The clay storage plant was designed with the object of securing a thorough mixing of the clay as received from the pit, and to remove as much water as possible before shipping. The clay is crushed to $2\frac{1}{2}$ in. in a 21 by 42 in. single-roll crusher. The crusher discharge is carried by an 18-in. belt conveyor to the top of the storage building, where it is spread in a thin layer over the surface of the bin by a self-propelled, self-reversing tripper. Drying by the hot summer air sweeping through the building is very effective. A concrete reclaiming tunnel under the floor of the storage building is equipped with hand-operated gates to discharge the clay to an 18-in. belt conveyor, which carries it to a cross-tunnel at one end of the building, where the clay is delivered to an inclined-belt conveyor, 18 in. wide, running up to the top of the three 50-ton storage bins in the mill building.

From the end bin the clay can be drawn directly into railroad cars on the spur track. From either or all of the bins, the clay can be fed by apron feeders to a chute leading to a five-roller low-side Raymond mill. The pulverized clay is blown to a cyclone collector in the top of the mill building, and is delivered to any one of three 50-ton bins, which are fitted with three sacking spouts each. The sacked clay is stored in the building while awaiting shipment.

The pit is operated in the dry season between May and December. The minimum operating force consists of the superintendent, two men on the shovel, two men on haulage, and two men to operate the plant. Two or three extra men may be required from time to time, and at the beginning of the season a track gang is employed for two weeks to prepare the track for the season's operation. Two men attend to shipping and pulverizing in the winter.

The capacity of the plant, from pit to storage, is three 5-car trains per hour, or slightly over 540 tons per 8-hr. day. The maximum capacity of the storage building is 18,000 tons. The total annual capacity of the plant when operated as described is 50,000 tons. This could be increased without extra equipment by two-shift operation during the summer, with storage of pulverized clay, as well as crushed clay, at the beginning of winter.

The storage and pulverizing plant require 192 hp., distributed as follows:

Unit	Horsepower of driving motor
21 by 42-in. single-roll crusher	40
18-in. conveyor, 366 ft. long	20
18-in. reclaiming conveyor, 265 ft. long	15
18-in. cross conveyor to mill building, 172 ft. long	15
Bin feeders	2
Raymond mill	60
Raymond mill fan	40
Total	192

Miscellaneous electric power used on the property include a compressor for operating rock drills, a pump for draining the pit, and a lighting system.

SAMPLES: At the time the pit was sampled, on August 13, 1925, the cut had not been carried to the bottom of the bed that corresponds to the No. 1–6 clay (sample No. 146, p. 303) on the pit of the Lincoln Clay Products Co. Two samples were taken, however, both of which overlie the No. 1–6 clay. In 1926, a sample of prepared clay was obtained from the company, and was tested under No. 280.

No. 152 is a plastic clay lying in a 6-ft. bed beneath the capping. The test results are given on page 304. No. 153 (p. 299) is a less plastic clay from a 3 to 4 ft. bed underlying No. 152. It is one of the clays included in the No. 0 (sample No. 145, p. 291) clay of the Lincoln Clay Products Co. No. 280 is more representative of the material available during the normal operation of the pit. (See page 305.)

Gladding, McBean and Company. Lincoln Plant. Atholl McBean, president; A. L. Gladding, vice president. General offices, 660 Market

Street, San Francisco. Chas. Gladding, manager at Lincoln. The Lincoln plant of Gladding, McBean & Co. was established in 1875, and has operated continuously since that time. The company was incorporated in 1886, and has steadily expanded the scope of its operations until at the present time it is the largest clay products manufacturing organization west of the Mississippi Valley. The company now owns three large plants, one at Lincoln, one at Glendale, Los Angeles County, and the third at Auburn, Washington. It has recently acquired control of the Los Angeles Pressed Brick Co., operating several large plants in southern California, and of the Denny-Renton Clay and Coal Co. of Seattle, Washington, operating two plants in Washington and one at Portland, Oregon.

The Lincoln plant specializes on architectural terra cotta, fire brick, face brick, roofing tile, sewer pipe, chimney pipe, and garden pottery. A fine example of the use of architectural terra cotta manufactured at

Photo No. 33. Clay pit of Gladding, McBean & Co., at Lincoln, Placer County.

Lincoln is the new Russ Building in San Francisco. Photo No. 1 (frontispiece) is a view of this building. Many other important buildings on the Pacific Coast have been faced with terra cotta from one of the company's plants.

Clay Deposit: The company owns 480 acres of clay land in Sec. 9 and 10 of T. 12 N., R. 6 E., M. D. M. The present working pit, shown in photo No. 33, is in the SE¼ of Sec. 9. A section through the pit is as follows:

Section Through Pit of Gladding, McBean & Co., at Lincoln.

Sample No.	Test data on page	Character of material	Thickness, feet
		Lava: Andesite-agglomerate	8
155	325	Pit sand: Iron-stained clay, sand and fine gravel	10
		Sand and gravel, not usd	15
156	299	Fire-proofing clay, corresponding in quality and thickness to L. C. P. Co., No. 0, sample No. 145	7
157	304	Terra cotta clay, corresponding in quality and thickness to L. C. P. Co., No. 1–6, sample No. 146	15

Data were not available for definitely determining the correlation with the clay beds exposed on the properties to the north, but it seems probable that the fire-proofing clay, sample No. 156, corresponds to the No. 0 clay of the Lincoln Clay Products Co., sample No. 145, and that the terra cotta clay, sample No. 157, corresponds to the No. 1–6 clay, sample No. 146. The overlying sand and gravel beds in the Gladding, McBean pit would indicate that the lava cap was laid down on this area before these beds were eroded, whereas to the north most of the material overlying the clay beds had been removed before the deposition of lava, and in some places the upper clay beds themselves had been partly encroached upon by erosion. However, the bed underlying the terra cotta clay is of similar material, which indicates either that the No. 7 and No. 8 clays of the Lincoln Clay Products Co. are absent here, or that the correlation does not hold.

Mining: The clay is mined by steam shovel in benches, as shown on photo No. 33. The pit is over 1100 ft. long. Waste is carried to the dump, and clay to the plant, on an industrial railroad, with a steam locomotive and 5-ton dump cars. The production of clay is at the rate of approximately 500 tons per day during the dry season. Water that runs into the pit during the winter is pumped out at the beginning of each dry season, and little pumping is ordinarily required during the summer.

Plant: The plant occupies a 25-acre tract, on the northern edge of the town of Lincoln, and nearly one mile southeast of the clay pit. An airplane view of the plant is shown on photo No. 34. In addition to clays from the local pit, clay and sand from Ione, clay from Natoma, quartz from various sources, and grog are used in the body mixtures. In the design and operation of the plant, extreme care is used to ensure uniformity of raw materials, and accuracy of body proportioning. Upon being delivered to the plant, all materials are stock-piled separately in a covered shed. A 4-ton traveling crane reclaims the materials and delivers them to one of nine small bins, which feed four dry pans, operated to grind through a 14-mesh screen. The ground materials, still separate, are then elevated to storage bins. The body mixtures are proportioned from these bins by means of disc feeders.

The terra cotta body mixture contains approximately 50% terra cotta clay, 10.0% non-plastic clay, and 40.0% grog, by volume of minus 14-mesh material.[1]

The body mixture is prepared by double pugging, and the average water content of the wads is 26%. The wads are aged under damp burlap in cool rooms before being sent to the pressers, but the minimum aging period is often only two or three hours. The pressing room has no unusual features. All of the terra cotta and garden pottery are shaped by hand pressing in plaster molds.

Terra cotta, roofing tile and electrical conduit are dried in Carrier ejector humidity driers, which are designed to give accurate control over the four factors of time, temperature, humidity and velocity during drying. The drying cycle in use at the time of visit on August 14, 1925, was as follows: The drying atmosphere began with five hours at 120° F. and 60% humidity was increased by steps to 212° and 50%

[1] Larkin, P. G., and Curry, E. R., Notes on Terra Cotta Body Shrinkage, Jour. Am. Cer. Soc. Vol. 8, p. 113, 1925.

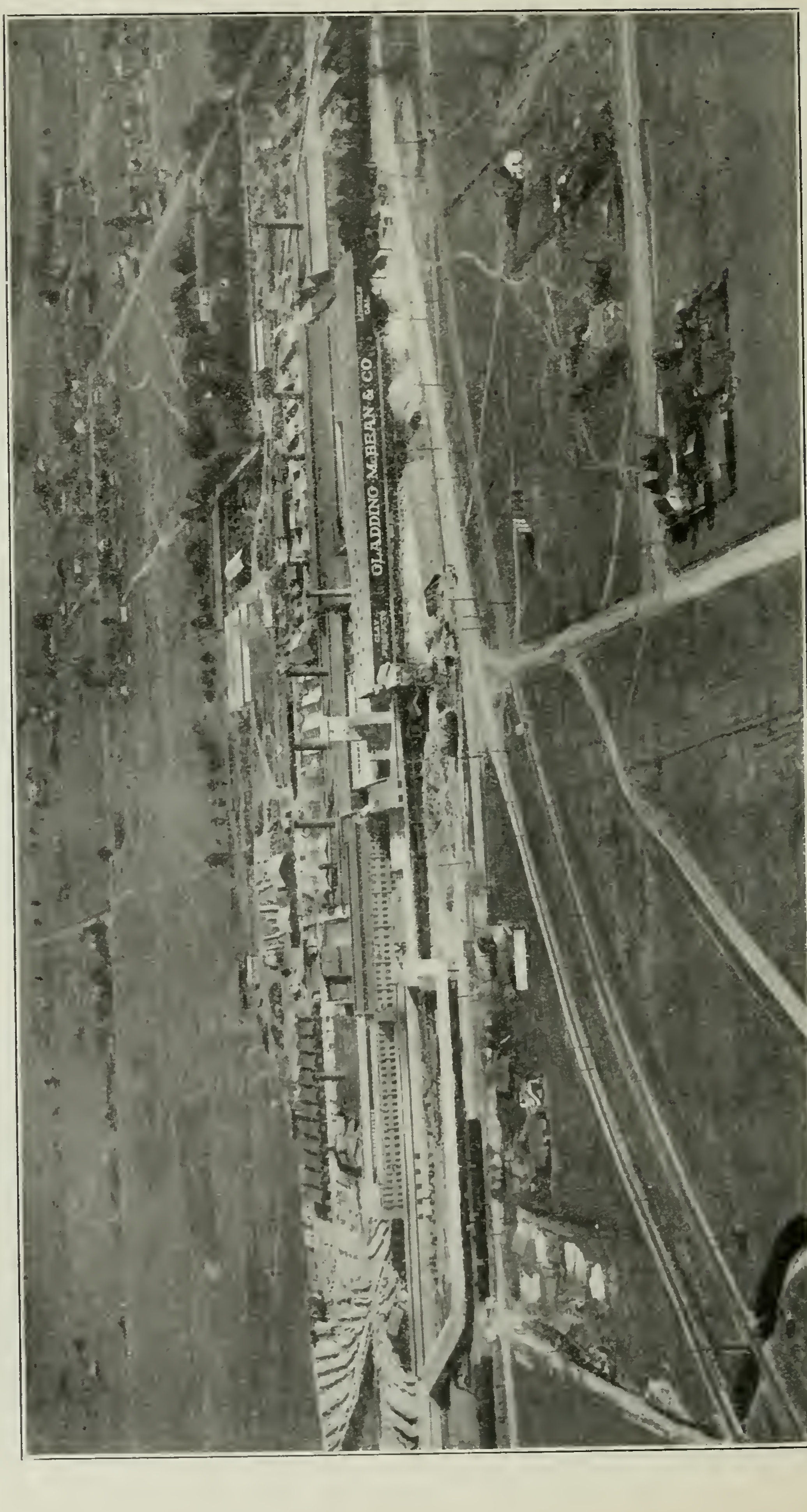

PHOTO No. 34. Airplane view of Gladding, McBean & Co. plant at Lincoln, Placer County. (Photo supplied through the courtesy of the company.)

humidity, in a period of five hours, then was held at 212° F. with gradually decreasing humidity for 12 hours, and the ware was finally drawn about one hour later. The average drying cycle thus occupied 23 hours. Waste-heat tunnel driers are used for firebrick and face brick.

Eleven down-draft oil-fired muffle kilns are in use for terra cotta firing. The body and glaze mature together at cone 4 (2000° F.), with a heating schedule of nearly four days. Four days are allowed for cooling, and three days for unloading and setting for the next burn, making the turn-over time 11 days. The average total linear shrinkage, on a plastic basis, is 6.9%. The body color is buff.

Fire brick are made from a mixture of terra cotta clay (sample No. 157), ground fire brick grog, and quartz. The brick are shaped in a side-cut auger-machine. Three round down-draft kilns are usually in use for firing fire brick. The firing cycle occupies five to six days firing, and about an equal time cooling. The finishing temperature corresponds to cone 11 down, or 1285° C.

Face brick are made from local materials, using all three of the materials mined in the company's pit, proportioned according to colors desired. Practically all the face brick produced in the plant is buff or cream color. An auger machine shapes the brick, which are either end- or side-cut. They are fired to 2200° F. in round down-draft kilns, four of which are usually in use for this class of ware.

The sewer pipe mixture contains 'fire-proofing clay' (sample No. 156), Ione sand and grog. Electrical conduit is made from the same mixture, with the addition of some Natoma clay (sample No. 212, p. 337). Twelve round down-draft kilns are in service on these two classes of ware, firing to a maximum temperature of 1200° C. in about seven days, including the salt glazing period, then cooling for a nearly equal period.

Roofing tile is made from a mixture of local materials and Natoma clay. Drain tile is made from a similar mixture. Both are shaped on an auger machine. The roofing tile is fired in a tunnel kiln, 363 feet long, with a 43 hour cycle to a maximum temperature of cone 3 (1145° F.). Studies made at the plant have demonstrated a saving of 50% of the fuel consumption of a round down-draft kiln for this class of ware.

In addition to the products already mentioned, flue lining is manufactured. Four round down-draft kilns are in use for firing this product.

All the firing is done with oil fuel, atomized by compressed air. A complete pyrometric control of all kilns ensures uniform firing conditions, and economy of fuel. Electric power is used throughout the plant.

The plant contains an architectural and sculpturing department, a drafting department, and a ceramic laboratory. As in most plants specializing in architectural terra cotta, the staff of the ceramic laboratory spend the greater part of their time developing glazes.

About 600 men are employed in the plant, of whom a large proportion are on piece work. A summary of the kiln equipment and the approximate annual capacity of various classes of ware are given in the following table:

Kiln Data and Approximate Annual Capacity of Gladding, McBean & Co. Plant at Lincoln.

Class of ware	No. of kilns	Type of kiln	Max. temp., °F.	Firing time, days	Annual capacity
Architectural terra cotta	11	Muffle d.d.	2000	3.75	12,000 tons
Sewer pipe and conduit	12	Round d.d.	2190	7	20,000 tons
Face brick	4	Round d.d.	2190	6	3,200 M
Fire brick	2	Round d.d.	2370	6	1,600 M
Chimney pipe	4	Round d.d.	1830	4	3,000 tons
Drain tile	Set with other ware				
Roofing tile	1	363 ft. tunnel	1975	43 hrs.	12,000 tons
Garden pottery	Occasional				

Lincoln Clay Products Co. M. J. Dillman, president, Lincoln. The Lincoln Clay Products Company has no manufacturing plant, and is exclusively engaged in the mining of clays.[1] The property is located two miles northwest of Lincoln, in the N½ of Sec. 4, T. 12 N., R. 6 E., M. D. M. It has been in operation for over thirty years.

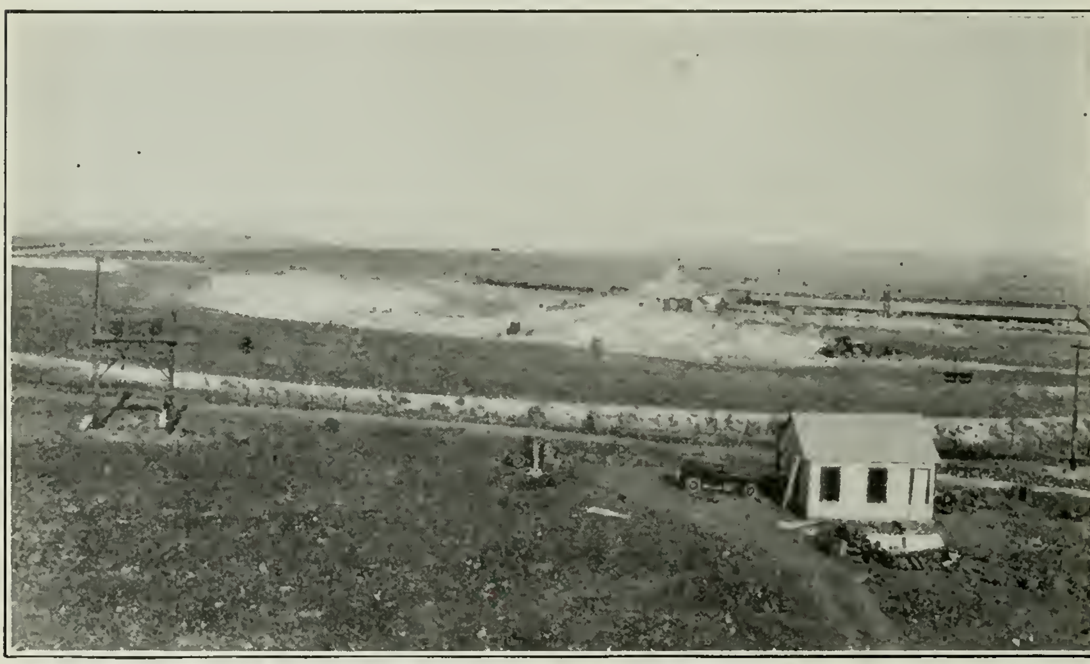

PHOTO NO. 35. General view of the pit and plant of the Lincoln Clay Products Co., looking south from the top of the storage building of the Clay Corporation of California. The Clay Corporation's office building is in the right foreground.

The pit is worked in benches by a combination of a spiral approach and an incline as shown in photos Nos. 35, 36 and 37. Benches are established on the bottom of each clay bed, or series of beds, that is to be mined separately. Gasoline locomotives are used to haul trainloads of stripping or clay from the upper beds and an incline hoist is used to remove the clay that is mined near the bottom of the pit. The pit is over 1200 feet long and 600 feet wide and the maximum depth is 60 feet.

The clay is loosened by hand drilling and blasting. A 1½ cu. yd. gasoline shovel is used for loading clay from the thicker beds, and hand loading is used on the thinner beds. Five gasoline locomotives are in service. Two of these weigh three tons and the others weigh four, six,

[1] A clay-working plant is contemplated in the near future.

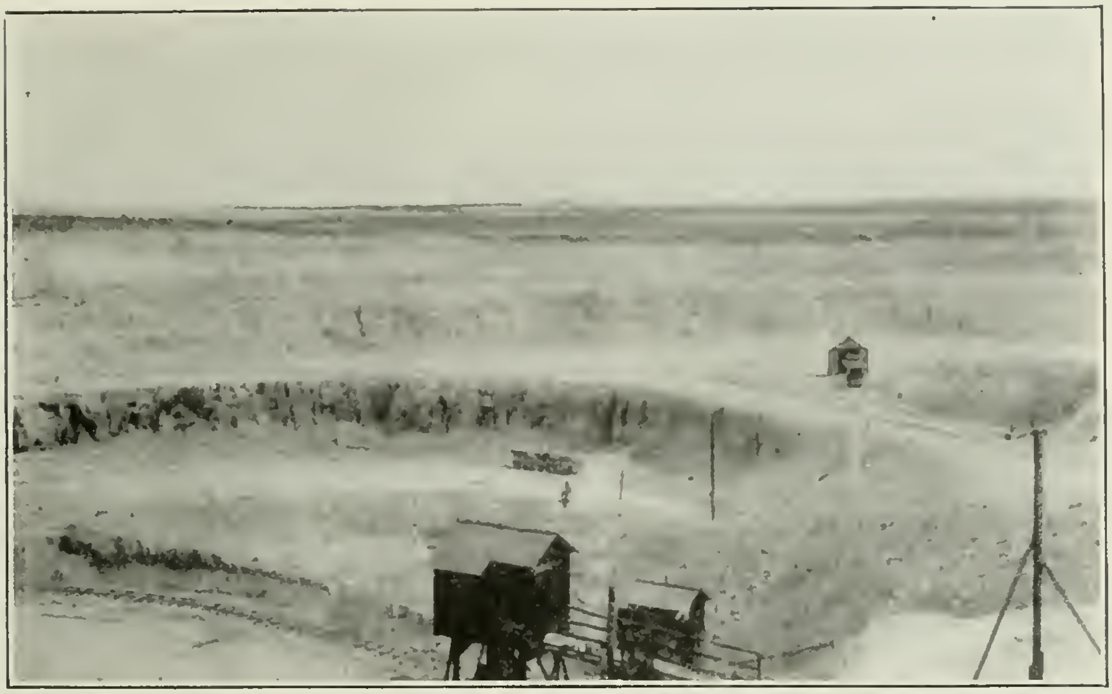

PHOTO No. 36. Eastern end of pit of Lincoln Clay Products Co., near Lincoln. Samples No. 145 to 150 were taken from the pit.

PHOTO No. 37. Western end of pit of Lincoln Clay Products Co. with clay grinding and storage plant of the Clay Corporation of California in the middle background.

and eight tons, respectively. A centrifugal pump is used to remove run-off water from the pit.

A section through the pit follows:

Sample No.	Test data on page	Class of material	Average thickness, feet
		Soil and gravel	1– 3
		Lava	1– 6
145	291	No. 0 clay: Face brick body	8
146	303	No. 1–6 clay: Terra cotta body	15
147	303	No. 7 clay: Tile, face brick, sewer pipe. High in iron	12
148	336	No. 8 clay: Higher in iron than No. 7	6
149	298	No. 9 clay: Similar to No. 1–6	8
150	291	No. 10 clay: Similar to No. 9	22

A large storage shed, shown in photo No. 35, provides storage of clay during the rainy season, allows for fluctuations in mining and shipping during the season, ensures a certain degree of mixing to minimize the effect of local variations in the quality of clay, and permits seasoning of clay for those customers who so desire.

In the fall of 1918 a washing plant was built for the purpose of investigating the commercial possibilities of marketing a washed product. The clay was ground in a Graupner centrifugal mill, mixed with water, and settled in vats. The thickened slip was dipped out by hand and sun-dried in shallow trays. The principal effect of this process was to eliminate a certain proportion of the sand that is present in the raw clay, thereby producing a finer grained clay that has a more uniform, but greater, shrinkage. On account of high freight rates on washed clay, compared to crude clay, and because of the fact that the washed clay did not possess sufficient advantages in use, washing was discontinued after a brief period. In order to permit a study of the properties of the washed material, Mr. Dillman kindly gave the writer a sack from the warehouse. This is sample No. 151, and the test results are given on page 303.

An average of 12 men are employed. The annual output varies with market demands, but is usually in excess of 50,000 tons. The selling price of the clay, f. o. b. cars at the plant, averages $1.75 per ton.

Miscellaneous Deposits.

Previous publications[1] by the State Mining Bureau have reported occurrences of clay at various points along or near the line of the Southern Pacific Railroad, from Alta to Gorge. The most promising of these were visited in August, 1925, and were in each case found to be derivatives of the andesitic tuff-breccias, rhyolite tuffs, or volcanic ashes that are remnants of the great Tertiary volcanic deposits that at one time completely covered the basement rocks of the west slope of Sierra Nevada Mountains, before the more recent period of tilting and stream cutting that has resulted in the present topography. Rock decomposition and alteration has progressed to a varying degree in many of these materials, with the result that in places there are extensive beds of fine-grained, white, greenish-white, or yellowish-white material having a certain degree of plasticity that are often mistaken for useful clays. They are, however, of no value for ceramic purposes, on account of high drying and firing shrinkage, low cohesion in the partly-dried condition which results in serious cracking during drying,

[1] Prel. Rept. No. 7, p. 67–73.

low fusibility, and dirty yellow or red firing colors. Even if they can be successfully dried without cracking, the excessive shrinkage will cause warping, and they are practically impossible to fire without splitting. A characteristic feature that renders easy the field elimination of such materials is the spongy, sticky plasticity developed upon the addition of water, coupled with the large amount of water that the material will absorb to develop this 'plasticity,' usually amounting to over 75% of the solids by weight.

As representative of this class of material, samples No. 161 to 165, inclusive, were taken, and two of them, No. 161 and 163, were submitted to a portion of the ceramic tests.

Sample No. 161 was taken from a 50-foot railroad cut, 1 mile west of Gorge, between mile 157 and 158 on the railroad. The bed sampled was 6 to 8 feet thick, and is exposed for a length of over 300 feet in the cut. It is overlain by 12 feet (maximum) of overburden on the south side of the cut, consisting of gravel and decomposed andesite, and is underlain by white rhyolitic tuff (?). The sample developed sticky plasticity with 71.5% water, and with less water was merely spongy without much cohesion. The test pieces all split badly during drying, and while hard, were very brittle. The calculated linear drying shrinkage, based on dry length, was 28.5%. It was not possible to obtain the dry transverse strength of the undiluted material, and the test pieces were not fired.

Samples No. 162, 163, and 164 were taken from successive beds (top to bottom) of material exposed along the highway 0.9 mile above Baxter, or 2.1 miles above Towle. Each bed is approximately 2.5 feet thick, and the series is exposed for a distance of over 100 feet. It is overlain by from 0 to 3 feet of white sand tuff. Some tests were made on No. 163, but the others were discarded. The plastic working properties of sample No. 163 are similar to those possessed by sample No. 161, except that the presence of a larger amount of non-plastic material somewhat modifies the stickiness. The water of plasticity is 67.1%, the calculated linear shrinkage, dry basis, is 18.4% and the total drying and firing shrinkage to cone 06 (1005° C.) is 22.1 per cent of the plastic length. Visible drying cracks did not develop, but the erratic results obtained from dry transverse strength tests indicates the presence of lines of weakness. All of the fired pieces cracked badly. (See page 350.)

Sample No. 165 was from a railroad cut 1100 feet above (east) of Alta station, described and illustrated in Preliminary Report No. 7, page 73. The exposed face is 35 feet thick and 600 feet long, consisting of alternating layers of fine grained yellowish plastic 'clay,' and of a sandier and whiter variety of the same material, overlain by red decomposed andesite varying from two to eight feet in thickness. The portion sampled was from a yellowish plastic bed varying from four to ten feet in thickness, midway between the top and bottom of the exposure. No tests were made other than pugging a small portion of the material with water and noting its general similarity to the materials represented by samples No. 161–164.

Valley View Mine. Owned by Judge J. B. Landis and Ed. Gaylord, of Auburn. This property is in SE¼ Sec. 12 and NE¼ Sec. 24, T. 13 N., R. 6 E., M. D. M., eight miles by road northeast of Lincoln.

Under the name of Whiskey Hill or Harpending Mine, it was worked for gold in the sixties, but later developed into a copper property. In the lower workings, sphalerite and pyrite increased in quantity and the

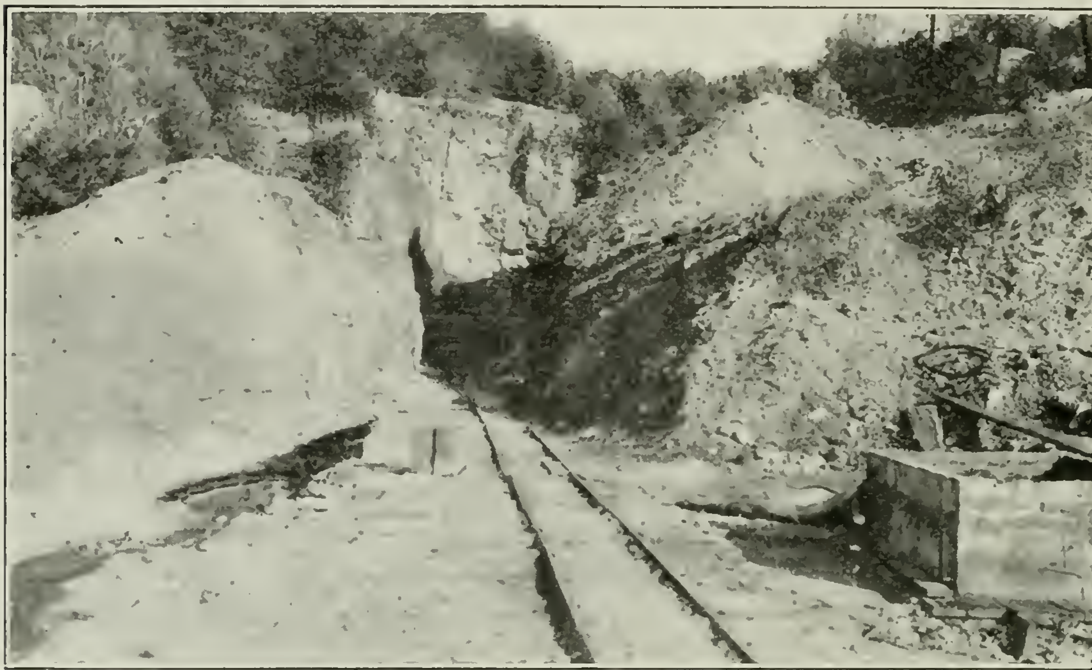

PHOTO No. 38. Valley View Mine, Placer County. Portal of lower tunnel. (Sample No. 261 from glory hole that connects with the tunnel.)

PHOTO No. 39. Valley View Mine, Placer County. Upper workings. (Sample No. 262 from bank to left (east) of center of view.)

copper minerals decreased. There has been no production since 1918. The ore occurs in part in altered dikes which intrude the amphibolite schist country rock. In the upper workings, still accessible through a tunnel, a glory hole, and an open cut, the dike rock has been kaolinized.

The degree of kaolinization and the percentage of iron vary considerably in different parts of the exposures, but in places the material is well kaolinized, has fair plasticity, and is comparatively free from iron.

Photos No. 38 and 39 are views of the property. Three samples were taken. No. 261 (p. 328) was taken from an underground chamber that connects by a chute to the tunnel, the portal of which is shown on photo No. 38. The sample represents a small kidney of kaolinized material, exposed over an area about 10 feet square, and at least 4 feet thick. A peculiarity of the sample is that while it is distinctly red-burning, it has a softening point of cone 28 (1615° C.). No. 262 (p. 350) was taken from the open cut shown in photo No. 39, and is representative of the material from the bank to the left (east) of the center of view. This material has little or no ceramic value. No. 263 (p. 292) is a sample of white kaolin from the same open cut. It occurs as small isolated pockets, some of which are clearly shown on the right-hand side of photo No 39 as white patches. The material is nearly white-burning, has fair plasticity, and a high softening temperature (cone 32–33, about 1720° C.). Unfortunately, there is little indication that large bodies of equally good material will be found on the property.

Bibl (Valley View Mine): Cal. State Min. Bur. Bull. 50, p. 174. Rept. XV, pp. 327–330; XXIII, pp. 246–247 and 286.

RIVERSIDE COUNTY.

General Features.

Riverside County lies in the southern portion of the state. It is bounded on the north by San Bernardino County, on the east by the state of Arizona, on the south by Imperial and San Diego counties, and on the west by Orange County. The county has an area of 7420 square miles and a population of 60,297 (1920 census). It is the fourth county in size and the seventh in regard to the total value of mineral output (1925).

The surface of Riverside County, like that of much of southeastern California, is characterized by bare mountain ranges, separated by nearly-level arid belts of varying width. The minor ranges of mountains rise abruptly from the desert plains, having the appearance of being the summits of larger ranges whose bases are buried beneath the loose deposits of the desert. The San Bernardino and San Jacinto mountains are the most prominent ranges, the peaks of which rise to more than 10,000 feet above sea level. On the western edge of the county, and separating it from Orange County, is the Santa Ana Range.

Geology.

A detailed study of the geology of Riverside County has not yet been made. In the desert areas of the eastern portion of the county, the principal formations, besides Quaternary gravels, are pre-Cambrian and Paleozoic metamorphics; some Tertiary sediments, mostly Pliocene; and various plutonic and volcanic rocks. In the western portion of the county, near Orange County, are extensive areas of Triassic, Upper Cretaceous, Eocene and Miocene age.[1]

[1] Smith, J. P., The geologic formations of California: State Min. Bur. Bull. 72 and Geological Map. See also for bibliography up to date of issue in 1916.

The mineral resources of the county include brick, cement, clay, coal, copper, feldspar, gems, gold, gypsum, iron, lead, limestone, manganese, magnesite, marble, mineral paint, mineral water, salt, soapstone, silver, miscellaneous stone, and tin. In 1925, seventeen different minerals were commercially produced, the most important being, in the order of their production, cement, miscellaneous stone, brick and hollow building tile, pottery clay, silica (quartz), granite, feldspar, and lead.

Clay Resources.

The Alberhill-Corona district in western Riverside County is one of the three most important clay producing areas in the state. The clay deposits extend in a belt along the Temescal Valley for fifteen miles from Elsinore on the southeast to Corona on the northwest. The clays were laid down in Eocene time, when the Temescal Valley was an arm of the sea opening northward into the valley of western San Bernardino County and extending southerly to Temecula. The width of the basin is from one to two miles, and the depth in places is over 600 feet. A property map of the district is given on plate X.

The general character of the deposits is well described in the following excerpts from an article by the late J. H. Hill,[1] then president of the Alberhill Coal and Clay Company, the largest producer in the district:

"At the Alberhill pits, the clays present a wide diversity of color, character, and degree of consolidation. An extraordinary variety is found, including siliceous fireclays, ball clays, plastic white- and buff-burning clays, highly aluminous and very refractory clays, numerous red-burning clays, and an extensive bed of material from which a china clay is obtained by washing. A bed of lignite coal ranging from two to eleven feet in thickness occurs conformably with the clay strata, and adjacent to this the best fireclays are found. The strata are regular and persistent, and dip to the southwest with an average value of 10 degrees, with local variations due to an undulatory or wavy folding.

"Minor local disturbances appear to have prevailed at intervals during deposition of these clays, and coarse sandy beds are interspersed with fine-grained plastic clays. In these sandy beds, the coarse silica sand is often intermixed in a sporadic and irregular fashion with the accompanying clay substance. Mottled clays apparently due to simultaneous deposition of different kinds of sediments derived from separate sources are also found. The beds in general seem to indicate that long quiescent periods during which fine-grained clays were laid down were preceded and followed by stormy periods when frequent freshets or strong tidal currents brought in coarse silica sand and granite debris from surrounding highlands. The top soils of the region consist of debris of disintegrated granite, and vary from a few inches to many feet in thickness.

"Owing to the masking of the surface by the layer of disintegrated granite material, the total extent of the Alberhill deposit has not yet been fully determined. However, a large number of bore holes have been put down on widely separated portions of the property, and in every case clays of good quality were found to the full extent of the hole in depth. From this and other evidence, it seems quite probable that the entire mass of the small mountain, above the valley floor and for an unknown depth, is clay. A few isolated occurrences of shale have been noted. Exploration to date has been sufficient to indicate beyond doubt that the quantity of readily available clay is so vast as to be inexhaustible for all practical purposes. * * * The hill comprising the deposit is about two and one-quarter miles long and one mile in width, with an average elevation of 1680 feet. The main line tracks of the railway * * * are at an elevation of 1277 feet. * * * The present pits are all somewhat above the level of the railroad tracks."

While Mr. Hill's estimate of clay reserves may have been somewhat optimistic, in the light of more recent work which indicates that the deposits lie in the form of a synclinal trough against the eroded surface of the mountain ranges on each side of the valley, it is substantially true that the supply of readily available clay is sufficient to last for many years, even at increased rates of production. Considering the district as a whole, the principal deposits lie on the eastern side of the

[1] Clay deposits of the Alberhill Coal and Clay Company: State Mineralogist's Report XIX, pp. 185–210, 1923.

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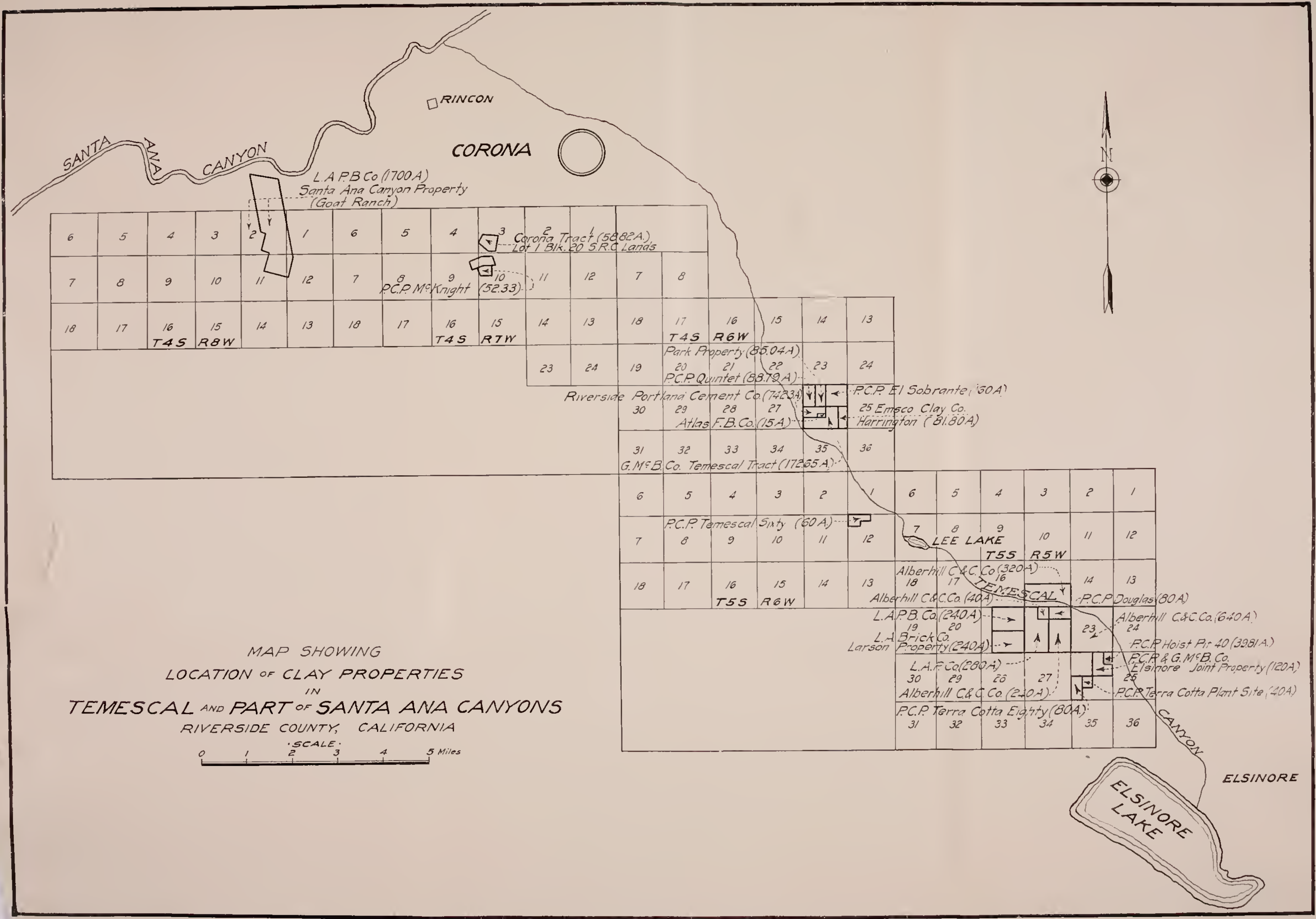

PLATE X. Property map of Alberhill-Corona district, Riverside County. (By courtesy of Robt. Linton.)

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valley, but deposits in the floor of the valley and toward the western side are of importance at a number of places. Folding, faulting, and erratic deposition are most pronounced on the eastern side of the valley in the vicinity of Alberhill. The Emsco deposit, on the same side of the valley, at an elevation of about 200 feet above the floor, and about six miles to the northwest of Alberhill (see map, plate X), shows little evidence of structural complexity, and the character of the material in the different beds is uniform over a large area. This same condition prevails at most of the west side pits, except the McKnight pit (Pacific Clay Products Company), near the northern limit of the clay belt, west of Corona, where the structure is more complex.

Most of the promising clay land in the district has been purchased or leased by various companies. The acquisition of property has been particularly active since 1924, when it became apparent that a railroad connection was to be made from Alberhill to Corona. This line is now

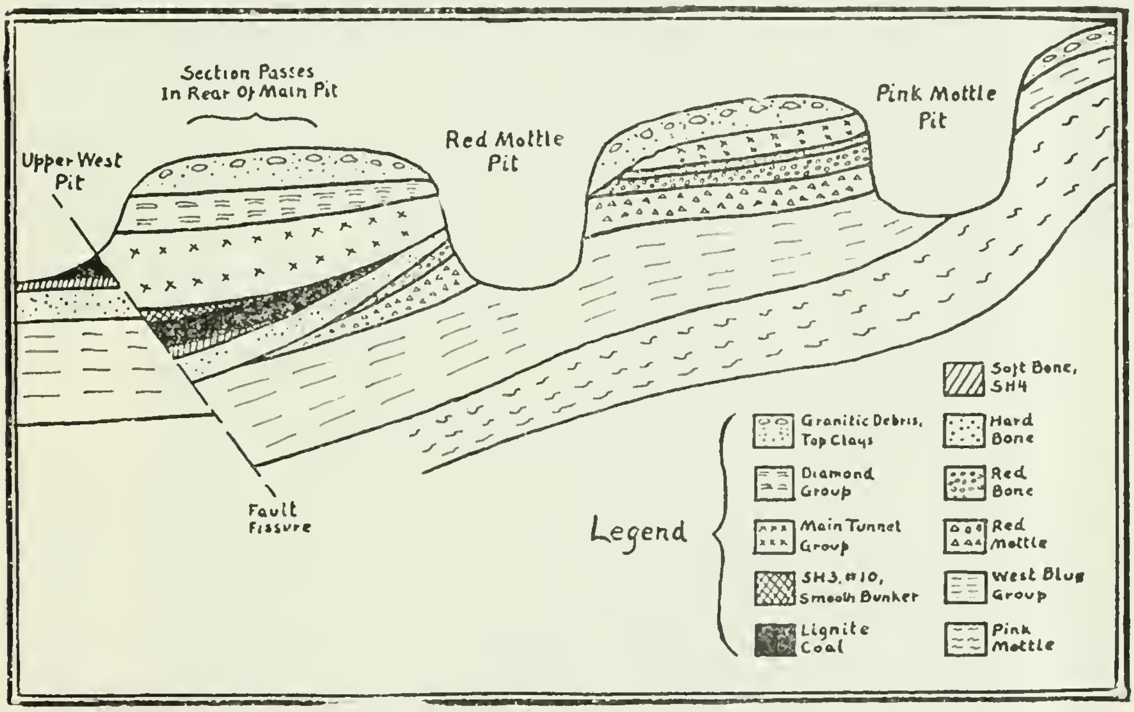

PLATE XI. Diagrammatic section of strata at Alberhill, in a general west-east line. (From State Mineralogist's Report XIX, p. 196, 1923.)

completed, and has not only resulted in a decrease in the freight rate from Alberhill to Los Angeles, but has eliminated long truck hauls throughout the district.

Outside of the Alberhill-Corona district, few commercial clay deposits have been found in the county. Common clays are sufficiently abundant near the more populous parts of the county to serve all requirements for the manufacture of common brick. The desert portions of the county have not been thoroughly prospected for clays, and there is a chance that in the future a few interesting deposits will be discovered.

Alberhill Coal and Clay Company. Chas. Biddle, general manager, Alberhill, California. This company owns nearly 2000 acres of property, parts of which are leased to other companies. The principal holdings are shown on plate X. The company was originally organized to work the coal beds that occur here, and for 13 years previous to 1895 the property was developed solely as a coal mine. The production

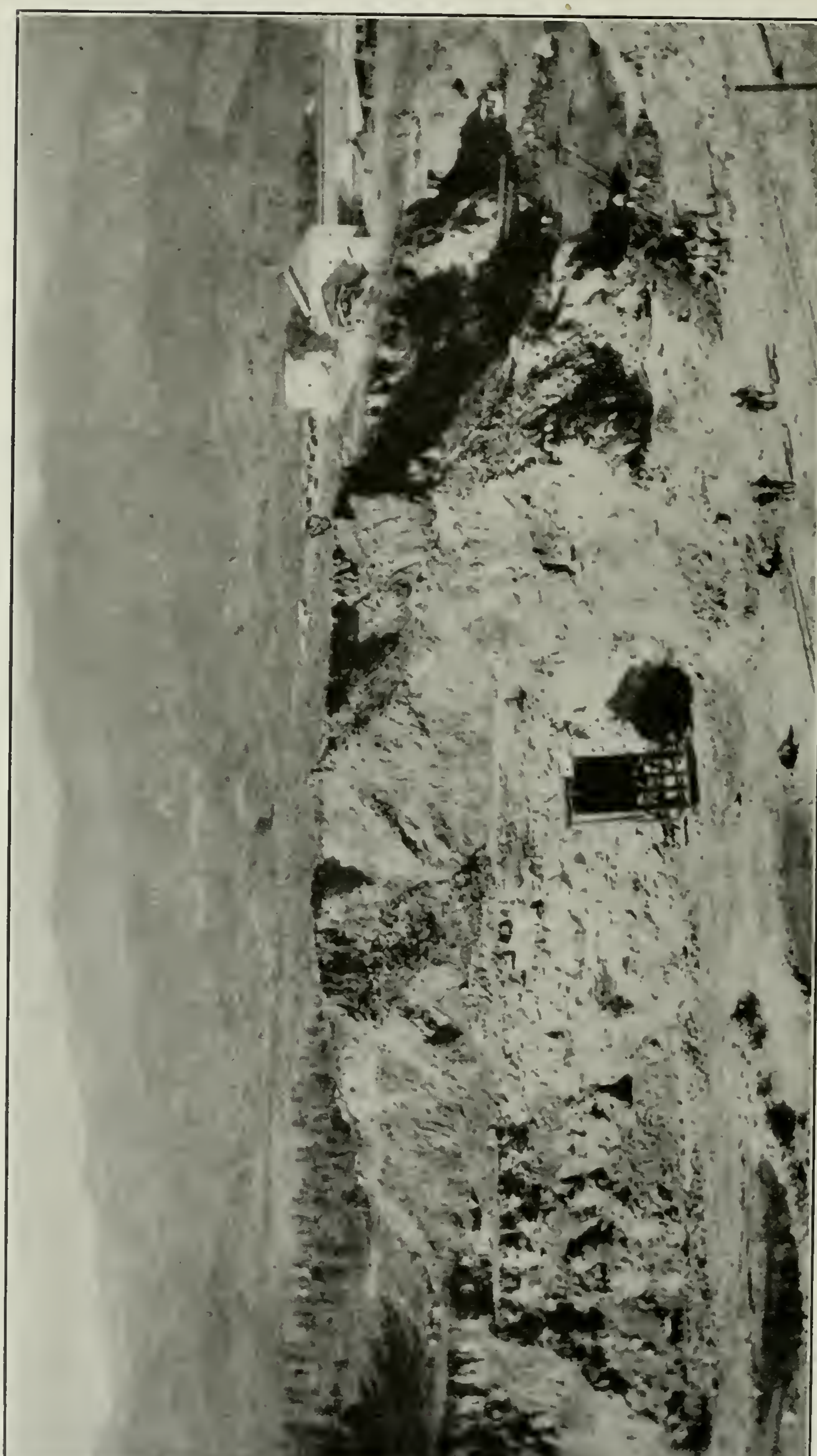

PHOTO No. 40. Southwest wall of the main pit of the Alberhill Coal & Clay Company. The heavy stratum of clay directly behind the bunker is main tunnel fire clay. In the background is Plant No. 4 of the Los Angeles Pressed Brick Company. Riverside County. (From State Mineralogist's Report XIX, p. 187, 1923.)

of clay started in 1895 and it has been continuous since. The company has no clay-working plants, but sells clays to many manufacturers throughout California, particularly in the Los Angeles district. More than thirty varieties of clay are mined and marketed.

PHOTO No. 41. Alberhill Coal & Clay Company. Cut connecting main and west pits. The Alberhill plant of Gladding, McBean & Company (formerly Los Angeles Pressed Brick Company) is in the background. Riverside County. (From State Mineralogist's Report XIX, p. 189, 1923.)

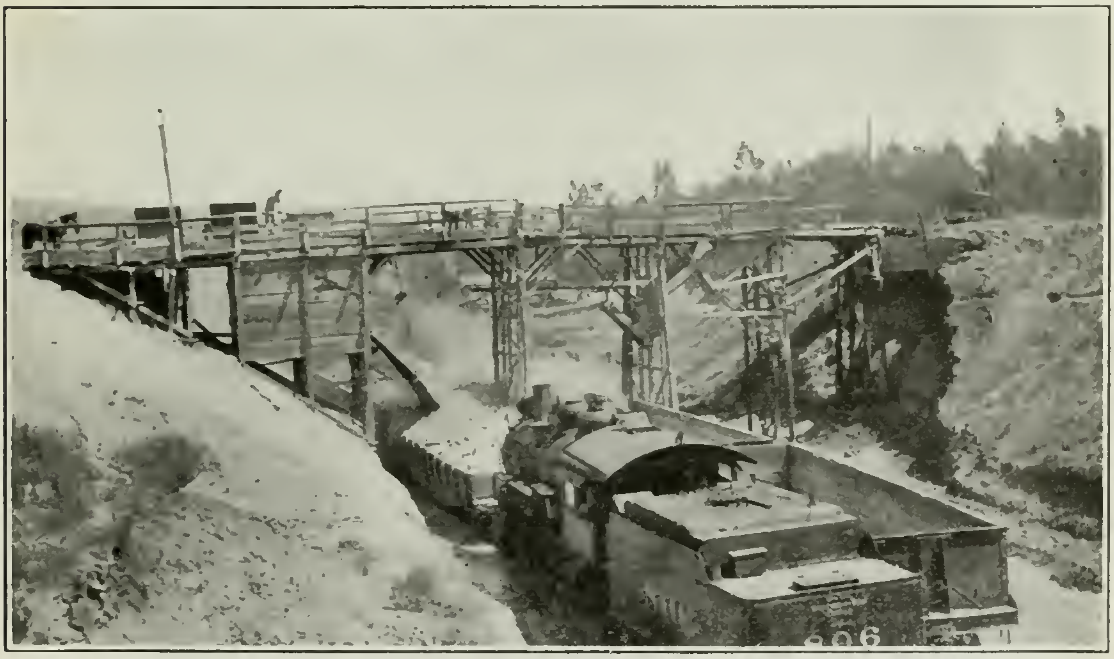

PHOTO No. 42. Alberhill Coal & Clay Company. One of the loading trestles. Riverside County. (From State Mineralogist's Report XIX, p. 191, 1923.)

The operations of the company were described by the late J. H. Hill in an earlier report[1] by the Bureau. For the sake of completeness, this article is freely used in the present report, with some additional

[1] Hill, J. H., *op. cit.*

PHOTO NO. 43. Lower portion of the west pit of the Alberhill Coal & Clay Company. Near the bunker is the mouth of the west tunnel, which extends for over 1000 feet under the upper workings to the west pit, connecting to the surface by numerous glory holes. Riverside County. (From State Mineralogist's Report XIX, p. 194, 1923.)

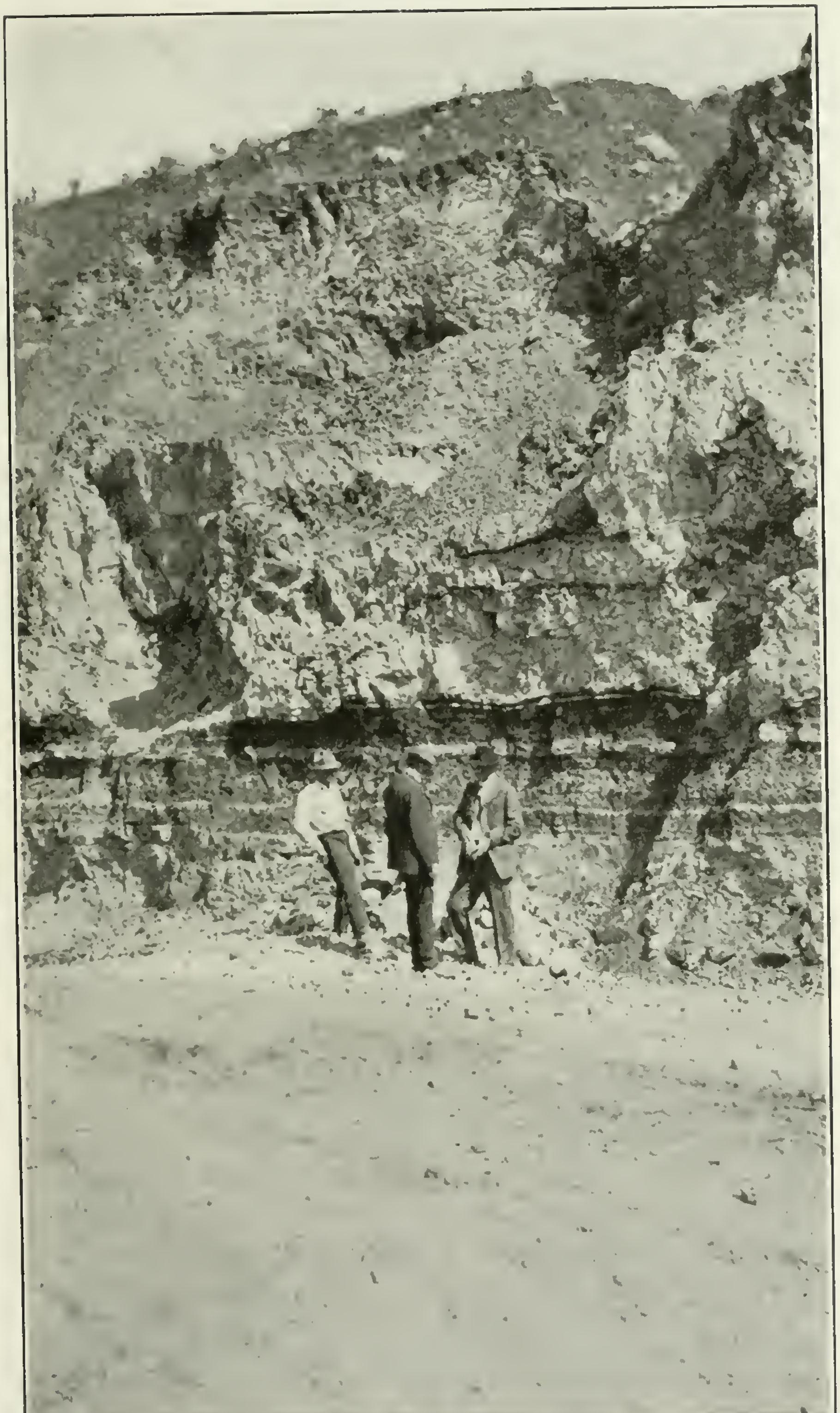

PHOTO NO. 44. Alberhill Coal & Clay Company. Riverside County. An exposure of lignite coal. The clay stratum directly below the coal is SH-4 (sample No. 273); that directly above is SH-3 (sample No. 28). (From State Mineralogist's Report XIX, p. 200, 1923.)

details on recent developments. The reader is referred to Mr. Hill's article for further details not covered herein.

Geological Section. An idealized geological section of the Alberhill pits, as prepared by Mr. Hill, is shown on plate XI. This sketch is broadly generalized, and may be considered as a composite of the various beds, in their normal stratigraphic sequence. There is perhaps no locality on the property where the series is complete, as some of the beds are thicker in one place than in another, and other beds are entirely lacking in places. Burchfiel [1] gives the following cross-section as being fairly representative:

No. of feet	Kind of strata
3	Soil
20	Yellow top clay
6	Yellow main tunnel clay
34	Main tunnel clay
6	Coal
4	Bone clay No. W–105
4	Clay between bone and blue clays
12	Select west blue clay
8	West tunnel blue clay
–	Shale

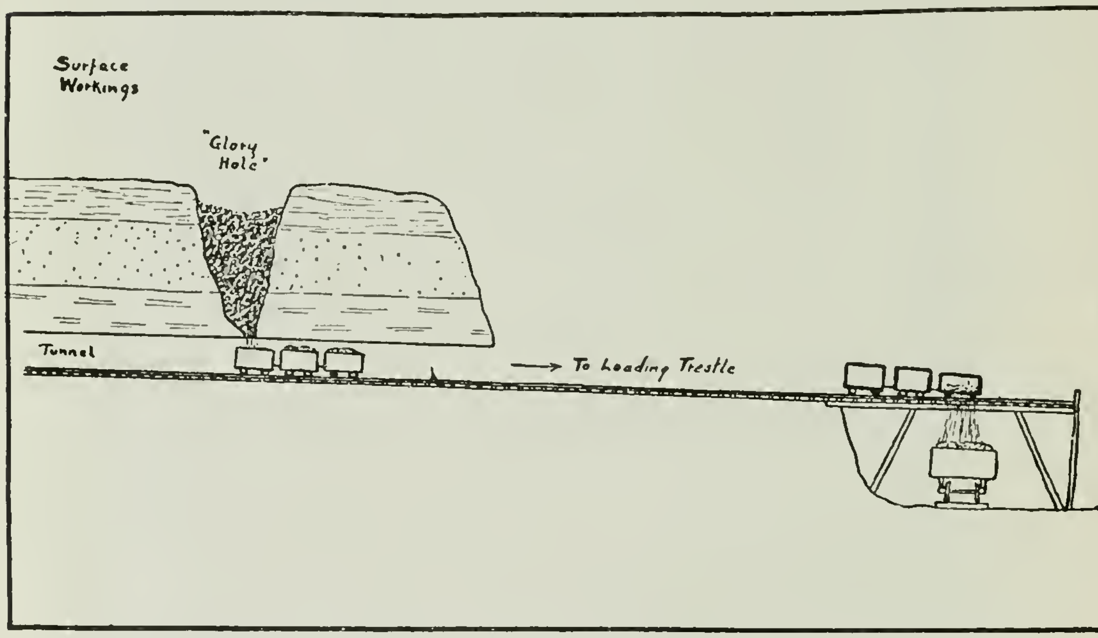

Plate XII. Handling and storage of clay by the "glory-hole" method. (From State Mineralogist's Report XIX, p. 193, 1923.)

Photos No. 40, 41, 43 and 44, all from Mr. Hill's article, illustrate various topographic and geologic features on the Alberhill property.

Mining Methods. Wherever possible, the clays are mined by open-pit methods. The clays stand well in vertical banks up to 40 or 50 feet in height. As operations are scattered, all loading is by hand. Glory-hole mining is used at various places. Underground mining by room-and-pillar methods is used where the overburden is thick, or where it is desired to mine special varieties of clay without removing overlying beds. In 1926, extensive underground operations were started for mining the 'hill blue' clay, and it is expected that most of the production of this important variety will be obtained from these workings in the future, rather than from open pits.

Plate XII, by Hill, illustrates the general method of glory-hole mining. Photos No. 40, 41, 43 and 44 illustrate various features of the

[1] Burchfiel, B. M., Refractory clays of the Alberhill, California, Deposits: Jour. Amer. Cer. Soc., Vol. 6, p. 1167, 1923.

mining operations, and photo No. 42 shows one of the loading trestles and bins for delivering the clay to railroad cars.

At many of the pits, wheelbarrows are used to deliver the clay to a loading chute, from which it is delivered by gravity into trucks for hauling to the railroad. At other pits, small mine cars are loaded by hand, and are trammed by horses to the dumping points. In the glory holes and underground workings, mine cars are used. These are trammed by hand, with horses, or by electric trolley locomotives, depending upon the length of haul and average daily production of the working.

The total production of clay from the company's property is about 15,000 tons annually, and prices (f.o.b. Alberhill) range from $1.25 per ton for the poorer varieties, such as yellow stripping, to $5.50 per ton for some of the selected varieties of white-burning clay. Most of the varieties sell for $2 to $3.50 per ton. The clays enter into the manufacture of a great diversity of products, ranging from china to heavy structural wares. The diversity of clays makes it possible to produce many specialized wares. This is particularly true of the refractory and face-brick branches of the clay industry.

SAMPLES. Twenty-six samples from this property were tested. For convenience of reference, these are grouped below according to the clay classification adopted in this report, which is fully described in Chapter IV.

Sample Record, Alberhill Coal and Clay Company.

Fired color	Clay class number	Clay sample number	Page reference	Local nomenclature	Cone fusion
White	1	11	257*	E–101 china clay	28–29
		12	257*	E–102 china clay	26–27
	2	15	264*	Select main tunnel	30–31
		28	264*	SH–3	30
		29	264*†	Main tunnel (M.T.)	30–31
	3	273	273*†	SH–4 (ball clay)	34
Buff	5	17	277*†	W–105 bone clay	34
		23	277*	West blue	29
	6	9	287*	Hill blue (1925)	29
		14	287	A–clay	31
		27	287*	No. 10	30–31
		272	292	Hill blue, M.T. (1926)	29
	7	13	296	Extra select M.T.	29–30
		271	301	Hill blue, lower tunnel	31–32
		274	302	Hill blue, upper tunnel	30
	9	19	311	Diamond	23
		25	311*†	West tunnel blue	16
	10	16	311*†	Select west blue	18
Red	12	8	321	Red clay No. 2	19–20
		18	321	Clark tunnel mottled	19
		24	321	West tunnel mottled	18–19
		26	321*	West yellow	not det.
	13	7	328*	Pink mottled	17
	14	10	334*	Hill blue green	14–15
		21	334	Sagger	23
		22	335	Yellow Owl cut	17

* The properties of these varieties are also given by Hill, *op. cit.*. The E–101 and E–102 varieties are discussed under "D.C. clay."
† The properties of these varieties are also given by Burchfiel, *op. cit.*

Emsco Clay Co. (Harrington Pit). LOCATION: The Emsco Clay Company of Los Angeles has leased from John Harrington the Harrington clay pit, in Sec. 35, T. 4 S., R. 6 W., in the Temescal Cañon, 10.5 miles by road southeast of the center of Corona, and 7 miles by road southeast of a loading siding on the southeastern side of Corona.

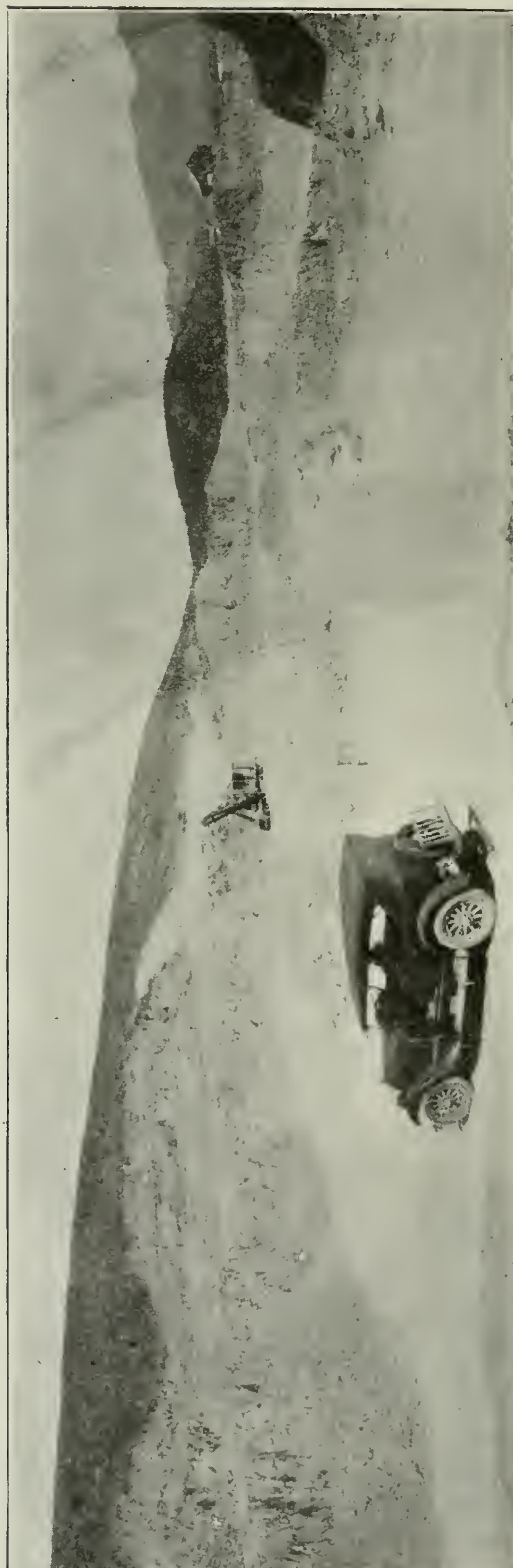

PHOTO No. 45. Emsco Clay Co., Harrington pit, facing east, 8 miles SE. from Corona, Riverside County. The shovel is standing on top of the 'Harrington No. 5' fireclay (sample No. 70) and is digging pink mottled clay (sample No. 71).

The newly completed railroad connection from Alberhill to Corona passes within 1½ miles of the property. The property under lease comprises 80 acres, and lies on the east side of the valley, 300 feet above its floor. It has been operated intermittently for many years, formerly by the now extinct Independent Sewer Pipe Co., who hauled the clay in wagons to the Chase railroad spur, south of Corona, for shipment to Tropico. It was later under lease to the Alberhill Coal and Clay Co., who did not actively develop the property, as the combined transportation costs to Los Angeles were considerably greater than from Alberhill, where the principal deposits of this company are located.

Development and Mining: A section of the deposit, from top to bottom, as exposed by existing workings, is as follows:

Sample No.	Test results on page		Thickness
--	---	Stripping, of sandy soil, with some clay	2–10 feet
73	323	"Bone" clay, over 35% alumina	4 feet
71	278	Pink mottled	16 feet
72	328	Red, high in iron	2– 4 feet
70	272	White, known as select Harrington No. 5	7 feet
69	323	Red Horse	40–50 feet

The clay beds are quite uniform in quality, but varying in thickness of individual varieties, over the greater part of 40 of the 80 acres under lease. The greatest demand is for the white plastic clay, but the production of this variety is limited by the amount of pink mottled that can be marketed. The Atlas Fire Brick Company uses the entire output of the white plastic clay. The other clays are marketed to Los Angeles consumers, especially to Gladding, McBean and Company and to the Pacific Clay Products Company.

The present (1926–27) mining is being done with a Thew type 0, ¾-yd. gasoline shovel in an open pit about 100 feet square with a 40- to 50-foot bank. Trucks are used to haul the clay from the floor of the pit to a loading bin and chute where it is loaded into larger trucks for the seven-mile haul to the railroad. Photo No. 45 is a view of the pit, and No. 46 shows the loading chute.

Considerable quantities of clay have been mined in the past from open cuts extending along the east side of the present workings, and running up the hill with the clay which dips about 10° to 15° toward the south. There are several tunnels from these pits. To the west, about one-quarter mile from the active pit, it is extensive open cut and chamber workings from which pink mottled and white plastic clay has recently been mined.

Three to four cars per day are being mined and three men are employed at the pit, exclusive of truck drivers.

Gladding, McBean and Company. Office of Southern Division at 621 S. Hope Street, Los Angeles. Through its merger with the Los Angeles Pressed Brick Company in 1926, this company now controls important clay lands and a clay working plant at Alberhill, in addition to the Temescal Tract already owned by the company prior to the merger.

Alberhill Clay Property. The clay property in which the plant is located totals 520 acres, in Secs. 21 and 22, T. 5 S., R. 5 W., as shown on plate X by legends L. A. P. B. Co. and L. A. P. Co. This property adjoins the Alberhill Coal and Clay Company's property on the east.

The main tunnel pit adjoins the Alberhill company's main tunnel pit, and is shown on photos No. 40 and 47. Clay from this pit is loaded by hand into side-dump mine cars, and hauled by electric trolley locomotives across a trestle to the plant on the west side of the railroad, or to railroad bins for shipment to the Los Angeles plants of the company. The principal clay obtained from the pit is main tunnel fireclay, which is used in the manufacture of fire brick.

PHOTO No. 46. Loading chute, Emsco Clay Co. (Harrington pit), Riverside County.

About a half mile southwest of the main pit is the Sloan pit, from which a number of varieties of clay are produced. A representative cross-section of this pit is given by Burchfiel[1] as follows:

No. of feet	Strata
40	Overburden and yellow top clay
30	Sloan clay
6	Sloan No. 5 clay
4	Sloan bone clay (1923)
50	Red clay

[1] *Op. cit.*, p. 1173.

This pit was still an important producer when the property was visited by the author in 1925 and 1926. The clay was being mined by hand methods, and was transported to the plant by auto trucks.

Various other pits have been opened up by the company.

Sixteen samples from the property were tested. No. 90 to 100, inclusive, are practically all from the main pit, and should be compared with similar varieties from the Alberhill company's property. No. 101 to 105, inclusive, are from the Sloan pit. For convenience of reference, they are arranged in the following table according to the clay classification adopted in this report, which is fully described in Chapter IV.

Sample Record, Gladding, McBean Co., Alberhill Pits.

Fired color	Clay class number	Clay sample number	Page reference	Local nomenclature	Cone fusion
White	1	91	260	Main tunnel sand	30–31
		103	260*	Sloan bone	35
	2	90	265	Main tunnel fireclay	31
		93	265	Select main tunnel	30–31
	3	96	272	No. 10	32
		98	272	Bone (W–105?)	35
Buff	5	104	279*	No. 5 Sloan	34–35
	6	92	289	Yellow main tunnel	28
		97	290	Smooth bunker	31
		102	290	Sloan sand	29
	7	101	298	Sloan white	30
	9	94	311	West blue	17
		95	311	Select west blue	18
		99	312	Tile	26–27
Red	12	100	323	Yellow stripping	14 plus
		105	324	Sloan red	18 plus

* Burchfiel, *op. cit.*, p. 1174, gives data on No. 5 Sloan, and states that the Sloan bone is "practically identically the same as the bone clay No. W–105." He also gives data for the yellow top clay from the Sloan pit.

The total clay production from all of the pits on the company's Alberhill property is about 500 tons per day, much of which is shipped to the company's plants in Los Angeles.

Alberhill Plant. The principal products of the Alberhill plant are fire brick and other fireclay refractories, face brick, and hollow tile. Hand-molded roofing tile is also made. The face brick, fire brick, and hollow tile are made by the stiff-mud process, after preparing the clays in dry pans. Most grades of fire brick are repressed. Waste-heat tunnel driers are used. All ware is fired in round down-draft kilns, of which there are twelve, of various sizes from 32 to 38 feet in diameter.

The plant is well arranged, and well equipped to handle all materials in so far as is feasible.

A well-equipped field laboratory is maintained for the study of raw materials and for research on the technical problems arising in the plant.

Temescal Tract. This property, totaling 173 acres, is west of the Emsco Clay Company's property, 0.4 mile east of the Corona-Elsinore highway, and 25–30 feet above the floor of the valley.

Development. The principal pit is 800 feet long, 500 feet wide and a maximum of 150 feet high. Red, pink-mottled and blue plastic clays have been mined. The varieties were apparently badly mixed, and the present exposures in the face of the bank do not offer much encouragement for expecting a satisfactory supply of uniform material. Some development work is being done in a tunnel at an elevation about 100 feet higher than the pit and it is stated that good clays were found underlying the Emsco clays.

At the times of visit, in 1925 and 1926, the pit was idle, but was being held in reserve for the future.

J. D. Hoff, of Elsinore, owns a clay property in Sec. 22, T. 5 S., R. 5 W., on which some prospecting has been done, by core-drilling and

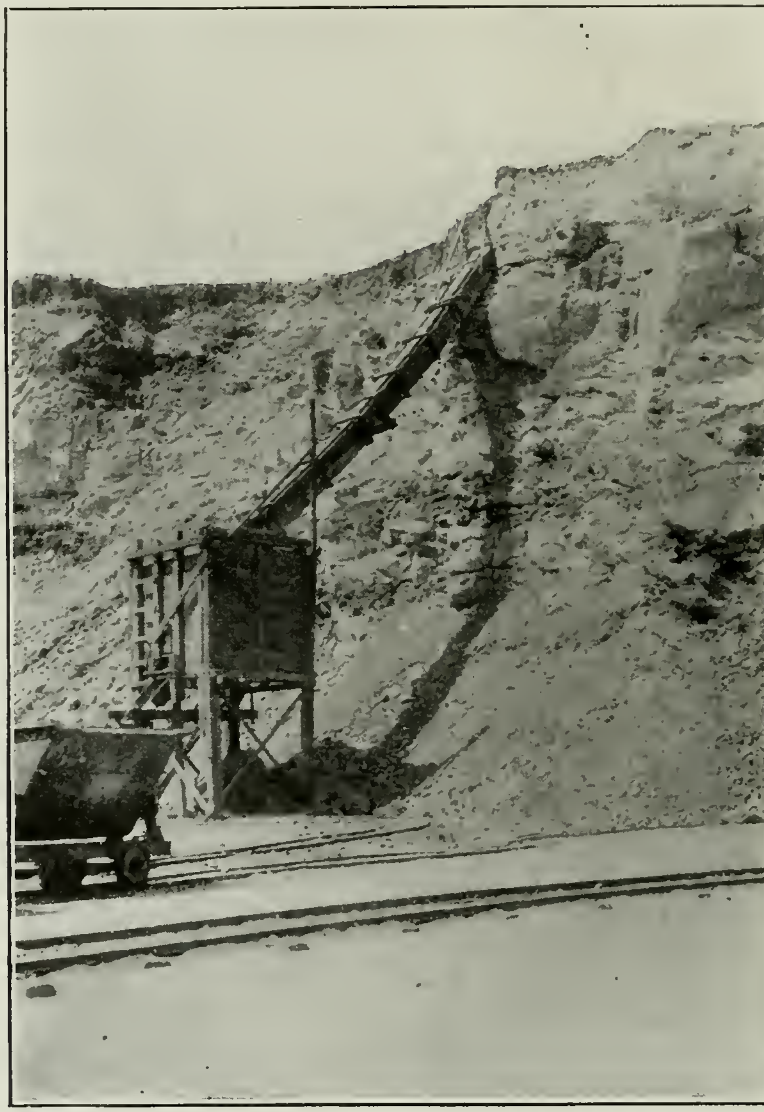

PHOTO NO. 47. Gladding, McBean and Company (formerly Los Angeles Pressed Brick Company), Alberhill, Riverside County. Main tunnel pit leased from the Alberhill Coal & Clay Company. (See also photos No. 40 and 41.)

test-pitting. A number of samples were sent to the Stanford laboratory by Mr. Hoff, but none of these were large enough to test. The general appearance of some of the samples is the same as that of certain clays from other properties in the district. Mr. Hoff expects to build a clay-working plant near Alberhill in the near future.

Los Angeles Brick Co. Gustave Larsen, director in charge of operations; Harvey Gardner, plant superintendent at Alberhill. Main office, 1078 Mission Road, Los Angeles. This company acquired the holdings of the former California Clay Manufacturing Company in the Alberhill district, and built a plant at Alberhill in 1925 for the manufacture of face brick, fire brick, roofing tile, floor tile, and hollow tile. The manufacture of other products is contemplated by the company.

The property at Alberhill consists of the SE¼ and the E½ SW¼ Sec. 21, T. 5 S., R. 5 W., S. B. M., and other nearby property totaling 720 acres. This lies to the west of the principal holdings of the Los Angeles Pressed Brick Co. Most of the clays that are being mined at present are from the western limb of the synclinal trough in which the clays of the district lie. The clays include most of the varieties that typify the Alberhill district, and occur in the same irregular fashion, without notable continuity of individual strata. There is apparently, however, a more extensive deposit of high-grade bone clay on this property than in any other known locality in California.

Clay Deposits: A number of pits have been opened on the property, but at the time of visit, in July, 1925, and September, 1926, it was not possible with the data at the writer's disposal to definitely establish the stratigraphic correlations between the various pits, nor between the nearby pits of other operators. A number of samples were taken on both occasions. No. 74 to 87, inclusive, were taken in 1925, and No. 229 to 232 inclusive, in 1926. Vertical sections through the "East," "West," and "Main" pits are given in the following tables. Photo No. 52 shows the East pit as it appeared in September, 1926.

Vertical Section, East Pit, Los Angeles Brick Co.

(From top to bottom.)

Sample No.	Page No.	Local name or number	Principal uses	Thickness, feet
---	---	Stripping	Sometimes for face brick	0–10
---	---	Pink-mottled	Face brick, tile	15–20
---	---	No. 1 red	Face brick, tile	10
230	300	No. 9	Fire brick	15

Vertical Section, West Pit, Los Angeles Brick Co.

(From top to bottom.)

Sample No.	Page No.	Local name or number	Principal uses	Thickness, feet
--	---	Tile clay	Hollow tile, roofing tile	6
81	289	No. 25	Fire brick and pottery	10
76	288	No. 23	Fire brick and pottery	10
77	278	No. 20	Pressed brick, fire brick	20
79	278	Fireclay	Fire brick	10
80	297	Plastic pink and yellow	Fire brick and pottery	?
78	288	No. 10	Fire brick	20

Vertical Section, Main Pit, Los Angeles Brick Co.

(From top to bottom.)

Sample No.	Page No.	Local name or number	Principal uses	Thickness, feet
85	298	Pink mottled	Fire brick, sewer pipe, tile, pottery	Up to 30 ft.
86	279	No. 26 bone	Fire brick	6
85	298	Pink mottled	See above	Up to 10 ft.
83	297	Red clay	Hollow tile, roofing tile	12–15
84	289	P. M. fireclay	Fire brick	10–20

A number of samples were taken from undeveloped or partially developed beds. For convenience, these are given in the following table:

Miscellaneous Samples. Los Angeles Brick Co.

Sample No.	Page No.	Local name or number	Name of pit from which sample was taken	Principal uses	Thickness, feet
74	278	West bone	West bone pit	Fire brick	4–6
75	335	Red No. 2	West bone, underlying No. 74	Tile and face brick	?
87	279	Smooth bone	100 yd. E. of main pit, overlying No. 86	Fire brick	15
232	281	Smooth bone	?	Fire brick	6
231	281	High-alumina bone	?	Fire brick	4
82	315	Clay shale	Blue pit	Tile and face brick	10–20
229	300	No. 7	No. 7 pit	Fire brick	34

Note.—Samples No. 231 and 232 were supplied by Mr. Gardiner in September, 1926. Name of pit from which sample was taken was not given.

The areal extent of these various clays can not be definitely determined in the absence of core-drilling data. Enough evidence is at hand, however, to warrant the statement that many of the beds are practically continuous over areas in excess of 300 acres, although it is doubtful if the clay in an individual stratum will be uniform in quality over such an area.

Mining: The clay is mined from the various open pits by hand methods and is transported to the plant by auto trucks.

Plant: Face brick, both plain and ruffled, is the principal product of the Alberhill plant. Fire brick is being made in increasing amounts and a special high-alumina fire brick is being manufactured from the bone clays that occur on the property. Photos No. 48 to 51 show various views of the plant, and photo No. 52 is a view of the east pit.

The clays as they are received from the pits are ground in dry pans, and elevated to separate steel bins for each variety of clay. From the bins, disc feeders are used to feed an augur machine, which is equipped with an automatic cutter. Repressing is applied on ware that requires it. A 32-tunnel waste-heat drier operates on a 48-hour cycle.

Firing is done in four 32-ft. and eight 34-ft. round down-draft kilns, fired with air-atomized oil. Buff and cream face brick and all firebrick are fired to cone 11, and red face brick are fired to cone 10. Four days is allowed for firing, four days for cooling, three days for drawing, and two days for setting. Each kiln is therefore fired about twice a month.

One hundred and twenty-five men are employed in the plant, and twenty in the pits.

Pacific Clay Products Company. Robt. Linton, general manager, 1151 S. Broadway Street, Los Angeles. This company, which has a number of manufacturing plants in Los Angeles County, owns and operates several clay properties in Riverside County. The location of the properties in the Alberhill-Corona district is shown on plate X, page 162.

Douglas Pit. This is an 80-acre tract consisting of the N½ of NE¼ Sec. 22, T. 5 S., R. 5 W., S. B. M., adjoining the active pits of the Alberhill Coal and Clay Co. on the north. A view of the pit is shown in photo No. 53. The pit is mined by hand methods, using shovel and wheelbarrow to deliver the clay to small loading chutes for loading the trucks which haul it to the railroad bins.

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232	281	Smooth bone	?	Fire brick	6
231	281	High-alumina bone	?	Fire brick	4
82	315	Clay shale	Blue pit	Tile and face brick	10–20
229	300	No. 7	No. 7 pit	Fire brick	34

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Photo No. 48. General view of Alberhill plant, Los Angeles Brick Company. (Photo by courtesy of the company.)

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Sample No.	Page No.
74	278
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87	279
232	281
231	281
82	315
229	300

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The clays are similar to those on the adjoining Alberhill and the Gladding, McBean properties. Four samples were taken, as described in the following table, which is arranged as a vertical section from top to bottom of the known deposits:

PHOTO NO. 49. Los Angeles Brick Company, Alberhill plant, during construction. Riverside County.

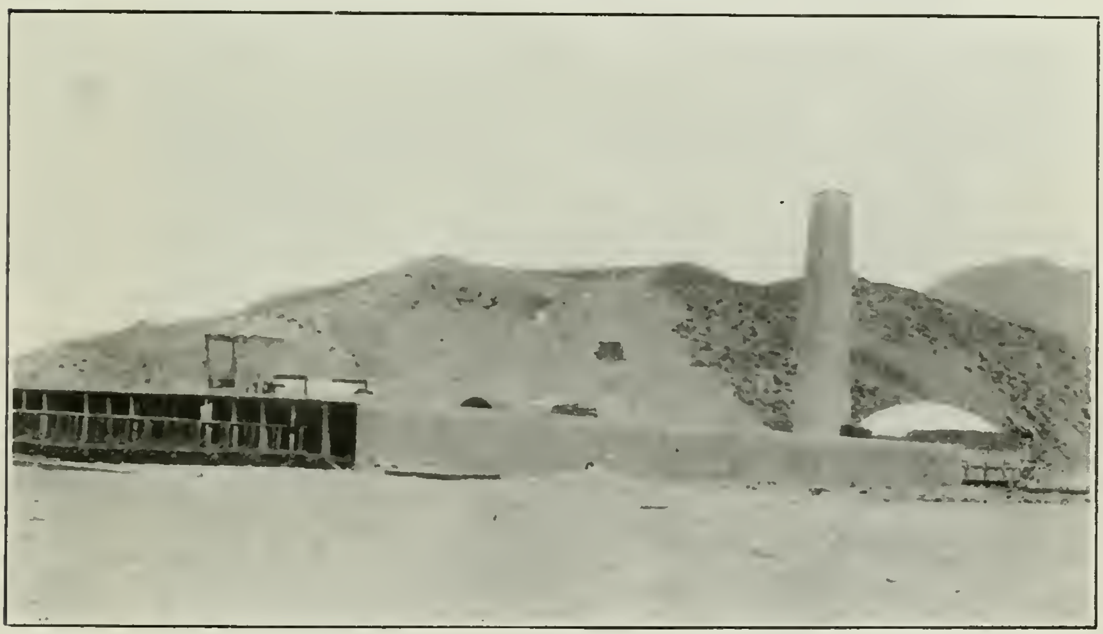

PHOTO NO. 50. Los Angeles Brick Company, Alberhill plant, tunnel driers, during construction. Riverside County.

Sample number	Page reference	Clay class number*	Local nomenclature	Thickness of bed, feet
108	290	6	Upper Douglas	5
109	266	2	Douglas main tunnel	4
110	298	7	Douglas	7
111	315	10	Lower Douglas	50–70

* Refers to clay classification, described fully in Chapter IV.

Hoist Pit. This is a 40-acre property, consisting of the NE¼ of NE¼ Sec. 26, T. 5 S., R. 5 W., and lies southeast of the active workings of the Alberhill company. The principal varieties of clay exposed in this pit are known as Hoist Pit blue (sample No. 112, p. 324) and Hoist Pit

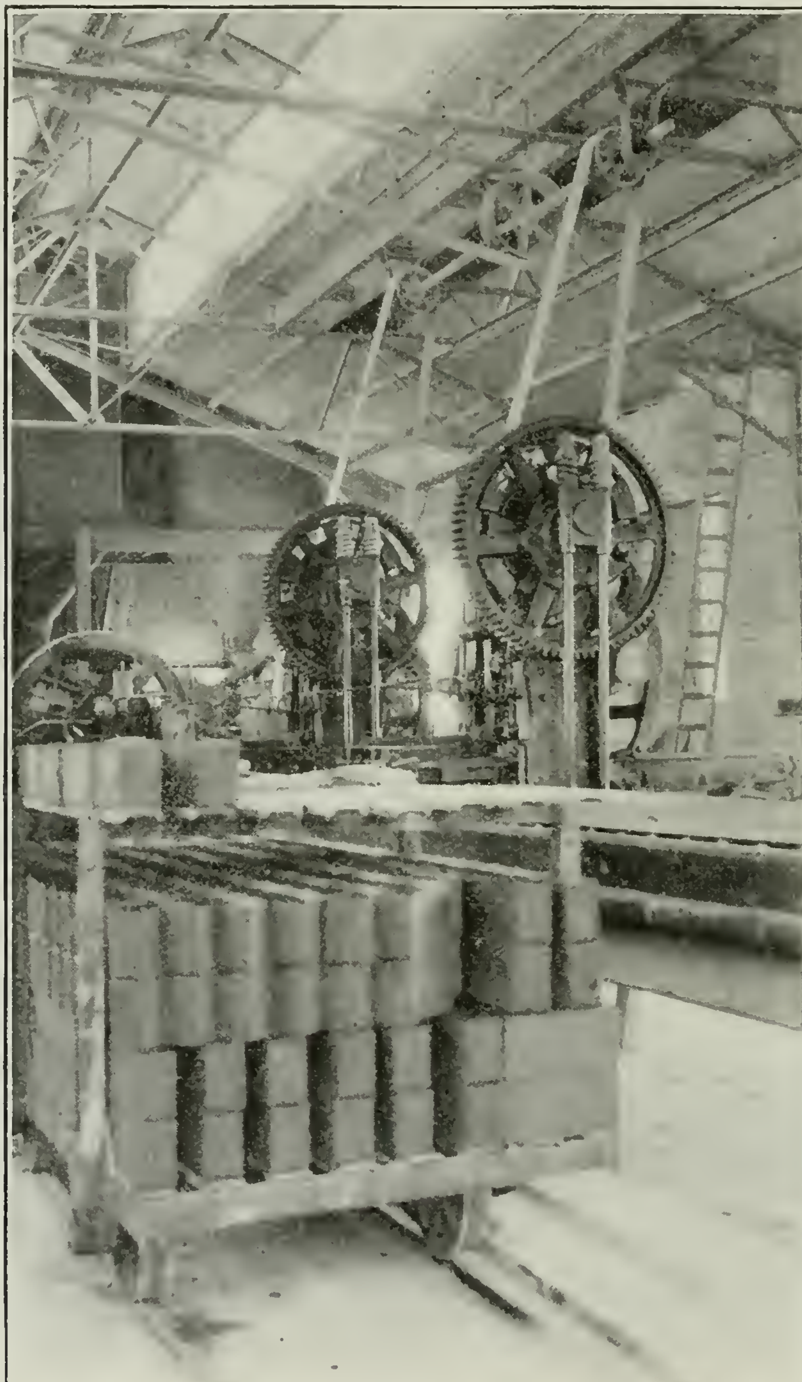

Photo No. 51. Los Angeles Brick Company, Alberhill plant, showing drier cars and brick represses. Riverside County.

red (sample No. 113, p. 324). The blue clay is about 40 feet thick and overlies the red clay, which is about the same thickness. Both varieties are red-burning plastic clays, of particular value in the manufacture of sewer-pipe.

McKNIGHT CLAY PIT. The McKnight clay pit, 3.5 miles by road southwest of Corona, Riverside County, in Secs. 3, 9 and 10, T. 4 S., R. 7 W., S. B. M., has been known and worked for over 30 years.

Description of Deposit and Workings. The deposit is composed of two typical varieties of clay; an upper bed, 60 feet thick, of red-burning plastic clay, used in the manufacture of sewer pipe, electric conduit, and hollow building tile, and a lower bed of fire clay, 30 feet thick, used for fire brick and flue lining. The sewer-pipe clay is represented by sample No. 66, page 277, and the fireclay by sample No. 67, page 277. From 2 to 4 feet of stripping overlies the clay beds.

The present workings attack the clay beds from exposures on the northerly side of a steep hill, into which the clay dips at an angle of approximately 35°. The fire clay is mined through a lower tunnel, 410 feet long, having its portal 500 feet east of an upper tunnel and

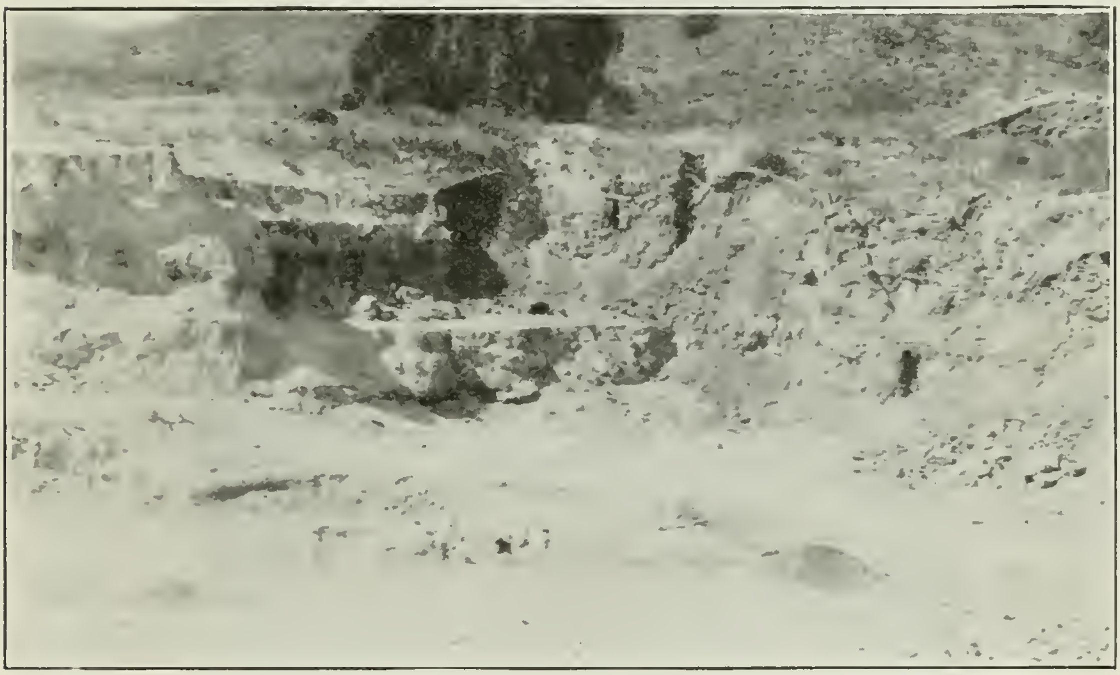

PHOTO No. 52. East pit, Los Angeles Brick Co., Alberhill, Riverside County.

70 feet lower in elevation. The two tunnels are connected by a raise, and clay is mined by room and pillar methods, dumped into the raise, and drawn off into small mine cars in the lower tunnel. The rooms in which the fire clay is mined are about 15 feet high, and connect with an open pit and tunnel at a still higher level from which the red sewer pipe clay is being mined. Extensive workings of a similar character, especially to the southeast, attest the active mining of this deposit over a long period of years. The southeastern portion of the deposit has been exhausted. It is known that the fire clay pinches out to the westward, but there is apparently a good tonnage of the sewer-pipe clay remaining.

All mining and loading is by hand methods. Each of the two working levels is equipped with a bin for receiving the clay from small mine cars and storing it for the light truck which is used for hauling 1.7 miles to a siding on the southeastern edge of Corona. At the time of visit, July 16, 1925, the output was 50 tons per day, of each clay.

WILDOMAR KAOLIN DEPOSIT. The Pacific Clay Products Company owns a deposit of non-plastic, quartzose, white-burning kaolin located ¼ mile east of the Inland Highway, from a point 2.6 miles southeast of Wildomar. The property comprises 18 acres, in R. 3 W., T. 7 S., S. B. M.

The material has been exposed by stripping in two places, about 150 feet apart. It lies in a bed from 30 to 42 inches thick dipping 30° west, forming the side slope of a low hill that rises above the valley floor. The southerly exposure is 100 feet long, and has been mined

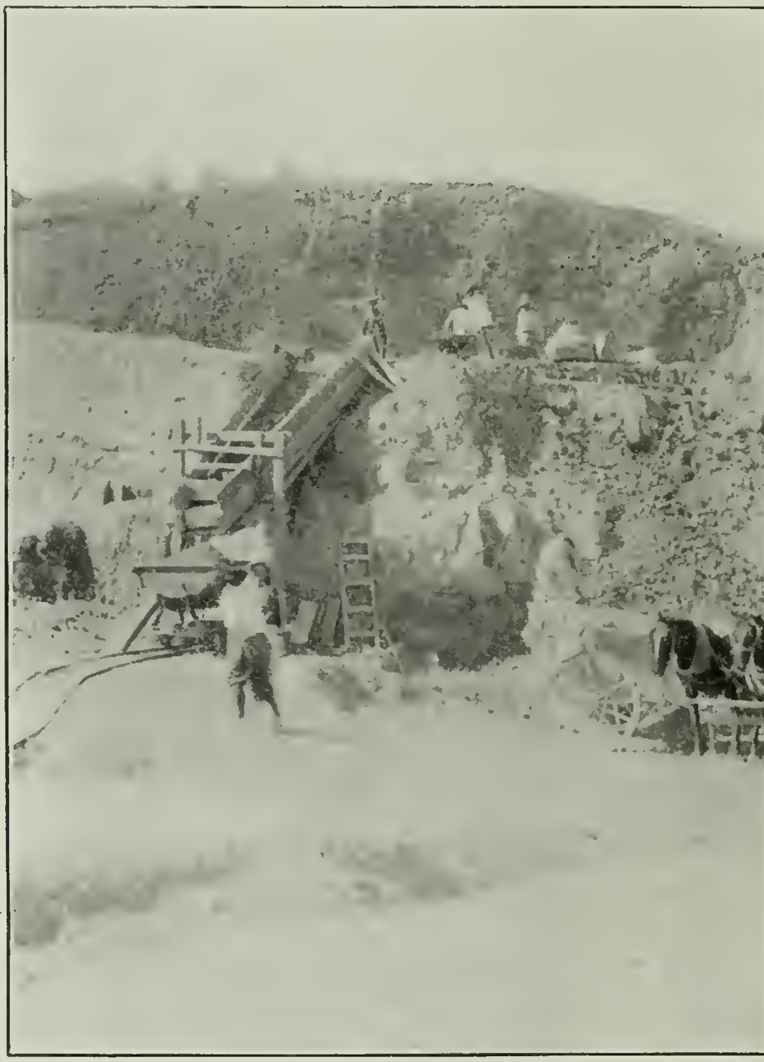

PHOTO No. 53. Douglas pit, Pacific Clay Products Company at Alberhill, Riverside County.

for 50 to 60 feet above the valley, and for a length of 50 feet. A shaft has been sunk to follow the bed beneath the valley floor. Access to the shaft was not convenient at the time of visit on July 21, 1925. The northern exposure is 70 feet long by 50 feet wide, and about half of the exposed material has been mined.

A thin layer of debris overlies the deposit, so that tracing beyond the stripped exposures is not possible without excavation or boring.

MISCELLANEOUS PROPERTIES. The company also owns the following properties in the Alberhill district: Quintet, consisting of 88.79 acres, in the W½ NW¼ Sec. 26, and El Sobrante, 160 acres, comprising the NE¼ Sec. 26, both in T. 4 S., R. 6 W.; Temescal Sixty, 60 acres, comprising the NW¼ NW¼ and N½ NE¼ NW¼ Sec. 12, T. 5 S., R. 6 W.; Terra Cotta Eighty, 80 acres, comprising the W½ SW¼ Sec. 26, and Terra Cotta Plant Site, 40 acres, comprising the NE¼ SW¼ Sec. 26, in T. 5 S., R. 5 W. In addition, the company owns a half interest with Gladding, McBean and Company in the Elsinore Joint Property, 120 acres, comprising the W½ NE¼ and the SE¼ NE¼ Sec. 26, T. 5 S., R. 5 W. Little or no development work has been done on these properties.

Hancock's Brick Yard.[1] C. P. Hancock and Son, owners, 1330 Lemon Street, Riverside. This yard, for the manufacture of common red brick only, is located on the southern outskirts of the city of Riverside. Clay is mined with a steam shovel from a 10- to 20-foot bank of red clay near the plant. The brick are molded by the stiff-mud process, and fired in gas-fired field kilns. The capacity of the plant is 43,000 brick per day. The length of the operating season depends upon local demand. Twenty men are employed.

Prado Tile Company. Losse and Romedas, owners. At Prado, two miles west of Corona. This is a plant for manufacturing hand-made roofing tile and Mexican pottery. The clay is mined from a local deposit and is pugged by treading. The ware is dried in air, and is fired in an oil-fired, rectangular up-draft kiln, holding about 1000 tile (4 squares of 100 square feet). About 10 men are employed at the plant when operating. The price of the tile, at the plant, was $17 per square in 1926.

Temescal Water Company. (?) A small pit in pink-mottled clay was opened up during the season of 1926 on a property in Sec. 35, T. 4 S., R. 6 W., about a mile southwest of the Emsco pit. The ownership of the property could not be determined, as no work was being done at the time of visit, in September, 1926. It is said to belong to the Temescal Water Company, and that it was being developed by 'Doc' Meyers. The pit had been opened by an open cut, 25 feet wide and 40 feet long. A horse scraper was used for removing overburden, and the clay was mined by hand methods. The only clay exposed was pink mottled, a sample of which was taken. See No. 218, page 329. The extent of the deposit could not be determined, but the clay could be traced around the hill for a distance of about 200 yards.

J. W. Wilson of Vidal, a station on the Parker cut-off of the Santa Fe Railroad, in San Bernardino County, has located 26 claims on an extensive clay deposit in a playa three miles by road south of Vidal in Riverside County.

The clay varies in color from nearly white to pinkish and blue-grey. The beds have a total thickness of at least 20 feet over the entire area, except where recent erosion has removed portions of the deposit. In many places, however, thin beds of unconsolidated sandstone, from less than inch to several inches in thickness, are interbedded with clay beds from one to three feet in thickness. The sandstone beds contain many poorly preserved fossils, notably sharks teeth, and small clam shells less than an inch in diameter. The clay beds are overlain by varying thicknesses of loosely consolidated sand and fine gravel, but

[1] Supplemented by data obtained by W. B. Tucker, November, 1927.

there are large areas where erosion has removed practically all of this capping, and has exposed the clay beds.

Samples No. 42 and 43 were taken for test. The results, given on page 340, indicate that the clay is unsuited for general ceramic purposes, although its extremely fine grain, and high plasticity, may indicate certain special uses.

Bibl (Clay resources of Riverside County): State Mining Bureau Bull. 38, pp. 221–224 and 252–253; Prel. Rept. 7, pp. 74–91. Rept. XV, pp. 559–574; XIX, pp. 185–219. Also Jour. Amer. Cer. Soc., Vol. 6, pp. 1167–1175, 1923.

SACRAMENTO COUNTY.

(By C. A. Logan and W. F. Dietrich.)[1]

General Features.

Sacramento County is almost in the geographic center of the state, and lies principally in the Great Central Valley, with the eastern part of the county rising into the foothills of the Sierra Nevada Mountains. The elevation varies from 30 feet above sea level at Sacramento (Southern Pacific depot) to about 900 feet above the sea on the east side of the foothills. The Sacramento and American rivers unite just northwest of Sacramento city limits, the former flowing south and forming the western county line. Cosumnes River traverses the southeastern part of the county, flowing into Mokelumne River on the southern county line.

The county and capital city are served by two transcontinental railways, the Western Pacific and Southern Pacific, which cross the county from north to south. The Central California Traction Company's line from Sacramento to Stockton connects with the Santa Fe system, and the San Francisco-Sacramento electric railway runs southwest to Oakland and San Francisco. A third electric interurban line, the Sacramento Northern, runs north as far as Chico. Three regular steamer lines ply between Sacramento and San Francisco on the river, giving freight and passenger service, besides which there are numerous other river cargo carriers. Two large power companies, Pacific Gas and Electric Company and Great Western Power Company, supply electric power, and the former company and Sacramento Gas Company supply gas. Transportation and power needs are thus well supplied. State highways radiate in all directions from Sacramento.

Sacramento County has been an important gold-producing district for a long time. Previous to the enactment of the anti-debris laws there was considerable hydraulic mining in the Folsom district and the gold production from this source and from drift mining was as high as half a million dollars a year. In 1899 gold dredging began and gold production reached its peak between 1909 and 1919, the maximum yield being over two and a half million dollars in 1919. From now on, production from the gold dredges will decline rather rapidly.

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[1] Mr. Logan's report on Sacramento County was made in 1925. See State Mineralogist's Report XXI, pp. 1–22. Mr. Dietrich visited some of the clay plants in the county in 1925 and 1926 and has added certain details to Mr. Logan's descriptions, especially to that referring to the Natoma Clay Company. He also added notes on the Michigan Bar clay deposits. In 1927, Mr. Logan visited the plant of the Valley Brick Company, and supplied the description that is included here.

As a by-product industry, utilizing the waste rock piles of the dredged land, the rock-crushing industry has become important and has grown rapidly with the increased use of concrete. Sand and gravel are also dredged in large quantities from the American River bed.

Brick, tile, and a great variety of clay products are produced, using local clay mostly. Natural gas is supplied for domestic use, in part from wells. Granite is quarried, and platinum metals and silver are recovered as by-products of dredging.

Clay Resources.

A few deposits of high-grade clay occur in the southeastern part of the county, adjoining Amador County. These are part of the Ione formation, which is so productive of clays in the vicinity of Ione. The deposits were worked a number of years ago, and were the basis for establishing one of the first clay-working plants in California, but have been idle for many years, and present exposures are insufficient to warrant development, in view of the lack of cheap transportation facilities in this area.

There are adequate supplies of common clay in the county, suitable for the manufacture of red structural ware. The gold-dredge silt now being mined by the Natoma Clay Company is of particular interest. The proximity to the important deposits of high-grade clays of Lincoln, Placer County, and Ione, Amador County, has encouraged the establishment of a number of clay plants in or near Sacramento.

Cannon and Company (formerly *Sacramento Clay Products Company*). Owner, Cannon and Company, a close corporation. D. A. Cannon, president and general manager. Main office, 400 Forum Building, Sacramento. The plant and clay beds are at Ben Ali siding, four miles from Sacramento, on what was formerly a part of Rancho del Paso, adjoining the Southern Pacific main line and state highway. There are about two hundred acres in the holdings. A view of the plant is shown on photo No. 54.

About sixty per cent of the clay used in the plant is mined on the property. White clay and sand are brought from Lincoln and Ione deposits for making fire brick and are mixed in desired proportions with the local clay for making other products.

The clay on the property is a firmly consolidated yellowish-brown sandy clay, red-burning, and locally called 'hardpan.' It is covered by a layer of reddish sandy loam, which is worked and marketed separately for molding sand. The 'hardpan' layer varies in thickness but the entire bank is similar in quality, and is worked to a depth of fifteen to twenty feet.

Clay is dug by a steam shovel and horse scrapers, loaded in cars and hoisted to the plant, where it is dumped and aged under cover. It is fed by an auger feed to two dry pans for grinding, after which a bucket elevator lifts it to a Hum-Mer electric screen, screening to the desired size depending on the product to be made. The clay then passes to storage bins, pug-mills, and brick or tile machines. The stiff-mud process is used. The products manufactured include face brick, interlocking and hollow tile, fire brick, hollow tile, Roman brick and other special shapes and sizes. The shrinkage of the local clay is one in thirteen, which is low compared with the white clays used, and

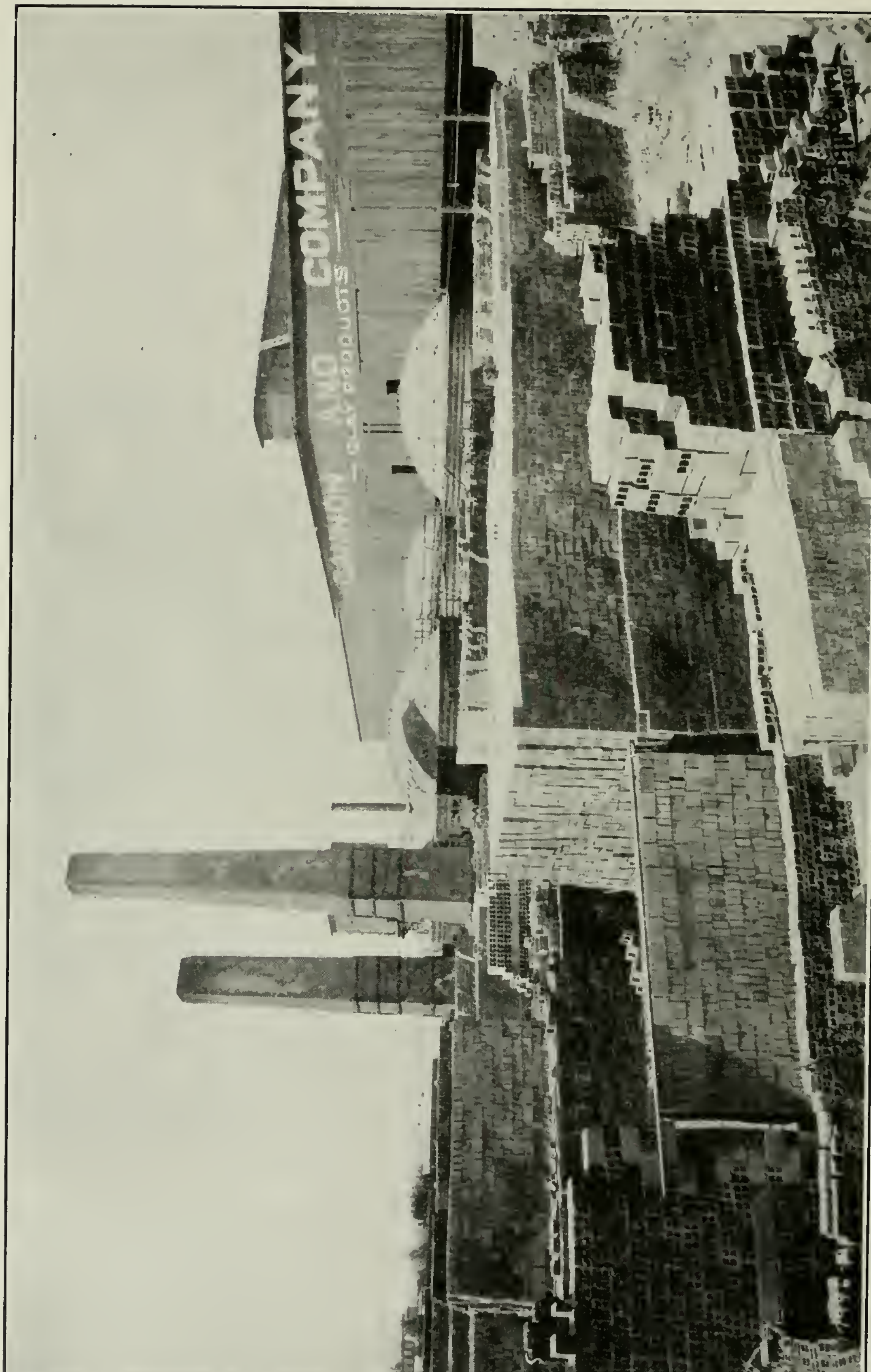

Photo No. 54. Cannon and Company's plant, Ben Ali, Sacramento County. (From State Mineralogist's Rept. XXI, p. 6, 1925.)

shrinkage of different products varies with proportions of the clays employed. Fusibility of the fire brick is above 3000° Fahrenheit and the face brick 2100° to 2200° Fahrenheit. For burning the brick and tile there are five down-draft round kilns, each with a capacity of 70,000 to 80,000 bricks. The bricks are burned five days and tile two and one-half to three days. Clay working machinery is operated from a main drive, using a 200-h.p. electric motor, and crude oil fuel is used for the kilns and steam shovel. There is a spur track to the plant from the railroad main line. Thirty-five to forty men are employed and the plant has a capacity of 10,000 to 12,000 tons a month.

Interlocking tile is used for bearing walls. This tile and the face brick have been used in the new California State Life Building and in other large buildings recently erected in Sacramento.

Bibl: State Mineralogist's Reports XV, p. 404; XXI, p. 7.

Michigan Bar Clay Deposits. In the vicinity of Michigan Bar, 6.5 miles north of Carbondale, are a number of exposures of clay belonging to the Ione formation. Attempts have been made at various times to develop these deposits, but on account of the distance from railroad transportation and the lack of large exposures of uniformly high-grade clay, no recent commercial production has been attained. The most promising showings are in Sec. 2, T. 7 N., R. 8 E., M. D. M., on the south side of Cosumnes River, 2 miles east of Bridge House. Van Vleck and Sons of Michigan Bar own the north half of the section, as well as large acreages to the south and east, some of which may cover deposits of future value. Geo. Cutter of Sacramento owns the NE¼ of the SE¼ of the section; C. E. Bundock of Michigan Bar owns the S½ of the NW¼ of the SE¼ of the section. The ownership of the remaining portions of the section was not determined.

Portions of the area investigated were formerly the scene of hydraulic gold mining operations, especially near the eastern side of the section, and extending over parts of section 1. Gravel still remains over portions of the area, in places to a depth of 20 feet. On the Geo. Cutter property, hydraulic mining has exposed a bed of white plastic clay (sample No. 143), underlying the remnants of gravel at that point. The clay bed has a dip of 7° west, following the slope of the hill. The total exposed thickness of clay is as much as 20 feet in places, but it was not possible to find a continuous and uniform stratum of clay that is not seriously contaminated with a network of hard, weather-resisting stringers of siliceous limonite. The erosion in the 45 to 50 years since hydraulic mining days has left the iron-bearing stringers in sharp relief on the exposed clay beds. At one point, near the center of the Cutter property, the clay is not greatly contaminated over an area about 50 feet square, and for a thickness of three to four feet. A sample, No. 143, was taken from this exposure, in order to indicate the possible utility of clay of such quality, if it could be found in sufficient abundance. The test results are given on page 274.

Just north of the Geo. Cutter property, on the eastern portion of the Van Vleck land, a stream bank affords a good exposure of a fine-grained, white- to cream- and buff-burning clay. The exposed thickness of the bed varies from 3 to 6 feet, extends for 200 feet in length, and can be traced in cross-gullies for at least 100 feet back from the bank of the stream. This bed apparently underlies the clay exposed in the gravel pits. Sample No. 144 was taken for testing, the results of which are given on page 273.

It is entirely possible that prospect drilling over this area, and in adjoining properties, might disclose clay deposits of commercial importance, but in view of the minimum truck haul of 6.5 miles to Carbondale, or 12 miles to the Western Pacific Railroad in the Sacramento Valley, it is unlikely that serious work will be done until some time in the future.

Muddox Pottery. H. C. Muddox Company, owner; H. C. Muddox, president. Office and plant at Thirtieth and L streets, Sacramento.

This company operates a plant for the manufacture of sewer pipe and chimney ware. They own some land at Carbondale, Amador County, where they dig clay, and also buy some common clay locally.

Bibl: State Mineralogist's Report XXI, p. 10.

Natoma Clay Company. This company was organized to produce clay from the settling basins that have resulted from gold dredging operations in the Natoma dredging area. The clay consists of the fine clay and silt that is carried by the reject water from the dredge ponds. This water is passed into shallow basins which were previously formed by the dredge, and the clay and silt are completely settled before the water is returned to the main stream. During the years of dredge operation in this district, many millions of tons of clay have been artificially produced in this fashion. The individual basins are trough-shaped, and are generally less than 30 feet deep, ranging from 75 to 100 feet wide at the surface. The sides of the troughs are formed by boulder piles on an angle of repose of approximately 45°, or by vertical banks of unmined gravel. Some of the basins are one and a half miles or more in length. Much of the clay area has been prospected by hand-augers, and in one summer's prospecting alone, over 6,500,000 tons were proved.

The clay is extremely fine grained, yet contains a sufficient proportion of non-plastic matter to impart desirable ceramic properties to the mass. The proportion of non-plastic matter, and the fineness of grain varies from place to place, but in any given basin there is a remarkably uniform gradation from top to bottom, with the finer material nearer the surface, making it possible to mine two or three different grades of material.

Many laboratory and full-scale tests have been made on the clay, and it has been found to be particularly useful where an excellent range of dark-red colors and a fine even texture is desired. High dry strength, and a long vitrification range, coupled with very low porosity when vitrified, have been thoroughly demonstrated. For the results of tests by the writer on two different samples, see No. 210 and 212, page 337.

Mining operations were started in the summer of 1926, on the Alder Creek pit, half a mile from a spur track of the Southern Pacific Co., and one and a half miles south of Natoma. The clay is mined by an Insley 10-ton gasoline shovel, loading into contractor's dump cars on a narrow-gauge track. See photo No. 55. Haulage to the loading bins at the siding is done with a gasoline locomotive.

Bibl: State Mineralogist's Report XXI, p. 3.

Panama Pottery. Owner, Panama Pottery Company, Inc., a close corporation. Victor Axelson, president; Andres Anderson and Gustav Johanson, principal owners. Address, post office box 797, Sacramento. The plant is just south of Sacramento city limits near Twenty-first Street road. See photo No. 56.

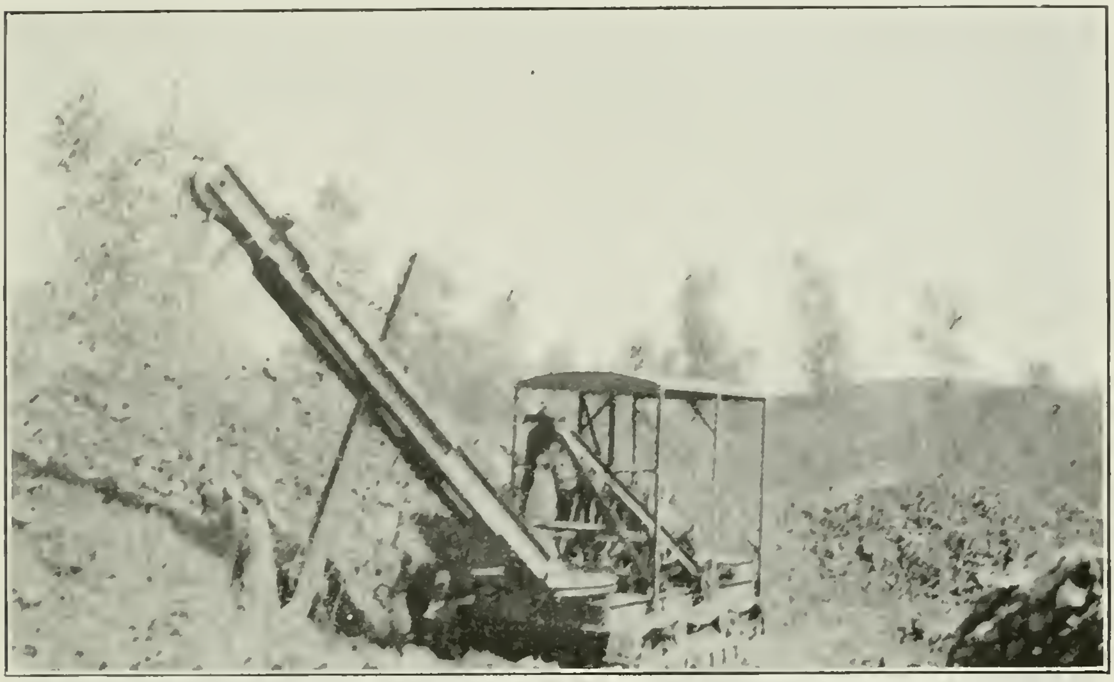

Photo No. 55. Electric shovel in preliminary cut. Natoma Clay Co., at Natoma, Sacramento County.

Photo No. 56. Panama Pottery Company's plant, near Twenty-first Street road, just south of Sacramento. (From State Mineralogist's Report XXI, p. 8, 1925.)

This company owns no clay deposits at present, but buys red-burning clay locally and white clay from Lincoln and Ione. The products of the plant are houshold stoneware, including jars, water coolers and filters, jugs, mixing bowls, pitchers, etc. Fancy garden pottery and common and fancy flower pots are also produced. The company has patented a new one-piece mold for embossed flower pots and are exclusive makers of this line which is made from cream-burning clays. See photo No. 57.

Clay for the various products is crushed in a dry pan and elevated to a 30-mesh shaking screen. It is then tempered and run through the pug mills, aged and run through the pug mill again. After molding, it stands for a short time on shelves and is taken thence to the dryer. White ware is burned 48 to 52 hours at a temperature of 2200 degrees Fahrenheit, and red ware 37 to 42 hours at a temperature of 1800 degrees Fahrenheit.

Equipment at the plant includes two pug mills, a dry pan, glaze grinder, one flower-pot machine, three jolly wheels, shaking screen, and two down-draft kilns with a total capacity of 16,000 gallons of stoneware. Crude oil is used for firing the kilns, and electricity for power.

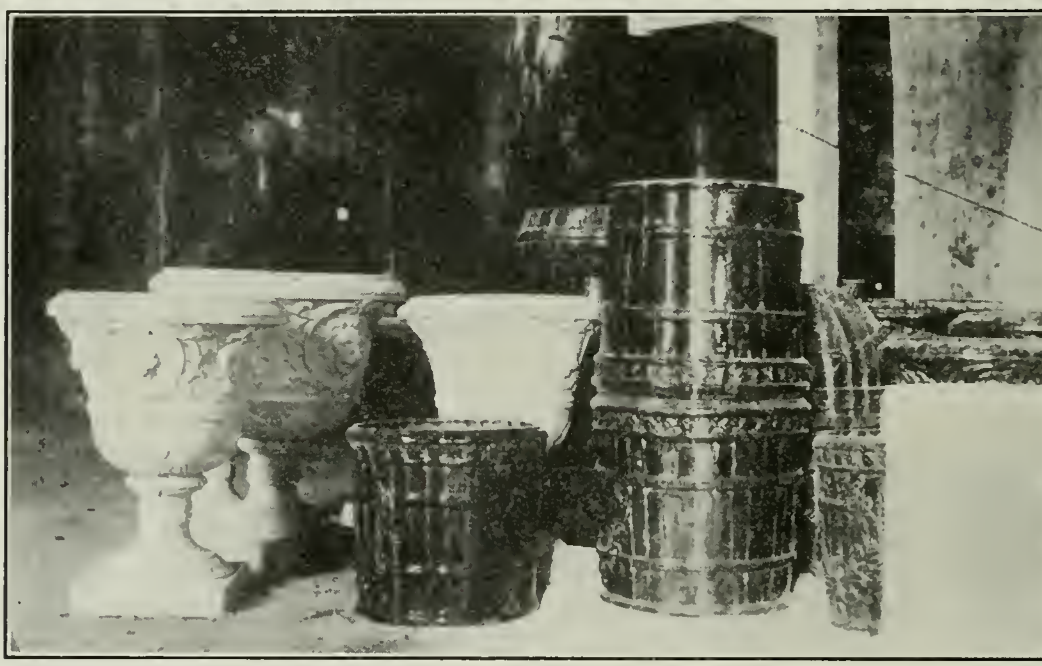

PHOTO No. 57. Fancy garden pottery, manufactured by Panama Pottery Company, Sacramento. (From State Mineralogist's Report XXI, p. 8, 1925.)

Sixteen men are employed. About ten days are required for a complete run, from setting to the time of drawing. The market for the goods is mostly in central California and deliveries are nearly all by automobile truck.

Bibl: State Mineralogist's Report XXI, p. 7.

Sacramento Brick Company (formerly *Riverside Brick Yard*). This is a stock company, subsidiary to Sacramento Navigation Company. W. P. Dwyer, president; A. J. Foster, general manager; H. K. Johnson, secretary. Main office, Front and N streets, Sacramento. The brick plant is three miles south of the Sacramento city limits, near Sacramento River.

The company makes common brick exclusively. The deposit is clay, sand, and loam, with no hardpan, and is worked about 16 feet deep by a steam shovel and drag-line scraper. Clay is loaded into four-ton side dump cars and hauled in trains by dinkey locomotives to the plant, where it is dumped into rolls, elevated to the pug mill and tempered. It passes thence to a soft-mud brick machine where bricks are pressed and dusted with ground red grog from an outside grog grinder and storage bin. From the brick machine the bricks pass by wire cableway to steam-rack dryers, where they are dried in about 18 hours. They are then burned in open-draft field kilns for seven days at a temperature of 1700° to 1750° Fahrenheit. The kilns contain from 400,000 to 500,000 bricks each. The shrinkage in burning is about 6%. The plant has a daily capacity of 60,000 bricks and employs a crew of sixty men. Crude oil is used for burning bricks, for the steam shovel and locomotives, and electric power is used for operating machinery. The direct operation of the brick machine requires only three or four men. The company has another plant between the present site of operation and the river, but this has been abandoned. It was formerly operated at a daily capacity of 125,000 bricks during the dry season only, but the present operations are carried on steadily.

Bibl: State Mineralogist's Reports XV, p. 403; XXI, p. 9.

Valley Brick Company. Main office, 809 J Street, Sacramento. Plant two miles southeast of Sacramento city limits, near S. P. and Central California Traction Company lines to Stockton. H. J. McClatchy, president; A. M. Weston, secretary; H. F. Goss, plant superintendent.

The property includes 40 acres of clay land and equipment for making common red brick. The deposit has an average depth of 20 to 22 feet, of which the upper 12 feet is yellowish-brown clay and the balance sandy clay. Near the surface, and covered by only a thin layer of loam, occurs about two feet of 'hardpan,' which is tight and difficult to dig. Clay is dug with an Erie shovel and loaded on cars which are hoisted up an incline to the grinding floor. After grinding the clay is stored in a bin. Rolls, previously used for grinding, are being replaced now by two 9-ft. dry pans. The stiff-mud process is used, employing a Freise auger machine, and wire cutter. Green brick are dried six to eight days.

Field kilns of up-draft type, containing about 180,000 brick each and using for fuel crude oil which has been atomized by air under 80 pounds pressure, have been in use heretofore. Brick was water smoked for three days and burned three days thereafter, reaching a maximum temperature of 1750° during the latter half of the burning. Eight Furman kilns, with a capacity of 600,000 brick each, will be built soon, and the other changes will increase the brick-making capacity from 42,000 to 63,000 daily. The season for digging clay and making brick extends from April to November. A new steam plant of 300-h.p. capacity is being built, and steam will be substituted for air to atomize the fuel oil. During the busy season 30 men are employed.

Bibl (Clay resources of Sacramento County): State Min. Bur. Bull. 38, pp. 225–226 and 253; Prel. Rept. 7, p. 91; Rept. XXI, pp. 2–10.

SAN BENITO COUNTY.

(By C. McK. Laizure and W. F. Dietrich.)[1]

General Features.

San Benito is one of the central counties situated between Monterey, a coast county, which adjoins it on the south and west, and Merced and Fresno, two of the great San Joaquin Valley counties, which bound it on the northeast. Santa Clara County and a corner of Santa Cruz adjoin it on the north.

The county extends southeasterly from Pajaro River for 70 miles with an average width of 20 miles. Its area is 1392 square miles and the population, most of whom reside in or near the few towns along the railroad in the northern part, is 8995 (1920 census).

About one-fourth of the county is government land. Most of the remainder was long held in the form of large land grants and immense ranchos. As may be expected, cattle-raising early became an important industry and it still is of prime importance. In later years some of these ranchos have evolved into fruit orchards and small farms, due to irrigation and intensive cultivation of the valley lands. As a result, fruits and vegetables, dairy and poultry products, as well as hay, grain, and live stock, have become important sources of wealth. Mining has been carried on since 1858, the total recorded mineral production to date approximating $30,000,000.

Transportation facilities are limited. There is a branch of the Southern Pacific railroad from Gilroy, via Hollister, the county seat, to Tres Pinos. The main coast line of the Southern Pacific also touches the county at Logan, after passing through Pajaro Gap. The 'California Central,' a line 8 miles in length, connects the Old Mission Portland Cement Company's plant with the Southern Pacific at Chittenden. Other parts of the county are served by auto stages from Hollister and Tres Pinos. The southern section can be reached equally as well through Coalinga or Mendota on the San Joaquin Valley side or from King City and San Lucas on the west. Excellent highways join Hollister with Merced on the valley highway route and with San Juan Bautista on the coast route of the highway system. The road to the interior is by way of Pacheco Pass.

The famous Santa Clara Valley penetrates the northern end of the county as far as Hollister. From this point the narrow valley of San Benito River continues southeasterly to the southern boundary. This river and its chief tributary, Tres Pinos Creek, with many smaller streams flowing in from east and west practically drain the entire area. Numerous smaller mountain valleys are found along the flanks of the two ranges of the Coast system, which roughly parallel one another and dominate the topography.

Geology.

There is considerable literature on the geology of portions of San Benito County, but most of the detailed geologic studies have been

[1] Mr. Laizure studied the mineral resources of this county in 1926. See State Mineralogist's Report XXII, pp. 217–247. His general description of the county and his notes on the clay resources were revised for the purposes of the present report by Mr. Dietrich, who visited the county in August, 1925, and made an unsuccessful attempt to find some of the deposits of high-grade clay that had been previously reported. Mr. Dietrich also added notes on the deposit at Paicines.

confined to those sections considered to be possible oil-bearing territory or to the quicksilver mining districts, and no single geologic report fully covers the county.

The general geology as shown on the geologic map of California published by the State Mining Bureau in 1916 is briefly outlined in the following paragraphs.

The Gavilan Range on the western side is composed of ancient granitic rocks associated with crystalline schists and limestones. Dolomite and more rarely barite deposits occur with the limestone and have been developed from San Juan Bautista southerly to Cienaga Valley. Farther south in a small area surrounding the Pinnacles National Monument, which in itself is an example of intense vulcanism, fine-grained volcanic rocks occur. In the southwestern portion of the county, from Topo Valley south and east to San Benito River, the formations exposed are sedimentary rocks of Tertiary age, which include numerous gypsum beds, some bituminous sandstones and diatomaceous earth.

On the northeastern side of the river the Diablo Range rises abruptly, and from near Hernandez south and east beyond San Carlos Peak it is made up of Franciscan rocks, chiefly serpentine but with much red chert, sandstone, slate and schist near the river. From Idria northwesterly nearly to Llanada, Cretaceous and Tertiary rocks make up the main range. From Llanada northward to the northern end of the county the Diablo Range is typical of the Coast Mountains, consisting of serpentine, chert, metamorphic sandstone, slate and schist. Quaternary and late Tertiary sediments comprise the valley area surrounding Hollister, and sandstone, shales, sands, gravels and clays are much in evidence along San Benito River as far south as Hernandez.

San Andreas fault, a dominant structural feature of the geology, enters the county near Chittenden and runs southeasterly along San Benito River as far as the town of San Benito. From here it crosses a low divide into Rabbit Valley, and from there it follows Bitterwater Creek to its junction with Lewis Creek and then continues southward up Lewis Creek.

An extensive and diversified number of mineral substances are found in San Benito County. Both metallic and nonmetallic minerals are included in its resources, but commercial production has been limited and many deposits have remained entirely undeveloped on account of their distance from railroad transportation. Neglect of mining opportunities may also be due in part to the fact that many deposits are on private lands, whose owners are interested in other lines of activity.

Quicksilver production has given San Benito its reputation in the mining world, as it ranks among the oldest and most important quicksilver producing counties. The New Idria mine, in the southern part, is the largest single producer of quicksilver in the state. Since 1918, however, the value of the county's annual output of quicksilver has been exceeded by that of cement. Crushed rock production closely follows quicksilver in annual value of output. Other mineral products which have been produced in greater or lesser amounts are: antimony, asbestos, asphalt, bituminous rock, brick, chromite, coal, dolomite, gems, gypsum, lime and limestone, magnesite, manganese, and mineral water.

Barite, clay, copper, diatomaceous earth, feldspar, gold, iron, montmorillonite, petroleum, strontium, and volcanic ash also occur here, but the commercial value of these deposits is not as yet established. A number of other mineral species are represented in the county, but their occurrence is of mineralogical interest only.

Clay Resources.

There have been a number of reported occurrences of high-grade clay in the county, but none of these have been of sufficient economic interest, in view of the comparative isolation of the county from industrial centers, and the lack of cheap transportation from the reported occurrences, to warrant serious investigation.

The larger valleys of San Benito River and its tributaries contain ample supplies of common clay suitable for the manufacture of heavy structural ware. The Paicines deposit, described herein, is typical of these. There has been no commercial output of clays, as such, in the county, and the only clay material being utilized at the present time (1926) is that mined by the Old Mission Portland Cement Company for the manufacture of cement at their plant at San Juan Bautista.

Abbe Ranch. There is a deposit of clay containing considerable sandy material on the C. H. Abbe Ranch, 12 miles south of Paicines on the Idria road. This clay fuses at a rather low temperature, but does not crack or swell. It appears to be an impure montmorillonite. The bed stands practically vertical and cuts across a ridge from top to bottom.

A white kaolinized rock that slowly breaks down in water, forming a slightly plastic clay with a comparatively low fusing point, is exposed in a cut along the San Benito road about 18 miles south of Tres Pinos. This variety of clay could probably be utilized in the ceramic industries. It is undeveloped.

The Alpine Quicksilver Mining Company in 1915 burned about 260,000 brick in field kilns on lower Clear Creek near Hernandez for use in building their reduction furnace. The clay was dug locally. Some of these brick still remain along the road and appear to be of good quality.

W. T. Maeder, 554 Sixty-sixth Street, Oakland, California, has submitted a sample of siliceous clay, possibly a fireclay, from the Bitterwater section. Undeveloped.

M. A. Martin, formerly of Hollister, located some clay which burns white, or nearly white, near the head of Willow Creek in T. 15 S., R. 6 E.

Dr. J. M. O'Donnell of Hollister owns a deposit along Bird Creek, three miles south of Hollister. The bed is exposed for a considerable depth in several of the gulches, and a well was sunk 80 feet without reaching the underlying rock. The clay is light grey in color, very plastic and without grit. It burns to a cherry red and is said to be suitable for pottery use.

Paicines Clay Deposit. In Sec. 36, T. 12 S., R. 6 E., M. D. M., 0.3 mile south of Paicines on the San Benito road is an exposure of yellow plastic clay of probable Pliocene age. A road cut at this point exposes a bank 6 feet high, but the deposit is probably at least 20 feet thick, and covers an area of many acres, with little or no overburden. Similar deposits occur in various other localities in the San Benito Valley.

See sample No. 118, page 341.

H. V. Underwood of Hollister has submitted samples of plastic clay of fairly-high alumina content found at several points in the county.

Bibl (On San Benito County clay resources): State Min. Bur. Bull. 38, p. 226; Prel. Rept. 7, p. 91; Rept. XXII, pp. 228–229.

SAN BERNARDINO COUNTY.

General Features.

San Bernardino, with an area of 20,157 square miles, is by far the largest county in the state. It is bounded on the north by Inyo County, on the east by the states of Nevada and Arizona, on the south by Riverside County, and on the west by Los Angeles and Kern counties. The population is 73,401 (1920 census).

The topography of the county consists largely of mountains and desert, and is characteristic of the Great Basin, which has been described by many geologists. The famous Mojave Desert is almost wholly confined within the limits of the county, but extends southward into Riverside County. Most points in the county can be reached with comparative ease by railroad or highway.

The geology of the entire county has never been studied in detail, but many interesting reports have been made by various members of the U. S. Geological Survey, and others, on different areas in the county. A large part of the county is covered by Tertiary and Quaternary volcanics, and Quaternary gravels, but many other formations are present, particularly in the numerous mountain ranges. Chief among these are pre-Cambrian and Paleozoic metamorphics, and various Tertiary formations, principally Miocene.

The mineral resources are varied, and the aggregate production places the county in fifth place (1926) among the counties of the state in the value of its mineral products. Cement is the most important product, and there are three plants in the county. Other mineral products are borates, calcium chloride, clay, copper, fuller's earth, gold, lead, lime, limestone, mineral water, petroleum, potash, salt, silver, soda, miscellaneous stone, talc, and tungsten concentrates. Occurrences of asbestos, barytes, gems, granite, gypsum, iron, manganese, marble, mineral paint, nitre, soapstone, strontium, vanadium, and zinc are known.

Clay Resources.

Deposits of high-grade clay occur at a number of localities in the county. Two or three of these have been developed. The most interesting deposits are those in the Hart Mountains, described below under H. F. Coors and Standard Sanitary Manufacturing Company. A plastic kaolin of exceptional quality has been developed on these properties. It is likely that more intensive prospecting will disclose hitherto unknown deposits of a similar type.

Common clays are sufficiently abundant in the vicinity of San Bernardino to serve all purposes, and the apparent lack of suitable deposits elsewhere in the county is of no importance, because of the fact that these areas can never be expected to support a large population.

Two ceramic materials of special interest occur in San Bernardino County, convenient to railroad transportation. These are ganister and talc schist. A large ganister deposit is being worked by the Atlas Fire Brick Company of Los Angeles in Sec. 31, T. 9 N., R. 3 W., four miles from Hicks Station on the Santa Fe railroad, between Victorville and Barstow. It is the equivalent of Pennsylvania ganister in the manufacture of silica brick. The talc schist occurs in Sec. 29, T. 19 N., R. 4 E., 13 miles northeast of Newberry Station on the Santa Fe railroad. It is being mined by John J. Kennedy of Daggett, and is in use as an ingredient of white tile bodies in a few Los Angeles plants.

H. F. Coors Deposit. Owned by H. F. Coors, Inglewood. The property consists of 7½ unpatented mineral claims in the old mining town of Hart. The claims cover parts of Secs. 13 and 24, T. 14 N., R. 17 E.,

PHOTO NO. 58. H. F. Coors Kaolin Deposit, Hart, San Bernardino County. (Sample No. 57.)

S. B. M. The clay is a white-burning ball clay, possessing the properties of a mixture of china clay and ball clay. It occurs as an alteration of an eruptive rock relatively high in alumina and low in alkalis and iron.

At the time of visit, in June, 1925, the property was idle, but enough development work had been done in two different places, one of which is shown in photo No. 58, to demonstrate the presence of an extensive deposit of uniform material. The trench shown in the photo was 150 feet long, 8 feet deep, and 15 feet wide. Ten to fifteen feet vertically below the bottom of the trench, a 100-ft tunnel had been driven. At another point on the property, about 200 yards to the southeast, a 65-ft. tunnel, originally driven in the search for gold, had been enlarged at the face into a room 20 by 12 feet in section, by 8 feet high, exposing similar material to that present in the cut.

Since 1926 Mr. Coors has been mining from the deposit to secure clay for his plant in Inglewood (see under Los Angeles County).

Sample No. 57 was taken for testing, the results of which are on page 264.

Gladding, McBean and Company. Office of Southern Division at 621 S. Hope Street, Los Angeles. This company owns a deposit of buff-burning clay, 4.2 miles by road northeast of Bryman, a station on the Santa Fe railroad between Victorville and Barstow. The clay is mined from an open cut, which at the time of visit, in June, 1925, was 40 feet wide and 100 feet long. The bank was 40 feet high at the face of the pit. From 100 to 150 tons per year were being mined and shipped to Los Angeles for use in the manufacture of face brick.

Sample No. 55 was taken for testing. The results are on page 314.

R. H. Holliman and D. Murphy have located 12 mineral claims covering extensive outcrops of clay beds in Sec. 14, T. 12 N., R. 14 E., S. B. M., on the western slope of the Mid Hills, which connect the Providence Mountains on the southwest with the New York Mountains to the northeast. By the existing road, the deposit is 13 miles southeast of Cima, but a road with easy down-grade could be built from the deposit to the Los Angeles and Salt Lake Railroad line south of Cima. This road would be from six to seven miles in length.

On the area covered by the claims there are three distinct beds of white semi-plastic clay, each of which is from six to fifteen feet thick and can be traced intermittently for some 2000 feet on the strike.

The clay shows the general characteristics of an impure kaolin, and is evidently derived from a highly feldspathic granite that is abundant in this locality. The quality of the clay as exposed on the surface and in the shallow workings is widely variable and it is likely that considerable development work will be needed in order to prove the existence of sufficiently large bodies of material of uniform quality to warrant commercial production.

Development: The development work consists, in part, of a shaft ten feet deep from the bottom of which ten feet of drifting has been done. The clay bed at this point is steeply tilted and the attempt was made to cut it by a 120-foot tunnel 25 feet below the outcrop, but so far as the work had progressed at the time of visit on June 18, 1925, the material encountered in the tunnel was inferior in quality to that exposed nearer to the surface.

The other two clay beds lie higher up on the mountain, and no development has been done. The upper beds lie nearly horizontal.

The geology is somewhat complex in this area. There are a number of rhyolitic flows, as well as a few remnants of sedimentary formations, principally sandstone and limestone.

Sample No. 46 was taken for testing. The results are on page 349.

Millet Clay Deposit. An extensive, but undeveloped deposit of clay occurs near the southern boundary of the west half of Sec. 31, T. 9 N., R. 3 W., S. B. M., owned by M. J. Millet and J. J. Kennedy of Daggett. The clay is exposed on the surface one-third of a mile south of a ganister deposit that is owned by the Atlas Fire Brick Company of Los Angeles. Several shallow pits and short tunnels have been excavated, giving indications of a clay bed 10 to 20 feet thick and extending discontinuously for a distance of nearly one-half mile, with an east-west strike.

It is impossible to estimate from the present state of development the probable tonnage and uniformity of the occurrence. Sample No. 53 was taken for test, and the results given on page 288 are sufficiently encouraging to warrant further investigation. The sample was taken from a shallow exposure made in a small cut, and it is not unlikely

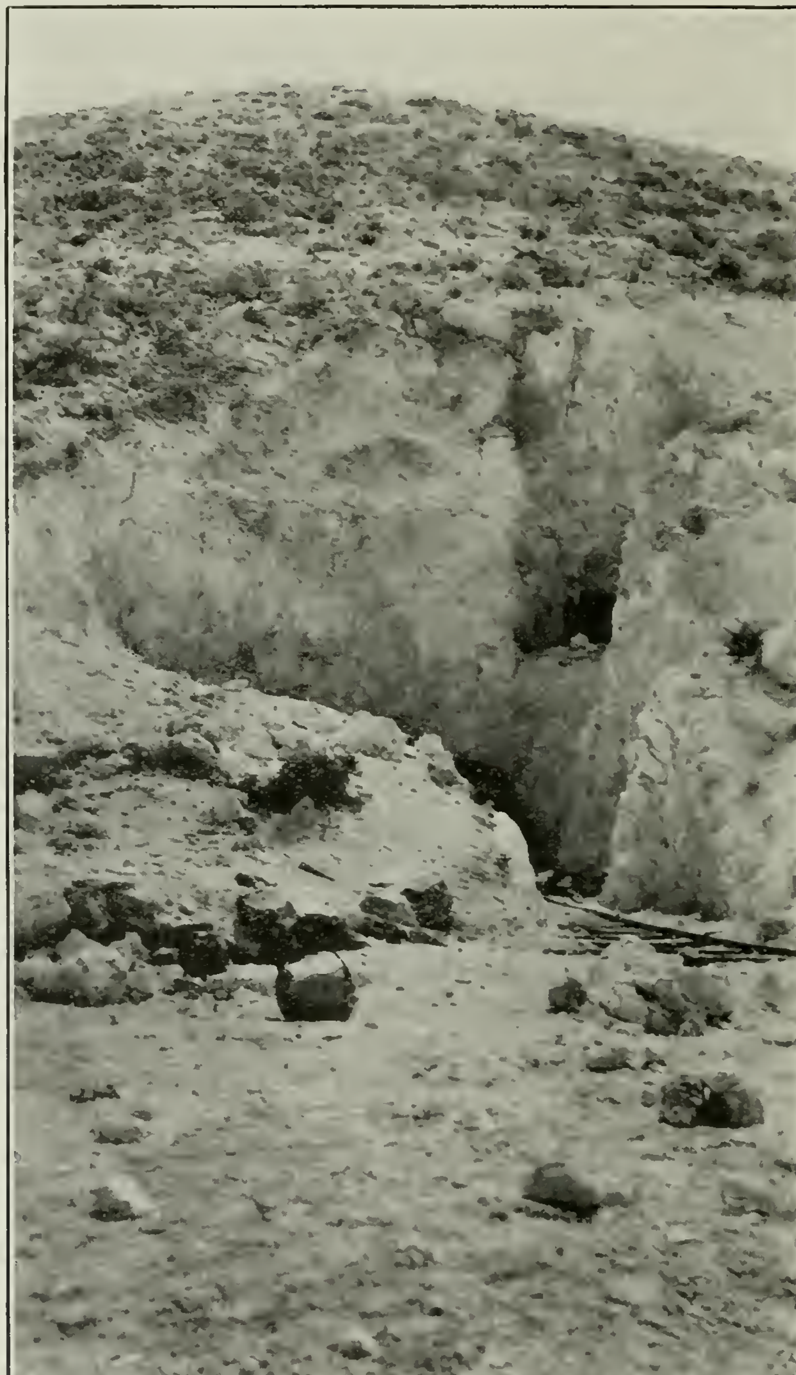

PHOTO No. 59. Pacific Kaolin Mine. Standard Sanitary Co. Upper workings. (Sample No. 45.)

that it shows more contamination with surface debris than would be found at points further beneath the present surface.

Standard Sanitary Company. One-half mile south of the old gold-mining town of Hart, the Standard Sanitary Company owns a deposit of white-burning ball clay that is being exploited by underground methods.

The clay is the result of alteration of a feldspathic igneous rock, the original nature of which was not determined. The enclosing and overlying rocks are rhyolite. The total extent of the deposit is unknown, but the height is from 60 to 70 feet, the width at least 50 feet, and the length over 200 feet, as exposed on the surface and in the workings. The dimensions given probably represent but a small proportion of the total material available.

Development and Mining: The development work consists of two sets of workings. The upper workings, now abandoned, lie up the slope of the hill some 30 feet vertically above the present tunnel level. The upper workings consist of an open cut extending into several underground chambers from which clay has been mined. See photo No. 59.

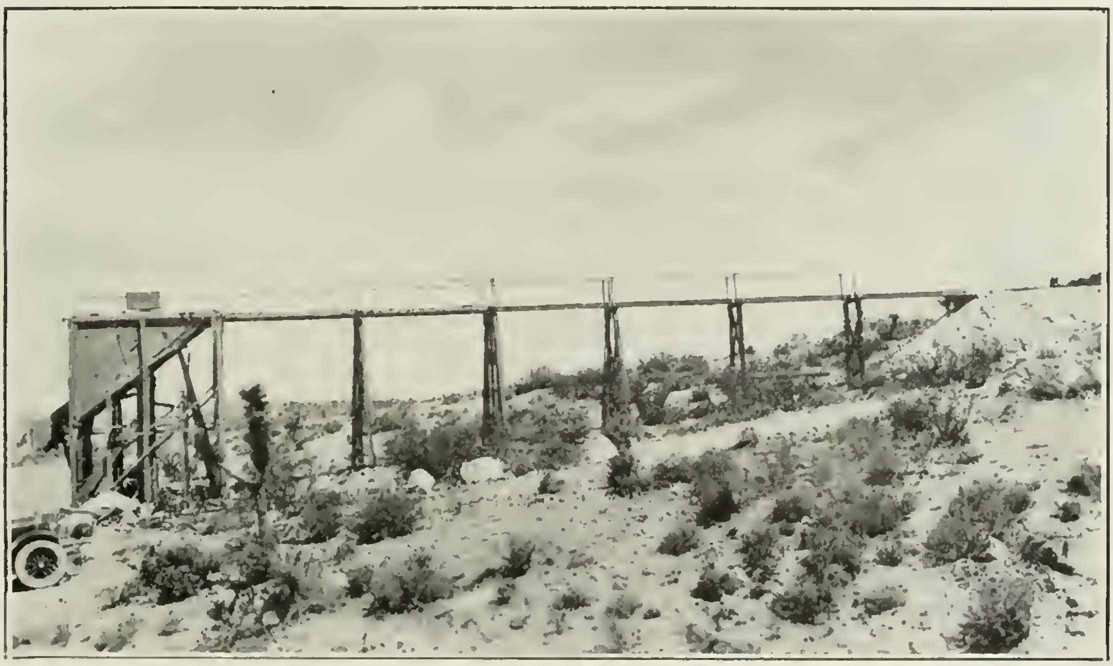

Photo No. 60. Pacific Kaolin Mine. Standard Sanitary Co. Trestle and bin on lower tunnel level. (Sample No. 44 taken from face of stope.)

The lower tunnel was driven in order to provide better facilities for breaking and loading the clay, and to permit more systematic mining. At the time of visit on June 17, 1925, this tunnel had been driven 150 feet in length and shortly after entering the hill, it had been gradually enlarged to a chamber which at the face was 30 x 30 feet in section.

The clay requires light blasting but is sufficiently soft so that hand augers can be used for most of the drilling, with the aid of hand-hammer drilling in the harder portions. The broken material is hand-loaded into mine cars and hand-trammed to the loading bins outside of the portal of the tunnel. See photo No. 60. A motor truck is used for hauling to Ivanpah, a distance of 15 miles over a rough road, but one that has a uniform down-grade in favor of the load.

At the time of visit, four men were working, including the foreman and the truck driver. The production varies from 15 to 20 tons per day.

This property is worked for three or four months of the year. During the idle period the same crew is employed at the company's feldspar property near Campo, San Diego County.

Samples No. 44 and 45 were taken for testing. The results are given on page 264.

Bibl (Clay resources of San Bernardino County): Cal. State Min. Bur. Bull. 38, pp. 226–227, 253–254; Prel. Rept. 7, pp. 92–93; Rept. XV, pp. 860–862. The most important references on the geology of the county are: Darton, N. H., et al., Guide Book of the Western U. S., Part C, U. S. G. S. Bull. 613; Ball, Sidney H., Geologic Reconnaissance of Southwestern Nevada and Eastern California, U. S. G. S. Bull. 308.

SAN DIEGO COUNTY.

General Features.[1]

San Diego was discovered in September, 1542, by Juan Rodriguez Cabrillo. This discovery of the San Diego region by Cabrillo was followed by the establishment of the first Franciscan Mission in California on June 16, 1769, by Padre Junipero Serra. The location of this mission at San Diego led to the early settlement of the Pacific coast and is of special prominence in the early history of California.

The principal industries are agriculture, stock raising, dairying, and commercial fisheries. The mining industry is relatively undeveloped, although the mineral resources of the county are varied and extensive. The rapid and continued growth of the city of San Diego and the manufacturing industries on the Pacific coast have led to the development of deposits of structural and industrial materials throughout the county.

San Diego is bounded on the east by Imperial County, north by Riverside and Orange counties, west by the Pacific Ocean, and south by Mexico. Its area is 4221 square miles and its population 112,248 (census of 1920).

The county and the city of San Diego are served by two railroads, the Santa Fe and the San Diego and Arizona. The Santa Fe railroad enters the county at San Onofre and follows the coast line to San Diego, connecting the lattter with the city of Los Angeles. From the main trunk line there is a branch line from Los Angeles Junction, known as the Fallbrook branch, that runs as far as Fallbrook; another branch line runs from Oceanside to Escondido, giving railroad transportation to an important citrus belt. The San Diego and Arizona railroad runs along the border of Mexico and the county, connecting San Diego with Imperial Valley at El Centro. The Cuyamaca branch of this line runs from San Diego to Lakeside, affording transportation for El Cajon Valley and other interior points. From the port of San Diego regular steamer lines ply between San Diego, Los Angeles, San Francisco, Seattle.

San Diego has a wonderful system of highways and good roads which give access to all parts of the county. Two main paved highways from Los Angeles to San Diego parallel the coast. The coast route follows the coast line, and the inland route is via Riverside, Fallbrook and

[1] This and the subsequent paragraphs on geology are abstracted from a recent report by W. Burling Tucker, State Mineralogist's Rept. XXI, pp. 325–327, 1925.

Escondido to San Diego. Two paved highways connect Imperial Valley with San Diego. Five scenic highways, stretching out from San Diego like ribs of a huge fan with its northern tip at Oceanside and its southern tip at Campo, within one mile of the Mexican border, afford easy access by automobile to all parts of the San Diego Mountains. Each one of these intersects the road, forming the outer rim of the fan, which traverses practically the entire Incopah Range from northeast to southwest, a distance of more than 170 miles. The total mileage of all the fan-shaped routes is nearly 600 miles.

The topographic features of the county consist of a series of parallel ranges of granite, with a southeast trend, including the southeastern continuation of the San Jacinto Range of Riverside County. Among these granite ranges are valleys occupied by parallel belts of metamorphic rock, chiefly slate and mica schist, with some quartzite and lentils of limestone. These have a general northwest strike, with steep dips to the east, and extend from Mexico into Riverside and Orange counties. The Cuyamaca and Laguna Mountain ranges extend northwest and southeast, and are over 5000 feet high at many points. Cuyamaca Peak has an elevation of 6515 feet, and Laguna Mountain an elevation of 6500 feet. These are intrusions of diorite and gabbro which occur at intervals in the granite area. Southwesterly from this elevated belt the altitudes decline toward the coast. West of the granite area is a belt of volcanic felsite and tuff that extends northwest some 40 miles from the Mexican line. The belt is only a few miles wide, for the most part being buried beneath mesa formations. It is exposed at many points, forming the peaks of Otay, San Miguel, and Black Mountains. The mesas of Tertiary deposits which occur on the west flank of the crystalline formations gently slope seaward, from an altitude of about 500 feet at its eastern margin to an elevation of about 300 feet near the coast line. From the main divide the surface slopes steeply eastward toward the Salton Basin.

The principal valleys of the county are those occupied by the Santa Margarita, San Luis Rey, San Dieguito, San Diego, Sweetwater, Otay, and Tia Juana rivers. They are characterized by wide, flat, gently-sloping floors, bordered by steep slopes or bluffs several hundred feet high, and they contain streams that rise far back in the mountain area. All these streams flow to the ocean. El Cajon Valley, Santa Maria Valley, and Warner Valley are comparatively flat tracts, some of them surrounded by steep mountain walls, and cover many square miles, within the highland area, and form the broad valleys.

Geology.

The geology of San Diego County has been described in detail by W. A. Goodyear in the Eighth Annual Report of the State Mineralogist, pp. 516–628, for the year 1888; by Harold W. Fairbanks in the Eleventh Report, pp. 76–120, for the year 1892; by Dr. F. J. H. Merrill in the Fourteenth Report of the State Mineralogist, pp. 637–645, for the years 1913 and 1914; in Water Supply Paper No. 446, U. S. Geological Survey, 'Geology and Ground Waters of the Western Part of San Diego County.'

The formations of San Diego County are granites and other igneous crystalline rocks, of several ages, metamorphic strata of great age, possibly Carboniferous or older, and sandstone, shales, conglomerates, sands, gravel, and clays of Mesozoic and Tertiary age.

The granites upon which the metamorphic rocks rest, and by which they are intruded, are of several types. These granites are in turn intruded here and there by basic rocks of the diorite and gabbro types. The latter are cut at many points by pegmatite dikes, which also appear as intrusives in the schists and in the granites. Two areas of these basic intrusives form substantial mountain ranges, one traversing the Cuyamaca Grant from north to south, and forming three peaks, of which the southermost, 6515 feet high, is known as Mount Cuyamaca. Ten miles southeast is a diorite ridge, known as Laguna Mountain, of which the summit attains an altitude of over 6500 feet.

On the southwest flank of the granite area is a volcanic flow, a few miles wide, extending northwest some 40 miles from the Mexican boundary. This area is largely overlain by Tertiary formations. The principal rocks exposed are felsite, tuffs, and volcanic conglomerates. The metamorphic formations are mica schists, slates, quartzites, and limestone; the mica schists are well exposed at Julian and on the west flank of the Laguna range of mountains. The Cretaceous strata exposed in this region are of the Chico series and appear in the bluffs on Point Loma and at La Jolla, as described by Harold W. Fairbanks in the Eleventh Report of the State Mineralogist, p. 95.

The earlier Tertiary or Eocene deposits appear at the surface from Los Peñasquitos Canyon northward to Buena Vista Creek; the later Tertiary deposits are exposed from Los Peñasquitos Canyon southward to the Mexican boundary, and from Buena Vista Creek northward to the north boundary of the county. The earlier Tertiary or Eocene beds are made up of white sandstone, underlain by alternating layers of shale, sandstone, and thin layers of clay and shale, limestone and sandstone, and marl and calcareous material.

The principal mineral products of San Diego County are miscellaneous stone, feldspar, brick and hollow building tile, granite, and pottery clay. Other minerals that have been produced in recent years are mineral water, gems, gold, silver, fuller's earth (Otaylite), lime, magnesium chloride, salt, and silica. Occurrences of bismuth, lithia, marble, nickel, soapstone, and tin are known. Potash has been produced from kelp.

Clay Resources.

Important commercial deposits of fireclay and pottery clay, mainly of Eocene and Pleistocene age, occur in northern San Diego County, in the vicinity of Carlsbad and Cardiff. Some of the fireclays are similar to the famous Gros-Almerode clays of Germany. On the top of El Cajon Mountain, in the southern part of the county, is an interesting deposit of residual kaolin, which was worked for a short time, but has little commercial value on account of its inaccessibility. It serves as a valuable guide to further prospecting in the region.

Red-burning shales suitable for the manufacture of common brick, paving brick, and hollow tile are reasonably abundant in the vicinity of San Diego, but softer clays that can be used without grinding are not plentiful in locations close to the center of consumption (principally the city of San Diego). Deposits of Miocene Tertiary clays on the eastern margin of the county were noted in an earlier report.[1] These are as yet commercially inaccessible, and but little is known of their properties.

The feldspar and quartz deposits of San Diego County are of particular interest to the clay-working industry. The greater part of the feldspar used in California is produced at Campo.

California Clay Products Company and *Mission China Company*. Victor Kremer, president. Offices, 315 Western Mutual Life Building, Los Angeles. These companies own a fireclay property in Sec. 4, T. 13 S., R. 3 W., S. B. M., 8 miles by road in a northeasterly direction from Cardiff, and two miles northeast of the property of Gladding, McBean and Company (*q. v.*).

The holdings of the California Clay Products Company consist of the Pearl and the Dorothy Ann placer claims, comprising 20 acres each; and the Mission China Company owns two adjoining claims known as the Robert Charles and the Thomas Hewitt, also 20 acres each. All these claims are patented.

The clay is a white, semi-plastic fireclay. It does not develop sufficient plasticity to be used alone, and is of value principally for its refractoriness. It is used in Los Angeles by the California Clay Products Company, as an ingredient in the manufacture of saggers, and also in San Diego by the Vitrified Products Corporation. These companies are controlled by the Victor Kremer Enterprises, Victor Kremer, president.

DEVELOPMENT AND MINING: A number of test pits and trenches have been dug, exposing clay over a considerable area. Mining is being done on the Pearl claim, where a loading bin has been built and a small open cut, 30 by 40 feet in area, has been excavated. The exposed bank of clay is 10 to 12 feet high. One carload per week is being mined and trucked to Cardiff.

Sample No. 36 was taken for testing. See page 311.

Bibl: State Mineralogist's Report XXI, p. 355.

El Cajon Kaolin Deposit. The deposit is located on Cajon Mountain, at an elevation of 2500 to 2700 feet, 4½ miles in a direction N. 55° E. from Lakeside. It is now owned by the *American Pottery Company* (?) of Los Angeles. The holdings comprise two claims in T. 14 S., R. 2 E., S. B. M., on or near Sec. 29, approximately one mile west of El Cajon Peak, but practically on top of the range.

The kaolin was formed by alteration in situ of an alaskite or similar pegmatitic derivative, containing but small quantities of ferro-manganesian minerals. The extent of alteration varies widely within comparatively short distances, so that the resultant material ranges from slightly-plastic kaolin containing an excess of free quartz and undecomposed feldspar, to extremely plastic, fine-grained, thoroughly-hydrated kaolin. Exposures of such material have been made at various points on the mountain, indicating that they occur in a zone that has a general northeast strike.

The deposit has been developed by a number of tunnels, shafts, and open cuts, the principal tunnel having been driven in a northwesterly

[1] State Mineralogist's Report XIV, p. 685.

direction for a distance of 75 feet, to a point 50 feet below the surface. This tunnel is connected by means of a raise to a small open pit, or glory hole. The material exposed by these workings shows all of the variations indicated above, with six feet of thoroughly altered, plastic kaolin near the face. During 1914 and 1916, some kaolin from these workings was shipped to the faience tile plant of the former California China Clay Products Company at National City. The total quantity shipped probably did not exceed 400 tons, to judge from the extent of the workings. The material was packed by mules over a rough and steep trail to a point on the San Diego River, then hauled by wagon to Lakeside, at a cost said to have been $7.50 per ton, exclusive of mining. Due to its inaccessibility, there has been no work on the deposit since 1916, excepting annual assessment work.

Two samples, Nos. 37 and 38, were taken and tested, the results of which are given on page 259.

Bibl: State Mineralogist's Report XXI, p. 354.

Gladding, McBean and Company. Office of Southern Division at 621 S. Hope Street, Los Angeles. This company owns a deposit of clay, of Eocene and Pleistocene age, on the Las Encinitas Ranch in the townsite of Olivenhain. The property includes a portion of Lot 18, and adjoins the property of the Vitrified Products Corporation (*q. v. post*) on the west.

At the time of visit, on June 9, 1925, the clay was being mined from an open cut, the floor of which was about 75 feet square. The bank was 30 feet high at the face of the pit. Mining was by hand, loading into small mine cars, which were trammed over a trestle to a bin, from which auto trucks were loaded. Three or four cars per week were being mined during part of the year, the annual production being 5000 to 7000 tons, which was used in the company's plants in Los Angeles. The clay is a red-burning material, with good plasticity, and is useful in face brick and sewer pipe mixes. Sample No. 35 was taken. The test results are on page 322.

Since the property was visited, it is understood that considerable drilling and other development work has been done, with the result that excellent deposits of fireclay have been found, in addition to the red-burning clay already known. The fireclays are said to closely resemble the Gros-Almerode clays of Germany.

H. T. Morris of Escondido owns a deposit of clay one mile south of Richland Station on the Escondido Branch of the Santa Fe Railroad.

The clay occurs in a low hill and is covered by black adobe soil. The deposit has not been developed and good exposures of the fresh clay are lacking. The deposit is apparently at least 15 feet in thickness, and underlies several acres of land. The attempt was made some time ago to make common red brick from this clay, but it was unsuccessful largely because of improper mixing, tempering, and firing of the brick. Some specimens of earthernware made from this clay can be seen in the Chamber of Commerce exhibit at Escondido.

Sample No. 41 was taken for testing. See page 348.

Bibl: State Mineralogist's Report XXI, p. 355.

National Brick Company. William Mulford, president; Edward Harrie, Jr., secretary. Offices and plant are located at Twenty-fourth Street and National Boulevard, National City. The holdings of the company comprise 13 acres, under lease from S. Christian, of National City. The company is manufacturing common red brick from adobe clay. The clay is hauled by scrapers to a hopper, from which it passes to a set of rolls, where the clods are broken up. It is then conveyed over a belt conveyor to a pug-mill, from which it passes to a brick press.

The brick are dried in sheds. The dried brick are fired in open oil-fired kilns. The plant is driven by a 50-h.p. electric motor, and has a capacity of 36,000 brick per day. Fifteen men are employed.

Old Mission Tile Company. W. C. Mitchell, president; J. F. Keenan, secretary; P. O. McCarthy, treasurer. Office and plant in North San Diego. This company was organized in 1927 with a capitalization of $50,000, to manufacture hand-made roofing and promenade tile.[1] Further details are lacking.

Pacific Clay Products Company. Wm. Lacy, president; Robert Linton, vice president and general manager. Offices, 1151 South Broadway Street, Los Angeles. Three miles east by road from Farr Siding, which is on the Santa Fe Railroad one mile south of Carlsbad, is one of the clay properties owned and operated by the Pacific Clay Products Company of Los Angeles. The property was formerly a part of the Kelley Ranch, and comprises 25 acres.

The clay beds are exposed on a low rounded hill. The upper 10 to 15 feet consists mainly of a white plastic vitrifying clay which is used in a mix for the manufacture of face brick and other products. This clay is slightly iron-stained, and is mixed with a small quantity of bluish plastic clay.

Underlying the bed of white clay is a bed of mixed yellow and blue clay of undetermined thickness. This clay is also plastic and will doubtless be extensively utilized as development of the property advances.

Development and Mining: The clay has been prospected by means of a number of test pits on the property. Mining was formerly done with horse scrapers and plows and with a wheel scraper drawn by a tractor but more recently a "Bear Cat" shovel has been installed. See photo No. 61. A bench has been established for mining the upper bed of white clay separately from the yellow clay. The exposed bank of white clay is 275 feet long. A motor truck is used to haul the clay to Farr Siding. The production is 20,000 tons per year.

Sample No. 39 of the white clay, and sample No. 40 of the yellow clay were taken for testing. See pages 296 and 322.

Other remnants of this same clay bed occur in various places on the Kelley ranch. Some test pits have been dug, but no deposit as satisfactory in quality or extent as that owned by the Pacific Clay Products Company has been disclosed.

Bibl: State Mineralogist's Report XXI, p. 356.

San Diego Tile and Brick Company. Wm. Roffe, president and manager. Office in San Diego. This company controls 100 acres of land in Rose Canyon. The clay pit and brick yard are on the west side

[1] Clay-Worker, August, 1927, p. 123.

of the canyon, 3.2 miles by road north from Balboa Avenue, Coast highway. The material used is a Tertiary shale, which is for the most part thin-bedded, moderately hard, and generally yellowish or yellowish gray in color. The same formation persists on the west side of the canyon for several miles.

The clay is scraped into chutes alongside of the Rose Canyon Road, at a point 50 feet vertically above the yard. The clay bank at present exposed is about 75 feet high at its highest point, and 300 feet long. Practically no overburden is present. Common red brick and hollow building tile are made by the stiff mud process. Drying is done partly in the open air and partly under shed. The dried brick are fired in open oil-fired kilns. The plant is operated as required to supply the local demand.

Sample No. 30 was taken for testing. See page 339.

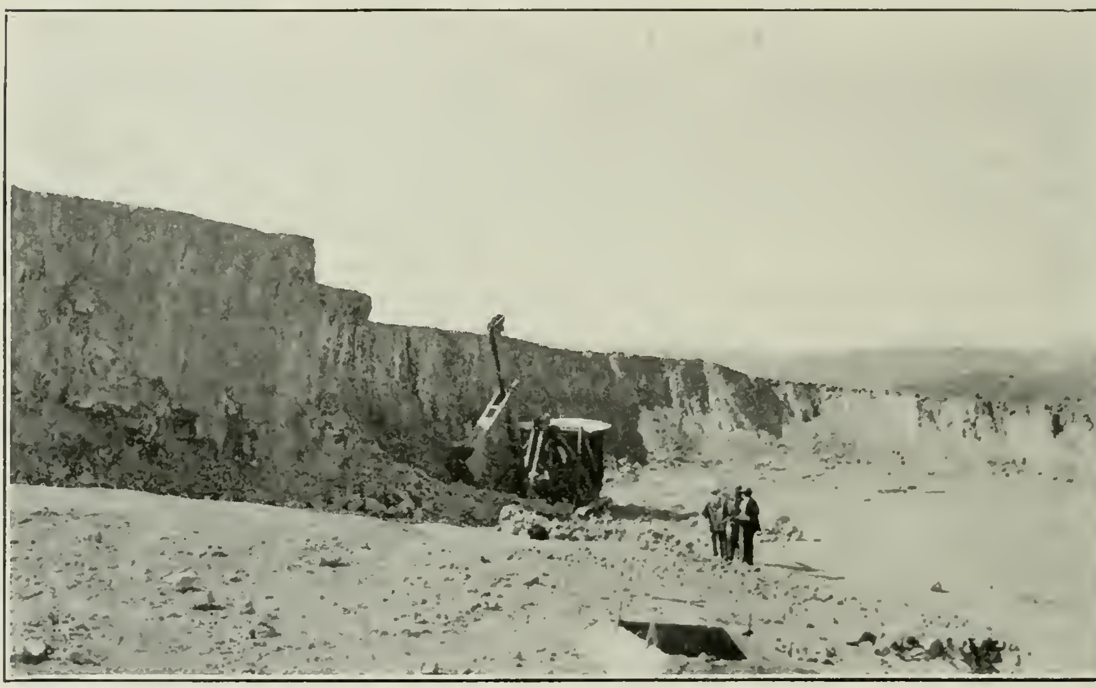

PHOTO NO. 61. "Bear Cat" shovel at Kelly No. 1 mine, Pacific Clay Products Co., Farr siding, San Diego County. (Samples No. 39 and 40.) (Photo by courtesy of the company.)

Union Brick Company. J. W. Rice, secretary. Offices, 3565 Third Street, San Diego. The plant is 1.1 miles north of Balboa Avenue, Coast Highway, on El Camino Real through Rose Canyon. It is about two miles south of the yard of the San Diego Brick and Tile Company. The shipping point is Ladrillo Station on the Santa Fe Railroad.

The clay, while apparently belonging to the same stratigraphic series as that of the San Diego Tile & Brick Company's deposit, is somewhat different in character, and consists mainly of a loose conglomerate composed of pebbles and boulders of all sizes up to two feet in diameter, intermingled with loose yellowish clay. Underlying this material is a bed of plastic clay shale, blue-gray in color.

The clay is mined with Fordson tractors and scrapers which dump the material into a chute leading to the brick yard located in the bottom of the canyon. Common red brick only is made at this point which is equipped with dry pan and two electric-driven presses. Oil-fired open field kilns are used. It is said that the clay has very little shrinkage during the brick-making process.

Sample No. 31 was taken for testing. See page 340.

Vitrified Products Corporation. Victor Kremer, president; George Kummer, general manager; John F. Keenan, superintendent. Sales office, 522–24 Spreckels Building, San Diego; general offices and plant in North San Diego. This plant started operations in November, 1923, to make semivitreous hollow tile, building tile, and brick. The company owns two clay deposits, one at Linda Vista, the other near Cardiff.

CARDIFF DEPOSIT: This is a deposit of fireclay on the Las Encinitas Ranch in the townsite of Olivenhain. The holdings consist of a portion of lot 18 in Rancho Las Encinitas, and comprises 16.6 acres. The property formerly belonged to the Wiro family, and is known to local

PHOTO NO. 62. Wiro Mine. Fireclay deposit east of Cardiff, San Diego County, owned by the Vitrified Products Co. of San Diego. (Sample No. 34.)

inhabitants as the *Wiro Mines.* It is 5.7 miles by road from Cardiff in an easterly direction.

The fireclay has been exposed by two small open cuts, each of which is about 50 feet square, with a bank of 15 to 20 feet in height. The bed of fireclay is from 10 to 12 feet thick, and is overlain by a thin layer of soil and yellow, sandy clay. The beds are nearly horizontal. Sample No. 33 was taken from the north pit, and sample No. 34 is from the south pit, and the test results are on page 287. See photo No. 62.

Underlying the fireclay is a bed of soft, loosely consolidated sandstone containing clay as filling material. The fire clay is moderately hard and varies in color from a buff to blue-gray and light purple.

At the time of visit (June, 1925), one to two cars per week were being mined and shipped from a siding one mile south of Cardiff.

LINDA VISTA DEPOSIT: This deposit is located on the south side of the Santa Fe Railroad at Mile 251, about two miles north of Linda Vista Station, in Sec. 9, T. 15 S., R. 3 W., S. B. M.

The holdings include the $N\frac{1}{2}$ and the $NE\frac{1}{4}$ of the $SW\frac{1}{4}$ of the section, a total of 360 acres, most of which is apparently underlain by the clay beds.

At the time of visit on June 9, 1925, the deposit had been opened by an electric shovel along a face 300 feet long and 50 feet high, adjacent to and adjoining the railroad tracks. The material is a clay shale, light yellow in color, and the individual strata are from a fraction of an inch to one or two feet in thickness. Two or three beds of siliceous sandstone about one foot thick are interbedded with the clay shale. These are sorted from the clay whenever possible. In places the clay is more sandy than in others, but is seldom too sandy for satisfactory use. The overburden is thin, varying from 6 inches to 3 feet in thickness. The same formation is quite extensive in this locality and can be traced for at least a mile along the Santa Fe tracks toward Linda Vista. The total thickness of the clay beds is probably not less than 100 feet.

At the time of visit about 200 tons per week were being shipped to the San Diego plant. When the plant is operating at full capacity, 300 tons per week are shipped.

Sample No. 32 was taken for testing. See page 322.

San Diego Plant: At the plant in North San Diego hollow tile and building tile are made by mixing 25% of the Cardiff fireclay with 75% of the Linda Vista clay. The material is crushed to $\frac{1}{8}$ inch and is fed from the crusher bin into a trough mixer, where it is tempered with water. The tempered clay passes through an auger machine and the tile are cut with an automatic wire cutter. The green tile are then hand-loaded on triple-deck trucks and trammed to the drying shed.

When not working at full capacity, the drying is completed in three or four days, but when crowded to capacity only one day is allowed for this part of the process. The drying is finished in oil-fired drying ovens where the heat is controlled according to the amount of moisture remaining in the tile. At times the dryer temperature is so high as to scorch the wooden platforms of the trucks.

The common brick are fired in open field kilns, using oil as fuel. The other shapes are fired in oil-burning round down-draft kilns. The firing temperature is from 2000° to 2100° F. for $4\frac{1}{2}$ to 5 days. An equal period is allowed for cooling. The firing range of the clays in use is 200° F. The brick and tile are remarkably uniform in color, which is a pink bordering on red. There is very little difficulty with lost ware and all of the products are strong and free from cracks. The drying shrinkage amounts to 1 in $11\frac{1}{2}$, and there is no cracking during the drying of the tile which are placed on the side rather than on end. The firing shrinkage is exceptionally low.

The capacity of the plant is 50,000 brick and 50,000 hollow tile per day.

Bibl: State Mineralogist's Reports XIV, pp. 685–688; XX, p. 369; XXI, pp. 354–358. Bull. 38, pp. 227, 254.

SAN FRANCISCO COUNTY.

The area of San Francisco County is 43 square miles, and the population is 506,676 (1920 census). The only mineral production in the county is crushed rock, sand and gravel. A number of brick yards at one time operated in the county, but land is now more valuable for other purposes.

The only ceramic plants in the county are an art ware pottery at 2928 Baker Street, San Francisco, owned and operated by *Jalanivich and Olsen*, and a dental porcelain laboratory at 830 Market Street, known as *Tara's Porcelain Laboratory*. Jalanivich and Olsen are making an attractive line of glazed pottery, using a buff-burning body and lead glazes. Their output is all hand-molded on a potter's wheel. It is fired in a round kiln, approximately 3-ft. inside diameter, of their own design and built by the gas company, city gas being used for fuel. The clay, from California sources, is fired up to 2000° and the glaze to 1600°–1700°.

SAN JOAQUIN COUNTY.

General Features.[1]

The county lies mainly in the great valley of the same name in the central portion of the state. It is bounded on the north by Sacramento County, on the east by Amador, Calaveras, and Stanislaus. The latter county extends around and adjoins it on the south also. Contra Costa and Alameda counties lie west of it.

Stockton, the county seat and largest city, has water transportation facilities, as well as rail. The area of the county is 1448 square miles, and its population is 79,905 (1920 census). By far the greatest part of its area is made up of farm lands; the so-called 'delta' region adjacent to Stockton being noted for its rich peat soil and heavy crops.

The most extensive geological formation exposed consists of unconsolidated sands, gravels and clays of Quaternary age, which compose the nearly-level valley floor. The western edge of this formation follows closely the Southern Pacific railroad line down the west side of the valley from Bethany to Vernalis. The corner of the county, southwest of the railroad, is composed of marine sandstone, and diatomaceous and clay shales of Tertiary and Cretaceous ages in the northern part. Its south half is rugged and broken, as the Franciscan rocks, typical of the Coast Range, including slates, cherts, limestones and sandstones, with much schist and serpentine, are exclusively in evidence.

Unconsolidated sands, gravels and clays extend practically to the county line on the eastern side of the valley, the only other rocks exposed being two small areas of extrusive volcanic rocks, just east and north of Bellota.

Comparatively few mineral substances are found in San Joaquin County, and of these the most important are nonmetallic structural and industrial materials and natural gas. Gold, silver and platinum have been obtained by dredging in Mokelumne River. Clay and clay products accounted for more than half the total mineral production of the county in 1923.

Clay Resources.

Common clays suitable for the manufacture of brick are abundant in the county, and two brick yards are in operation. High-grade clays were at one time produced near the San Joaquin and Alameda county line, in the vicinity of Tesla and Carnegie, and were utilized at the

[1] Laizure, C. McK., State Mineralogist's Rept. XXI, p. 184.

plant of the Carnegie Brick and Pottery Company, which has been dismantled for many years. See under Alameda County for further details.

One of the important fire brick plants of the state, that of the Stockton Fire Brick Company, is operating in Stockton. The plant is strategically situated with respect to the clay mines of Amador and Placer counties, and is within the range of cheap transportation to the marketing centers.

San Joaquin Brick Co. I. F. Stine, secretary-manager; Ernest Rossi, plant superintendent. Home office, 33 South El Dorado Street, Stockton. The property is located on a 60-acre tract on Roberts Island, six miles by road southwest from Stockton. Common red brick is the sole product. The clay is an extremely sandy bottom-land loam. The water level lies within six feet of the surface, so that economical mining has always been a serious problem. A horse-scraper is used above the water level, dumping through trap doors into horse-drawn cars operating on a light industrial track. A gasoline locomotive was purchased and tried in place of horses for haulage, but the track was not of sufficient weight to obtain satisfactory results.

Below the water level, the clay is excavated with a Marion steam shovel mounted on a barge. The clay is dumped along the bank, and allowed to dry in the air before it is reclaimed by the horse scraper.

The soft-mud process is used for shaping the brick. The clay is given a double pugging before passing to a 6-mold press. A continuous rope conveyor takes the brick from the press to the drying sheds. The sandiness of the clay is indicated by the fact that the drying period in warm weather is only three days, with a maximum of five days in cooler weather.

A Hoffman continuous kiln burning coal screenings is used for firing. The kiln is 175 feet long, with 12-ft. by 12-ft. chambers. The firing cycle is 14 days, and the capacity is 24,000 brick per day. The machinery is operated by electric power. The total installed capacity of the motors is 100 horsepower. Forty men are employed.

Bibl: State Mineralogist's Report XXI, p. 188.

Stockton Brick and Tile Co. Ralph Wilcox, president; Paul Weston, secretary; G. Birtolini, plant superintendent. Home office, 245 North El Dorado Street, Stockton. The plant is on McKinley Avenue near the southern boundary of the city of Stockton, about one-half mile west of the Municipal Baths. A Southern Pacific spur track runs to the plant. The plant was built in 1921. Common brick and some hollow building tile are manufactured, using surface clay from the property.

The clay is a bottom-land deposit of yellowish sandy loam and is mined to a depth of 15 feet below the surface by horse-drawn scrapers. The clay is found at greater depths, but is below the water level. The scrapers deliver the clay to a dry pan, from which the crushed product is elevated by a bucket elevator to a pug-mill and auger machine. The brick are taken from the wire-cutter belt by hand and loaded on trucks which are trammed by hand to oil-fired tunnel driers.

Firing is done in a Hoffman continuous kiln. The capacity of the kiln is 450,000 brick, and 25,000 brick are set and drawn each day. Coal screenings from Utah coal are used as fuel. The coal holes are spaced three feet apart. One man on each 8-hr. shift attends to the firing. The fires must be carefully controlled, as the kiln is too short for successful firing if irregular fluctuations in temperature are permitted. Natural stack draft is used.

In order to keep the plant in continuous operation during the year, it is customary to shape 40,000 brick, or the equivalent volume of brick and hollow tile, per day, during the summer and fall. Half of this output of green ware is stored for firing during the winter months, so that it is not necessary to operate the pit or the auger machine during the wet season.

The plant employs 25 men during the summer and about 15 men during the winter. The annual output is over 3,000,000 brick, or an equivalent volume of brick and hollow tile. The hollow tile production is never a large proportion of the total. All machinery is operated by electric power.

Bibl: State Mineralogist's Report XXI, p. 188.

Stockton Fire Brick Co. John T. Roberts, president; Percy T. Cleghorn, secretary; E. H. Horner, plant superintendent. Main office, 12 Russ Building, San Francisco. Plant address, P. O. Box 314, Stockton.

The company's plant is just west of the Southern Pacific railroad at the foot of S. California Street, Stockton. See photos No. 63 and 64. The output includes several different grades of fireclay brick and special shapes, high-temperature fireclay cement, and diatomaceous insulating brick. The company owns or leases deposits of most of the raw materials in use at the plant, the most important of these being Edwin clay (No. 120, p. 272), from Jones Butte near Ione; Ione sand (No. 140, p. 280), from the pit of the Ione Fire Brick Co., and Lincoln fireclay (sample No. 280, p. 305), from the newly developed pit of a subsidiary company, the Clay Corporation of California. Quartz for grogging some of the grades of fire brick is purchased from various California sources, mainly in Placer County, and diatomaceous shale for the manufacture of insulating brick and special shapes is purchased from producers in Santa Barbara County.

The principal grades of fire brick are as follows: 'Gasco XX,'' quartz grogged, auger-made, single pressed; 'Stockton,' quartz grogged, auger-made, repressed; 'Gasco R,' quartz grogged, auger-made, repressed; and 'Carnegie,' which is grogged with calcined fireclay, hand-made in sanded molds, and repressed. The 'Carnegie' brick is the best grade of standard brick being produced at present for resisting high temperatures under adverse load and spalling influences. Among the specialties regularly produced are a high-grade checker-brick which is made from a mixture grogged with calcined clay and shaped on an end-cut auger machine, and runner-brick, made from a similar mixture, formed on an auger-machine, and then passed to a specially designed machine for making the joints and cutting the side-holes.

The mixtures are prepared by dry-pan grinding, followed by pug-mill tempering for the material that is to be hand-molded.

All of the shapes except runner brick are dried in waste-heat tunnel driers. The runner brick, which require especially uniform drying on all sides during the shrinkage period, are dried in a Carrier ejector humidity drier, which is operated on a 13 to 15 hr. schedule, beginning

PHOTO No. 63. Plant of the Stockton Fire Brick Company, at Stockton, San Joaquin County. (Photo by courtesy of the company.)

with a three-hour period at 145° F. and 40% humidity, and finished at 240° to 250° F. with steadily declining humidity. The brick are set on the drier cars in a direction parallel to the direction of the air current in the drier, so that the air passes through and around the brick simultaneously, thus drying the inside and outside of the brick at the same rate.

The manufacture of diatomaceous insulating brick, known by the trade name 'Diatex,' is becoming an increasingly important part of the operations of the plant. Standard 9-in. brick and many special shapes are made. They are hand molded from diatomaceous shale containing sufficient clay for bonding. Slow and careful uniform drying is necessary to avoid loss by warping or cracking. In connection with the development of this product a conductometer, the principle of which has been described by R. D. Pike,[1] was constructed in the laboratory, for the purpose of comparing the heat conductivities of the various experimental mixtures.

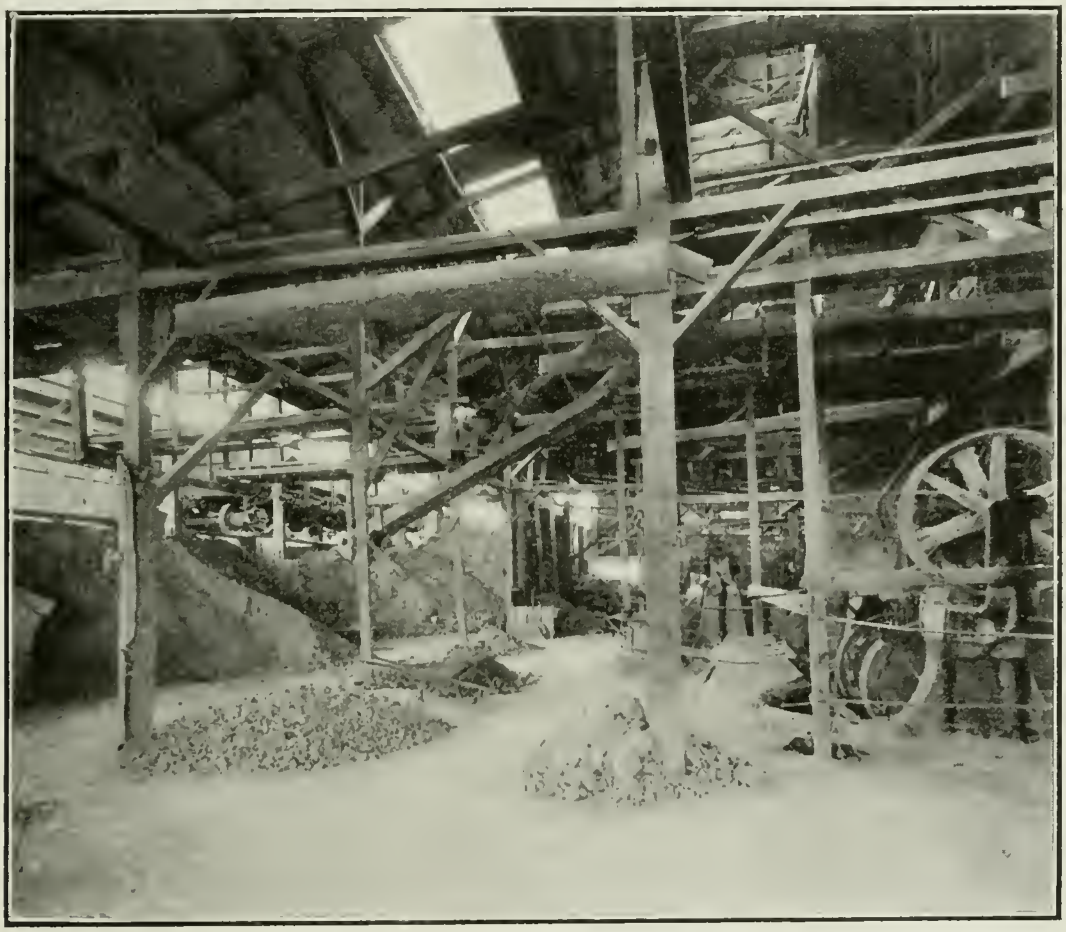

PHOTO No. 64. Clay bins and dry pans in plant of the Stockton Fire Brick Company. (Photo by courtesy of the company.)

The fireclay products are fired in 12 oil-fired round down-draft kilns, which are of various sizes from 12-ft. to 32-ft. in diameter, with capacities ranging from 80 to 400 tons each. The usual firing cycle is seven to eight days firing, to a temperature of 1370° C., corresponding to cone 11 down, followed by a cooling period of equal length.

[1] Pike, R. D., Need for more refractory heat insulators: Proposed conductometers for measuring thermal conductivity: Jour. Amer. Cer. Soc., 5, 554, August, 1922.

The insulating brick are fired in four 12-ft. by 23--ft rectangular kilns.

Base-metal thermocouples with automatic recorders are installed in all kilns for the accurate control of the firing cycle.

The plant is noteworthy for the high degree of technical control to which all operations are subjected, and for the continual improvements that are being made in the processes of manufacture and in the quality of the finished product, through the cooperation of an efficient technical staff and a progressive management.

An average of 110 men are employed.

Bibl (Clay resources of San Joaquin County): State Min. Bur. Bull. 38, pp. 227–228; Prel. Rept. 7, pp. 94–95; Rept. XIV, pp. 607–610, and XXI, pp. 188–190.

SAN LUIS OBISPO COUNTY.

General Features.[1]

San Luis Obispo County borders on the Pacific Ocean and occupies a position midway between San Francisco and Los Angeles. It is bounded on the north by Monterey County, on the east by Kern and on the south by Santa Barbara. It contains 3334 square miles and has a population of 21,893 (1920 census). The coast line of the Southern Pacific railroad passes through the county from north to south. The railroad follows Salinas River Valley through Paso Robles to a point near Santa Margarita, thence it crosses the Santa Lucia Range via Cuesta Pass, reaching San Luis Obispo at the foot of the grade, and the ocean near Pismo. It continues south along the ocean shore, giving through transportation. The Pacific Coast railroad (narrow gauge) connects Port San Luis with San Luis Obispo and continues to Santa Maria and other points in Santa Barbara County. The paved coast highway closely parallels the Southern Pacific railroad through the county.

From Santa Margarita fair dirt roads extend to the eastern part of the county, but McKittrick, in Kern County, is a nearer railroad point to this section. Steamer service is available at Port San Luis. This harbor is the terminus of pipe lines from the San Joaquin Valley oil fields and is an important loading point for oil tankers.

The Coast Range mountain system traverses the county from northwest to southeast. Within the county this mountain block consists of three main ranges, the Santa Lucia Mountains, the San Luis Range, and the San Jose Range.

The geology of that portion of the county from the southern boundary to latitude 35° 30′ N. and from the coast to longitude 120° 30′ W. has been described and mapped in detail by H. W. Fairbanks.[2] A discussion of the geology of the county with relation to petroleum resources will be found in Bulletins No. 69 and No. 89 of the State Mining Bureau. A folio of geologic maps accompanies Bulletin No. 69.

As indicated on the Bureau's geological map of the state, the Santa Lucia Range from San Luis Obispo northwestward to the northern boundary line is made up of Franciscan rocks, including slates, cherts,

[1] From Laizure, C. McK., San Luis Obispo County: State Mineralogist's Rept. XXI, pp. 499–501, 1925.

[2] Fairbanks, H. W., San Luis Folio, No. 101: U. S. Geological Survey.

limestones, and sandstones, with much serpentine and many dikes and intrusions of deep-seated igneous rocks. On the flanks of the range are narrow belts of Cretaceous sandstone and shales. Southeast of San Luis Obispo the formations are mainly Tertiary marine sandstones and diatomaceous shales. Unconsolidated sands, gravels, and clays extend from Pismo to Santa Maria River and well up the valley of the Santa Maria. East of Santa Margarita there is a large area in which granite predominates. The balance of the county lying east and north of the Santa Lucia Range consists almost entirely of sedimentary rocks of Tertiary age, shales, sandstones, tuffs, and gravels with an area of Quaternary sediments comprising Carrizo Plain.

Among the mineral resources of the county, both developed and undeveloped, are asphalt, bituminous rock, brick, chromite, coal, copper, diatomite, gypsum, iron, limestone, marble, mineral water, onyx, petroleum, quicksilver, soda, and miscellaneous. Miscellaneous stone, petroleum, brick, and mineral water are the principal commercial mineral products at present.

Clay Resources.

There are no known deposits of high-grade clays in this county, but red-burning clays suitable for making brick occur in the valley silts of recent origin at various places. Since the population of the county is small, the demand for clay products is limited, and a single common-brick plant at San Luis Obispo supplies the market of the county as well as of a few nearby towns in Santa Barbara and Monterey counties. The territory to the south is supplied by brick yards in Santa Barbara, while plants in San Jose furnish brick for the communities in Monterey and San Benito counties.

San Luis Brick Works. Owned and operated by Faulstick Bros., San Luis Obispo. This plant, formerly known as the San Luis Brick Company, is located one mile south of town, near the lines of the Southern Pacific and Pacific Coast railroads. The clay is a yellowish loam, with little or no overburden. The proportion of sand is sufficient to prevent excessive shrinkage and cracking in the brick-making process, yet is not so high as to interfere with the binding properties of the clay. The clay is mined to a depth of 15 feet by hand shoveling into dump cars, which are hauled up an incline by a steam winch, to dump through a hopper into a 10-foot dry pan. After screening, the fines pass to a pug-mill, then to an American Clay Machinery Co. auger machine equipped with a Freese cutter. The oversize from the screen is returned to the dry pan.

The brick are dried in the open without auxiliary heat. This requires an average of three weeks. Burning is done in open field kilns, usually with 18 arches, each kiln containing 590,000 brick. Heat is supplied by oil, with steam atomization. Firing requires five days, and cooling about three weeks.

The plant operated three months during the season of 1925, producing about 1,500,000 brick. Twenty-eight men are employed when in full operation. See photo No. 65.

Bibl: State Mineralogist's Report XXI, p. 505.

Santa Margarita. Two miles south of Santa Margarita is an extensive undeveloped deposit of red-burning shale. The deposit is easily

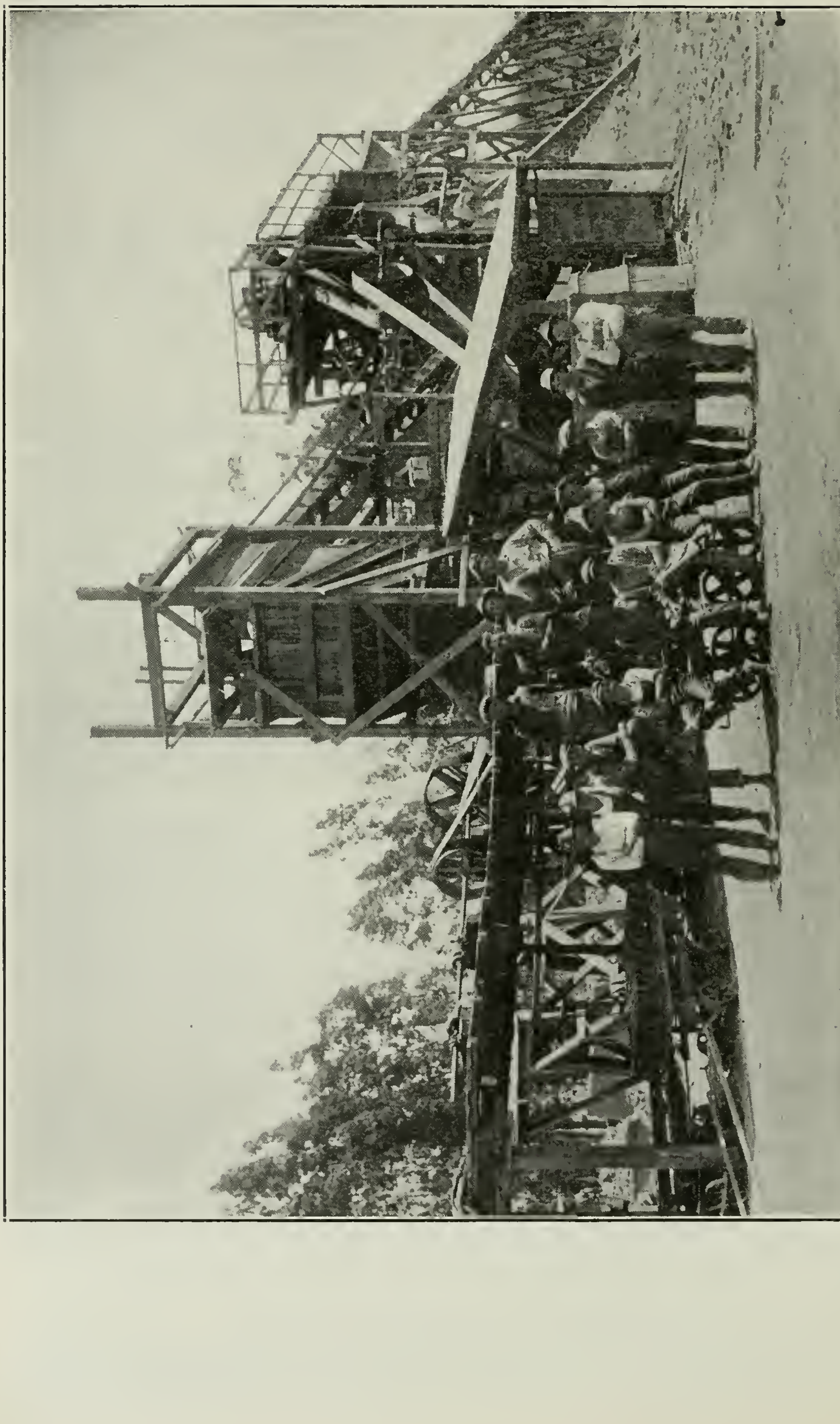

Photo No. 65. Plant of San Luis Brick Works, San Luis Obispo. (Photo by courtesy of the company.) (From State Mineralogist's Report XXI, p. 506, 1925.)

accessible at a point 2.0 miles (by road) south of the center of Santa Margarita, where it lies in a broad belt between the state highway and the Southern Pacific railroad for a distance of at least one-half mile. The strike of the beds is S. 25° E., and the dip is 75° NE.

Two samples were taken. No. 216 was taken from a road cut, 2.0 miles from Santa Margarita. Sample No. 217 was taken from the same formation, 2.5 miles from Santa Margarita, and 0.3 miles north of the northern boundary of the Santa Barbara National Forest. The test results are on page 327. The material would be well suited for the manufacture of vitrified red-burned structural ware.

Bibl (Clay resources of San Luis Obispo County): State Min. Bur. Bull. 38, p. 255; Prel. Rept. 7, p. 95; State Mineralogist's Rept. XV, p. 679; XXI, p. 505.

SAN MATEO COUNTY.

General Features.

San Mateo County lies on the San Francisco Peninsula, south of San Francisco city and county. Its southern boundary adjoins Santa Clara and Santa Cruz mountains. Its area is 447 square miles, and the population is 36,781 (1920 census).

Aside from a narrow strip of alluvial plain along the shores of San Francisco Bay, the entire county is mountainous, as the western spur of the Coast Range extends through the county. The principal geological formations exposed in the mountainous portion of the county are Franciscan (Jurassic) sandstones, jaspers, serpentines, etc.; Chico (Upper Cretaceous), Pliocene and Miocene sedimentary deposits, mainly sandstones and shales, and granite.

The most important mineral products are cement, miscellaneous stone, and salt. Jasper, magnesium chloride, natural gas, petroleum, and potash are also produced. Small amounts of barytes, chromite, diatomite, and quicksilver have also been found.

Clay Resources.

No high-grade clays have been reported in the county. Deposits of clay and shale suitable for brick making are plentiful.

The only clay-working plant in the county is that of the West Coast Porcelain Manufacturers, described below. The Steiger Terra Cotta and Pottery Works, and the Baden Brick Company, mentioned in earlier reports, were dismantled many years ago.

West Coast Porcelain Manufacturers. Henry Weiss, president and general manager; Ed. Durant, plant manager; T. B. Gotham, superintendent and ceramist. The plant is near Millbrae station on the Southern Pacific Railroad. Vitreous sanitary porcelain is the only product. The body, which contains 50% clay and 50% flint and feldspar, is made from English china and ball clay, Tennessee ball clay, Ottawa or Illinois sand and feldspar from Campo, San Diego County. Alberhill bone clay is used in the sagger mix, as the aluminous structural clay; Ione clays as the binders.

All of the ware is shaped by casting, and the slip room is one of the most modern and best equipped in the West. Special precautions are taken to secure uniformity of grinding and proportioning and freedom from contamination.

The body is prepared by the dry-mix process. Three 30-hp. Crossley dry pebble mills are used for grinding the Ottawa sand and feldspar. Seven hours grinding is necessary for each batch of sand or feldspar. The English ball clay is passed through a disintegrator to crush it to less than $\frac{3}{8}$ in. diameter. The Tennessee ball clay does not require previous crushing. The dry pulverized materials are stored in bins from which they are weighed out for the casting slip batches. Three double casting slip blungers are used for the preparation of the slip, which weighs 30 oz. per pint. The discharge from the blungers is passed over a Ding magnetic separator to remove any particles of metallic iron, then through a 100-mesh screen, and finally to Crossley slip agitators below the floor of the slip room. From the agitators the slip is pumped to the casting room.

A small blunger and a 70-leaf round-rail filter press are used to retreat the scrap body-mix from the casting and drying departments. This is necessary in order to remove the alkali which is added to all slips as a deflocculator, and which, if left in the rejected material, would build up in the casting slip to the point where blisters would form on the ware during firing.

The glaze batches are ground in a Crossley, style B pebble mill, 8 feet diameter and 5 feet 8 inches long, driven by a 20-hp. induction motor. When ground, the slip is passed through a 100-mesh screen, and is pumped into a Patterson single-action glaze agitator, where it is kept in suspension until drawn off for use. A magnetic separator is used to remove any particles of iron that might accidentally have been introduced into the glaze.

The casting slip is piped to all parts of the casting floor, where the ware is cast in the usual manner in plaster molds.

Waste-heat driers are used. After drying, the ware is loaded into saggers in preparation for the biscuit firing.

The firing equipment consists of two 366-ft. tunnel kilns, operated on a 48-hour cycle. The biscuit kiln is fired to a maximum of cone 11, which corresponds to 1205° C. on the recording pyrometer. After cooling from the biscuit kilns, the glaze is applied by dipping, and the ware is sent through the glost kiln, which is fired to cone 6, corresponding to 1150° C. on the pyrometer. Oil fuel, atomized with air, is used on both kilns. The capacity of the kilns is 400 pieces per 24 hours.

Saggers are made by machine at the plant. Alberhill bone clay has proved a better structural clay in sagger manufacture than Ione clay. The Ione clay body burns too tight, and losses from cracking after repeated use are high, but used as a binder it is more or less satisfactory.

The company has recently developed a line of crystalline-glaze artware, and many attractive shapes and color schemes are being produced.

The plant has a well-equipped laboratory, and through careful technical control the products of the plant are of remarkably high quality and free from defects. The plant employs 150 men.

Bibl (Clay resources of San Mateo County): State Min. Bur. Bull. 38, pp. 228–229, 255; Prel. Rept. 7, pp. 95–96.

SANTA BARBARA COUNTY.

General Features.[1]

Santa Barbara County consists of 2740 square miles, including the islands of San Miguel, Santa Rosa, and Santa Cruz, which are located twenty miles off the coast. It is bounded on the north by San Luis Obispo County, on the east by Ventura County, on the south by the Santa Barbara Channel, and on the west by the Pacific Ocean.

The population, according to the census of 1920, was 41,097, and is now estimated as over 50,000. The city of Santa Barbara, the county seat, with a population of over 30,000, lies on the shores of the channel. Santa Maria is the second community in Santa Barbara County and has a population of over 5000.

Much of Santa Barbara County is hilly and mountainous; the Santa Ynez, a low range of mountains, follows the trend of the coast across the southern part of the county, and the San Rafael, a higher range, strikes through the center of the county and extends almost to its northern limits. These mountains, with their foothills and spurs, impart to the whole county a rugged and diversified aspect.

The principal valleys are the Santa Maria, Los Alamos, Lompoc, Santa Ynez, and Cuyama. These fertile areas are well adapted for the growing of cereal crops and citrus fruits and cattle raising.

The principal drainage systems of the county are the Santa Maria and Santa Ynez rivers.

The county is traversed by the Southern Pacific railroad, which follows the coast line, with branch lines from Guadalupe to Betteravia, and from Surf to Lompoc. The Pacific Coast railroad, a narrow-gauge line, runs from Port Hanford, in San Luis Obispo County, through Santa Maria to Los Olivos, with branches from Santa Maria to Betteravia and Sisquoc. Santa Maria Valley railroad connects with the Southern Pacific railroad west of Santa Maria and runs southeast through the Santa Maria Valley to Leonard.

The coast route of the state highway enters the county north of Santa Maria, and runs the length of the county, connecting Santa Barbara city with Los Angeles and San Francisco. Different laterals from this railway afford transportation for auto trucks and stages to interior towns.

Geology and Mineral Resources.

The principal geological formations exposed in Santa Barbara County are Tertiary shales and sandstones, including those of Eocene, Miocene, and Pliocene age. Quaternary sediments also cover a large area, especially in the western part of the county. There is a small area of Franciscan (Jurassic) in the center of the county, and a larger area of Cretaceous (Undifferentiated) in the north-central part of the county.

Santa Barbara County owes its position of fifteenth in the state in regard to its mineral output to the presence of productive oil fields within its boundaries. The total value of its mineral production during

[1] From Tucker, W. Burling, Santa Barbara County: State Mineralogist's Rept. XXI, pp. 539–540, 1925.

the year 1926 was $2,583,548; of this amount the value of natural gas and petroleum was $1,772,678.

Among its mineral resources, both developed and undeveloped, are: Asphalt and bituminous rock, barytes, brick, chromite, copper, diatomaceous earth, gilsonite, gold, gypsum, limestone and lime, manganese, mineral water, natural gas, oil shale, petroleum, sandstone and the stone industry.

Clay Resources.

No commercial deposits of high-grade clays have been found in the county. Common clay is fairly abundant, and several brick yards and a roofing tile plant are in operation.

Angulo Tile Company, Plant No. 1. R. F. Angulo and Sons, owners. Address P. O. Box 128, Santa Barbara. This company has two plants for the manufacture of hand-made roofing tile and terrace tile. Plant No. 1 is on Central Avenue, between Modoc Road and the state highway, Santa Barbara, and Plant No. 2 is at Reseda, Los Angeles County (see under Los Angeles County. At *Plant No. 2* a local surface clay is mined from an area immediately adjoining the plant. The plant is equipped with three kilns, fired with oil.

L. L. Brentner. Carpinteria. The property is west of the coast highway, 14 miles north of Ventura, and four miles south of Carpinteria. Ten acres were at one time under lease to the Builder's Supply Company of Santa Barbara, who operated a plant for the manufacture of common brick. It is understood that the property is now idle (1927). The clay beds are nearly vertical, have an east-west strike, and are about 200 feet thick. The material is a light-colored thin-bedded shale, with quartz, limestone, and sandstone boulders, which were partly removed by screening. A drag-line scraper was used for mining. The plant is equipped with crushing machinery to deliver a 20-mesh product to the brick plant, which consists of a 14-ft. pug-mill and an auger machine, with a wire cutter. The brick were dried in the open and fired in oil-fired field kilns.

Sample No. 3 was taken for testing, the results of which are on page 348. The material is not of good quality for the manufacture of brick.

Bibl: State Mineralogist's Rept. XXI, pp. 546–547, 1925.

Muengenberg and Whitiker. R. Muengenberg and E. H. Whitiker, of 230 de la Guerra Street, Santa Barbara, are operating two of the brick yards formerly operated by the Builder's Supply Company in Santa Barbara and Montecito.

The Santa Barbara plant, formerly the Parker Brick Company, is on West Montecito Street, one-half mile from the Southern Pacific railroad tracks. Common red brick, hollow building tile, and drain tile are made from clays obtained from pits on the plant site and from other sources in the vicinity. The stiff-mud process is used. The ware is dried in the open, and fired in oil-fired field kilns. Sample No. 1 was taken for test, the results of which are on page 338. The sample was taken from the pug-mill, and is typical of the class of material available in the district, and for which the plant has been designed, rather than being representative of a specific clay bank.

The Toro Canyon plant, formerly the Toro Canyon Brick and Tile

Company, is in Toro Canyon, near Montecito. There is an ample supply of plastic clay, intermingled with blocks of soft, yellow sandstone. The clay is mined from a shallow side-hill open cut with tractors and scrapers. Common red brick, hollow building tile, and roofing tile are made. Drying is done under sheds and in the open, and oil-fired field kilns are used for firing. Sample No. 2 (see p. 338) was taken.

Bibl: State Mineralogist's Repts. XV, p. 735; XXI, pp. 546–547. Bull. 38, p. 256. Prel. Rept. 7, p. 96.

SANTA CLARA COUNTY.

General Features.

Santa Clara County lies in the west-central portion of the state. It is bounded on the north by San Mateo and Alameda counties, on the east by Stanislaus and Merced, on the south by San Benito, and on the west by Santa Cruz and San Mateo. The area of the county is 1328 square miles, and the population is 100,588 (1920 census). The principal towns are San Jose, Palo Alto, Santa Clara, and Gilroy, all of which lie in a broad valley between two parallel ranges of the Coast Range system of mountains. This valley is noted as one of the most productive fruit-growing sections in California.

The geological formations that are most widespread in the county are Quaternary sediments in the valleys, and Franciscan (Jurassic), Cretaceous, Miocene, and Pliocene formations in the mountains.

The New Almaden district, about 15 miles south of San Jose, was for many years famous as a quicksilver producer, but the production has declined in recent years owing to the exhaustion of the mines. The following mineral products are produced commercially: brick, clay, limestone, magnesite, mineral water, natural gas, petroleum, quicksilver, and miscellaneous stone. Of these miscellaneous stone, brick, and quicksilver are the most important, in the order given. Occurrences of chromite, manganese, and soapstone are known.

Clay Resources.

No commercial deposits of high-grade clays are known in the county. Common clays suitable for the manufacture of brick and tile are abundant throughout the valley portions of the county. On account of favorable manufacturing and marketing conditions, a number of clay-working plants have been established in and near San Jose and Santa Clara. Some of these plants use common clay from extensive deposits along Coyote Creek within the city limits of San Jose. The clay bed is from 15 to 20 feet thick.

Garden City Pottery Company.[1] H. M. Stammer, president; D. Raymond, vice president; N. J. Mahan, secretary. Office and plant at 560 N. Sixth Street, San Jose. This company was established in 1904, under the name of the Garden City Pottery. The products of the plant are flower pots and stoneware. Lincoln clay is used for the stoneware, and a local red clay, from Coyote Creek, is used for flower pots. The stoneware mix is prepared by grinding, washing, and filter-pressing, followed by pugging. After shaping, the ware is dried in steam-heated drying rooms for a period of three or four days.

[1]Data obtained by D. R. Irving, Stanford University.

Firing is done in four round down-draft kilns. Two of the kilns are 20 feet, and the other two are 18 feet in diameter. They are fired with oil, which is atomized with steam. The stoneware is fired to 2200° F. (about cone 5) in 72 hours, and the flower pots are fired to 1800° F. (about cone 07) in 48 hours.

The plant operates throughout the year and employs 30 men.

Bibl: State Min. Bur. Bull. 38, p. 229; Prel. Rept. No. 7, p. 96.

Gilroy Brick and Tile Company. Chas. Bolfing, Gilroy. Mr. Bolfing built and operated a small common brick plant for a few years on his ranch about one mile north of Gilroy, using a clay shale obtained from a deposit on the Redwood Retreat Road, about eight miles from Gilroy. The plant was not commercially profitable, and has been partly dismantled.

Kartschoke Clay Products Company. G. Kartschoke, president and manager. Plant at 1098 S. Third Street, San Jose. The principal products of the plant are sewer pipe, flue lining, and patent chimney pipe. The plant is also equipped to make machine-made roofing tile. The clays are obtained from banks along Coyote Creek, with the addition of some clay that is purchased from the Yaru deposit in Amador County.

The clays are ground in a dry pan and elevated to a double-shaft pugmill, from which the mix passes to an American sewer pipe press. Drying is done in a building which is heated by steam during the winter. Four to five days are usually required for drying.

The ware is fired in three oil-fired round down-draft kilns, 22 feet, 26 feet and 28 feet in diameter, respectively. Cone 2 (1165° C.) is reached in 80 to 90 hours, the entire cycle, including setting and drawing, requiring about two weeks.

Bibl: State Mineralogist's Rept. XIII, p. 618; State Min. Bur. Prel. Rept. 7, p. 97.

J. B. King, of Skyland, P. O., Wrights Station (Santa Cruz County). It is reported that there is a "fine, large deposit of pottery clay" on this property. No investigation was made. As the locality is relatively inaccessible, near the summit of the Santa Cruz Mountains, the clay would need to be of exceptional quality to be of commercial importance.

Platt's Premier Porcelain, Incorporated.[1] H. D. Melvin, president; A. A. Baker, vice president; N. E. Wretman, secretary. Office and plant on Lafayette Street, Santa Clara. This company makes sanitary porcelain from a mixture of English china and ball clays, Arizona feldspar, and California silica. The feldspar and flint are received at the plant in pulverized form. The mixes are prepared by blunging and filter-pressing. The ware is shaped by the casting process, although hand-pressing was formerly used, and is dried in steam-heated rooms for a period of one week. Three 16-ft. round up-draft ('bottle') kilns are used for firing. These use oil fuel, atomized with steam. The biscuit ware is fired to cone 9 (1250° C.) in 36 hours, and the glost ware is fired to cone 8 (1225° C.) in 30 hours. The plant was idle during 1927, but expected to resume operations early in 1928.

[1] Data obtained by D. R. Irving, Stanford University.

Remillard Brick Company. C. Remillard, president; R. C. Giroux, secretary. Office, 332 Phelan Building, San Francisco. This company has operated a brickyard at Pleasanton, Alameda County, for many years, and has recently established a plant in San Jose, on Storey Road, on the eastern edge of town. Common red brick are made from a local clay, using open field kilns for firing. The plant is operated for about eight months during the year.

San Jose Brick and Tile Company. J. J. Jamiesen, president; R. L. Richards, secretary-treasurer. Address P. O. Box 274, San Jose. The plant is on Fruitvale Avenue, and the property comprises 35 acres. Common red brick is manufactured. The clay deposit consists of a 30-ft. bed of red-brown plastic clay overlain by three to five feet of soil. The clay is mined and delivered to the plant by a drag-line scraper.

The plant is equipped with an E. M. Freeze K-B brick machine, which has a capacity of 75,000 brick per day and is driven by a 150-h.p. electric motor. An industrial car system is used in the drying and kiln yard. Drying in open racks requires from seven to eight days. One round down-draft kiln and two down-draft continuous kilns are used for firing. Coal screenings are used as fuel. The firing schedule of the continuous kilns is as follows: three days water smoking, four days firing and ten days cooling.

The plant is usually operated for nine months of the year, employing 50 men, and using 345 h.p. of electric power. The average fuel consumption is 300 lb. of coal per thousand brick.

San Jose Tile Company. A partnership, consisting of L. W. Austin, D. W. Wallace, L. F. Wallace, W. D. Rice, and L. H. Bruns. The plant is at 333 S. Eighteenth Street, San Jose, on the banks of Coyote Creek. Hand-made floor, wall, and mantel tile are manufactured, using a red-burned body consisting largely of clay from the Natoma Clay Company in Sacramento County. Local clay from Coyote Creek and some Lincoln and Ione materials are used to a certain extent. The equipment consists of a disintegrator and pug-mill, and a rectangular kiln, burning oil. The kiln is equipped with a pyrometer. The firing period is from 40 to 48 hours, finishing at cone 5 (1180° C), or higher.

An excellent market has been established for the ware, and the plant is expected to grow rapidly.

S & S Tile Company. A. L. Solon and F. P. Schemmel, owners. Office and plant at 1881 S. First Street, San Jose. This company specializes in the manufacture of decorative tile, both glazed and unglazed, from a buff, or red-colored body. Local clay from Coyote Creek is used in conjunction with Lincoln clay and Ione sand. Biscuit rejects and kiln dirt are used as grog.

The clays are mixed in batches on the floor, fed to a Jeffrey swing-hammer mill, and elevated to a bin, from which they are fed by a disc feeder to a pug-mill. A Muller auger is used for shaping all plain tile, whereas fancy tile is hand-pressed in plaster molds. Some dry-pressed tile are made at times. A specially designed waste-heat drier is used. To secure partial humidification, the drier is arranged so that the hot air can be retained in closed circuit. Drying requires three days. Two oil-fired round kilns are used. These are 18 and 22 feet in diameter, respectively. They are fired to cone 2 (1135° C.) in 48 hours. Cooling requires four days. Both kilns are equipped with base-metal thermocouples. All glazed ware is biscuited first, then glazed. About eight men and six women are employed.

SANTA CRUZ COUNTY.

General Features.[1]

Santa Cruz County borders on Monterey Bay and the Pacific Ocean, south of San Mateo County, and north of Monterey County. Its area is 435 square miles, and the population is 26,269 (1920 census). The greater part of the county is rugged and mountainous.

The geology of most of the county is described in U. S. Geological Survey, Santa Cruz Folio, No. 163, by J. C. Branner, J. F. Newsom, and Ralph Arnold. The principal sedimentary formations are of Miocene and Pliocene age. There is an extensive area of quartz-diorite, and smaller areas of metamorphic schist, marble, and limestone.

The mineral production of the county includes cement, lime, limestone, and miscellaneous stone, and bituminous rock.

Clay Resources.

Common brick clays occur along the San Lorenzo River and at other points. In the early nineties, two brickyards were in operation near Santa Cruz, but these have long since been dismantled. Clay is being mined at Tank Siding, 1.8 miles southwest of Glenwood, and at Davenport, for use in the manufacture of cement at the plant of the Santa Cruz Portland Cement Company, at Davenport.

Bibl: State Mineralogist's Repts. X, p. 625; XII, p. 383; XIII, p. 619; XVII, p. 234; XXII, pp. 78–79. Prel. Rept. No. 7, p. 97.

SHASTA COUNTY.

General Features.

Shasta County lies at the northern end of the Sacramento Valley. Redding, the county seat, is on the Shasta line of the Southern Pacific Railroad, 175 miles north of Sacramento, and is the principal railroad and supply point for Shasta and Trinity counties. The Pacific highway connecting California and Oregon, traverses the county in a north and south direction, paralleling the Southern Pacific railroad in the Sacramento River Canyon.

The area of Shasta County is 3858 square miles and the population in 1920 was 13,311. The southern portion of the county adjacent to the Sacramento River is open and rolling, and is devoted to farming and stock raising. The northern and western portions of the county are mountainous, and the eastern portion is a succession of rising plateaus covered by recent volcanic flows. Most of the important mineral deposits of the county are confined to the western half. The Pit River, which joins the Sacramento River near Redding, is an important source of hydro-electric power. Timber is an important resource of the county, especially in the eastern portion.

Shasta County is characterized by the variety of its geologic formations, and the diversity of its mineral resources. Copper, gold, zinc

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[1]See Laizure, C. McK., Santa Cruz County: State Min. Bur. Rept. XXII, pp. 68–93, 1926.

and iron are the principal metals that have been produced in the county. The limestone resources are very extensive, but to date have not been exploited on a large scale. Extensive beds of low-grade lignite occur in the central part of the county. These have been investigated many times in the past, and an attempt is now being made to place them upon a sound commercial basis.

Clay Resources.

There is at present no clay industry in the county. At various times in the past, brick yards have been operated at Redding and Anderson, to supply local needs, but these have been idle for many years. There is an abundant supply of clay and silt suitable for common-brick manufacture in the flood plain of the Sacramento River south of Redding, and along other streams in the county.

No commercial deposits of high-grade clays have yet been discovered in the county. It is possible that with the serious development of the lignite properties northeast of Oak Run, mainly in T. 33 N., R. 1 W., M. D. M., refractory clays may be encountered, as the lignites occur in the Ione formation, which is the important source of terra cotta and fireclays in Placer and Amador counties. A small sample of micaceous kaolin, slightly tinged with iron, was supplied by Mr. I. J. Johnson, of the Johnson Iron Works, Redding, but no data could be secured as to the source of this material, except that it was found on a property some 20 miles northeast of Palo Cedro.

For convenience of reference, the following descriptions of common-brick clay deposits are abstracted from previous publications of the Bureau:

State Mineralgist's Report XXII, p. 131, 1926; Prel. Rept. No. 7, p. 98, 1920.

Holt and Gregg, J. N. Gregg, president, Kennett. A brick plant was formerly operated at Anderson, in Sec. 17, T. 30 N., R. 4 W., M. D. M. The deposit was 15 feet thick.

Block 29, Redding Grant, 1¼ miles south of Redding. Clay bed six feet thick. A brick kiln was operated here many years ago.

Redding Brick and Tile Company formerly operated a deposit on 40 acres in Sec. 19, T. 31 N., R. 5 W., M. D. M., and made brick in small kiln at Redding.

Redding Homestead Deposit is on the Sacramento River east of Cottonwood. Deposit is a mile long by one-fourth mile wide and contains 30 feet of clay, covered by 15 feet of sand and gravel. Undeveloped. No recent information available.

Southern Pacific Company owns an undeveloped clay deposit in Sec. 19, T. 32 N., R. 4 W., M. D. M.

In addition to the foregoing, a deposit of fireclay is reported in Sec. 24, (34?) T. 34 N., R. 5 W., M. D. M., that was at one time operated by Holt and Gregg for use as kiln lining. No recent information since the report of 1920.

SISKIYOU COUNTY.

General Features.

Siskiyou County borders on the state of Oregon in a sparsely-settled mountainous portion of California. The total area of the county is 6256 square miles, and the population (1920) is 18,500. The county is traversed by the Shasta line of the Southern Pacific railroad. The principal industries of the county are lumbering, stock-raising and farming. The mineral industry of the county is not at present of great importance, although in the past the county has been celebrated for its placer mines, and during the late war it was an important source of chromite. The geology and mineral resources of the county have been discussed in a recent report.[1]

Clay Resources.

On account of the remoteness of the county from the centers of population and the small population within the county itself, none but exceptionally high-grade clay deposits could have commercial value. A deposit of 'pottery clay' 16 ft. thick has been reported [2] in Sec. 8, T. 43 N., R. 6 W., near Gazelle. A careful search for this deposit was made in August, 1925, and local inhabitants were questioned concerning it, but no knowledge of such a deposit could be obtained. The report probably refers to a deposit of yellow plastic clay that occurs on the property. A deposit of fireclay in the roof of a coal mine in Sec. 26, T. 46 N., R. 6 W., has also been reported [3] but could not be verified. The coal mine referred to is now inaccessible.

Common brick clays occur in irregular alluvial deposits at various places in the county. Some of these, near Yreka, Etna Mills, and Fort Jones have been used in the past for producing brick for local use during the early construction periods of the larger towns in the county. None of the brick yards have been operated for many years, and have long since been dismantled. If at any time in the future it should become necessary to manufacture small quantities of red brick in the county, enough clay of satisfactory quality could probably be found, but it is unlikely that large deposits of uniformly good material will be encountered.

For convenience of reference, the previous reports of the bureau on common clay deposits in Siskiyou County are summarized below, but as these reports are over 20 years old, the names of the men who were formerly associated with the deposits are omitted here, as few of them can now be found.

T. 43 N., R. 9 W., M. D. M. Surface clay deposits were reported in Sec. 2, 11, 21 and 32, in the vicinity of Fort Jones, Greenview, and Etna. These clays have been used for brick making.

Sec. 27, T. 45 N., R. 7 W. Bricks were once manufactured from a reddish clay near Yreka.

Near Montague a small quantity of brick clay has been found.

Bibl: Cal. State Min. Bur. Bull. 38, p. 230 and 257, 1906; Prel. Rept. No. 7, p. 98, 1920 (a copy of the material in Bull. 38).

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[1] State Mineralogist's Report XXI, pp. 413–498. 1925.
[2] Prel. Rept. No. 7, p. 99.
[3] *Op. cit.*, p. 98.

SOLANO COUNTY.

General Features.[1]

Solano County radiates in a northeasterly direction from San Pablo Bay, an arm of San Francisco Bay. Its area is 822 square miles, and the population is 40,602 (1920 census). About 80 per cent of the land is arable and the balance is mountainous. Cretaceous and Tertiary sediments, and late Tertiary (probable) lavas are found in the mountainous portion of the county. The rest of the county is covered with Recent alluvium.

Among the mineral resources of Solano County are cement, clay, fuller's earth, limestone, mineral water, natural gas, onyx, quicksilver, salt and miscellaneous stone. Recent production has been confined to cement, miscellaneous stone, mineral water, onyx and travertine. The only cement plant in the county was closed down in November, 1927, and is available as a stand-by plant.

Clay Resources.

Common brick clays are abundant in the argicultural section of the county. A number of clay-working plants, including a pottery at Benicia and brick and tile plants at Vallejo, were active a number of years ago.

Steiger Brick and Tile Company (formerly the Vallejo Brick and Tile Company). Plant two miles northwest of the center of Vallejo. This is the latest attempt to operate a brickyard in the county, and operations were discontinued in 1923. The plant is equipped for the manufacture of brick and hollow tile. The clay deposit is a yellow shale, an analysis of which is reported by Laizure[2] as follows:

Loss on ignition	8.03%
Silica	57.83%
Alumina	19.52%
Iron oxides	7.46%
Calcium oxide	1.24%
Magnesium oxide	2.06%
Alkalies (by difference)	3.86%
	100.00%

Clay from a bank at the base of the hills near Goodyear Station was utilized about 20 years ago in a pottery.

Bibl: State Mineralogist's Repts. VIII, p. 631; XIII, p. 619; XIV, p. 300; XXIII, pp. 204–205. State Min. Bur. Bull. 38, p. 258. Prel. Rept. No. 7, p. 99.

SONOMA COUNTY.

General Features.[3]

Sonoma County is situated north of Marin County and San Pablo Bay, extending eastward from the Pacific Ocean, which it borders for 50 miles, to the crest of the Coast Range, which forms the boundary separating it on the east from Lake and Napa counties. Mendocino County bounds it on the north. The land area of the county is 1577

[1] See Laizure, C. McK., Solano County: State Mineralogist's Rept. XXIII, pp. 203–213, 1927.
[2] *Op. cit.*, p. 204.
[3] From Laizure, C. McK., Sonoma County: State Mineralogist's Rept. XXII, pp. 327–329, 1926.

square miles, and the population is 51,990 (1920 census). There are no improved harbors on the coast side, but water shipping facilities are available in the southern portion, which borders the bay. The Northwestern Pacific railroad traverses the county from south to north through the central valley, with branch lines into Sonoma Valley, to Sebastopol and to the Russian River region around Guerneville, Duncan Mills and Cazadero. A narrow-gauge branch also extends from Marin County northward through Valley Ford to Monte Rio in the western part. A line of the Southern Pacific railroad from Napa Junction in Napa County traverses the Sonoma Valley and terminates at Santa Rosa. The Petaluma and Santa Rosa electric system also gives service to the southern portion of the county. The paved 'Redwood Highway' of the state system closely parallels the Northwestern Pacific railroad through the county. Its main laterals are also paved or well-kept graveled roads.

The county produces a great variety of agricultural products, and dairying and stock-raising are important sources of wealth. Its mineral deposits have been exploited more or less continuously since the sixties, and although it can scarcely be classified as a 'mining' county, metals and nonmetallic minerals exceeding $11,000,000 in value have been produced to date. Its resources are still far from exhausted.

Many health-giving mineral springs are found here, and its resorts have made the county one of the favorite playgrounds of central California.

Situated in the midst of the Coast Range, its topographic features include level valleys, low rolling hills and rugged mountains, with deep-cut canyons. The drainage of the southern portion is to the bay, while that of the northern two-thirds is to the Pacific Ocean, chiefly by the Russian River and its tributaries. The main valley area, beginning at the bay, extends through the center of the county for about 60 miles, with an average width of 25 miles, but narrowing toward the northern end. Numerous smaller valleys separate the lesser spurs and ridges of the main range.

Geology.

Sonoma County is not covered by any of the United States Geological Survey Folios, and the geologic literature on this area is fragmentary. The general geology has been described in part by Osmont,[1] and by Vander Leck,[2] in its relation to possible oil production. The geology of the quicksilver ore deposits has also been covered in considerable detail by various writers.

As shown on the State Mining Bureau's geological map of the state, the Franciscan rocks of the Coast Range cover probably three-fourths of Sonoma County, extending in a broad belt from the Marin County line northwesterly the entire length of the county and beyond. This belt of metamorphic rocks widens toward the north. It consists mainly of sandstone, with smaller amounts of limestone, slates, cherts, schist, and much serpentine. Bordering the coast from Salmon Creek north, is a belt of Cretaceous sandstone and shale a few miles in width. Tertiary sedimentary rocks are exposed in a small area around Valley

[1] Osmont, V. C., A Geological Section of the Coast Ranges North of San Francisco: Bull. Dept. of Geol., University of California, Vol. 4, No. 3, pp. 39–87.

[2] Vander Leck, Lawrence, Petroleum Resources of California: State Min. Bur. Bull. 89, pp. 36–38.

Ford. The main valley area is composed of Quaternary sands, gravels, and clays along the Russian River from Cloverdale to Healdsburg. These formations narrow at Windsor and then widen again between Forestville and Santa Rosa and continue south through Sebastopol and Cotati nearly to Petaluma. The lowlands area around the mouth of Petaluma Creek and Sonoma Creek is also of Quaternary age. Most of Sonoma Valley, the Sonoma Hills and the area surrounding Santa Rosa on the east and north is made up of Tertiary sediments consisting of fine and medium sands, clay and shale. Late volcanic lavas cover a considerable area in the neighborhood of Mount St. Helena. They also appear along the eastern boundary of the county, on the west side of Sonoma Valley, and near Petaluma. The lavas are mainly andesitic, but in places grade into basalt. Volcanic tuffs are found interbedded with the Tertiary sediments at many points.

Among Sonoma County's mineral resources are chromite, clay, copper, graphite, diatomite, magnesite, manganese, marble, mineral paint, mineral water, quicksilver, and miscellaneous stone. Of these, miscellaneous stone, quicksilver, mineral water, pottery clay, building stone (tuff) and manganese ore were produced in 1925.

Clay Resources.

There has been in the past a considerable output of brick and clay in Sonoma County, but no clay-working plants are active at present. Common clays are sufficiently abundant for all probable needs of the county.

A number of deposits of high-grade clay have been reported from time to time, but only one of these, the Weiss deposit, has been developed sufficiently to be of interest.

Beltane. Sample No. 197 (see p. 291) was taken from a deposit that is exposed in a cut on a side road, 1.3 miles northwest of the state highway. The side road branches from the main highway at a point 0.5 mile north of Warfield Station. The deposit is probably near the eastern edge of Sec. 2, T. 6 N., R. 6 W., M. D. M., about two miles east of Beltane Station. The clay is buff-burning and refractory. The extent of the deposit and its ownership were not determined. This should not be confused with the Weiss clay, described below, which is sometimes known as 'Beltane clay.'

Weiss Deposit. J. H. Weiss, Glen Ellen, owner. This is a deposit of white, moderately plastic, kaolin fireclay, in Sec. 3, T. 6 N., R. 6 W., M. D. M., less than a mile by road east of Beltane station on the Southern Pacific. The deposit has been worked at various times in the past, and over 2000 tons have been shipped to clay products manufacturers and to the Santa Cruz Portland Cement Company for experimental purposes. Five cars were mined and shipped in June, 1925, by Frank A. Asbury, lessee, of 753 Banning Street, Los Angeles, and was tried in several fire-brick plants in the Los Angeles district, notably by the St. Louis Fire Brick and Clay Company.

The appearance of the deposit and the extent of development work is shown in photo No. 66. The tunnel is said to be 100 feet long, with various secondary workings, but it is now caved near the portal. Borings from the floor of the pit are said to have encountered clay of quality equal to that exposed in the workings, to a depth of 20 to 30 feet. There is a smaller abandoned pit 100 feet to the east, in which clay of a similar nature is exposed.

The origin and structural relations of the deposit was not definitely determined, but all available evidence points to the theory that it is an alteration in place of a flat-bedded, fine-grained aplitic rock. The overburden of several feet of soil, and the thick vegetation make tracing of the clay beyond the development faces difficult.

About 400 yards to the north, and at a slightly higher elevation, is a prominent exposure of a rock containing quartz and a high proportion of feldspar. Some of this rock has been mined from an open cut, and the exposed bank is over 40 feet high. The rock has been tried as a fire-brick grog by several plants. Near the top of the bank, the rock is similar in color and aggregation to the clay from the pit to the south, but is hard and non-plastic. The more typical rock from the lower part of the bank closely resembles a chert. It is harder than steel, has

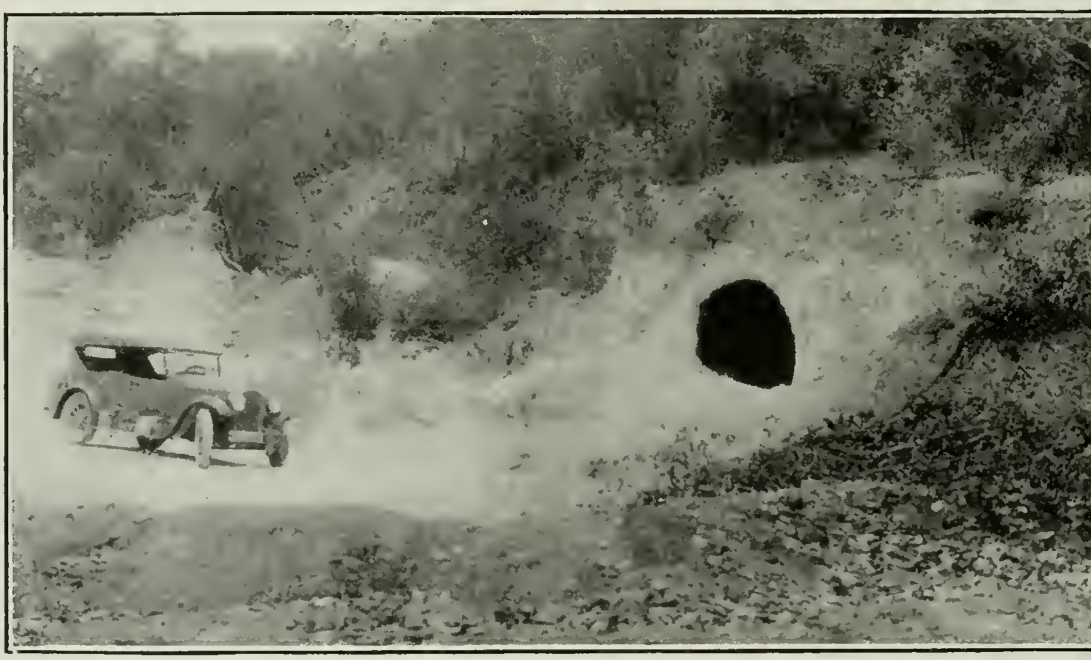

PHOTO No. 66. Weiss clay deposit, facing northwest. Near Glen Ellen, Sonoma County. (Samples No. 194 and 195.)

a dull waxy luster, and contains isolated quartz and altered feldspar crystals, and scattered discontinuous veinlets of quartz.

Sample No. 194 is a general sample from the clay pit. Sample No. 195 is a selected sample of the whiter clay from the pit and from the tunnel, near the portal. It represents from 10% to 15% of the clay exposed in the workings. The test results are on page 262.

Bibl: State Mineralogist's Reports VIII, p. 635; XII, p. 384; XIV, pp. 316–318; XXII, p. 332. Bull. 38, p. 258; Prel. Rept. 7, p. 99.

STANISLAUS COUNTY.

General Features.[1]

Stanislaus County is situated in the San Joaquin Valley between San Joaquin County on the northwest and Merced on the southeast. It is

[1] From Laizure, C. McK., Stanislaus County: State Mineralogist's Rept. XXI, pp. 200–201, 1925.

bounded on the northeast by Calaveras and Tuolumne counties, and by Santa Clara on the southwest side. Stanislaus County contains 1486 square miles, and its population is 43,557 (1920 census). The greater part of its acreage is arable, and about one-half is capable of irrigation. The various branches of agriculture and stock-raising are the principal sources of wealth.

The county extends across the San Joaquin Valley in a northeasterly direction from the summit of the Mount Diablo Range on the west to the foothills of the Sierra Nevadas on the east. The central portion is composed of unconsolidated sands, gravels and clays. Bordering this formation on the northeast, with the line of contact a little above Oakdale and Waterford, is a belt of older Tertiary clays, shales and sandstones. This Tertiary belt extends to and comes in contact with the slates, limestones and other rocks of the Jurassic along a line which closely follows the northeastern boundary of the county. On the southwest, the low foothills of the Coast Range are made up of Cretaceous sandstones and shales. The extreme western portion is rugged and composed of Franciscan formations, typical of the Coast Range; consisting of altered slates, cherts, massive sandstone, schists and serpentine. Deposits of magnesite, manganese, and quicksilver occur in this area.

Gold has usually been the chief mineral product of Stanislaus County, but gold was exceeded in value in 1918–1919 by manganese, and in 1921–1923 by miscellaneous stone. Gold, platinum, and silver are obtained mainly by dredging. Quicksilver and manganese are other metals found here also. Among its nonmetallic resources are clay, ocher, magnesite, silica, and miscellaneous stone, including crushed rock, gravel and sand. Other minerals occur, but the deposits in most cases have not been sufficiently developed to determine their commercial value.

Clay Resources.

Deposits of common clay, suitable for the manufacture of common brick, occur abundantly in the county, and have been worked at various times in the past near Modesto, Grayson, Newman, and Patterson, but there have been no recent operations.

The Craycroft brickyard at Modesto operated between 1908 and 1916, but is now dismantled. In 1918 and 1919 Martin Kelch made brick from a clay deposit having a maximum thickness of 20 feet, on the Waterford road, about one mile east of Modesto.

No deposits of high-grade clay are known to occur in the county. The Cummings Ranch deposit, described below, has been noted in various reports of the Bureau. On investigation, it was found to have little or no commercial value.

Cummings Ranch Clay Deposit. On the property of J. H. Cummings of Patterson, in Sec. 20 and 21, T. 5 S., R. 7 E., M. D. M., is an undeveloped deposit of hard, white clay-shale. The deposit occurs near the edge of the foothills west of Patterson, near the ranch house of W. J. Hammond. The deposit is exposed on the hillside 200 yards northwest of the ranch house. The total distance by road from Patterson is 5.9 miles. The shale occurs in a bed from 10 to 15 feet thick having a strike of N. 50 W., and dipping 45° NE. The overburden of shale, sandstone and soil varies from a few feet to over 15 feet in thickness.

Sample No. 205 was cut from a five-foot portion of the bed that was whiter in color than the rest. The test results are on page 299.

Bibl (Clay resources of Stanislaus County): State Mineralogist's Repts. XVII, p. 253, and XXI, pp. 204–205; State Min. Bur. Prel. Rept. 7, p. 99.

SUTTER COUNTY.

General Features.

Sutter County lies north of Sacramento County, mainly between the Sacramento and Feather rivers. Its area is 608 square miles, and the population is 10,115 (1920 census).

The outstanding topographic and geologic feature of Sutter County is the Marysville Buttes, which occupy a circular area about 10 miles in diameter in the north-central portion of the county, and rise to a maximum elevation of 2128 feet above sea level. The rest of the county is flat and is covered with deep alluvial soil. The Buttes consist of a core of andesite with intrusions of rhyolite surrounded by upturned Ione (Eocene) sedimentary strata overlain by andesite tuff and breccia.[1] The mineral production of the county is practically nil, and consists principally of crushed rock.

Clay Resources.

Clay beds of considerable extent have been reported to occur in the sedimentary Eocene strata of the Marysville Buttes. A reconnaissance of the region was made by the author in August, 1925, but no further information could be obtained, even after considerable search and local inquiry.

Bibl: State Mineralogist's Rept. XV, p. 258; State Min. Bur. Prel. Rept. No. 7, p. 100.

TEHAMA COUNTY.

General Features.

Tehama County is in the upper part of the Sacramento Valley. It extends east to the summit of the Sierras, and west to the crest of the Coast Range. Its area is 3166 square miles, and the population is 2551 (1920 census). The Sacramento River flows through the center of the county, from north to south.

The eastern half of the county is covered with sheets of lava, which had their origin from and around Lassen Peak. The central part of the county shows an extended plateau of gravels, sands and clays, which extend to the serpentines and metamorphic rocks of the Coast Range.

Among the mineral resources of Tehama County are brick, chromite, copper, gold, manganese, marble, mineral water, salt, and miscellaneous stone. Brick and miscellaneous stone are the only commercial products at present.

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[1] Turner, H. W., and Lindgren, W., Marysville Folio No. 17, U. S. Geol. Surv., 1895.
Lindgren, W., U. S. Geol. Surv. Prof. Paper No. 73, pp. 23–25, 1911.
Watts, W. L., Cal. State Min. Bur. Bull. 3, pp. 9–10, 1894.
Cooper, J. G., Cal. State Min. Bur. Bull 4, pp. 36–45, 1894.
Dickerson, R. E., Bull. Dept. of Geol., Univ. of Calif., Vol. 7, No. 12, pp. 257–298; pls. 11–14, April, 1913.

Clay Resources.

Common brick clays are abundant in the Sacramento Valley portion of the county, especially near the river. A brickyard has been operating intermittently at Red Bluff for many years.

Banks of clay of fine quality are reported in the *Flournoy* district.[1] Flournoy is in T. 24 N., R. 5 W., about fourteen miles west of the Southern Pacific railroad at Corning. No investigation was made of this occurrence.

O'Connor Brothers Brickyard. Address, Red Bluff. The clay deposit and brickyard are on the Reed Tract, in Sec. 29, T. 27 N., R. 3 W., M. D. M. The deposit covers an area of over 19 acres, and is from 8 to 12 feet thick,, underlain by gravel. The soft-mud process is used, a small brick press being operated by horse power. The brick are fired in open field kilns. The plant is operated intermittently to supply the local demand.

Bibl: State Mineralogist's Rept. XV, p. 260; State Min. Bur. Bull. 38, pp. 258–259; Prel. Rept. 7, p. 100.

TULARE COUNTY.

General Features.

Tulare County is in the southern San Joaquin Valley, and is bounded on the north by Fresno, on the east by Inyo, on the south by Kern, and on the west by Kings County. It has an area of 4856 square miles, and the population is 59,031 (1920 census).

The western half of the county lies in the San Joaquin Valley, and the eastern half is in the Sierra Nevada, culminating in a number of peaks along the summit at elevations exceeding 14,000 feet above sea level. The rocks in the mountains are mainly granites and other plutonics, whereas the valley is covered with Quaternary sediments. Various metamorphic and sedimentary rocks are found in the foothills.

Climatic, soil and water conditions in the foothills and in the San Joaquin Valley section of the county are especially favorable to the growth of citrus fruits. This and other agricultural pursuits, including stock raising and dairying, are the principal industries of the county.

The mineral resources of the county include brick, clay, copper, feldspar, graphite, gems, limestone, magnesite, marble, quartz, glass-sand, soapstone, miscellaneous stone, and zinc. The commercial mineral products are brick, granite, lime, limestone, magnesite, natural gas, and miscellaneous stone, of which magnesite and granite are the most important.

Clay Resources.

Common clay of good quality for the manufacture of red-burned structural ware is plentiful in the valley and foothill section of the county. One brickyard has been in operation for a number of years.

A deposit of buff-burning refractory clay has been found eight miles southeast of Ducor, but has not been developed commercially. See under Sears Clay Deposit.

[1] Clay-Worker, August, 1926, p. 131.

Sears Clay Deposit. W. A. Sears, of Porterville, owner. Eight miles southeast of Ducor, in Secs. 26, 27, 35, T. 24 S., R. 28 E., M. D. M. This locality was visited in September, 1925, but the author was unable to meet Mr. Sears, or to find the deposit by personal search or by inquiry among residents in the locality. Later, Mr. Sears sent a number of samples of clay from the property. These were tested under numbers 283-A, 283-B, 284, and 285. See pages 314, 316, and 282. A description of the deposit was given in Preliminary Report No. 7, p. 100, and is quoted below:

"The clay bearing strata extend about one-half mile south of White River and about two miles in length along the south bank of the river. An overburden of gravel and clay 6 to 8 feet thick overlies a bed of white and blue plastic clay. A number of small cuts have been made along the south bank of the river. These pits show a white clay 6 to 8 feet thick overlying a blue plastic clay. The strata of clay beds have a general northwest strike. The development of this deposit has been only superficial, so the depth of the clay bed has not been determined. The clay is suitable for tile, sewer pipe, fire brick, vitrified brick and terra cotta."

S. P. Brick and Tile Co. W. D. Trewhitt, president; H. W. Shields, secretary-treasurer; H. G. Hayes, superintendent. General office, 435 Rowell Building, Fresno. The plant is three-quarters of a mile south of Exeter, in Sec. 14, T. 19 S., R. 26 E., M. D. M. The property comprises 20 acres, all of which is underlain by workable clay to a depth of 12 to 18 ft., underlain by coarse gravel. The products of the plant are common brick and hollow tile.

The clay is mined by a ½-yd. electric shovel, having a capacity of 200 tons per eight hours. The clay is passed through a roll disintegrator, from which it is elevated, screened, and passed to an American pug-mill and auger machine, equipped with a Freese cutter. Some of the ware is dried under sheds, and some in a waste-heat drier. The drying sheds have a capacity of 550,000 brick, and drying is usually completed in three weeks. The waste-heat drier has a capacity of 135,000 brick, and the drying period is three days.

The brick and tile are fired in open-field kilns. The fuel is oil, atomized with steam. The firing period is 5½ days, and the kiln turnover cycle is 12 days. Two round down-draft kilns are available, but are not used, as they are more expensive to operate than the field kilns.

The capacity of the plant is 8,000,000 brick, or the equivalent volume of brick and hollow tile, per year.

Valencia Heights Shale Deposit. C. H. Weed, of Porterville, owner. The deposit is six miles east of Porterville, in Sec. 34, T. 21 S., R. 28 E., M. D. M., and consists of black clay shale, almost a slate. The shale is 1500 to 2000 feet in width, and cuts through a serpentine belt. The strike of the beds is northwest and the dip is 75° SE. Sample No. 206 was taken from a road cut, 5.3 miles from Porterville. The test results are on page 327.

Bibl: State Min. Bur. Prel. Rept. 7. p. 101.

Former Operations.

The Pioneer Brick Company and the McKnight Firebrick Company, mentioned in Preliminary Report No. 7, pp. 100–101, are out of business.

VENTURA COUNTY.

General Features.[1]

Ventura County is bounded on the north by Kern County, on the east by Los Angeles County, on the south by Los Angeles County and the Pacific Ocean, and on the west by Santa Barbara County. The total area is 1878 square miles. The population as shown by the census of 1920 was 28,724.

The city of Ventura, originally called San Buenaventura, is the county seat, and is located on the shores of the Santa Barbara Channel. The cities of Oxnard, Santa Paula, and Fillmore are next in importance.

Ventura County is essentially an agricultural and stock-raising county. The increasing production of petroleum in the past few years, however, is rapidly bringing it forward on the list of mineral-producing counties.

The northern portion of the county is characterized by the convergence of several important mountain ranges, which make of it a high and rugged region. The more mountainous and rugged parts of Pine Mountain and Topatopa Mountain form what is considered one of the roughest and most inaccessible regions in California. Its lofty peaks range in elevation from 6000 to 9000 feet. To the northwest extend the San Emigdio Mountains, which form the connection between the Coast Range and the Sierra Nevada Mountains. To the west extend the San Rafael Mountains, while farther southward the Santa Ynez Mountains diverge from this group, running westward through Santa Barbara County.

The southern part of the county is characterized by a series of parallel folds, the axes of which lie east and west, forming low mountain ranges of no great continuity. The principal valleys are Santa Clara, Ojai, Simi, and Las Posas.

The two principal drainage systems of the county are the Santa Clara River and the Ventura River. Next in importance, but subordinate to these is Calleguas Creek, which drains the Simi and Las Posas valleys.

The county is traversed by the Southern Pacific railroad, with a branch line from Ventura to Ojai. At Montalvo, five miles east of Ventura, the main line divides into two branches, one going to Los Angeles via Las Posas and Simi valleys, the other through the Santa Clara Valley, joining the San Joaquin Valley line at Saugus.

With the exception of the higher mountainous areas, the county is easily accessible by roads, the main arteries being paved. Access to the gold and borax districts is obtained over the state highway from Bakersfield to Los Angeles via Tejon Pass.

Mineral Resources.

Ventura was the fourth county in the state in respect to the value of its mineral production in 1926. Petroleum and natural gas are the principal products. The only other products, in 1926, were miscellaneous stone, brick, and clay. Undeveloped resources include asphalt, borax, diatomite, gypsum, limestone, mineral water, mineral paint, molding sand, phosphates, and sandstone.

[1] From Tucker, W. Burling, Ventura County: State Mineralogist's Report. XXI, pp. 223–225, 1925.

Geology.

The rocks of the Ventura region fall into three classes: a metamorphic and granite complex, which is commonly referred to as the 'basement' complex, a series of sedimentary rocks, and a series of igneous extrusive and intrusive rocks.

The metamorphic rocks are all of pre-Jurassic age and have been intruded by granite that is probably of the same age as that of the Sierra Nevada, which is considered to be late Jurassic or early Cretaceous.

The sedimentary rocks, which in this region form the greater percentage, range in age from Upper Cretaceous to Recent.

The igneous rocks are practically all of Miocene age and are mainly andesite, dacite, basalt, andesite breccia, and associated mud flows.

Clay Resources.

Common clays are sufficiently abundant in Ventura County to serve all purposes. Two brickyards are operated as needed to supply the local market.

No high-grade clays have been reported in the county.

Anderson and Hardison. This is a common brick plant, 2.7 miles north of Santa Paula, on the Ojai Valley road. The clay is obtained from an extensive deposit of sandy clay and is mined by a tractor-drawn scraper. The clay is prepared by crushing and screening, and the brick are shaped by dry pressing. So far as known, this is the only brickyard in California using the dry-press process of making common brick. Gas-fired field kilns are used.

Sample No. 6 was taken for testing. The results are on page 339.

Bibl: State Mineralogist's Rept. XXI, p. 237.

People's Lumber Company. C. E. Bonistell, general manager. Office in Ventura. Clay pit and brickyard on the Ventura Avenue road, two miles north of Ventura. The clay is mined from an extensive deposit of Pliocene (Fernando ?) age, which is also utilized as an oil-well mud. Two varieties of clay are found: a yellow clay, sample No. 4, p. 338, which is considered best for use in making brick, and a bluish clay, sample No. 5, p. 339, which is more fine-grained and plastic, and is especially desirable for use in the oil fields. Common brick, red ruffled brick, drain tile, roofing tile, and hollow building tile are made, by the stiff-mud process. Open field kilns are used for firing, and natural gas is available as fuel.

Bibl: State Mineralogist's Repts. XV, p. 759, and XXI, pp. 236–238. Bull. 38, p. 259; Prel. Rept. 7, pp. 101–102.

YOLO COUNTY.

General Features.

Yolo County is in the Sacramento Valley, bounded by Sutter on the east and Colusa on the north. Its area is 1014 square miles, and the population is 17,105 (1920 census). The western edge of the county is in the foothills of the Coast Range, and the rest of the county is in the basin of the Sacramento River.

The only commercial mineral resource at present is miscellaneous stone. Quicksilver was at one time produced. Deposits of iron and sandstone have been noted.

Clay Resources.

Common brick clay is abundant near Winters, Woodland, and Capay. Small quantities of brick were made, chiefly at Woodland and Winters, in the eighties, using deposits of clay and clayey loam.

Bibl: State Mineralogist's Rept. X, p. 791; XIV, p. 367. State Min. Bur. Bull. 38, p. 259; Prel. Rept. 7, p. 102.

YUBA COUNTY.

General Features.

Yuba County lies in the north-central part of the state and borders the east side of the Feather River. It is bounded on the northwest by Butte and Plumas counties, on the southeast by Placer and Nevada counties, and on the east by Sierra County. Its area is 625 square miles, and the population is 10,375 (1920 census).

Since its boundaries extend from the floor of the central valley of California to the middle western slope of the Sierra Nevada Mountains, Yuba County includes diversified topography and climate.

Geology.[1]

The general geology of Yuba County is similar to that in Nevada and Placer counties. The main central portion of the county consists generally of gabbro-diorite and granodiorite, which in turn grade into metamorphic, amphibolitic rocks. Schists and slates in places overlie the igneous rocks and are intruded by serpentine in the northern part of the county. Alluvial sands and gravels cover the entire western portion of the county, while auriferous gravels, in places, lie along the old channel courses.

The areal geology of Yuba County has been covered by U. S. Geological Survey Folios No. 17, 18 and 43.

Yuba County is still an important producer of gold, which is recovered by dredging and hydraulic mining. Other mineral products are miscellaneous stone, silver, natural gas, and platinum.

Clay Resources.

High-grade clay in small quantities has been mined from the J. F. Dempsey Ranch (see below) near Smartsville. Common clays suitable for the manufacture of red-burned structural ware are plentiful in the vicinity of Marysville.

Dempsey Ranch Kaolin Deposit. A deposit of kaolin fire clay occurs on the ranch of J. F. Dempsey, in the E½ of Sec. 3, T. 15 N., R. 6 E., M. D. M., 2 miles southeast from Smartsville. The clay occurs as irregular bunches exposed in small chamber workings at the end of a 100-foot tunnel. The clay was evidently formed by the alteration in place of diabase or a similar intrusive rock which penetrates the serpentine mass of the hill in which the deposit occurs. The clay is badly contaminated with limonitic iron in most of the exposed workings, but occasional bunches of 5 to 10 tons can be found that are quite free from

[1] From State Mineralogist's Rept. XV, p. 420.

iron. It is doubtful if a commercial quantity of white kaolin could be found.

J. V. Chown of Oakland at one time held a lease on the property, and shipped 150 tons of kaolin for the manufacture of fire brick. The kaolin was found to be satisfactory for this purpose, but on account of the isolation of the property, expensive mining, and the irregular occurrence of the clay, it was not possible to compete with other sources of material. The kaolin was hauled 20 miles to Marysville, over a rough road, at a cost of $5 per ton for haulage alone.

Sample No. 173 was taken for testing. The results are on page 313.

Durst Ranch. One-half mile east of Wheatland. This locality was not visited, but a note on the occurrence of clay on this property was given in earlier reports as follows: "Shipments of clay were occasionally made, before 1905 . . . to Gladding, McBean and Company at Lincoln. . . . The black clay loam used was 6 feet deep and overlain by 18 inches of soil. Deposits similar to that on the Durst Ranch are abundant in the valley portion of Yuba County."[1]

Marysville Brick Company. This plant is a short distance north of Marysville, on the Feather River. A local surface clay is used for the manufacture of common brick. The plant was not visited and no details are available for publication. The production in 1925 was 1,100,000 brick.[2]

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[1] State Mineralogist's Rept. XV, p. 424, 1915–16, evidently abstracted from Bull. 38, p. 230, 1906.
[2] Clay-Worker, February, 1926, p. 139.

Chapter IV.

CLAY TESTS AND THEIR INTERPRETATION AND THE CLASSIFICATION OF CLAYS.

FIELD TESTS.

While no field tests of clays were made in preparing this report, the prospector or clay miner often wishes to determine the possible economic value of clays before incurring the labor or expense of securing adequate samples and sending them to clay plants or commercial laboratories for testing. If samples are sent to clay plants it is usually necessary to send material to more than one plant, as a clay may be rejected by one operator as not being suitable for his ware or his plant routine, but this same clay may be eminently suitable in some other plant.

The following simple field tests for making a rough preliminary classification of clays, from the Third Report of the West Virginia Geological Survey, have been quoted many times, but are of such general interest to prospectors and others who are searching for clays in the field, that they are repeated here.

1. A small lump of clay may be roasted in the flame of a gas stove. If it turns red or brown, the percentage of iron is high, probably more than four per cent.

2. By tasting the clay, bitter salts, such as alum and epsom, may be detected, or such salts may occur as white coatings on the outcrops of the clay in the bank. These salts are apt to form white wash coats on the finished brick, injuring their appearance. Sand may be detected by grit against the teeth. A rough idea of the percentage of such sand may thus be made.

3. A good idea of its plastic qualities may be obtained by working the moist clay with the fingers. A good test for pottery clay is to thus moisten it, and determine whether it can be worked into a definite shape, and whether or not it will retain its form when dry without cracking.

4. Shrinkage: A rough brick can easily be made and dried, and a good idea of the shrinkage arrived at. If it cracks or crumbles when dry or shrinks out of shape, its value is very doubtful. For this test, however, the clay should be ground thoroughly, tempered with water, and dried slowly.

5. If carbonates of lime are present, a few drops of hydrochloric acid will cause effervescence or bubbling, as the carbonic acid gas passes off. Very high percentages of lime are apt to ruin the clay. Good fire bricks are made of clay low in lime content.

6. The slaking of clays, or the crumbling down in tempering is tested by dropping a lump of clay in a cup of water. Some clays slake in a very few minutes, and so are easily tempered.

7. The color of a finished clay product is largely determined by the amount of iron present. It is not always possible to predict the color of the burned ware from the color of the clay. It is true that red clays will usually burn red, but blue clays or those of other shades also commonly burn red or buff. The color of the raw clay is often due to organic matter which is combustible, and will be consumed in the burning.

While the above tests may not prove absolutely the quality of any given clay, at the same time they furnish considerable valuable information in regard to it, and may be used to advantage by the owner of a deposit which has never been developed. If these simple tests seem to give positive results it may then be well worth while to get in touch with buyers and consumers.

LABORATORY TESTS.

The methods of testing used for this report followed the standards or tentative standards of the American Ceramic Society,[1] in so far as it was possible to do so with the equipment and funds available.

These methods or their equivalent have been followed in a number of recent state reports on clays.[2] Only such explanation of the testing methods and their interpretation is given here as is necessary to an understanding of the text of this report and to indicate the divergences from the recommended methods. The reader is referred to the literature for further details.

Preparation of Samples.

The weight of the sample collected in the field was usually approximately fifty pounds, but a number of them were smaller, owing to special difficulties of securing proper samples or of transporting them. In sampling, the usual precautions were taken to secure material that was representative of the clay that would actually be mined. Notes on the macroscopic character of the material sampled were made at the time of sampling, and are recorded in the description of the sample, if of special interest. All foreign matter that normally would not be mixed with the clay, or that would be removed by screening before the clay is used in a clay-working plant, was removed from the sample before shipment to the laboratory.

In the laboratory, the entire sample was crushed to pass a 20-mesh screen, by passing through a laboratory jaw-crusher, followed by passing through a set of rolls. One sample, a flint fireclay (sample No. 282), was further crushed in a pebble mill to develop maximum plasticity.

Sufficient water was added to the ground clay to permit the mixture to be worked into a plastic condition. The attempt was made to maintain a uniform consistency, so that all determinations of water of plasticity and drying shrinkage would be comparable, but with a series of clays of widely-varying plastic properties, it is impossible to attain a high degree of uniformity in the plastic state, without the use of more elaborate methods than the scope of the investigation warranted.

After thoroughly working (wedging) the plastic mass, it was covered

[1] Report of the Committee on Standards, American Ceramic Society, Reprint from Yearbook, 1921–22, Ohio State University, Columbus, Ohio. Price fifty cents.

[2] Wilson, Hewitt, The Clays and Shales of Washington, Their Technology and Uses, Bull. No. 18, University of Washington, Engineering Experiment Station, Seattle, Washington, October, 1923.

Skeels, F. H., and Wilson, Hewitt, Preliminary Report on the Clays of Idaho. Bull. No. 2, Department of Mines and Geology, Idaho, 1920.

Parmelee, C. W., and Schroyer, C. R. Further Investigations of Illinois Fire Clays, Bull. No. 38, pp. 273–417. Illinois Geological Survey, 1922.

Reis, H., The Clays of Kentucky, Ky. Geol. Surv. Series VI, Vol. 8, Frankfort, Ky., 1921.

with wet sacking and seasoned for at least 24 hours before test pieces were prepared.

Test Pieces.

The test pieces were shaped in brass molds, 1¼ in. by 1¼ in. by 8 in., inside dimensions. Full length bars were used for dry transverse-strength tests, and test pieces for drying and firing data were made by cutting the bars into four pieces. A minimum of four 8-in. bars and sixteen 2-in. test pieces were made for all important clays of which there was a sufficiently large sample. The plastic weight and volume of three test pieces were determined as soon as they were molded. All volume measurements were made in a Goodner mercury volumeter.[1]

Drying.

The test pieces and bars were thoroughly air dried in the laboratory, then heated in an automatic electric oven for five hours at a temperature between 64° C. and 76° C. and finally at 105 to 110° C. for at least 12 hours. They were then transferred to a desiccator, where they remained until needed for dry weight and volume measurements, and for the dry transverse-strength test.

Plastic and Drying Properties.

Plasticity: Notes on plasticity and molding properties were made at the time the test bars were molded. There is no satisfactory standard test or even a standard nomenclature to describe the plasticity of a clay in unambiguous terms. The term 'good plasticity' means a different condition to the common brick worker than it does to a stoneware worker. In general, the plasticity terms used in this report bear some relation to the typical uses of the clay in question. The words 'short,' 'weak,' 'crumbly,' 'smooth,' and 'sticky' are used wherever they serve to clarify the meaning of the more general words 'poor,' 'fair,' 'good,' and 'excellent.'

Some shales and indurated clays can be rendered more plastic by fine grinding.[2] The test data on such clays are of little value without particular reference to the preliminary preparation of the sample.

Water of Plasticity: The water of plasticity is the amount of water required to render a clay readily workable. It is calculated as a percentage of the weight of the dry clay bar, according to the following formula:

$$\text{Per cent water of plasticity} = \frac{\text{plastic weight} - \text{dry weight}}{\text{dry weight}} \times 100 \qquad (1)$$

Shrinkage Water: The water that is removed from a clay while it is shrinking from the plastic to the dry state is called the shrinkage water. It is calculated as follows:

$$\text{Per cent shrinkage water} = \frac{\text{Plastic volume} - \text{dry volume}}{\text{dry weight}} \times 100 \qquad (2)$$

[1] Goodner, E. F., A Mercury Volumeter, Jour. Am. Cer. Soc. Vol. 4, p. 228, 1921.
[2] Walker, T. C., The Effect of Fine Grinding on an Industrial Clay. Jour. Am. Cer. Soc., Vol. 10, p. 449, June, 1927. (A Southern California clay was used in this study.) See also the results on sample No. 282, this report, page 282.

Pore Water: Pore water is that portion of the water of plasticity that is retained in the pores after shrinkage ceases. It is calculated as follows:

$$\text{Per cent pore water} = \text{per cent water of plasticity} - \text{per cent shrinkage water} \qquad (3)$$

Clays in which the percentage of shrinkage water is high may have excessive or sticky plasticity, and usually must be carefully dried to prevent warping or cracking. According to A. V. Bleininger,[1] the ratio of pore to shrinkage water should not exceed 1.00 for bond clays, nor 0.75 for strong heavy plastic clays.

Shrinkage: Drying shrinkage is most accurately determined by determining the volume shrinkage, then calculating the linear from the volume shrinkage. Volume shrinkage is calculated as follows, in percentage of dry volume.

$$\text{Per cent dry volume shrinkage} = \frac{\text{plastic volume} - \text{dry volume}}{\text{dry volume}} \times 100 \qquad (4)$$

The linear drying shrinkage, in per cent of dry length, is calculated as follows:

$$\text{Calculated linear drying shrinkage} = \left[\sqrt[3]{1 + \frac{\text{dry volume shrinkage}}{100}} - 1 \right] \times 100 \qquad (5)$$

In addition to calculated values of linear drying shrinkage, direct measurements were made by means of shrinkage marks on the 8-in. bars. These measurements are not reported, as they are inaccurate, and serve only as an approximate check on the calculated values.

For many purposes, the drying shrinkage is expressed in per cent plastic volume or length. Either of these may be calculated from the data given in this report by means of the following formulæ:

$$\text{Volume drying shrinkage, per cent plastic volume} = \frac{\text{volume drying shrinkage, per cent dry volume}}{100 + \text{volume drying shrinkage, per cent dry volume}} \times 100 \qquad (6)$$

$$\text{Linear drying shrinkage, per cent plastic length} = \frac{\text{linear drying shrinkage, per cent dry length}}{100 + \text{linear drying shrinkage, per cent dry length}} \times 100 \qquad (7)$$

$$\text{Linear drying shrinkage, per cent plastic length} = \left[1 - \sqrt[3]{1 - \frac{\text{vol. dry. shrink., \% plastic vol.}}{100}} \right] \times 100 \qquad (8)$$

For convenience in making the large number of calculations for this report, tables of values were prepared for equations (5) and (8). As will be noted later, equation (8) is the proper form to use for the calculation of linear firing shrinkage, in per cent of dry volume.

Dry Transverse Strength: The dry modulus of rupture was determined on practically all of the clays tested. The 8-in. dried test bars

[1] Bleininger, A. V., Properties of American Bond Clays, etc., U. S. Bur. of Standards, Tec. Paper No. 144, p. 51, 1920.

were of such a length that one 5-in. break and two 3-in. breaks could be obtained on each bar. The bars rested on ½-in. rollers, and the pull stirrup also was equipped with a roller-bearing surface, so that the danger of shear breaks was minimized. No difference was noted in the average values obtained on the 5-in. and the 3-in. breaks. At least ten breaks were made on all clays of which sufficient material was available for making the requisite number of test bars. A variation of plus or minus 15% from the average modulus of rupture was allowed, and at least eight out of ten breaks came within these limits, unless noted in the text by the approximation symbol (±). Where necessary, the tests were repeated until a set of consistent results was obtained.

The modulus of rupture is calculated by the following formula:

$$\text{Modulus of rupture, lb. per sq. in.} = \frac{3 \times \text{breaking load in pounds} \times \text{distance between supports in inches}}{2 \times \text{breadth in inches} \times (\text{depth in inches})^2} \qquad (9)$$

On the stronger clays, especially on the 3-in. breaks, it was necessary to use a lever with a ratio of 2.86. The lever ratio is multiplied by the breaking load to determine the breaking load at the point of application for use in equation (9).

A nomograph was used to minimize the calculations involved.

The following classification of clays by modulus of rupture is used in the text of this report:

	Low	Medium low	Medium	Medium high	High
Modulus, lb. per sq. in.	0 to 100	100 to 200	200 to 400	400 to 800	above 800

This is the same classification as that suggested by Watts [1] for bonding strength (*q. v.* below) and is an elaboration of that used by Parmelee and Schroyer.[2]

Bonding Strength: The modulus of rupture of dried bars containing equal parts of clay and standard Ottawa sand [3] is known as the bonding strength. It is of importance in all clays that are to be used with non-plastic material. A few bonding strength determinations were made for this report. See samples No. 83, 273 and 280, pages 297, 273 and 305. It was intended to include more of these determinations, but it was found that to do so would unnecessarily delay the publication of this report. For an especially interesting comparison between dry modulus of rupture and 'bonding strength,' the reader is referred to the test results of Parmelee and Schroyer.[4] It will be noted that in some cases the bonding strength is higher than the dry modulus, but that in general the addition of 50% of sand to a clay lowers the transverse strength by 30% to 60% of its original value.

Fineness: The percentage of non-plastic material remaining on a 200-mesh (0.0029 in. aperture) screen was determined for most of the clays tested. Fifty grams of the clay was taken, broken in a mortar and passed through a 10-mesh screen. The sample was placed in an

[1] Watts, A. S., Classification of Clays on a Ceramic Basis. Jour. Am. Cer. Soc., Vol. 3, p. 247, 1920.
[2] Parmelee, C. W., and Schroyer, C. R., *op cit.*, p. 293.
[3] Standard sand is sized between the limits of minus 20-mesh (0.0328 in. aperture) and plus 28-mesh (0.0232 in. aperture). It is used in the testing of cement.
[4] *Op. cit.*

Erlenmeyer flask with 150 cc. of distilled water and 1 cc. of ammonia. The pulp was thoroughly shaken, let stand for 18 hours, and agitated for 10 minutes in a shaking machine such as that commonly used in the phosphorus determination in steel. The pulp was transferred to a 200-mesh screen, and all undersize was washed through the screen with a fine jet. The oversize was dried and weighed, and the result reported in per cent of plus 200-mesh material.

Firing Properties.

Firing Treatment: A test piece of each clay was fired to each alternate cone number from cone 010 to cone 13, except where insufficient

Photo No. 67. Assay laboratory, Stanford University, showing muffle furnaces in which test pieces were fired.

material was available to make enough test pieces for the complete series. In addition, most of the refractory clays were fired to cone 15. Denver Fire Clay Company oil-fired assay muffle furnaces were used for all firing from cone 010 to cone 13. These furnaces, shown on photo No. 67, were very satisfactory for the purpose, as the temperatures could be readily controlled, and since ten furnaces were available, it was possible to place one or two sets of 30 samples in each muffle. If two sets of test pieces were placed in the same muffle, the set in the rear of the muffle was fired to two cones higher temperature than the set in the front, and the two sets were separated from each other by a full sized fire brick. This method of firing eliminated most of the transferring of test pieces to a cooling furnace that is a disagreeable and unsatisfactory feature of most test work of this kind. The bottom tiers of test pieces were kept from contact with the muffle floor by placing them on small fireclay saddles. The furnace that was used for firing to cones 11 and 13 was equipped with a Carbofrax muffle, and with Carbofrax stools and muffle protector plates. It was difficult to fire to these temperatures without flashing the test pieces.

A Fisk[1] pre-mix gas-fired kiln was used for firing to cone 15. This furnace, shown on photo No. 68, has a 12-in. circular firing chamber,

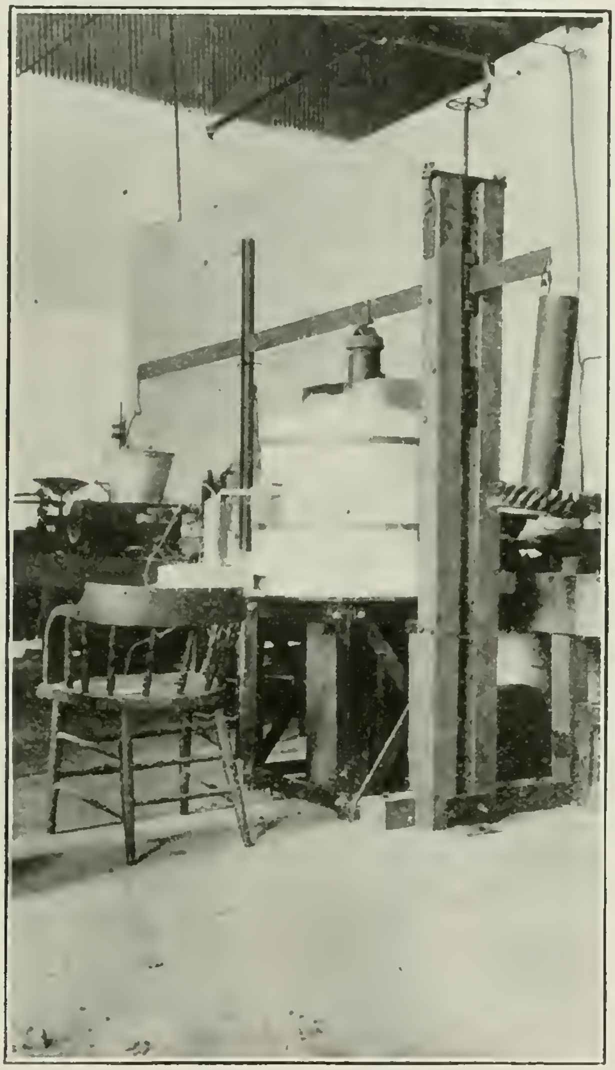

PHOTO No. 68. Fisk pre-mix gas-fired laboratory kiln, in ceramic laboratory, Stanford University. This is used as a load and spall furnace and for firing tests to a maximum temperature of cone 30 (1650° C.). All cone 15 tests were fired in this kiln.

and is capable of accurate temperature control and good heat distribution. The same furnace is used for load and spall tests of refractories, and is suitable for test work up to cone 30 (1650° C.).

Pyrometric Control: Temperatures were controlled with the aid of base-metal or precious-metal thermocouples, in addition to Orton standard pyrometric cones alongside the test pieces. The firing schedule

[1] Fisk, H. G., A Practical Gas-Fired Test Furnace for Plant Use. Jour. Am. Cer. Soc., Vol. 9, p. 151, March, 1926.

was at a rate 50% faster than the fastest schedule recommended by the American Ceramic Society, averaging approximately 90° C. per hour, but at a slower rate during the water-smoking period, a faster rate between the range of 600° C. and 100° C. below the desired finishing temperature, and a slower rate again at the finish. While this schedule caused more shattering and splitting of some of the test pieces than would have been the case if a slower schedule had been followed, the data on shrinkage and porosity at various firing temperatures are comparable with each other, and can be correlated with the results that have been reported by other investigators.[1] In the final analysis, no laboratory tests of clays can be interpreted in a strict quantitative sense with the results obtained in commercial practice, and the purpose of the small-scale tests is to tentatively classify a given clay according to its commercial uses with the minimum expenditure of time and money. The final decision as to the utility of a clay and the methods of working it to obtain the best results, must always be determined in a commercial plant, where the shaping, drying and firing can be done on full-sized ware.

For convenience of reference, the end points of Orton cones are given in degrees Centigrade and Fahrenheit, in table No. 9.

TABLE No. 9.

End Points of Orton Pyrometric Cones, in Centigrade and Fahrenheit Degrees (Heated in Air).

(From Fairchild, C. O., and Peters, M. F., Characteristics of Pyrometric Cones, Jour. Amer. Cer. Soc., Vol. 9, p. 738, 1926.)

Cone No.	End point: Heated at 20° C./hr. °C.	End point: Heated at 20° C./hr. °F.	End point: Heated at 150° C./hr. °C.	End point: Heated at 150° C./hr. °F.
022	585	1085	605	1121
021	595	1103	615	1139
020	625	1157	650	1202
019	630	1166	660	1220
018	670	1238	720	1328
017	720	1328	770	1418
016	735	1355	795	1463
015	770	1418	805	1481
014	795	1463	830	1526
013	825	1517	860	1580
012	840	1544	875	1607
011	875	1607	905	1661
010	890	1634	895	1643
09	930	1706	930	1706
08	945	1733	950	1742
07	975	1787	990	1814
06	1005	1841	1015	1859
05	1030	1886	1040	1904
04	1050	1922	1060	1940
03	1080	1976	1115	2039
02	1095	2003	1125	2057
01	1110	2030	1145	2093
1	1125	2057	1160	2120
2	1135	2075	1165	2129
3	1145	2093	1170	2138
4	1165	2129	1190	2174
5	1180	2156	1205	2201
6	1190	2174	1230	2246
7	1210	2210	1250	2282
8	1225	2237	1260	2300
9	1250	2282	1285	2245
10	1260	2300	1305	2381

Cone No.	End point: Heated at 20° C./hr. °C.	End point: Heated at 20° C./hr. °F.	End point: Heated at 150° C./hr. °C.	End point: Heated at 150° C./hr. °F.
11	1285	2345	1325	2417
12	1310	2390	1335	2435
13	1350	2462	1350	2462
14	1390	2534	1400	2552
15	1410	2570	1435	2615
16	1450	2642	1465	2669
17	1465	2669	1475	2687
18	1485	2705	1490	2714
19	1515	2759	1520	2768
20	1520	2768	1530	2786
23	In Arsem		1580	2876
26	furnace at		1595	2903
27	600° C. (=1080° F.)		1605	2921
28	per hr.		1615	2939
29			1640	2984
30			1650	3002
31			1680	3056
32			1700	3092
33			1745	3173
34	1755	3191	1760	3200
35	1775	3227	1785	3245
36	1810	3290	1810	3290
37	1830	3326	1820	3308
38	1850	3362	1835	3335
39	1865	3389		
40	1885	3425		
41	1970	3578		
42	2015	3659		

[1] See in this connection: Brown, G. H., and Murray, G. A., The Function of Time in the Vitrification of Clays, Trans. Am. Cer. Soc., Vol. XV, p. 193, 1913.

Firing Shrinkage: The shrinkage resulting from firing may be expressed as the per cent volume or linear shrinkage, in terms of plastic or dry volume or length. The data in this report are given in terms of volume and linear shrinkage, dry basis, and in the written summaries of each clay, the maximum total linear shrinkage, plastic basis, is given. The equations for calculating these various methods of expressing fired shrinkage from the volume determinations are as follows:

$$\text{Volume firing shrinkage, per cent dry volume} = \left[\frac{\text{dry volume}-\text{fired volume}}{\text{dry volume}}\right] \times 100 \qquad (10)$$

$$\text{Linear firing shrinkage, per cent dry length} = \left[1 - \sqrt[3]{1 - \frac{\text{volume firing shrinkage, \% dry volume}}{100}}\right] \times 100 \qquad (11)$$

(See equation 8)

$$\text{Total linear shrinkage, per cent plastic length} = \left[\frac{\text{(lin. dry shrink., \% dry length + lin. firing shrink. \% dry length)}}{100 + \text{lin. dry shrink., \% dry length}}\right] \times 100 \qquad (12)$$

All fired volume measurements were made in the mercury volumeter after saturating the test pieces with water[1] and weighing them for the absorption and apparent porosity calculations. In this way, the volume measurements approximate the bulk, or outside, volume of the test pieces, as the mercury does not readily enter the small pores and displace water, during the short time of contact in the volumeter. However, some mercury undoubtedly enters the larger of the open pores (excluding from consideration all vugs, cavities and drying or firing cracks), hence the calculations of volume and linear firing shrinkage, as well as those of absorption, apparent porosity, apparent specific gravity, and apparent density, are slightly erroneous.

Absorption: The absorption of fired test pieces was determined by noting the weight of water absorbed by boiling the piece in distilled water for two hours.

$$\text{Per cent absorption} = \left[\frac{\text{saturated weight}-\text{dry fired weight}}{\text{dry fired weight}}\right] \times 100 \qquad (13)$$

Apparent Porosity: Apparent porosity is the ratio between the volume of the unsealed pores and the volume of the whole piece (=bulk volume). It is calculated from the following equation:

$$\text{Per cent apparent porosity} = \left[\frac{\text{saturated weight}-\text{dry fired weight}}{\text{fired volume}}\right] \times 100 \qquad (14)$$

Apparent Specific Gravity: Apparent specific gravity or bulk specific gravity is the relation between the weight of a mass of material as a whole and that of a volume of water equal to the volume of the solid material plus the sealed pores[2]. No values of apparent

[1] The pieces were boiled in distilled water for at least two hours, then allowed to cool in the water. Before weighing, the surplus water was removed from the surface of the test pieces with a damp cloth.

[2] Searle, A. B., The Chemistry and Physics of Clays and other Ceramic Materials, p. 203.

specific gravity are given in this report, but they may be calculated for the fired test pieces from the absorption and apparent density, if these are not zero, according to the following equation:

$$\text{Apparent specific gravity} = \frac{\text{per cent apparent porosity} \times 100}{\text{per cent absorption} \times (100 - \text{per cent app. porosity})} \qquad (15)$$

Apparent Density: Apparent density or bulk density is the relation between the weight and volume of an article or material as a whole (including any pores or voids) and that of the weight of an equal volume of water[1]. Values of apparent density are not given in this report, but if the absorption and apparent porosity are not zero, the apparent density can be calculated as follows:

$$\text{Apparent density} = \frac{\text{per cent apparent porosity}}{\text{per cent absorption}} \qquad (16)$$

True Specific Gravity: True specific gravity is the relation between the weight of a substance and the true volume of the grains of which the material is composed. On porous materials, which may contain sealed pores, the sample must first be ground to a fine powder to remove all pores.. The true specific gravity of the powder is then determined by means of a specific gravity bottle or pycnometer. No such determinations were made for this report, nor can they be calculated from the data available. In many cases, the apparent specific gravity closely approximates the true specific gravity.

Softening Point.

The softening point of a clay or ceramic mixture is defined as that temperature (usually expressed in cone numbers) at which a standard tetrahedron of the clay when mounted and heated in a manner hereafter described, will bend until it touches the base upon which it stands. The standard tetrahedron is the same size and shape as the small Orton standard pyrometric cones, 7 mm. along the edge of the base and 30 mm. high. The word 'cone' is in general use to describe these tetrahedra. The test cones are mounted on a plaque of refractory material, and are embedded not more than 2 mm. in the plaque, at an angle of 75° from the horizontal.

The terms 'fusion point' or 'deformation point' are often used interchangeably with 'softening point.' 'Fusion point' should be used to indicate the temperature at which complete loss of the original shape occurs, and 'deformation point' is best applied to the temperature at which alteration of the original shape begins.

The softening-point determinations recorded in this report were made in an oxy-acetylene furnace, after a design by Hewitt Wilson.[2] An illustration of the furnace is given in photo No. 69.

Six cones were placed on each plaque, which were usually made from alundum cement. The cones were arranged in two rows of three each, back to back, and were spaced as close together as possible. The

[1] Searle, *op. cit.*

[2] Wilson, Hewitt, An Oxygen-Acetylene High-Temperature Furnace. Jour. Am. Cer. Soc., Vol. 4, p. 835, 1921.

four cones at the corners were Orton standard cones, and the two middle cones were of the clay to be tested. Preliminaries were first run, with four different standard cones in the corners, and usually with different unknown cones in the middle positions. A final check was always made with two cones of the same clay in the middle positions, a pair of standard cones of one number on one side, and a pair of standard cones of the next higher (or lower) number on the other side of the plaque.

After the furnace was heated to the desired temperature, each fusion normally required from three to six minutes. All cones of clays tested for this report were biscuited at 1800° F. before setting

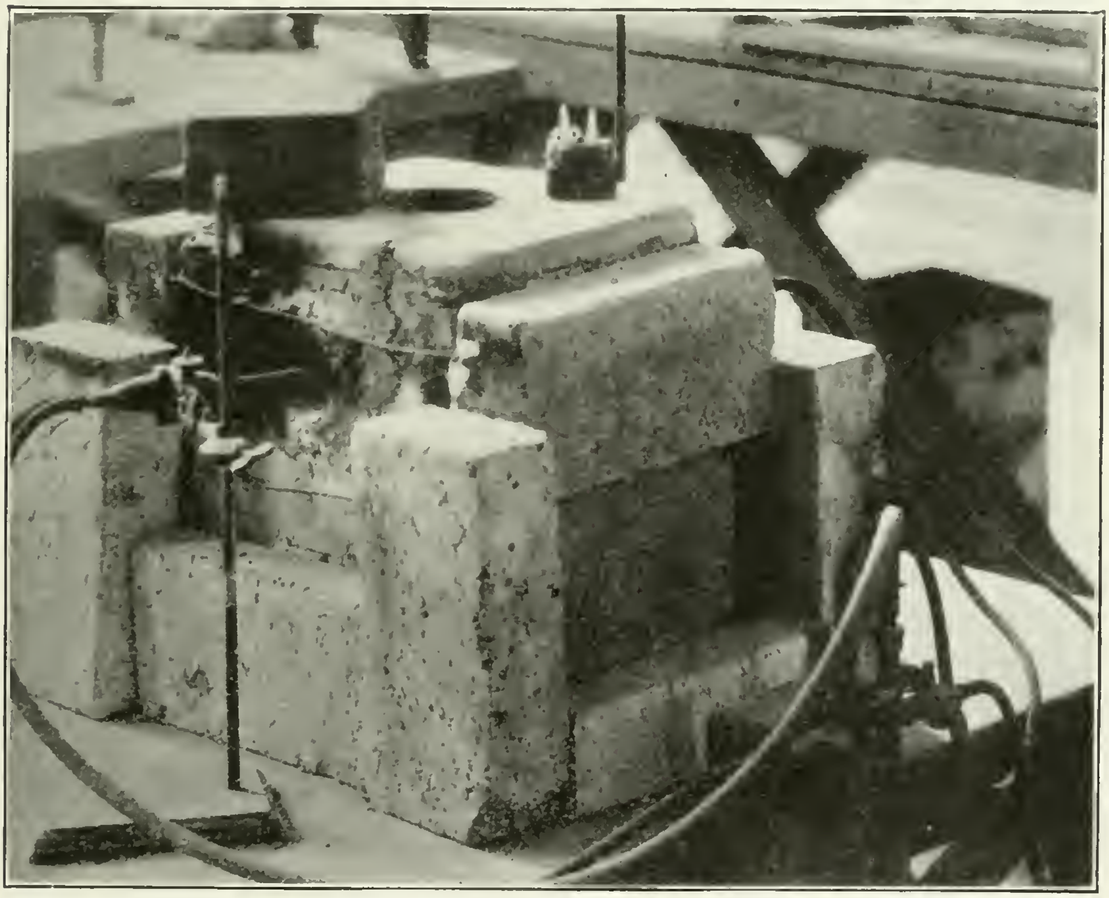

PHOTO No. 69. Wilson oxy-acetylene cone fusion furnace in ceramic laboratory, Stanford University. (After design of Prof. Hewitt Wilson.)

in plaques for the softening-point determination. If this is done, and if the plaques are dried, and pre-heated by placing on top of the furnace, they may be introduced into the hot furnace without danger of spalling.

The results are reported to the nearest half-cone number, using the notation A–B (*e.g.*, 31–32) to signify that the softening point lies nearer to A$\frac{1}{2}$ than to either A or B. Closer estimation, such as A —, A +, B —, or B +, was not considered to be justified by the limits of accuracy of the method itself, and leads to indefiniteness in that such notations might be read to signify 'less than' or 'greater than,' without setting the maximum or minimum range of the values as reported.

For the purposes of this bulletin, all clays having a softening point of cone 27 or higher are classified as refractory, and those which fuse at cone 33 or above are considered to be highly refractory.[1]

Texture, Structure, and Hardness.

Texture: The texture of dried and fired test pieces is reported as fine-, medium-, or coarse-grained, depending upon the average size of the grains in the mass, and as close- or open-textured, depending upon the grading of the grains. This classification is used in order to permit a distinction between those clays that may contain a large proportion of non-plastic grains that approximate uniform size, and those that contain clay and graded non-plastic grains in such proportions as to give a closely knit, dense texture.

Structure: The structure of fired test pieces is reported as granular, stony, homogenous (with textural qualifications), or heterogeneous (with textural qualifications). The soundness of a fired test piece is indicated by such terms as sound, hair-cracked (the development of what many ceramic workers term 'crow-feet'), shattered, or as containing one or more small or large cracks.

Hardness: The hardness of the fired test pieces is reported as greater or less than finger-nail (= 2½ in Moh's scale) or steel (= 5½ in Moh's scale). The hardness of dried clays is reported as very soft, soft, medium, equal to the finger-nail, or greater than the finger-nail.

Color.

The natural and fired colors of clays and ceramic products are too often expressed in indefinite terms that can not be duplicated by other investigators. Since the fired color of a clay or clay mixture is one of its most important properties, some standard scale of colors should be used. For that reason, more attention is paid in this work to an accurate designation of color than is customary in similar publications. While the colors obtained under laboratory firing conditions are not exactly the same for each firing temperature as would be obtained in commercial kilns, the color possibilities of a given clay are clearly indicated by the laboratory tests.

The two principal standard color scales in use in the United States are the Ridgway[2] and the Munsell[3] systems.[4] For reasons hereafter noted, the Ridgway system is used in this bulletin. Since this is, so far as is known, the first time that either system has been used in a bulletin of this nature, a brief explanation of color terms and of each of the systems is given, together with an approximate correlation of parts of the two systems with each other.

To adequately express a color, three variables must be used:[5] (1) Hue, or the series of spectrum colors and their intermediates, through

[1] Parmelee, C. W., and Schroyer, C. R., *op. cit.*, p. 281.
[2] "Color Standards and Color Nomenclature," by Robert Ridgway. Published by A. Hoen and Company, Baltimore, Maryland, 1912. Price $12.
[3] "A Color Notation," by A. H. Munsell, 7th edition, 1926 (price $2), and "Atlas of the Munsell System," 1915 (price $25), both published by the Munsell Color Company, Baltimore, Maryland.
[4] Lenchner, Theodor, "A Study of Color and Its Application to Ceramic Art," Jour. Amer. Cer. Soc., Vol. 10, p. 538, July, 1927, in which a combination of the Munsell and the Prang (an earlier work) systems is proposed.
[5] In preparing this paragraph, Munsell's "A Color Notation" was freely drawn upon.

red, orange, yellow, green, blue and violet. Hue can be accurately expressed by determining the wave length of the light waves of each color sensation. (2) Tone or value, by which a light color is distinguished from a dark one. When white is added to a color, various tints result, and when black is added, the shades are produced. Tone can be measured by means of a photometer, and is expressed scientifically in terms of the amplitude of the light waves reflected by the color. (3) Chroma, by which strong colors are distinguished from weak ones. It is the effect produced by adding neutral gray to a hue of any given tone. Scientifically, it is the purity of one wave length separated from all others.

Ridgway Color Standards: The key to the Ridgway classification consists of 36 hues, which include the six fundamental spectrum colors, red, orange, yellow, green, blue, and violet, which are connected by intermediate hues. The chromatic scale forms the horizontal line of the entire series of charts. The vertical scale on all charts, except the carbon-gray series, represents the tone (Munsell's "value") or luminosity. That is, the proportion of black or white which is mixed with the full color.

The first series of Ridgway's plates contains the pure colors. This series is repeated five times with successively increasing amounts of neutral gray, but with some hues omitted in the last three series. These series are designated "broken color scales" by Ridgway, but Munsell's term "chroma" is to be preferred.

The complete designation of a color from Ridgway's charts therefore involves the use of three symbols: (1) an arabic numeral to designate the hue; (2) the superscript (′ to ′′′′′) to indicate the chroma; and (3) a lower-case letter to designate the tone (or value). Thus, 5′k is a hue containing 60% red and 40% orange, shaded with 70.5% of black, and the whole mixed with 32% of neutral gray. The result is a brick red. It is possible to interpolate between the Ridgway colors whenever an exact match can not be found, and these can be designated by the alternate symbols that are omitted from the color charts. No attempt was made to express the clay colors in this bulletin closer than the nearest Ridgway number.

Expressed in common color names, the Ridgway hues 1, 3, 5 and 7 either of tone "b" or unaltered as to tone, are "red"; 9, 11, 13 and 15 of the same tones are "orange"; and 17, 19, 21 and 23 of the same tones are "yellow." Colors that would be classed as "pale" or "very light" are of tone "f." "Pink," "light orange," "light yellow," "buff," etc., are tone "d." The "i" tones, as well as the "k" tones in hues 1, 3 and 5, are those that would be designated as "dark." The "k" tones, except in hues 1, 3 and 5, are "browns"; for example, "red-brown." The "m" tones are "dark-browns." With respect to chroma, the pure spectrum series is purer than will be found in most ceramic products, although many glazes fall into this class. The (′) series includes most glazes, especially matt glazes, as well as the more brilliantly colored red- and pink-burning bodies. The (′′) series includes the greater portion of all pink-, buff-, and red-burned clay products. The (′′′) series includes colors that are generally too dull for artistic purposes. The (′′′′) and the (′′′′′) series are decided grays, of little interest in decorative wares.

Munsell Color Standards: The Munsell system uses the conception of a sphere to evaluate the three color constants. Each of the constants is theoretically divided into ten equal parts. Hue is the horizontal scale around the circumference of the sphere, and is designated by an upper-case letter representing an abbreviation of the color, as red (R), yellow-red (YR), Yellow (Y), etc. These letters are preceded by a numeral from 1 to 9 to represent the position of the color in the scale of hues. For example, "5R" is the "middle hue" of red. These symbols are followed by a fraction, the numerator of which designates the value and the denominator of which designates the chroma. "Value" is represented as the vertical axis of the color sphere, with white (value 10) at the top and black (value 0) at the bottom, but samples are shown only for values 2 to 9, inclusive. "Chroma" is traced by radii at right angles to the vertical axis of the sphere. An approximation of Ridgway's 5′k is given in the Munsell system as 7R 3/7 but the nearest color actually shown on the charts is 5R 3/7, which lies between Ridgway's 1′k and 1′m.

Ridgway vs. Munsell: The Ridgway system was chosen for this work in preference to the Munsell system for the following reasons: (1) Ridgway's system includes 1115 named and systematized colors, whereas the Munsell Atlas contains but 340 different colors, which, however, are completely duplicated in two different arrangements, and partly duplicated in two other arrangements. (2) The Ridgway system has 36 colors in the scale of hues, whereas the Munsell system presents but 10 different hues. Each system uses the same number of subdivisions in the scale of tone. While the Munsell system provides for a maximum of 10 divisions of chroma compared to 6 for the Ridgway charts, not all of these divisions are used on all tones and hues in either system and the average chroma scale has approximately the same number of divisions in each system. As noted by by Lenchner[1] the Munsell system would be greatly improved by the addition of more hues. (3) The Ridgway charts are bound in an octavo book, of approximately one-third the bulk and weight of the Munsell Atlas, yet each color has an area of 0.5 sq. in., compared to 0.4 sq. in., and the minimum space between each color sample is $\frac{1}{4}$ inch, compared to $\frac{1}{8}$ inch on the Munsell charts. These are important factors influencing the efficiency of use of the two systems for the purpose of matching colors. The charts in either system may be removed from the book, and mounted side by side on a wall or table, preferably under glass. In this case, the Ridgeway charts occupy a minimum space of 10.3 sq. ft., and the Munsell charts occupy 11.2 sq. ft. When so arranged, the Ridgway system still possesses a distinct advantage in the time required to match a color and record it accurately. (4) All of the Ridgway colors are named, as well as numbered. This is frequently of value in preparing written descriptions, and for other purposes. (5) The Ridgway system costs less than half as much as the Munsell system, and there is no difference in the life of the colors when exposed to light, hence replacements of Ridgway's charts can be made more cheaply when the colors have faded.

A tabulation of the Ridgway colors most frequently used in this report is given in Table No. 10, with an approximation of the corres-

[1] *Op. cit.*

ponding Munsell color. This comparison was made visually by three persons [1] independently, and average values are reported. This correlation makes no claim to scientific accuracy but approximates the result that would be obtained by the average user of either set of charts.

TABLE No. 10.

Visual Correlation of Certain Ridgway Colors with Munsell Colors.

Ridgway symbol	Approximate Munsell equivalent
5′i	7R 5/9
k	7R 3/7
m	6R 3/4
7′f	7R 8/4
d	8R 7/6
b	8R 6/8
–	9R 5/8
i	9R 4/7
k	9R 4/6
m	7R 3/4
9′f	8R 8/4
d	9R 7/5
b	1YR 6/7
–	1YR 6/8
i	2YR 5/7
k	1YR 5/7
m	9R 3/4
11′f	9R 8/4
d	3YR 8/5
b	3YR 7/7
–	3YR 6/8
i	3YR 5/7
k	4YR 4/5
m	5YR 3/5
13′f	5YR 8/5
d	3YR 8/5
b	3YR 7/7
15′f	4YR 8/5
d	6YR 7/7
b	7YR 7/8
17′f	7YR 8/5
d	7YR 8/5
b	9YR 7/8
19′f	5Y 8/6
1″f	2R 7/3
d	8RP 7/4
b	1R 7/5
–	3R 5/5
3″f	3R 7/3

Ridgway symbol	Approximate Munsell equivalent
3″d	1R 7/4
b	4R 6/5
–	3R 5/7
i	5R 4/5
5″f	3R 7/3
d	5R 7/4
b	5R 6/5
–	5R 5/7
i	7R 4/5
k	7R 3/4
m	7R 3/3
7″f	6R 8/3
d	7R 7/4
b	9R 6/5
–	9R 5/7
i	9R 4/5
k	9R 4/4
m	8R 3/4
9″f	6R 8/4
d	9R 7/6
b	9R 6/5
–	9R 5/6
i	1YR 5/5
k	1YR 4/3
m	1YR 3/4
11″f	7R 8/3
d	2YR 7/5
b	1YR 6/6
–	1YR 5/6
i	2YR 5/6
13″f	9R 8/3
d	3YR 8/5
b	3YR 7/7
–	3YR 6/6
i	3YR 5/6
15″f	9R 8/4
d	4YR 8/5
b	3YR 6/6
–	4YR 6/6
i	5YR 5/5

Ridgway symbol	Approximate Munsell equivalent
17″f	2YR 8/4
d	6YR 8/4
b	7YR 7/7
–	7YR 6/5
i	7YR 5/5
19″f	7YR 8/3
d	9YR 8/5
b	9YR 7/7
–	9YR 6/7
i	9YR 5/6
1‴f	6RP 8/2
d	6RP 7/4
b	9RP 6/4
5‴f	9RP 8/2
d	9RP 7/3
b	3R 6/4
–	3R 5/4
i	3R 4/4
9‴f	4R 8/2
d	4R 8/2
b	4R 6/4
–	6R 5/4
i	8R 4/4
k	8R 3/4
13‴f	5R 8/1
d	5R 8/2
b	7R 7/3
–	1YR 5/4
i	2YR 4/4
k	3YR 4/3
17‴f	5YR 8/2
d	3YR 7/3
b	4YR 6/3
–	7YR 6/3
i	7YR 5/3
k	8YR 4/2
21‴f	4Y 8/2
d	6Y 8/3

Color Classification of Clays: The clays described in this report are classified as to color into four groups, following Parmelee and Schroyer,[2] but definitely fixing the boundaries of each group by the use of Ridgway's colors. The classification is as follows:

I. Clays Burning White or Cream Colored, not Calcareous. Into this group are placed all clays that fire at the highest firing temperatures used, to tones nearer to white than Ridgway's "f" tones. There is need for an extension of standard color nomenclature into this range,[3] but in lieu of a well-established system, the terms "yellowish- white," "pinkish-white," "grayish-white," etc., are used in this report. All of the clays in this group fire to colors that are sufficiently good to permit the use of the clay in stoneware bodies, most of them can be used to some extent in sanitary ware and electrical porcelain, if other

[1] Prof. F. G. Tickell, Stanford University, Mrs. Bernice L. Tickell, and the author.

[2] Parmlee, C. W., and Schroyer, C. R., "Further Investigations of Illinois Fire Clays," Ill. Geol. Surv. Bull. No. 38, p. 278.

[3] See in this connection: Lofton, R. E., A Measure of the Color Characteristics of White Papers, U. S. Bur. Std. Tech. Paper 244, 1923.

properties are suitable, and a few are white enough for use, when washed free from sand, in place of English china clay.

II. Buff-Burning Clays. Into this class are placed all clays that fire to tones corresponding to Ridgway's "f" tones, all "d" tones from hue 9 to 19, inclusive, and all "b" tones from hue 15 to 19, inclusive. Exceptions are noted in group IV.

III. Clays Burning Red, Brown, or Other Dark Colors. Into this group are placed all clays, excepting those of group IV, that fire to colors darker than those of group II.

IV. Clays burning Dirty White, Cream White, or Yellowish White. The clays of this group are mainly calcareous or magnesian, and color is not an important criterion.

Chemical Analysis.

The relative value of chemical analyses in the study of clays has been well summarized by Hewitt Wilson[1] as follows:

"Chemical analysis provides its most effective usefulness, in the case of the high-grade clays, in estimating the degree of purity of the white-burning, kaolin-like materials and the alumina-silica-flux ratio in the fire clays, but in the case of the red- and brown-burning structural-ware clays, the impurities furnish the most important data. We can but guess the fired color, strength, shrinkage, porosity, and vitrification range from the analytical data and for these properties, must rely on practical firing tests. If the chemical analysis is complete, however, it gives a good idea of the troublesome materials present, *i.e.*, those which cause early fusion, short vitrification range, scumming, and troublesome gases which delay oxidation. It happens that the usual commercial chemical analysis does not include carbon and sulphur and other troublesome impurities except when combined with water of chemical combination and called 'ignition loss' or 'volatile matter.' Likewise, a complete chemical analysis of the complicated silicate mixture called 'clay' is a difficult analytical procedure, and many hundreds of the analyses are inaccurate.

"In studying clays of the whiteware and fire-clay type, a knowledge of the chemical composition is always desirable, but it must be assigned a secondary value because of the influence and modification of the physical properties. Clays of the fire-clay type must primarily have a composition corresponding to refractory clays. But this is not enough. For instance, there are in the United States a large number of clays of practically the same composition as the imported European plastic fire clays, so highly prized for glass-pot, brass, and steel-crucible work, but which fail completely in satisfying the physical, dry, and fired requirements. A cone fusion test costs less in time and money than a chemical analysis. The best way to determine the refractory value of a clay, having given only the chemical analysis, is to translate it to terms of cone fusion.

"When physical tests of clay bodies are not satisfactory and changes are desired, the chemical analysis will often locate the trouble and indicate the proper remedy."

Relatively few chemical analyses were made for the purpose of this report. A few typical samples were selected from those clays whose ceramic properties were studied in the laboratory, and analyses were made in the Stanford University ceramic laboratory, using the methods recommended by the American Ceramic Society.[2] Practically all of these analyses were made in duplicate or triplicate, and exceptional precautions were taken to insure accuracy, especially in the determinations of alumina and silica, which are so often inaccurately reported. A few analyses of laboratory samples were made by K. W. Baum, of the Stevenson Engineering Company. Analyses of various California clays were submitted by some of the clay manufacturers in the state, or were found in the literature. Where these apply to definite clay beds that were sampled by the author, the analyses are included under the clay sample number to which they refer. It must be understood, however, that such analyses were not made on the same sample as that which was tested in the laboratory, hence some of them do not correlate

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[1] Ceramics, pp. 45–46. McGraw-Hill Book Co., 1927.

[2] Report of the Committee on Standards, Amer. Cer. Soc., reprint from Yearbook, 1921–1922.

very well with the ceramic properties noted. Another group of analyses is included of clays not studied by the author. Most of these are from the San Joaquin Valley, and were contributed by K. W. Baum.

For convenience of reference, the analyses are grouped according to the clay classification used in this report, and are to be found near the end of Chapter V.

Classification of Clays.

The clay classification used in this report is essentially that of Parmelee,[1] but is presented in a simplified form. This classification is based upon the physical properties that determine the important uses of a given clay. The modified classification follows, with notations to correlate it with that of Parmelee.

I. CLAYS BURNING WHITE OR CREAM COLORED, NOT CALCAREOUS.[2]

A. Open-burning clays, *i.e.*, having an apparent porosity of 6% or more at cone 15.

The dividing line between open-burning and dense-burning clays is placed at 5% in Parmelee's classification. In this report the dividing line is at 6% in order to make some allowance for the more-rapid firing cycle used.

Parmelee states "still distinctly porous at cone 15."

1. Low strength, dry modulus less than 200 lb. per sq. in., *e.g.*, residual kaolins and sandy fireclays.

It is not clear whether Parmelee intends to include sandy fireclays in this group.

2. Medium and high strength, dry modulus exceeding 200 lb. per sq. in., *e.g.*, secondary kaolins.

Open-burning clays are valuable in the manufacture of pottery because of good color or good strength and good color. They are often highly refractory, and may be of value for special refractories.

B. Clays burning dense, *i.e.*, have less than 6% apparent porosity between cones 10 and 15.

Parmelee states "becoming nearly or completely non-porous between cones 10 and 15."

3. Generally, but not always, refractory.

Parmelee divides this group into three subdivisions, as follows:

"a. Non-refractory clays.

"3. Good color, medium to high strength, medium shrinkage. Uses: Pottery, including certain whiteware, porcelain, stoneware.

"4. Poor color, medium to high strength, medium shrinkage. Uses: Stoneware, terra cotta, abrasive wheels, zinc retorts, face brick, saggers.

"b. Refractory clays.

"5. Good color, medium to high strength, medium shrinkage. Uses: Refractories, especially for glass, if they do not overburden seriously for 5 cones higher. Also uses as stated in Parmelee's No. 3."

[1] Parmelee, C. W., and Schroyer, C. R., Further Investigations of Illinois Fire Clays, Ill. Geol. Surv. Bull No. 38, pp. 278–9, 1922.

[2] The color limitations used in this report are given on page 251.

C. Dense-burning clays, *i.e.*, having less than 6% apparent porosity between cones 5 and 10.

Parmelee states ". . . become nearly or completely non-porous between cones 5 and 10 and do not overburn seriously at 5 cones higher than the temperature at which minimum porosity is reached."

4. Generally, but not always, refractory.

Parmelee divides this group into five classes, as follows:

"a. Non-refractory clays.

"6. Good color, medium to high strength, medium shrinkage, usually reach minimum porosity between cones 5 and 8. Type: Ball clays. Uses: Pottery, whiteware, porcelain, and stoneware.

"7. Poor color, medium to high strength, medium shrinkage. Uses: Stoneware, terra cotta, abrasive wheels, zinc retorts, face brick, saggers.

"b. Refractory clays.

"8. Non-porous or practically so at cone 5; do not seriously overburn for 12 cones higher; highly refractory; softening point at cone 31 or higher; bending strength minimum 325 pounds per square inch. Use: Graphite crucibles for melting brass.

"9. Non-porous at about 1275° C. (cone 8), not overfiring at 1400° C. or higher. Strength and softening point as above. Use: Steel crucibles.

"10. Become dense at about 1275° C. (cone 8). Do not overburn below 1425° C. Bonding strength, 250 pounds per square inch or higher. Softening point, cone 29 or higher. Use: Glass pots."

II. BUFF-BURNING CLAYS.

A. Refractory clays (softening point, cone 27 or above).

a. Open-burning, *i.e.*, having a porosity of 6% or more at cone 15.

Parmelee states ". . . porosity of 5% or more at cone 15 or above."

5. Low strength. Usually high in non-plastic material.

6. Medium and high strength.

Parmelee uses four subdivisions to cover (5) and (6) as follows:

"Indurated—non-plastic or slightly plastic unless it has been weathered. Type: Flint clay.

"11. Normally aluminous; maximum alumina 40%. Uses: Refractories.

"12. Highly aluminous; alumina exceeds 40%. Type: Diaspore clay. Uses: Refractories, abrasives.

Plastic.

"13. Normally siliceous; maximum silica not exceeding 65%. Uses: Firebrick and other refractory wares, terra cotta, sanitary ware, glazed and enameled brick (see specific requirements).

"14. Siliceous; having a silica content above 65%. Type: Many of the New Jersey fire clays. Uses: Firebrick and other refractories."

b. Dense-burning between cones 10 and 15, *i.e.*, attaining an apparent porosity of 6% or less within that range.

Parmelee states ". . . a minimum porosity of 5% or less . . ."

7. Generally medium to high strength.

This is Parmelee's class 15, and is explained as follows:

"15. Medium to high strength. Do not overburn for 5 cones higher than point of minimum porosity. Uses: Glass pots and other refractories; also used for firebrick, saggers and miscellaneous refractories, architectural terra cotta, sanitary ware, enameled and face brick."

c. Dense-burning, *i.e.*, attaining a porosity of 6% or less at cone 10 or lower.

Parmelee states ". . . a porosity of 5% or less . . ."

8. Generally medium to high strength.

Parmelee divides this group into three classes, as follows:

"16. See (Parmelee's) 8.

"17. See (Parmelee's) 9.
"18. See (Parmelee's) 10.

"These three classes, 16, 17 and 18, are used also for zinc retorts, firebrick, saggers, and miscellaneous refractories, architectural terra cotta, sanitary ware, enameled and face brick."

B. Non-refractory clays.

a. Open-burning, *i.e.*, do not attain a porosity of 6% or less at any cone lower than cone 10.

Parmelee states ". . . a porosity of 5% or less . . ."

9. High or medium strength. Uses: Architectural terra cotta, stoneware, yellow ware, face brick, sanitary ware.

10. Low strength. Use: Brick.

Classes (9) and (10) correspond to Parmelee's 19 and 20, respectively.

b. Dense-burning, *i.e.*, attain an apparent porosity of less than 6% at cones lower than 10.

Parmelee states ". . . a porosity of less than 5% . . ."

11. Generally medium or high strength.

This is Parmelee's class 21, and is described as follows:

"21. High or medium strength. Uses: Architectural terra cotta, stoneware, abrasive wheels, sanitary ware, face brick, paving brick."

III. CLAYS BURNING RED, BROWN, OR OTHER DARK COLORS.

A. Open-burning clays, *i.e.*, those that do not attain an apparent porosity of 6% or less at any temperature short of bloating or fusion.

Parmelee states ". . . do not attain low porosity at any temperature short of actual fusion."

12. Medium or high strength. Uses: Brick, drain tile, hollow blocks, flower pots, pencil clays, ballast.

13. Low strength. Use: Brick.

Classes (12) and (13) correspond to Parmelee's 22 and 23, respectively.

B. Dense-burning clays, *i.e.*, those that attain an apparent porosity of 6% or less at any temperature short of bloating or fusion.

Parmelee makes no special statement to qualify the meaning of "Dense burning," but the definition follows from III–A, above.

a. Having a long vitrification range (4 cones).

Parmelee requires a 5–cone vitrification range, but the data of this bulletin do not permit such a segregation, as only alternate cone numbers were studied.

14. Generally medium or high strength. Uses, if medium or high strength: Conduits, sewer pipe, face brick, roofing tile, paving brick, promenade tile, architectural terra cotta, and similar ware. If low strength: Common brick, floor tile, dust body in various wares.

Parmelee makes two classes, 24 and 25, divided as to medium to high strength or low strength, with the uses practically as indicated above.

b. Having a short vitrification range (less than 4 cones).

15. Generally medium to high strength. Uses: Common brick, face brick, hollow tile, flower pots.

This is Parmelee's class 26, described as "High or medium strength," with the same uses as given above.

c. Fusing at a low temperature, approximately cone 5, to form a glass.

16. Slip clays.

This is Parmelee's class 27. No clays were found in California in this class, but room is left in the classification in case any are found in the future.

IV CLAYS BURNING DIRTY WHITE, CREAM WHITE, OR YELLOWISH WHITE.

17. Generally containing calcium or magnesium carbonate or both. Seldom reach very low porosity. Have a very short heat range. Use: Common brick, or may be worthless.

This is essentially Parmelee's class 28, which is described as follows:

> "28. Containing calcium or magnesium carbonate or both. Never reach very low porosity. Have a very short heat range. Use: Common brick."

The foregoing classification is not presented as being preferable for general use to Parmelee's more complete one, but it serves the purposes of this bulletin better, in that the tests on the California clays were not sufficiently comprehensive to permit the degree of refinement of clay classification that characterizes Parmelee and Schroyer's report. For example, bonding-strength determinations are necessary in order to segregate Parmelee's classes 8, 9 and 10, and 16, 17 and 18; firing tests to cone 19 or 20 are necessary to fully determine the properties of a clay for his classes 5, 8 and 16; chemical analyses are necessary in order to segregate his classes 11, 12, 13 and 14, and firing to each cone number, instead of to alternate cone numbers, is required in order to separate the red-burning clays having a long vitrification range from those having a short range. To complete the data for a satisfactory allocation of clays according to Parmelee's classification, would have required more than twice the amount of work than that represented by the testing for this bulletin, without considering the extra field work that should be entailed to secure thoroughly representative samples of entire clay beds. It is questionable if 50-pound field samples, unless obtained by quartering down a number of larger channel-cut samples, or by combining a number of coredrill samples, are sufficiently reliable to warrant more elaborate tests than have been made.

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[1] The Clays and Shales of Washington, Their Technology and Uses. Bull. Univ. of Wash., Engin. Exp. Sta., No. 18, p. 203, *et seq.*

Parmelee makes two classes, 24 and 25, divided as to medium to high strength or low strength, with the uses practically as indicated above.

b. Having a short vitrification range (less than 4 cones).

15. Generally medium to high strength. Uses: Common brick, face brick, hollow tile, flower pots.

This is Parmelee's class 26, described as ''High or medium strength,'' with the same uses as given above.

c. Fusing at a low temperature, approximately cone 5, to form a glass.

16. Slip clays.

This is Parmelee's class 27. No clays were found in California in this class, but room is left in the classification in case any are found in the future.

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Photo No. 70. Cabinet of fired test pieces, ceramic laboratory, Stanford University.

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Chapter V.

RESULTS OF LABORATORY TESTS.

Table No. 11 is a complete classified list of all samples tested. The fired test pieces, samples of dried bars (salvaged from the dry transverse-strength tests), and lump and ground samples of all the clays are kept in an accessible file in the ceramic laboratory at Stanford University. Photo No. 70 shows the case containing the fired and dried test pieces. These files may be of interest to clay workers who wish to select clays for specific purposes, and it is hoped that new clays can be added from time to time as they are disclosed in prospecting and mining operations.

Tests are included on two clays from outside of the state that are being used in local plants. These are No. 56 in class 7, a German plastic fireclay, and No. 59 in class 2, the Edgar kaolin from Florida. Tests were made on English china and ball clay but the detailed data are not included herein. The china clay was found to belong to class 1, and the ball clay belongs in class 4. The data on the English clays and the Edgar kaolin correlate closely with those given by Hewitt Wilson.[1]

The page numbers cited in the descriptive text, following the clay sample number, refer to the pages containing the description of the deposit from which the sample was taken.

I. WHITE- OR CREAM-BURNING NON-CALCAREOUS CLAYS.

A. Open-Burning, More Than 6% Apparent Porosity at Cone 15.

1. Low Strength.

No. 11 (p. 163). Riverside County. Alberhill C. & C. Co. "E–101 China Clay." This is a sandy clay of the kaolin type, and is principally used in stoneware bodies. See also No. 12. It contains 33.0% of + 200-mesh sand, which is mainly quartz, but there are enough ferro-magnesian minerals to cause red and black specks when fired. The plasticity is good, though short, the dry strength is low, and the dry condition is weak, crumbly and sandy. The colors are: Dry and wet, yellowish white; from cone 010 to cone 1, 13″f; above cone 1, buff-white, considerably nearer to white than Ridgway's "f" tints. Finger-nail hardness is developed at cone 04, and at cone 13 the hardness is still slightly less than steel. The total linear shrinkage, plastic basis, at cone 15, is 11.4%. The softening point is cone 28–29. The best firing range is from cone 3 to cone 13. The clay could be washed to remove non-plastic impurities, which would eliminate the specking, and increase the plasticity and strength, as well as lower the vitrification point, but as no large bodies of this variety have been found, washing at the mine is not warranted.

No. 12 (p. 163). Riverside County. Alberhill C. & C. Co. "E–102 China Clay." This is similar in every respect to No. 11, but is of slightly poorer quality, as it contains more impurities, and the fired colors are darker. The percentage remaining on 200-mesh is 22.6.

[1] The Clays and Shales of Washington, Their Technology and Uses. Bull. Univ. of Wash., Engin. Exp. Sta., No. 18, p. 203, *et seq.*

TABLE No. 11.

Key to Classification of Clay Samples Tested.

I. White or cream-burning				II. Buff-burning							III. Red-burning					IV. Dirty white
A. Open + 6% A. P. at cone 15—		B. Dense —6% A. P. at cones 10-15	C. Dense —6% A. P. at cones 5-10	A. Refractory (cone 27+)				B. Non-refractory (cone 27—)			A. Open		B. Dense			
				a. Open-burning		b. Dense bet. cones 10-15	c. Dense at cone 10	a. Open +6% A. P. at cone 10—		b. Dense	Medium or high strength	Low strength	a. Vitr. range 4 cones	b. Short vitr. range	c. Fusing to form a glass	(Calcareous)
Low strength	Med.-high strength	Refractory	Refractory	Low strength	Med.-high strength			High-med. strength	Low strength							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
11	15	70	125	17	9	13	121	19	16		8	7	10	1		3
12	28	96	143	23	14	39	124	25	55	166	18	72	21	2		41
37	29	98	240	66	27	56	136	36	82		24	122	22	4		46
38	44	120		67	33	80	146	94	88		26	131	75	5		115
62	45	144		71	34	83	147	95	111		32	171	123	6		116
63	57	273		74	53	85	151	99	167		35	198	127	30		163
64	59			77	76	101	152	114	170		40	218	148	31		205
91	90			79	78	110	157	135	238		65	256	177	43		262
103	93			86	81	133	175	168	269		69		181	60		
128	109			87	84	149	201	169	284		73		188	61		
129	137			104	92	153	252	173			100		202	89		
134				126	97	156	280	255			105		203	118		
159				138	102	204		283A			112		210	172		
160				140	108	213		283B			113		212	184		
190				141	130	229					117			185		
194				142	139	230					119			200		
195				191	145	245					155			211		
208				192	150	246					176			223		
209				231	197	247					178			264		
235				232	257	248					180			265		
236				233	258	249					182					
237				244	263	253					183					
259				250	266	254					199					
268				270	272	271					206					
				282		274					214					
				285							216					
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											251					
											261					

Finger-nail hardness is developed at cone 02, and knife hardness at cone 12. The total linear shrinkage, plastic basis, at cone 12 is 12.2%. The softening point is cone 26–27. The best firing range is from cone 3 to cone 13.

No. 37 (p. 201). San Diego County. El Cajon Mountain. The sample is representative of the more kaolinitic phase of a residual kaolin deposit, of which No. 38 is a more general sample. It is not entirely free from fine quartz and feldspar grains, and also contains some ferro-magnesian minerals which appear as numerous black specks in the fired clay. The proportion of + 200-mesh sand is 13.0%. The plasticity is workable, but is weak and sticky. The dry strength is medium low, and in the dry state the sample is soft and crumbly. Slow drying is necessary to avoid drying cracks. The colors are nearly white, with a pinkish tinge at low cone numbers, and a yellowish tinge when fired above cone 1. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Fine cracks appear at high temperatures. The total linear shrinkage, plastic basis, at cone 15, is 20.9%. The softening point is cone 34. This clay could be washed to remove the ferro-magnesian minerals, but the deposit is too small and irregular, and too isolated for commercial operations. It was at one time mined on a small scale and the clay was used in the manufacture of Faience tile, and some attempts were made to use the material as a substitute for English china clay in whiteware bodies.

No. 38 (p. 201). San Diego County. El Cajon Mountain. This is a general sample of the residual kaolin deposit from which sample No. 37 was taken. It contains 57.0% of + 200-mesh grains, most of which are undecomposed quartz and feldspar, but there is a smaller proportion of ferro-magnesian minerals than in sample No. 37. It effervesces slightly in hydrochloric acid. The plasticity is poor, the dry strength is medium low, and the dry and fired structure is coarse and granular. The colors closely approximate white, with a faint pink hue. Steel hardness is not developed at cone 13. The total linear shrinkage, plastic basis, at cone 13, is 4.75%. The softening point is cone 32–33. The best structure and color is obtained by firing above cone 7. The amount of kaolin that could be extracted by washing was not determined, but not over 20% could be expected.

No. 62 (p. 145). Orange County. East of San Juan Capistrano, on the O'Neill ranch. "White bone." This is a plastic fireclay that usually contains over 45% of alumina. Although the pisolitic structure of the raw clay is lacking, or is but poorly developed, it may be classed as a bone clay on account of its high alumina content, and its ceramic properties. The plasticity is short, the dry strength is low, and the dry condition is medium hard, medium-grained, and open-textured. The residue on 200-mesh is 46.4%. The colors are nearly white throughout, with a pink hue at low firing temperatures, changing to yellowish white at higher firing temperatures. Scattering yellow and brown iron specks appear at high temperatures. Finger-nail hardness is obtained below cone 010, and steel hardness develops at cone 1. Light crow-foot cracks appeared in all pieces fired above cone 1. The fired texture is granular and open. The total linear shrinkage, plastic basis, at cone 15, is 17.5%. The softening point is cone 34. The best firing range is above cone 1, and well vitrified structures are obtained at cone 11 or above.

No. 63, 64 and *268* (p. 140). Orange County. 12 m. E. of El Toro. Hunter ranch deposit. These three samples, from different portions of the Hunter ranch, are practically identical in all respects. The material consists of an admixture of high-grade china clay and quartz sand, in the proportion of approximately 35% clay. No. 63 contains 54.4% of + 200-mesh sand, and No. 64 contains 63.6%. In places, a small amount of hornblende occurs in the clay, which must be removed by washing, if the clay is to be used in whiteware bodies. The most important use at present is in the manufacture of high-grade fire brick, at the plant of the American Refractories Co., of Los Angeles, but Mr. H. F. Coors has stated [1] that he believes that the washed clay could be substituted in any ceramic body to replace 75% of the English china clay now in use. The by-product from washing would yield a quartz sand, which, if hornblende is removed by tabling, would be suitable for glass manufacture. All three samples were tested by the usual methods, without washing. The plasticity is weak, the dry strength low, and the dry condition is coarse, sandy, open and friable. The colors are nearly white, with a pinkish hue at low firing temperatures, changing to yellowish above cone 1. Steel hardness is not developed within the firing range employed. The fired structure is coarse, granular, and weak. The total linear shrinkage, at cone 13, is 4.0% for No. 63, 5.1% for No. 64, and 5.2% for No. 268. The softening point in all cases is cone 33.

No. 91 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Main Tunnel Sand." This belongs to the same group as No. 13, 15, 29, 84, 91, 96 and 229, but has a larger proportion of sand than any of the others. It contains 55.0% of + 200-mesh sand. The plasticity is weak, the dry strength is medium low, and in the dried state it is friable, coarse-grained and open-textured. The colors are: dry, 13''''f; wet 17''''i; cones 010 to 13, pinkish white at the lower temperatures, changing to yellowish white at the higher temperatures. Steel hardness appears at cone 9. The fired structure is sound, and coarsely granular. The total linear shrinkage, plastic basis, at cone 13, is 3.1%, which is a slight expansion over the dried condition. The softening point is cone 30–31. This material is used with more plastic clays in firebrick and terra cotta mixes.

No. 103 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Sloan Bone." See also No. 74, 86, 87, 231, and 232 in class 5, and No. 98 in class 3. This is a white bone clay of exceptional purity. It contains 46.2% of +200-mesh material. The plasticity is weak, the dry strength is low, and in the dried condition it is soft, friable, and open-textured. The colors are: dry, grayish white; wet, 17'''f; cone 010, 15''f; cones 08 to 13, fades to pinkish white at cone 1, then to yellowish white at cone 13. Finger-nail hardness is present at cone 010, and steel hardness at cone 3. All fired test pieces are hair-cracked, and one or two of them broke into two pieces. Less than 10% absorption is obtained at cone 9. The total linear shrinkage, plastic basis, at cone 15, is 16.9%. The softening point is cone 35.

[1] Private communication, July, 1925.

No. 128 (p. 54). Amador County. Ione. Arroyo Seco Grant. "Shepard Sand." This is one of the 'fire-sands' for which the Ione district is noted. The material consists of a fine-grained quartz-mica-feldspar sand with sufficient fireclay to render it weakly plastic. It contains 48.4% of +200-mesh sand, and a high percentage of the—200-mesh material is non-plastic. The dry strength is low, and in the dried condition it is very soft. The colors are nearly white with a slight yellowish hue throughout. Finger-nail hardness appears at cone 02, but steel hardness is not developed on firing to cone 15. The fired structure is sound, and fine-granular. The total linear shrinkage, plastic basis, at cone 15 is 6.7%. The softening point is cone 32. The sand has important uses as an ingredient in fire brick, terra cotta, pottery, etc.

No. 129 (p. 62). Amador County. Ione. "Newman Sand." This is almost identical in its properties to No. 128, except that it contains a lower percentage of fluxing impurities, and has a softening point of cone 33–34. The percentage of +200-mesh sand is 55.4.

No. 134 (p. 58). Amador County. Ione (Carbondale). N. Clark & Sons. "Clark Sand." This is fire-sand, nearly identical in its properties to No. 128 and 129, with a softening point of cone 32–33. It contains 55.8% of +200-mesh sand.

No. 159 (p. 137). Nevada County. Wolf. Coe property. Pine Hill Mine. See also No. 160, 166 (class 11), and 167 (class 10). This is a plastic impure kaolin that has not yet been used commercially. It contains 12.4% of +200-mesh sand. The plasticity is fair, though somewhat 'rubbery' and weak. The dry strength is medium low, and in the dried condition it is medium hard, fine-grained, and open-textured. The colors are: dry, yellowish-white; wet, 19″f; cone 010, 17″f, decreasing with increasing temperature to yellowish white at cone 1 and above. Steel hardness is developed at cone 5. The fired structure is sound, and stony, except for light hair-cracks at cones 11 and 13. The fired surface texture is smooth. The total linear shrinkage, plastic basis, at cone 15 is 18.8%. The softening point is cone 32–33. The best firing range is from cone 1 to above cone 13. If this clay were found in sufficient abundance, it might find important uses in the manufacture of pottery, tile, and fire brick.

No. 160 (p. 137). Nevada County. Wolf. Coe property. Pine Hill Mine. See also No. 159, 166 (class 11), and 167 (class 10). This is similar to No. 159, but contains more non-plastic matter, and burns to a whiter color. The plasticity is smooth, but not strong, the dry strength is low, and in the dried condition it is soft-fine-grained, and open-textured. The colors are: dry, 13‴f; wet, 13‴d; cones 010 to 1, 1‴f; cones 3 to 9, whiter than 9‴f; cones 11 and 13, grayish white. Steel hardness is not developed within the firing range studied, up to cone 15. The fired structure is sound, fine-granular, and smooth-textured. The maximum total linear shrinkage, plastic basis, at cone 13, is 11.7%. The softening point is cone 32–33. If it could be placed on the market cheaply, this clay would find use in pottery, tile, and fire brick manufacture.

No. 190 (p. 133). Napa County. Calistoga. Clark and Marsh kaolin. This is a residual kaolin, hand-sorted to remove iron-stained impurities. A large proportion of the sample consists of non-plastic kaolin in the form of hard grains, and some quartz is present. The percentage remaining on 200-mesh is 41.4. The plasticity is poor, the dry strength is medium low, and in the dried condition it is medium hard, coarse-grained, and open-textured. The colors are nearly white throughout, with a slight pinkish hue in the raw condition and when fired below cone 3, and a slight yellowish hue when fired above cone 3. The fired structure is weak, granular, rough-textured, and with a tendency to crack. Steel hardness does not develop within the firing range studied, up to cone 15. The total linear shrinkage, plastic basis, at cone 15, is 12.0%. The softening point is cone 31–32.

Professor Hewitt Wilson tested a sample from this deposit, and has supplied the following notes:[1] "The fusion was cone 34, indicating a high degree of purity, and a high degree of refractoriness for a kaolin fire brick, superior to that now on the market.

"For white chinaware, it will be necessary to use 15 to 20% of a plastic white-burning clay like a ball clay, 20–25% Calistoga clay, 20% feldspar, and 35–40% ground quartz. This gave (with Washington materials) satisfactory results as to molding, drying, firing and white color."

It is apparent that the sample tested by Prof. Wilson differed somewhat from that tested by the writer.

No. 194 (p. 227). Sonoma County. Glen Ellen. J. H. Weise property. This is a white-burning kaolin, with fair plasticity and low dry strength. It contains 34.8% of +200-mesh material. In the dried condition it is soft, medium-grained, and open-textured. Approximately 25% of quartz sand is present, together with a small proportion of ferro-magnesian mineral grains. The colors are: dry, 11′f; wet, 11′d; cone 010, 9″f, gradually fading to nearly white at cone 7 and higher, except for widely scattered black specks. Steel hardness is not developed within the firing range studied. The fired structure is sound, weak, granular, and open, and the surface texture is slightly rough. The total linear shrinkage, plastic basis, at cone 15, is 6.1%. The softening point is cone 32. This clay could be washed free from quartz, and used in the manufacture of a kaolin fire brick, but would require the addition of a refractory bond clay in order to secure sufficient dry and fired strength. It might also be used in tile and porcelain bodies, in place of a portion of the china clay usually used, if the ferro-magnesian minerals were removed by washing.

No. 195 (p. 227). Sonoma County. Glen Ellen J. H. Weise property. This is a hand-picked sample of the whitest material in the pit from which No. 194 was taken. It is more plastic than No. 194, has better dry strength, better fired color, and higher refractoriness. The residue on 200-mesh is 30.2%. Very few iron specks can be found. The total linear shrinkage, plastic basis, at cone 15 is 9.9%. The softening point is cone 33. A peculiarity of both of these samples is that the firing shrinkage is greater at cone 9 that at cone 13, but the shrinkage increases again at cone 15.

No. 208 (p. 57). Amador County. Ione. Wm. Haverstick. This is a sample of Ione sand supplied by Mr. Haverstick. It is somewhat

[1] Personal communication, September, 1925.

more plastic and burns whiter than other samples that were tested (see No. 128, 129 and 134). The total linear shrinkage, plastic basis, at cone 15, is 8.6%. The softening point is cone 32. The sample contains 28.2% of +200-mesh sand.

No. 209 (p. 59). Amador County. Ione. Sample supplied by Wm. Haverstick. This is a sand containing a higher proportion of clay than the more typical samples (see No. 128, 129 and 134), hence possessing better plasticity and greater shrinkage. The residue on 200-mesh is 15.8%. The color is good, but green scumming is especially noticeable. Steel hardness is developed at cone 9. The total linear shrinkage, plastic basis, at cone 15 is 15.2%. The softening point is cone 32.

No. 235 (p. 70). Calaveras County. Valley Springs. Texas Mining Company. This is a kaolinized sericite-talc schist that has sufficient plasticity to permit molding or pressing. The dry strength is low, and in the dried condition it is soft and friable. The colors are: dry, 17″f; wet, 15″d; cone 06 to 1, 13″f; cones 5 to 13, pinkish-white. Finger-nail hardness is developed at cone 1. The fired structure is sound, weak, and fine granular. The total linear shrinkage, plastic basis, at cone 13, is 14.6%. The softening point is cone 30–31. The material could be used as a nonplastic ingredient in white floor and wall tile.

No. 236 (p. 68). Calaveras County. Nigger Hill. "Kaolin." This is an impure kaolin that has resulted from the alteration of a sericite-talc schist. The plasticity is fair, the dry strength is low, and in the dried condition it is soft, friable and fine-grained. The colors are: dry, nearly white; wet, grayish white; cones 06 to 13, nearly white. Finger-nail hardness is developed at cone 06, and steel hardness at cone 5. The fired structure is sound, medium strong, and fine-granular. The total linear shrinkage, plastic basis, at cone 13, is 20.9%. The softening point is cone 29–30. The material can be used as a nonplastic ingredient in white tile bodies.

No. 237 (p. 68). Calaveras County. Nigger Hill. Sericite-talc schist. This is similar to No. 235, but contains a slightly higher percentage of iron. The total linear shrinkage, plastic basis, is 14.5% at cone 13. The softening point is cone 27–28.

No. 259 (p. 45). Alameda County. Tesla. This is a white-burning fireclay with excellent plasticity and medium low dry strength. It contains 1.6% of +200-mesh sand. In the dried condition it is soft, fine-grained and close-textured. The colors are: dry, 17‴f; wet, 15″f; cones 010 to 04, pinkish white; cones 02 to 9, nearly white; cones 11 to 15, yellowish white. Steel hardness is developed at cone 3, and less than 10% absorption at cone 11. The fired structure is stony and smooth-textured. A few small cracks appear in some of the fired test pieces. Slight blistering is noted at cone 13. The total linear shrinkage, plastic basis, is 20.4% at cone 15. The softening point is cone 34–35. This is one of the best fireclays tested and if it can be found in commercial quantities, it will undoubtedly be in great demand for firebrick, whiteware, and tile.

No. 268. This sample has already been described (see No. 63, p. 260).

2. Medium to High Strength.

No. 15 (p. 163). Riverside County. Alberhill C. & C. Co. "Select Main Tunnel." See also No. 13 (class 7) and 29. This clay is hand sorted from the main tunnel fireclay bed, in order to make a marketable grade that is intermediate in quality between the run-of-mine material (No. 29) and the extra-select main tunnel clay (No. 13). It is used principally in the manufacture of fire brick. It is fine-grained, with excellent plasticity, medium high dry strength, and good dry condition. It contains 11.3% of plus 200-mesh sand. The colors are: dry, 13‴f; wet, 17⁗b; fired, cream white, considerably whiter than Ridgway's "f" tone. Finger-nail hardness is developed below cone 010, and steel hardness is reached at cone 5. The total linear shrinkage, plastic basis, at cone 15 is 11.7%. The softening point is cone 30–31. The best firing range is from cone 5 to cone 15.

No. 28 (p. 163). Riverside County. Alberhill C. & C. Co. "SH–3." This is a clay with excellent plasticity, medium dry strength, and a fine grained, close-textured dry condition. It contains 11.2% of +200-mesh sand. It is used for art title and architectural terra cotta. The colors are: dry, 13‴f; wet, 13‴d; cone 010 to cone 1, 17″f; cone 3 and above, the pink gives way to yellow, and the tone is nearer white than Ridgway's "f" tone. Finger-nail hardness is developed below cone 010, and steel hardness at cone 7. Vitrification is not well advanced at cone 13. The total linear shrinkage, plastic basis, at cone 13, is 10.0%. The softening point is cone 30. The best firing range is from cone 3 to cone 13 or above. If this clay were more plentiful, it would find a wide use in art title, terra cotta, and similar products.

No. 29 (p. 163). Riverside County. Alberhill C. & C. Co. "Main Tunnel." See also No. 13 (class 7) and No. 15. This is the run-of-mine main tunnel fireclay, and differs from the selected varieties, No. 13 and No. 15, mainly in that it contains more sand and more coloring matter. The percentage remaining on 200-mesh is 37.2. The clay is widely used in fire brick, art title, architectural terra cotta, and for similar purposes. It has a good working plasticity, but the plastic strength is low. In the dry condition it is medium hard, with a coarse, open texture, and the dry strength is medium. The colors are: dry, 17‴f; wet, 17‴d; cones 010 to 04, 13″f; cones 02 to 3, 13‴f; cones 5 to 13, nearer white than 17‴f. Finger-nail hardness appears below cone 010, but steel hardness does not develop within the firing range of the tests. The total linear shrinkage, plastic basis, is 5.6%, at cone 15. The softening point is cone 30–31. The best·firing range is from cone 5 to cone 15 and above.

No. 44, 45 and *57* (p.196 and p. 194). San Bernardino County. Hart. No. 44 is from the lower tunnel, and No. 45 is from the upper tunnel of the deposit owned by the Standard Sanitary Manufacturing Co., while No. 57 is from a similar deposit in the same district, owned by H. F. Coors. They are white-burning clays that may be classed as china-ball clays, as they possess the properties of a mixture of china and ball clays as usually used in porcelain and whiteware bodies. No. 44 contains more quartz than the other two samples. It contains 33.4% of +200-mesh material. No. 45 contains 28.2%, and No. 57 contains 21.8%. All three samples contain a small proportion of undecomposed ferro-magnesian minerals, which is readily removed in the usual processes of slip preparation. Enough colloidal iron is present in No. 44 and 45 to impart a yellowish tint to the fired clay, but No. 57 is the whitest clay that was tested, and has a distinctly better color than English china clay or Edgar (Florida) kaolin. The plasticity of all three samples is excellent and the dry strength is exceptionally high. Finger-nail hardness is present in the dry state, and steel hardness develops at cone 06. Although the softening point is cone 30 for No. 44 and 45, and cone 29 for No. 57, bloating begins at cone 11 to 13. The maximum total linear shrinkage, plastic basis, is 9.5% at cones 3 to 5 for No. 44, 16.0% at cone 15 for No. 45, and 14.8% at cone 11 for No. 57. Small firing cracks are found in some of the test pieces of No. 45, fired above cone 3, but all test pieces of No. 44 and 57 are sound. The tendency of these clays to bloat when used in porcelain bodies to be fired above cone 8 is their most serious defect, and has prevented their continued use in two sanitary ware plants that formerly used them in place of Eastern or English clays. No. 44 and 45 are now used in the enameling plant of the Standard Sanitary Manufacturing Co., and No. 57 is used in the manufacture of electrical and plumbing accessory porcelain, in the plant of the H. F. Coors Co. The best firing range is from cone 06 to cone 8 to 11.

No. 59. Edgar kaolin (Florida), used by the American Encaustic Tiling Company. This is a white-burning kaolin, with smooth and strong plasticity, medium dry strength, and a soft, fine grained, close-textured, dry condition. Some finely divided mica is present, but the sample contains only 0.6% of +200-mesh material. A faint pink color can be noted when fired below cone 1, but at higher temperatures the color closely approximates pure white. Finger-nail hardness is obtained below cone 010, and steel hardness develops at cone 3. The fired structure is stony, and with the firing schedule used, all test pieces had deep crow-foot cracks, which, however, were not continuous enough to cause disintegration. The total linear shrinkage, plastic basis, at cone 15 is 24.8%. The softening point is cone 34–35. The best firing range is from cone 1 to above cone 15.

No. 90 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Main Tunnel Fire Clay." This should be compared with No. 13 and 229 (class 7), 15, 29, 84 (class 6), 91 (class 1), and 93, *post*. No. 90 contains 17.4% of +200-mesh sand. The plasticity is excellent, the dry strength is medium, and in the dried condition it is medium hard, fine grained and close-textured. The colors are: dry, 17''''d; wet, neutral gray k; cones 010 to 13, pinkish white, changing at the higher temperatures to yellowish white. Finger-nail hardness is developed below cone 010, and steel hardness appears at cone 11. The fire structure is sound and fine-granular. The total linear shrinkage, plastic basis, at cone 13, is 10.7%. The softening point is cone 31.

No. 93 (p. 171). Riverside County. Alberhill. G., Mc.B. & Co. "Select Main Tunnel." The properties of this clay are almost identical with those of No. 90, except that it is finer-grained, has lower porosities, and the colors are slightly whiter throughout. The sample contains 1.0% of +200-mesh sand. Steel hardness is developed at cone 1. The total linear shrinkage, plastic basis, at cone 13, is 11.8%. The softening point is cone 30–31. It is a useful clay for terra cotta, faience tile, face brick and fire brick, and may be used in stoneware and pottery.

No. 109 (p. 176). Riverside County. Alberhill. P. C. P. Co. "Douglas Main Tunnel." This is from an extension of the formation from which the Alberhill Coal and Clay Company's "Main Tunnel" clays are mined, see No. 13 (class 7), 15, and 29, but is more closely related to the G., McB. Co. "Main Tunnel Fire Clay," No. 90, in its ceramic properties. It contains 22.6% of +200-mesh quartz sand, and a small proportion of ferro-magnesian minerals. The plasticity is very good, and the dry strength is medium high. In the dried condition it is medium hard, and has a medium fine grain and close texture. The colors are: dry, 13″f; wet, 15″d; cones 010 to 1, 7″d; cone 3, 7″f; cones 5 to 13, whiter than 17″f. Finger-nail hardness appears below cone 010, and steel hardness develops at cone 5. The fired structure is sound and fine granular, with a slightly rough exterior. The total linear shrinkage, plastic basis, at cone 13, is 9.7%. The softening point is cone 30–31. The principal uses for this clay are for fire brick, face brick and stoneware.

No. 137 (p. 57). Amador County. Ione. M. J. Bacon. "Chocolate." This is a plastic fire clay that is occasionally marketed as a sagger clay. It contains 7.0% of +200-mesh sand. The plasticity is excellent, the dry strength is medium, and in the dried condition it is medium hard, fine-grained, and close-textured. The colors are: dry, 13″f; wet, 9″d; cone 010, 13″f, fading to yellowish-white at cone 02, and continuing to cone 13 without appreciable change. Yellow scumming is especially noticeable. Steel hardness is developed at cone 11. The fired structure is sound, fine-granular, and with a slightly roughened surface texture. The total linear shrinkage, plastic basis, at cone 15 is 16.2%. The softening point is cone 32.

TABLE No. 12.

I. White- or Cream-Burning Non-Calcareous Clays.

A. Open-burning, more than 6% apparent porosity at cone 15.

1. Low strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
11	8.4	18.8	27.2	94	14.5	4.7	28–29
12	10.6	21.6	32.2	49	17.8	5.6	26–27
37	16.7	29.7	46.4	141	24.4	7.5	34
38	5.6	18.3	23.9	109	9.6	3.1	33
62	7.3	20.0	27.3	94	12.2	3.9	34
63	5.5+	11.85	17.40	69	11.0	3.5	33
64	5.7	12.0	17.7	84	11.2	3.5	33
91	5.5	10.9	16.4	194	11.0	3.5	30–31
103	5.0	22.5	27.5	69	8.0	2.6	35
128	8.9	19.5	28.7	29	15.2	4.9	32
129	7.7	14.1	21.8	33	14.2	4.4	33–34
134	6.8	17.3	24.1	17−	12.1	3.9	32–33
159	13.3	21.4	34.7	135	21.5	6.8	32–33
160	11.5	30.4	41.9	84	16.5	5.3	32–33
190	19.9	33.3	53.2	171	25.9	7.9	31–32
194	14.1	34.7	48.8	95	18.7	5.9	32
195	14.4	29.3	43.7	188	20.5	6.4	33
208	9.2	17.7	26.9	±50	16.1	5.1	32
209	12.9	17.8	30.7	±90	22.5	7.1	32
235	6.6	31.7	38.3	Low	9.3	3.0	30–31
236	13.3	30.6	43.9	34	19.2	6.0	29–30
237	6.4	25.9	32.3	33	9.8	3.1	27–28
259	15.7	19.5	35.2	120	26.5	8.1	34–35
268	6.0	11.9	17.9	90	11.8	3.8	33

2. Medium to high strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
15	12.2	13.3	25.5	467	23.4	7.3	30–31
28	12.1	14.0	26.1	356	22.7	7.1	30
29	8.0	11.8	19.8	242	15.8	5.1	30–31
44	18.7	13.6	32.3	1375	34.8	10.5	30
45	26.9	15.5	42.4	1562	49.4	14.0	30
57	23.3	13.3	36.6	1744	44.4	13.0	29
59	20.9	24.0	44.9	221	32.6	9.9	34–35
90	13.8	16.0	29.8	370	24.4	7.5	31
93	14.3	16.9	31.2	350	25.2	7.8	30–31
109	12.9	13.4	26.3	437	25.0	7.7	30–31
137	17.0	20.6	37.6	211	28.1	8.5	32

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Dry shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 13.

I. White- or Cream-Burning Non-calcareous Clays.

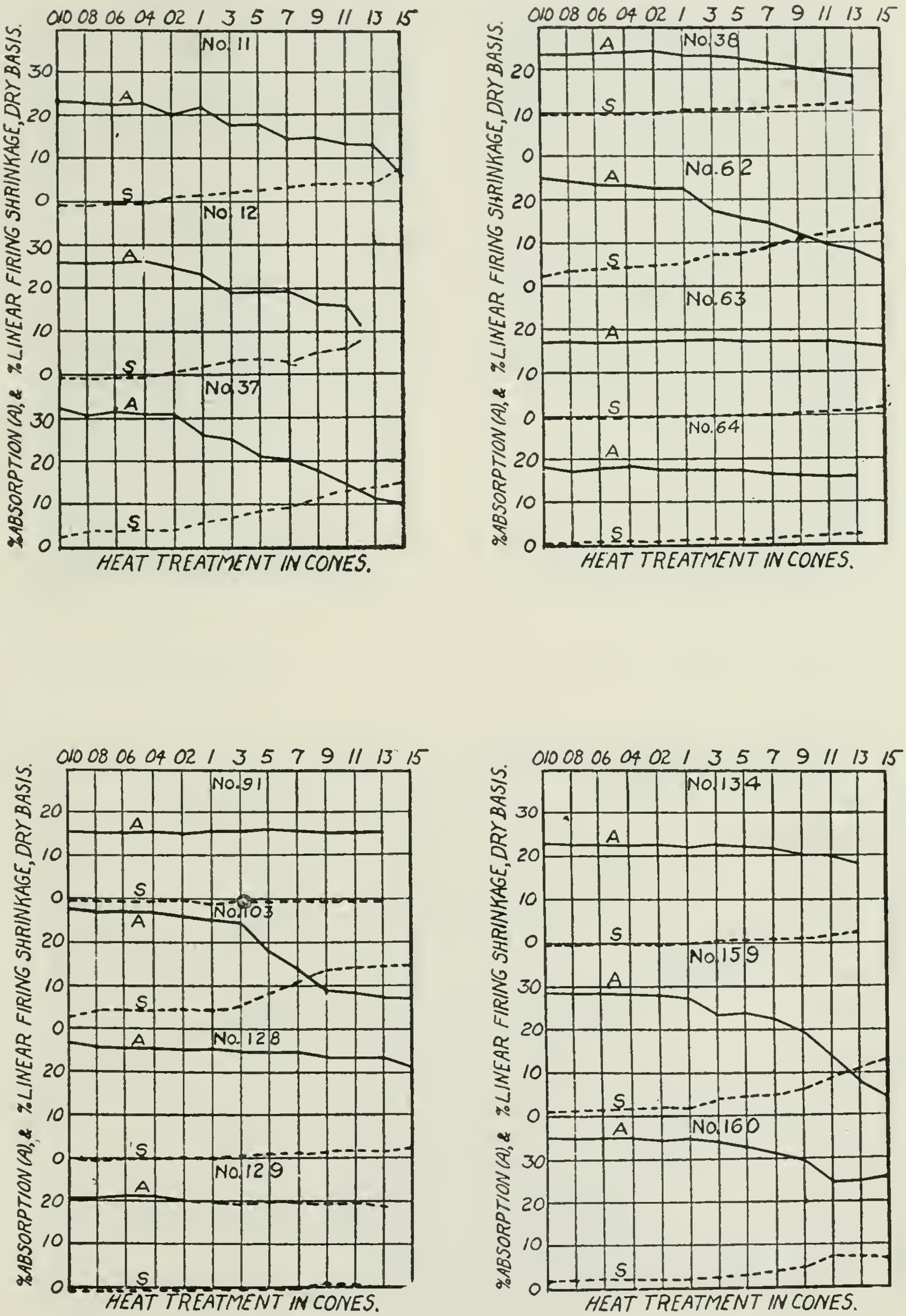
A. Open-burning, more than 6% apparent porosity at Cone 15.

1. Low strength. 2. Medium to high strength.

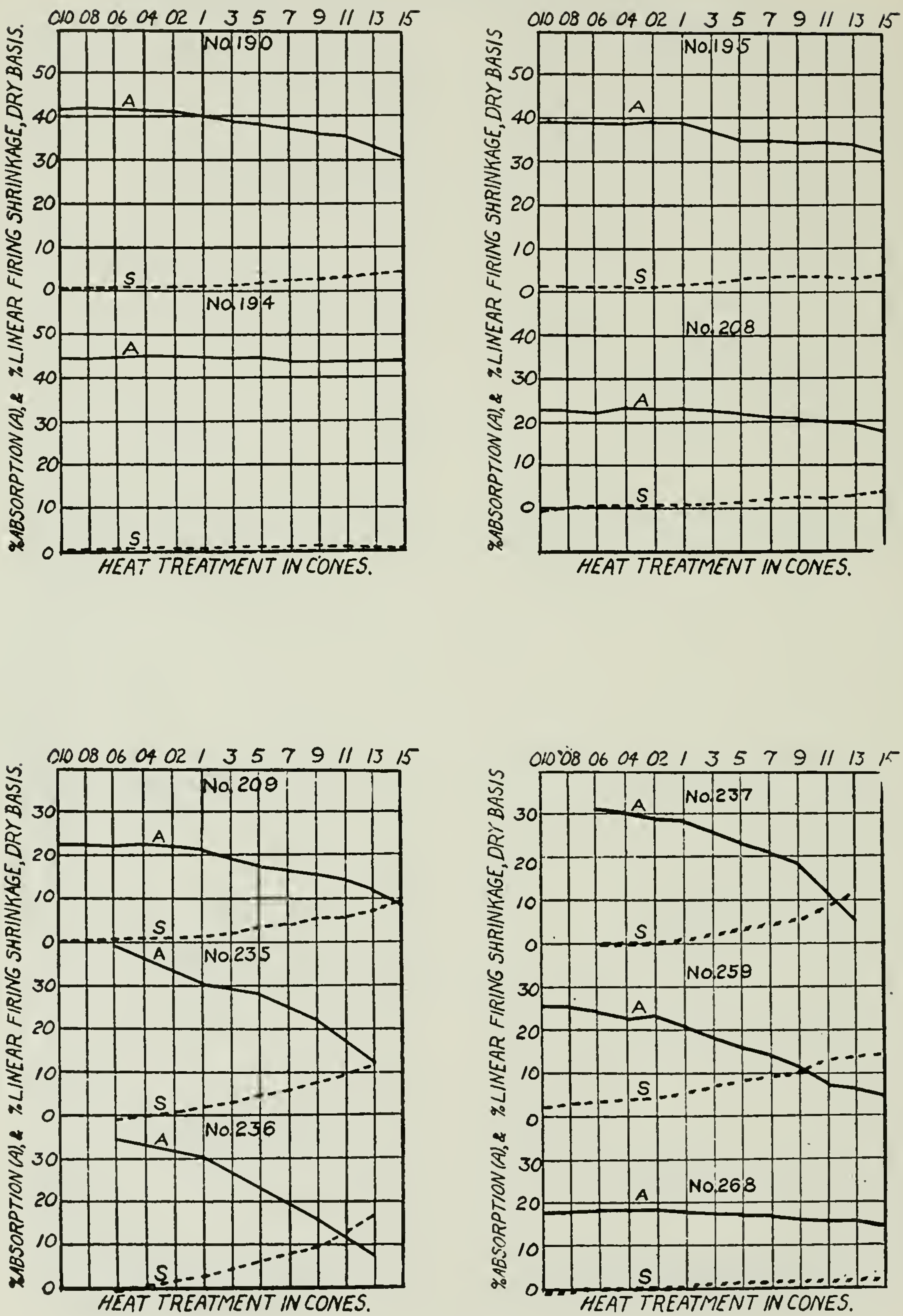
Class No.	Clay No.	Cone 010		Cone 08		Cone 06		Cone 04		Cone 02		Cone 1		Cone 3		Cone 5		Cone 7		Cone 9		Cone 11		Cone 13		Cone 15	
		% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.
1	11	—2.3	37.1	—2.6	36.6	—1.2	36.5	—1.4	37.4	+2.3	34.5	2.9	36.2	6.4	31.2	6.9	30.7	9.9	27.6	12.3	27.8	12.6	25.2	13.1	24.9	20.0	12.7
	12	—1.9	39.8	—2.1	39.8	—1.3	40.3	—1.3	40.6	+1.7	39.2	4.6	37.0	9.1	33.3	9.1	33.2	7.9	33.1	13.7	29.6	15.5	29.1	20.3	21.8	------	------
	37	8.0	45.0	11.2	44.6	11.6	45.6	12.6	45.0	12.6	45.1	17.1	41.2	19.9	40.3	24.9	36.0	25.8	35.4	31.3	32.2	34.0	28.7	36.4	22.5	38.4	20.9
	38	—0.7	38.1	—0.6	38.0	—0.3	38.5	—0.3	39.2	—0.6	39.1	+1.2	38.1	+1.9	37.8	2.1	37.4	2.4	35.9	3.5	34.2	3.5	33.4	5.4	31.8	------	------
	62	8.2	39.5	10.0	38.9	13.4	39.8	12.2	40.3	13.9	38.3	14.1	38.5	21.1	32.4	21.6	33.0	26.2	28.0	28.6	25.0	32.0	20.4	34.2	18.4	37.0	14.8
	63	—1.6	30.6	—1.2	30.8	—0.8	31.6	—0.6	31.9	—0.5	31.8	—0.1	31.8	+0.1	31.6	—0.1	32.2	—0.1	31.6	+0.9	31.5	+0.8	31.6	+1.9	30.9	4.6	33.8
	64	+0.1	32.2	1.2	31.3	1.6	32.0	1.6	33.3	1.2	32.5	1.6	32.5	1.7	32.0	2.5	31.1	3.2	30.5	5.3	30.2	5.4	29.8	5.2	30.0	------	------
	91	—1.9	29.1	—1.8	29.5	—1.7	29.6	—1.5	29.5	—1.6	29.1	—4.0	28.9	—1.9	29.3	—1.6	29.9	—1.4	29.6	—0.6	28.9	—0.7	28.6	—0.8	28.7	------	------
	103	6.9	42.2	11.5	42.3	11.5	43.2	11.5	43.0	12.3	42.2	11.8	41.0	14.6	40.3	23.2	33.2	29.2	27.7	34.5	19.8	36.5	19.1	37.6	16.3	37.9	16.0
	128	—0.1	41.1	—1.0	40.2	—0.1	40.3	0.0	40.4	—0.1	43.3	0.0	40.9	+0.9	40.2	1.2	42.8	2.3	42.8	4.4	38.9	4.2	38.7	4.2	38.5	6.1	36.5
	129	—1.7	35.8	—2.8	35.0	—1.2	36.2	—1.2	36.1	—1.3	34.9	—1.4	34.7	—0.5	35.1	—0.5	34.8	—0.1	34.5	+0.5	34.2	+0.1	34.4	+0.1	33.7	------	------
	134	—0.8	38.1	—0.8	37.8	—0.4	37.2	—0.7	37.4	—0.8	37.9	—0.4	37.2	+0.8	37.3	+0.5	37.2	+0.8	36.8	2.7	35.2	4.2	34.4	5.7	32.5	------	------
	159	2.3	42.7	3.6	42.8	4.0	42.9	4.3	43.1	4.6	42.4	5.6	41.8	11.5	38.6	12.3	38.5	13.4	37.6	16.8	34.6	24.2	26.2	29.5	15.1	34.6	8.3
	160	5.3	48.5	5.2	48.1	5.5	48.1	5.9	48.6	5.7	47.5	5.5	48.2	6.9	47.6	7.7	46.8	10.7	45.0	12.4	44.2	18.8	39.2	19.7	38.7	17.5	39.6
	190	0.9	50.5	1.2	51.0	0.9	50.8	1.2	50.7	1.4	50.3	2.0	49.9	4.3	49.0	5.8	48.7	7.7	48.0	8.2	47.5	9.1	47.0	11.9	45.0	14.4	42.8
	194	0.0	54.0	0.7	54.7	0.9	54.8	0.6	54.9	0.6	54.9	0.6	54.8	0.9	54.6	1.0	54.7	1.8	54.2	2.7	54.0	2.1	53.3	1.2	53.2	1.9	52.7
	195	2.9	51.0	3.1	50.8	3.0	51.2	3.4	50.8	3.7	51.5	4.7	51.2	6.3	49.9	*9.3	*48.5	†9.9	†48.4	11.0	47.8	9.7	47.5	9.2	47.2	11.8	45.7
	208	—0.3	37.1	0.0	37.3	+0.4	37.1	1.0	38.6	0.8	38.0	1.4	38.0	2.4	37.7	4.2	36.5	5.6	36.0	6.8	35.5	7.5	35.0	9.4	34.1	11.0	31.7
	209	0.0	35.9	+1.1	36.2	1.9	36.5	2.4	37.0	3.3	36.2	4.7	35.2	6.7	33.7	10.8	31.0	13.3	29.9	15.0	28.2	16.5	27.0	20.0	23.5	25.1	17.4
	235	------	------	------	------	—1.8	50.8	------	------	------	------	+5.5	43.8	------	------	13.1	43.2	------	------	19.9	36.5	------	------	31.7	23.6	------	------
	236	------	------	------	------	—0.3	47.1	------	------	------	------	+7.1	43.7	------	------	17.0	37.1	------	------	26.0	28.3	------	------	41.2	16.4	------	------
	237	------	------	------	------	—1.3	44.8	------	------	------	------	+3.2	42.5	------	------	9.8	38.0	------	------	16.1	32.4	------	------	31.6	11.7	------	------
	259	8.1	40.0	9.3	40.4	10.2	40.5	11.7	38.7	12.1	38.9	15.5	35.4	20.2	32.4	*22.4	*30.0	†26.2	†27.5	29.0	22.7	34.2	15.9	------	------	36.5	10.3
	268	—0.7	31.7	—0.3	32.8	+0.1	32.9	0.1	33.0	0.2	33.4	0.1	33.0	0.7	32.1	*2.0	*31.0	†2.3	†30.5	4.0	30.2	4.5	29.6	4.8	29.9	5.7	28.5
2	15	+0.8	30.9	1.4	28.8	2.0	29.0	1.7	29.6	4.3	27.9	6.3	25.8	7.6	24.4	8.0	24.2	9.6	23.3	10.1	22.2	9.6	23.1	15.1	16.1	------	------
	28	—0.1	30.1	+0.9	29.8	+0.9	31.6	1.4	30.8	1.8	30.1	6.1	26.6	6.9	26.8	7.3	25.9	7.8	26.0	8.5	24.0	9.9	24.0	10.3	21.9	------	------
	29	—4.3	29.4	—1.7	29.4	—1.6	30.4	—1.3	30.1	—0.6	30.0	—0.6	29.6	0.0	29.1	+0.1	29.5	1.2	28.6	1.4	28.6	1.2	28.0	1.5	28.0	2.5	25.3
	44	—2.1	32.3	—2.0	31.8	—1.9	31.2	—1.6	31.8	—1.3	31.8	—0.6	32.6	0.0	32.0	0.0	31.6	—1.4	31.8	—5.2	33.0	—6.9	33.3	—7.6	33.7	------	------
	45	—3.2	35.0	—1.3	32.8	+0.6	31.8	1.0	31.6	4.2	29.5	4.3	28.1	4.5	27.4	4.9	27.0	5.1	25.8	6.1	26.0	8.9	23.8	12.1	20.7	------	------
	57	—3.1	29.8	—0.5	23.7	+0.5	22.4	1.6	21.7	5.1	20.4	5.7	20.3	9.1	18.1	9.7	17.2	10.4	10.1	10.3	10.5	10.8	6.7	1.6	15.8	------	------
	59	6.3	45.3	6.3	44.9	11.5	44.9	11.4	44.7	12.8	44.3	13.6	44.0	------	------	19.2	39.7	28.6	31.9	30.3	30.0	31.4	29.3	39.5	17.6	43.6	13.9
	90	0.6	36.6	—0.1	36.2	+0.8	36.4	1.1	36.8	2.9	36.3	5.4	34.9	6.1	34.5	7.2	34.1	8.5	32.9	9.8	31.0	10.9	29.9	11.6	29.4	------	------
	93	1.5	34.0	1.4	33.8	2.4	35.1	3.4	36.5	4.5	33.7	5.1	32.9	6.4	32.3	8.8	31.0	9.4	30.4	12.0	28.1	13.7	25.7	14.1	26.0	------	------
	109	—0.6	30.1	—0.1	31.0	0.0	31.2	0.0	31.2	+1.4	30.7	2.1	29.7	1.9	29.9	4.1	28.5	5.5	27.6	5.4	27.4	6.6	26.2	7.9	24.6	------	------
	137	4.2	38.0	3.9	37.2	4.4	38.0	4.1	36.9	5.3	36.9	6.9	36.4	10.1	33.8	12.0	32.9	16.8	29.2	19.3	26.7	18.0	27.8	------	------	25.8	16.1

% V. S.=Firing shrinkage, per cent dry volume. % A. P.=—Per cent apparent porosity. *Cone 5+. †Cone 7—.

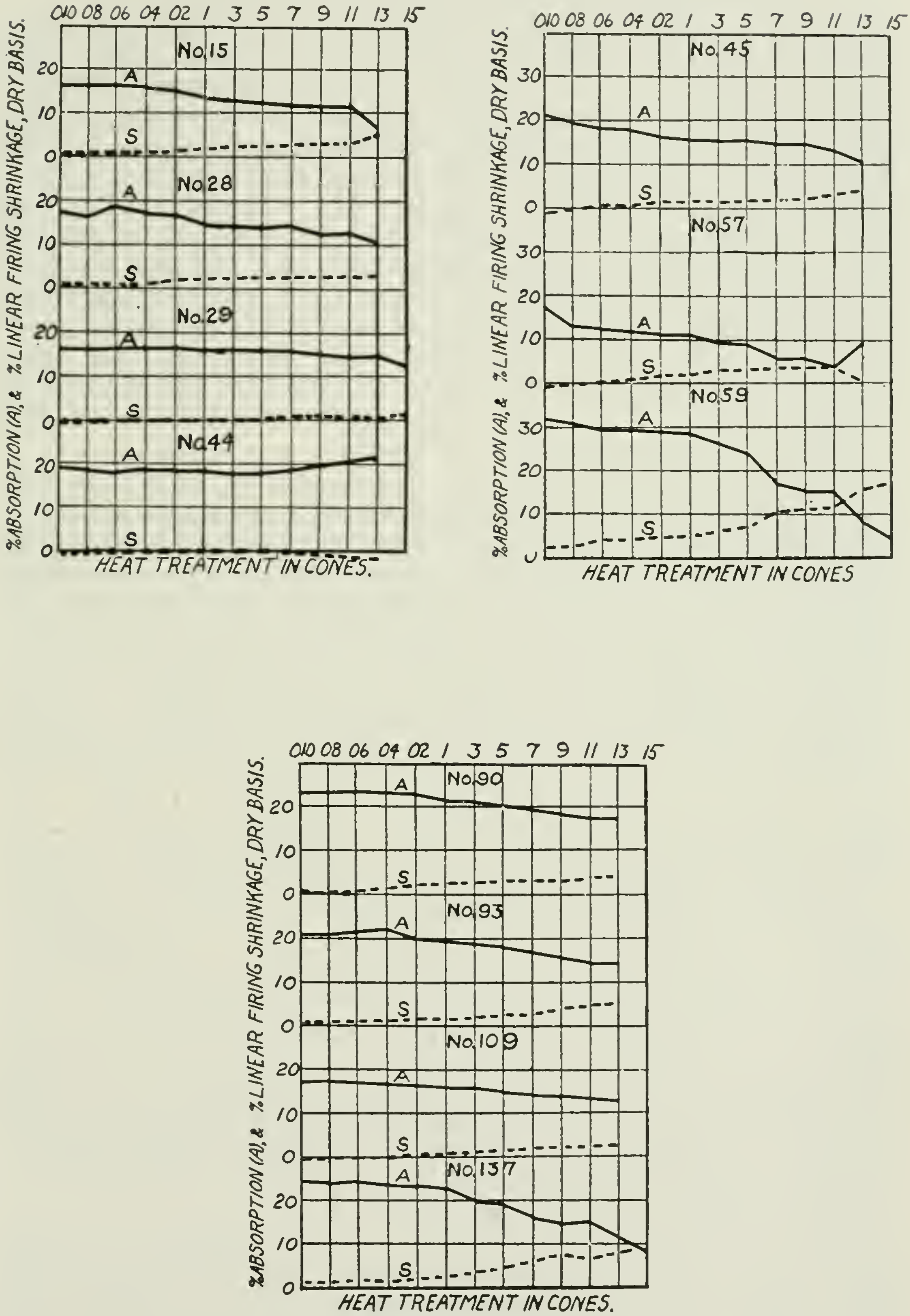
Absorption and linear shrinkage curves for clays of class 1.



Absorption and linear shrinkage curves for clays of class 1.



Absorption and linear shrinkage curves for clays of class 2.



I-B. Dense-Burning, Less Than 6% Apparent Porosity Between Cones 10 and 15.

3. Generally Refractory, Softening Point Cone 27+.

No. 70 (p. 169). Riverside County. Emsco Clay Co. "White Plastic." This is a white burning, plastic fireclay, similar in its general properties to No. 56 (class 7), a German fire clay, but with lower dry strength, higher firing shrinkage, higher softening point, and whiter color. It contains 6.4% of +200-mesh sand. It has a strong and smooth plasticity, medium low dry strength, and in the dry state it is soft and fine-grained. The colors are: dry, 13″f; wet, 17‴d; cones 010 to 1, 11″f; above cone 1, nearly white, but with a faint yellowish hue. Finger-nail hardness is developed below cone 010, and steel hardness at cone 02. Deep cracks developed in firing, but the pieces did not shatter sufficiently to fall apart. The total linear shrinkage, plastic basis, at cone 15 is 17.8%. The softening point is cone 32. The principal use of the clay at present is in the manufacture of fire brick, but its white color, fineness of grain, and excellent plasticity should make it desirable for Faience tile and other uses.

No. 96 (p. 171). Riverside County. Alberhill. G., McB. & Co. "No. 10." This is a white-burning clay with excellent smooth plasticity, that is extensively used in terra cotta bodies. It contains 1.2% of +200-mesh sand. The dry strength is medium, and the dried condition is medium hard, fine grained, and close textured. The colors are: dry, 17⁗d; wet, 17⁗b; cones 010 and 08, 13″f; cones 06 to 13, buff white. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Absorptions under 10% are obtained at cone 9. The fired structure is sound and stony, and the texture is smooth. The total linear shrinkage, plastic basis, is 16.0% at cone 15. The softening point is cone 32. The best firing range is from cone 1 to above cone 13.

No. 98 (p 171). Riverside County. Alberhill. G., McB. & Co. "Bone." See also No. 74, 86, 87, 231, and 232 in class 5 and No. 103 in class 1. In the natural state, the pisolitic structure of this clay is not so well developed as in some of the other bone clays from the district. It contains 30.0% of +200-mesh sand. The plasticity is spongy and weak, the dry strength is low, and in the dried condition the clay is soft, friable and open-textured. The colors are: dry, 13″f; wet, 17⁗b; fired, from cone 010 to cone 15, pinkish to yellowish white, finishing at a color that is whiter than that of No. 96. Finger-nail hardness appears below cone 010, and steel hardness is present at cone 3. All fired test pieces are hair cracked. The surface texture of the fired tests is smooth. The total linear shrinkage, plastic basis, at cone 15 is 18.3%. The softening point is cone 35. The calcined clay is especially valuable as a fire-brick grog.

No. 120 (p. 53). Amador County. Ione. Jones Butte. Arroyo Seco Grant. Leased by the Stockton Fire Brick Co. "Edwin Fireclay." This is one of the best of the Ione fireclays. It contains 30.2% of +200-mesh quartz-mica sand. The plasticity is 'soapy' and moderately strong, the dry strength is low, and in the dried condition the clay is soft, medium-grained, and close-textured. Some fine-grained sand is present. The colors are: dry, 17″f; wet, 17‴d; cones 010 to 02, 11″f; cones 1 to 5, pinkish white; cones 7 to 15, grayish white.

Steel hardness is developed at cone 3. Less than 10% absorption appears at cone 9. All test pieces develop a network of hair cracks on firing, but do not disintegrate. The total linear shrinkage, plastic basis, at cone 15 is 23.0%. The softening point is cone 34. The calcined clay is used as grog, and the raw clay as a plastic agent, in the manufacture of heavy-duty fire brick.

No. 111 (p. 185). Sacramento County. Michigan Bar. Van Vleck property. This is similar to No. 143 (class 4), but contains more impurities. It contains but 0.6% of +200-mesh sand. The plasticity is smooth and strong, the dry strength is medium low, and in the dried condition it is medium hard, fine-grained, and close textured. The colors are: dry, 17″f; wet, 17″d; cones 010 to 06, 13″f; cones 04 to 1, 17″f; cones 3 to 15 whiter than 19″f. Steel hardness is developed at cone 1. Less than 10% absorption appears at cone 7. The fired structure is sound and stony, and the surface texture is smooth. The total linear shrinkage, plastic basis, at cone 15 is 20.6%. The best firing range is from cone 1 to cone 15.

No. 273 (p. 163). Riverside County. Alberhill. A. C. & Co. "SH–4." This clay is classed by California consumers as a ball clay, on account of its smooth and strong plasticity, its good bonding strength, nearly white fired colors, and good vitrification range within commercial firing limits. It is very similar to the Florida kaolin (see No 59, class 2). The proportion of + 200-mesh sand is 4.6%. The dry strength is medium, and in the dried condition it is medium hard, fine-grained, and close textured. With 50% of —20-mesh to +30-mesh Ottawa sand, the bonding strength is 70 lb. per sq. in. There is slight effervescence in hydrochloric acid. The colors are: dry, 9‴f; wet, 17‴; cones 010 to 06, 11″f; cones 04 to 5 whiter than 11″f; cones 7 to 13, nearly white. Steel hardness is developed at cone 02, and less than 10% absorption at cone 9. The fired structure is stony and badly shattered at all cone numbers, and the surface texture is smooth. The total linear shrinkage, plastic basis, at cone 15, is 22.4%. The softening point is cone 34. It is used in stoneware and whiteware bodies.

I–C. Dense-Burning, Less Than 6% Apparent Porosity Between Cones 5 and 10.

4. Generally Refractory, Softening Point Cone 27+.

No. 125 (p. 53). Amador County. Ione (Carbondale). Arroyo Seco Grant. "Gage." This is a white, fine-grained clay, with a talcy feel, and smooth, but weak, plasticity. The dry strength is low, and in the dried condition it is soft and friable. The colors are dry and wet, white with a greenish hue; cones 010 to 9, pinkish white; cones 11 and 13, nearly white. The plasticity of the clay is not entirely destroyed until cone 06 is reached, at which point finger-nail hardness appears. Steel hardness develops at cone 5. Less than 10% absorption appears at cone 5, and vitrification is complete at cone 11. Slight bloating is noticeable at cone 13. From cone 06 to cone 9 the structure is stony, and above cone 9 it is glassy. No firing cracks develop. The maximum total linear shrinkage, plastic basis, is 19.8%, at cone 11. The softening point is cone 30. The best firing range is from cone 5 to cone 11. The clay has been used in the manufacture of calcimine, and is suggested as a possible ingredient of white tile and stoneware bodies.

No. 143 (p. 185). Sacramento County. Michigan Bar. Property of Geo. Cutter. This is a fine-grained, cream-burning, plastic clay, quite similar to No. 144 (class 3). It is not now in use, but was used many years ago as a stoneware clay. The plasticity is smooth and strong, the dry strength is medium, and in the dried condition it is medium hard, fine-grained and close-textured. The colors are: dry, pinkish white; wet, 21‴f; cones 010 to 1, pinkish white; cones 3 to 7, 19″f; cones 9 to 13, 21‴f. Steel hardness is developed at cone 1. The fired structure is sound, and stony, and the surface texture is smooth. Less than 10% absorption is obtained at cone 5. The maximum total linear shrinkage, plastic basis, at cone 11, is 23.2%. The softening point is cone 32. When used alone, the clay warps seriously both during drying and firing, but will stand much abuse without cracking. The best firing range is from cone 1 to cone 11.

No. 240 (p. 52). Amador County. Ione. Core drill sample, East side of Lot 237, Arroyo Seco Grant. This is a cream-burning clay. The dry strength is medium, and in the dried condition it is soft, friable, fine-grained, and close-textured. The colors are: dry, 15″f; wet, 1‴f; cones 010 to 02, 13″f; cones 1 to 7, 21‴f; cones 9 to 13, 23⁗′f. Steel hardness is developed at cone 02, and less than 10% absorption at cone 1. The fired structure is stony, and one or two small cracks are present in each fired test piece. The surface texture is smooth. The maximum total linear shrinkage, plastic basis, at cone 13, is 23.6%. The softening point is cone 32–33. The long vitrification range is especially to be noted. The possible uses are as a refractory bond clay in fire brick, terra cotta, faience tile, and stoneware. It is the equivalent of the well-known Dosch clay, No. 136 (class 8), and has a slightly better color.

TABLE No. 14.

I. White- or Cream-Burning Non-Calcareous Clays.

B. Dense-burning, less than 6% apparent porosity between cones 10 and 15.

3. Generally refractory, softening point cone 27+.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
70	12.8	18.7	31.5	171	21.9	6.9	32
96	13.7	15.9	29.6	398	25.0	7.7	32
98	6.5	20.9	27.4	81	10.8	3.4	35
120	6.8	29.6	36.4	93	9.9	3.1	34
144	17.7	22.1	39.8	165	29.4	8.9	31
273	15.6	21.9	37.5	249*	25.7	7.9	34

* Bonding strength, with 50% of Ottawa sand (—20–,+30-mesh) is 70 lb. per sq. in.

C. Dense-burning, less than 6% apparent porosity between cones 5 and 10.

4. Generally refractory, softening point cone 27+.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
125	11.7	31.1	42.8	26	16.5	5.3	30
143	22.5	21.7	44.2	245	36.8	11.0	32
240	20.6	22.3	42.9	335	33.7	10.2	32–33

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 15.

I. White- or Cream-Burning Non-Calcareous Clays.

B. Dense-burning, less than 6% apparent porosity between cones 10 and 15.

3. Generally refractory, softening point cone 27+.

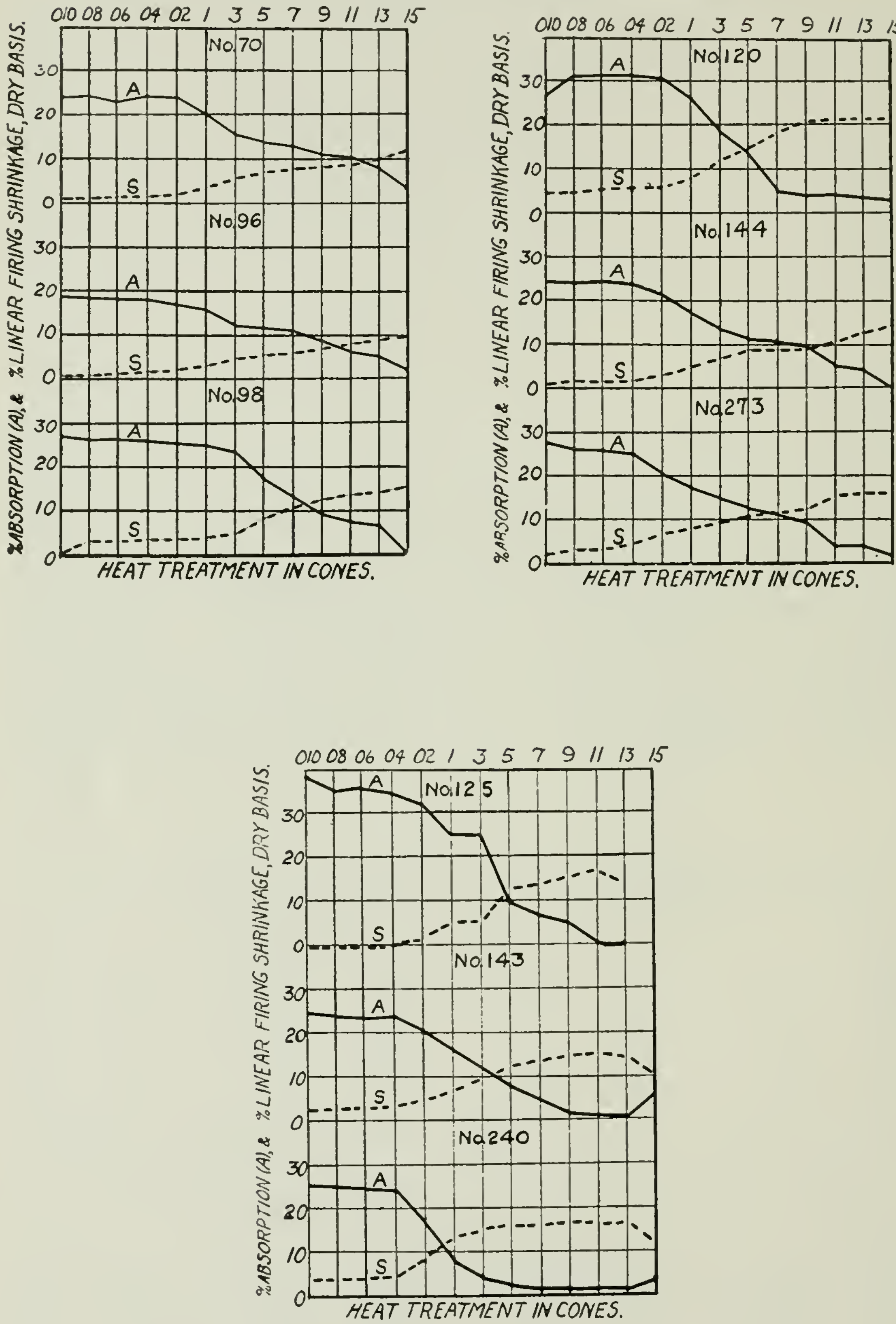
C. Dense-burning, less than 6% apparent porosity between cones 5 and 10

4. Generally refractory, softening point cone 27+.

Class No.	Clay No.	Cone 010		Cone 08		Cone 06		Cone 04		Cone 02		Cone 1		Cone 3		Cone 5		Cone 7		Cone 9		Cone 11		Cone 13		Cone 15	
		% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.
3	70	2.2	37.8	3.4	38.6	4.5	38.0	4.5	39.4	6.1	38.7	10.4	34.7	16.6	30.1	19.7	26.6	21.1	25.1	23.5	22.8	21.0	21.0	26.8	17.9	32.0	5.2
	96	+1.9	31.7	3.7	31.9	3.9	31.6	4.4	31.2	5.3	30.2	8.2	28.4	13.5	23.6	15.0	22.9	16.4	21.1	18.2	18.2	21.6	12.6	23.5	10.6	26.0	1.1
	98	0.6	41.4	9.3	42.0	9.6	42.2	10.6	42.7	10.5	41.5	10.9	40.7	12.7	40.0	22.1	32.1	28.6	26.6	33.3	19.9	36.1	16.7	37.6	15.3	39.5	0.5
	120	15.0	39.8	14.1	45.3	15.4	46.3	16.0	46.3	16.5	46.1	22.5	41.9	31.9	33.8	37.0	27.4	46.2	10.7	49.5	8.6	49.4	9.9	59.4	7.7	50.0	6.0
	144	3.1	37.4	4.4	37.4	4.5	38.6	5.0	37.7	8.2	35.5	14.8	29.8	20.3	25.0	21.6	21.2	25.2	19.9	26.7	17.8	28.8	9.7	32.6	7.7	35.6	0.0
	273	5.6	42.0	10.0	41.5	10.0	41.4	12.4	40.5	19.0	36.0	22.5	32.0	26.4	27.6	29.5	25.3	31.2	23.6	32.9	29.6	39.1	8.1	39.9	8.5	41.2	3.6
4	125	—2.0	50.5	—1.6	46.3	—0.4	47.6	—0.7	46.2	+5.3	44.4	14.0	38.7	14.0	37.7	32.6	18.5	34.9	14.0	38.2	9.4	29.9	0.0	35.4	0.0	. . .	
	143	7.0	38.6	7.1	37.9	7.9	37.0	8.5	38.2	11.6	34.8	18.4	30.0	26.2	22.7	33.0	14.9	35.7	8.8	36.8	1.7	38.2	0.0	37.7	0.0	25.0	8.5
	240	9.2	39.9	9.1	40.0	10.5	39.4	11.7	39.3	23.5	28.2	31.4	14.2	38.9	6.1	38.9	3.7	39.3	2.2	40.8	1.6	39.8	2.2	40.5	1.6	29.2	6.4

% V. S.—Firing shrinkage per cent dry volume. % A. P.—Per cent apparent porosity.

Absorption and linear shrinkage curves for clays of classes 3 and 4.



II. BUFF-BURNING CLAYS.

A. Refractory Clays, Softening Point Cone 27+

a Open-Burning, More Than 6% Apparent Porosity at Cone 15.

5. Low Strength.

No. 17 (p. 163). Riverside County. Alberhill C. & C. Co. "Bone." A medium-grained bone clay, with a decided, but not well-developed pisolitic structure in the crude state. It is used in the manufacture of fire brick, high-temperature cement, and to some extent in saggers. It contains 29.0% of + 200-mesh grains, has short plasticity, and dries rapidly to a soft, rough textured condition, with medium low dry strength. The colors are: dry, 13''''d; wet, 13''''i; cones 010 to 06, 17''f; cone 04, 17'''f; cones 02 to 5, whiter than 17'''f; cones 7 to 13, 17'''f. All test pieces fired above cone 02 were 'crow-footed.' Finger-nail hardness is developed below cone 010, and knife hardness appears at cone 5. The total linear shrinkage, plastic basis, is 18.5% at cone 15. The softening point is cone 34. The best firing range is above cone 5. The principal value of this clay is to increase the refractoriness of fire brick bodies.

No. 23 (p. 163). Riverside County. Alberhill C. & C. Co. "West Blue." This is one of the more important Alberhill clays, and is widely used for light-pink and buff face brick, for sewer pipe, and in fire brick to decrease porosity. It contains 11.0% of + 200-mesh sand. The plasticity is excellent and the dry strength is medium low. In the dry condition the clay has a medium hardness, a fine grain and a close texture. The colors are: dry, 17''''f; wet, 21''''; cones 010 to 04, 5'f; cone 02, 11''f; cones 1 and 3, 13''f; cones 5 to 9, 17''f; cone 11, 17''d; cones 13 and 15, 15''b, with prominent iron specking. Finger-nail hardness is developed at cone 08, and steel hardness at cone 3. The maximum total linear firing shrinkage, plastic basis, at cone 13, is 13.7%. Slight bloating is apparent at cone 15. The softening point is cone 29. The best firing range is from cone 1 to cone 13. A pleasing mottled texture can be produced by flashing.

No. 66 (p. 179). Riverside County. Corona. McKnight pit. Pacific Clay Products Co. "Red McKnight." This is a buff-burning clay containing a large proportion of non-plastic material. It is suitable for face brick manufacture, and as an ingredient of sewer pipe mixes. The plasticity is good, though weakened by the presence of 54.4% of + 200-mesh sand. The dry strength is medium low, and the dry condition is coarse, open, soft and friable. The colors are: dry, 9''; wet, 9''i; cones 010 to 02, 9'b; cone 1, 9'd; cone 2, 11'd; cone 5, 9'f; cones 7 and 9, 9''d; cones 11 and 13, 15''d. Finger-nail hardness develops below cone 010, and steel hardness at cone 7. The fired condition is sound, open, granular, and medium strong. The total linear shrinkage, plastic basis, at cone 13, is 5.6%. The softening point is cone 28. The best firing range is above cone 5.

No. 67 (p. 179). Riverside County. Corona. McKnight pit. Pacific Clay Products Co. "McKnight Fire Clay." This is a sandy fire clay with fair plasticity, medium low dry strength, and a granular, friable, dry condition. It contains 64.2% of + 200-mesh sand. The colors are: dry, 13''''d; wet, 13''''i; cones 010 to 7, 17''f; cones 9 to 13, nearly

17‴f. Steel hardness is not developed within the firing range studied, up to cone 15. The fired structure and texture is weak, coarse-grained, and friable. The total linear shrinkage, plastic basis, at cone 15 is 7.2%. The softening point is cone 33. For best results in firebrick manufacture, this clay should be mixed with a more plastic fire clay.

No. 71 (p. 169). Riverside County. Emsco Clay Co. "Pink Mottled." This is a buff-burning plastic fire clay that is especially valuable as a face-brick clay. The plasticity is smooth and strong, without stickiness, the dry strength is medium low, and in the dried state it is soft, fine-grained and open-textured. The sample contains 11.0% of +200-mesh sand. The colors are: dry, 7″d; wet, 7″; cones 010 and 08, 5′f; cone 06, 9″f; cone 04, 7″f; cone 02, 13″f; cone 1, 15″f; cones 3 and 5, 17″f; cones 7 to 1, 17‴f; and cone 13, 17″d. A good range of pinks, buffs, and creams is covered. The fired exteriors, especially above cone 5, are lightly mottled with iron specks. Finger-nail hardness is developed at cone 010, and steel hardness at cone 5. The fired structure is sound, stony and strong. The total linear shrinkage, plastic basis, at cone 13, is 13.1%. The softening point is cone 30–31. The best firing range is from cone 04 to above cone 13.

No. 74 (p. 174). Riverside County. Alberhill. Los Angeles Brick Co. "Bone." See also No. 86, 87, 231 and 232 in the same class, No. 98 in class 3, and No. 103 in class 1. In the natural state, this clay has a well developed pisolitic structure, and is hard and brittle. It is used in the manufacture of high-grade fire brick. The sample contains 47.6% of +200-mesh sand. The plasticity is spongy and weak, the dry strength is low, and the dried condition is soft, friable, and open-textured. The colors are: dry, 11′d; wet, 11′i; cones 010 and 08, 7′d; cones 06 and 04, 5′f; cones 1 to 5, 9′f; cones 7 to 11, 15′f; cone 13, 13′d. Finger-nail hardness is developed at cone 08 and steel hardness appears at cone 1. All fired test pieces have deep hair cracks, but do not disintegrate. The total linear shrinkage, plastic basis, at cone 15 is 24.6%, most of which takes place during firing. The softening point is cone 33–34. The clay is especially valuable as a grog in fire brick mixtures after calcination at cone 11 to 15.

No. 77 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Gray No. 20." This clay is very similar to No. 76 (class 6), but contains more silica, is finer-grained, and has a stronger fired structure. It is used in face brick and fire brick. It contains 6.6% of +200-mesh sand. The plasticity is excellent, the dry strength is medium low, and the dried condition is medium hard, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 13‴f; cone 010 to 04, 13″f; cones 02 to 13, 17‴f, or slightly whiter. Steel hardness appears at cone 1. All fired structures are sound, and above cone 1 are stony. Absorption below 10% is obtained at cone 7. The maximum total linear shrinkage, plastic basis, at cone 13, is 16.3%. Bloating begins above cone 13. The softening point is cone 30–31. The best firing range is from cone 1 to above cone 13.

No. 79 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Fireclay." This is a buff-burning, sandy fireclay with low plastic strength, and medium low dry strength. It contains 48.4% of +200-mesh sand. In the dried condition it is friable, coarse-grained and open-textured.

The colors are: dry, 17″f; wet, 13‴b; cones 010 to 04, 9″f; cone 02, 11″f; cone 1, 13″f; cone 3, 17″f; cones 5 to 15, 17‴f. Very few black specks appear on firing. Finger-nail hardness appears below cone 010, but steel hardness is not reached below cone 15. The fired structure is sound, coarse-grained, and open-textured. The total linear shrinkage, plastic basis, at cone 15 is 5.4%, most of which takes place during drying. The softening point is cone 31–32. The best firing range is above cone 9.

No. 86 (p. 174). Riverside County. Alberhill. L. A. B. Co. "No. 26 Bone." See also No. 74, 87, 231 and 232, to which this clay is closely related. The plasticity is spongy and weak, the dry strength is low, and the dried condition is soft, friable, and open-textured. The sample contains 57.8% of +200-mesh material. The colors are: dry, 17‴d; wet, 19″; cones 010 to 5, 9′d; cones 7 to 11, 15′f; cone 13, 17″d. Finger-nail hardness is developed at cone 08, and steel hardness appears at cone 1. Test pieces have hair cracks, when fired above cone 1, but do not disintegrate. The total linear shrinkage, plastic basis, at cone 13, is 12.3%. The softening point is cone 33–34.

No. 87 (p. 174). Riverside County. Alberhill. L. A. B. Co. "White Bone." See also No. 74, 86, 231 and 232. This variety is now designated "Smooth Bone," and is closely similar to sample No. 232. It contains 31.0% of +200-mesh material. The plasticity is better than that of No. 86, the dry strength is low, and the dried condition is soft, friable and open. The colors are: dry, 17″f; wet, 17‴f; cones 010 to 06, 7′f; cones 04 to 13, pinkish and yellowish white. Finger-nail hardness is developed at cone 08, and steel hardness at cone 3. All fired test pieces are lightly hair-cracked. Less than 10% absorption is obtained at cone 11. The total linear shrinkage, plastic basis, at cone 15 is 18.3%. The softening point is cone 34.

No. 104 (p. 171). Riverside County. Alberhill. G., McB. & Co. "No. 5 Sloan." This is a plastic fireclay, high in alumina. The dry strength is medium low, and the dried condition is soft, medium-grained, and open-textured. It contains 32.2% of +200-mesh sand. The colors are: dry, 17″f; wet, 13″d; cones 010 to 02, 7″b; cone 1, 11″f; cones 3 to 9, 17″f; cones 11 and 13, 13‴f. Numerous small iron specks are visible when fired to cone 11 or above. Finger-nail hardness appears below cone 010 and steel hardness at cone 1. All fired test pieces are lightly hair cracked, and those that were fired at the higher temperatures fell apart into two or more pieces. The surface texture of the fired pieces is smooth. Less than 10% absorption is obtained at cone 5. The maximum total linear shrinkage, plastic basis, at cone 13, is 23.6%. The softening point is cone 34–35.

No. 126 (p. 52). Amador County. Ione. Arroyo Seco Grant. "Baker." This is a plastic fireclay containing 19.6% of +200-mesh quartz and undecomposed feldspar grains. The plasticity is good, the dry strength is low, and in the dried condition it is soft, friable and medium-grained. The colors are: dry, 17‴f; wet, 17‴d; cones 010 to 9, 17″f; cones 11 and 13, 17‴f. Steel hardness does not appear within the firing range studied (cones 010 to 15). Less than 10% absorption appears at cone 11. All fired test pieces are hair-cracked. The total linear shrinkage, plastic basis, at cone 15 is 19.5%. The softening point is cone 33–34. The best firing range is above cone 9.

No. 138 (p. 57). Amador County. Ione. M. J. Bacon. "Bacon Bottom." This clay has a smooth plasticity, medium-low dry strength, and in the dried condition it is soft, fine-grained and open-textured. It contains 4.2% of +200-mesh sand. The colors are: dry, 13″f; wet, 17″f; cone 010, 17″f; fading to pinkish white at cone 02, and to yellowish white at cone 5; cones 11 to 15, 19″d. Scattered iron specks are noticeable at cones 11 to 15. Finger-nail hardness is approximated at cone 010, and steel hardness is reached at cone 11. The fired structure is sound and fine-granular, and the fired surface is slightly rough. The total linear shrinkage, plastic basis, at cone 15 is 18.1%. The softening point is cone 29–30. The clay may be used in sanitary porcelain bodies to replace part of the flint and china clay ordinarily used.

No. 140 (p. 56). Amador County. Ione. Arroyo Seco Grant. Ione Fire Brick Co. "Sand." This is a fire-sand, nearly identical in its properties to No. 128 (class 1) with a softening point of cone 32. It contains 45.0% of +200-mesh sand. The fired colors are: cones 010 to 04, 7″b; cone 02, 7″d; cone 1 to 7, 17″ d; cones 9 and 11, 19″d; cone 13, 19″f.

No. 141 (p. 58). Amador County. Jackson Valley. Ione. Leased to W. S. Dickey Clay Manufacturing Co. This is a high-grade plastic fireclay, yet it contains 38.8% of +200-mesh material. The plasticity is fair, the dry strength is low, and in the dried condition it is soft, medium-grained and open-textured. The colors are: dry 1″‴f; wet, light gull gray (9)f; cones 010 to 06, 7″f; cone 04, 17″f. With increasing temperature, yellow replaces pink, and at cones 11 and 13, the color approximates 19″f. Steel hardness is not developed within the range of temperatures studied (up to cone 15). The fired structure is granular, and hair-cracked, and the texture is slightly rough. The total linear shrinkage, plastic basis, at cone 15, is 14.1%. The softening point is cone 34. This is one of the best fireclays in the state, and brick made from this clay, with a calcined grog of the same material, are exceptionally good.

No. 142 (p. 58). Amador County. Jackson Valley. Ione. Leased to W. S. Dickey Clay Manufacturing Company. This is similar to No. 141, but contains more coloring and fluxing impurities. There is 35.8% of +200-mesh sand. The dry strength is medium low. The colors are: dry, 17″f; wet, 15″d; cones 010 to 06, 7″b; cones 04 and 02, 7″d; cone 1, 7″f; cone 3, 9″f; cone 5, 9‴f; cone 7, 17‴f; cones 9 to 13, 17″d. Steel hardness is developed at cone 3. The fired structure is coarse-granular, and lightly hair-cracked, with a roughened surface texture. The total linear shrinkage, plastic basis, at cone 13 is 14.7%. The softening point is cone 32–33. Except for lower refractoriness, this clay is more workable than No. 141, on account of greater strength and less fire-cracking.

No. 191 (p. 133). Napa County Calistoga. Clark and Marsh. Average sample. This is similar to No. 190 (class 1), but contains more iron, and has even less plasticity and fired strength. The colors are:

dry, 17′d; wet, 11′b; cones 010 and 08, 9′b; cone 06, 9′d; cones 04 to 5, 7′d; cone 7, 9′f; cones 9 to 13, 17‴f. The total linear shrinkage, plastic basis, at cone 13, is 8.1%. The softening point is cone 30–31.

No. 192 (p. 133). Napa County. Calistoga. Tunnel below Clark and Marsh property. This sample contains a much higher proportion of plastic matter than No. 190 or 191, but at the same time contains sufficient iron to give pale buff fired colors. The residue on 200-mesh is 26.2%. The plasticity is fair, the dry strength is medium low, and in the dried condition it is medium-hard, fine-grained, and open-textured. The colors are: dry, pinkish white, wet, 17″f; cone 010, 13″f; fading to pinkish white at cone 3, then changing to 17‴f at cones 11 to 15. Steel hardness is not developed within the firing range studied, up to cone 15. The fired structure is medium-strong, fine-granular, and at high firing temperatures is slightly hair-cracked. The surface texture is slightly roughened. A few iron specks are present. The total linear shrinkage, plastic basis, at cone 15 is 17.1%. The softening point is cone 31.

No. 231 (p. 174). Riverside County. Alberhill. L. A. B. Co. "High Alumina Bone." See also No. 74, 86, 87, and 232. In the natural state this clay has a well-developed pisolitic structure. The plasticity is spongy and weak, the dry strength is low, and in the dried condition it is soft, coarse, and open. The colors are: dry, 9″d; wet, 11″b; cones 010 and 08, 9′d; cones 06 to 02, 9″f; cones 1 to 5, 17″f; cones 7 to 13, 19″f. Finger-nail hardness is developed at cone 1, but steel hardness is not present at cone 15. The fired structure is crumbly and weak at low firing temperatures, and hair-cracked at higher temperatures. The total linear shrinkage, plastic basis, at cone 15, is 19.6%. The softening point is cone 34–35.

No. 232 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Smooth Bone." See especially No. 87, to which this sample is closely similar, except that it is more plastic, and less than 10% absorption is obtained at a lower firing temperature, cone 9, instead of at cone 11. The total linear shrinkage, plastic basis, at cone 15 is 20.6%. The softening point is cone 34–35.

No. 239 (p. 52). Amador County. Ione. Core drill sample, Lot 254. Arroyo Seco Grant. A sandy clay with fair plasticity and low dry strength. It contains 58.0% of +200-mesh sand. In the dried condition it is soft, fine-grained, and open-textured. The colors are: dry, 1⁗f; wet, 15⁗′b; cones 1 and 5, 9‴f; cones 9 and 13, 17‴d. Steel hardness is not developed at cone 13. The fired structure is sound and fine-granular. The total linear shrinkage, plastic basis, at cone 13, is 3.1%. The softening point is cone 31. The material could be mixed with a more plastic clay for the manufacture of firebrick.

No. 244 (p. 52). Amador County. Ione. Core drill hole No. 54, Arroyo Seco Grant. This is similar to No. 240 (class 4), but contains a larger proportion of fine sand and ferro-magnesian minerals. The plasticity is good, but with a tendency to stickiness. The dry strength is medium low, and in the dried condition it is soft, fine-grained, and open-textured. The colors are: dry, pinkish white; wet, 1⁗′f; cone 1, 19″f; cones 5 and 9, 17″d; cone 13, 17⁗d. Steel hardness is present at cone 1, and less than 10% absorption appears at cone 5. Blistering was noted at cone 13, although the softening point is cone 31–32. The fired structure is stony, and sound, except for a few small cracks at cone 13. The surface texture is smooth. The maximum total linear shrinkage, plastic basis, is 20.8%, at cone 9. It could be used in terra cotta and faience tile bodies.

No. 250 (p. 52). Amador County. Ione. Core drill No. 56–3, Arroyo Seco Grant. This sample contains but 1.4% of +200-mesh sand. The plasticity is good, without stickiness, the dry strength is medium-low, and in the dried condition it is soft, fine-grained, and open-textured. The colors are: dry, grayish white; wet, carbon gray; cone 1, nearly white; cones 5 and 9, 19″f; cone 13, 17″d. Steel hardness and less than 10% absorption are developed between cone 1 and cone 5. In the fired condition the non-plastic grains are well cemented in a groundmass of clay. Numerous fine, but deep, cracks appear in the fired test pieces. The surface texture is moderately rough. The total linear shrinkage, plastic basis, at cone 13, is 14.7%. The softening point is cone 31. It is a suitable material for terra cotta, tile, and fire brick bodies.

No. 270 (p. 140). American Refractories Co. "Arc Fire Clay." This is a sample of fireclay from which the "Arc" brand of fire brick is manufactured. There is slight effervescence in hydrochloric acid. The plasticity is excellent, the dry strength is medium low, and in the dried condition it is soft, medium-grained, and open-textured. It contains 32.0% of +200-mesh sand. The colors are: dry, 13‴d; wet, 13‴b; cones 010 to 06, 9″f; cones 04 and 02, 15″f; cones 1 to 7, yellowish white; cones 9 to 13, 19″f. The surface is slightly mottled with iron specks above cone 9. Steel hardness is developed at cone 11. The fired structure is sound, and granular, and the surface texture is rough. The total linear shrinkage, plastic basis, at cone 13, is 12.8%. The softening point is cone 32.

No. 282 (p. 141). Orange County. Santa Ana Canyon. Goat Ranch. G., McB. & Co. "Flint Fire Clay." This sample was prepared by wet pebble-mill grinding through 200-mesh, followed by seven days' ageing in the plastic state, with frequent pugging. This produced good plasticity. The dry strength is medium low, and in the dried condition it is medium hard, fine-grained, and close-textured. The colors are: dry, 17⁗f; wet, 21⁗d; cones 010 to 04, 13″f; cones 02 to 9, nearly white; cones 11 and 13, 17″d. Steel hardness is developed at cone 5 and less than 10% absorption at cone 13. The fired structure is fine-granular, and the surface texture is smooth. All test pieces are shattered, but most of them remain in one piece. The total linear shrinkage, plastic basis, at cone 15 is 18.0%. The softening point is cone 33.

No. 285 (p. 232). Tulare County. Ducor. W. A. Sears deposit. See also No. 283–A and B, class 9, and 284, class 10. This is the most satisfactory of the clays that were tested from this property. The material is an impure kaolin, has fair plasticity, and medium-low dry strength. In the dry condition it is medium hard, fine-grained, and open-textured. The colors are: dry, cream white; wet, 15 b; cones 010 to 06, 9″f; cones 04 to 5, 17″d; cones 7 and 9, 15″d; cones 11 and 13, 13″d; cone 15, 15″d. These are suitable buffs for face brick, but the surface is badly contaminated with yellow staining. There is no evidence of vitrification up to cone 15, the upper limit studied. The fired structure is sound, fine-grained, and open-textured, without great strength. The total linear shrinkage, plastic basis, at cone 15, is 10.8%. The softening point is cone 30–31. The clay might have uses as a refractory filler in face brick and terra cotta.

TABLE No. 16.

II. Buff-Burning Clays.

A. Refractory clays, softening point cone 27+.

a. Open-burning, more than 6% apparent porosity at cone 15.

5. Low strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
17	9.3	20.1	29.4	136	15.8	5.1	34
23	11.8	19.3	31.1	161	20.3	6.2	29
66	7.1	10.3	17.4	185	14.6	4.7	28
67	5.6	9.0	14.6	142	11.7	3.7	33
71	9.6	16.4	26.0	131	17.2	5.2	31
74	5.6	23.2	28.8	97	9.1	3.0	33–34
77	12.7	18.0	30.7	±190	22.5	7.0	30–31
79	5.9	11.7	17.6	163	11.8	3.8	31–32
86	6.8	19.9	26.7	76	11.7	3.7	33–34
87	8.0	14.9	28.4	76	13.5	4.1	34
104	12.4	24.0	36.4	178	19.7	6.2	35
126	13.0	25.4	38.4	95	19.7	6.2	33–34
138	18.2	25.8	44.0	160	27.9	8.4	29–30
140	7.8	18.0	25.8	46	13.5	4.4	32
141	5.6	23.0	28.6	92	8.9	2.9	34
142	6.5	21.3	27.8	178	10.7	3.4	33
191	13.9	30.2	44.1	180	18.9	6.0	30–31
192	15.4	27.1	42.5	143	22.0	6.9	31
231	5.1	22.8	27.9	41	8.1	2.6	34–35
232	8.1	21.7	29.8	58	13.3	4.3	34–35
239	4.4	13.9	18.3	50	8.4	2.8	31
244	20.4	20.1	40.5	±190	34.1	10.3	31–32
250	11.0	17.4	28.4	179	19.4	6.1	31
270	11.1	17.5	28.6	183	19.7	6.2	32
282	12.9	17.0	29.9	±113	23.5	7.3	33
285	10.7	44.0	54.7	130	11.8	3.8	30–31

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 17.

II. Buff-Burning Clays.

A. Refractory clays, softening point cone 27+.

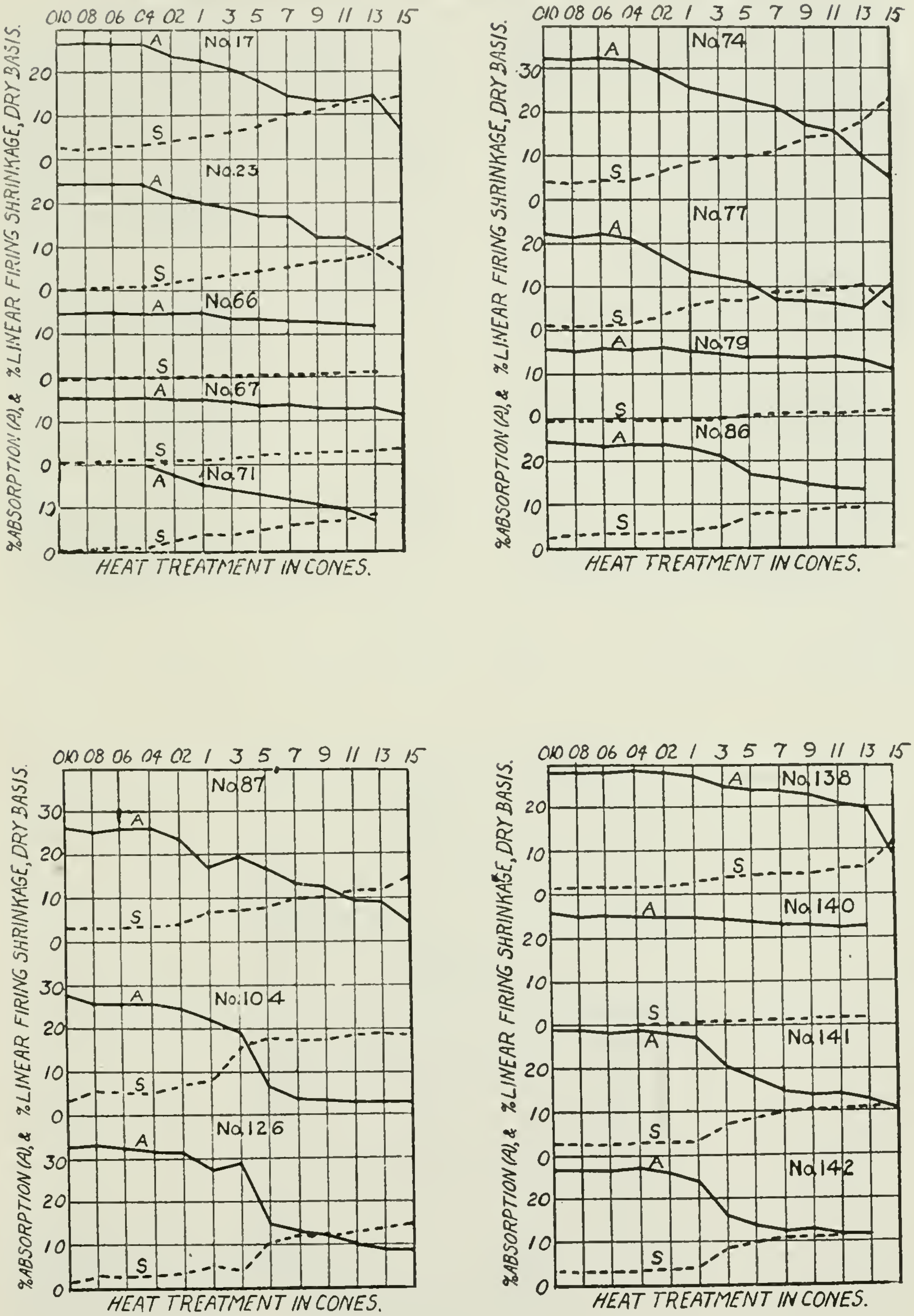
a. Open-burning, more than 6% apparent porosity at cone 15.

Class No.	Clay No.	Cone 010 % V. S.	Cone 010 % A. P.	Cone 08 % V. S.	Cone 08 % A. P.	Cone 06 % V. S.	Cone 06 % A. P.	Cone 04 % V. S.	Cone 04 % A. P.	Cone 02 % V. S.	Cone 02 % A. P.	Cone 1 % V. S.	Cone 1 % A. P.
5	17	+7.6	41.2	5.5	42.0	8.6	42.7	8.5	42.5	12.1	40.0	13.1	38.9
	23	0.1	38.0	1.7	38.2	1.7	38.6	1.9	39.5	6.2	36.3	8.3	34.5
	66	—0.8	28.0	—0.7	29.1	—0.3	29.1	+0.1	29.1	+0.1	28.8	+0.5	29.5
	67	1.0	28.4	2.7	29.2	2.7	29.8	3.0	29.7	3.6	28.7	3.5	26.6
	71	0.3	34.0	0.9	31.0	2.3	36.6	2.5	34.2	7.6	30.2	10.8	28.1
	74	12.0	48.2	11.8	48.0	13.2	49.4	13.4	49.3	18.2	47.0	23.2	44.0
	77	3.0	36.2	2.8	35.9	3.4	37.0	5.2	36.1	10.5	31.4	16.6	26.0
	79	—2.0	28.9	—2.0	28.8	—1.8	29.8	—1.7	29.6	—1.5	29.6	—1.2	30.5
	86	7.1	39.2	9.0	39.1	10.0	39.2	9.4	40.2	9.5	40.3	11.3	39.4
	87	8.3	41.5	8.0	40.8	8.8	41.7	8.9	41.8	11.0	39.6	20.1	30.9
	104	8.5	42.6	14.1	41.8	14.7	42.0	14.5	41.9	16.7	40.6	19.0	38.1
	126	4.3	47.0	7.8	47.0	8.2	46.9	8.4	46.3	10.1	45.8	13.7	43.0
	138	4.0	40.6	4.7	41.2	4.9	41.5	4.7	41.6	5.2	41.3	7.0	40.9
	140	0.0	40.3	0.0	39.9	0.0	40.2	0.2	40.4	0.4	40.0	‡1.6	‡39.6
	141	7.8	44.5	8.1	44.8	8.3	44.2	8.6	44.4	9.0	43.8	10.1	43.1
	142	9.2	42.5	8.6	42.8	9.3	43.0	9.0	43.0	10.3	42.5	12.7	40.7
	191	1.2	48.8	1.2	49.3	1.4	49.3	1.6	49.5	2.3	49.3	2.3	49.2
	192	5.2	44.1	6.7	44.2	7.0	44.3	8.4	43.7	10.4	44.0	12.9	42.5
	231	10.0	48.5	12.2	48.7	13.6	49.8	13.7	50.0	.....	.....	18.1	46.5
	232	8.2	40.9	11.8	40.4	13.2	40.6	13.3	41.1	16.9	38.3	21.1	34.7
	239	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—1.6	35.0
	244	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.7	26.2
	259	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.7	30.0
	270	1.8	39.2	3.1	39.6	3.2	39.1	5.5	38.6	5.6	38.5	9.1	35.8
	282	8.7	34.9	.....	.....	9.4	34.8	9.1	34.4	12.2	32.2	15.3	29.4
	285	5.4	44.2	5.3	44.2	9.2	42.8	13.0	41.7	15.6	42.0	17.5	41.8

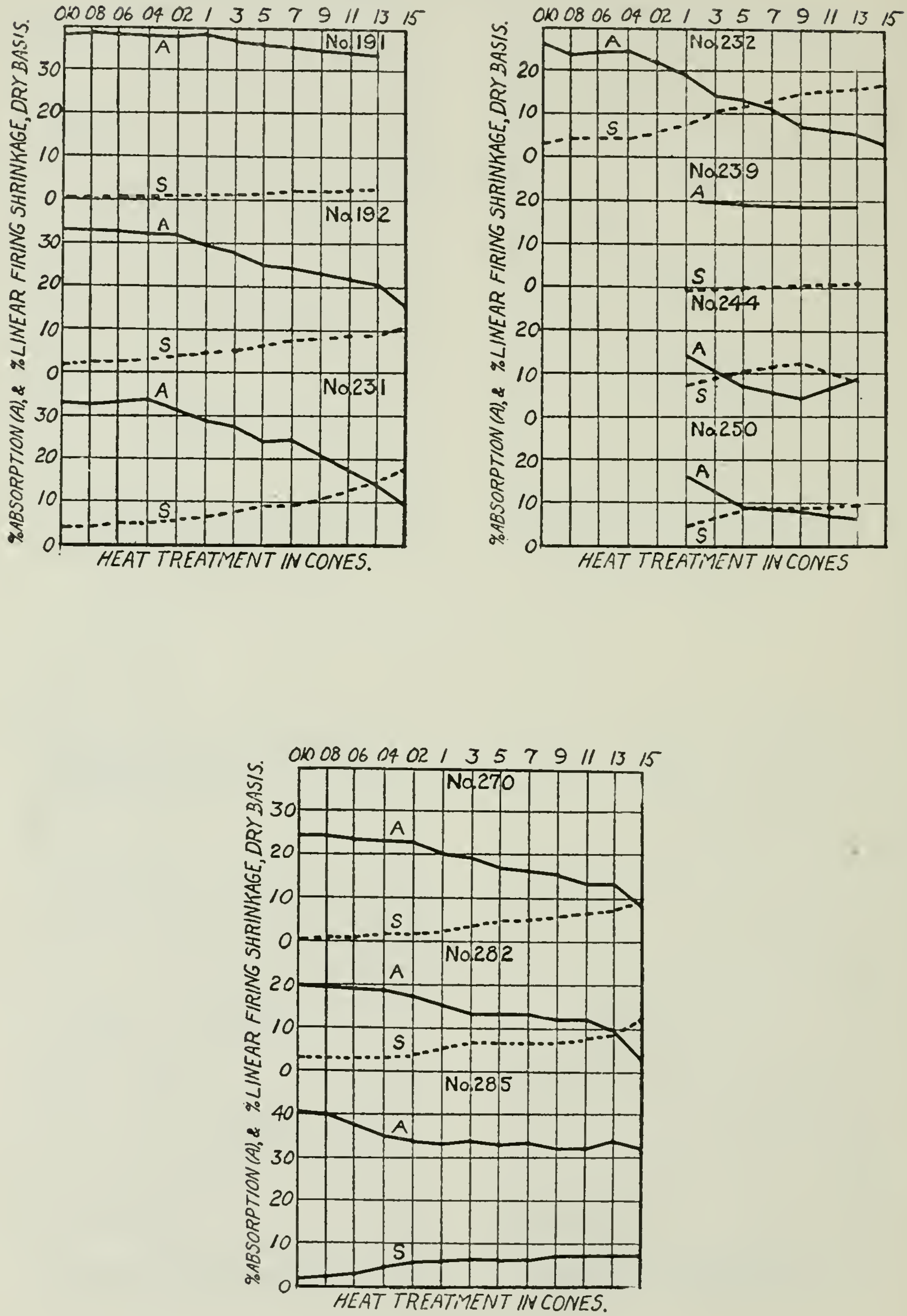
Class No.	Clay No.	Cone 3 % V. S.	Cone 3 % A. P.	Cone 5 % V. S.	Cone 5 % A. P.	Cone 7 % V. S.	Cone 7 % A. P.	Cone 9 % V. S.	Cone 9 % A. P.	Cone 11 % V. S.	Cone 11 % A. P.	Cone 13 % V. S.	Cone 13 % A. P.	Cone 15 % V. S.	Cone 15 % A. P.
5	17	17.0	36.6	21.0	33.3	27.1	28.2	29.2	26.9	33.1	29.2	32.8	30.0	37.0	16.0
	23	10.2	33.5	13.5	32.2	14.2	30.7	18.8	24.9	19.3	23.7	23.2	18.6	14.5	22.2
	66	1.4	27.6	2.1	26.8	2.5	25.8	2.7	26.0	2.9	25.1	3.4	24.2	.....	.....
	67	4.7	28.1	*6.0	*26.7	†6.3	†26.7	7.8	26.2	7.9	25.8	8.7	26.0	10.9	23.4
	71	12.2	27.0	14.3	25.2	16.9	23.1	18.3	21.8	19.2	20.0	23.6	15.0	.....	.....
	74	25.8	41.7	27.2	41.2	30.2	39.1	36.3	31.5	37.9	35.4	44.3	22.7	52.7	7.7
	77	19.3	23.6	20.3	22.4	25.0	15.8	25.1	14.9	25.6	14.5	28.0	11.2	.....	.....
	79	—0.7	29.1	+0.5	28.2	1.8	27.0	2.0	26.6	1.5	26.8	2.0	25.2	5.4	21.5
	86	13.6	37.4	*21.4	*31.7	†21.8	†30.8	23.8	28.2	25.0	27.2	24.6	26.6	.....	.....
	87	20.1	34.9	22.2	31.5	26.9	26.0	27.8	24.7	31.2	20.9	32.2	20.4	38.6	10.4
	104	22.4	35.6	38.8	16.5	13.6	6.9	43.2	7.9	45.8	6.2	46.6	6.4	45.4	6.1
	126	11.7	44.1	29.0	28.5	32.5	21.9	32.1	23.7	31.4	20.2	36.4	18.9	37.4	19.7
	138	10.8	39.1	12.9	37.8	13.2	38.1	11.6	37.2	15.9	35.8	16.7	33.1	30.1	17.6
	140	#1.4	#39.5	2.6	38.5	3.2	37.7	5.0	38.0	5.2	37.7	5.2	37.6	.....	.....
	141	20.2	35.9	23.2	31.8	26.8	27.8	27.6	27.5	28.4	28.2	28.7	25.9	30.9	21.4
	142	24.0	31.0	26.7	27.3	29.5	25.3	29.5	25.9	30.4	24.2	31.4	24.1	.....	.....
	191	3.8	48.3	5.1	48.0	5.5	47.6	6.4	47.3	7.0	46.8	7.7	46.3	.....	.....
	192	15.1	41.0	18.7	38.6	20.9	37.8	21.7	37.2	23.9	35.8	24.6	34.6	30.5	28.8
	231	21.2	45.0	§25.2	§11.5	x25.5	x12.0	29.1	38.0	33.7	33.8	38.0	29.6	43.8	22.4
	232	28.6	28.0	§32.4	§27.5	x32.6	x25.6	37.9	16.2	39.4	14.3	40.5	13.2	43.2	8.0
	239	.....	.....	—0.8	34.4	.....	.....	+0.3	33.7	.....	.....	1.3	33.6	.....	.....
	244	.....	.....	28.8	15.0	.....	.....	33.3	8.8	.....	.....	23.3	17.0	.....	.....
	259	.....	.....	22.7	18.9	.....	.....	23.2	17.4	.....	.....	25.8	14.5	.....	.....
	270	10.9	34.5	*14.7	*31.7	†15.0	†31.0	17.3	29.2	19.9	26.7	20.5	26.4	26.0	18.9
	282	19.0	26.7	19.0	26.7	19.4	26.6	20.5	25.0	21.7	21.8	24.6	21.0	32.2	7.3
	285	17.7	42.3	17.9	41.8	18.0	43.0	19.6	42.0	20.2	42.2	20.2	44.1	22.6	42.8

% V. S.=Firing shrinkage, per cent dry volume. % A. P.=Per cent apparent porosity. *Cone 5+. †Cone 7—. ‡Cone 1+. #Cone 3—. §Cone 6—. xCone 6+.

Absorption and linear shrinkage curves for clays of class 5.



Absorption and linear shrinkage curves for clays of class 5.



6. Medium to High Strength.

No. 9 (p. 163). Riverside County. Alberhill. C. & C. Co. "Hill Blue." See No. 271, and 274 in class 7, and 272 in this class, which are better samples of the material that will be available in the future. This is a smooth, fine grained, buff-burning refractory clay with good plasticity, and medium high dry strength. It contains 4.8% of +200-mesh sand. It is used in art tile, stoneware, terra cotta, and sagger bodies, and represents one of the most widely used of the Alberhill clays. The colors are pinkish and buffish white, approximating Ridgway's "f" tone. Finger-nail hardness is developed below cone 010, and steel hardness at cone 02. Vitrification is well advanced at cone 13. The maximum total linear shrinkage, plastic basis, is 13.3% at cone 13. Bloating is apparent at cone 15. The softening point is cone 29. The best firing range is from cone 04 to cone 13, and hard, strong bodies with absorptions below 10% are obtained above cone 3.

No. 14 (p. 163). Riverside County. Alberhill C. & C. Co. "A–Clay." This is a pink and buff-burning plastic clay used in the manufacture of face brick. It contains 19.2% of +200-mesh sand, develops excellent plasticity, has a good dry structure, and medium high dry strength. The colors are: dry, 17‴d; wet 17‴b; cone 010, 9′f; cones 08 to 04, 5′f; cone 02, 11″f; cones 1 to 5, 13″f; cones 7 to 9, 17″f; cone 11, 17″f; cone 13, 15″d. Finger-nail hardness is developed below cone 010, and steel hardness at cone 3. The total linear shrinkage, plastic basis, is 11.1% at cone 13. The softening point is cone 31. The best firing range is from cone 3 to cone 13 or above. A wide range of buff and pink colors can be secured in the normal kiln run.

No. 27 (p. 163). Riverside County. Alberhill C. & C. Co. "No. 10." This is a pale buff-burning clay with excellent smooth plasticity, medium-high dry strength, and a medium-hard, fine-grained, close-textured dry condition. It contains 2.6% of + 200-mesh sand. It is used in sagger, art tile and dry-pressed brick mixtures, and was formerly used in architectural terra cotta. The colors are: dry, 13‴f; wet, 13‴k; cones 010 to 1, 15″f; cone 3, 17‴f; beyond cone 3, to cone 15, increasing yellow, decreasing pink, with scattered fine brownish and black specks. Finger-nail hardness appears below cone 010, and steel hardness at cone 3. The total linear shrinkage, plastic basis, at cone 13 is 16.1%. Bloating is apparent at cone 15. The softening point is cone 30–31. The best firing range is from cone 3 to cone 13. The smooth texture, light colors, and excellent plastic, drying and firing qualities of this clay make it especially desirable for many purposes.

No. 33 (p. 205). San Diego County. Cardiff. Vitrified Products Co. See also No. 34. This is a light-colored fireclay, of Pleistocene (?) age, containing 41.0% of + 200-mesh sand. It is used for fire-brick and for buff or cream face brick. It has weak plasticity without stickiness, medium-high dry strength, and in the dry state it is hard, with a granular structure. The colors are: dry and wet, yellowish white; cones 010 and 08, 13‴f; cone 06, 17‴d; cones 04 and 02, 15″d; cones 1 to 13, 17″d. These colors, coupled with a granular texture, make pleasing effects for buff and cream face brick. Finger-nail hardness appears below cone 010 and the hardness at cone 13 is slightly less than steel. The total linear shrinkage, plastic basis, at cone 13, is 8.6%.

The softening point is cone 30. The best firing range is from cone 1 to above cone 13.

No. 34 (p. 205). San Diego County. Cardiff. Vitrified Products Co. See also No. 33. This clay is from another part of the same bed from which No. 33 was taken, and is similar to it in every respect, but has less sand, more iron, stronger plasticity, and slightly greater shrinkage. It contains 31.0% of +200-mesh sand. The colors are: dry, 9‴f; wet, 9‴d; cones 010 to 04, 7″f; cone 02, 1″d; cones 1 to 7, 15″d; cones 9 and 11, 17″d; cone 13, 17″b. Steel hardness appears at cone 13. The total linear shrinkage, plastic basis, at cone 15, is 11.5%. The softening point is cone 31. The best firing range is from cone 1 to cone 15.

No. 53 (p. 195). San Bernardino County. Hicks. Millet and Kennedy. This is a buff-burning, plastic fireclay of Tertiary age from an undeveloped deposit. The plasticity is good, the dry strength is medium high, and the dry condition is hard and close grained, with a heterogeneous texture caused by the presence of non-plastic grains of a different color than the clay portion. The sample contains 10.4% of + 200-mesh material. The colors are: dry, nearly white; wet, 19″f; cones 010 to 1, 11″f; cones 3 to 9, 17‴d; cones 11 and 13, 17‴f, mottled, with slag spots. Finger-nail hardness is obtained below cone 010, and steel hardness develops at cone 02. The fired structure is sound throughout, and vitrification is well advanced, but not complete, at cone 15. The maximum total linear shrinkage, plastic basis, at cone 13, is 20.1%. The softening point is cone 30. The best firing range is from cone 04 to cone 13. The clay is suitable for the manufacture of pink and buff face brick, and as a bond clay in fire brick. It is possible that material of improved quality can be found if the deposit is developed.

No. 76 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Gray No. 23." See No. 77, class 5. This is a plastic buff-burning fireclay that is particularly useful in sagger and pottery mixes. The clay contains 2.2% of + 200-mesh sand, the plasticity is excellent, the dry strength is medium, and the dried condition is medium hard, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 17‴d; cones 010 and 08, 7′f; cones 06 and 04, 9′f; cone 02, 13″f; cones 1 to 13, 17‴f, or slightly whiter. The fired colors are good buffs and creams for face brick, faience tile, and similar products. Finger-nail hardness is developed below cone 010, and steel hardness at cone 1. The fired structure is sound and stony, and smooth textures are obtained. Absorptions below 10% are obtained at cone 9. The maximum total linear shrinkage, plastic basis, is 15.6%, at cone 11. The softening point is cone 29. The best firing range is from cone 1 to cone 13.

No. 78 (p. 174). Riverside County. Alberhill. L. A. B. Co. "No. 10." This is a dark colored, buff-burning, plastic fireclay, containing carbonaceous matter. It is used for fire brick and face brick. The sample contains 16.2% of + 200-mesh sand. The plasticity is excellent, the dry strength is medium-high, and the dried condition is medium-hard, medium fine-grained and close-textured. The colors are: dry, 13⁗d; wet, 13⁗i; cones 010 to 04, 9′f; cone 02, 13″f; cones 1 to 13, between 17‴f and 21‴f, although slightly whiter at some cone numbers. Scattered yellowish specks appear at low firing temperatures, which darken and become more prominent at high temperatures. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Absorptions above 10% are found above cone 8. The fired structure is sound and above cone 02 is stony. The total linear firing shrinkage, plastic basis, at cone 13, is 17.1%. Slight bloating was noted at cone 15. The softening point is cone 29. The best firing range is from cone 1 to cone 13. The plasticity, dry and fired strength, and wide vitrification range at commercially attainable temperatures are the most valuable properties of this clay.

No. 81 (p. 174). Riverside County. Alberhill. L. A. B. Co. "No. 25." This is a plastic fireclay, similar to No. 76, but with more coloring matter, and a higher proportion of clay substance. It is used for face brick and fire brick. It contains only 1.8% of +200-mesh sand, the plasticity is smooth and strong, the dry strength is medium high, and the dry condition is medium soft, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 17‴b; cones 010 to 1, 11′d; cones 3 and 5, 11′f; cones 7 to 11, 17‴f; cone 13, 17″f. These are suitable buffs and tans for face-brick manufacture. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Absorptions below 10% are obtained at cone 7 and above. The total linear shrinkage, plastic basis, at cone 13, is 15.8%. The softening point is cone 28. The best firing range is above cone 1.

No. 84 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Main Pit Fireclay." This is a plastic fireclay, similar to the "Main Tunnel" clays mined by the Alberhill C. & Co. Co. and by G., McB. & Co., see samples No. 15, 29, 90, and 93 in class 2, and No. 13 and 229 in class 7. It contains 11.0% of +200-mesh sand, the plasticity is smooth and strong, the dry strength is medium, and the dry condition is soft, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 17‴d; cones 010 to 13, 9′f to 17′f. Green staining is pronounced. Finger-nail hardness develops below cone 010, and steel hardness at cone 3. Less than 10% absorption is obtained at cone 5. Vitrification is well advanced at cone 13. With the exception of a few cracks that resulted from the rapid firing schedule used, the fired test pieces are sound. The total linear shrinkage, plastic basis, at cone 13 is 12.2%. The softening point is cone 28. The best firing range is above cone 3. The clay may be used in fire brick, face brick, faience tile, stoneware, and pottery mixes. The color is not white enough for whiteware bodies.

No. 92 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Yellow Main Tunnel Clay." This is a plastic, buff-burning clay that can be used in fire brick and face brick. It contains 16.8% of +200-mesh sand. The plasticity is smooth and strong, the dry strength is medium-high, and in the dried state it is medium hard, fine-grained, and close-textured. The colors are: dry, 17″d; wet, 17″; cones 010 to 02, 7′d; cones 1 to 7, 7′f; cones 9 to 13, 17″d. Scattered slag spots appear above cone 9. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Absorptions under 10% are found at cone 11. The fired structure is sound, and at high temperatures, is stony. The total linear shrinkage, plastic basis, at cone 13, is 13.6%. The softening point is cone 28.

No. 97 (p. 171). Riverside County. Alberhill. G., Mc.B. & Co. "Smooth Bunker." This is a buff-burning terra cotta clay with excellent plasticity and medium high dry strength. There is slight effervescence in hydrochloric acid. In the dried condition it is soft, fine-grained, and close-textured. It contains 15.6% of +200-mesh sand. The colors are: dry, 13''''d; wet, 17''''d; fired, from cone 010 to cone 13, 13''f to 17'''f. The color at cone 13 is deeper than in No. 96 (class 3), and a few iron specks appear which are not present in No. 96. Finger-nail hardness appears below cone 010, and steel hardness at cone 02. The fired structure is sound and stony, and the texture is slightly rough. Absorptions under 10.0% are obtained at cone 11. The total linear shrinkage, plastic basis, at cone 13, is 11.4%. The softening point is cone 31. The best firing range is from cone 1 to cone 13.

No. 102 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Sloan Sand." This is a sandy fireclay with fair plasticity, medium dry strength, and a medium-hard, medium-grained, open-textured dried condition. It contains 30.6% of +200-mesh sand. The colors are: dry, 17''f; wet, 15''; cones 010 to 02, 9''b; cone 1, 9''d; cones 3 to 11, 13''d; cone 13, 17''d. At cones 11 and 13, scattering gray and brown specks appear. Finger-nail hardness appears below cone 010, and steel hardness develops at cone 3. The fired condition is sound, granular, and rough-textured. The total linear shrinkage, plastic basis, at cone 13, is 9.7%. The softening point is cone 29. The clay is suitable for the manufacture of face brick, and as an ingredient in low-grade fire-brick mixes.

No. 108 (p. 176). Riverside County. Alberhill. Pacific Clay Products Co. "Upper Douglas." This is a deep buff-burning sewer-pipe clay with good plasticity, high dry-strength, and in the dried condition it has finger-nail hardness, and a fine grained and close texture. It contains 5.8% of +200-mesh sand. The colors are: dry, 17''f; wet, 13''d; cones 010 to 02, 11'd; cone 1, 15'd; cones 3 to 13, 15''d. Steel hardness is developed at cone 1. Less than 10% absorption is developed at cone 3. Vitrification is complete at cone 11, after which bloating begins. The fired structure is sound and stony. The maximum total linear shrinkage, plastic basis, is 20.0%, at cone 11. The softening point is cone 27–28.

No. 130 (p. 62). Amador County. Ione. "Newman Carbonaceous Sand." This is a fire sand high in carbonaceous matter for which no uses have been found. Some iron compounds are present which are partly soluble in the mixing water, and cause discoloration by efflorescence. The residue on 200-mesh is 16.0%. More clay is present than in No. 129 (class 1), resulting in better plasticity, and medium dry strength. The interior colors are: dry, 15''''b; wet, 15''''m; cones 010 to 1, 15''b; cones 3 to 5, 13''b; cones 7 and 9, 13''b. The efflorescence has a 5'i color from cone 010 to cone 1. Steel hardness is approximated at cone 3. The fired structure is sound, fine-grained, and open textured. Light hair-cracks appear on the surface of test pieces fired above cone 3. The total linear shrinkage, plastic basis, at cone 9, is 11.6%. The softening point is cone 27.

No. 139 (p. 52). Amador County. Ione. M. J. Bacon. "Bacon Blue." This is a fine-grained, cream-burning, plastic clay that is suitable for stoneware manufacture. It contains 1.4% of +200-mesh sand. The plasticity is very good, the dry strength is medium low, and in the dried condition it is medium-hard, fine-grained, and open-textured. The colors are: dry, 13''''f; wet, 17''''f; cone 010, 17''f, changing to pinkish white at cone 02, then to cream-white up to cone 9; cones 11 and 13, 19''d. Finger-nail hardness is approximated at cone 010, and steel hardness develops at cone 7. Less than 10% absorption is developed at cone 9. The fired structure is sound and stony, and the surface texture is smooth. The total linear shrinkage, plastic basis, at cone 13, is 17.7%. Bloating is pronounced at cone 15. The softening point is cone 29–30. The best firing range is from cone 5 to cone 11.

No. 145 (p. 156). Placer County. Lincoln. Lincoln Clay Products Co. "No. 0." This variety of the Lincoln clay contains a large proportion of sand, and enough iron to give buff and pink colors on firing. It effervesces slightly in hydrochloric acid. The plasticity is good, the dry strength is medium-high, and in the dried condition, it is medium soft, medium-grained, and open-textured. The colors are: dry, 17''f; wet, 17''d; cones 010 to 02, 11'f; cones 1 to 5, 13'f; cones 7 to 13, 17'f. Steel hardness is developed at cone 1. Less than 10% absorption appears at cone 9. The fired structure is sound, and consists of sand particles imbedded in a clay ground mass. The fired surface texture is rough, and at high firing temperatures, the surface is mottled. The maximum total linear shrinkage, plastic basis is 17.7% at cone 13. Slight bloating develops at cone 15. The softening point is cone 30–31. The best firing range is from cone 1 to cone 13. The clay is used in face brick mixes, and could be used for the cheaper grades of fire brick, and in terra cotta.

No. 150 (p. 156). Placer County. Lincoln. Lincoln Clay Products Co. "No. 10." For all practical purposes this clay is identical to No. 149 (class 7) although the dry strength is 25% higher, and the porosities are somewhat higher. No blistering can be detected when fired to cone 13, but bloating is apparent at cone 15. The total linear shrinkage, plastic basis, at cone 13, is 20.6%. The softening point is cone 32.

No. 197 (p. 227). Sonoma County. Two miles east of Beltane. This clay, from an undeveloped deposit, has good plasticity, but with a tendency to sponginess, medium-high dry strength, and in the dried condition it has finger-nail hardness, is fine-grained, and open-textured. A tendency to crack during drying was noted. The colors are: dry, yellowish white; wet, 19''f (yellow-buff); cones 06 and 02, 17''f; cone 1, 17''b; cone 3, 17''d. The fired colors are too yellowish for good face-brick effects. Steel hardness was not developed at cone 3, which was the highest temperature studied. The fired structure is sound. The total linear shrinkage, plastic basis, at cone 3, is 12.3%. The softening point is cone 27–28. More data are needed before a prediction of possible uses can be made, but the clay seems worthy of further investigation.

No. 257 (p. 52). Amador County. Ione. Core drill hole No. 62, Arroyo Seco Grant. This is one of the best of the core-drill samples that were tested. The plasticity is good, with a tendency to stickiness, the dry strength is medium high, and in the dried condition it is medium-hard, fine-grained, and close-textured. There is slight effervescence in hydrochloric acid. The colors are: dry, 17''''d; wet, 13''''k; cone 1, nearly white; cones 5 and 9, buff-white; cone 13, 17''f. Steel hardness is developed between cone 1 and cone 5, and less than 10% absorption between cones 9 and 13. The fired structure is sound and stony, and the surface texture is smooth. The total linear shrinkage, plastic basis, at cone 13, is 18.7%. The softening point is cone 31–32. This clay is suitable as a refractory bond clay in fire brick, terra cotta, and tile, and might be used in stoneware bodies.

No. 258 (p. 52). Amador County. Ione. Core drill hole No. 61, Arroyo Seco Grant. This is a sandy clay containing a large proportion of ferro-magnesian mineral grains. The residue on 200-mesh is 18.8%. The plasticity is fair, but sticky, the dry strength is medium, and in the dried condition it is medium-hard, medium-grained, and open-textured. The colors are: dry, grayish white; wet, 1''''f; cones 1 and 5, 17''f; cone 9, 17''d; cone 13, 17''b. At cone 9 and above, numerous slag pits appear. Steel hardness is developed between cones 1 and 5, and less than 10% absorption slightly above cone 5. The fired structure is sound, moderately strong, and granular. The total linear shrinkage, plastic basis, is 14.2%, at cone 13. The softening point is cone 28–29.

No. 263 (p. 159). Placer County. East of Lincoln. Valley View Mine. This is a plastic kaolin that burns nearly white. It contains 1.2% of + 200-mesh material. The plasticity is good, but with a tendency to stickiness, the dry strength is medium high, and in the dried condition it is medium-hard, fine-grained, and close-textured. The colors are· dry, pinkish white; wet, 17''f; cones 08 and 04, 15''f; cone 1, whiter than 17''f; cones 7 and 13, slightly whiter than 17'''f. It can nearly be classed as a white-burning clay. Steel hardness is developed at cone 7 and less than 10% absorption at cone 9 (approx). The fired structure is sound, stony, and smooth-textured. The total linear shrinkage, plastic basis, is 21.4%, at cone 13. The softening point is cone 32–33. This clay is suitable for use in terra cotta, wall tile, and possibly in fire brick.

No. 266 (p. 140). American Refractories Co. "Amreco Fire Clay." This is a sample of fireclay from which the "Amreco" brand fire brick is manufactured. It contains 32.8% of + 200-mesh sand. The plasticity is excellent, the dry strength is medium, and in the dried condition it is medium-hard, medium-grained, and medium-textured. The colors are: dry, 17'''d; wet, 13'''b; cones 010 to 06, 9''f; cone 04, 15''f, first fading with increasing temperature, then becoming more yellowish; cones 11 and 13, 17'''f. Slight mottling is produced at high temperatures by the presence of iron minerals. Steel hardness is developed at cone 9. The fired structure is sound and moderately strong. The surface texture is slightly rough. The total linear shrinkage, plastic basis, at cone 15, is 11.8%. The softening point is cone 32.

No. 272 (p. 163). Riverside County. Alberhill. A. C. & C. Co. "Main Tunnel Hill Blue." See also No. 9 in this class and No. 271 and 274 in class 7. This sample contains more sand and fluxing impurities than the other three samples of "Hill Blue" clay. The percentage of +200-mesh sand is 37.0. The plasticity is good, the dry strength is medium, and in the dried condition it is medium-hard, coarse-grained, and open-textured. There is slight effervescence in hydrochloric acid. The colors are: dry, 13''''f; wet, 15'''''f; cones 010 to 1, 13''f; cones 3 to 9, 17''f; cones 11 and 13, 17''d. Steel hardness and less than 10% absorption are developed at cone 11. A mottled and heterogeneous fired structure is produced by the presence of a large percentage of ferro-magnesian minerals. The fired structure is sound, and the surface texture is rough. The total linear shrinkage, plastic basis, at cone 13, is 9.8%. The softening point is cone 29.

TABLE No. 18.

II. Buff-Burning Clays.

A. Refractory clays, softening point cone 27+.

a. Open-burning, more than 6% apparent porosity at cone 15.

6. Medium to high strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
9	12.6	13.3	25.9	770	24.8	7.7	29
14	11.6	12.4	24.1	420	22.6	6.9	31
27	15.5	14.8	30.3	458	28.6	8.6	30–31
33	10.6	11.4	22.0	550	20.7	6.4	30
34	9.0	13.6	22.6	449	17.5	5.5	31
53	25.2	19.1	44.3	795	42.4	12.3	30
76	13.5	18.1	31.6	240	23.9	7.4	29
78	17.4	19.4	36.8	462	29.1	8.8	29
81	16.7	16.8	33.5	414	30.0	9.1	28
84	11.4	12.7	24.1	326	22.5	7.0	28
92	15.0	13.5	28.5	480	28.8	8.7	28
97	11.8	14.1	25.9	412	22.3	7.0	31
102	9.9	14.0	23.9	271	19.0	6.0	29
108	27.1	13.1	40.2	±1118	52.3	15.0	27–28
130	14.2	22.9	37.1	387	22.5	7.1	27
139	16.5	17.8	34.3	201	28.7	8.7	29–30
145	17.4	21.0	38.4	447	29.1	7.8	30–31
150	20.7	18.5	39.2	337	35.7	10.7	32
197	33.7	31.9	65.6	529	44.9	13.2	28
257	21.8	19.5	41.3	403	36.7	11.0	32
258	9.7	16.1	25.8	217	18.1	5.7	28–29
263	21.5	20.0	41.5	417	36.2	10.8	32–33
266	8.9	15.2	24.1	231	16.4	5.2	32
272	10.2	12.5	22.7	348	19.8	6.2	29

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 19.

II. Buff-Burning Clays.

A. Refractory clays, softening point cone 27+.

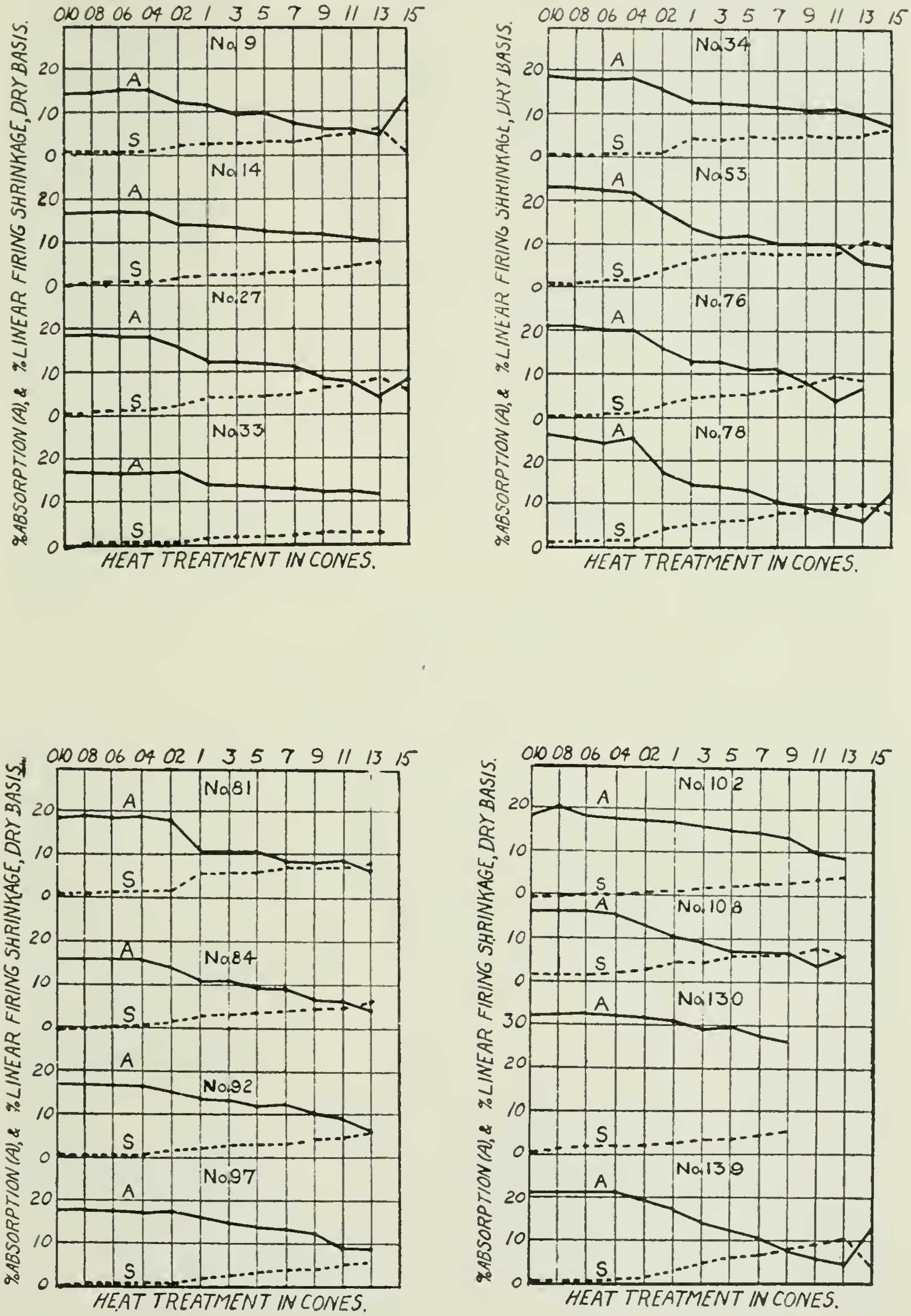
a. Open-burning, more than 6% apparent porosity at cone 15.

6. Medium to high strength.

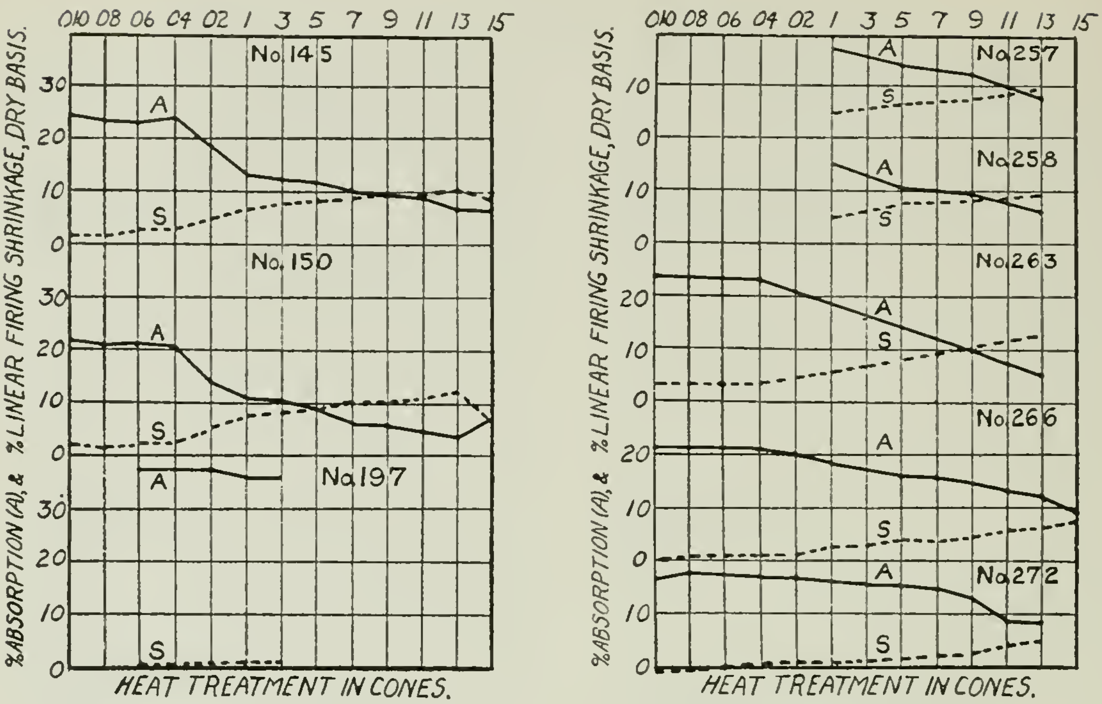
Class No.	Clay No.	Cone 010		Cone 08		Cone 06		Cone 04		Cone 02		Cone 1		Cone 3		Cone 5		Cone 7		Cone 9		Cone 11		Cone 13		Cone 15	
		% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.
6	9	0.6	26.7	1.5	27.0	2.2	27.8	3.0	27.9	7.3	23.2	8.1	22.7	8.7	18.4	10.3	19.9	10.3	15.5	12.8	12.4	15.1	12.8	18.5	10.2	4.5	25.2
	14	0.0	31.0	1.7	31.0	2.0	31.0	2.4	31.5	6.3	27.4	7.5	27.3	7.3	26.5	9.3	24.5	10.8	21.2	10.0	24.0	13.1	22.5	14.4	20.6	------	------
	27	1.0	32.4	2.9	32.6	3.7	32.0	4.7	32.0	7.0	28.6	13.3	23.5	13.5	23.8	14.5	23.4	15.0	22.6	18.3	17.4	19.8	15.2	24.5	8.8	16.2	15.7
	33	—0.3	31.1	+0.3	31.0	+0.6	31.1	+0.6	31.1	+0.7	31.3	5.2	27.4	5.7	27.2	6.0	26.8	6.4	26.1	7.3	25.2	7.3	25.2	8.0	21.5	------	------
	34	2.0	34.2	1.7	32.9	2.4	33.0	2.7	32.6	6.9	30.0	12.0	25.6	12.6	25.2	12.9	24.8	13.4	23.8	15.5	21.8	15.1	22.3	16.5	20.0	18.5	16.7
	53	2.9	36.6	3.7	36.1	4.8	36.0	5.7	35.9	12.4	30.6	18.9	25.3	21.1	22.5	21.0	23.6	21.6	20.0	22.2	20.3	22.4	20.1	27.8	12.0	26.0	11.4
	76	1.5	35.3	1.6	35.4	2.7	34.5	2.6	34.2	9.8	30.0	13.5	24.4	14.6	21.4	16.5	22.0	18.9	20.9	20.3	17.5	23.5	7.5	23.2	13.7	------	------
	78	2.7	38.5	2.5	37.5	3.8	36.6	4.2	37.6	12.1	28.5	15.2	26.3	16.5	25.3	17.7	23.2	21.6	19.0	21.9	17.7	24.0	14.9	26.7	11.7	20.9	22.6
	81	3.3	31.9	3.7	33.4	4.1	32.2	4.6	32.4	6.4	30.1	16.5	21.8	17.0	21.0	17.0	21.2	19.7	16.6	19.7	16.3	19.5	17.1	22.5	13.3	------	------
	84	—0.8	29.4	—0.3	29.2	+0.6	29.0	+0.8	29.4	4.0	26.8	‡8.6	‡21.8	9.1	21.7	*10.7	*18.9	11.1	18.2	13.0	14.1	13.6	12.5	17.0	8.8	------	------
	92	0.9	30.2	0.5	29.8	1.6	30.4	1.1	30.2	5.0	28.2	‡7.4	‡26.0	#7.3	#26.0	*9.1	*23.7	†9.4	†24.2	12.1	20.4	12.9	19.3	17.3	13.4	------	------
	97	—0.1	30.7	+1.4	31.6	1.4	31.5	1.8	31.4	2.6	31.4	4.9	29.9	7.2	27.8	8.6	26.4	9.8	25.6	x10.5	x23.5	13.9	18.2	14.8	17.7	------	------
	102	—1.5	31.9	—0.9	35.5	—0.1	32.8	—0.1	32.0	+1.0	32.3	2.4	30.6	4.6	29.3	5.6	27.8	7.1	27.0	7.0	26.0	10.8	19.8	12.4	18.1	------	------
	108	4.7	29.3	4.4	29.4	4.9	29.5	5.8	28.1	9.6	24.6	13.5	20.8	13.5	19.4	*17.5	*15.3	†17.7	†14.8	18.0	14.3	22.0	8.4	17.1	13.1	------	------
	130	2.4	44.5	4.3	46.0	5.1	46.2	5.3	45.8	6.0	45.7	6.9	45.0	10.2	43.9	10.3	41.4	12.0	42.9	15.2	41.0	------	------	------	------	------	------
	139	1.6	34.5	1.9	34.6	1.8	34.3	2.0	34.5	4.2	33.2	8.6	30.4	13.7	25.4	16.0	23.4	18.3	21.2	22.4	15.5	24.6	11.7	23.3	8.8	13.2	23.4
	145	4.7	38.8	5.0	38.5	6.0	37.7	7.0	38.6	14.0	32.8	21.5	25.6	22.5	24.2	23.0	23.3	24.9	20.4	25.5	19.5	26.4	17.9	28.4	14.6	24.9	12.9
	150	5.5	35.4	4.1	34.2	6.4	35.6	6.3	34.0	15.4	26.5	21.2	21.6	22.4	20.3	24.5	18.2	28.4	13.8	28.8	13.7	29.9	11.1	32.0	9.1	19.0	13.5
	197	------	------	------	------	1.4	47.5	------	------	1.6	47.5	2.1	45.7	2.1	46.2	------	------	------	------	------	------	------	------	------	------	------	------
	257	------	------	------	------	------	------	------	------	------	------	13.6	31.4	------	------	18.5	26.1	------	------	20.9	22.5	------	------	26.4	15.6	------	------
	258	------	------	------	------	------	------	------	------	------	------	15.2	29.0	------	------	22.2	22.2	------	------	23.0	20.9	------	------	25.3	13.0	------	------
	263	------	------	8.6	39.5	------	------	------	------	------	------	16.5	33.6	------	------	------	------	25.7	24.2	------	------	------	------	33.8	11.6	------	------
	266	0.1	36.0	1.7	36.9	1.9	36.9	9.7	38.8	3.4	35.3	6.8	33.3	8.3	32.0	*10.7	*30.5	†11.0	†30.0	13.1	28.2	16.3	25.6	17.2	24.6	20.0	19.8
	272	—0.6	31.0	—0.4	31.9	—0.1	32.0	+1.1	31.5	2.8	30.4	3.1	30.2	3.7	29.4	4.5	29.4	4.7	28.5	6.6	25.5	11.5	17.5	12.2	17.2	------	------

% V. S.=Firing shrinkage, per cent dry volume. % A. P.=Per cent apparent porosity. ‡Cone 1+. *Cone 5+. #Cone 3—. †Cone 7—. xCone 9—.

Absorption and linear shrinkage curves for clays of class 6.



Absorption and linear shrinkage curves for clays of class 6.



b. Dense-Burning, Less Than 6% Apparent Porosity Between Cones 10 and 15.

7. Mainly Medium to High Strength.

No. 13 (p. 163). Riverside County. Alberhill C. & C. Co. "Extra Select Main Tunnel." See also No. 15 and 29 in class 2. This clay is hand sorted from the main tunnel fireclay bed, in order to prepare a grade for the market that has better fired colors than the run-of-mine material, but for some undetermined reason the sample is distinctly inferior as to color, compared to No. 15 and 29. It is used principally in the manufacture of art tile, and to some extent in firebrick. It has excellent plasticity, medium dry strength, and a sandy, open texture in the dry condition. It contains 2.6% of +200-mesh sand. The colors are: dry, 17''''f; wet, 17''''b; cones 010 to 06, 11'f; cone 04, 17''f; cones 02 to 13, 17'''19'''f. Finger-nail hardness is developed below cone 010, and steel hardness is approached at cone 7, but vitrification is not complete until cone 15 is reached. The total linear shrinkage, plastic basis is 14.5% at cone 15. The softening point is cone 29–30. The best firing range is from cone 7 to cone 15.

No. 39 (p. 203). San Diego County. Near Carlsbad. Pacific Clay Products Co. "Kelley Ranch White." This is a buff-burning clay with excellent plasticity, suitable for the manufacture of face brick and fire brick. It contains 2.6% of +200-mesh sand, has medium dry strength, and in the dry state it is soft, fine-grained, and dense. The colors are: dry, 11''; wet, 5''; cones 010 to 04, 7''f; cone 02, 5''f; cone 1, 9''f; cone 3, 13''f; cones 5 and 7, 17''f; cones 9 and 11, 17''d; cone 13, 15''d. A pleasing assortment of buffs, creams, and yellow-browns is obtained by varying the firing conditions. Finger-nail hardness is obtained below cone 010, and steel hardness develops at cone 1. The fired structure is sound, fine-grained, and above cone 1, it is stony.

The total linear shrinkage, plastic basis, at cone 15 is 17.9%. The softening point is cone 29. The best firing range is from cone 1 to cone 15.

No. 56. German fireclay, used by Atlas Fire Brick Co. This is a fine-grained clay with a smooth and strong plasticity, medium-high dry strength, and a hard, fine-grained, close-textured dry condition, with a slight tendency to laminate. It contains 2.8% of +200-mesh sand. The colors are: dry, whiter than 17''''f wet, 17''''f; cones 010 to 1, somewhat whiter than 17'''f; cones 3 and 5, 19''f; cones 7 to 13, 17'''f. The fired structure is stony, and with the firing schedule used, one or more large cracks developed in many of the test pieces. Finger-nail hardness develops below cone 010, and steel hardness at cone 06. Absorptions below 10.0% appear at cone 1. The total linear shrinkage, plastic basis, at cone 13, is 11.9%. The softening point is cone 27. The best firing range is from cone 06 to cone 13 and above. The clay is particularly well suited for use as a firebrick bond.

No. 80 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Plastic Pink and Yellow." This is a buff and gray-burning refractory clay, containing but 2.6% of +200-mesh sand, and with smooth and strong plasticity. The dry strength could not be accurately determined without adding sand, as incipient lines of weakness are developed during air-drying. With 50% of —20-mesh to +30-mesh Ottawa sand, the bonding strength is 56 lb. per sq. in. In the dried condition, it is medium soft, fine-grained, and close textured. The colors are: dry, 13''d; wet, 13''; cones 010 to 04, 7'd; cones 02 to 5, 7''d; cone 7, 9'''f; cones 9 to 13, 17''''f. Steel hardness is developed below cone 010, absorptions of less than 10% are present at cone 3 or above, and vitrification is complete at cone 9. All fired test pieces are severely shattered, and broken into several pieces. The fired structure is stony and brittle. The maximum total linear shrinkage, plastic basis, was noted at cone 9, 25.0%, but on account of the serious shattering of the test pieces at cones 11 and 13, which invalidated the accuracy of measurement, it is likely that the true value of the shrinkage at these latter temperatures is higher than at cone 9. The softening point is cone 33. The clay is similar in many respects to No. 273 in class 3 (Alberhill S11—4), except that it contains more iron. It is a useful bond clay in buff-burned ware, but can not be used alone.

No. 83 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Main Pit Red." This is a plastic, light-red-burning clay of value in the manufacture of roofing tile, face brick, hollow building tile, and similar products. It contains 11.6% of +200-mesh sand, and has a smooth and strong plasticity. The dry strength is medium, and the dried condition is medium hard, dense, and fine-grained. The colors are: dry, 5''b; wet, 5''; cones 010 to 02, 5'd; cones 1 to 5, 7'd; cones 7 to 13, 11''d. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Absorptions below 10% appear at cone 5. The fired structure is dense and stony, and is sound up to cone 3. At higher temperatures, the test pieces are broken into two or three pieces. The total linear shrinkage, plastic basis, at cone 13, is 18.3%. The softening point is cone 29. The best firing range is from cone 1 to cone 5, but slow firing to cone 13 will doubtless result in sound structures and thorough vitrification.

No. 85 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Pink Mottled." This is a plastic, buff-burning clay that has wide uses in sewer-pipe, hollow-tile, pottery, flower pot, and face brick mixes. The plasticity is excellent, the dry strength is medium, and the dry condition is soft and fine-grained. It contains 3.4% of +200-mesh sand. A tendency to laminate was noted. The colors are: dry, 7″d; wet, 9″b; cones 010 to 04, 9′b; cone 02, 7′d; cones 1 to 5, 7′f; cone 7, 11′f; cones 9 to 13, 13′f. Finger-nail hardness is developed below cone 010, and steel hardness at cone 1. Less than 10% absorption is present at cone 7. The total linear shrinkage, plastic basis, at cone 13, is 18.3%. The softening point is cone 31–32. The best firing range is above cone 1.

No. 101 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Sloan White." This is a buff-burning face brick or fire brick clay with excellent plasticity, medium dry strength, and a medium hard, fine-grained, close-textured, dry condition. It contains 7.0% of +200-mesh sand. The colors are: dry, 17‴f; wet, 17⁗d; cones 010 to 02, 9″d; cone 1, 13″f; cones 3 to 11, 17″f; cone 13, 17″d. Finger-nail hardness appears below cone 010, and steel hardness develops at cone 3. The fired condition is sound, stony, and smooth-textured. The total linear shrinkage, plastic basis, at cone 15 is 17.5%. The softening point is cone 30.

No. 110 (p. 176). Riverside County. Alberhill. P. C. P. Co. "Douglas." This is a plastic fireclay, similar to No. 104 (class 5) but not quite so refractory. It is also related to No. 27 (class 6) and No. 273 (class 3), but differs from these in several important respects, as will be noted by a close study of the data. It contains 3.4% of +200-mesh sand. The plasticity is very good, the dry strength is medium, and the dried condition is medium-hard, fine-grained, and close-textured. The colors are: dry, 13⁗b; wet, 13⁗; cones 010 to 02, 7″d; cones 1 and 3, 7″f; cone 5, 17″f; cones 7 to 11, 21‴f; cone 13 slightly darker than cone 11. Steel hardness develops at cone 06. Absorptions below 10% develop at cone 3 and above. All fired test pieces are badly shattered, and broken into two or more pieces. The texture is smooth, and peppery with finely divided specks of iron. The total linear shrinkage, plastic basis, at cone 13, is 22.5%. Slight bloating was noted at cone 15. The softening point is cone 32–33. The clay is used for stoneware and pressed brick.

No. 133 (p. 63). Amador County. Ione (Carbondale). Yos. P. C. Co. "Harvey Clay." This is a buff-burning fireclay with good plasticity, medium-low dry strength, and a medium-hard, fine-grained, close-textured dried condition. It contains 6.8% of +200-mesh sand. The colors are: dry, 9⁗f; wet, 5⁗d; cones 010 to 06, 13″f; cones 04 to 1, 17‴f; cones 3 to 7, 19″f; cone 9, 21‴f; cones 11 and 13, 17⁗f. Steel hardness develops at cone 1, and less than 10% absorption at cone 3. The fired structure is stony and sound, except at cones 11 and 13, at which small tension cracks appear. Blistering is noticeable at cone 13. The maximum total linear shrinkage, plastic basis, is 24.5% at cone 11. The softening point is cone 33. The best firing range is from cone 1 to cone 11. The clay may be used in fire brick, terra cotta, face brick, etc.

No. 149 (p. 156). Placer County. Lincoln. Lincoln Clay Products

Co. "No. 9." This clay is similar to No. 146 in class 8, but does not vitrify so completely at cones 9 to 13, nor can blistering be detected at cone 13, but bloating is apparent at cone 15. The total linear shrinkage, plastic basis, at cone 13, is 19.9%. The softening point is cone 31–32.

No. 153 (p. 147). Placer County. Lincoln. Clay Corporation of California. See No. 152 and 280 in class 8. This sample has lower refractoriness, slightly more sand, and more coloring matter than No. 152. It contains 25.0% of +200-mesh sand. The plasticity is excellent, the dry strength is medium-high, and in the dried condition it is medium-hard, medium-grained, and open-textured. The colors are: dry, 21‴f; wet, 19″d; cones 010 to 1, 11′d; cones 3 and 5, 15″d; cones 7 to 13, 17″d. Steel hardness is developed at cone 1. Less than 10% absorption appears at cone 7. The fired structure is sound, stony, and the fired surface texture is slightly rough. The maximum total linear shrinkage, plastic basis, is 21.0% at cone 11. The softening point is cone 30. The best firing range is from cone 1 to cone 11.

No. 156 (p. 151). Placer County. Lincoln. Gladding, McBean & Co. "Fire-proofing Clay." This is a plastic, low-grade buff-burning fireclay that is used in various bodies to increase the refractoriness of the mixture. It contains 8.4% of +200-mesh sand. The plasticity is good, the dry strength is medium-high, and in the dried condition, it possesses finger-nail hardness, is fine-grained, and close-textured. The colors are: dry, 17″d; wet, 17″b; cones 010 to 5, 11′d; cones 7 and 9, 17‴d; cones 11 and 13, 17‴b. Steel hardness is developed at cone 02. Less than 10% absorption appears at cone 1. The fired structure is sound and stony. Slight blistering appears when fired under neutral or reducing conditions to cone 11 and 13. The fired surface texture is slightly rough. The maximum total linear shrinkage, plastic basis, is 18.9%, at cone 9. The softening point is cone 28–29. The best firing range is from cone 02 to cone 9.

No. 204 (p. 151). Calaveras County. Valley Springs. California Pottery Co. "Blue Plastic." The properties of this clay are closely similar to those of No. 203, in class 14, but it contains less iron, which results in lighter fired tones, and in greater refractoriness. It contains 1.0% of +200-mesh material. The colors are: dry, 17″d; wet, 17″b; cones 010 to 04, 9″d; cones 02 to 7, 13″d; cone 9, 15″d. The total linear shrinkage, plastic basis, is 18.4%, at cones 11 and 13. The softening point is cone 27. This is an excellent clay for buff-burned face brick and roofing tile.

No. 213 (p. 59). Amador County. Ione. Eckland pit. This is a buff-burning clay with smooth and strong plasticity, and medium-low dry strength. In the dried condition it is medium-hard, fine-grained, and close-textured. The residue on 200-mesh is 12.6%. The colors are: dry, 13″d; wet, 15″; cones 010 to 02, 11′d; cones 1 to 7, 13″f; cones 9 to 13, 17″d; strongly mottled with iron specks. Steel hardness is developed at cone 3, and less than 10% absorption at cone 13. The fired structure is sound and stony, except at cones 11 and 13, when a few large cracks appear in the fired test pieces. The surface texture is smooth until cone 9 is reached, when the reduction of the non-plastic ferro-magnesian minerals causes a pitted surface. The total linear shrinkage, plastic basis, at cone 13, is 22.1%. The softening point is cone 31. The best firing range is from cone 3 to cone 8. The clay is suitable for face brick and faience tile mixes, and could be used in some fire brick mixes.

No. 229 (p. 174). Riverside County. Alberhill. L. A. B. Co. "No. 7 Pit." This is a buff-burning plastic fireclay that is suitable for face brick or fire brick manufacture. There is slight effervescence in hydrochloric acid. It contains 0.8% of +200-mesh sand. The plasticity is smooth and strong, the dry strength is medium-low, and in the dried condition it is medium-hard, fine-grained and close-textured. The colors are: dry, 9″d; wet, 7″b; cones 010 to 06, 5′f; cones 04 to 3, 5″f; cones 5 to 9, 17″f; cones 11 and 13, 17″d. Steel hardness is developed at cone 1, and less than 10% absorption at cone 9. The fired structure is sound and stony, and the surface texture is smooth. The total linear shrinkage, plastic basis, at cone 13, is 20.4%. Slight bloating appears at cone 15. The softening point is cone 32.

No. 230 (p. 174). Riverside County. Alberhill. G., McB. & Co. East Pit. "No. 9 Clay." This is a buff-burning refractory clay with smooth and strong plasticity, and medium-high dry strength. It contains 2.0% of +200-mesh sand. In the dried condition it is medium-hard, fine-grained, and close-textured. The colors are: dry, 13″″d; wet, 17″″d; cones 010 to 04, pinkish white; cones 02 to 7, yellowish white; cones 9 and 11, 19″f; cone 13, 17‴d. Steel hardness is developed at cone 02, and less than 10% absorption appears below cone 5. The fired structure is stony, and all test pieces are broken into two or more pieces by fracturing. The total linear shrinkage, plastic basis, at cone 13, 17.5 %. The softening point is cone 32–33. The clay can not be used alone, but when mixed with non-plastic material, it is an excellent clay for face brick, fire brick, and terra cotta.

No. 245 (p. 52). Amador County. Ione. Core drill hole No. 55–1. Arroyo Seco Grant. This is a buff-burning clay with good, but sticky, plasticity and medium dry strength. In the dried condition it is soft, friable, fine-grained, and close-textured. The colors are: dry, buff-white; wet, 17″″f; cone 1, 19″f; cones 5 and 9, 17″d; cone 13, 15″i. Steel hardness develops below cone 1, and less than 10% absorption between cone 1 and cone 5. The fired structure is sound and stony, and the surface texture is smooth. The total linear shrinkage, plastic basis, at cone 13, is 19.0%. The softening point is cone 30–31. It could be used in face brick, terra cotta, tile, and fire brick.

No. 246 (p. 52). Amador County. Ione. Core drill hole No. 55–3, Arroyo Seco Grant. The plasticity is good, but sticky; the dry strength is medium, and in the dried condition it is soft, friable, fine-grained, and close-textured. The colors are: dry, grayish white; wet, 15″‴f; cones 1 and 5, 19″f; cone 9, 17″″f; cone 13, 17″″d. Steel hardness is developed below cone 1, and less than 10% absorption is produced between cone 1 and cone 5. The fired structure is sound and stony, and the surface texture is smooth. The total linear shrinkage, plastic basis, at cone 13, is 16.7%. The softening point is cone 29.

No. 247 (p. 52). Amador County. Ione. Core drill hole No. 55–2, Arroyo Seco Grant. This is similar to No. 246, but has greater shrinkage, a higher softening point, and effervesces slightly in hydrochloric acid. The total linear shrinkage, plastic basis, at cone 13, is 19.5%. The softening point is cone 32.

No. 248 (p. 52). Amador County. Ione. Core drill hole No. 56–1, Arroyo Seco Grant. The plasticity is good, the dry strength is medium high, and in the dried condition it is medium-hard, fine-grained, and close-textured. A part of the sample consists of soft grains of partly kaolinized matter that is not rendered plastic by the usual methods of preparation. This results in a heterogeneous structure. The colors are: dry, 17‴f; wet, 17‴d; cones 1 and 5, 17″d; cones 9 and 13, 17⁗b. Steel hardness is developed below cone 1, and less than 10% absorption appears between cone 1 and cone 5. Blistering is noticeable at cone 13. The maximum total linear shrinkage, plastic basis, is 21.1%, at cone 9. The softening point is cone 30–31. It is suitable for the manufacture of terra cotta and tile, but is not suitable for making a good fire brick.

No. 249 (p. 52). Amador County. Ione. Core drill hole No. 56–2, Arroyo Seco Grant. This is very similar to No. 245, and does not require a separate description. The total linear shrinkage, plastic basis, is 18.2% at cone 13. The softening point is cone 30–31.

No. 253 (p. 52). Amador County. Ione. Core drill hole No. 57–3, Arroyo Seco Grant. This is similar to No. 136 (class 8) and 240 (class 4), with the differences as noted. There is slight effervescence in hydrochloric acid. The colors are: dry, pinkish white; wet, yellowish white; cone 1, nearly white; cones 5 and 9, 19″f; cone 13, 17‴b. Steel hardness and less than 10% absorption are developed between cones 1 and 5. No firing cracks were noted. The total linear shrinkage, plastic basis, is 21.5%, at cone 13. The softening point is cone 31–32.

No. 254 (p. 52). Amador County. Ione. Core drill hole No. 57–4, Arroyo Seco Grant. This sample contains more coloring matter and more non-plastic ferro-magnesian minerals than No. 253. There is slight effervescence in hydrochloric acid. The plasticity is good, the dry strength is medium, and in the dried condition it is soft, fine-grained, and open-textured. The colors are: dry, 17″f; wet, 17‴f; cone 1, 15″f; cone 5, 17‴d; cone 9, 17⁗d; cone 13, 17‴b. Steel hardness appears below cone 1, and less than 10% absorption is developed between cone 1 and cone 5. The fired structure is sound and stony, except that at cone 13, one large crack developed in the test piece. Blistering is noted at cone 13. The maximum total linear shrinkage, plastic basis, is 21.6%, at cone 9. The softening point is cone 31. This is a suitable clay for face brick, terra cotta and tile.

No. 271 (p. 163). Riverside County. Alberhill. Alberhill Coal & Clay Co. "Lower Tunnel, Hill Blue." See also No. 9 and 272 in class 6, and No. 274 in this class. The plasticity of No. 271 is smooth and strong, the dry strength is medium-high, and in the dried condition it is hard, fine-grained, and close-textured. It contains 2.0% of +200-mesh sand. There is slight effervescence in hydrochloric acid. The colors are: dry, 13⁗ f; wet, 5⁗f; cones 010 to 9, 17″f; cones 11 and 13, 21⁗d. Steel hardness is developed at cone 1, and less than 10% absorption at cone 5. One or two of the test pieces show small cracks, otherwise the fired structure is sound and stony, and the surface texture is smooth. The total linear shrinkage, plastic basis, is 17.8%, at cone 13. The softening point is cone 31–32. For uses, see No. 9, in class 6.

No. 271 (p. 163). Riverside County. Alberhill. A. C. & C. Co. "Upper Tunnel Hill Blue." See also No. 9 and 272 in class 6, and No. 271 above. No. 274 is intermediate between No. 271 and 272 in its content of sand and its ceramic properties. The dry strength is medium. There is no effervescence in hydrochloric acid. The sample contains 11.4% of +200-mesh sand. The colors are: dry, 1''''f; wet, 15''''b; cones 010 to 06, 15''f; cones 04 to 9, 17''f; cones 11 and 13, 17''d. Steel hardness is developed at cone 5, and less than 10% absorption at cone 9. The fired structure is sound, slightly heterogeneous, and the surface is slightly rough. The total linear shrinkage, plastic basis, at cone 13, is 19.8%. The softening point is cone 30. This is a suitable clay for fire brick, face brick and terra cotta.

c. Dense-Burning, Less Than 6 Per Cent Apparent Porosity Between Cones 5 and 10.

8. Medium to High Strength.

No. 121 (p. 53). Amador County. Ione. Arroyo Seco Grant. Jones Butte. Leased by Stockton Fire Brick Co. "Unctuous Clay." The available quantity of this clay is insufficient for commercial production, but a sample was tested as a matter of general interest. It has a smooth and strong plasticity, medium dry strength, and in the dried condition it is medium-hard, fine-grained and close-textured. The colors are: dry, nearly white; wet, 21'''f; cones 010 to 06, pinkish white; cones 04 to 9, yellowish white; cones 11 and 13, 1'''f. Steel hardness is developed at cone 04. Less than 10.0% absorption appears at cone 5. The fired test pieces are stony below cone 11, and glassy at cone 11 or above. They are sound, but seriously warped. The total linear shrinkage, plastic basis, at cone 13, is 25.6%. The softening point is cone 33. The clay is closely similar to some of the varieties that are mined at Lincoln, Placer County, especially No. 146, *post*.

No. 124 (p. 56). Amador County. Ione (Carbondale). Leased by G. A. Starkweather. "Yaru No. 1." This is a pink-and-cream burning clay with smooth, moderately-strong plasticity and medium dry strength. It contains 1.0% of +200-mesh sand. The dried condition is soft, "soapy," fine-grained and open-textured. A strong tendency to warp and to laminate was noted. The colors are: dry, 21'''f; wet, 21'''d; cones 010 to 04, 9'f; cone 02, 17''f; cones 1 to 7, 17''d; cones 9 to 13, 19''f. Steel hardness is developed at cone 1. Less than 10% absorption appears at cone 3. The fired structure is generally sound, but a few pieces split in firing. The total linear shrinkage, plastic basis, at cone 13, is 20.8%. The softening point is cone 32. The best firing range is above cone 1. The clay is suitable for fire brick, terra cotta, stoneware, etc.

No. 136 (p. 58). Amador County. Ione (Clarksona). N. Clark and Sons. "Dosch." This clay has been well known for many years in the pottery, stoneware, and terra cotta industries. It contains but 1.2% of +200-mesh sand. It is smooth and has strong plasticity, medium dry strength, and in the dried condition it is medium-hard, fine-grained, and close-textured. The colors are: dry, yellowish white; wet, 17‴f; cone 010, 17″f, becoming nearer to white with increasing firing temperature, approximating 19″f at cone 3; cones 11 and 13 (flashed) 17‴. Steel hardness appears at cone 1, and less than 10% absorption at cone 3. The fired structure is sound, stony and smooth-textured. The maximum total linear shrinkage, plastic basis is 21.0% at cone 13. Slight bloating was noted at cone 15. The softening point is cone 31. The best firing range is from cone 1 to cone 13. The clay can be cast and jiggered.

No. 146 (p. 156). Placer County. Lincoln. Lincoln Clay Products Co. "No. 1–6." This is the best known variety of Lincoln clay at the present time. It is shipped to all parts of the Pacific Coast for use in stoneware, pottery, faience tile, terra cotta, fire brick, and other purposes. It is an excellent clay for casting and jiggering. The plasticity is smooth and strong, and it contains but 0.6% of +200-mesh sand. The dry strength is medium, and in the dried condition it is soft, fine-grained and close-textured, with a talcy feel. The colors are: dry, buff-white; wet, 17″d; cones 010 to 04, 11″f; cone 02, 13″f; cones 1 and 3, 17″f; cone 5, 17′f; cones 7 and 9, 21‴f; cone 11, 17⁗f; cone 13, 13⁗f. Steel hardness is developed at cone 1. Less than 10% absorption appears at cone 3, and vitrification is complete at cone 9. Slight blistering is noticeable on test pieces fired under reducing or neutral conditions at cones 11 to 15. The fired structure is sound and stony. The maximum total linear shrinkage, plastic basis, is 21.5%, at cone 11. The softening point is cone 31–32. The best firing range is from cone 1 to cone 11. The long vitrification range, the excellent plasticity, and the ability to withstand abuse in drying and firing, are the important advantages that this clay possesses to a greater degree than any other clay in the state that is available in commercial quantities to the entire industry. The same is true of No. 280, see *post*.

No. 147 (p. 156). Placer County. Lincoln. Lincoln Clay Products Co. "No. 7." This clay is very similar to No. 146, but fires to slightly darker tones. It is used in faience tile, face brick, and sewer-pipe mixes, but is not quite as suitable for casting and jiggering as No. 146. The colors are: dry, 9″d; wet, 13‴b; cones 010 to 04, 5′f; cones 02 and 1, 11″f; cone 3, 15″f; cone 5, 17″f; cones 7 and 9, 17‴f; cone 11, 17⁗f; cone 13, 13⁗d. Steel hardness is developed at cone 1, and less than 10% absorption is developed at cone 3. Vitrification is complete at cone 9—, and blistering is well developed at cone 13. The maximum total linear shrinkage, plastic basis, is 21.4%, at cone 11. The softening point is cone 31.

No. 151 (p. 156). Placer County. Lincoln. Lincoln Clay Products Co. "Washed China Clay." This sample was supplied by Mr. Dillman from a warehouse stock of some material that was prepared some years ago by washing the No. 1–6 (sample No. 146) clay, in an attempt to produce a china clay for the local market. The color was improved slightly by this treatment, but not sufficiently to permit the use of the clay as a substitute for English china clay, and the shrinkage was increased greatly beyond the already high shrinkage of the crude clay. Slight blistering appears at cone 11. The maximum total linear shrinkage, plastic basis, is 25.6%, at cone 9. The softening point is cone 30.

There is slight effervescence in hydrochloric acid. Scumming was not noticed, as in the majority of the crude Lincoln and Ione clays, but no special tests were made to determine if washing had completely removed the vanadium salts which have been stated to be the cause of scumming of these clays.[1]

No. 152 (p. 147). Placer County. Lincoln. Clay Corporation of California. This sample of plastic fire clay, together with No. 153 (class 7), was taken from the pit approach during the preliminary development of this property. The test results should be compared with those of No. 280, which sample was supplied by the company from the warehouse after full-scale production had been reached. No. 152 has excellent plasticity, medium-high dry strength, and in the dried condition it is soft, fine-grained, and open-textured. It contains 23.6% of +200-mesh sand. The colors are: dry, nearly white, wet, 17‴f; cones 010 to 02, pinkish white; cones 1 to 7, 17′f; cones 9 to 13, 17‴f. Steel hardness appears at cone 1. Less than 10% absorption is developed at cone 1. Slight blistering is apparent at cone 13. The fired structure is stony, and most of the fired test pieces contain one or more large cracks, some of which cause rupture of the test piece into two or more fragments. The maximum total linear shrinkage, plastic basis, is 26.4%, at cone 11. The softening point is cone 33. It was stated by the company that as a rule the softening point of this clay is below cone 29, so that the sample obtained for testing may not be representative.

No. 157 (p. 151). Placer County. Lincoln. Gladding, McBean & Co. "Terra Cotta Clay." This corresponds to No. 146, and is used as the basis for terra cotta and faience tile body mixes. It contains 2.2% of +200-mesh sand. The plasticity is excellent, the dry strength is medium, and in the dried condition it is medium-hard, fine-grained, and close-textured. The colors are: dry, 17″f; wet, 17″d; cones 010 to 1, 11″f; cones 3 to 9, 17″d; cones 11 and 13, 17‴d (flashed). Steel hardness is developed at cone 04, and less than 10% absorption appears at cone 3. The fired structure is sound and stony, except that a few small cracks appeared in some test pieces during firing. The fired surface texture is smooth. Slight blistering is noticeable at cone 13. The maximum total linear shrinkage, plastic basis, is 23.6%, at cone 13. The softening point is cone 32–33.

No. 175 (p. 65). Butte County. Oroville. Table Mountain Clay Products Co. This is a plastic, buff-burning clay from the Ione formation. The plasticity is smooth and strong, the dry strength is medium, and in the dried condition it is soft, "talcy," fine-grained, and close-textured. It contains 2.4% of +200-mesh sand. The colors are: dry, 17″f; wet, 15″d; cones 010 to 04, 7′f; cone 02, 11′f; cones 1 to 5, 15′d; cones 7 and 9, 15″d; cones 11 and 13, 17‴b. Steel hardness is developed at cone 02, and less than 10% absorption at cone 1. The fired structure is stony, and the surface texture is exceptionally smooth. Up to cone 7, all test pieces are sound, and at cone 7 and above, each test piece is fractured into two or more fragments. The total linear shrinkage, plastic basis, at cone 13, is 18.9%. Bloating is pronounced at cone 15. The softening point is cone 30–31. The best firing range is from

[1] See Curry, E. R., Notes on Green Scumming: Jour. Am. Cer. Soc., Vol 9, p. 392, 1926.

cone 02 to cone 13. Since the sample was taken near the surface during the preliminary development of the property, it may not be representative. The clay is suitable for the manufacture of fire brick, roofing tile, terra cotta, and for any pottery or decorative tile in which the buff color is not objectionable.

No. 201 (p. 69). Calaveras County. Helisma. This is a plastic, buff-burning clay from the Ione formation. The plasticity is smooth and strong, the dry strength is high, and in the dried condition it has finger-nail hardness, is fine-grained, and close-textured. The sample contains 11.4% of +200-mesh sand. The colors are: dry, 17‴f; wet, 17‴f; cones 010 to 04, 17″f; cones 02 and 1, 17″d; cones 3 to 6, 17″b; cones 9 to 13, 17‴. Steel hardness and 10% absorption are developed at cone 04. The fired structure is tough, stony and sound, except at cones 11 and 13, where large cracks appear. Vitrification is complete at cone 9, above which temperature bloating begins, but the softening point is cone 28. The maximum total linear shrinkage, plastic basis, is 21.5% at cone 9. The clay is suitable for the manufacture of face brick.

No. 252 (p. 52). Amador County. Ione. Core drill hole No. 57–2, Arroyo Seco Grant. This sample is similar to No. 245 and 249, in class 7, with the important differences as noted below. The colors are: dry, 17″f; wet, 17‴f; cone 1, 13″f; cone 5, 17‴f; cone 9, 17‴d; cone 13, 17⁗d. Slight blistering is noted at cone 13. The maximum total linear shrinkage, plastic basis, is 22.4%, at cone 9. The softening point is cone 32–33.

No. 280 (p. 147). Placer County. Lincoln. Clay Corporation of California. See also No. 153 and 146. The plasticity is excellent, the dry strength is medium-high, and in the dried condition it is medium-hard, close-grained, and fine-textured The bonding strength, with 50% Ottawa sand from —20 to +30-mesh, is 211 lb. per sq. in. It contains 11.2% of +200-mesh sand. There is slight effervescence in hydrochloric acid. The colors are: dry, nearly white; wet, 17‴f; cones 010 to 04, 7′f; cones 2 to 5, 7″f; cones 7 to 13, 21⁗d. Steel hardness is developed at cone 02, and less than 10% absorption at cone 1. The fired structure is stony, and is sound up to cone 9. At cones 11 and 13, a few cracks are noted, and there is slight blistering. The surface texture is smooth. The maximum total linear shrinkage, plastic basis, is 20.3%, at cone 9. The softening point is cone 30–31. The clay is used by the Stockton Fire Brick Co. in the manufacture of fire brick and refractory cement, and is marketed to tile manufacturers and others.

TABLE No. 20.

II. Buff-Burning Clays.

A. Refractory clays, softening point cone 27+.

b. Dense-burning, less than 6% apparent porosity between cones 10 and 15.

7. Mainly medium to high strength, but also including some clays of low strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Soften-ing pt. in cones
13	12.4	15.9	28.3	255	22.4	7.0	29–30
39	14.7	18.1	32.8	257	25.5	7.8	29
56	13.1	10.9	24.0	628	26.4	8.1	27
80	17.0	24.8	41.8	Erratic	27.1	8.2	33
83	12.8	17.5	30.3	230*	22.8	7.2	29
85	16.3	17.7	34.0	245	28.6	8.6	31–32
101	16.5	17.1	33.6	355	30.0	9.1	30
110	20.3	20.6	40.9	200–400	34.2	10.3	32–33
133	22.4	21.5	47.9	140	34.6	10.4	33
149	18.6	18.8	37.4	260	32.5	9.8	31–32
153	20.7	21.8	42.5	616	33.7	10.2	30
156	20.3	17.1	37.4	670	36.1	10.8	28–29
204	17.1	17.7	34.8	280	29.9	9.1	27
213	15.5	23.8	39.3	105	24.7	7.6	31
229	17.0	18.4	35.4	181	29.7	9.1	32
230	15.4	18.4	33.8	±419	27.4	8.3	32–33
245	19.6	17.2	36.8	335	34.5	10.4	30–31
246	15.2	17.2	32.4	328	26.8	8.2	29
247	18.1	20.7	38.8	309	30.4	9.2	32
248	27.3	16.4	43.7	±680	48.4	14.1	30–31
249	18.7	16.8	35.5	±395	33.8	10.2	30–31
253	20.2	20.5	40.7	204	33.3	10.1	31–32
254	19.6	21.8	41.4	±251	32.2	9.7	31
271	17.0	17.5	34.5	531	30.4	9.2	31–32
274	19.1	15.4	34.5	444	35.1	13.4	30

* Bonding strength with 50% Ottawa sand (— 20–, + 30-mesh) is 56 lb. per sq. in.

c. Dense-burning, less than 6% apparent porosity between cones 5 and 10.

8. Medium to high strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Soften-ing pt. in cones
121	27.4	20.7	48.1	340	45.3	13.2	33
124	17.4	19.6	37.0	219	29.4	8.9	32
136	20.9	20.1	41.0	270	35.4	10.6	31
146	19.7	19.1	38.8	239	34.0	10.3	31–32
147	20.5	18.7	39.2	284	35.6	10.7	31
151	29.5	28.4	37.9	301	43.4	12.8	30
152	26.8	22.6	49.4	710	43.0	12.8	33
157	20.2	22.1	42.3	379	33.2	10.1	32–33
175	15.4	17.1	32.5	369	27.5	8.3	30–31
201	23.2	18.2	41.4	894	40.2	11.9	28
252	17.6	21.1	38.7	296	29.2	8.9	32–33
280	19.5	20.7	40.2	466*	33.1	10.0	30–31

* Bonding strength with 50% Ottawa sand (— 20–, + 30-mesh) is 211 lb. per sq. in.

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P = Per cent water of plasticity.
D.T.S = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 21. II. Buff-Burning Clays.

A. Refractory clays, softening point cone 27+.

b. Dense-burning, less than 6% apparent porosity between cones 10 and 15.

7. Mainly medium to high strength, but also including some clays of low strength.

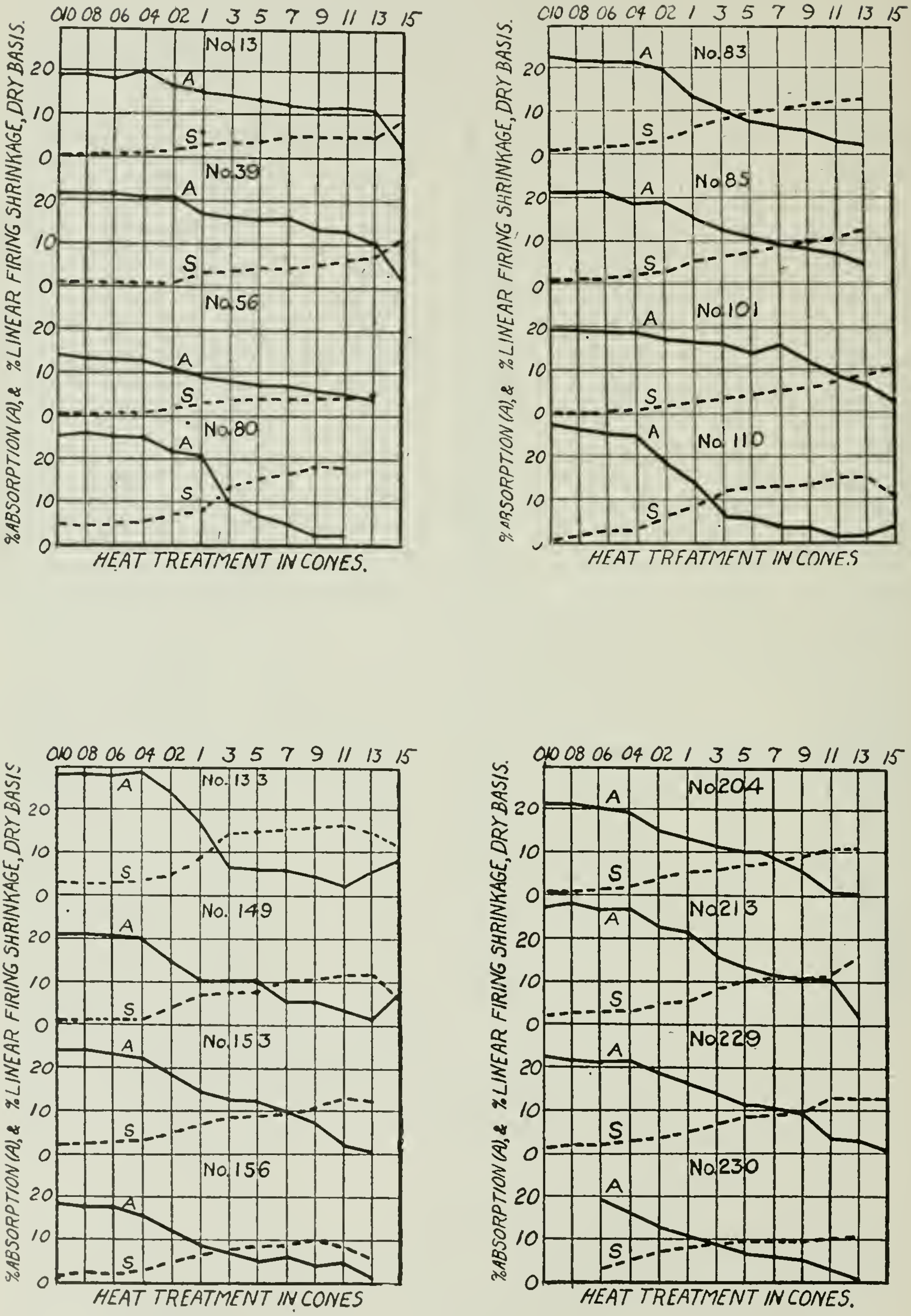
c. Dense-burning, less than 6% apparent porosity between cones 5 and 10.

8. Medium to high strength.

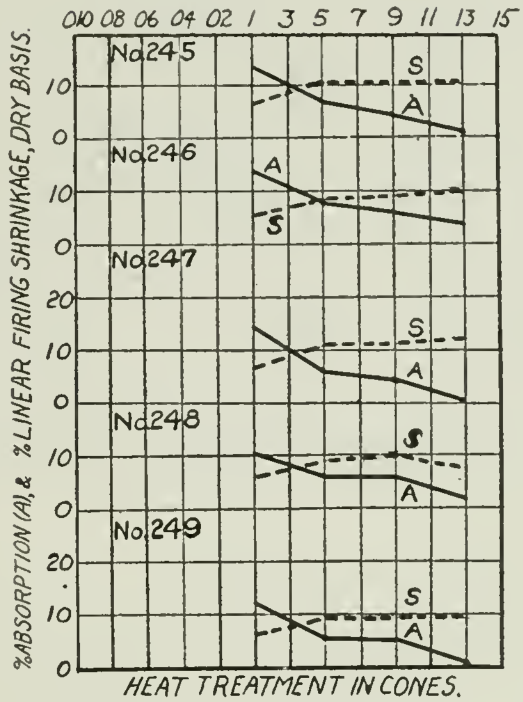
Class No.	Clay No.	Cone 010		Cone 08		Cone 06		Cone 04		Cone 02		Cone 1		Cone 3		Cone 5		Cone 7		Cone 9		Cone 11		Cone 13		Cone 15	
		% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.
7	13	+1.0	32.1	1.2	32.8	1.9	31.0	2.8	34.1	5.3	30.0	8.1	27.2	9.8	26.6	10.5	24.2	13.6	23.3	13.8	22.3	13.7	22.1	14.3	21.0	23.4	5.3
	39	3.1	35.0	3.1	35.3	3.0	35.0	3.3	34.7	3.5	34.9	10.3	30.2	11.9	29.0	13.2	28.2	13.7	30.8	16.4	25.0	17.6	24.2	20.5	21.2	30.6	4.4
	56	1.5	26.4	1.4	26.0	2.1	26.0	2.1	25.7	6.0	22.2	9.3	19.5	10.9	17.0	*11.1	*14.8	†11.5	†15.6	11.5	12.8	12.2	11.2	13.7	8.2	......	......
	80	14.2	41.2	14.4	42.0	14.8	41.3	15.5	41.5	20.6	38.4	22.0	37.0	36.3	20.6	40.8	16.6	42.7	11.3	46.5	5.8	45.4	5.7	......	......	......	......
	83	1.7	37.7	2.3	36.3	4.7	37.3	4.8	37.0	7.4	35.7	17.2	26.8	22.2	21.0	24.8	17.2	28.2	13.2	x28.8	x12.2	32.2	5.9	32.8	5.2	......	......
	85	2.2	34.4	3.2	34.8	3.3	34.6	6.0	33.2	7.0	33.0	14.4	26.4	17.7	23.4	20.3	29.9	22.8	18.9	24.3	16.5	26.8	13.5	30.2	8.4	......	......
	101	+0.1	33.2	1.5	32.5	2.5	32.5	2.9	32.6	5.7	31.0	7.3	29.2	9.6	28.6	12.5	25.5	14.4	28.7	14.7	22.1	19.6	16.0	22.0	11.9	27.0	3.9
	110	+2.4	41.8	5.3	40.8	9.0	40.5	10.0	39.8	18.6	32.2	23.9	26.6	32.9	13.0	34.1	13.0	34.9	9.0	31.9	9.0	38.0	3.9	37.4	4.3	28.1	5.8
	133	8.4	42.1	7.9	42.2	8.2	41.8	9.3	43.0	13.5	37.6	25.1	30.1	37.4	13.3	38.1	12.8	39.1	12.4	40.4	10.0	42.0	4.6	37.4	11.4	30.2	15.7
	149	3.1	34.2	3.1	34.2	4.2	34.1	4.5	33.2	13.3	27.0	19.6	21.0	20.6	20.7	22.5	20.9	27.8	13.0	28.3	12.2	31.0	7.9	32.2	2.2	18.3	12.7
	153	6.2	37.1	6.9	37.6	7.7	37.0	8.5	35.9	14.2	31.9	19.4	27.0	22.2	23.8	24.0	23.5	26.1	19.6	29.8	14.3	34.1	4.0	32.5	0.5	......	......
	156	5.0	31.1	6.7	31.4	5.8	30.4	8.4	27.0	14.6	22.6	19.0	17.2	22.1	14.2	24.2	10.7	21.9	13.5	27.3	9.2	23.5	10.0	16.5	2.0	......	......
	204	2.3	34.4	2.9	34.5	3.9	33.8	6.0	32.8	12.4	27.3	15.6	24.3	17.8	21.9	‡19.3	‡20.0	#19.6	#19.8	23.8	13.3	29.4	1.3	29.6	0.4	......	......
	213	6.5	42.3	7.3	42.8	7.7	41.6	8.2	42.6	14.3	38.0	15.0	36.3	24.0	29.6	27.4	26.5	29.8	23.6	30.0	21.6	31.1	21.8	41.2	3.4	......	......
	229	3.7	35.7	5.5	36.0	6.5	36.0	8.9	35.1	10.7	33.0	14.9	30.0	19.0	26.4	‡22.5	‡22.6	#23.2	#22.7	24.9	19.4	33.6	7.1	34.4	6.2	33.3	1.4
	230	......	......	......	......	8.3	34.4	......	......	19.6	24.4	......	......	......	......	26.6	14.9	......	......	26.6	11.7	......	......	28.9	1.4	......	......
	245	......	......	......	......	......	......	......	......	......	......	17.3	26.0	......	......	28.9	14.2	......	......	28.3	9.3	......	......	28.3	2.3	......	......
	246	......	......	......	......	......	......	......	......	......	......	14.6	25.7	......	......	22.4	16.1	......	......	24.6	13.0	......	......	26.9	7.5	......	......
	247	......	......	......	......	......	......	......	......	......	......	18.6	26.7	......	......	30.0	13.4	......	......	30.3	10.2	......	......	32.4	0.5	......	......
	248	......	......	......	......	......	......	......	......	......	......	17.3	20.1	......	......	25.2	13.0	......	......	27.2	13.6	......	......	20.0	3.6	......	......
	249	......	......	......	......	......	......	......	......	......	......	16.9	21.0	......	......	26.2	12.3	......	......	26.1	10.7	......	......	26.6	2.0	......	......
	253	......	......	......	......	......	......	......	......	......	......	15.6	32.2	......	......	31.4	14.3	......	......	32.2	12.0	......	......	35.6	1.6	......	......
	254	......	......	......	......	......	......	......	......	......	......	20.6	29.3	......	......	35.8	7.6	......	......	36.2	7.9	......	......	34.0	2.6	......	......
	271	6.1	34.8	6.1	34.6	7.4	32.9	8.0	33.2	13.0	29.5	14.0	28.6	20.4	22.7	22.0	20.5	23.3	18.3	23.4	17.1	26.2	12.6	27.9	5.2	......	......
	274	2.0	29.2	4.0	29.6	4.3	29.1	7.5	27.1	9.5	28.0	12.9	25.2	13.5	21.4	14.6	23.0	16.1	21.4	17.5	18.2	24.4	9.9	24.8	2.2	......	......
8	121	7.6	40.3	11.1	40.3	12.4	38.5	12.3	37.4	15.2	36.5	21.0	30.8	26.8	24.4	35.5	13.7	37.6	10.7	38.0	8.1	40.0	1.8	40.3	2.3	......	......
	124	5.8	38.3	5.5	39.7	6.9	36.2	7.1	38.0	17.0	30.9	25.0	21.7	30.1	17.3	31.6	13.8	33.8	10.4	33.5	10.5	35.2	3.0	36.0	3.6	......	......
	136	6.7	35.8	5.9	36.8	6.5	35.9	8.3	35.4	9.4	33.6	15.4	27.9	25.9	17.6	26.6	17.5	29.0	13.3	29.8	10.3	33.0	2.5	33.2	0.0	27.1	9.2
	146	1.4	36.6	4.7	35.7	5.7	35.7	7.3	35.4	18.3	25.2	22.9	20.8	25.4	18.6	30.6	12.9	34.2	2.9	34.4	0.0	35.1	0.0	32.0	0.0	22.5	3.1
	147	1.0	35.3	3.4	35.7	4.0	35.0	5.3	34.6	16.5	25.6	22.0	20.0	25.4	17.0	(32.6)	4.0	31.8	8.2	33.8	0.0	34.0	0.0	21.1	13.6	15.1	6.6
	151	5.2	39.5	6.2	40.1	8.9	38.7	12.5	37.0	23.2	27.4	28.9	22.5	32.2	20.4	35.4	14.6	40.2	0.0	40.9	0.0	39.6	0.0	32.8	11.2	......	......
	152	8.6	41.2	8.0	40.3	11.4	40.2	12.2	39.7	14.0	37.5	31.2	19.4	37.9	6.9	39.2	4.0	39.8	2.4	41.7	2.3	42.6	1.9	41.0	2.9	......	......
	157	9.0	40.2	9.6	39.1	9.7	39.3	11.3	38.2	18.3	32.2	28.8	22.5	36.5	7.9	36.4	7.9	38.6	2.0	39.9	1.1	39.9	1.1	40.6	2.6	29.0	7.1
	175	5.0	36.7	6.0	36.8	8.6	34.2	8.8	34.8	20.4	23.0	28.1	18.3	28.6	13.5	29.9	10.7	30.6	2.3	31.9	1.8	31.4	1.3	32.4	1.0	11.8	14.8
	201	5.8	34.7	6.4	32.9	8.8	31.0	20.2	19.7	24.1	15.2	28.3	9.5	30.8	5.7	‡32.0	‡2.0	#32.0	#2.2	32.4	1.8	19.2	14.5	19.7	14.0	......	......
	252	......	......	......	......	......	......	......	......	......	......	28.0	23.6	......	......	39.8	1.5	......	......	39.4	2.7	......	......	38.8	4.1	......	......
	280	5.0	37.0	5.2	36.9	9.5	34.4	12.1	33.3	21.8	24.4	25.0	19.7	29.0	13.5	30.8	12.1	31.1	3.3	32.7	1.9	30.1	5.1	23.2	13.7	20.1	8.3

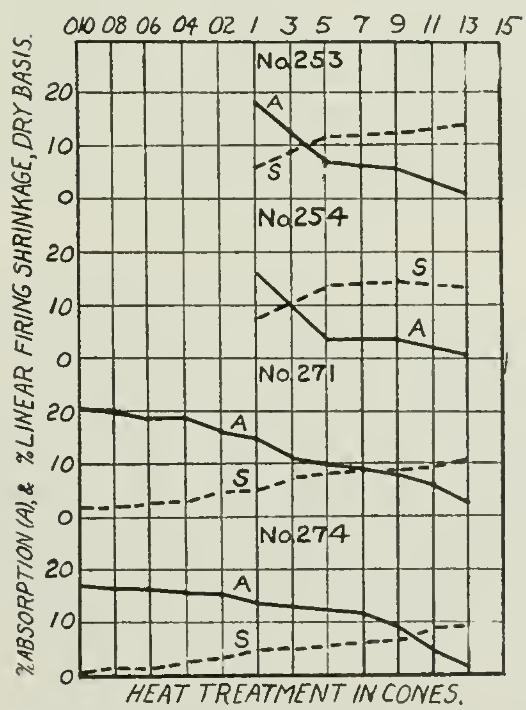
% V. S.=Firing shrinkage, per cent dry volume. % A. P.=Per cent apparent porosity. *Cone 5+. †Cone 7—. xCone 9—. ‡Cone 6—. #Cone 6+.

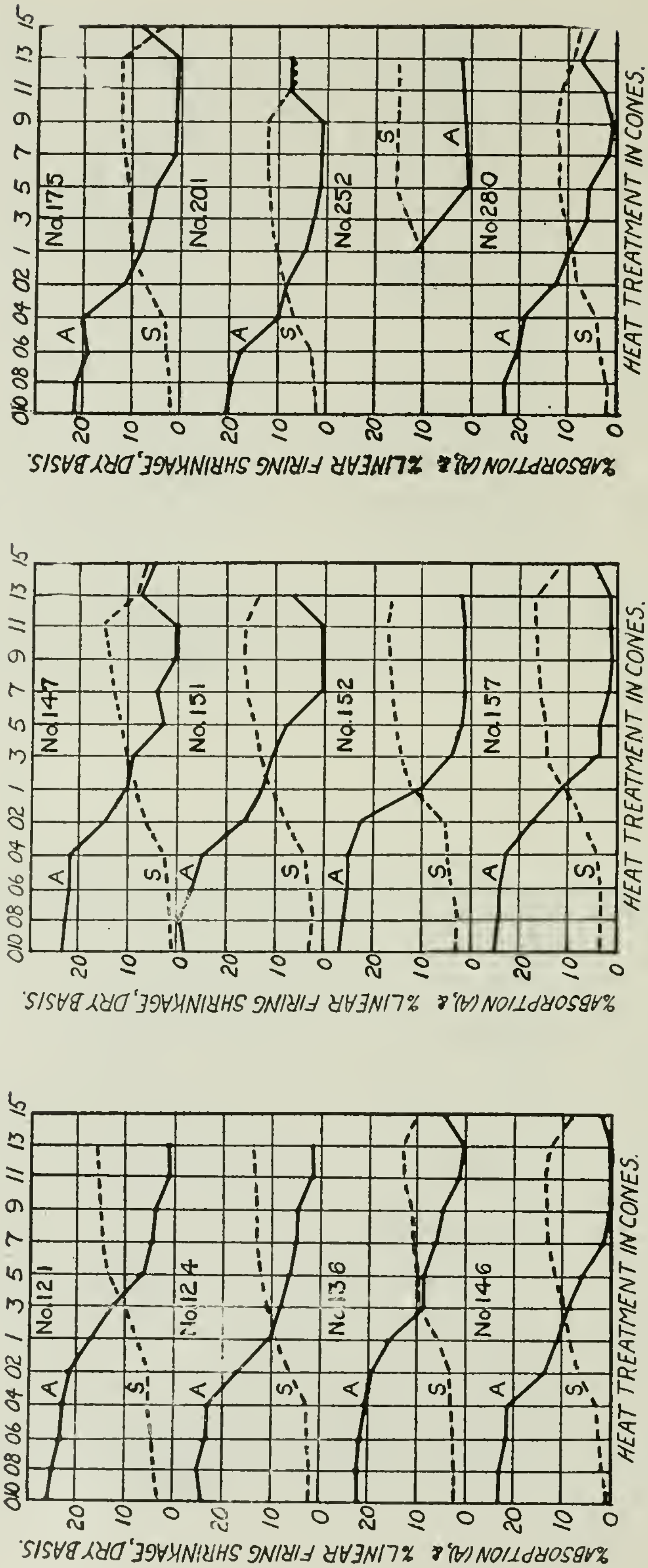
Absorption and linear shrinkage curves for clays of class 7.



Absorption and linear shrinkage curves for clays of class 7.







Absorption and linear shrinkage curves for clays of class 8.

II-B. Non-refractory Clays, Softening Point Cone 27—.

a. Open-Burning, Not Below 6% Apparent Porosity Below Cone 10.

9. Medium to High Strength.

No. 19 (p. 163). Riverside County. Alberhill C. & C. Co. "Yellow Stripping." This is a yellowish, sandy clay that occurs as overburden on parts of the property. It contains 28.2% of +200-mesh sand, and has sufficient plasticity and strength to permit its use in a superior grade of common brick, which is marketed under the name of "Diamond Brand." The dry strength is medium-high, and the dried clay is hard, with a medium grain and open texture. The colors are: dry, 15″d; wet, 15″; cones 010 to cone 3, 7′d; cone 5, 9′f; cones 7 to 9, 11′f; cone 11, 15′f; and cone 13, 15′b. Finger-nail hardness develops below cone 010, and steel hardness at cone 11. A few small cracks developed in the test piece that was fired to cone 13, but all other test pieces were sound. The total linear shrinkage, plastic basis, is 8.4%, at cone 13. The softening point is cone 23. The best firing range is from cone 010 to cone 11. The clay seems entirely suited for making buff and pink face brick. It does not vitrify at sufficiently low temperatures to be suitable as the sole ingredient of bodies with low porosity.

No. 25 (p. 163). Riverside County. Alberhill C. & C. Co. "West Tunnel Blue." See No. 94 and 95. This is a pink and buff-burning sewer-pipe clay having a fair plasticity and medium dry strength. It contains 18.8% of +200-mesh sand. In the dry state it has a medium grain and open texture. The colors are: dry, 23″‴f; wet, 23″‴d; cones 010 to 04, 17″f; cones 02 to 5, 15″d; cones 7 to 11, 15″b; cone 13, 5‴. It is practically red-burning at cone 13, but is best classed as a buff-burning clay. Finger-nail hardness is developed at cone 010, and steel hardness at cone 1. Vitrification is well advanced at cone 9. The total linear shrinkage, plastic basis, at cone 13, is 19.3%. The softening point is cone 16. The best firing range is from cone 1 to cone 13. The principal value of this clay lies in its vitrification range and temperature, coupled with good fired strength.

No. 36 (p. 20). San Diego County. Cardiff. California Clay Products Co. This is a Pleistocene (?) fireclay, similar to samples No. 33 and 34 in class 6, but with less iron and a higher percentage of fluxes, probably feldspars. It contains 44.4% of +200-mesh sand. The plasticity, and the dry and fired properties are closer to sample No. 33 than to No. 34, but the colors are uniformly of lighter tones and the fired porosities are greater, though the shrinkage is practically the same. The total linear shrinkage, plastic basis, at cone 13, is 8.2%. The softening point is cone 26. The best firing range is from cone 1 to over cone 13.

No. 94 and 95 (p. 171). Riverside County. Alberhill. G., McB. & Co. No. 94 is the "West Blue" and No. 95 is the "Select West Blue" clay. These two samples should be compared with No. 25, the "West Tunnel Blue" of the Alberhill C. & C. Co., and not with their "West Blue" (No. 23, class 5) and "Select West Blue" (No. 16, class 10) varieties. No important differences between No. 94 and 95 were disclosed by the testing, but they both have a higher proportion of sand and a lower percentage of iron than No. 25, which results in a large difference in the ceramic properties and uses of No. 94 and 95, compared with No. 25. No. 94 contains 24.2%, and No. 95 contains 27.6% of +200-mesh sand, compared to 18.8% for No. 25. The plasticity of No. 94 and 95 is good, the dry strength is medium, and in the dried state they are soft, medium-grained and open-textured. The colors are: dry, 17''''f; wet, neutral gray; cones 010 to 02, 13'''d; cones 1 to 13, 13''''d. Abundant particles of ferro-magnesian minerals give a pleasing granitic texture to the test pieces fired above cone 1. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Absorptions under 10% are obtained at cone 3. Bloating is pronounced at cone 11, especially when a reducing flame is used. No. 95 has lower shrinkage and lower absorption at cone 9 than No. 94. The maximum total linear shrinkage, plastic basis, is at cone 9, and is 11.7% for No. 94, and 10.5% for No. 95. The softening points are cones 17 and 18, respectively. The best firing range is from cone 1 to cone 9. No. 94 is used in tile bodies, and No. 95 in terra cotta bodies.

No. 99 (p. 171). Riverside County. G., McB. & Co. "Tile Clay." This is a red and tan-burning plastic clay that is used for the manufacture of roofing tile, face brick, and similar products. There is slight effervescence in hydrochloric acid. It contains 30.8% of +200-mesh quartz-mica sand. The plasticity is excellent, the dry strength is medium high, and in the dried condition it is medium hard, medium-grained, and open-textured. The colors are: dry, 13''''d; wet, 17''''; cones 010 to 02, 7''b; cone 1, 11''b; cones 3 to 11, 13''b; cone 13, 15''. Mottling from the presence of ferro-magnesian minerals is pronounced above cone 5, giving pleasing textural effects. Finger-nail hardness is developed below cone 010, and steel hardness develops at cone 5. Absorptions below 10% are not obtained until cone 11 is reached. The fired structure is sound and stony and the texture is rough. The total linear shrinkage, plastic basis, at cone 13, is 11.9%. The softening point is cone 26–27. The best firing range is from cone 02 to cone 9.

No. 114 (p. 90). San Bernardino County. Near Rosamond. Titus deposit. This is a buff-burning clay with fair plasticity, medium dry strength, and a medium hard, medium-grained, dried condition. It has not been produced steadily, but tests have been made by various clay manufacturers. The colors are: dry, grayish white; wet, 23'''''f; cones 010 to 3, 17''f; cones 5 to 9, 17'''f; cones 11 and 13, grayish white. Finger-nail hardness is developed below cone 010, and steel hardness appears at cone 1. The fired structure is sound, homogeneous, stony, and without warp. The surface texture is slightly rough. Above cone 11, scattered iron specks become noticeable. Absorptions below 10% are obtained at cone 9. The total linear shrinkage, plastic basis, is 6.9%, at cone 13. The softening point is cone 17–18. The clay might be useful in stoneware, vitrified floor tile, and similar mixtures, although for the highest purposes, washing would be necessary to remove the non-plastic coloring impurities.

No. 135 (p. 58). Amador County. Ione (Clarksona). N. Clark and Sons. "Dosch Stripping." This is a sandy yellow-burning clay with good plasticity and medium-high dry strength. It contains 18.0% of

+200-mesh sand. In the dried condition it is medium hard, fine-grained, and close-textured. The colors are: dry, 15″d; wet, 15″b; cones 010 to 5, 9″d; cone 7, 19″b. Steel hardness develops at cone 02, and less than 10% absorption at cone 3. The fired structure is sound, granular and rough-textured. A vesicular structure develops above cone 7. The maximum total linear shrinkage, plastic basis, is 15.1% at cone 7. This material is used in sewer-pipe mixes.

No. 168 (p. 136). Nevada County. Chicago Park. Beaser Ranch. This is a pink-burning clay from near the surface of an undeveloped deposit. The plasticity is smooth, but weak, the dry strength is medium, and in the dried condition it is medium hard, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 17‴d; cones 010 to 06, 15′f; cones 04 and 02, 15′d; cone 1, 13′b. The fired colors are ochraceous salmons and buffs, which are unusual. No scumming or efflorescence was noted. Steel hardness is developed at cone 02. The fired structure is sound, and stony, and the surface texture is exceptionally smooth. The total linear shrinkage, plastic basis, is 8.6% at cone 1. The clay could be used locally for common brick, and might be used to make an attractive, though unusual, face brick.

No. 169 (p. 138). Nevada County. Pearldale. Sonntag Ranch. This is a buff-burning clay from a surface exposure of an undeveloped deposit. The plasticity is fairly smooth and strong, the dry strength is medium, and in the dried condition it is soft, medium grained, and open-textured. The colors are: dry, 17″f; wet, 17″d; cones 010 and 08, 11′f; cone 06, 13′f; cones 04 and 02, 15′f; cones 1 to 5, 17′f; cone 7, 17″d; cones 9 to 13, 17‴b, but with a distinctly mottled appearance. Some interesting color effects for floor tile and face brick can be produced with this clay. Steel hardness is developed at cone 1. Less than 10% absorption appears at cone 7. Slight bloating is apparent from the shrinkage and porosity data at cones 11 and 13, but no loss of shape was noted. The fired structure is sound and stony, and the surface texture is slightly rough. The maximum total linear shrinkage, plastic basis, is 11.1%, at cone 9. The softening point is cone 19–20. The best firing range is from cone 1 to cone 9.

No. 173 (p. 235). Yuba County. Smartsville. J. F. Dempsey Ranch. Kaolinitic material from a copper prospect in volcanic rocks. It was not possible to secure a sample entirely free from limonite. The plasticity is fair, the dry strength is medium, and in the dried condition, it has finger-nail hardness, is medium grained, and open-textured. A high percentage of non-plastic matter is present. The colors are: dry, yellowish white; wet, 17‴f; cone 010, 7″b; fading progressively with increasing firing temperatures to 13‴d at cone 5. Green scumming is pronounced. Steel hardness is developed at cone 04. The fired structure is sound, and fine-granular, except at cone 6, where light superficial hair-cracks appear. The surface texture is slightly rough. The total linear shrinkage, plastic basis, at cone 9, is 19.1%.

No. 255 (p. 52). Amador County. Ione. Core drill hole No. 57–5, Arroyo Seco Grant. This is similar to No. 254 in class 7, but fires to darker colors. The plasticity is good, the dry strength is medium, and in the dried condition it is medium hard, fine-grained and open-textured. There is slight effervescence in hydrochloric acid. The colors are: dry, 9″d; wet, 9″b; cone 1, 9″d; cone 5, 15″d; cone 9, 17″b; cone 13, 15″i. Steel hardness is developed below cone 1, and less than 10% absorption between cone 1 and cone 5. The fired structure is sound and stony, and the surface texture is smooth. No blistering was noted at cone 13. The total linear shrinkage, plastic basis, at cone 13, is 21.6%. The softening point is cone 26. This is a good clay for face brick, roofing tile, and similar products.

No. 283–A and B (p. 232). Tulare County. Ducor. W. A. Sears deposit. See also No 284, class 10, and 285, class 5 These are samples of impure kaolin, and have fair plasticity and medium dry strength. The dry condition is medium-hard, fine-grained, and open-textured. The colors of No. 283–A are: dry, nearly white; wet, 15′f; cones 010 to 3, 17″d; cones 5 and 7, 17′d; cone 9, 15′d; cones 11 and 13, 13′d. The colors of No. 283–B are: dry, grayish white; wet, 21″″f; cones 010 to 02, 17″″f; cones 010 to 5, 21‴f; cones 7 to 13, 17″d. The colors are rather disagreeable yellowish buffs, and are irregular. Yellow scumming is very pronounced. Steel hardness is not developed up to cone 13, the upper temperature limit studied. The fired structure is sound, and there is no evidence of vitrification up to cone 13. The total linear shrinkage, plastic basis, at cone 13, is 10.7% for No. 283–A, and 9.7% for No. 283–B. The softening point of No. 283–A is cone 26–27. Further studies are needed before the possible uses of these clays can be predicted.

10. Low Strength.

No. 16 (p. 163). Riverside County. Alberhill C. & C. Co. "Select West Blue." See also No. 23 in class 5. This is a plastic, buff-burning clay that has a wide vitrification range above cone 7, and is used for face brick and pottery. It contains 22.6% of +200-mesh sand, high in ferro-magnesian minerals, which results in a pleasing granitic texture when fired above cone 7. The plasticity is fair, the dry strength is low, and the clay is soft and friable in the dry state. The colors are: dry, 15″″′f; wet, 15″″′b; cones 010 to 02, 17″f; cones 1 to 5, 17‴f; cones 7 to 13, 17″″f, with a granitic texture. Finger-nail hardness is developed at cone 06, steel hardness at cone 02, and bloating begins at cone 13. The total maximum linear shrinkage, plastic basis, is 14.0%, at cone 11. The softening point is cone 18. The best firing range is from cone 02 to cone 11.

No. 55 (p. 195). San Bernardino County.. 4.2 m. N.E. of Bryman. Gladding, McBean and Co. This is a vitrifying clay of value in face-brick manufacture. It has poor plasticity, low dry strength, and a soft, open, dry condition. A large proportion of non-plastic matter is present which is high in iron, and results in a pleasing granitic texture when fired. The percentage remaining on 200-mesh is 48.6. The colors are: dry, 7″f; wet, 7″d; cones 010 to 04, 7″f, cones 02 to 5, 9‴d; cones 7 to 11, 17″″d; cone 13, 15″″′d. Finger-nail hardness is obtained below cone 010, and steel hardness develops at cone 1. Absorptions below 10% are obtained at cone 3 or above, and bloating begins above cone 11. The maximum total linear shrinkage, plastic basis, is 9.5%, at cone 11. The softening point is cone 18. The best firing range is from cone 02 to cone 11.

No. 82 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Clay Shale." This is a sandy, buff-burning clay shale, with weak plasticity and medium low strength. It effervesces slightly in hydrochloric acid. In the dried condition it is soft, medium-grained and open-textured. The colors are: dry, 17″d; wet, 17″; cones 010 to 3, 5′f; cones 5 to 11, 9′f; cone 13, 17′f. Iron specks are numerous. Finger-nail hardness develops below cone 010, but steel hardness is barely attained at cone 13, at which point bloating begins. The fired structure is sound, granular, and open. The maximum total linear firing shrinkage, plastic basis, is 3.5%, at cone 11, nearly all of which takes place during drying. The softening point is cone 23–26. The best firing range is from cone 010 to cone 11. The clay may be used with more plastic clays as an ingredient of face brick mixtures, if the mottled texture is not objectionable.

No. 88. (Deposit not described.) Riverside County. Hudson Ranch, near Elsinore. This is an impure silica sand, mixed with enough clay to impart weak plasticity to the mass. The dry strength is medium low, and in the dried condition it is coarse, open, and friable. The colors are: dry, 21″″f; wet, 17″″f; fired, from cone 010 to cone 11, grayish-white, with black specks above cone 7. Steel hardness is developed at cone 11. The fired structure is coarse-grained, and weak. Enough fluxes are present to cause fusion to begin at cone 9. The total linear shrinkage, plastic basis, at cone 9, is 8.3%. The material has little ceramic value.

No. 111 (p. 178). Riverside County. Alberhill. P. C. P. Co. "Lower Douglas." This is a pink-burning clay containing 28.6% of +200-mesh sand, but nevertheless possessing good plasticity, and a medium low dry strength. The dried condition is soft, medium-grained, and open-textured. The colors are: dry, 17″f; wet, 15″d; cones 010 to 1, 9″f; cone 3, 15″ f; cones 5 to 9, 13‴f; cones 11 and 13, 17‴f. Above cone 5, the clay is strongly mottled with iron specks, resulting in a pleasing fine-granitic texture. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. The fired structure is sound and fine-granular. Slight bloating begins at cone 11. Absorptions below 10% are obtained at cone 5 or above. The maximum total linear shrinkage, plastic basis, is 12.4%, at cone 9. The softening point is cone 19–20. The clay is useful in terra cotta, face brick, and faience tile bodies.

No. 167 (p. 138). Nevada County. Wolf. Coe property. Pine Hill Mine. See also No. 159 and 160 in class I, and 166 in class II. This is similar to No. 160, but contains more iron. The plasticity is weak, the dry strength is low, and in the dried condition it is soft, fragile, fine-grained, and open-textured. The colors are: dry, 7″b; wet, 9′b; cones 010 to 3, 7″b; cones 5 to 9, 7″d; cones 11 and 13, 17‴d. Finger-nail hardness is developed at cone 010, and steel hardness at cone 11. Less than 10% absorption is obtained at cone 13. The fired structure is sound, and below cone 11, is fine-granular. Above cone 11, it is stony. The total linear shrinkage, plastic basis, at cone 13, is 13.6%. The softening point is cone 23.

No. 170 (p. 136). Nevada County. Banner Mountain road. This is an impure, sandy, pink-burning clay with weak plasticity, and medium-low dry strength. In the dried condition it is medium-hard, coarse-grained, and open-textured. The colors are: dry, 17″d; wet, 17″ b; cones 010 to 06, 13″b; cones 04 to 1, 13″d. Steel hardness is developed at cone 02. The fired structure is sound, granular, open-textured, and the surface texture is smooth. The total linear shrinkage, plastic basis, is 4.8%, at cone 3. It could be used for common brick, but the plasticity is barely sufficient.

No. 238 (p. 70). Calaveras County. Campo Seco. This is an impure sericite schist that is said to have been used as a refractory clay in the former smelter of the Penn Mining Co. The plasticity is weak, the dry strength is low, and in the dried condition it is very soft and friable. The colors are: dry and wet, grayish white; cone 010, 17″f; cones 06 to 1, 17″d; cones 5 and 9, 21″″f. Steel hardness is developed at cone 02, and less than 10% absorption at cone 5. A vesicular structure developed at cone 9. The maximum total linear shrinkage, plastic basis, is 9.3%, at cone 5. The material is of doubtful value in ceramics.

No. 269. Inyo County. American Silica Co. "Death Valley Superfine." This is a very fine-grained, sandy material, with sufficient clay to give a short and spongy plasticity to the mass. There is considerable effervescence in hydrochloric acid. The dry strength is medium low, and in the dried condition it is hard, and has a fine sandy texture. The colors are: dry, 17‴d; wet, 17‴b; cones 010 to 06, 15″f; cones 04 to 1, whiter than 17″; cone 3, 17″d. Steel hardness is developed at cone 3. The fired structure is sound and fine-granular. The total linear shrinkage, plastic basis, is 26.6%, at cone 3. The softening point was not determined.

No. 284 (p. 232). Tulare County. Ducor. W. A. Sears deposit. See also No. 285, class 5, and 283–A and B, class 9. This is an impure kaolin, having weak plasticity, low dry strength, and a medium-hard, coarse-grained, open texture in the dry condition. It was only fired to four cone numbers. The colors are: dry, 15″d; wet, 17″; cones 1, 5, 9 and 13, 15″. The fired colors are rather unsatisfactory yellows for most ceramic products. The fired structure is weak and coarse-granular. The total linear shrinkage, plastic basis, is 6.4%. The softening point was not determined. This is the least satisfactory of the samples tested from this deposit. Yellow scumming is pronounced.

b. Dense-Burning, Less Than 6% Apparent Porosity Below Cone 10.

11. Low Strength.

No. 166 (p. 138). Nevada County. Wolf. Coe property. Pine Hill Mine. See also No. 159 and 160 in class 1 and 167 in class 10. This is similar to No. 159, but contains a higher proportion of fluxes and coloring matter. The residue on 200-mesh is 4.6%. The plasticity is smooth, and moderately strong, the dry strength is medium-low, and in the dried condition it is medium-hard, fine-grained and close-textured. The colors are: dry, 13″f; wet, 9″d; cones 010 to 06, 7″f; cones 04 to 3, 5″f; cones 5 and 7, 5″″f; cone 9, 13″″f. Plasticity is not destroyed until cone 06 is reached, but steel hardness is developed at cone 02. Less than 10% absorption appears at cone 02, and a vesicular structure is developed above cone 3. The fired structure, from cone 02 to cone 3, is sound, and stony, with a smooth surface texture. The maximum total linear shrinkage, plastic basis, is 15.8%, at cone 3. The softening point is cone 13. The clay might find some use as a vitrifying agent in buff, cream, or pink bodies burned between the limits of cone 02 and cone 3.

TABLE No. 22.

II. Buff-Burning Clays.

B. Non-refractory clays, softening point cone 27—.

a. Open-burning, not below 6% apparent porosity below cone 10.

9. Medium to high strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
19	11.0	12.2	23.2	463	21.9	6.8	23
25	19.3	18.9	38.2	388	34.0	10.3	16
36	11.8	19.2	31.0	566	19.9	6.3	26
94	9.1	13.3	22.4	207	17.7	5.6	17
95	7.3	12.3	19.6	241	14.7	4.7	18
99	12.5	14.2	26.7	538	23.7	7.4	26–27
114	8.3	13.9	22.2	231	15.6	5.0	17–18
135	15.7	14.3	30.0	437	29.1	8.8	
168	9.0	16.7	25.7	315	16.1	5.1	
169	8.3	15.1	23.4	246	15.5	5.0	19–20
173	20.0	21.3	41.3	391	33.0	10.0	
255	20.6	21.0	41.6	238	35.2	10.6	26
283 A	9.3	34.2	43.5	347	11.7	3.7	26–27
283 B	11.2	15.7	26.9	369	19.9	6.3	

10. Low strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
16	9.3	17.9	27.2	88	16.7	5.3	18
55	3.9	15.7	19.6	97	7.3	2.4	18
82	6.3	20.6	26.9	129	10.5	3.3	23–26
88	2.8	16.9	19.7	175	4.6	1.5	
111	9.9	16.3	26.2	165	18.4	5.8	19–20
167	8.8	21.5	30.3	62	14.5	4.7	23
170	5.3	19.5	24.8	105	9.1	2.9	
238	4.3	16.8	21.1	38	7.8	2.5	
269	31.5	36.8	68.3	166	39.8	11.9	
284	5.0	18.7	23.7	80	8.6	2.8	

b. Dense-burning, less than 6% apparent porosity below cone 10.

11. Low strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
166	11.5	24.1	35.6	117	18.8	5.9	13

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 23.

II. Buff-Burning Clays.

B. Non-refractory clays, softening point cone 27—.

a. Open-burning, not below 6% apparent porosity below cone 10.

9. Medium to high strength.

10. Low strength.

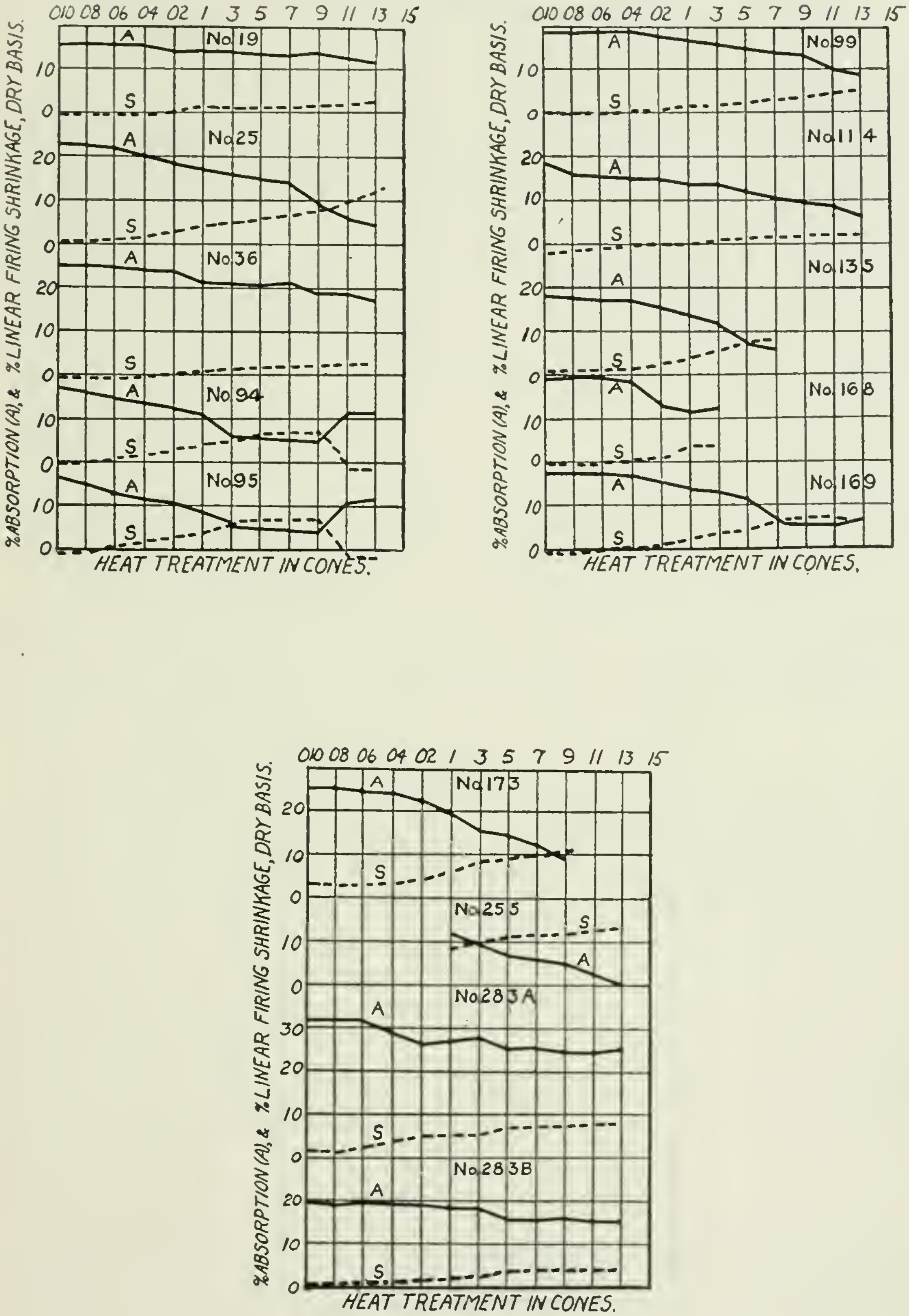
b. Dense-burning, less than 6% apparent porosity below cone 10.

11. Low strength.

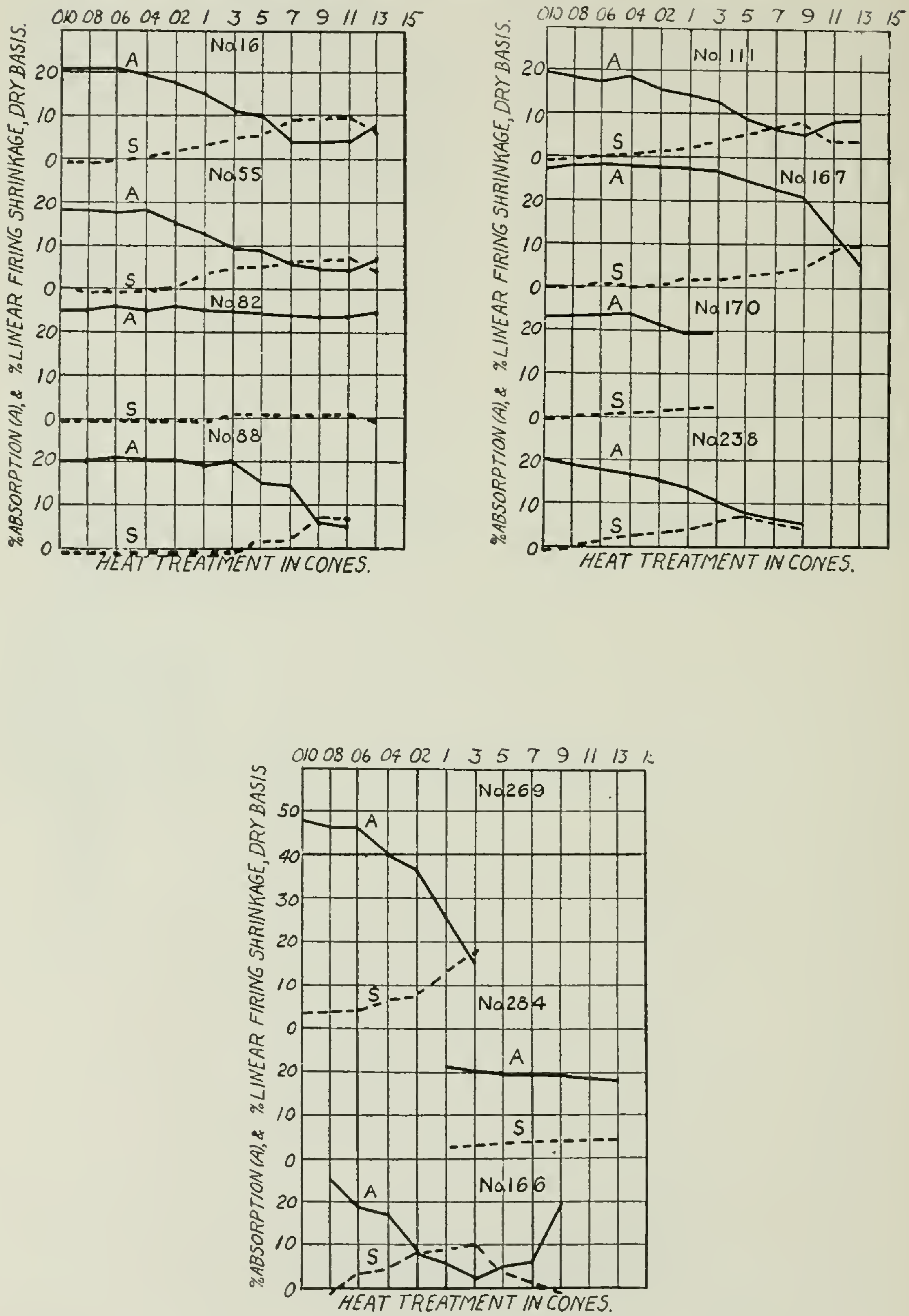
Class No.	Clay No.	Cone 010 % V. S.	Cone 010 % A. P.	Cone 08 % V. S.	Cone 08 % A. P.	Cone 06 % V. S.	Cone 06 % A. P.	Cone 04 % V. S.	Cone 04 % A. P.	Cone 02 % V. S.	Cone 02 % A. P.	Cone 1 % V. S.	Cone 1 % A. P.	Cone 3 % V. S.	Cone 3 % A. P.	Cone 5 % V. S.	Cone 5 % A. P.	Cone 7 % V. S.	Cone 7 % A. P.	Cone 9 % V. S.	Cone 9 % A. P.	Cone 11 % V. S.	Cone 11 % A. P.	Cone 13 % V. S.	Cone 13 % A. P.	Cone 15 % V. S.	Cone 15 % A. P.
9	19	−1.2	29.1	−0.6	30.4	−0.5	30.3	−0.3	29.9	+2.4	28.3	2.7	28.0	2.8	28.4	3.5	27.2	3.5	26.7	4.2	26.7	4.8	26.0	6.4	23.6	------	------
	25	+1.4	37.1	1.6	37.2	3.7	36.5	6.2	35.2	8.8	33.8	12.9	32.0	14.3	29.6	16.3	26.6	16.6	26.8	23.6	18.8	25.7	13.4	29.6	9.8	------	------
	36	−1.8	39.1	−2.0	39.1	−1.3	39.8	−1.0	39.0	0.0	38.3	3.2	35.5	+3.5	35.5	3.8	34.9	4.4	35.2	6.1	32.7	6.1	32.2	6.9	29.6	------	------
	94	−1.8	30.1	−1.1	30.2	+2.8	27.8	+4.1	26.4	+6.8	24.8	9.3	22.1	16.3	13.0	17.0	12.3	18.1	11.4	19.0	10.0	−3.5	20.3	−4.1	20.1	------	------
	95	−2.6	29.2	−1.2	28.2	2.7	25.3	+4.5	21.8	7.0	22.1	9.5	19.5	16.0	11.5	16.6	9.8	17.6	8.4	17.7	6.6	−5.8	18.5	−7.3	19.5	------	------
	99	−0.1	33.5	+0.7	34.0	1.0	34.5	1.2	34.4	4.2	33.1	5.5	31.5	5.9	31.0	7.8	29.4	9.4	28.2	11.6	26.2	14.1	19.9	15.4	17.8	------	------
	114	−5.7	33.3	−3.3	29.1	−2.3	28.3	−1.9	28.5	+1.5	26.8	2.8	25.6	3.1	25.0	5.1	23.2	6.6	20.6	6.7	19.2	7.3	17.9	6.6	12.4	------	------
	135	3.4	32.0	3.1	32.4	3.4	31.9	3.6	30.8	6.8	29.1	12.3	25.0	13.4	23.5	19.7	14.7	21.0	12.2	------	------	------	------	------	------	------	------
	168	−1.1	33.0	−1.3	33.2	+0.1	32.9	+0.7	32.5	2.1	22.4	11.3	20.6	10.0	22.5	------	------	------	------	------	------	------	------	------	------	------	------
	169	−1.7	31.3	−1.6	31.5	−0.4	31.2	−0.3	31.2	+3.4	28.5	6.2	25.6	8.3	23.2	10.0	20.8	16.7	12.3	18.7	10.5	16.8	10.7	14.0	12.9	------	------
	173	7.4	40.7	7.2	41.0	7.8	40.3	8.5	39.9	11.6	43.8	16.4	34.9	23.6	29.4	21.9	28.4	26.8	23.6	29.6	18.3	------	------	------	------	------	------
	255	------	------	------	------	------	------	------	------	------	------	23.6	24.2	------	------	29.4	15.6	------	------	32.3	11.4	------	------	34.8	0.5	------	------
	283-A	4.1	38.8	3.6	39.2	6.5	39.0	11.0	37.6	15.1	36.6	14.7	37.6	15.2	38.2	19.0	36.1	19.7	37.0	20.2	36.0	20.2	36.0	20.6	37.0	------	------
	283-B	1.8	33.3	1.5	32.5	2.0	33.3	2.8	33.0	3.9	32.8	5.2	32.1	6.2	31.9	10.5	29.0	10.6	28.6	10.7	29.0	11.2	27.7	11.5	28.0	------	------
10	16	−2.8	34.6	−2.4	34.7	−1.3	35.0	+1.3	33.9	5.5	31.3	10.0	27.4	14.8	22.0	15.6	20.2	25.4	8.4	25.5	8.5	25.8	9.3	17.2	15.6	------	------
	55	0.4	32.5	−2.2	32.2	−1.4	31.9	−0.5	32.4	+0.5	28.9	9.3	24.8	14.1	19.8	14.3	19.2	18.8?	13.2?	19.6	9.7	20.4	9.3	11.0	12.2	------	------
	82	−0.5	40.0	−0.5	39.7	−0.7	40.4	−0.6	40.2	−0.7	40.5	−1.7	38.9	+1.1	39.2	1.4	38.8	+0.9	37.3	0.6	37.1	0.8	37.6	−1.5	37.6	------	------
	88	−2.8	34.4	−2.7	34.6	−3.2	35.2	−2.8	34.8	−3.4	34.9	−2.4	33.4	−1.8	34.1	+4.6	28.2	+5.4	27.2	19.4	12.3	18.2	11.2	------	------	------	------
	111	−2.9	32.6	−2.3	31.8	−0.1	30.9	0.0	31.3	+4.4	27.8	6.8	26.0	10.7	23.1	16.1	16.7	18.3	12.9	20.4	11.0	9.8	16.3	9.4	15.9	------	------
	167	−0.7	41.2	−0.8	42.7	+2.1	44.0	−0.7	42.3	+0.4	42.7	2.5	42.3	3.0	41.8	7.3	39.1	9.2	37.8	11.7	35.0	22.3	24.0	25.9	7.4	------	------
	170	−0.5	37.5	−1.0	38.1	0.0	38.6	+0.3	38.6	3.7	36.3	5.4	34.4	5.9	33.3	------	------	------	------	------	------	------	------	------	------	------	------
	238	−2.3	35.0	------	------	+2.7	32.0	------	------	7.8	27.6	9.1	26.1	------	------	19.7	14.9	------	------	12.0	7.8	------	------	------	------	------	------
	269	8.3	57.5	10.1	57.2	10.4	57.3	18.4	53.6	21.2	52.3	33.8	42.0	44.7	29.7	------	------	------	------	------	------	------	------	------	------	------	------
	284	------	------	------	------	------	------	------	------	------	------	5.7	34.6	------	------	10.2	32.4	------	------	9.4	32.6	------	------	11.1	31.1	------	------
11	166	------	------	−2.7	39.2	+8.6	30.1	11.9	28.4	24.0	16.5	24.1	12.9	29.1	3.9	11.7	8.8	3.3	10.3	−2.5	31.5	------	------	------	------	------	------

% V. S.=Firing shrinkage, per cent dry volume. % A. P.=Per cent apparent porosity.

Absorption and linear shrinkage curves for clays of class 9.



Absorption and linear shrinkage curves for clays of classes 10 and 11.



III. RED-BURNING CLAYS.

A. Open-Burning, Do Not Attain Less Than 6% Apparent Porosity at Any Temperature Short of Actual Fusion.

12. Medium to High Strength.

No. 8 (p. 163). Riverside County. Alberhill C. & C. Co. "Red Clay No. 2." This is used principally as a red-coloring clay in the manufacture of face brick and other high-grade red-burned products. It is similar in its properties to No. 7 (class 13), but is not quite as uniformly fine-grained, has greater shrinkage and strength, and vitrifies more thoroughly at cone 13. The colors are as follows: dry, 11″b; wet, 11″; cones 010 to 3, 9′b; cone 5, 9″b; cone 7, 7″b; cones 9 and 11, 5″; and cone 13, 5‴b (flashed). Finger-nail hardness is found at cone 08, and steel hardness at cone 9. The total linear shrinkage, plastic basis, at cone 13, is 15.8%. The softening point is cone 19–20. The best firing range is from cone 08 to cone 11, and especially good results are obtained from cone 1 to cone 7.

No. 18 (p. 163). Riverside County. Alberhill C. & C. Co. "Clark Tunnel Mottled." This is a plastic red-burning clay, used in sewer-pipe mixes to increase the vitrification range of the mix. It contains 15.6% of +200-mesh sand, has excellent plasticity, medium dry strength, and in the dried state is medium hard and has a medium grain. The colors are: dry, 11″b; wet, 9″; cones 010 to 06, 9′b; cones 04 to 02, 11′; cones 1 to 7, 9′i; cones 9 to 11, 5″. Finger-nail hardness is developed at cone 010, and steel hardness at cone 3. The total linear shrinkage, plastic basis, is 17.8% at cone 11. The softening point is cone 19. The best firing range is from cone 1 to cone 11.

No. 24 (p. 163). Riverside County. Alberhill C. & C. Co. "West Tunnel Mottled." This is a red-burning clay used in sagger mixes and face brick. It contains 13.8% of +200-mesh sand and has smooth and strong plasticity, medium dry strength. In the dry condition it is medium-hard, fine-grained, close-textured, with a tendency to laminate. The colors are: dry, 11″d; wet, 9″; cones 010 to 04, 9′b; cones 02 to 3, 7″b; cone 5, 9″; cone 7, 5″k; cone 9, 5″i; cones 11 and 13, 1‴. Finger-nail hardness develops below cone 010, and steel hardness at cone 7. The specimens appear to be well vitrified at cones 11 and 13, but the absorptions are greater than 10% at these temperatures. Some of the test pieces are slightly cracked. The maximum total linear shrinkage, plastic basis, is 14.2% at cone 11. The softening point is cone 18–19. The best firing range is from cone 5 to cone 11. Slight bloating is noted at cone 13.

No. 26 (p. 163). Riverside County. Alberhill C. & C. Co. "West Yellow Stripping." This is used for face brick and sewer-pipe. It contains 21.8% of +200-mesh sand and has a smooth and strong plasticity, exceptionally high dry strength, high drying shrinkage, and medium firing-shrinkage. It laminates easily, warps badly in drying, and in the dry state is hard, with a fine grain and close texture. The colors are: dry, 19″; wet, 19″i; cone 010, 11″b, cones 08 and 06, 9″; cone 04, 11″; cones 02 to 3, 7″; cones 5 and 7, 5″; cone 9, 7″; cone 11, 5‴; cone 13, 5‴i. The fired colors are excellent for the darker shades of face brick. Finger-nail hardness is present in the dry condition, and steel hardness appears at cone 1. Absorptions below 10% appear at cone 02. Bloating begins at cone 9. The total maximum linear shrinkage, plastic basis, is 18.5%, at cone 7, and bloating appears at higher temperatures. The best firing range is from cone 02 to cone 7. The clay is especially valuable for its high dry and fired strength, and its wide vitrification range at commercial temperatures.

No. 32 (p. 205). San Diego County. Linda Vista. Vitrified Products Co. A yellow clay-shale of Tertiary age. It is used for structural ware. It has good plasticity, medium high dry strength, and good dry condition. Some lime is present, which does no harm if the larger lime boulders are avoided in mining, and if the mix is well prepared in the plant. The colors are: dry, 17″d; wet, 17″; cone 010, 11′b; cone 08, 11′; cones 06 to 02, 9′; cones 1 and 3, 5‴k. Finger-nail hardness is present in the dry state, and steel hardness appears at cone 04. In the sample tested, the maximum total shrinkage, plastic basis, is 11.2%, at cone 1. The absorption at this point is 8.7%, and at higher temperatures bloating begins, accompanied by the development of yellow-green colors typical of the presence of lime. It is possible that the sample contains more lime than is usually present in the material delivered to the plant. The best firing range is from cone 010 to cone 1.

No. 35 (p. 202). San Diego County. Cardiff. Gladding, McBean and Co. This is a red-burning face-brick clay with excellent plasticity, high dry strength, and safe drying properties. It contains 16.4% of +200-mesh sand. In the dry state it is hard, and has a medium grain and open texture. The colors are: dry, 17″f; wet, 15″d; cones 010 and 08, 11″b; cones 06 and 04, 11′b; cone 01, 9′b; cone 1, 9′; cones 3 to 7, 7″; cones 9 and 11, 5″i; cone 13, 13″i. The fired colors are excellent intermediate shades for face brick. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Vitrification is well advanced, but not complete, at cone 13. The total linear shrinkage, plastic basis, at cone 13, is 14.6%. The softening point is cone 17–18. The best firing range is from cone 1 to above cone 13. The long firing range and high dry strength of this clay are its specially desirable features.

No. 40 (p. 203). San Diego County. Near Carlsbad. Pacific Clay Products Co. "Kelly Ranch Yellow." This is a red-burning, plastic clay with a long vitrification range, from a bed underlying that from which sample No. 39 was taken. It is suitable for the manufacture of face brick, sewer-pipe, roofing tile, and similar products. The sample contains 4.8% of +200-mesh sand. It has a smooth, strong plasticity, high dry strength, and the dry structure is hard, fine-grained, and dense. The colors are: dry, 17‴b; wet, 17″i; cones 010 to 04, 9′b; cone 02, 9′; cones 1 to 5, 9′i; cones 7 and 9, 5″. The fired colors cover a good range of brilliant reds for face brick and roofing tile. Finger-nail hardness is approached in the dry state, and steel hardness appears at cone 08. Porosity under 10% is found at cone 1, and bloating begins above cone 5. The total maximum linear shrinkage, plastic basis, is 18.9% at cone 9. The softening point is cone 18–19. The best firing range is from cone 02 to cone 13.

No. 65 (p. 141). Orange County. Brea. Brea Brick Co. This is a red-burning surface clay suitable for the manufacture of common brick. It effervesces slightly in hydrochloric acid. The plasticity is good, with a tendency to become sticky with excess water, the dry strength is medium high, and the dry condition is hard, dense, and granular. It contains 45.2% of +200-mesh sand. The colors are: dry, 17‴b; wet, 15″k; cones 010 and 08, 9′b; cone 06, 9′; cone 04, 9′i; cone 02, 9′k; cones 3 and 5, 5′k; cone 7, 5″m. The fired colors are excellent for common brick. Finger-nail hardness is obtained below cone 010, and steel hardness develops at cone 3. Vitrification is complete at cone 7, and bloating begins below cone 9. The fired condition is sound, open, and strong. The maximum total linear shrinkage, plastic basis, is 11.9%, at cone 7. The best firing range is from cone 010 to cone 7, and good structures are obtained from cone 3 to cone 7.

No. 69 (p. 169). Riverside County. 10 m. south of Corona. Emsco Clay Co. "Red Horse." This is a red-burning clay with smooth, strong plasticity. It is suitable as an ingredient of red earthenware, roofing tile, face brick, and sewer-pipe mixes. The sample contains 13.8% of +200-mesh sand. The dry strength is medium, and the dry condition is medium hard, fine-grained and close-textured. The colors are: dry, 9′b; wet, 9′i; cones 010 to 04, 7′b; cones 02 to 3, 9′; cone 5, 7″; cone 7 to 11, 5″i. The fired colors cover an interesting range of deep reds. Finger-nail hardness is developed below cone 010, and steel hardness at cone 04. Vitrification is practically complete at cone 7, but the apparent porosity is still above 8 per cent. All test pieces above cone 08 are slightly cracked. The fired condition is strong, tough and fine-grained. The total linear shrinkage, plastic basis, at cone 7, is 14.4%. The softening point is cone 18–19. The best firing range is from cone 04 to cone 7. [The shrinkage and apparent porosity data at cones 11 and 13 were lost. See absorption curve for general trend.]

No. 73 (p. 169). Riverside County. Emsco Clay Co. "Bone." Although this is locally classed as a bone clay on account of its pisolitic structure in the raw state, it is lateritic, and contains so much iron as to give a low fusion point. It contains 46.8% of +200-mesh material. The plasticity is spongy, but fairly strong, the dry strength is medium, and the dry condition is granular, and open-textured. The colors are: dry, 9′d; wet, 11′i; cones 010 to 04, 11′f; cones 02 to 5, 7″b; cone 7 to 11, 9‴b; cone 13, 5‴k. The fired colors are suitable for red face brick and roofing tile. Finger-nail hardness is developed below cone 010, and steel hardness at cone 1. All fired test pieces are sound, granular, and strong. Vitrification is complete at (approx.) cone 7, beyond which temperature, bloating gradually develops. The maximum total linear shrinkage, plastic basis, is 9.2%, at cone 7. Absorptions below 10% are obtained at cone 02 or higher. The softening point is cone 15. The best firing range is from cone 02 to cone 7. The clay can be used as a coloring agent, and to prolong the vitrification range of red-burned structural ware.

No. 100 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Yellow Stripping." This is an impure, sandy clay that is used in face-brick and sewer-pipe mixtures. It effervesces slightly in hydrochloric acid. The plasticity is good, the dry strength is exceptionally high, and in the dried condition the clay has finger-nail hardness, and is dense and fine-grained. It contains 20.8% of +200-mesh sand. The colors are: dry, 15″d; wet, 17″; cones 010 to 02, 9′b; cone 1, 9′i; cones 3 to 11, 5′i. Steel hardness is developed at cone 06. Absorptions below 10% are obtained from cone 02 to cone 9, inclusive. All fired test pieces are sound, and have a stony structure. Vitrification is complete at cone 5, and bloating begins above cone 9. The maximum total linear shrinkage, plastic basis, is 17.3%, at cone 5. The softening point is cone 14–15.

No. 105 (p. 171). Riverside County. Alberhill. G., McB. & Co. "Sloan Red." This is a red-burning clay with good plasticity, medium dry strength, and in the dried condition it is soft, medium-grained, and open-textured. It contains 17.0% of +200-mesh sand. It is used for face brick, roofing tile, and similar products. The colors are: dry, 11′d; wet, 9′k; cones 010 to 5, 9′b; cone 7, 7″b; cones 9 to 13, 5″i. Finger-nail hardness is developed at cone 06, and steel hardness at cone 1. The fired structures are all sound and stony, with a slightly roughened surface texture. Absorptions below 10% are obtained at cone 7 or above. The total linear shrinkage, plastic basis, at cone 13, is 15.0%. The softening point is cone 18–19.

No. 112 (p. 178). Riverside County. Alberhill. P. C. P. Co. "Hoist Pit Blue." This is a plastic, pink-burning clay that is used in sewer-pipe mixes. The plasticity is excellent, the dry strength is medium, and in the dried condition the clay is soft, medium-grained, and open-textured. It contains 25.0% of +200-mesh sand. The colors are: dry, 17‴b; wet, 19″k; cones 010 to 02, 7′d; cones 1 to 7, 7″d; cone 9, 9″d; cones 11 and 13, 13‴i. Finger-nail hardness appears below cone 010, and steel hardness at cone 1. Absorptions below 10% are obtained at cone 7. The fired structure is sound and heterogeneous, and the fired surface texture is smooth. The total linear shrinkage, plastic basis, at cone 13, is 16.1%. The softening point is cone 19.

No. 113 (p. 176). Riverside County. Alberhill. P. C. P. Co. "Hoist Pit Red." This is a red-burning sandy clay of use in sewer-pipe mixes, roofing tile, red earthenware, etc. It contains 18.6% of +200-mesh sand. The plasticity is excellent, the dry strength is medium high, and in the dried condition the clay is hard, brittle, fine-grained and close-textured. The colors are: dry, 9′b; wet, 7′i; cones 010 to 7, 9′; cones 9 to 13, 9‴. Finger-nail hardness (nearly) is present in the dried state, and steel hardness appears at cone 3. The fired condition is sound and fine-grained, and the fired surface texture is slightly rough. The total linear shrinkage, plastic basis, at cone 13, is 11.3%. The softening point is cone 23–26.

No. 117 (p. 131). Santa Cruz County. Castroville. Joe Arca. This is an excessively plastic surface clay, that can almost be classed as an adobe. It is used for making hand-made roofing tile on a small scale. It has an exceptionally high dry strength, but must be dried carefully to prevent warping and cracking. In the dried condition it is dense, fine grained, and has finger-nail hardness. The colors are: dry, 17‴b; wet, 17‴i; cones 010 to 06, 9′b; cone 04, 9′; cone 02, 9″i. Steel hardness develops at cone 02. Bloating is well advanced at cone 1. All test pieces cracked on firing. The maximum total linear shrinkage, plastic basis, is 18.0%, at cone 02. Most of the shrinkage takes place during drying. The best firing range is from cone 010 to cone 02. The short vitrification range and the poor drying qualities of this clay preclude its general use for structural-clay products.

No. 119 (p. 74). Contra Costa County. Point Richmond. Richmond Pressed Brick Co. This is one of the typical red-burning Tertiary clays of the San Francisco Bay region that are widely used for the manufacture of common brick and building tile. As ground, the sample contains 43.2% of +200-mesh sand. The plasticity is good, the dry strength is medium, and the dried condition is hard, medium-grained, and open-textured. The colors are: dry, 17''''; wet, 17''''i; cone 010, 13''b; cone 08, 11''b; cones 06 and 04, 9''; cone 01, 7''i; cone 1, 5'k. Steel hardness is developed at cone 04+. Vitrification is complete at cone 1, and bloating begins at slightly higher temperatures. The fired structure is sound and fine-granular, and slightly roughened surface textures are obtained. The maximum total linear shrinkage, plastic basis, is 12.1%, at cone 1.

No. 155 (p. 151). Placer County. Lincoln. Gladding, McBean & Co. "Pit Sand." This is a red-burning sand-clay mixture that is used in the manufacture of roofing tile, sewer pipe, and other red-body ware. The residue on 200-mesh is 31.8%. The plasticity is fair, the dry strength is medium high, and in the dried condition it is hard, medium-grained, and open-textured. The colors are: dry, 17'''d; wet, 17''''; cones 010 to 06, 13''; cones 04 and 02, 1''; cones 1 to 5, 11''i; cone 7, 5''m. Finger-nail hardness is present in the dried condition, and steel hardness is developed at cone 1. The fired structure is sound, except for light hair-cracks on the surface. The fired surface texture is rough. Bloating begins at cone 7, before the body is vitrified to a low absorption. The maximum total linear shrinkage, plastic basis, is 15.0%, at cone 5.

No. 176 (p. 66). Butte County. Oroville. Quincy road. This sample is representative of a residual deposit of decomposed granite. The plasticity is fair, the dry strength is medium high, and in the dried condition it is medium hard, coarse-grained, and open-textured. The colors are: dry, 15''d; wet, 15''; cone 010, 15''; cone 08, 13''; cones 06 and 04, 11'; cone 02, 9'; cone 1, 7'i. These are good colors for common brick. Steel hardness is not developed up to cone 1, the upper temperature limit studied. The fired structure is sound and granular, and the surface texture is moderately rough. The total linear shrinkage, plastic basis, is 8.2%, at cone 1. The material is suited for the manufacture of common brick.

No. 178 (p. 66). Butte County. Palermo. Lund Brick Yard. This is a clay-gravel mixture from a Tertiary river channel and is being used for the manufacture of common brick. Three separate samples were taken, No. 178–1, 2, and 3, each representing different phases of the material. Only one of these, No. 178–2, was tested completely. The others were fired to but three different temperatures each. The differences between the three varieties are the result of differing proportions of sand, silt, and gravel. No. 178–1 contains 51.6% of +200-mesh sand, No. 178–2 contains 23.6%, and No. 178–3 contains 15.2%. This description covers No. 178–2, and the reader is referred to the tabulated data for the results on the other samples. The plasticity is strong, but with a tendency to stickiness when excess water is used. The dry strength is high, and in the dried condition it has finger-nail hardness, is medium-grained, and open-textured. The tendency to laminate is pronounced. The colors are: dry, 11′b; wet, 11′i; cones 010 to 3, 9′i; cone 6, 5′k. Steel hardness is developed at cone 02, and less than 10% absorption at cone 6. The fired structure is strong and stony, with a slight tendency to crack. The surface texture is moderately rough. The total linear shrinkage, plastic basis, is 15.8%, at cone 6. The best firing range is from cone 02 to cone 6, for hard-burned ware, and from cones 06 to 02 for soft-burned ware. The material makes a strong brick with good colors, but the irregularity of the deposit is an uncertain factor that makes the close control of shrinkage difficult.

No. 180 (p. 77). Del Norte County. Crescent City. Elk Valley. This is a common-brick clay. The plasticity is good, the dry strength is medium, and in the dried condition it is hard, fine-grained, and close-textured. It contains 19.2% of +200-mesh sand. The colors are: dry, 17″b; wet, 17″i; cones 010 to 06, 9′; cones 04 to 3, 9′i; cone 6, 5′k. Steel hardness is developed at cone 1, and less than 10% absorption at cone 3. All test pieces are sound. The total linear shrinkage, plastic basis, is 17.5%. The best firing range is from cone 010 to cone 3. The clay is entirely suitable for the manufacture of red brick either by the soft-mud or stiff-mud process.

No. 182 (p. 81). Humboldt County. Eureka. Thompson Brick Co. This is a common-brick clay with good plasticity, high dry strength, and in the dried condition it has finger-nail hardness, is fine-grained and close-textured. It contains 16.8% of +200-mesh sand. The colors are: dry, 17″d; wet, 17″k; cones 010 to 06, 11′; cone 04, 9′; cone 02, 7′i; cone 1, 7′m; cones 3 and 5, 7″m. Steel hardness is developed at cone 010, and less than 10% absorption at cone 02. The fired structure is generally sound, but with a tendency to crack. Bloating begins above cone 3. The maximum total linear shrinkage, plastic basis, is 16.6%, at cone 3. The clay is mixed at the plant with a sandier variety to insure safer drying and firing.

No. 183 (p. 81). Humboldt County. Eureka. Second Slough. This is a common clay that has not been used. It has sticky plasticity, high dry strength, and in the dried condition it is hard, medium-grained, and close-textured. The colors are: dry, 17″d; wet, 17″k; cones 010 to 08, 9′d; cones 06 and 04, 9′b; cone 02, 7″; cone 1, 5″k; cones 3 and 5, 5″m. Steel hardness and less than 10% absorption are developed at cone 02. The fired structure is sound, up to cone 1, beyond which bloating begins. The maximum total linear shrinkage, plastic basis, is 18.9%, at cone 1. The clay would be satisfactory for common-brick manufacture, if mixed with less plastic material.

No. 199 (p. 74). Contra Costa County. Port Costa. Port Costa Brick Co. This is a plastic, red-burning Tertiary shale that is used for the manufacture of common brick and hollow tile. There is strong effervescence in hydrochloric acid. The plasticity is good, with a tendency to stickiness, and dry strength is medium, and in the dried condition it is medium-hard, medium-grained, and close-textured. The sample, as ground, contains 40.2% of +200-mesh sand. The colors are:

dry, 21''''f; wet, 21''''; cones 010 to 04, 11'b; cone 02, 9'; cone 1, 7''; cone 3, 7''k. Steel hardness is developed at cone 04, and less than 10% absorption at cone 02. The fired structure is sound, up to cone 1, above which bloating begins. The surface texture is slightly rough. The total linear shrinkage, plastic basis, is 14.8%, at cone 1. The best firing range is from cone 04 to cone 1.

No. 206 (p. 232). Tulare County. Porterville. Black slate. This is a black slate that develops good plasticity, medium dry strength, and fires to a red color. In the dried condition it has finger-nail hardness, is coarse-grained, and open-textured. It should be finely ground to avoid excessive lamination. The colors are: dry, 15'''''; wet, nearly black; cones 010 and 08, 17''b; cone 06, 13''b; cone 04, 11''; cone 02, 7''. Steel hardness is developed at cone 04. The fired structure is sound and strong and the surface texture is rough. The total linear shrinkage, plastic basis, is 7.9%, at cone 3. This should be a good clay for common brick and hollow tile.

No. 214 (p. 131). Monterey County. Near Monterey on Salinas road. Monterey Mission Tile Co. This is an adobe clay that is used for the manufacture of hand-made roofing and step tile. The plasticity is strong and sticky, the dry strength is high, and in the dried condition it has finger-nail hardness, is fine-grained, and close-textured. Serious warping and cracking results in drying when the clay is used alone. The colors are: dry, 15'''''; wet, 15'''''k; cones 010 to 06, 15'' b; cone 04, 11''. Steel hardness and less than 10% absorption are present at cone 010. All test pieces cracked in firing, and serious bloating takes place at cone 04. The maximum total linear shrinkage, plastic basis, is 15.4%, at cone 06. This clay can not be used alone, but when grogged with crushed tile made from the same clay, very attractive hand-made tile can be made.

No. 216 and 217 (p. 213). San Luis Obispo County. State highway 2 m. south of Santa Margarita. These two samples are representative of a large deposit of red-burning shale. The shale develops good plasticity without the necessity of fine grinding. The dry strength is medium, and in the dried condition it is hard and close-textured. The colors are: dry, 17''i to 15''; wet, 15''k; cones 010 and 08, 11'; cones 06 and 04, 9'i; cone 02, 7'k; and cone 1, 7'm. Steel hardness and less than 10% absorption are developed at cone 02. The fired structure is strong, but the test pieces that were fired at or above cone 02 are slightly checked. The total linear shrinkage, plastic basis, at cone 1, is 12.4% for No. 216, and 13.3% for No. 217. The best firing range is from cone 04 to cone 1. The material seems entirely suitable for the manufacture of hard or soft-fired heavy clay products, and is a possible material for paving brick.

No. 251 (p. 52). Amador County. Ione. Core drill hole No. 57–1, Arroyo Seco Grant. This is a red-burning clay with smooth and strong plasticity, and medium dry strength. In the dried condition it is medium hard, fine-grained, and close-textured. It effervesces slightly in hydrochloric acid. Some fine sand is present. The colors are: dry, 15'd; wet, 15'b; cones 1 and 5, 9''b; cones 9 and 13, 11''i. Steel hardness and less than 10% absorption are developed below cone 1. Blistering is noted at cone 13, otherwise the fired structure is sound and stony. The surface texture is smooth. The maximum total linear shrinkage, plastic basis, is 18.8%, at cone 9. The softening point is cone 23. This clay is suitable for face brick.

No. 261 (p. 159). Placer County. East of Lincoln. Valley View Mine. This is an iron-stained kaolin, with fair plasticity and medium dry strength. In the dried condition it is hard, fine-grained, open-textured and heterogeneous. The colors are: dry, 11″d; wet, 15″b; cones 010 to 1, 7″b; cone 3, 7″d; cones 5 and 7, 13″; cones 9 and 13, 15″. Steel hardness is not developed at cone 3. The fired structure is sound, except for a few superficial hair cracks. The surface texture is moderately rough. The total linear shrinkage, plastic basis, is 17.7% at cone 13. The softening point is cone 28, yet it is distinctly a red-burning clay. The material might be used in face brick and terra cotta.

13. Low Strength.

No. 7 (p. 163). Riverside County. Alberhill C. & C. Co. "Pink Mottled." This is one of the important face-brick, roof-tile, and floor-tile clays from the Alberhill district. It is a fine-grained, pink-yellow mottled clay of medium hardness, develops a smooth and strong plasticity, and has medium low dry strength. It contains 14.2% of +200-mesh sand. The colors are as follows: dry, 11″d; wet, 11″; cones 010 to 3, 9′b; cone 5, 7′d; cone 7, 7′b; cones 9 and 11, 7″; cone 13, 7″i. These are good pinks and light reds for face brick, floor tile, etc. At cone 13, fine black specks appear, giving a not unpleasing mottled effect, which could be reproduced at lower temperatures by flashing. The fired surfaces have a smooth texture, capable of taking a polish. Finger-nail hardness is not developed until cone 06 is reached. The hardness at cone 13 is slightly less than steel, although vitrification is not complete at that temperature. The total linear shrinkage, plastic basis, is 10.5% at cone 13. The softening point is cone 17. The best firing range is from cone 06 to cone 11.

No. 72 (p. 169). Riverside County. Emsco Clay Co. "Red." This is similar to No. 8 (class 12) "Red Clay No. 2" from the Alberhill Coal and Clay Co. pits, but has lower drying and firing shrinkage, and lower strength. It is used mainly as a coloring clay in face brick, and other high-grade red-burning products. The residue on 200-mesh is 12.6%. It has a smooth and moderately strong plasticity, medium low dry strength, and a soft, fine-grained, close-textured dry condition. The colors are: dry, 7′; wet, 7′i; cones 010 to 13, 9′, with a slight darkening toward the higher cone numbers. Finger-nail hardness is developed below cone 010 and steel hardness at cone 3. The fired structure is tough and stony. The total linear firing shrinkage, plastic basis, is 12.5%, at cone 13. The softening point is cone 20. The best firing range is from cone 02 to cone 13. Vitrification is practically complete at cone 11.

No. 122 (p. 53). Amador County. Ione. Arroyo Seco Grant, Jones Butte. Leased by Stockton Fire Brick Co. Laterite. This is a true laterite for which no ceramic uses have yet been found, but which occurs in sufficient abundance to be of possible interest. The sample contains a large proportion of non-plastic grains, and the plasticity is weak and short. The dry strength is medium low, and the dried condition is medium hard, medium grained, and open-textured. The colors are: dry, 5″; wet, 5′i; cones 010 to 3, 5″; cones 5 and 7, 9‴; cone 9, 9″i; cone 11, 11″k. Steel hardness appears at cone 1. Less than 10% absorption is present at cone 3. The fired structure is granular and hair-cracked. The total linear shrinkage, plastic basis, at cone 11, is 17.5%. The softening point is cone 17–18.

No. 131 (p. 62). Amador County. Ione. "Newman Red Mottled." This is a red-burning clay with good plasticity, low dry strength, and in the dried condition it is very soft, fine-grained, and close-textured. It contains 3.2% of +200-mesh sand. The colors are: dry, 9″b; wet, 9″; cones 010 to 02, 9′b; cones 1 to 7, 9′; cones 9 to 13, 7′. Steel hardness appears at cone 1, and less than 10% absorption at cone 11. The fired structure is stony, and at cones 11 and 13 several tension cracks appeared during firing. The total linear shrinkage, plastic basis, at cone 13, is 20.0%. The softening point is cone 23–26. The best firing range is from cone 1 to cone 9. The clay can be used as a coloring clay for face brick, roofing tile, and similar ware.

No. 171 (p. 136). Nevada County. North Bloomfield road. This is a red-burning clay that could be used for common-brick manufacture. The plasticity is fair, the dry strength is medium low, and in the dried condition it is hard, fine-grained, and close textured. A tendency to develop drying cracks was noted. The colors are: dry, 17′f; wet, 21‴; cones 010 to 06, 15″b; cone 04, 15″d; cone 02, 11′; cone 1, 9′. The fired colors are suitable for common brick, roofing tile, etc. Steel hardness appears at cone 02, and less than 10% absorption at cone 1. The fired structure is stony, and is sound except for a few small cracks, which may have been formed during drying. The surface texture is smooth. The total linear shrinkage, plastic basis, is 16.1%, at cone 1. Non-plastics should be added.

No. 198 (p. 125). Marin County. San Rafael. McNear Brick Co. This is a red-burning, sandy, clay-shale that develops sufficient plasticity for brick and hollow-tile making. The dry strength is medium-low, and in the dried condition it is medium-hard, coarse-grained, and open-textured. The sample as ground contains 55.8% of +200-mesh material. The colors are: dry, 15″b; wet, 15″i; cones 010 and 08, 7′b; cones 06 and 04, 9′b; cones 02 to 6, 9″b. Steel hardness is developed at cone 1. The fired structure is coarse-granular and open, and hair-cracks are prominent, especially when fired above cone 1. The total linear shrinkage, plastic basis, is 11.8%, at cone 6. The best firing range is from cone 04 to cone 6. The sample contains more non-plastic matter than the normal run-of-pit material.

No. 218 (p. 181). Riverside County. 8 m. south of Corona. This is a pink-mottled clay with excellent plasticity and medium-low dry strength. It is similar to No. 72 (Emsco Red). In the dried condition it is medium-hard, brittle, fine-grained and close-textured. The colors are: dry, 11′b; wet, 9′i; cones 010 to 3, 11′; cone 5, 7′b. Steel hardness is developed at cone 3. The fired structure is sound and stony and the surface texture is smooth. The total linear shrinkage, plastic basis, is 19.5%, at cone 11. The softening point is cone 23. The clay is suitable for the manufacture of face brick, roofing tile, and similar products.

No. 256 (p. 52). Amador County. Ione. Core drill hole No. 60, Arroyo Seco Grant. This is a red-burning clay with good, but sticky, plasticity and medium-low dry strength. In the dried condition it is medium-hard, fine-grained, and open-textured. The colors are: dry, 11″d; wet, 11″; cone 1, 9″; cone 5, 7″i; cone 9, 9‴; cone 13, 9‴i. Steel hardness is developed at cone 5, and less than 10% absorption at cone 13. The fired structure is weak and hair-cracked. The total linear shrinkage, plastic basis, at cone 13, is 20.3%. The softening point is cone 19–20. This is not a good clay, but could be used as part of a face-brick mixture.

TABLE No. 24.

III. Red-Burning Clays.

A. Open-burning, do not attain less than 6% apparent porosity at any temperature short of actual fusion.

12. Medium to high strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
8	11.7	17.6	29.3	221	21.1	6.3	19–20
18	20.7	21.6	42.3	305	34.7	10.4	19
24	13.2	19.7	32.9	252	23.1	7.0	
26	28.7	11.6	40.3	1569	56.8	16.1	
32	16.0	20.1	36.1	794	27.6	8.4	
35	19.1	12.8	31.9	1094	37.3	11.1	17–18
40	22.7	12.8	35.5	1412	44.3	13.0	18–19
65	11.2	12.9	24.2	569	22.1	6.9	
69	12.1	15.4	27.5	265	23.4	7.3	18–19
73	8.5	13.5	22.0	334	16.8	5.2	15
100	36.6	12.8	49.4	1821	71.4	11.9	14–15
105	11.4	17.4	28.8	235	21.0	6.4	18–19
112	11.9	19.7	31.6	291	20.8	6.5	19
113	13.4	13.5	26.9	509	26.2	8.0	23–25
117	30.4	10.5	40.9	±990	63.0	17.8	
119	9.5	13.5	23.0	374	18.5	5.8	
155	23.3	16.6	39.9	580	42.3	12.2	
176	9.9	19.2	29.1	615	16.7	5.3	
178–1	22.6	14.1	36.7	905	44.1	12.9	
178–2	18.0	12.8	30.8	1224	35.8	10.7	
178–3	10.3	14.7	25.0	498	19.5	6.1	
180	18.6	18.8	37.4	300	32.5	9.9	
182	22.1	10.0	32.1	1181	44.7	13.2	
183	24.3	14.4	38.7	±983	46.4	13.5	
199	12.0	14.3	26.3	352	23.3	7.3	
206	5.1	15.3	20.4	340	9.6	3.1	
214	28.5	12.1	40.6	±1000	54.4	15.5	
216	8.0	15.8	23.8	305	15.3	4.9	
217	10.5	15.5	25.9	306	19.9	6.3	
*221	21.2	14.7	35.9	453	39.0	11.6	26
251	17.6	17.9	35.5	381	31.4	9.5	23
261	17.1	25.6	42.7	289	26.8	8.2	28

13. Low strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
7	9.9	18.0	27.9	149	17.6	5.3	17
72	7.3	16.4	23.7	133	13.6	4.4	20
122	7.9	22.2	30.1	110	13.9	4.5	17–18
131	17.4	22.8	40.2	94	28.4	8.6	23–26
171	13.5	24.6	38.1	±164	20.9	6.5	
198	6.7	18.9	25.6	166	10.0	3.2	
218	12.9	15.3	28.2	186	24.3	7.5	23
256	16.8	23.5	40.3	156	27.7	8.4	19–20

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

* Impure flint clay from Goat Ranch, Gladding, McBean & Co., Orange County. Description of ceramic properties omitted. See p. 141 for description of deposit.

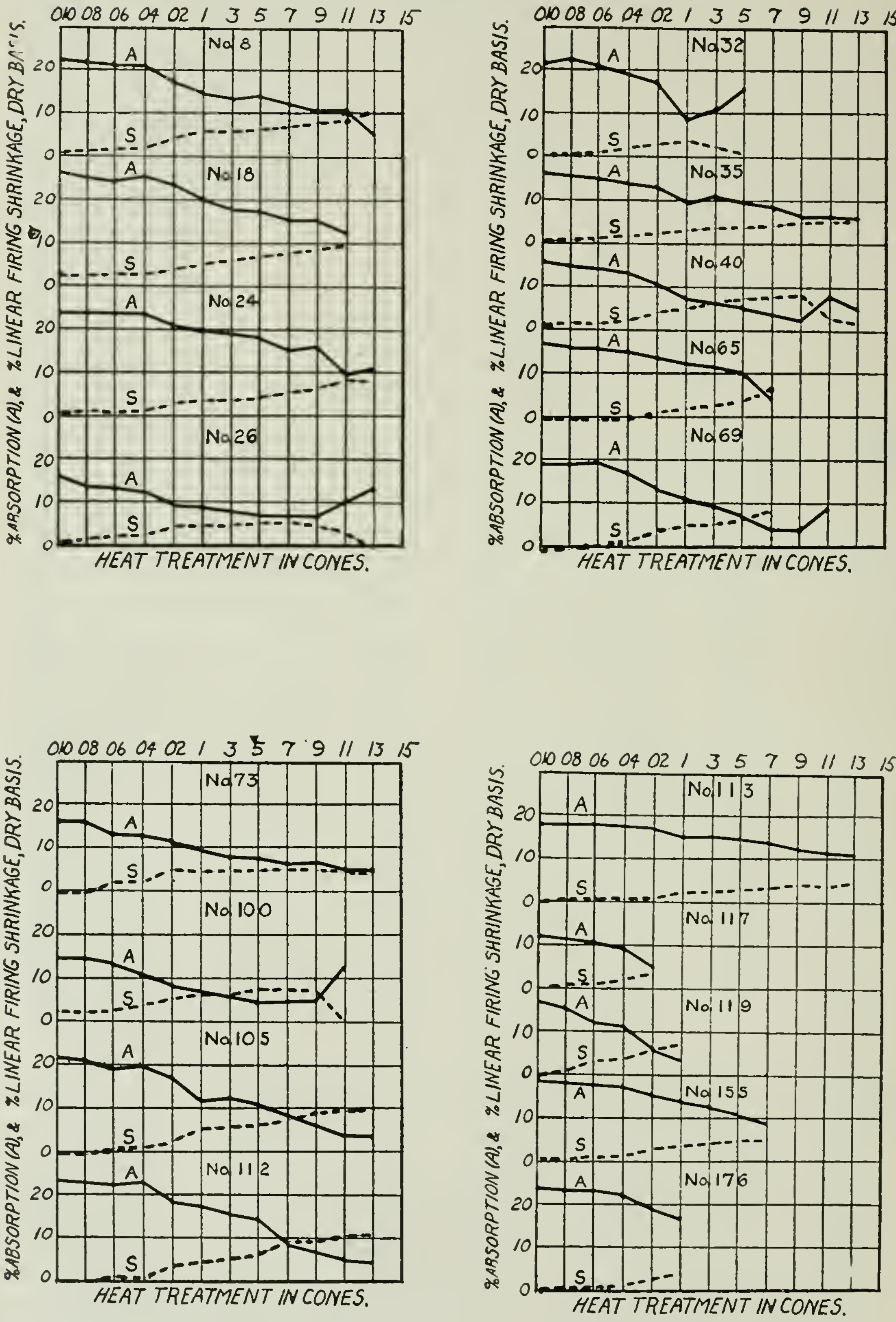
TABLE No. 25. III. Red-Burning Clays.

A. Open-burning, do not attain less than 6% apparent porosity at any temperature short of actual fusion.
12. Medium to high strength. 13. Low strength.

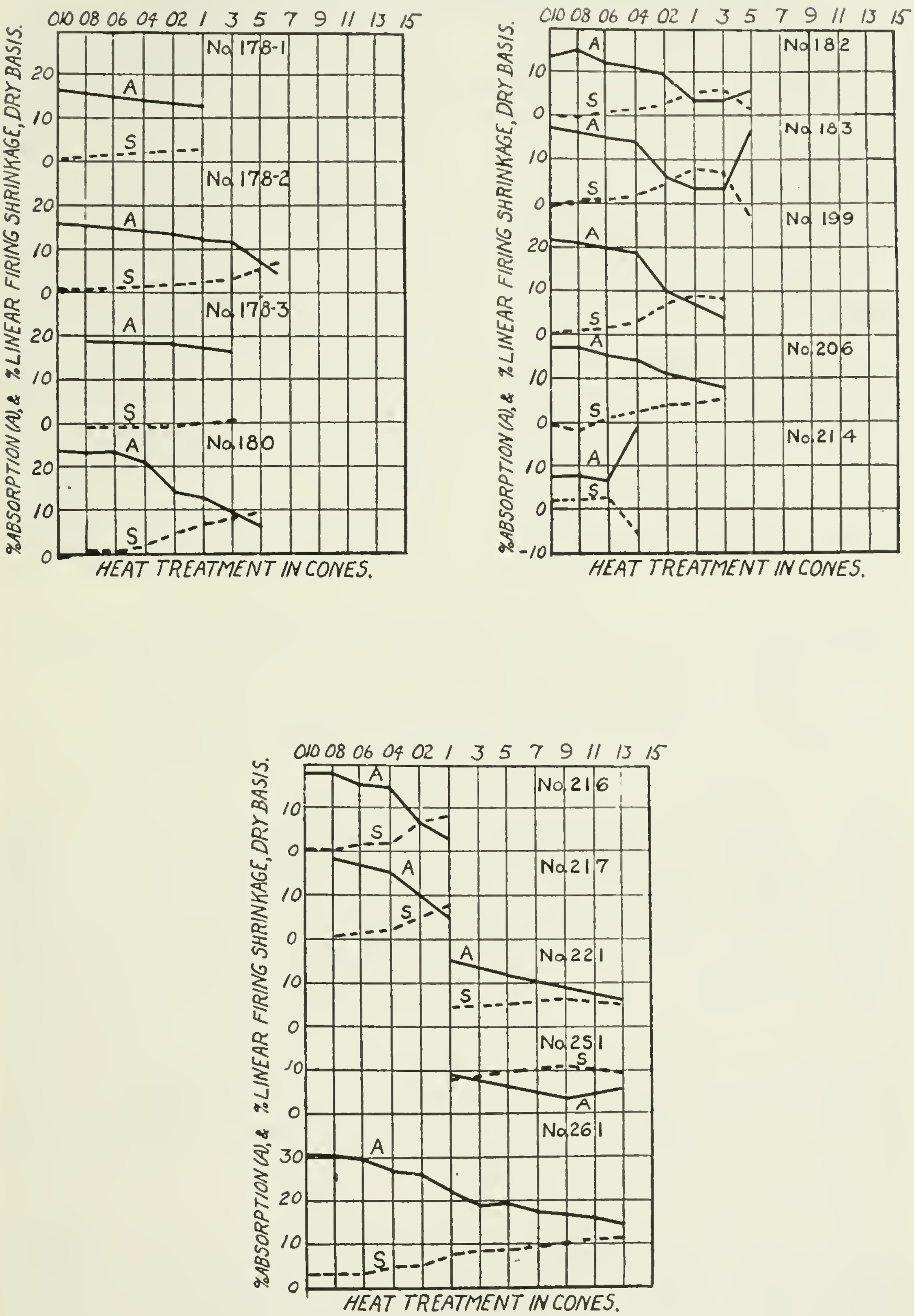
Class No.	Clay No.	Cone 010		Cone 08		Cone 06		Cone 04		Cone 02		Cone 1		Cone 3		Cone 5		Cone 7		Cone 9		Cone 11		Cone 13		Cone 15	
		% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.
12	8	1.9	37.7	3.2	37.1	3.9	37.0	4.3	36.2	11.6	31.9	16.2	29.2	16.4	27.7	17.3	27.2	19.4	25.0	21.6	22.4	22.0	21.8	28.4	11.5		
	18	+5.2	41.5	6.0	40.1	7.2	39.4	7.3	40.5	11.1	38.8	15.4	35.5	17.4	32.0	19.4	32.3	22.3	29.6	23.6	29.2	25.3	21.3				
	24	1.0	38.8	2.6	39.2	2.0	39.0	3.7	38.6	7.7	36.0	9.5	31.8	10.9	34.5	11.8	33.0	15.4	30.1	18.3	31.6	22.6	19.9	21.6	24.9		
	26	1.8	29.0	4.1	25.3	5.3	24.6	6.4	23.8	11.9	18.9	12.5	18.3	12.8	17.2	14.8	15.5	15.5	14.9	14.8	13.5	8.2	19.8	−1.1	23.7		
	32	0.0	35.5	+0.5	37.0	2.6	35.2	5.0	33.6	8.1	30.6	10.9	16.3	5.8	18.8	1.4	26.9										
	35	1.1	29.9	2.2	29.5	3.3	28.6	4.7	26.6	6.2	21.5	9.4	17.9	10.4	22.0	10.5	19.8	11.7	18.0	14.0	13.2	14.2	13.1	14.4	10.7		
	40	2.5	28.9	3.2	27.5	3.7	26.7	6.5	25.4	14.3	21.0	14.9	15.2	16.8	13.4	19.2	12.2	21.3	8.1	23.1	5.4	7.5	15.2	4.9	9.2		
	65	−1.0	30.1	−1.3	29.5	−0.8	29.3	−0.8	28.5	+3.3	25.9	4.7	23.3	7.4	22.6	9.2	20.6	16.3	7.6								
	69	1.5	33.4	−0.5	33.3	+0.2	33.6	2.6	31.7	9.7	25.7	12.7	22.1	14.3	20.0	17.6	11.9	22.4	8.8								
	73	−0.3	29.4	0.4	29.5	4.8	25.7	5.4	21.7	8.8	21.0	11.1	19.5	12.6	16.6	12.7	15.3	13.0	12.8	12.5	12.7	11.2	10.7	10.4	8.5		
	100	5.8	27.6	5.7	27.0	6.6	21.9	10.3	21.7	14.9	17.1	17.2	14.6	17.9	11.9	20.5	9.6	20.0	9.6	19.3	9.5	0.6	22.9				
	105	−0.2	37.0	−0.7	35.5	+2.4	33.9	2.4	34.6	6.3	31.7	14.7	24.1	16.1	22.7	16.2	22.6	19.7	18.3	24.2	12.7	25.2	8.3	26.2	6.8		
	112	+0.4	37.9	−0.1	37.4	+2.5	37.1	1.2	37.9	9.4	32.9	11.2	31.1	14.1	28.6	16.6	26.5	24.3	17.0	25.6	14.6	28.4	10.2	28.6	9.7		
	113	−0.6	31.5	+0.5	32.2	1.2	32.5	4.1	32.4	2.0	31.4	6.5	28.9	7.2	28.7	7.4	28.0	8.5	26.4	10.9	24.0	11.5	23.3	12.2	22.3		
	117	0.0	23.5	2.0	22.8	2.3	21.7	5.4	19.8	10.0	10.4																
	119	−0.4	31.6	+2.2	29.7	9.3	23.8	10.1	23.0	17.0	13.6	19.6	7.0														
	155	1.3	32.2	0.9	32.2	2.4	31.5	3.6	30.6	7.3	28.0	10.0	25.6	11.2	24.0	13.3	21.8	12.3	16.4								
	176	0.0	38.6	+0.7	38.0	1.6	38.3	2.1	37.1	6.6	33.2	9.6	30.6														
	178–1	1.2	30.4					5.7	26.8			7.8	25.0														
	178–2	0.5	29.5	0.5	29.2	1.7	28.6	3.0	27.8	4.7	26.3	6.4	21.8	7.5	23.8	19.0	9.5										
	178–3			−1.7	33.6					−1.2	32.6			+0.7	29.8												
	180	−0.8	38.3	+0.2	37.8	0.7	38.3	5.2	36.1	12.7	27.3	17.6	25.4	21.8	19.7	25.4	13.2										
	182	0.0	21.9	−0.4	21.8	1.9	22.8	3.4	21.1	7.2	18.9	14.9	6.9	16.0	6.8	2.5	10.5										
	183	−0.8	29.8	+0.7	29.7	2.9	28.2	4.8	26.3	18.9	13.2	22.0	7.6	19.2	7.0	−10.4	27.2										
	199	1.9	37.2	3.2	37.1	4.2	35.8	6.7	31.3	19.0	21.2	23.6	11.5	22.3	8.6												
	206	−1.3	31.3	−3.9	30.2	+3.1	28.6	6.1	26.8	10.0	22.7	12.5	20.2	14.6	16.1												
	214	5.3	14.7	6.0	14.4	6.8	12.6	−18.1	28.2																		
	216	0.8	33.1	0.6	33.2	4.1	29.4	5.1	28.6	17.6	15.5	22.5	6.5														
	217			1.4	33.3			6.1	28.6			21.6	10.4														
	221											12.6	28.8			16.0	23.2			18.0	18.0			14.3	11.7		
	251											23.0	19.3			26.6	13.8			29.8	7.8			26.3	12.0		
	261	7.8	46.3	8.6	46.0	8.7	45.6	13.3	42.9	11.0	42.4	20.1	38.4	24.0	34.4	24.0	35.2	26.5	32.6	27.4	34.4	28.6	30.6	29.5	28.2		
13	7	−0.4	36.5	0.9	36.8	+0.4	38.5	1.0	37.4	3.7	36.0	5.6	34.9	5.9	35.0	7.7	33.5	10.4	31.7	11.4	31.3	11.0	29.9	6.5	24.4		
	72	+0.6	35.0	0.7	34.3	1.7	35.7	1.9	35.8	4.3	33.0	7.8	30.9	10.6	28.4	11.8	27.8	12.0	26.8	14.2	25.6	20.5	18.7	23.8	9.6		
	122	10.2	14.2	10.4	43.9	12.2	49.3?	12.8	43.9	15.8	41.8	20.2	38.0	33.8	22.0	33.9	22.8	33.9	22.2	34.0	22.0	36.0	21.2				
	131	0.8	40.8	2.5	41.0	3.5	41.0	3.6	40.0	6.4	39.6	16.4	32.6	17.8	31.6	19.7	29.5	20.8	28.8	25.4	23.4	28.8	18.5	31.6	10.2		
	171	+1.0	40.5	6.5	39.2	9.4	37.2	12.4	35.5	22.8	25.4	28.8	18.4														
	198	10.8	38.0	11.3	37.9	11.4	38.3	14.7	38.0	14.4	37.8	17.8	33.1	19.8	32.1	24.7	27.1										
	218	0.9	33.9	0.3	34.2	1.5	33.1	1.9	33.8	7.3	30.0	7.0	31.0	9.9	28.8	10.9	28.2	27.7	25.1	30.0	22.2	34.9	13.2				
	256											13.0	43.1			18.0	39.8			20.8	37.1			35.6	20.3		

% V. S. = Firing shrinkage, per cent dry volume. % A. P. = Per cent apparent porosity.

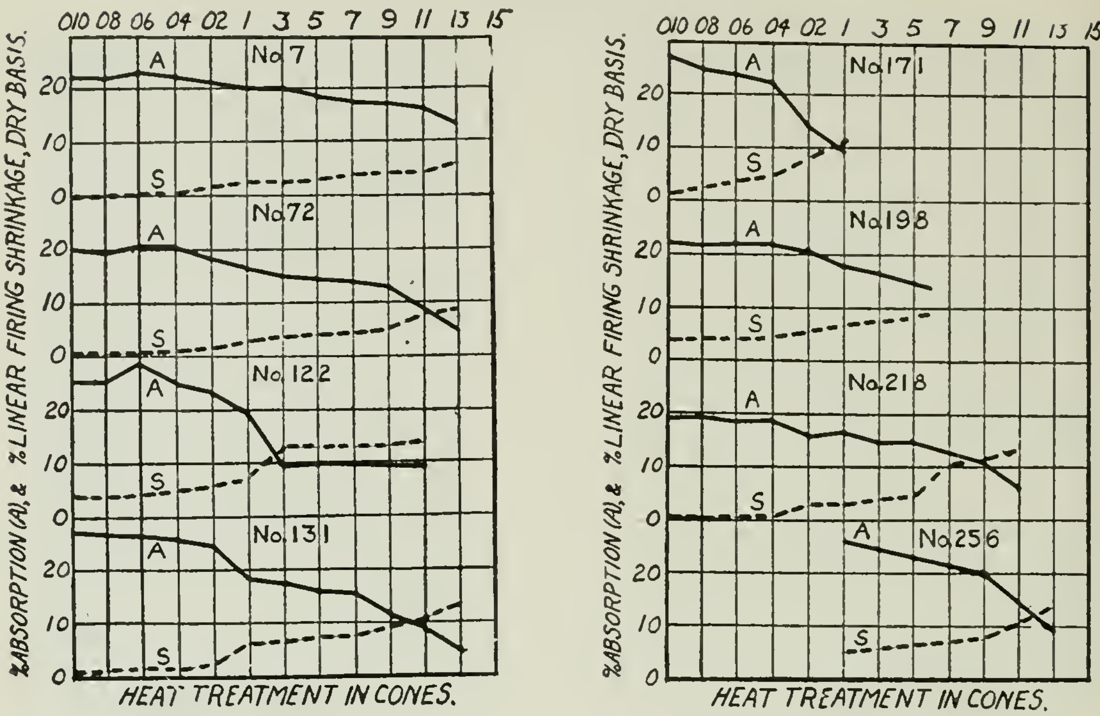
Absorption and linear shrinkage curves for clays of class 12.



Absorption and linear shrinkage curves for clays of class 12.



Absorption and linear shrinkage curves for clays of class [illegible]



III–B. Dense-Burning. Less Than 6% Apparent Porosity at Vitrification.

a. With Long Vitrification Range, 4 Cones or More.

14. Mainly Medium to High Strength, But Also Including Some Clays of Low Strength.

No. 10 (p. 163). Riverside County. Alberhill C. & C. Co. "Hill Blue Green." This is a fine-grained, excessively-plastic clay that serves mainly as a strengthening clay in sewer-pipe and similar mixes. The dry strength is very high, but the excessive drying shrinkage causes serious warping and cracking when used alone. The dry clay is very hard and dense. The colors are: dry, 23′′′′′b; wet, 21′′′′; cones 010 to 06, 9′b; cones 04 to 1, 9′′; cones 3 to 5, 9′′′; cone 7, 1′′′; cone 9, 1′′′′b; cone 11, 13′′′′d (flashed). All test pieces cracked on firing, except those at cones 010 and 08. Finger-nail hardness is found in the dry state, steel hardness is developed at cone 04, vitrification is complete at cone 1, and bloating begins above cone 5. The total maximum linear shrinkage is 22.3%, at cones 3 to 5. The softening point is cone 14–15. The long vitrification range and excellent dry strength of this clay are its principal merits.

No. 21 (p. 163). Riverside County. Alberhill C. & C. Co. "Sagger Clay." This is a pink-burning, plastic clay that finds use as a vitrifying agent in sagger bodies. It has a smooth, strong plasticity, and a medium low dry strength. There is slight effervescence in hydrochloric acid. In the dry state it is soft, with a medium-fine grain, and has a tendency to laminate. The colors are: dry, 7′′b; wet, 7′′; cones 010 to 04, 5′d; cone 02, 7′d; cones 1 to 5, 7′′d; cone 7, 13′′′d; cones 9 to 13, 17′′′d. Iron specks are prominent at cone 7 or above. Finger-nail hardness is developed below cone 010, and steel hardness at cone 1. A few small cracks appeared in the test firing, probably caused by too rapid firing during the water-smoking stage. The total linear shrinkage, plastic basis, at cone 13, is 21.3%. The softening point is cone 23. The best firing range is from cone 02 to cone 13. The wide vitrification range of this clay within the limits of commercial firing is its principal merit. With the addition of non-plastic material, it is suitable for pink- and buff-burned face brick, roofing tile, and similar products, as well as for saggers.

No. 22 (p. 163). Riverside County. Alberhill C. & C. Co. "Yellow Owl Cut." This is a yellowish clay containing 12.6% of +200-mesh sand, and has good plasticity, high drying shrinkage, medium-high dry strength, and good dry condition, though with a tendency to laminate. It is used in sewer-pipe mixes. The colors are: dry, 15″d; wet, 15″; cones 010 to 08, 5′d; cones 06 to 04, 7′d; cones 02 and 1, 9′b; cones 3 to 7, 7″b; cones 9 to 13, 9‴d. Finger-nail hardness is developed at cone 010, and steel hardness at cone 1. The total linear shrinkage, plastic basis, is 18.6%, at cone 11, and slight bloating appears at cone 13. The softening point is cone 17. The best firing range is from cone 02 to cone 11. The most desirable features of this clay are its dry strength and wide vitrification range.

No. 75 (p. 174). Riverside County. Alberhill. L. A. B. Co. "Red No. 2." This is a vitrifying clay with its light-red firing colors that is valuable in roofing-tile and face-brick mixtures. In the natural state it is hard and brittle and the color is mottled pink and cream. It contains 16.4% of +200-mesh sand. The plasticity is excellent, the dry strength is medium, and the dried condition is medium-hard, and medium close-grained. The colors are: dry, 7″b; wet, 7″; cones 010 to 1, 9′b; cones 3 to 9, 9″b; cones 11 and 13, 1⁗i (flashed). Finger-nail hardness appears below cone 010, and steel hardness at cone 3. Absorptions below 10% are obtained at cone 5, and vitrification is complete at cone 11. Slight bloating appears at cone 13, under reducing conditions. The fired test pieces are moderately hair-cracked, and at cones 11 and 13 a few large open cracks appear. The maximum total linear firing shrinkage, plastic basis, is 24.0%, at cone 11. The softening point is cone 20–23. The best firing range is from cone 3 to cone 11. The clay should be mixed with non-plastics to obtain safe firing properties.

No. 123 (p. 56). Amador County. Ione (Carbondale). Leased by G. A. Starkweather. "Yaru No. 2." This is a red-burning clay with smooth and weak plasticity, and medium dry strength. It contains 5.4% of +200-mesh quartz-mica sand. In the dried condition it is soft, fine-grained and close-textured. The colors are: dry, 17″d; wet, 17″b; cones 010 to 7, 9′; cone 9, 9⁗; cones 11 and 13, 7⁗. Steel hardness is developed at cone 02. Less than 10% absorption appears at cone 1. The fired structure is sound, and the texture is smooth. Vitrification is complete at cone 11, and blistering appears at cone 13. The maximum total shrinkage, plastic basis, is 22.1%, at cone 11. The softening point is cone 27–28. The best firing range is from cone 1 to cone 11. The clay may be used for face brick, roofing tile, red-burned pottery, etc.

No. 127 (p. 57). Amador County. Ione. M. J. Bacon. "Bacon Red." This is a red-burning clay with excellent smooth plasticity, and medium low dry strength. In the dried condition it is soft, and fine-grained. The colors are: dry, 7″b; wet, 7″; cones 010 to 5, 9′b; cone 7, 7′b; cones 9 to 13, 7″b. Steel hardness appears at cone 1. Less than 10% absorption is obtained at cone 7. The fired structure is sound, and the fired surface is smooth. The total linear shrinkage, plastic basis, at cone 13, is 20.0%. The softening point is cone 27. The best firing range is above cone 1. The clay may be used for face brick and roofing tile, and for pink colored pottery or tile bodies.

No. 148 (p. 156). Placer County. Lincoln. Lincoln Clay Products Co. "No. 8." This is a red burning variety that possesses nearly the same plastic, drying and firing properties as No. 146, in class 8, but with a lower softening point. It contains 12.4% of +200-mesh sand. It is used for face brick, sewer pipe, roofing tile, etc. The colors are: dry, 15′b; wet, 15′b; cones 010 to 04, 5′d; cones 02 to 3, 7″b; cone 5, 7″; cone 7, 7″; cone 9, 1‴i; cones 11 and 13, 1⁗. Steel hardness develops at cone 1. Less than 10% absorption is developed at cone 3. The fired structure is sound and stony. Blistering is noticeable at cone 11. The maximum total linear shrinkage, plastic basis, is 20.2%, at cone 9. The softening point is cone 20. The best firing range is from cone 1 to cone 9.

No. 177 (p. 66). Butte County. Oroville. Quincy road. This sample contains a high proportion of partly-decomposed volcanic ash. Since it is the only sample of its type on which test data could be secured, the results are given as a matter of general interest. The plasticity is weak and spongy, the dry strength is medium-high, and in the dried condition it is hard, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 17″i; cones 010 and 08, 15″d; cone 06, 13′b; cone 04, 13′d; cones 02 and 1, 17″i. Steel hardness is developed at cone 04. The sharp change from 16.8% porosity at cone 04 to 0.1% porosity at cone 02 should be especially noted, together with the corresponding sharp decrease in volume. The fired structure at cone 02 is glassy, and large cracks are present. Bloating and fusion follow when fired above cone 1. The total linear shrinkage, plastic basis, is 26.6%, at cone 1.

No. 181 (p. 80). Humboldt County. Angel Ranch. This clay has been used by Mr. R. H. Jenkins at the Humboldt State Teachers College, as a casting clay for pottery. It has good plasticity, with a tendency to stickiness. The residue on 200-mesh is 8.8%. The dry strength is medium high, and in the dried condition it is medium hard, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 17‴b; cone 010, 11′f; cone 08, 11′d; cones 06 and 04, 9′d; cone 02, 11′d; cone 1, 9″i; cone 3, 11″i; cone 5, 15″. Steel hardness appears at cone 08, and less than 10% absorption at cone 04. Vitrification is complete at cone 1, and a vesicular structure is developed beyond cone 1. The fired structure is sound and stony, and the surface texture is smooth. The maximum total linear shrinkage, plastic basis, is 14.0%, at cone 1. The best firing range is from cone 08 to cone 1.

No. 188 (p. 92). Lake County. Kelseyville. This is a red-burning thin-bedded clay shale. The clay slakes readily in water, and works into a smooth and moderately strong plasticity. It effervesces slightly in hydrochloric acid. The dry strength is medium, and in the dried condition it is medium hard, fine-grained, and close-textured. The colors are: dry, 17‴f; wet, 17‴i; cone 010, 11″; cone 08, 13″; cones 06 to 02, 9′; cones 1 and 3, 7″k. Steel hardness is developed at cone 04, and less than 10% absorption at cone 1. The fired strength is medium and a few small cracks are present in all fired test pieces. The total linear shrinkage, plastic basis, is 25.4% at cone 3. On account of excessive shrinkage, short vitrification range, and medium strength, this material is only useful for manufacturing a poor quality of common brick, even if mixed with non-plastic material.

No. 202 (p. 68). Calaveras County. Valley Springs. California Pottery Co. "Pink Mottled." This is a fine-grained, red-burning clay, with smooth and strong plasticity, and medium dry strength. It contains 4.4% of +200-mesh sand. In the dried condition it is soft, fine-grained, and close-textured. A strong tendency to laminate was noted. The colors are: dry, 11′; wet, 7′i; cones 010 to 04, 9″b; cones 02 to 5, 11″; cones 7 and 9, 9″. Steel hardness is developed at cone 02, and less than 10% absorption at cone 1. The fired structure is sound, tough, and stony. The surface texture is smooth. The maximum total linear shrinkage, plastic basis, is 20.6%, at cone 11, and bloating is apparent at cone 13. The softening point is cone 20. This is an excellent face brick and roofing tile clay.

No. 203 (p. 68). Calaveras County. Valley Springs. California Pottery Co. "Yellow Plastic." This is similar in its ceramic properties to No. 202, but is not so fine-grained, and contains more non-plastic matter. The residue on 200-mesh is 10.2%. The colors are: dry, 15″b; wet, 15″b; cones 010 to 04, 11′b; cone 02, 9′; cones 1 to 5, 11″; cone 7, 7″; cone 9, 5″. Steel hardness is developed at cone 1, and less than 10% absorption at cone 5. The surface texture is rougher than that of No. 202. The total linear shrinkage, plastic basis, is 18.0%, at cone 13. The softening point is cone 19–20.

No. 210 and 212 (p. 186). Sacramento County. Natoma. No. 210 is a sample of "Natoma No. 1," and No. 212 is a sample of "Natoma No. 3." They differ only in the proportion of non-plastic matter, which is greater in No. 212 than in No. 210. The clay is extremely fine-grained, and contains a high proportion of mica. The plasticity is strong, and in the dried condition the samples have finger-nail hardness, are fine-grained, and close-textured. The clay must be dried carefully to avoid cracking. The dry strength of No. 210 is high, and of No. 212 is medium high. The colors of No. 210 are: dry, 13″b; wet, 13″i; cones 010 to 04, 9′; cone 02, 9′i; cones 1 and 3, 9k; cone 5, 9′m. The colors of No. 212 are: dry, 13″; wet, 11″; cones 010 to 06, 13″; cone 04, 7″; cones 02 to 3, 7″i; cone 6, 5″m. Steel hardness and less than 10% absorption are developed at cone 04, and vitrification is complete at cone 5. A vesicular structure appears at cones 7 to 9. The fired structure is sound and strong and the surface texture is smooth. The total linear shrinkage, plastic basis, of No. 210 is 19.1%, at cone 5, and of No. 212 is 16.9%, at cone 6.

Mr. L. W. Austin, of the company, kindly gave the following data on No. 210:

Sizing Test of Natoma Clay No. 1.

Size in mm.	Equivalent mesh	Accumulative on	Per cent through
0.02	1,000	0.40	99.60
0.01	2,000	2.08	97.97
0.006	3,000	7.06	92.94
0.004	4,000	13.36	86.64
0.003	5,000	20.19	79.81
0.002	10,000	29.89	70.11
0.001	20,000	52.07	47.93
0.0006	30,000	59.22	40.78

Mr. Austin reports the results of commercial firing tests on Natoma No. 1 (our number 210) as follows: Drying shrinkage, 7.5 to 9.0%; total linear firing shrinkage at cone 5, approximately 15%; absorption at cones 5 to 7, 0.35 to 0.1%; bloating usually begins at cone 9. Another firing test gave a total linear shrinkage, plastic basis, of 20.5%, after heating to cone 5 in 36 hours and holding the finishing temperature for 4 hours.

A number of clay products manufacturers have tested this clay, and some have introduced it into their mixes. It is particularly valuable for the purpose of producing a hard, strong vitrified body, with rich-red colors, and a smooth texture. In some plants the successful use of this clay will require a modification of the drying procedure. The clay can be cast, or pressed, and takes die impressions very perfectly. In an auger machine, the finely divided mica is an aid to lubrication, yet the flakes are not so large as to cause excessive lamination.

b. With Short Vitrification Range, Less Than 4 Cones.

15. Medium to High Strength.

No. 1 (p. 218). Santa Barbara County. R. Muengenberg and E. H. Whitiker, West Montecito Street, Santa Barbara. This is a mixture of a yellowish sandy clay and a plastic black adobe, mined locally and used for structural wares. It effervesces slightly in hydrochloric acid. It develops a sticky plasticity and has high dry strength and good dry structure. The percentage of +200-mesh sand is 33.2. The dry color is 17'''', the wet color is 17''''i, and the fired color to cone 3 is 9'i, a good color for common brick. Steel hardness is developed at cone 1, and bloating appears at cone 5. The maximum total linear shrinkage, plastic basis, is 12.8% at cone 3. The best firing range is from cone 02 to cone 3.

No. 2 (p. 218). Santa Barbara County. Toro Canyon, near Montecito. An adobe clay, used in the Toro Canyon brickyard operated by Muengenberg and Whitiker for the manufacture of red structural wares. The percentage of +200-mesh sand is 33.4. It develops a sticky plasticity and high dry strength with good dry structure. The dry color is 13''' and the wet color is 13'''i. The fired color is 9'i from cones 010 to 02, and 7''i from cones 1 to 3, both of which are good common brick colors. Steel hardness is developed at cone 1, and bloating appears at cone 5. The maximum total linear shrinkage, plastic basis, is 12.5% at cone 3. The best firing range is between cones 02 and 3.

No. 4 (p 234). Ventura County. A yellow plastic clay from the Fernando (Pliocene) formation, north of Ventura, and used by the People's

Lumber Co. for the manufacture of red structural ware. It is fine-grained, and develops sticky plasticity and high dry strength, but has a high drying shrinkage and a tendency to warp when used alone. It contains but 1.4% of +200-mesh sand. The dry color is 17‴b, the wet color is 17‴, and the fired colors are 9′b from cones 010 to 06, 9′ at cone 04, and 9′i from cones 02 to 1, giving an excellent range for common brick, building tile, and roofing tile. Steel hardness is developed at cone 02, and bloating begins above cone 1. The maximum total linear shrinkage, plastic basis, is 21.4%, at cone 1. The best firing range is from cone 04 to cone 1. The high shrinkage should be reduced with non-plastic material for best results in making structural ware.

No. 5 (p. 234). Ventura County. A grayish blue plastic clay overlying No. 4. Used principally for oil-well mudding, and with clay No. 4 in the manufacture of structural ware. The ceramic properties are similar to those of sample No. 4. The dry color is 21⁗b, the wet color is 21⁗, and the fired colors are 7″b from cone 010 to cone 04, 5′d at cone 02, 7″ at cone 1, and 13‴i (flashed) at cone 3. Knife hardness is developed at cone 02, maximum shrinkage at cone 1, and bloating begins near cone 3. The maximum total linear shrinkage, plastic basis, is 20.0%, at cone 1. The best firing range is from cone 04 to cone 1. For best results, the clay should be mixed with non-plastic material for manufacturing structural ware.

No. 6 (p. 234). Ventura County, 2.7 miles north of Santa Paula. A yellowish plastic clay used for making dry-pressed common brick in the yard of Anderson and Hardison. It contains 17.8% of +200-mesh sand and develops good, but sticky, plasticity, and high dry strength. There is slight effervescence in hydrochloric acid. The dry color is 17‴b, the wet color is 17‴i, and the fired colors are 7′b from cone 010 to cone 02, 7″ at cone 1, and 7″i (flashed) at cone 3. These are good red brick colors. Knife hardness is developed at cone 02, and slight bloating is apparent at cone 3. The maximum total shrinkage, plastic basis, is 17.5%, at cone 1. The best firing range is from cone 04 to cone 1+. The wide vitrification range, from cone 02 to cone 3—, coupled with other desirable qualities, make this a good clay for hard burned structural ware.

No. 30 (p. 203). San Diego County. Rose Canyon. San Diego Tile and Brick Co. This is a yellow and gray Tertiary clay shale, used for making common brick and hollow building tile. It effervesces slightly in hydrochloric acid. It contains 13.0% of +200-mesh sand, has good plasticity for either the auger or the brick-press, medium high dry strength, and a good dry structure. It can be dried rapidly without danger of cracking. The colors are: dry, 21⁗; wet, 17⁗; cones 010 to 04, 9′d; cones 02 and 1, 9″; cone 3, 9‴; cone 5, 9‴i. The fired colors cover a good range of desirable common brick reds. Finger-nail hardness is present in the dry state, and knife hardness appears at cone 1. Vitrification is complete at cone 3, and bloating begins at cone 5. The fired brick are hard, dense and sound. The maximum total linear shrinkage, plastic basis, is 16.4%, at cone 3. The best firing range is from cone 010 to cone 3, and excellent hard-burned brick are obtained from cone 1 to cone 3.

No. 31 (p. 204). San Diego County. Rose Canyon. Union Brick Co. An unconsolidated yellowish sandy-clay of Tertiary age. The formation contains pebbles and boulders, the larger part of which are removed by screening. The sample contains 32.6% of +200-mesh sand. It is used for common brick, but is suitable also for making hollow building tile. The plastic and drying properties are such that it can be used alone. It has a high dry strength, and in the dry state it is hard, with a medium grain and open texture. The colors are: dry, 17‴b; wet, 13‴i; cones 010 to 02, 9′i; cones 1 and 3, 7″; cone 5, 9″i. These are nearly the same as in sample No. 30, and cover a good range of common brick colors. Finger-nail hardness is present in the dry state, and steel hardness appears at cone 1. Vitrification is complete at cone 3, and bloating appears at cone 5. The maximum total linear shrinkage is 10.4% at cone 3. The best firing range is from cone 010 to cone 3, and well vitrified products are obtained from cone 1 to cone 3.

No. 42 (p. 181). San Bernardino County. Vidal. "Blue." See also No. 43. This is a bluish, extremely fine-grained clay-shale of the bentonitic type. In water, it slakes readily to a smooth slip. It effervesces strongly in hydrochloric acid. When mixed with 57.7% water, it develops a smooth, workable plasticity, without excessive stickiness. The drying shrinkage is high, and ordinary air-drying methods caused large drying cracks and excessive warping to develop. In the dried state, it is hard, fine-grained, brittle and close-textured. The dry strength could not be determined accurately. With the firing schedule employed, the clay was badly shattered, but data were obtained for cone 010 and cone 08. The colors are: dry, 17‴f; wet, 21‴d; cones 010 and 08, 15″b. Finger-nail hardness appears in the dry state, and steel hardness at cone 010. In view of the isolation of the deposit, it has no commercial value. The fineness of grain, plastic strength, and apparently high dry strength are interesting features. No tabulated data or charts of firing shrinkage and absorption are presented.

No. 43 (p. 181). San Bernardino County. Vidal. "Pink." This clay is similar to No. 42, except that it contains more iron and more non-plastic matter, resulting in deeper fired colors, and lower drying and firing shrinkage. It effervesces strongly in hydrochloric acid. The dry strength is high. The colors are: dry, 11′f; wet, 17‴d; cones 010 to 1, 11″; cone 3, 13″k. Efflorescence is especially pronounced. Finger-nail hardness is present in the dried state, and steel hardness is developed at cone 08. At cone 3, kiln-marking and bloating begins. The maximum total linear shrinkage, plastic basis, is 20.0%, at cone 1. The fired structure is tough and strong. The best firing range is from cone 08 to cone 1.

No. 60 (p. 100). Los Angeles County. Los Angeles, Davidson Brick Co. This is a red-burning clay suitable for the manufacture of common structural ware. The ratio of clay to sand is such that the plasticity, drying and firing properties are entirely satisfactory without admixture with other materials. It contains 5.4% of +200-mesh sand. There is slight effervescence in hydrochloric acid. The dry strength is medium-high, and the dry structure is hard, fine-grained, and open-textured, with a tendency to laminate. The colors are: dry, 17″d; wet, 17‴i; cone 010, 9′d; cone 08, 11′b; cone 06, 9′b; cone 04, 9″b; cone 02, 7″; cone 1, 9‴; cone 3, 5‴i; and cone 5 (bloated) 9‴k. This affords an excellent range for red brick. Finger-nail hardness is obtained below cone 010, and steel hardness develops at cone 1. Vitrification is complete at cone 3, and bloating begins just below cone 5. All fired test pieces were sound and strong. The maximum total linear shrinkage, plastic basis, is 16.9%, at cone 3. The best firing range is from cone 010 to cone 3, or if vitrified products are desired, from cone 1 to cone 3.

No. 61 (p. 102). Los Angeles County. Santa Monica. Gladding, McBean and Co. This is representative of the clay used by several other plants in the same locality, and in some of the sewer-pipe and conduit plants in the Los Angeles district. It is a red-burning clay, with suitable plastic, drying, and firing properties to permit its use as the sole ingredient of common brick, hollow building tile, roofing tile, etc., and as a vitrifying and bonding clay in sewer-pipe and electrical conduit mixes. It contains 18.0% of +200-mesh sand. The dry strength is medium high, and the dry condition is hard, fine-grained, and close-textured. The colors are: dry, 17‴; wet 13‴k; cone 010, 11′b; cone 08, 11′; cones 06 and 04, 9′; cone 02, 9′i; and cones 1 and 3, 9″k. These colors give a suitable range for the uses indicated above. Finger-nail hardness is obtained below cone 010, and steel hardness at cone 02. Vitrification is complete at cone 1, and bloating begins at cone 3. The fired structure is sound and strong. The maximum total linear shrinkage, plastic basis, is 13.1%, at cone 1. The best firing range is from cone 010 to cone 1, or if vitrified products are desired, from cone 02 to cone 3.

No. 89. Riverside County. Elsinore. Hudson Ranch clay. This is a red-burning sandy clay from an undeveloped deposit. It effervesces slightly in hydrochloric acid. It has good plasticity, medium-high dry strength, and the dried condition is hard, medium fine-grained, and close-textured. The colors are: dry, 17⁗b; wet, 17⁗; cones 010 to 06, 15″b; cones 04 to 1, 13″b; cones 3 and 5, 7″; cones 7 to 13, 7″k. Finger-nail hardness is present in the dried state, and steel hardness is developed at cone 7. Absorptions under 10% are obtained at cone 11, and bloating is well developed at cone 13. All fired test pieces are sound. The maximum total linear shrinkage, plastic basis, is 20.2% at cone 11. The clay might have local use as a coloring and bonding clay, but its high shrinkage and short vitrification range are undesirable features.

No. 118 (p. 192). San Benito County. Paicines. This is a yellowish, plastic surface clay, with a smooth, strong plasticity and exceptionally high dry strength. There is slight effervescence in hydrochloric acid. In the dried condition it is hard, fine grained, and close textured. It contains 4.0% of +200-mesh sand. The colors are: dry, 21⁗d; wet, 21⁗; cone 010, 9′d; cones 08 and 06, 9′b; cone 04, 9′; cones 02 and 1, 9′k; cone 3, 7″k. Finger-nail hardness is developed below cone 010, and steel hardness at cone 04. Less than 10% absorption is developed at cone 04, and vitrification is complete at cone 02, above which temperature bloating begins. The fired structure, up to cone 02, is sound and stony. The maximum total linear shrinkage, plastic basis, is 18.8%, at cone 02. This clay is not in use, but would be entirely suitable for red-burned structural ware, and is worthy of investigation as a casting clay.

No. 172 (p. 136). Nevada County. Manzanita Mine, near Nevada City. This is the so-called "pipe clay" of the hydraulic mines. It develops fair plasticity, medium-high dry strength, and a medium-hard, fine-grained and open-textured dried condition. The colors are: dry, grayish white; wet, 23''''d; cones 010 to 04, 15''b; cones 02 to 3, 11''b; cone 5, 5''i; cone 7, 5''k. Steel hardness is developed at cone 04, and less than 10% absorption at cone 02. The fired structure is sound and stony, and the surface texture is slightly rough. The maximum total linear shrinkage, plastic basis, is 24.8% at cone 5. Bloating is apparent at cone 7. The clay could be mixed with non-plastics and used locally for the manufacture of common brick.

No. 184 (p. 80). Humboldt County. Eureka. Freshwater Slough. This is a common clay with good plasticity, and medium high dry strength. In the dried condition it has finger-nail hardness, is fine-grained, and close textured. The colors are: dry, 17''''b; wet, 17''''i; cones 010 to 06, 13'b; cones 04 and 02, 11'b; cone 1, 13'k. Steel hardness is developed at cone 04, and less than 10% absorption at cone 02. Vitrification is complete at cone 1. The fired structure is sound, and the surface texture is smooth. The maximum total linear shrinkage, plastic basis, is 22.8%, at cone 1. The clay is entirely suitable for the manufacture of common brick, hollow tile, and roofing tile, but should be mixed with non-plastic material to decrease the shrinkage.

No. 185 (p. 80). Humboldt County. Eureka. Loofbourrow Ranch. This is a common clay with sticky plasticity, and medium-high dry strength. It is extremely fine-grained and contains carbonaceous matter. In the dried condition it has finger-nail hardness. The colors are: dry, 15''''b; wet, 15''''i; cones 010 to 04, 11''b; cone 02, 5''; cone 1, 7''m. Steel hardness and less than 10% absorption are developed at cone 02, and vitrification is complete at cone 1. The fired structure is sound. The total linear shrinkage, plastic basis, is 19.3%, at cone 1.

No. 200 (p. 73). Contra Costa County. Walnut Creek (Oxley siding). N. Clark & Sons. This is a red-burning, calcareous shale that is used as a non-plastic ingredient in sewer-pipe mixtures. The plasticity is weak, the dry strength is medium, and in the dried condition it is medium hard, fine-grained, and open-textured. The colors are: dry, 17'''f; wet, 17'''b; cones 010 and 08, 15''b; cone 06, 11'; cones 04 and 02, 9'; cone 1, 9'k; cones 3 and 5, 11'm. Steel hardness and less than 10% absorption are developed at cone 1. The fired structure is fine-granular, and the surface texture is slightly rough. Above cone 1, the test pieces are disrupted by one or more large cracks, and the greenish-brown coloration due to the presence of lime is apparent. The maximum total linear shrinkage, plastic basis, is 19.7%, at cone 3.

No. 211 (p. 81). Humboldt County. Near Strong's Station, Van Duzen River. This is a common-brick clay that has good plasticity, medium-high dry strength, and in the dried condition has finger-nail hardness, is fine-grained, and close-textured. The colors are: dry, 21''''d; wet, 21''''b; cones 010 and 08, 13''b; cones 06 to 02, 11''; cones 1 and 3, 5''''. Steel hardness and less than 10% absorption appear at cone 1. The fired structure is sound and strong, and the surface texture is slightly rough. The total linear shrinkage, plastic basis, is 15.1%, at cone 3. The material could be successfully used for the manufacture of common brick and hollow tile, although the fired colors are not especially attractive.

No. 223 (p. 141). Orange County. Goat Ranch. G., McB. & Co. Red-burning shale. This material develops good plasticity if properly ground and pugged. The dry strength is medium-high, and in the dried condition it has finger-nail hardness, and is close-textured. There is slight effervescence in hydrochloric acid. The colors are: dry, 15''d; wet, 17''k; cones 010 to 06, 13''b; cones 04 and 02, 11''; cone 1, 5''i; cone 3, 5''k; and cone 7, 5''m. Steel hardness and less than 10% absorption are developed at cone 1, and bloating appears at cone 5. The fired structure is sound and strong. The maximum total linear shrinkage, plastic basis, is 14.5%, at cone 3. This is an excellent material for the manufacture of vitrified heavy clay products, such as sewer pipe, electrical conduit, paving brick, and similar ware.

No. 264 (p. 42). Alameda County. Decoto. M & S Tile Co. This is a common alluvial clay that is used for making hand-made roofing tile. The plasticity is good, the dry strength is high, and in the dried condition it has finger-nail hardness, is fine-grained, and close-textured. The colors are: dry, 17''i; wet, 15''k; cones 010 and 08, 11'; cones 06 and 04, 9'i; cone 02, 7'k. Steel hardness and less than 10% absorption are developed at cone 02. Bloating begins above cone 1. The fired structure is sound, and the surface texture is smooth. The total linear shrinkage, plastic basis, is 14.2%, at cone 02. This clay belongs to the same geologic formation as No. 265, and its ceramic properties are closely similar.

No. 265 (p. 40). Alameda County. Niles. W. S. Dickey Clay Manufacturing Company, Plant No. 18. This is a common alluvial clay that is used for manufacturing hollow tile and paving brick. The plasticity is fair, but it is usually necessary to add from 15 to 20% of a plastic clay from Lincoln or Ione to secure suitable working properties for an auger machine. The dry strength is medium high, and in the dried condition it is hard, fine-grained, and close-textured. The colors are: dry, 15''i; wet, 13''k; cones 010 and 08, 11'; cones 06 and 04, 9'i; cones 02 and 1, 9'm. Steel hardness and less than 10% absorption are developed at cone 02, and vitrification is complete at cone 1. The fired structure is sound and strong. The total linear shrinkage, plastic basis, is 14.0%, at cone 1.

TABLE No. 26.

III. Red-Burning Clays.

B. Dense-burning. Less than 6% apparent porosity at vitrification.

a. With long vitrification range, 4 cones or more.

14. Mainly medium to high strength, but also including some clays of low strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
10	36.0	10.5	46.5	1530±	73.4	20.0	14–15
21	13.5	21.7	35.2	187	23.3	7.2	23
22	23.5	14.8	38.3	525	45.0	13.0	17
75	16.6	21.7	38.3	292	28.7	8.7	20–23
123	19.2	23.2	42.4	228	31.0	9.4	27–28
127	16.9	20.7	37.6	121	28.8	8.7	27
148	15.9	19.3	35.2	255	28.1	8.6	20
177	22.1	39.7	61.8	582	26.4	8.1	
181	14.2	12.3	26.5	794	28.6	8.6	
188	25.1	31.7	56.8	364	36.2	10.8	
202	17.5	21.5	39.0	230	29.4	8.9	20
203	15.3	18.6	33.9	232	27.1	8.2	19–20
210	21.5	15.5	37.0	1009	40.3	12.0	
212	18.9	16.3	35.2	625	35.0	10.5	

b. With short vitrification range, less than 4 cones.

15. Medium to high strength.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
1	14.0	13.1	27.1	848	27.8	8.5	
2	12.0	11.9	23.9	845	24.4	7.6	
4	29.4	17.8	47.2	1212	54.0	15.5	
5	22.1	18.3	40.4	1034	39.7	11.8	
6	22.2	13.7	35.9	1258	43.5	12.8	
30	15.3	19.5	34.8	595	27.3	8.0	
31	6.4	13.5	19.9	903	12.5	4.0	
43	30.4	16.7	42.7	1158	59.4	16.8	
60	14.2	18.7	32.9	720	25.1	7.8	
61	11.4	14.2	25.6	639	22.0	6.9	
89	27.5	13.9	41.4	597	52.4	15.0	
118	26.4	13.1	39.5	1363	53.2	15.3	
172	16.6	41.0	57.6	352	20.0	6.3	
184	26.4	20.9	47.3	703	43.8	12.9	
185	18.7	21.4	40.1	502	31.2	9.4	
200	14.7	28.3	43.0	363	21.8	6.9	
211	14.2	16.5	30.7	619	26.1	8.0	
223	10.2	16.8	27.0	412	18.5	5.8	
264	15.6	10.8	26.4	1020	31.8	9.6	
265	12.5	12.4	24.9	791	25.2	7.8	

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 27.

III. Red-Burning Clays.

B. Dense-burning. Less than 6% apparent porosity at vitrification.

a. With long vitrification range, 4 cones or more.

14. Mainly medium to high strength, but also including some clays of low strength.

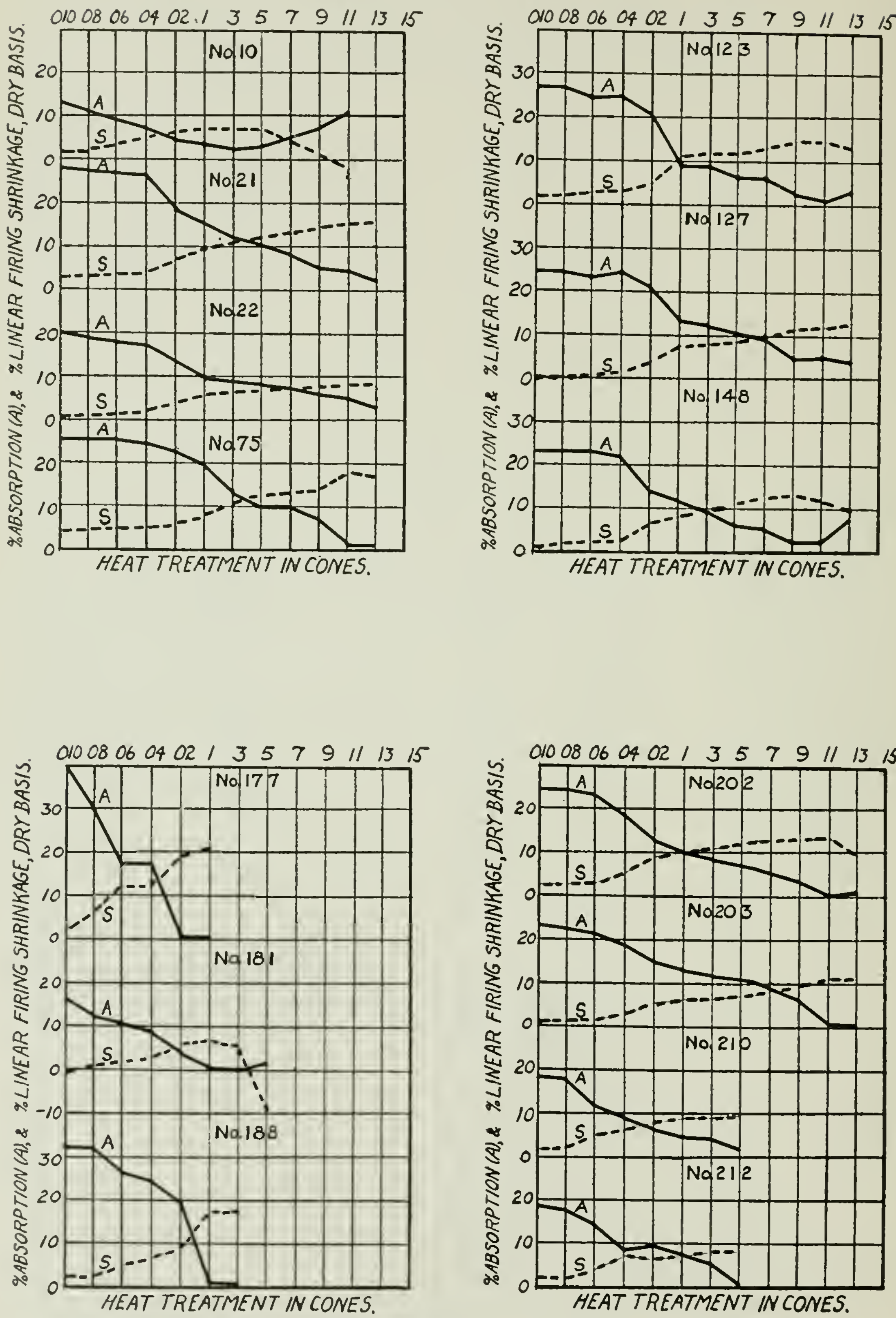
b. With short vitrification range, less than 4 cones.

15. Medium to high strength.

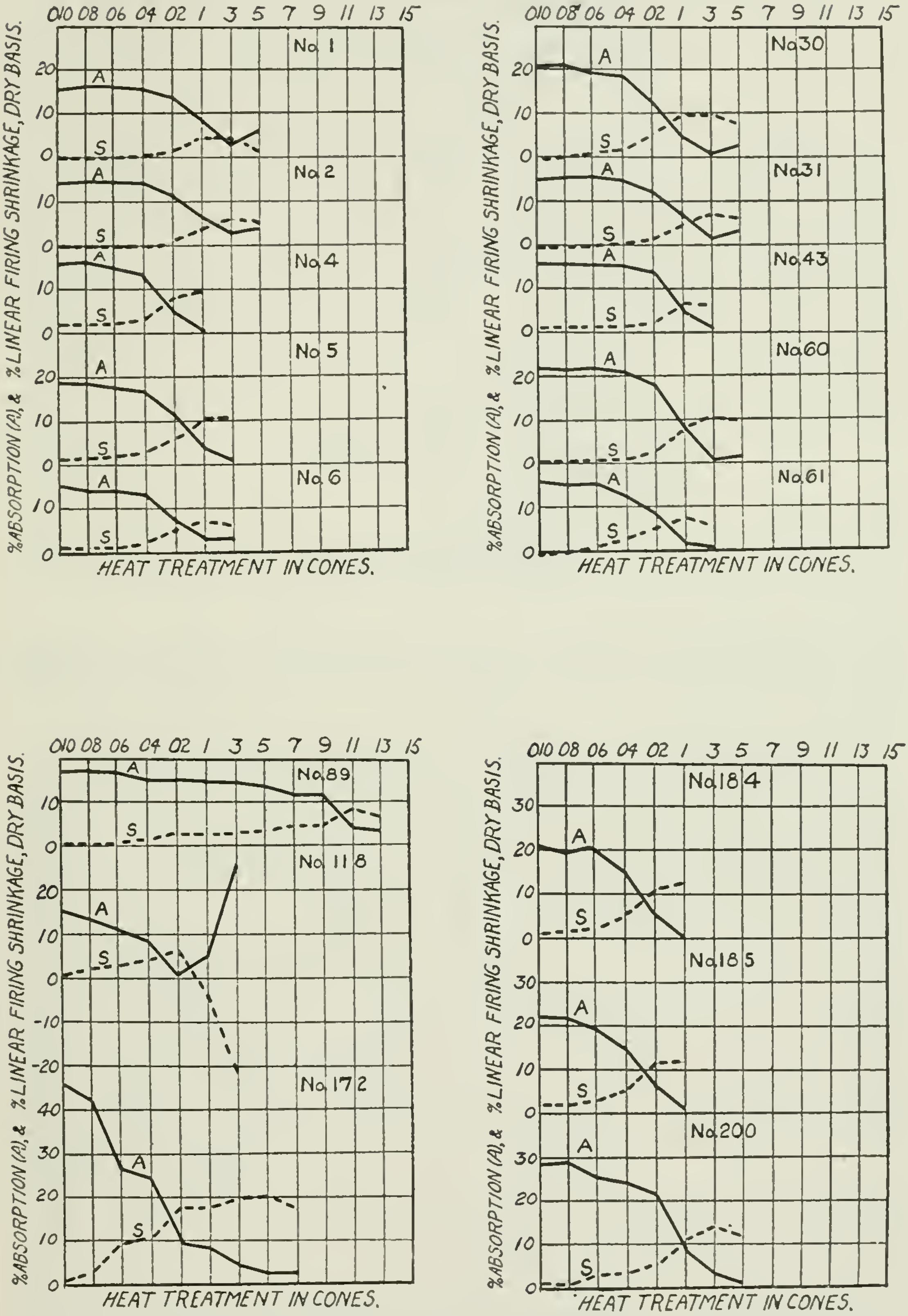
Class No.	Clay No.	Cone 010		Cone 08		Cone 06		Cone 04		Cone 02		Cone 1		Cone 3		Cone 5		Cone 7		Cone 9		Cone 11		Cone 13		Cone 15	
		% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.
14	10	3.3	24.0	1.3	21.4	7.0	18.7	11.8	13.6	16.8	8.4	18.2	5.4	18.8	2.6	18.8	3.6	11.4	9.0	1.8	12.1	−6.3	20.3				
	21	5.9	43.6	7.8	43.5	9.6	43.2	9.9	42.5	19.1	34.5	25.8	30.5	29.8	24.1	30.6	21.8	33.5	17.0	38.0	10.9	39.0	10.0	10.0	2.5		
	22	0.0	34.8	1.3	31.1	3.9	32.5	6.1	30.8	11.3	25.9	16.7	20.6	16.8	18.5	17.8	16.7	18.5	14.9	20.8	12.3	22.0	10.0	20.4	3.3		
	75	10.3	43.1	11.3	42.6	11.2	42.9	12.1	12.7	15.2	39.9	19.4	36.2	29.2	26.8	33.1	22.0	33.4	21.6	35.8	17.3	43.7	2.7	41.3	2.8		
	123	4.8	10.2	4.8	39.8	7.8	38.3	7.8	38.5	13.4	34.6	30.4	18.7	31.6	18.2	31.7	12.4	31.0	13.3	38.0	5.2	38.2	1.5	34.1	5.6		
	127	0.0	38.1	1.7	39.0	3.0	37.6	3.8	39.0	8.4	35.3	20.0	26.0	21.8	24.6	24.0	21.8	26.0	18.7	31.2	10.2	32.2	11.5	34.2	9.1		
	148	2.2	36.8	1.2	37.6	4.9	37.4	6.0	36.4	17.6	27.3	22.6	23.2	25.7	19.2	30.2	13.8	32.4	12.0	34.8	4.3	32.1	4.7	26.0	16.9		
	177	5.9	47.6	16.9	40.4	31.6	27.6	32.2	27.6	47.2	0.3	50.0	0.3														
	181	−1.2	26.2	+2.6	22.6	4.3	20.4	6.7	17.4	16.5	8.9	18.5	0.0	11.9	0.0	−23.9	2.1										
	188	6.0	45.4	6.0	45.4	13.7	40.6	18.6	39.2	24.9	33.6	13.4	0.9	43.4	0.6												
	202	5.9	39.1	6.5	39.1	18.3	38.0	15.1	33.4	21.4	24.2	27.1	20.5	29.7	17.7	‡32.3	‡13.4	#33.1	#12.3	34.5	6.7	35.0	0.0	25.2	1.6		
	203	1.9	37.3	2.5	37.0	3.7	35.7	7.7	33.4	15.2	28.0	16.9	25.0	18.2	23.4	‡21.0	‡21.0	#21.5	#20.8	25.6	13.3						
	210	4.6	32.8	5.0	32.0	14.5	23.4	17.1	19.0	21.6	13.8	24.4	10.4	24.4	9.3	25.6	3.3										
	212	3.8	32.8	4.4	31.8	10.8	27.4	19.7	18.5	17.8	20.2	20.1	16.0	22.5	11.5	22.7	1.6										
15	1	−0.8	28.4	−0.8	29.1	−0.2	29.2	+0.3	28.6	+3.2	26.0	11.6	17.3	15.2	4.9	5.3	12.1										
	2	−1.5	26.9	−1.5	27.3	−1.3	27.4	−0.4	26.9	+3.1	23.6	11.1	13.5	16.8	5.8	15.1	7.6										
	4	4.5	27.8	4.4	28.8	5.1	26.5	8.5	23.7	21.9	12.2	25.1	1.2														
	5	4.2	31.7	1.6	31.7	5.4	30.2	7.9	28.8	16.4	21.6	28.5	7.4	27.9	1.2												
	6	2.6	27.5	3.1	26.6	3.3	26.2	5.6	24.4	14.5	15.2	19.3	5.8	17.6	5.5												
	30	−0.6	31.3	0.0	34.7	+2.0	33.2	4.2	32.2	11.3	23.8	26.0	9.7	26.5	0.7	20.6	4.4										
	31	−0.3	27.9	−0.6	28.8	−0.3	28.6	+0.2	28.0	+4.0	24.3	13.5	15.3	19.0	2.7	16.8	6.8										
	43	2.8	28.9	2.3	28.4	3.1	28.5	3.7	28.4	5.9	25.8	18.6	9.8	16.7	1.1												
	69	0.3	36.5	0.5	36.2	1.0	36.8	2.0	35.9	6.7	32.3	22.3	17.5	28.1	0.4	25.9	2.8										
	61	−0.8	28.8	+0.1	28.4	2.1	27.8	6.4	21.2	13.9	16.5	19.2?	2.8?	14.5	0.7												
	89	1.1	30.5	0.9	31.1	1.8	30.1	4.2	28.2	7.1	28.5	7.1	28.0	7.7	27.8	8.5	26.6	12.9	23.1	13.1	23.0	22.8	8.3	17.8	1.6		
	118	1.5	27.8	4.9	25.1	7.3	21.4	11.5	17.7	17.9	1.9	−12.3	8.1	−52.8	30.8												
	172	3.0	51.0	8.1	51.7	25.0	40.0	28.4	38.1	43.2	18.9	43.8	16.8	47.9	8.5	49.0	4.5	42.6	4.3								
	184	3.1	32.8	4.7	32.2	5.6	31.2	14.0	27.2	30.3	12.5	31.1	0.0														
	185	4.5	35.1	4.8	34.4	7.4	32.8	15.3	27.6	30.7	13.6	31.3	0.5														
	200	3.1	41.7	2.4	42.1	7.8	39.0	9.5	38.2	14.1	34.8	31.0	17.0	36.6	6.3	31.6	1.3										
	211	0.0	33.4	0.0	33.0	1.6	33.0	3.5	32.9	7.8	28.6	18.9	1.5	22.8	8.1												
	223	0.8	34.4	1.1	33.6	2.9	33.3	7.2	29.8	10.3	25.6	20.7	14.5	26.0	3.5			#−7.5	#29.9								
	264	−0.3	26.4	+0.3	25.7	2.9	23.8	4.0	23.6	16.9	3.8																
	265	−0.6	27.2	−0.6	27.0	+3.0	21.4	1.9	25.3	13.9	13.4	20.3	4.7														

% V. S.—Firing shrinkage, per cent dry volume. % A. P.—Per cent apparent porosity. ‡Cone 6—. #Cone 6+.

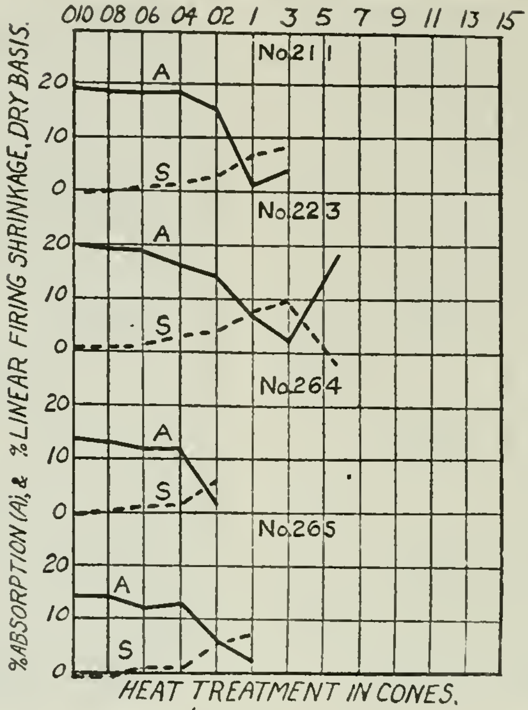
Absorption and linear shrinkage curves for clays of class 14.



Absorption and linear shrinkage curves for clays of class 15.



Absorption and linear shrinkage curves for clays of class 15.



IV. CLAYS BURNING DIRTY WHITE, CREAM WHITE, OR YELLOWISH WHITE.

17. Generally Contain Calcium or Magnesium Carbonate or Both, and Seldom Reach Low Porosity. Very Short Firing Range.

No. 3 (p. 218). Santa Barbara County. One mile south of Carpinteria. Formerly used for making light-colored common brick and building tile, in the Carpinteria plant of the Santa Barbara Builders' Supply Co. A light-yellowish sandy-shale, which develops a weak and sticky plasticity, but with medium-high dry strength. The deposit contains lime concretions which were sorted out as much as possible, but the sample contains too much lime for satisfactory testing, as all test pieces fired below cone 04 slaked in air after firing. The dry color is 17‴d, the wet color is 17‴b, and the fired colors range from 9′f to 19′f, from cone 010 toward cone 02, giving a fair range of pinks and buffs. Fusion begins slightly above cone 02, without preliminary vitrification or the development of steel hardness. The fired porosity is too high to permit the manufacture of structural ware of good quality. The total maximum linear shrinkage, plastic basis, is 10.8%, at cone 02. The best firing range is between cones 04 and 02. No charts of linear firing shrinkage or absorption are given.

No. 41 (p. 202). San Diego County. Escondido. H. T. Morris. This is a poor quality of common-brick clay, containing too much lime for satisfactory use. It effervesces strongly in hydrochloric acid. The plasticity is sufficient for brick-pressing, the dry strength is medium, the drying characteristics are satisfactory, and in the dry state the clay is hard and coarse-grained. The colors are: dry, 19″f; wet, 21‴f; cones 010 to 06, 15″; cones 04 and 02, 13″; and cone 1+, 9″i, with yellow-green blotches indicating the presence of lime. The fired colors are too dull for good exterior effects. Finger-nail hardness is present in the dried state, but steel hardness is not developed below the fusion point. Fusion commences at cone 1+, without previous vitrification. The maximum total linear shrinkage is 6.9%, at cone 1+. The best firing range is from cone 010 to cone 02.

No. 46 (p. 195). San Bernardino County. Government Holes, 12 m. E. of Cima. R. H. Holliman. This is a residual kaolin, too high in coloring compounds, fluxes and non-plastics to be of value. There is strong effervescence in hydrochloric acid. As the deposit has been reported on numerous occasions, the test data are presented for those who may be interested. The material has fair, though short, plasticity, medium dry strength, and is hard and close-textured in the dried state. The colors are: dry, yellowish gray; wet, 17‴f; cone 010, 13″f; cones 08 and 06, 13″d; cones 04 and 02, 13″b; cone 1, 13⁗; cones 3 and 5, 17⁗. Finger-nail hardness is developed below cone 010, and steel hardness at cone 3. Bloating begins at cone 5, and complete loss of shape occurs at cone 13 (with the laboratory firing schedule used). The maximum total linear shrinkage, plastic basis, is 7.3%, at cone 5.

No. 115 and 116 (p. 90). San Bernardino County. Near Rosamond. Merry Widow Mine. These are samples of fault gouge and altered volcanic rock from an abandoned gold mine. Many clays of this type are called to the attention of the State Mining Bureau. They are usually worthless from the ceramic standpoint, on account of weak plasticity, excessive shrinkage, poor fired colors, low fusion point, short vitrification range, and low fired strength. Test data are presented for two varieties for the purpose of pointing out the defects of such material. No. 115 is a fault gouge. It has sticky and weak plasticity, high dry strength, and in the dried condition, is hard, medium-grained and medium-textured. The high ratio of pore water to shrinkage water should be especially noted. The colors are: dry, nearly white; wet, grayish white; cone 010, 13″d; cones 08 to 04, 15″b; cones 02 to 3, 15″i; cone 5, 15″. Finger-nail hardness is present in the dried state, and steel hardness appears at cone 04. The fired structure is weak, and when fired below cone 02, is granular. At cone 02 and above, the structure is glassy. Most of the fired test pieces have one or more large cracks. Vitrification is complete at cone 1, but kiln-marking begins at this point, and bloating begins at cone 3. The total linear shrinkage, plastic basis, is 24.5% at cone 1.

No. 116 is a sample of decomposed trachyte (?). The properties are similar to those of No. 115, but the shrinkage is less, and the fired structure is stronger.

No. 205 (p. 229). Stanislaus County. Near Patterson. Cummings Ranch. This is a shale with poor plasticity and medium dry strength. In the dried condition it is medium hard, coarse-grained, and open-textured. The colors are: dry, yellowish white; wet, 17″d; cones 010 to 06, 17″d; cones 04 to 3, 17″b; cone 7, 17″d. Steel hardness is not developed up to the firing limit studied, cone 9. The fired structure is moderately strong, sound, granular, and open. The surface texture is slightly rough. The grains composing the mass are heterogeneous in color. The total linear shrinkage, plastic basis, at cone 9, is 13.1%.

The clay would need to be mixed with more plastic material in order to permit its successful use in common brick or face brick manufacture.

No. 262 (p. 159). Placer County. East of Lincoln. Valley View Mine. This is an altered igneous rock of undetermined origin and composition. It develops good plasticity, although a large proportion of the material is non-plastic. The dry strength is medium, and in the dried condition, it is medium hard, open-textured, and heterogeneous. The colors are: dry, 17‴f; wet, 17‴b; cones 010 to 3, 15″d; cone 7, 17‴i. The fired colors are too dull for pleasing brick colors. Steel hardness is developed at cone 7. The fired structure is sound, and medium strong, except for superficial cracks at cone 7. Fusion without vitrification begins above cone 7. The total linear shrinkage, plastic basis, at cone 7, is 10.7%. The material has doubtful ceramic value.

TABLE No. 28.

IV. Clays Burning Dirty White, Cream White, or Yellowish White.

17. Generally contain calcium or magnesium carbonate or both, and seldom reach low porosity. Very short firing range.

Clay No.	% S.W.	% P.W.	% W.P.	D.T.S.	% D.V.S.	% D.L.S.	Softening pt. in cones
3	13.6	26.3	39.9	463	20.8	6.1	
41	11.2	18.5	29.7	322	19.6	6.2	
46	7.6	10.2	17.8	579	15.7	5.1	
115	16.5	37.6	54.1	432	20.4	6.4	
116	24.9	29.1	54.0	550	34.4	10.4	
163	43.0	24.1	67.1	±350	66.8	18.4	
205	9.4	39.8	49.2	269	11.4	3.6	
262	10.1	18.2	28,3	334	18.0	5.7	

% S.W. = Per cent shrinkage water.
% P.W. = Per cent pore water.
% W.P. = Per cent water of plasticity.
D.T.S. = Dry transverse strength, pounds per square inch, without sand.
% D.V.S. = Drying shrinkage, per cent dry volume.
% D.L.S. = Calculated linear drying shrinkage, per cent dry length.

TABLE No. 29.

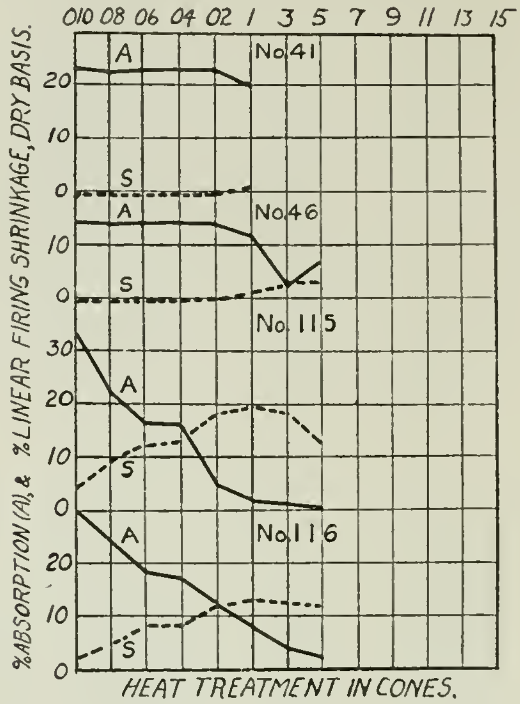
IV. Clays Burning Dirty White, Cream White, or Yellowish White.

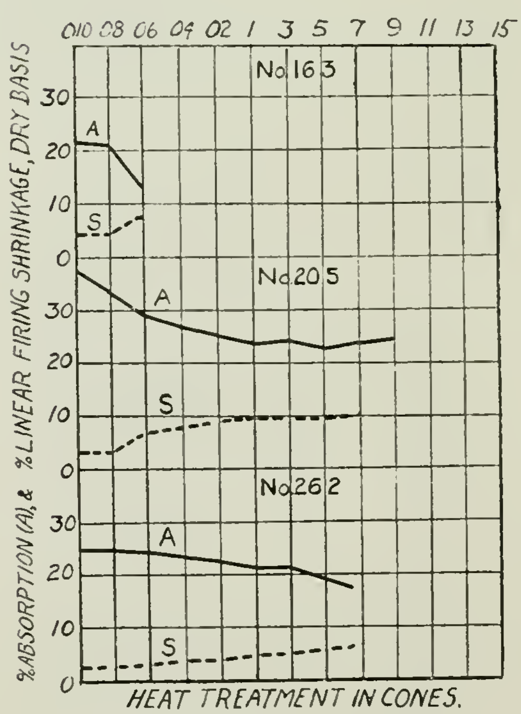
17. Generally contain calcium or magnesium carbonate or both, and seldom reach low porosity. Very short firing range.

Class No.	Clay No.	Cone 010		Cone 08		Cone 06		Cone 04		Cone 02		Cone 1		Cone 3		Cone 5		Cone 7		Cone 9		Cone 11		Cone 13		Cone 15	
		% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.	% V. S.	% A. P.
17	3	.....	.....	.....	.....	.....	.....	7.0	51.9	14.9	45.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	41	—2.0	35.7	—1.6	36.7	—1.8	37.0	—1.0	37.4	—0.8	37.2	†+3.2?	†33.6?	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	46	—2.8	26.0	—2.3	26.2	—2.1	26.7	—1.8	26.7	—0.4	26.1	+2.7	22.7	+6.9	3.5	.....	.....	7.7	14.9	.....	.....	.....	.....	.....	.....	.....	.....
	115	11.1	45.1	21.9	34.7	32.6	27.9	33.9	28.2	45.7	9.6	48.2	3.2	46.2	2.1	32.0	0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	116	5.1	42.0	13.0	36.8	21.9	30.6	22.4	29.5	31.5	22.0	34.0	16.1	35.1	7.6	30.6	2.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	163	12.1	34.5	12.1	32.4	21.7	22.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	205	8.8	45.7	10.9	43.2	18.0	39.9	21.3	38.2	24.6	37.1	26.5	35.8	26.5	36.2	26.4	34.8	26.9	35.6	27.0	36.7	.....	.....	.....	.....	.....	.....
	262	6.9	42.4	6.6	42.7	7.8	41.9	10.8	40.5	10.9	39.8	13.1	38.6	13.4	38.3	15.9	32.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

% V. S.—Firing shrinkage, per cent dry volume. % A. P.—Per cent apparent porosity. †Cone 1+.

Absorption and linear shrinkage curves for clays of class 17.





CHEMICAL ANALYSES.

Table No. 30 gives chemical analyses of certain clays from deposits that were sampled and tested. About one-half of the analyses were made on a portion of the same samples that were tested for ceramic properties and therefore can be directly correlated with the results of the tests. The other half of the analyses were compiled from the literature and from data presented by certain of the clay manufacturers. The sample numbers to which these analyses correspond are given in parentheses, but owing to variations in the character of the clay being mined at different times, the analyses of the samples actually tested may be considerably different from those given in the table.

Table No. 31 presents a group of chemical analyses of deposits that were not sampled. Very few of these clays have possible uses in ceramic manufacture, except for common brick. The analyses are given as being of possible interest in the future and to serve as a guide to the character of material to be found in the localities noted.

TABLE No. 30. CHEMICAL ANALYSES OF CLAYS FROM SAMPLED DEPOSITS.

Clay Class No.	Clay Sample No.[1]	Location of Deposit	Analysis, moisture free basis										Analyst or authority
			SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	K_2O %	Na_2O %	TiO_2 %	MnO %	Ign Loss %	Total %	
1	11	Alberhill: A. C. & C. Co. E-101	63.19	26.99	1.98	0.16	0.04	[2]1.19				6.45	100.00	G. W. Briggs, Stanford University
	(12)	Alberhill: A. C. & C. Co. E-102?	48.18	35.99	1.74	0.48	0.55	[2]2.03				11.22	100.19	Smith, Emery & Co., S. M. R. XIX, p. 207
	37	El Cajon Mtn., San Diego Co.	49.14	31.28	1.44	0.89	0.20	Tr.	0.51			16.52	99.98	Smith, Emery & Co., S. M. R. XIX, p. 207
	62	O'Neill Ranch, Orange Co.	59.21	31.13	0.41	0.46	Tr.	[2]0.31				8.48	100.00	C. W. Briggs, Stanford University
	63	Hunter Ranch Clay, Orange Co.	73.85	18.32	1.38	0.11	0.16	0.11	0.94			6.10	100.97	V. J. Minner, Stanford University
	(128)	Ione sand (type)	71.22	19.27	1.23	0.21	0.34					7.73	100.00	Gladding, McBean & Co.
	160	Pine Hill Kaolin, Nevada Co.	60.18	26.28	2.68	0.64	Tr.	[2]0.89				9.33	100.00	C. W. Briggs, Stanford University
	190	Clark & Narsh, picked kaolin	60.15	27.80	1.12	0.39	Tr.	[2]0.75				9.79	100.00	C. W. Briggs, Stanford University
	(194)	Weiss, Glen Ellen, No. 2 (med.)	56.29	31.13	0.59	0.05	0.05			0.31		11.67	100.09	Smith, Emery & Co., S. M. R. XXII, p. 332
	(195)	Weiss, Glen Ellen, No. 3 (soft)	58.10	26.79	1.17	0.32	0.05			0.56	Tr.	12.66	99.65	Smith, Emery & Co., S. M. R. XXII, p. 332
	236	Nigger Hill, Calaveras Co.	64.67	25.34	1.39	0.61	0.06	[2]1.13				6.81	100.00	C. W. Briggs, Stanford University
	259	Ryan Ranch, Tesla	48.93	36.13	1.15	0.36	0.21	[2]0.87				12.35	100.00	C. W. Briggs, Stanford University
	268	Amer. Ref. Co., El Toro crude	54.42	32.54	1.90	0.20	0.00	[2]0.42				10.52	100.00	C. W. Briggs, Stanford University
2	(15)	Alberhill: A. C. & C. Co. Sel. M. T.	59.44	26.28	2.24	0.26	0.20	[2]0.15				11.64	100.21	Smith, Emery & Co., S. M. R. XIX, p. 201
	(28)	Alberhill: A. C. & C. Co. S. H.-3	63.63	24.07	1.29	0.77	none	[2]0.57		0.90	none	8.77	100.00	Smith, Emery & Co., S. M. R. XIX, p. 199
	(29)	Alberhill: A. C. & C. Co. M. T.	75.46	16.22	2.24	0.03	Tr.	[2]0.20				6.24	100.39	Smith, Emery & Co., S. M. R. XIX, p. 201
	44	Hart Mt. Stand. San. Mfg. Co.	71.76	17.88	1.00	1.52	0.73	0.14	0.75			6.48	100.26	V. J. Minner, Stanford University
	57	Hart Mt. Coors	63.52	25.85	0.58	1.06	0.44	1.74	1.65			6.10	100.94	V. J. Minner, Stanford University
	(57)	Hart Mt. Coors	64.00	25.26	Tr.	0.80	0.14	[2]1.79				8.01	100.00	H. F. Coors, Los Angeles
	(90)	[3]Alberhill (G. McB. Co.) M. T.	73.70	22.88	2.36	0.42	Tr.	[2]0.64					100.00	Burchfiel, J. A. C. S. 6, 1169
3	(70)	Alberhill: Emsco white	60.78	26.00	0.32	0.50	0.04	0.22	0.85	0.80	0.01	10.98	100.50	Smith, Emery & Co.
	(98)	Alberhill: G. McB. & Co. W-105 bone	54.85	43.43	0.72	Tr.	Tr.	[2]0.86				0.26	100.12	Burchfiel, J. A. C. S. 6, 1169
	120	Ione: Jones Butte fireclay	42.17	42.48	1.26	0.16	Tr.	[2]0.96				12.97	100.00	C. W. Briggs, Stanford University
	(273)	Alberhill: A. C. & C. Co. SH-4	48.81	34.58	0.99	0.68	Tr.	[2]0.13		1.43	Tr	13.36	99.98	Smith, Emery & Co., S. M. R. XIX, p. 198
	(273)	Alberhill: A. C. & C. Co. SH-4	37.72	42.21	0.51	0.72	0.05	[2]0.09				18.96	100.26	Burchfiel, J. A. C. S., 6, 1173
4	125	Ione: Gage	61.25	27.00	1.58	0.24	0.58	2.84	1.83			6.34	101.66	V. J. Minner, Stanford University
5	(17)	Alberhill: A. C. & C. Co., Bone	44.30	39.59	2.08	0.39	Tr.	Tr.		1.50		12.13	[4]100.01	Smith, Emery & Co., S. M. R. XIX, p. 203
	(67)	Corona: McKnight fireclay	57.38	27.62	2.06	1.90	0.11	[2]0.13				10.62	99.82	Pac. Clay Prod. Co.
	86	Alberhill: L. A. B. Co. No. 26 bone	45.08	37.31	3.74	0.10	Tr.	0.44	0.72			13.15	100.54	V. J. Minner, Stanford University
	(104)	Alberhill: G. McB. Co. Sloan No. 5	41.48	41.50	0.80	Tr.	Tr.	[2]0.35				15.72	99.85	Burchfiel, J. A. C. S. 6, 1174
	141	Ione: Fancher blue	48.51	36.88	1.91	0.21	0.26	0.09	0.25			12.80	100.92	V. J. Minner, Stanford University
	231	Alberhill: L. A. B. Co. High Alumina bone	30.35	46.52	3.33	0.36	0.10	0.16	1.03			18.34	100.19	C. W. Briggs, Stanford University
	282	[3]Goat Ranch flint fireclay Orange Co.	53.82	41.83	2.13	0.92	0.08	[2]1.22					100.00	C. W. Briggs, Stanford University
6	(9)	Alberhill, A. C. & C. Co. (Hill blue)	60.80	24.75	2.70	0.94	0.51	0.54	0.57		[5]0.03	9.11	99.95	Smith, Emery & Co., S. M. R. XIX, p. 205
	(9)	Alberhill, A. C. & C. Co. (Hill blue)	55.59	26.36	3.95	1.33	0.61	0.41	0.57		[5]0.29	10.90	100.01	Smith, Emery & Co., S. M. R. XIX, p. 205
	33	Cardiff, Wiro Purple	68.59	20.33	2.88	0.09	0.50	0.17	0.48			7.62	100.68	V. J. Minner, Stanford University
	(33)	Cardiff, Wiro Purple	64.48	22.22	2.72	0.68	Tr.	[2]0.57				9.25	100.92	Gladding, McBean & Co.
	(92)	Alberhill: G. McB. & Co. Yellow M.T.	58.06	27.48	2.52	0.52	0.31	[2]1.12				10.08	100.09	Burchfiel, J. A. C. S. 6, 1168

	145	Lincoln: L. C. P. Co. No. 0 (1925 sample)	55.65	28.89	2.61	1.28	0.89	0.20	0.72			9.83	100.07	W. F. Dietrich, Stanford University
	(145)	Lincoln: L. C. P. Co. No. 0 (1928 sample)	55.36	29.23	4.53	0.95	0.12	[2]1.02				8.79	100.00	C. W. Briggs, Stanford University
	150	Lincoln: L. C. P. Co. No. 10 (1925 sample)	52.72	32.39	2.45	0.90	0.39	0.12	0.20			10.70	98.87	W. F. Dietrich, Stanford University
	(150)	Lincoln: L. C. P. Co. No. 10 (1928 sample)	57.28	31.10	2.11	0.51	0.08	0.16	0.38			8.63	100.31	C. W. Briggs, Stanford University
	263	Valley View Mine, Placer Co.	54.18	32.28	1.76	0.08	Tr.	[2]0.65				11.05	100.00	C. W. Briggs, Stanford University
7	(101)	Alberhill, G. McB. & Co. Sloan	55.56	28.79	1.77	0.90	0.20	[2]1.40				10.90	99.52	Burchfiel, J. A. C. S. *6*, 1171
	(110)	Alberhill, P. C. P. Co. Douglas	51.76	29.83	2.10	0.44	0.30	[2]0.79				13.96	99.18	Pac. Clay Prod. Co.
	(133)	[3]Ione: Harvey clay (average)	59.97	35.91	2.89	0.68	0.45	[2]0.10					100.00	K. W. Baum
	149	Lincoln: L. C. P. Co. No. 9 (1925 sample)	55.30	30.29	2.41	1.01	0.52	0.16	0.30			9.51	99.56	W. F. Dietrich, Stanford University
	(149)	Lincoln: L. C. P. Co. (1928 sample)	58.36	28.92	2.06	0.66	0.12	0.48	0.45			9.06	100.06	C. W. Briggs, Stanford University
	201	Valley Springs: blue plastic	61.00	22.38	4.02	0.56	1.14	[2]0.78				10.12	100.00	K. W. Baum
8	146	Lincoln: L. C. P. Co. No. 1-6	52.49	33.45	2.53	0.80	0.63	0.18	0.56			10.30	100.94	W. F. Dietrich, Stanford University
	147	Lincoln: L. C. P. Co. No. 7	52.85	33.50	2.46	0.55	0.33	0.20	0.49			10.03	100.11	W. F. Dietrich, Stanford University
	(157)	Lincoln: G. McB. & Co. terra cotta clay	50.38	32.11	2.99	1.15	1.07			0.38	0.56	11.29	99.93	Gladding, McBean & Co.
	201	Helisma, Calaveras Co.	55.72	24.56	4.02	0.45	1.15	[2]1.18				12.92	100.00	K. W. Baum
9	(25)	Alberhill: A. C. & C. Co. W. T. blue	58.22	16.39	10.36	1.48	2.54	[2]1.10		1.10	Tr.	8.55	[6]100.02	Smith, Emery & Co., S. M. R. XIX, p. 209
	(94)	Alberhill: G. McB. & Co. West blue	68.57	22.99	1.82	0.16	0.04	[2]1.22				5.20	100.00	C. W. Briggs, Stanford University
10	(111)	Alberhill: P. C. P. Co. Lower Douglas	70.20	18.48	4.26	0.42	0.38	[2]1.11				5.46	100.34	Pac. Clay Prod. Co.
12	35	Cardiff: G. McB. & Co.	66.84	17.79	7.54	1.12	0.34	0.20	0.46			6.43	109.72	V. J. Minner, Stanford University
	(40)	Kelly Ranch Yellow	56.58	21.81	8.27	0.10	0.16	[2]0.59				9.98	100.19	Pac. Clay Prod. Co.
	(100)	Alberhill: G. McB. & Co. yellow top clay	62.12	19.22	5.01	2.00	0.68	[2]1.22				10.06	100.31	Burchfiel, J. A. C. S. *6*, 1168
	(112) (113)	Alberhill: P. C. P. Co. hoist pit	63.10	21.08	5.86	0.90	0.05	[2]0.13				8.44	99.86	Pac. Clay Prod. Co
13	(7)	Alberhill: A. C. & C. Co. pink mottled	68.57	15.19	7.75	none	Tr.	[2]2.70		0.97	Tr.	4.69	[7]100.00	Smith, Emery & Co., S. M. R. XIX, p. 208
	122	Ione: Jones Butte Laterite	40.61	37.43	7.27	0.11	Tr.	0.26	0.89			13.10	99.97	V. J. Minner, Stanford University
14	148	Lincoln: L. C. P. Co. No. 8	46.80	26.02	13.72	0.91	0.49	0.25	0.33			11.17	99.99	W. F. Dietrich, Stanford University
	202	Valley Springs: Pink mottled	51.61	23.81	9.78	0.67	1.21	[2]0.91				11.92	100.00	K. W. Baum
	203	Valley Springs: Yellow plastic	57.56	18.97	9.31	0.45	1.16	[2]1.25				11.30	100.00	K. W. Baum
	210	Natoma, Sacramento Co.	46.35	22.62	11.38	2.09	2.21	[2]0.24				15.11	100.00	L. W. Austin

[1] Where the sample number is given in parenthesis ( ), the analysis was not made on the laboratory sample, but on another sample from the same deposit. In all other cases, the analysis was made on the same sample that was used for the determination of the ceramic properties.
[2] Total alkalis by difference.
[3] Ignited basis.
[4] Cl = 0.02.
[5] SO_3.
[6] P_2O_5 = 0.21%; Cl = 0.07%.
[7] Cl = 0.13%.

TABLE No. 31. CHEMICAL ANALYSES OF MISCELLANEOUS CALIFORNIA CLAYS, NOT SAMPLED.

County	Description	Chemical analysis, moisture free basis							
		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Alk.	Ign.	Authority
Alameda	Midway (R.R. cut)	55.06	16.38	7.56	2.85	2.02	und.	und.	K. W. Baum
Calaveras	Near Milton	57.24	18.63	3.21	.82	.61	und.	und.	K. W. Baum
Calaveras	Near Milton	60.12	16.92	und.	und.	und.	und.	und.	K. W. Baum
Calaveras	Near Milton	55.12	20.98	5.68	2.27	1.51	und.	und.	K. W. Baum
Imperial	[1]Full Moon	28.15	42.66	1.93	0.53		[3]0.71	12.53	A. J. Forget, St. Min. Rept. XXII, p. 269
Mariposa	Bryceburg-Merced River Canyon	71.70	12.91	4.57	1.11	2.06	und.	3.82	K. W. Baum
Mariposa	Bryceburg-Merced River Canyon	49.37	17.93	11.90	3.53	2.91	und.	13.35	K. W. Baum
Mariposa	[2]Kittredge, Merced River Canyon	58.06	15.98	10.16	3.39	10.79	und.		K. W. Baum
Mariposa	[2]Kittredge, Merced River Canyon	56.98	16.27	11.67	8.41	5.97	und.		K. W. Baum
Mariposa	[2]Kittredge, Merced River Canyon	60.57	18.18	8.07	8.12	3.56	und.		K. W. Baum
Mariposa	[2]Detwiler, Merced River Canyon	53.91	24.14	13.20	4.56	3.44	und.		K. W. Baum
Mariposa	[2]Detwiler, Merced River Canyon	54.99	14.17	8.73	12.96	7.98	und.		K. W. Baum
Mariposa	Merced (8 mi. north)	63.46	17.18	3.94	2.70	1.70	und.	4.74	K. W. Baum
Merced	[2]Merced Falls, Merced River Canyon	69.47	18.36	7.93	1.24	2.71	und.		K. W. Baum
Merced	Ryer	62.58	17.04	4.28	2.71	1.90	und.	4.68	K. W. Baum
Merced	Merced Falls (2 mi. north)	68.46	17.60	4.50	trace	.30	und.	7.60	K. W. Baum
Merced	Merced Falls (2 mi. north)	70.16	16.82	4.23	und.	und.	und.	7.34	K. W. Baum
Merced	Merced Falls (2 mi. south)	59.10	17.42	5.11	und.	und.	und.	14.30	K. W. Baum
Merced	Snelling (on ditch line)	55.18	16.26	4.10	2.26	2.54	und.	16.96	K. W. Baum
Merced	Snelling (on ditch line)	70.98	und.	und.	und.	und.	und.	12.82	K. W. Baum
Merced	Dalton (1 mi. N. of R.R.)	60.00	15.85	5.95	2.14	1.65	und.	12.54	K. W. Baum
Merced	Merced (8 mi. south)	56.98	14.32	6.08	und.	und.	und.	11.40	K. W. Baum
Merced	Merced Falls (1½ mi. S. on River)	58.90	17.60	5.04	0.56	1.35	und.	15.42	K. W. Baum
Riverside	Laterite (G. McB. and Co.)	38.96	35.76	8.30	0.62	0.16	1.02	15.32	Burchfiel, J. A. C. S. 6 pg. 1173
Riverside	Luscardi lease (Pac. C. P. Co.)	67.40	21.99	2.16	0.02	0.19	2.58	4.72	Pac. Clay Prod. Co.
Riverside	Serrano (Pac. C. P. Co.)	65.94	22.65	1.41	0.10	0.26	0.21	8.42	Pac. Clay Prod. Co.
Riverside	Wildomar (Pac. C. P. Co.)	70.14	14.97	1.61	1.58	0.09	3.94	7.78	Pac. Clay Prod. Co.
San Joaquin	Near Carbona	55.86	15.80	6.20	2.13	1.71	und.	und.	K. W. Baum
San Joaquin	Patterson Pass (nr. W. P. R. R.)	31.76	7.68	2.96	28.29	1.51	und.	und.	K. W. Baum
Solano	Vallejo (2 mi. N. W.)	57.83	19.52	7.46	1.24	2.06	3.86	8.03	St. Min. Rept. XXIII, p. 204
Stanislaus	[2]Oakdale (12 mi. so.)	62.31	19.53	9.68	3.40	2.46	und.		K. W. Baum
Stanislaus	[2]Oakdale	67.31	18.70	6.83	3.73	1.91	und.		K. W. Baum
Stanislaus	[2]Oakdale	62.70	20.31	7.61	3.98	2.69	und.		K. W. Baum
Stanislaus	[2]Oakdale	69.17	16.85	6.39	2.64	1.67	und.		K. W. Baum
Stanislaus	Modesto (2 mi. E. of town)	60.66	18.74	4.10	und.	und.	und.	4.76	K. W. Baum
Stanislaus	Modesto (nr. S. Fe. R. R.)	61.22	18.20	4.41	und.	und.	und.	5.04	K. W. Baum
Stanislaus	Empire (1 mi. E. of town)	61.46	18.01	4.89	und.	und.	und.	5.12	K. W. Baum
Stanislaus	San Joaquin River bank	60.10	15.60	7.70	4.09	2.51	und.	und.	K. W. Baum
Stanislaus	San Joaquin (Lane bridge)	65.90	16.40	3.06	2.41	1.00	und.	und.	K. W. Baum
Stanislaus	San Joaquin (So. of Lane bridge)	63.10	17.46	3.84	und.	und.	und.	und.	K. W. Baum
Stanislaus	Patterson (Hammond Ranch)	57.58	18.33	4.99	.51	.86	und.	und.	K. W. Baum
Stanislaus	Patterson (T 6 S, R 7 E)	60.26	21.00	5.08	.57	.80	und.	und.	K. W. Baum
Tuolumne	Near Jamestown	58.06	27.16	2.84	20	.24	und.	und.	K. W. Baum

[1] SO_3=13.49%. [2] Ignited basis. [3] Na_2O.

INDEX OF CLAY SAMPLE NUMBERS

Sample No.	Property description, page	Test data, page	Sample No.	Property description, page	Test data, page	Sample No.	Property description, page	Test data, page	Sample No.	Property description, page	Test data, page	Sample No.	Property description, page	Test data, page
1	218	338	59	—	265	111	176	315	162	159	—	223	141	343
2	218	338	60	100	340	112	178	324	163	159	350	229	175	300
3	218	348	61	102	341	113	178	324	164	159	—	230	175	300
4	234	338	62	145	259	114	90	312	165	159	—	231	175	281
5	234	339	63	140	260	115	90	349	166	138	316	232	175	281
6	234	339	64	140	260	116	90	349	167	138	315	233	70	—
7	169	328	65	141	322	117	131	324	168	136	313	234	70	—
8	169	324	66	179	277	118	192	341	169	138	313	235	70	263
9	169	287	67	179	277	119	74	325	170	136	315	236	68	263
10	169	334	69	169	323	120	53	272	171	136	329	237	68	263
11	169	257	70	169	272	121	53	302	172	136	312	238	70	316
12	169	257	71	169	278	122	53	328	173	235	313	239	52	281
13	169	296	72	169	328	123	56	335	175	65	304	240	52	274
14	169	287	73	169	323	124	56	302	176	66	325	243	52	—
15	169	264	74	175	278	125	53	273	177	66	336	244	52	281
16	169	314	75	175	335	126	52	279	178	65	325	245	52	300
17	169	277	76	175	288	127	57	335	180	77	326	246	52	300
18	169	321	77	175	278	128	54	261	181	80	336	247	52	300
19	169	311	78	175	288	129	62	261	182	81	326	248	52	301
21	169	334	79	175	278	130	62	290	183	81	326	249	52	301
22	169	335	80	175	297	131	62	329	184	80	342	250	52	282
23	169	277	81	175	289	133	63	298	185	80	342	251	52	327
24	169	321	82	175	315	134	58	261	188	92	336	252	52	305
25	169	311	83	175	297	135	58	312	190	133	261	253	52	301
26	169	321	84	175	289	136	58	302	191	133	280	254	52	301
27	169	287	85	175	298	137	57	266	192	133	281	255	52	313
28	169	264	86	175	279	138	57	280	194	227	262	256	52	330
29	169	264	87	175	279	139	57	290	195	227	262	257	52	291
30	203	339	88	—	315	140	56	280	197	227	291	258	52	292
31	204	340	89	—	341	141	58	280	198	125	329	259	45	263
32	205	322	90	173	265	142	58	280	199	74	326	261	159	328
33	205	287	91	173	260	143	185	274	200	73	342	262	159	350
34	205	288	92	173	289	144	185	273	201	69	305	263	159	292
35	202	322	93	173	265	145	156	291	202	68	337	264	42	343
36	201	311	94	173	311	146	156	303	203	68	337	265	40	343
37	201	259	95	173	311	147	156	303	204	68	299	266	140	292
38	201	259	96	173	272	148	156	336	205	229	349	268	140	260
39	203	296	97	173	290	149	156	298	206	232	327	269	—	316
40	203	322	98	173	272	150	156	291	208	57	262	270	140	282
41	202	348	99	173	312	151	156	303	209	59	263	271	169	301
42	181	340	100	173	323	152	147	304	210	186	337	272	169	292
43	181	340	101	173	298	153	147	299	211	81	342	273	169	273
44	196	264	102	173	290	155	151	325	212	186	337	274	169	302
45	196	264	103	173	260	156	151	299	213	59	299	280	147	305
46	195	349	104	173	279	157	151	304	214	131	327	282	141	282
53	195	288	105	173	324	158	138	—	216	213	327	283A	232	314
55	195	314	108	176	290	159	137	261	217	213	327	283B	232	314
56	—	297	109	176	266	160	137	261	218	181	329	284	232	316
57	194	264	110	176	298	161	159	—	221	141	330	285	232	282

INDEX TO CLAY SAMPLES, BY COUNTIES

County	Name of property	Designation of clay	Sample No.	Class No.	Description of property, page	Test data, page
Alameda	W. S. Dickey C. M. Co.	Niles	265	15	40	343
	M. & S. Tile Co.	Niles	264	15	42	313
	Ryan Ranch	Tesla	259	1	45	263
Amador	Arroyo Seco Grant	Baker	126	5	52	279
		Gage	125	4	53	273
		Jones Butte fireclay	120	3	53	272
		Jones Butte laterite	122	13	53	328
		Jones Butte 'unctuous'	121	8	53	302
		Lot 237, E. side	240	4	52	274
		Hole 55-1	245	7	52	300
		55-2	247	7	52	300
		55-3	246	7	52	300
		56-1	248	7	52	301
		56-2	249	7	52	301
		56-3	250	5	52	282
		57-1	251	12	52	327
		57-2	252	8	52	305
		57-3	253	7	52	301
		57-4	254	7	52	301
		57-5	255	9	52	313
		Lot 254, N. E. cor.	239	5	52	281
		Lot 255, Hole 60	256	13	52	330
		61	258	6	52	291
		62	257	6	52	292
		Lot 324, Hole 54	244	5	52	281
		Lot 336, Hole 47	243		52	
		Shepard sand	128	1	54	261
		Yaru No. 1	124	8	56	302
		Yaru No. 2	123	14	56	335
	Bacon and Bacon	Bacon blue	139	6	57	290
		Bacon bottom	138	5	57	280
		Bacon red	127	14	57	335
		Chocolate	137	2	57	266
	Carlile	Carlile sand	208	1	57	262
	N. Clark & Sons	Clark sand	134	1	58	261
		Dosch	136	8	58	302
		Dosch stripping	135	9	58	312
	Eckland	Mottled	213	7	59	299
		Sand	209	1	59	263
	Fancher (W. S. Dickey C. M. Co.)	Fancher yellow	141	5	58	280
		Fancher blue	142	5	58	280
	Ione Fire Brick Co.	Sand	140	5	60	280
	Newman Estate	Carbonaceous sand	130	6	61	290
		Pink mottled	131	13	61	329
	Yosemite Portland Cement Co.	Sand	129	62	61	261
		Harvey	133	7	63	298
Butte	Lund Ranch	Common	178–1	12	65	325
			–2	12	65	325
			–3	12	65	325
	Oroville-Quincy Road	Common	177	14	66	336
		Decomp. igneous	176	12	66	325
	Table Mt. C. P. Co.	Yellow plastic	175	8	66	304
Calaveras	California Pottery Co.	Nigger Hill 'kaolin'	236	1	68	263
		Nigger Hill 'kaolin'	237	1	68	263
		Valley Spgs. blue	204	7	68	299
		Valley Spgs. pink-mottled	202	14	68	337
		Valley Spgs. yellow	203	14	68	337
	Helisma	Helisma	201	8	69	305
	Penn. Min. Co.	Kaolinized schist	238	10	70	316
	Texas Min. Co.	Kaolinized schist	233		70	
		Kaolinized schist	234		70	
		Kaolinized schist	235	1	70	263
Contra Costa	N. Clark & Sons	Walnut Cr. shale	200	15	73	342
	Port Costa Brick Co.	Shale	199	12	73	326
	Richmond P. B. Co.	Shale	119	12	74	325
Del Norte	Musick	Common	180	12	77	326
Humboldt	Angel Ranch	Pottery (red)	181	14	80	336
	Loofbourrow	Common	185	15	80	342
	Strong's Station	Common	211	15	81	342
	Sunny Avenue	Common	183	12	81	326
	Thompson Brick Co.	Common	182	12	81	326

INDEX TO CLAY SAMPLES, BY COUNTIES—Continued

County	Name of property	Designation of clay	Sample No.	Class No.	Description of property, page	Test data, page
Inyo	Amer. Silica Co.	Death Valley superfine	269	10	------	316
Kern	Merry Widow Mine	Impure kaolin	115	17	90	349
		Impure kaolin	116	17	90	349
	Titus	Titus	114	9	89	312
Lake	Kelseyville	Common	188	14	92	336
Los Angeles	Davidson Brick Co.	Common	60	15	100	340
	Gladding, McBean & Co.	Santa Monica common	61	15	102	341
Marin	McNear Brick Co.	Shale	198	13	124	329
Monterey	Arca	Common	117	12	130	324
	Monterey Mission Tile Co.	Adobe	214	12	131	327
Napa	Clark and Marsh	Kaolin, average	190	1	133	261
		Kaolin, selected	191	5	133	280
		Kaolin, lower tunnel	192	5	133	281
Nevada	Banner Mt. Road		170	10	136	315
	Beaser Ranch		168	9	136	313
	Manzanita Mine	Pipe clay	172	15	136	342
	North Bloomfield Rd.		171	13	136	329
	Pine Hill Mine	Kaolin	159	1	137	261
		Kaolin	160	1	137	261
		Kaolin	166	11	138	316
		Kaolin	167	10	138	315
	Sonntag Ranch		169	9	138	313
	Sweet Ranch (Pine Hill)	Kaolin	158	------	138	------
Orange	American Silica Co.	Amreco fireclay	266	6	140	292
		Arc fireclay	270	5	140	282
		El Toro crude	268	1	140	260
		Hunter Ranch—lower	64	1	140	260
		Hunter Ranch—upper	63	1	140	260
	Brea C. P. Co.	Common	65	12	140	322
	Gladding, McBean & Co.	Goat Ranch flint	221	12	141	330
		Goat Ranch flint	282	5	141	282
		Goat Ranch shale M M 3	223	15	142	343
	Vitrefrax Co.	O'Neill Ranch fireclay	62	1	145	259
Placer	Clay Corporation of Cal.	Lincoln fireclay	280	8	147	305
		Lincoln top clay	152	8	147	304
		Lincoln top clay	153	7	147	299
	Gladding, McBean & Co.	Lincoln fire-proofing	156	7	152	299
		Lincoln pit sand	155	12	152	325
		Lincoln terra cotta	157	8	152	304
	Lincoln C. P. Co.	No. 0	145	6	156	291
		No. 1-6	146	8	156	303
		No. 7	147	8	156	303
		No. 8	148	14	156	336
		No. 9	149	7	156	298
		No. 10	150	6	156	291
		Washed china clay	151	8	156	303
	Miscellaneous	Alta	165	------	159	------
		Baxter	162	------	159	------
		Baxter	163	17	159	350
		Baxter	164	------	159	------
		Gorge	161	------	159	------
	Valley View Mine	Kaolin (impure)	261	12	159	328
		Kaolin (impure)	262	17	159	350
		Kaolin (impure)	263	6	159	292
Riverside	Alberhill C. & C. Co.	A-clay	14	6	169	287
		Bone, W-105	17	5	169	277
		Clark tunnel mottled	18	12	169	321
		China, E-101	11	1	169	257
		China, E-102	12	1	169	257
		Diamond	19	9	169	311
		Hill blue	9	6	169	287
		Hill blue, lower tunnel	271	7	169	301
		Hill blue, main tunnel	272	6	169	292
		Hill blue, upper tunnel	274	7	169	302
		Hill blue green	10	14	169	334
		Main tunnel	29	2	169	264
		Main tunnel ex. select	13	7	169	296
		Main tunnel select	15	2	169	264
		No. 10	27	6	169	287

INDEX TO CLAY SAMPLES, BY COUNTIES—Continued

County	Name of property	Designation of clay	Sample No.	Class No.	Description of property, page	Test data, page
		Pink mottled	7	13	169	328
		Red No. 2	8	12	169	321
		Sagger	21	14	169	334
		SH-3	28	2	169	264
		SH-4	273	3	169	273
		West blue	23	5	169	277
		West blue select	16	10	169	314
		West tunnel blue	25	9	169	311
		West tunnel mottled	24	12	169	321
		West yellow	26	12	169	321
		Yellow Owl Cut	22	14	169	335
	Emsco Clay Co. (Harrington pit)	Bone	73	12	171	323
		Pink mottled	71	5	171	278
		Red	72	13	171	328
		Red Horse	69	12	171	323
		White (No. 5)	70	3	171	272
	Gladding, McBean & Co. (Alberhill pits)	Bone (W-105?)	98	3	173	272
		Main tunnel	90	2	173	265
		Main tunnel select	93	2	173	265
		Main tunnel sand	91	1	173	260
		Main tunnel yellow	92	6	173	289
		No. 10	96	3	173	272
		Sloan, bone	103	1	173	260
		Sloan, No. 5	104	5	173	279
		Sloan, red	105	12	173	324
		Sloan, sand	102	6	173	290
		Sloan, white	101	7	173	298
		Smooth bunker	97	6	173	290
		Tile	99	9	173	312
		West blue	94	9	173	311
		West blue select	95	9	173	311
		Yellow stripping	100	12	173	323
	Hudson Ranch	Clay	89	15	------	341
		Sand	88	10	------	315
	Los Angeles Brick Co.	Bone, high-alumina	231	5	175	281
		Bone, smooth	87	5	175	279
		Bone, smooth	232	5	175	281
		Clay shale	82	10	175	315
		No. 7	229	7	175	300
		No. 9	230	7	175	300
		No. 10	78	6	175	288
		No. 20	77	5	175	278
		No. 23	76	6	175	288
		No. 25	81	6	175	289
		No. 26 bone	86	5	175	279
		Pink mottled	85	7	175	298
		P. M. fireclay	84	6	175	289
		Red	83	7	175	297
		Red No. 2	75	14	175	335
		West bone	74	5	175	278
		West pit fireclay	79	5	175	278
		West pit mottled	80	7	175	297
	Pacific C. P. Co. (Alberhill and Corona pits)	Douglas	110	7	176	298
		Douglas lower	111	10	176	315
		Douglas main tunnel	109	2	176	266
		Douglas upper	108	6	176	290
		Hoist pit blue	112	12	178	324
		Hoist pit red	113	12	178	324
		McKnight fireclay	67	5	179	277
		McKnight sewer pipe	66	5	179	277
	Temescal Water Co.	Pink mottled	218	13	181	329
	Wilson, J. W.	Common	42	15	181	340
		Common	43	15	181	340
Sacramento	Michigan Bar	Cutter	143	4	185	274
		Van Vleck	144	3	185	273
	Natoma Clay Co.	No. 1	210	14	186	337
		No. 3	212	14	186	337

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County	Name of property	Designation of clay	Sample No.	Class No.	Description of property, page	Test data, page
San Benito	Paicines	Common	118	15	192	341
San Bernardino	Coors	Hart kaolin	57	2	194	264
	Gladding, McBean & Co.	Bryman clay	55	10	195	314
	Holliman & Murphy	Impure kaolin	46	17	195	349
	Millet & Kennedy	Buff-burning	53	6	196	288
	Standard San. Mfg. Co.	Pacific kaolin (Hart)	44	2	196	264
		Pacific kaolin (Hart)	45	2	196	264
San Diego	California C. P. Co.	Cardiff fireclay	36	9	201	311
	El Cajon Mt.	Kaolin, average	38	1	201	259
		Kaolin, selected	37	1	201	259
	Gladding, McBean & Co.	Cardiff	35	12	202	322
	Morris, H. T.	Common	41	17	202	348
	Pacific C. P. Co.	Kelley Ranch white	39	7	203	296
		Kelley Ranch yellow	40	12	203	322
	San Diego T. & B. Co.	Rose Canyon	30	15	203	339
	Union Brick Co.	Rose Canyon	31	15	204	340
	Vitrified Products Co.	Cardiff fireclay	33	6	205	287
		Cardiff fireclay	34	6	205	287
		Linda Vista shale	32	12	205	322
San Luis Obispo	Santa Margarita	Shale	216	12	215	327
		Shale	217	12	215	327
Santa Barbara	Brentner	Carpinteria	3	17	218	348
	Muegenberg & Whitiker	Santa Barbara	1	15	218	338
		Toro Canyon	2	15	218	338
Sonoma	Beltane	Buff-burning	197	6	227	291
	Weiss, J. H.	Average white	194	1	228	262
		Selected white	195	1	228	262
Stanislaus	Cummings Ranch	Shale	205	17	229	349
Tulare	Sears, W. A.	Kaolin (impure)	283-A	9	232	314
		Kaolin (impure)	283-B	9	232	314
		Kaolin (impure)	284	10	232	316
		Kaolin (impure)	285	5	232	282
	Valencia Heights	Shale	206	12	232	327
Ventura	Anderson & Hardison	(Santa Paula)	6	15	234	339
	People's Lumber Co.	Blue	5	15	234	339
		Yellow	4	15	234	338
Yuba	Dempsey Ranch	Kaolin (impure)	173	9	235	313
	Florida	Edgar koalin	59	2	------	265
	Germany	Fireclay	56	7	------	297

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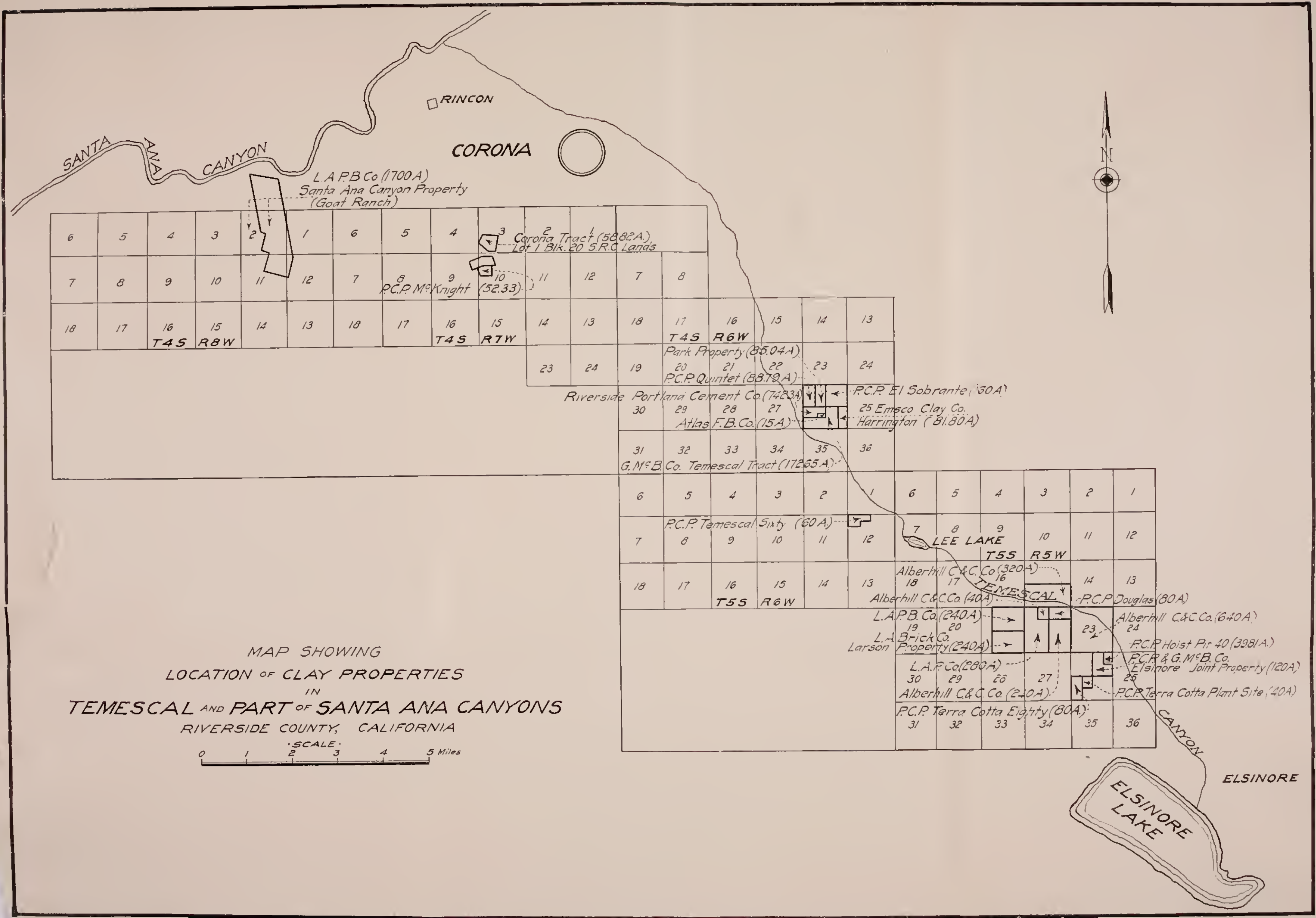

Plate X. Property map of Alberhill-Corona district, Riverside County. (By courtesy of Robt. Linton.)

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Field Trip No. 4

GEOLOGY OF THE NORTHERN PENINSULAR RANGES, SOUTHERN CALIFORNIA: GEOLOGIC GUIDE AND ROAD LOG

by

D.M. Morton and C.H. Gray, Jr.
California Division of Mines and Geology
Los Angeles, California

March 1971

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INTRODUCTION AND ACKNOWLEDGMENTS

This guide covers the north-central part of the Peninsular Ranges, principally in western Riverside County, southern California. Commencing and terminating at the University of California, Riverside campus, the route of travel is a loop of 124 miles, with one short side trip (Fig. 1). The route affords ready access to a variety of geologic features: prebatholithic rocks, rocks of the southern California batholith, Upper Cretaceous to Pleistocene sedimentary rocks, Holocene alluvial deposits, recent fault features, and various geomorphic features. A considerably longer guide, overlapping part of this guide, has been prepared by Jahns (1954a).

The entire Peninsular Range province has been best described in some detail by Jahns (1954b, pp. 29-52) who included a map, and all but the Los Angeles basin part, more briefly by Gray *et al.*, (1971). In 1948 Larsen described the southern California batholith and included a map at a scale of 1:125,000. A number of workers have mapped and described parts of the northern Peninsular Ranges. Published regional reports include the Perris block (Dudley, 1935, 1936), Corona-Elsinore-Murrieta area along the Elsinore fault (Gray, 1954), the Temecula region of the Elsinore fault zone (Mann, 1955) and the Los Angeles basin (Yerkes *et al.*, 1965). For a synthesis of general distribution of major rock units and faults, the reader is referred to Dibblee (1968).

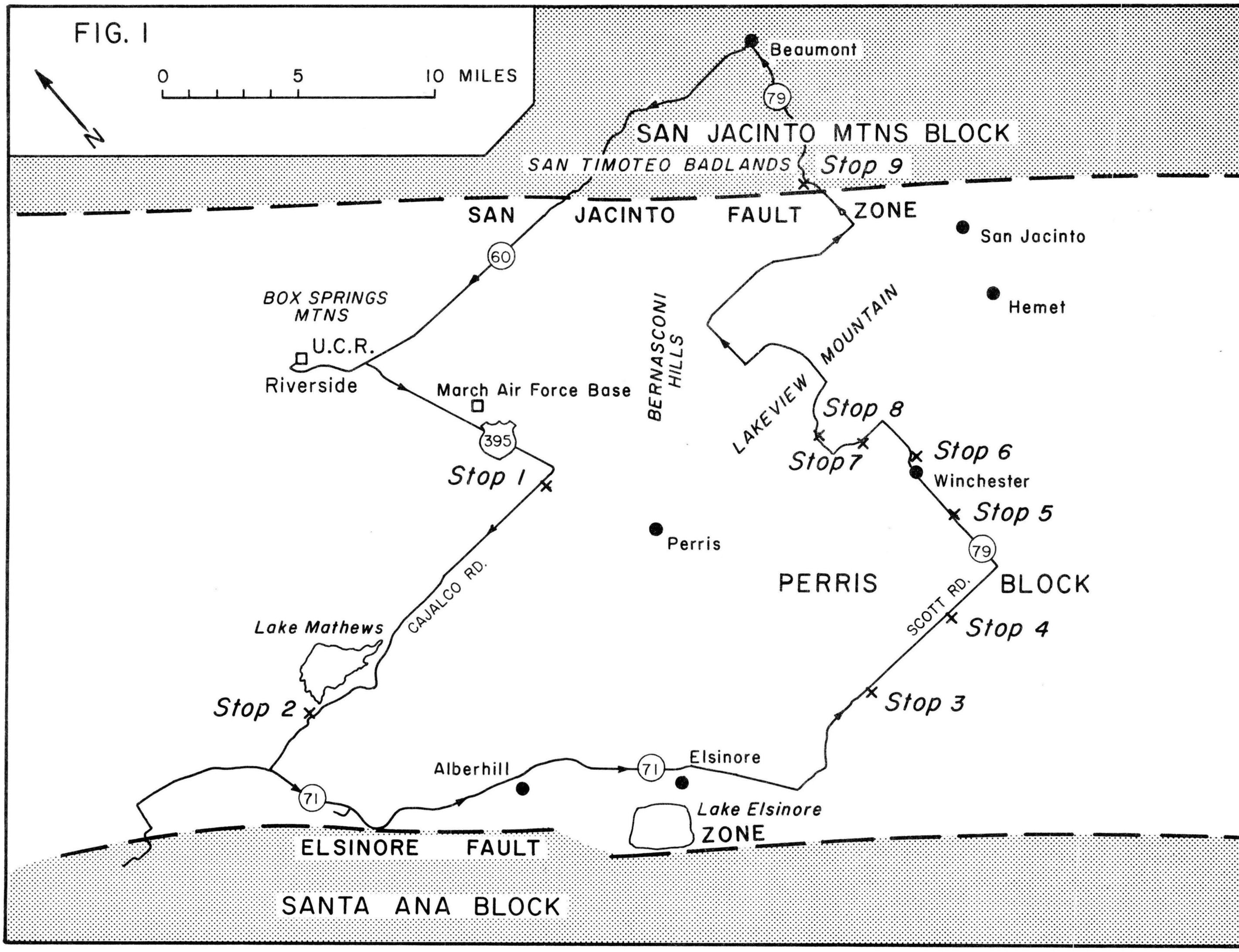
The accompanying generalized geologic map, Figure 2, is after Rogers (1966); modified by the authors. Additional data, mainly structural, were obtained from Engel (1959), English (1953), Gray (1961 and unpublished mapping), Jahns (1954b), Jenney (1968), Larsen, Norman (1962), Menzie (1962), Morton (1969, 1971, and unpublished mapping), and Schwarcz (1969).

A.O. Woodford, Pomona College, kindly made available an unpublished manuscript. Professor Woodford and R.F. Yerkes, U.S. Geological Survey, critically read the geologic synopsis of this guide.

GEOLOGIC SYNOPSIS OF THE NORTHERN PENINSULAR RANGES

An elongate, physiographic domain, the Peninsular Range province extends south-southeast from the latitude of Los Angeles-San Bernardino to the southern tip of Baja California. The western part of the province is submerged, and is part of the area termed the continental borderland (Shepard and Emery, 1941). High prominences of the Peninsular Ranges contintental borderland form the islands of Santa Catalina, Santa Barbara, San Nicolas, and San Clemente off the southern California coast.

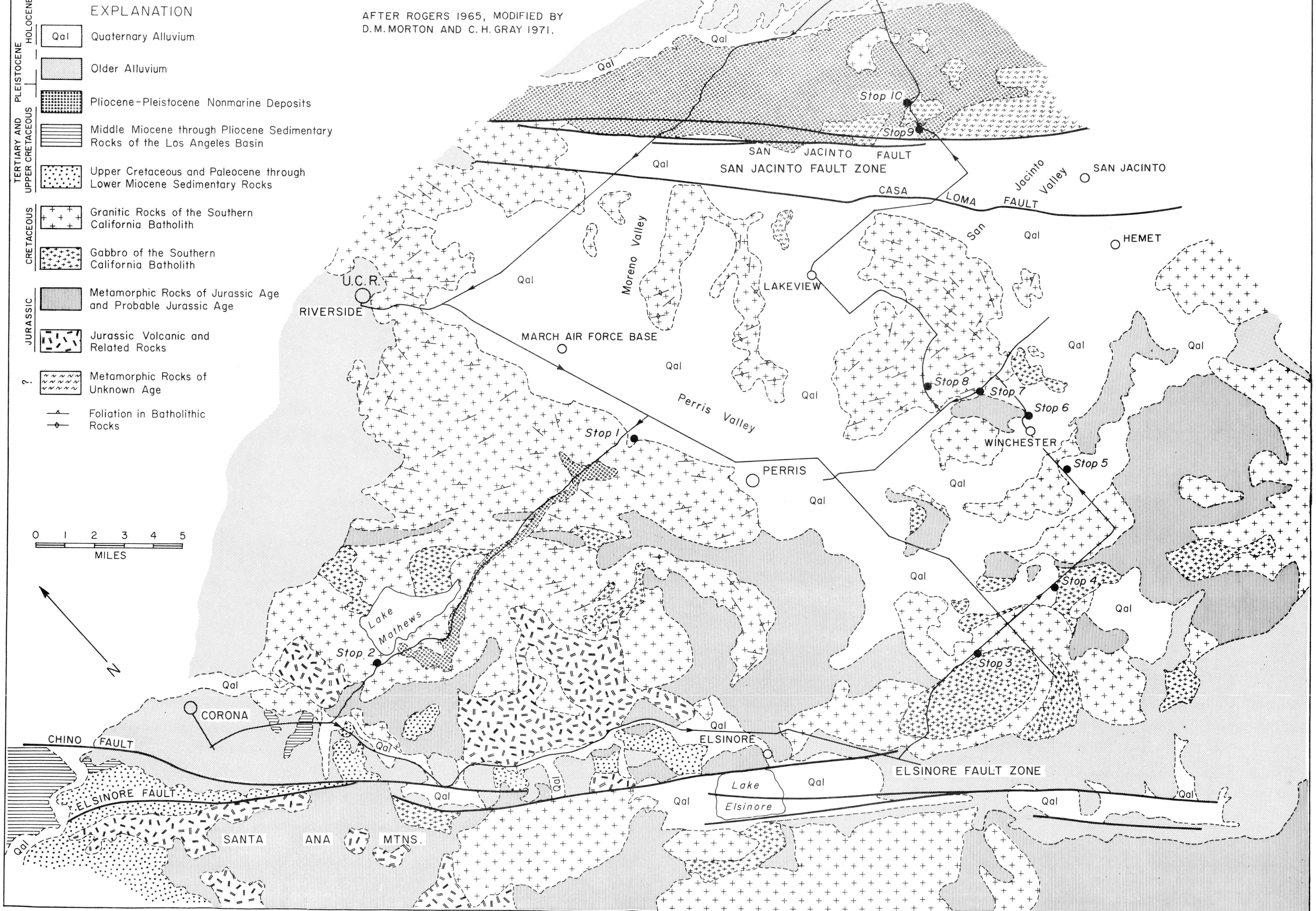
Within the province is a general coincidence of both structural and physiographic features—all having a northwest trend (Jahns, 1954b; Larsen, 1948, pp. 119-127). This trend predates the emplacement of the southern California batholith ($\cong$110 m.y.) and has been repeatedly reinforced. Topographically, the province tilts gently westward to depths of about 5,000 feet below sea level over the United States part of the continental borderland. The San Jacinto Mountains along the eastern margin reach elevations in excess of 10,000 feet and drop precipitously to the Salton trough on the east.



INDEX MAP SHOWING MAJOR GEOMORPHIC FEATURES AND ROUTE OF TRAVEL.

GENERALIZED GEOLOGIC MAP OF PART OF THE NORTHERN PENINSULAR RANGES, SOUTHERN CALIFORNIA.

FIG. 2



The landward northern Peninsular Ranges are 60 to 80 miles in width, and divided into three elongate structural blocks separated by major northwest-striking fault zones. From west to east: the Newport-Inglewood zone forms the boundary between the largely submerged continental borderland block to the west and the Santa Ana block to the east; the Elsinore zone and associated Elsinore-Temecula graben separate the Santa Ana block from the Perris block. Eastward, the San Jacinto zone separates the Perris block and San Jacinto Mountains block.

Basement Rocks

The northern Peninsular Ranges consist of pre-Turonian basement rocks separated by a profound unconformity from a superjacent sedimentary sequence of Turonian and younger age. The basement rocks can be divided into two distinctly different complexes: a western complex west of the Newport-Inglewood zone and an eastern complex east of this zone (Woodford, 1960; Yerkes *et al., 1965).*

Western Basement Complex: The western basement complex belongs to the blueschist metamorphic facies characterized by lawsonite and glaucophane. The dominant rock is the Catalina Schist (Catalina metamorphic facies of Woodford, 1924), made up of metamorphosed clastic and volcanic rocks, and serpentinite, which is, in part, intruded by Miocene dacite porphyry and quartz diorite (Forman, 1970; Schoellhamer and Woodford, 1951; Woodford, 1960). Conspicuous by their absence are the granitic rocks that are elsewhere widespread in the Peninsular and Transverse Ranges.

Although the Catalina Schist is of low metamorphic grade, no fossils have been reported. Woodford (1924), on the basis of lithology, correlated this schist with the Franciscan Formation to the north, which is Late Jurassic to early Late Cretaceous in age (Bailey *et al.,* 1964; Irwin, 1967). Forman (1970) reports a K-Ar age of about 100 m.y. for the Catalina Schist.

Eastern Basement Complex: East of the Newport-Inglewood zone the basement consists of granitic rocks, incipiently metamorphosed clastic and volcanic rocks, and locally, marble. Metamorphic grade of the clastic rocks increases progressively eastward, noticeably in the Perris block. Granitic rocks of the southern California batholith have invaded all of these rocks. The eastward increase in regional metamorphic grade is independent of the distribution of individual plutons of the batholith. Local contact metamorphism, however, accompanied the emplacement of the batholith and gave rise to several well-known complex mineral assemblages (e.g., Crestmore—see Burnham, 1959; Murdoch, 1961). Foliation in the metamorphic rocks, which generally strikes northwest, predates emplacement of the batholith (Schwarcz, 1969). Local deviation in the foliation has been produced by the emplacement of some plutons (e.g., Morton, 1969).

In the Santa Ana block the oldest dated rock is a sequence of incipiently metamorphosed, thin-bedded argillite, graywacke, and quartzite, with local pods of marble, termed the Bedford Canyon Formation (Gray, 1961; Larsen, 1948). The

TABLE 1

GENERALIZED GEOLOGIC COLUMN NORTHERN PENINSULAR RANGES (EXCLUDING THE LOS ANGELES BASIN)

Age	*Formation*	*Description*	*Distribution*	*Max. Estimated Thickness in Feet*
Quaternary	Holocene alluvium; Pleistocene nonmarine; Bautista Beds and Temecula Arkose; Pleistocene marine deposits.	Continental sands, gravels, lake beds. Marine fossiliferous terrace deposits.	Marine terrace deposits along coast. Alluvial fan deposits, lake beds, and valley fill in interior areas.	8,000 (?) in San Jacinto Valley.
Continental Pliocene	San Timoteo and Mt. Eden.	Continental sandstones, silt stones and conglomerate; redbeds. Upper part of San Timoteo is Pleistocene.	West of San Jacinto Mts. along San Jacinto fault.	7,000
Marine Pliocene	Repetto (?)	Thick-bedded white sandstone, conglomerate, silt, and shale. Marine.	Northwest end of Elsinore Trough at Corona on margin of Los Angeles Basin.	2,000 near Corona
Pliocene	Santa Rosa Basalt	Basalt, andesite, and pyroclastics.	Mesa-capping basalt near Murrieta.	Several hundred
Upper Miocene	Puente	Sandy siltstone and shale; minor sandstone, conglomerate and diatomite. Marine.	Northwest end of Elsinore Trough at Corona on margin of Los Angeles Basin.	1,000 (?)
Middle Miocene	San Onofre Breccia	Blocks of glaucophane and similar schists.	Oceanside north on coastal margin of region.	2,500
	Topanga	Buff sandstone, conglomerate, and sandy siltstone. Marine.	Northwest end of Elsinore Trough near Corona.	800
Lower Miocene to Upper Eocene	Vaqueros (Lower Miocene) and Sespe (Upper Eocene-Lower Miocene).	White, buff, red and green sandstone, conglomerate, sandy clay, and siltstone. Interfingering marine and nonmarine.	Northwest end of Elsinore Trough near Corona. West flank of Santa Ana Mts. at Trabuco Canyon.	3,000 combined
Eocene	Santiago	Buff sandstone, siltstone, and conglomerate. Marine.	North and northeastern margins of Santa Ana Mts. near Corona.	600 near Corona
Paleocene	Silverado	Upper part marine sandstone, conglomerate, siltstone, and shale; lower part nonmarine or brackish water sandstone, conglomerate, clay, lignite.	Elsinore Trough from Elsinore to Santa Ana River at northwest tip of Santa Ana Mts.	2,000 (?) at Corona
Upper Cretaceous	Williams and Ladd	Sandy shale or siltstone, arkosic sandstone, boulder conglomerate, Well stratified, fossiliferous. Marine.	Along northern part of coastal strip and around northwest tip of Santa Ana Mts. Underlies younger formations.	5,500
Cretaceous	Trabuco	Red and gray-green boulder conglomerate and sandstone. Nonmarine (?).	In Santa Ana Mts. northerly from Plano Trabuco to Black Star Canyon; southwest of Corona.	1,000; 600 near Corona
	Unconformity			
Cretaceous	Plutonic intrusive rocks of southern California batholith.	Granite, adamellite, granodiorite, quartz diorite, tonalite, diorite, and gabbro.	Basement rocks throughout the region.	
Jurassic	Santiago Peak	Volcanics, metavolcanics and hypabyssal intrusive rocks.	Part of basement rocks along western margin of plutonic basement rocks.	Several thousand
	Bedford Canyon	Argillite, slate, schist, quartzite, and minor marbles.	Roof pendants widely distributed in western part of batholith.	Several thousand
Jurassic (?)	French Valley [may overlie Bedford Canyon Fm.].	Quartzite, schist, and amphibolite.	Central part of Perris block.	13,000
Paleozoic (?)	Unnamed	Schist, gneiss, phyllite, quartzite, and marble.	Roof pendants widely distributed in eastern part of batholith; chiefly in San Jacinto and Santa Rosa Mts.	Several thousand

orientation of sedimentary structures indicates that the Bedford Canyon is highly deformed. Owing to the structural complexity and monotonous nature of this sequence, the overall structure and original thickness are unknown (Gray, 1961). Larsen (1948, p. 22) considered the unit to have a stratigraphic thickness of 20,000 feet; Gray (1961, p. 12) believes this thickness to be excessive.

Prior to 1960 the Bedford Canyon Formation was generally considered to be Triassic (Gray, 1961, pp. 12-13), but Fairbanks (1893, p. 116) originally regarded these rocks as Carboniferous. The Triassic age was based upon a sparse collection of the pelecypod *Daonella sanctaeanae* Smith, the Upper Triassic ammonite genera *Discotropites* and *Juvavites,* and rhynchonellid brachiopods of the Triassic genus *Halorella* (Engel, 1959, p. 20, 23, and 24). Subsequent collections, however, indicate an early Late Jurassic (Callovian) (Imlay, 1963; Silberling *et al.,* 1961) and lower Middle Jurassic (Bajocian) (Imlay, 1964) age for the Bedford Canyon. Brachiopods formerly considered to be *Halorella* are now thought to be a new genus, perhaps transitional between *Halorella* of the Upper Triassic and *Peregrinella* of the Lower Cretaceous (Silberling *et al.,* 1961).

Unconformably overlying the Bedford Canyon Formation is the Santiago Peak Volcanics (Larsen, 1948). Most of the rock is of dacitic to andesitic composition. In the northern Santa Ana Mountains this unit has an apparent maximum thickness of 2,300 feet (Gray, 1961, p. 15). The age of the Santiago Peak Volcanics is considered to be Jurassic (Fife *et al.,* 1967). Shallow, intrusive rocks related to the Santiago Peak Volcanics occur in the Bedford Canyon Formation.

Metamorphic rocks in the western and central parts of the Perris block have been correlated, on the basis of lithology, with the Bedford Canyon Formation and Santiago Peak Volcanics (Gray, 1961; Larsen, 1948; Schwarcz, 1969). They are, however, in general more intensely metamorphosed than the Bedford Canyon in the Santa Ana Mountains. Also widespread in the northwestern part of the block is the Temescal Wash Quartz Latite Porphyry (Dudley, 1935, p. 497). Supposedly of Jurassic age, this porphyry may be related to the Santiago Peak Volcanics.

In the Winchester area (north-central part of the Perris block) rocks correlated with the Bedford Canyon Formation are considered by Schwarcz (1969) to be conformably overlain by a 13,000 foot thick sequence of quartzite, schist, and amphibolite. Schwarcz (1969, p. 19) considered the original sediment of this sequence, which he named the French Valley Formation, "to have been deposited in a marginal basin (Krumbein and Sloss, 1963, p. 418), flanking a cratonic highland and possibly transitional on the west into a eugeosyncline." These rocks earlier were considered to be of Paleozoic age (Larsen, 1948; Webb, 1939), as based on a fossil later believed to have been imported (letter to A.O. Woodford from R.W. Webb, November 20, 1959; ref. in Woodford, 1960). Schwarcz's work clearly shows the incompatibility of the fossil with the rocks in the area of its reported occurrence. Just west of the Winchester area, in rocks apparently equivalent to the French Valley Formation, M.A. Murphy (pers. comm., 1968) collected pelecypods of uncertain age. These pelecypods have been considered to be either Late Triassic or Jurassic in age (Schwarcz, 1969).

The metamorphic grade of French Valley Formation rocks increases abruptly eastward in the Winchester area, passing in map distance of less than two miles from a muscovite zone, through andalusite, sillimanite, and garnet isograds. Based on mineral assemblages (Morton, 1969; Schwarcz, 1969) metamorphism was of the Abukuma (andalusite-sillimanite) type (Winkler, 1965).

At the northern end of the Perris block (e.g., Crestmore, Jurupa Hills, Slover Hill) and southeast of Hemet (Bautista Canyon), the metamorphic rocks commonly contain marble, on the basis of which they may be possibly Paleozoic in age (see Woodford, 1960).

The western San Jacinto Mountains block includes banded gneiss, marble, amphibolite schist, quartzite, and metaconglomerate of the almandine amphibolite facies (Sharp, 1967, p. 717). On the east side of the San Jacinto Mountains and passing southward through the Santa Rosa Mountains is a thick zone of cataclastic rocks as well as abundant marble and dolomite (Sharp, 1967, 1968; Theodore, 1966, 1970). These rocks are of unknown age.

Southern California Batholith

Larsen (1941) gave the name Southern California batholith to a sequence of plutonic rocks that makes up much of the eastern basement complex. Rocks of this composite batholith range in composition from olivine gabbro to granite and form myriad bodies of differing shapes and sizes. The general sequence of emplacement has been basic to silicic (gabbro to granite). Although Dudley (1935) first mapped the northern Perris block, the batholith is best known through the works of Larsen, especially his 1948 Memoir.

In the Santa Ana Mountains batholithic rocks intrude the Jurassic Bedford Canyon Formation and are overlain by the Upper Cretaceous Trabuco Formation, a nonmarine conglomerate that contains clasts of granitic rocks resembling those of the batholith. In northern Baja California, early Upper Cretaceous rocks (upper Cenomanian and Turonian) are intruded by rocks of the batholith and are in turn overlain by late Upper Cretaceous (Senonian) sedimentary rocks (see Woodford and Harris, 1938) which there indicates that the batholith is of middle Late Cretaceous age. Geochronological data from U-Pb isotopes in zircon have yielded dates in the interval 100 to 120 m.y. (e.g., Banks and Silver, 1961). K-Ar dates for batholith rocks give consistently younger ages, clustering in the low 90 m.y. range (Evernden and Kistler, 1970; Morton, 1969).

Lithologically, the batholith is composed of essentially three rock types: gabbro, quartz diorite (tonalite), and granodiorite. In its northwestern part, Larsen (1948, 1951, 1954) found the batholith to consist of 7% gabbro, 63% quartz diorite, and 28% granodiorite, with granite constituting only 2%. Gabbro, generally called San Marcos Gabbro (Larsen, 1948; Miller, 1937, 1938), is typically a hornblende or hornblende-bearing gabbro, but is extremely variable in mineralogy. Rocks called San Marcos Gabbro include allivalite, troctolite, norite, quartz norite, and anorthosite. Quartz diorite (tonalite) is the most abundant rock type and Bonsall Tonalite (Hurlbut, 1935) the most common unit. Typically the quartz diorites are medium- to coarse-grained biotite-hornblende quartz diorites. Most are foliated and commonly contain flattened, discoidal, dark inclusions; some exposures exhibit abundant schlieren. Granodiorite, most of which is termed the Woodson Mountain Granodiorite, is generally a relatively uniform, medium-grained rock, either massive or foliated (Larsen, 1948). Some exposures are essentially inclusion free; others are choked with inclusions. Locally a porphyritic or sub-porphyritic texture is prominent.

A number of discrete plutonic bodies or complexes have been studied in detail. These studies indicate the batholith was emplaced by a variety of processes including magmatic, both forceful (Menzie, 1962; Morton, 1969) and passive (Jenney, 1968; Morton and Baird, 1971), and by replacement (Jahns, 1948). Complex internal structures have been demonstrated for some granitic rocks (Morton, 1969; Osborn, 1939).

An exhaustive chemical investigation of the batholithic rocks has been conducted in the northern Peninsular Ranges. Preliminary results of this study show a marked systematic chemical variation parallel to the structural grain (Baird *et al.,* 1965, 1966, 1970). Two individual plutons have been studied chemically. Both bodies show a chemical variation essentially parallel to their structural configuration. In the Box Springs Mountains complex, Joshi (1969) found the core to be more silicic than the margin and considered the variation to be a function of elevation differences. The Lakeview Mountains pluton has a more basic core than margin, reflecting original magma differences (Baird *et al.,* 1967; Morton *et al.,* 1969).

Superjacent Series Sedimentary rocks and unconsolidated sediments range in age from Upper Cretaceous to Holocene and recent. The northern Santa Ana Mountains and adjacent Elsinore fault zone contain the greatest variety of these units. On the Perris and San Jacinto Mountains blocks the superjacent series is essentially limited to late Tertiary and Quaternary nonmarine deposits.

Santa Ana Block and Elsinore Fault Zone

The northern Santa Ana Mountains and the adjacent Elsinore fault zone are part of the Los Angeles basin, which developed during Miocene time. Thus, the later history of this part of the Peninsular Ranges differs considerably from that to the east. Prior to the inception of the Los Angeles basin, this part of the Peninsular Ranges was the site of discontinuous deposition beginning in Late Cretaceous time. For a summary of the history of the Los Angeles basin, the reader is referred to Yerkes *et al.* (1965).

Upper Cretaceous rocks in the northern Santa Ana Mountains attain a thickness of 5,500 feet (Woodford *et al.,* 1954). Resting unconformably upon basement is the Trabuco Formation (Packard, 1916), a 400- to 700-foot sequence of unfossiliferous conglomerate (Gray, 1961, p. 18-19). Clasts in the conglomerate are primarily Santiago Peak Volcanics and related rocks, with minor, but strikingly ubiquitous, clasts of biotite granodiorite.

Above the Trabuco Formation is an Upper Cretaceous marine sequence of conglomerate, sandstone, siltstone, and shale. Termed the Ladd Formation, it has a stratigraphic thickness of 1,700 feet. In places this formation has been divided into two members: the Baker Canyon Conglomerate Member (with fauna of Turonian age) and overlying Holz Shale Member (Turonian to Campanian) (Gray, 1961; Woodring and Popenoe, 1942). Unconformably overlying the Ladd Formation is the Williams Formation. The lower part (Schulz Ranch Sandstone Member) is an unfossiliferous arkosic sandstone and the upper part (Pleasants Sandstone Member) is a fossiliferous (Campanian), shaly sandstone with intercalated lenses of sandstone (Popenoe, 1937; p. 380).

Paleocene rocks, about 1,400 feet thick in the Santa Ana Mountains (Woodford *et al.*, 1954, p. 69), are called the Silverado Formation (Woodring and Popenoe, 1945). They rest unconformably upon Upper Cretaceous and basement rocks in the Santa Ana Mountains and in the Elsinore fault zone (Gray, 1961). Basal Silverado consists of nonmarine conglomerate and feldspathic sandstone. Locally, the sandstone is extremely rich in biotite and resembles biotite schist (Woodford *et al.*, 1954, p. 69). The upper part of the Silverado is a fossiliferous marine sandstone and siltstone.

The basal part of the formation contains large amounts of high-alumina clay. This clay includes both residual and sedimentary clay, some of which is bauxitic (Gray, 1961, p. 25). The residual clay was derived from *in situ* weathering of a variety of basement rocks (Gray, 1961, p. 63). The clay and local silica sand deposits of the Silverado support a number of mining operations which date back over 80 years, among which are the most productive clay operations in southern California.

The Eocene Santiago Formation apparently conformably overlies the Silverado Formation (Woodring and Popenoe, 1945). Predominantly sandstone, the lower part of the Santiago contains a middle Eocene molluscan fauna; the Santiago has a maximum thickness of approximately 2,700 feet. The upper part of the Santiago at least locally contains nonmarine conglomerate and sandstone and is gradational with the Sespe Formation. Late Eocene to earliest Miocene nonmarine Sespe Formation and the early Miocene marine Vaqueros Formation have been mapped as an undifferentiated unit as much as 3,000 feet thick. They consist of vari-colored (maroon, gray, red, and greenish) sandstone and conglomerate (Gray, 1961). These rocks apparently rest conformably upon the Santiago Formation in the Santa Ana Mountains (Woodford *et al.*, 1954, p. 69) and unconformably upon the Santiago west of Corona (Gray, 1961, p. 30).

Following the deposition of lower Miocene sediments was a period of general emergence and erosion which produced a widespread unconformity throughout much of the Los Angeles basin. During middle Miocene time, a northwest-trending embayment covered the site of the basin, with highlands rising both to the northeast and southwest (Yerkes *et al.*, 1965). During part of this time, the western basement (Catalina Schist) emerged and rapidly shed debris which entered the southwest side of the marine embayment to form the San Onofre Breccia (Woodford, 1925).

Marine middle Miocene rocks crop out in the northwestern Santa Ana Mountains and in limited exposures in the Corona area where they have been assigned to the Topanga Formation. In the Corona area these rocks consist of sandstone and conglomerate which have yielded middle Miocene megafossils and microfossils (Gray, 1961, p. 31).

During upper Miocene to lower Pliocene time, with the main phase of basin development there was essentially continuous subsidence and deposition in the Los Angeles basin (Yerkes *et al.*, 1965, p. 17).

Upper Miocene marine sedimentary rocks, the Puente Formation as much as 13,400 feet thick in the Los Angeles basin, occur in the northernmost Santa Ana Mountains and underlie the Puente-Chino Hills to the north. In the Corona area a few patches of siltstone, sandstone, and conglomerate contain upper Miocene foraminifera and are assigned to the Puente Formation (Gray, 1961, p. 31-35). Immediately east of Corona the apparent eastward limit of deposition of this unit is marked by a cliff-like, buttressed unconformity between granitic rock and fossiliferous sandstone and conglomerate tentatively correlated with the Puente Formation (Gray, unpublished map, 1969).

Lower Pliocene sandstone and siltstone with interbedded conglomerate conformably overlie the upper Miocene rocks in the northeasternmost Santa Ana Mountains and along the margins of the Puente Hills. East of there, these strata have not been named. At the end of the Pliocene, the Puente-Chino Hills and Santa Ana Mountains emerged, which have subsequently not been submerged. During late Pleistocene through Holocene, the Los Angeles basin gradually ceased to be a site of major deposition with a continual westward withdrawal of the sea (Yerkes *et al.,* 1965, p. 19-20).

Alluvial deposits of Pleistocene to Recent age are similar over most of the northern Peninsular Ranges. Stream terrace deposits are widespread along major drainages; most consist of unconsolidated gravels in a poorly sorted, sandy matrix, reddish-brown to tan or buff in color. Clasts are of differing composition, depending upon source area. Older terrace deposits are commonly dissected and have nearly flat upper surfaces. They range in thickness from less than one foot to over 100 feet.

Older alluvium is widespread and occurs generally as dissected alluvial fan deposits. Characteristically, the older alluvium is red-brown and well-indurated. It contains considerable clay, with subangular to rounded small clasts.

Tertiary and Quaternary deposits on the Perris and San Jacinto Mountains Blocks

Nonmarine Pliocene to Pleistocene deposits, other than "older alluvium," are very restricted in the northern Perris block. Two east-trending, largely obscured stream channels cross the northwestern part of the block. During recent construction, a Pliocene mammalian fauna was discovered near Lake Mathews (Proctor and Downs, 1963) in poorly sorted, arkosic sandstone that fills a channel cut in basement rock on the Perris surface, an erosion surface at the 1,700 foot elevation.

A much smaller, somewhat sinuous stream channel occurs on the Lakeview-Gavilan surface, a 2,100-foot erosion surface south of Lake Mathews. Mantled by cobbles, it stands in base relief above a largely bedrock surface (Dudley, 1953). Small patches of gray, poorly bedded sediment of unknown age occur on the Lakeview-Gavilan surface in the Lakeview Mountains (Morton, 1971).

Unconsolidated, buff colored, decomposed arkosic sediment underlies older alluvium in the Canyon Lake area (formerly Railroad Canyon) east of Elsinore. This sediment apparently fills an east-trending depression in the basement.

Nonmarine Pliocene and Pleistocene deposits are widespread in the northern San Jacinto Mountains block; the northern 25 miles of the block is underlain by sedimentary deposits comprising the "San Timoteo Badlands." Sediments overlying basement are generally coarse, arkosic sandstone and conglomerate red beds. Overlying the red beds are buff- to gray- and greenish-gray sandstone, conglomerate beds and lenses, and siltstone. Some conglomerate lenses are monolithologic, composed of quartz diorite clasts as much as 20 feet in diameter (Morton, 1971). The lower part of the sequence is generally termed the Mt. Eden Formation, or Beds, and the higher part, the San Timoteo Formation. The Mt. Eden Formation is probably mainly middle Pliocene in age and the San Timoteo is upper Pliocene in age.

These and similar sediments, east and southeast of Hemet have yielded a mid-Pliocene (Hemphillian), early Pleistocene (Blancan) and later Pleistocene (Irvingtonian) fauna (Frick, 1921; Savage *et al.*, 1954). They have also yielded a mid-Pliocene to early Pleistocene flora (Axelrod, 1937, 1945, 1966).

Faults

The Peninsular Ranges abruptly terminate to the north against the east-trending Transverse Ranges. The Malibu Coast-Santa Monica-Raymond Hill-Sierra Madre-Cucamonga fault complex marks their northern terminus, extending from the Pacific Ocean to the Devore area near Cajon Pass. East of Devore this boundary is apparently offset on the San Jacinto fault approximately 15 miles right laterally to the Redlands area. From this point the boundary is termed the Banning fault, which continues eastward into the San Gorgonio Pass area.

The several blocks of the Peninsular Ranges are separated by northwest-striking faults belonging to the San Andreas fault system (Crowell, 1962). The major fault zones are, from west to east: the Newport-Inglewood, the Elsinore-Whittier, and San Jacinto. The Newport-Inglewood zone is poorly exposed; the other zones consist of a complex of subparallel, en échelon, or anastomosing faults. Individual faults within each zone show evidence of recent displacement as indicated by ephemeral features such as closed depressions and scarps.

The presence of unlike metamorphic rocks on opposite sides of the Newport-Inglewood fault zone suggests considerable displacement and recently it has been considered the "proto-San Andreas" fault in southern California (Suppe, 1970). Pre-late middle Miocene displacement of undetermined amount and sense juxtaposed the Eastern and Western basement complexes and exposed Western basement to erosion. Lower Pliocene strata are separated as much as 5,000 feet in a right lateral sense along faults of the zone. Vertical separation at the basement surface locally attains 4,000 feet across the zone, but that of Pliocene strata commonly does not exceed 1,000 feet and that at the base of the Pleistocene 200 feet. Late movement on the fault has resulted in arching of young sediments to form low hills along the zone (Yerkes *et al.*, 1965, p. 48) and seismic activity (i.e., Long Beach earthquake of 1933) indicates continued movement (Barrows, in press, 1971).

The Elsinore-Whittier fault zone, with a known length of about 135 miles, extends from the Whittier Narrows area, east of Los Angeles, southeast to at least within a few miles of the International Border. Bifurcating at the north end of the Santa Ana Mountains, its west branch is termed the Whittier fault. The east branch, the Chino fault, passes along the east side of the Chino (Puente) Hills northwest of Corona. From the Corona area southward the zone is designated Elsinore.

Along the Whittier fault, local structural data indicate an oblique net slip (right-lateral reverse) of about 15,000 feet since Miocene time; this part of the fault zone may have been active since middle Miocene time (Yerkes *et al.*, 1965, p. 50).

Displacement on the Elsinore fault zone has been considered essentially normal, reverse, as well as lateral by various workers (Gray, 1961, p. 46). Distribution of basement rocks across the faults suggests possible lateral displacement on the order of a few miles. Sag ponds and scarps along faults of this zone indicate recent movement (e.g., Glen Ivy, Willard, and Wildomar).

The San Jacinto is the only fault of the San Andreas system, including the San Andreas, to cross the southern Transverse Ranges without deviating from its general strike or being terminated. On the contrary, the San Jacinto fault appears to offset the southern, east-striking faults of the Transverse Ranges (Allen, 1957, p. 339; Sharp, 1967, p. 726). Based on its straightness, continuity, and seismic history, it appears to be the most active fault of the San Andreas system in southern California (Sharp, 1967). Based on a number of offset basement contacts southeast of Hemet, Sharp (1967) determined a 15-mile right-lateral displacement across the San Jacinto. He also found Pleistocene deposits offset right laterally at least 3.2 miles and stream courses offset half a mile.

In the San Jacinto Valley, a remarkably deep, narrow graben has developed between the San Jacinto and adjacent Casa Loma faults. North of San Jacinto the depth to basement in this alluvial-filled graben is some 8,000 feet beneath the present valley floor (Fett, 1968). It is thought this graben developed and filled since the early Pleistocene. Currently, parts of the graben are undergoing rapid subsidence. Surface expression of this subsidence is widespread (Fett *et al.*, 1966) and includes major surface fissures (Morton, 1971). This active subsidence, which in part may be of tectonic origin, appears to be mainly the result of ground-water withdrawal. A large number of recent surface expressions of faulting occur on the San Jacinto fault (Sharp, 1970).

Seismically, the San Jacinto fault zone has been the most active member of the San Andreas system; many destructive earthquakes having occurred along the zone since the turn of the century (e.g., 1899, 1918, 1923, 1937, and 1954) (Allen *et al.*, 1967).

Geomorphology

A number of low-relief, erosional surfaces occur throughout much of the northern Penisnular Ranges at different elevations. They are best developed, and exposed, on the Perris block. Erosional surfaces are present there at elevations of 1,700; 2,100; and 2,500 feet (Dudley, 1936; Larsen, 1948). There is also a largely buried canyon system. Dudley (1936, pp. 358-387) believed that the Perris block, which is bounded on the southwest by the Temecula-Elsinore trough, had a geomorphic history briefly summarized as follows:

1. A mature surface was developed in the area of the Perris block. Drainage was at that time toward the east.

2. This old topography was partly buried by sediments, and the Perris surface was developed. This surface, cut on crystalline rocks and interrupted here and there by monadnocks, lies at an altitude of about 1,700 feet.
3. Sediments accumulated over a large area, and the Lakeview-Gavilan surface at an altitude of about 2,100 feet was formed.
4. Erosion exhumed the Perris surface, and the San Jacinto River then flowed across this surface and through the Santa Ana Mountains to the sea. The river thus is superimposed where it crosses monadnocks on the Perris surface.
5. The San Jacinto River was captured by Temescal Creek, a tributary of the Santa Ana River. Elsinore Lake is a temporary feature, incidental to recent faulting.

A revised interpretation of the development of these features, and their relations to contemporary tectonism has been proposed by Woodford *et al.* (in press, 1971).

Of particular interest is the San Jacinto River course, which may once have flowed across the present area of the Santa Ana Mountains. Apparently movement of the Elsinore fault zone uplifted the Santa Ana Mountains across its path, disrupting the earlier westward course of the drainage and causing the present northward drainage along the Elsinore fault zone toward present-day Santa Ana Canyon. The canyon itself is probably antecedent, as uplift of the Santa Ana Mountains continued after the initial disruption of the San Jacinto River course. Currently except for periods of extraordinary runoff, such as during 1916-1917, the San Jacinto River runoff terminates at Lake Elsinore, a closed depression marking the northern end of the Temecula-Elsinore graben.

FIELD TRIP ROAD LOG

The starting point of the trip is located on the west flank of a funnel-shaped granitic complex (see Fig. 2). This complex, part of the southern California batholith, and termed the Box Springs body (Menzie, 1962), is elliptical in plan (5 x 8 miles) with its long dimension oriented N.40°W. It consists principally of two parts: an outer zone composed of foliated quartz diorite (tonalite) and granodiorite, with minor quartz monzonite and granite; and an interior or center (2 x 3 miles), of massive quartz diorite. Quartz diorite (Bonsall Tonalite), the most abundant rock in the outer zone, is strongly foliated with common to abundant inclusions most of which are disc-like in shape. The long dimensions of the inclusions, as well as the long dimensions of tabular and platy minerals, define the foliation. Quartz diorite comprising the center contains sparse unoriented inclusions. Menzie considers the complex resulted from mobilization of largely crystallized quartz diorite (which forms the outer zone) and was later intruded by magma which formed the central part of the complex. Movements in the largely crystallized quartz diorite resulted in formation of the foliation and "flattening" of the inclusions (after Menzie, 1962).

0.0 Start trip. Parking Lot, Ramada Inn, Riverside. Proceed east from parking lot to University Avenue and hence onto southbound US 395. Highway proceeds up Box Springs grade passing through exposures of typical Bonsall Tonalite. Note the foliated nature of the rock and the common pancake shaped dark inclusions.

3.6 Highway grade decreases on entering the 1,700+ foot Perris erosional surface.

4.1 Overpass across Santa Fe tracks. Here a thin veneer of gray Pleistocene (?) sediments covers the Bonsall Tonalite.

4.3 Highway branches. Bear to the right on US 395.

4.6 To left (northeast) is the east-striking, north-dipping southern part of the Box Springs complex.

5.5 The valley floor, termed the Paloma surface (Woodford *et al.,* 1971), subtly reaches elevation 100-200 feet below the Perris surface.

6.5 Highway crosses Allesandro Road (traffic light).

7.6 March Air Force Base Depot. Strategic Air Command (SAC) headquarters to left.

8.6 Highway crosses Van Buren Boulevard (traffic light).

8.8 Ahead to the right the low relief hills silhouette the Perris surface rising above the alluviated valley.

11.0 Four miles east are the Bernasconi Hills. These hills are upper parts of a buried stream system which drained towards the highway, where at this point the valley fill is over 800 feet deep (Bean, 1955). The former drainage direction abruptly reversed at the west edge of the Bernasconi Hills and flowed eastward towards the San Jacinto Mountains and emptied into a graben along the San Jacinto fault zone (Woodford *et al.,* 1971).

12.5 Right turn off US 395 onto Cajalco Road.

12.6 Low dump 200 yards south of Cajalco Road is spoilage from the Metropolitan Water District's (MWD) Val Verde Tunnel. This tunnel is part of the elaborate aqueduct that brings water from the Colorado River to the metropolitan areas of southern California. Our route follows the aqueduct for the next ten miles to Lake Mathews, an MWD reservoir.

12.9 Near horizontal skyline to south is the Perris surface developed on Bonsall Tonalite.

13.5 Contact between alluvium and Bonsall Tonalite.

13.8 **Stop 1:** Turn left (south) onto dirt road. Proceed for 0.2 mile to dump from MWD tunnel to view abundant fresh boulders of quartz diorite. This quartz diorite is from the Riverside-Perris pluton (Jenney, 1968), a large elongated (4.9 x 13 miles) body of Bonsall Tonalite of predominantly a biotite-hornblende quartz diorite. To the northeast it merges with the Box Springs Mountain body. Like the outer quartz diorite in the Box Springs Mountains, this rock is strongly foliated with abundant inclusions oriented north-northwest and dipping moderately to the northeast. In general the dip flattens from west to east across the pluton. Jenney (1968) considers the quartz diorite to have been intruded into a tensional environment which allowed permissive entry of the quartz diorite magma (after Jenney, 1968). Return to Cajalco Road.

14.1 Cajalco Road reaches top of the Perris surface.

14.8 Intersection of Cajalco Road and Clark Street. A few hundred feet to the left is a buried Pliocene-Pleistocene stream channel marked by the low rounded hills. Note the lack of rounded boulders which would indicate the presence of granitic rocks.

15.4 Cajalco Road crosses north-trending arm of the channel.

16.3 Exposure of Bonsall Tonalite.

16.5 To the left is dump from MWD Val Verde tunnel. To right is an exposure of hybrid rocks. Folded inclusion-like layers in migmatite are oriented with fold axes striking northwest and plunging to southeast. (Note: As of 12/30/70 road was in process of being straightened. In the future the road will pass through the migmatitic rocks.)

17.5 Intersection with Wood Road. To the north is brown-weathered quartz diorite within typical gray-weathered Bonsall Tonalite.

17.6 Road cut in red older alluvium covering buried Pliocene channel. The buried channel is essentially parallel to, and to the left of, the road.

18.1 Smooth hills to the north and south of road are underlain predominantly by pre-batholithic schist.

18.5 Lazy MC Ranch. To the southwest the upper surface of the flat topped hills is the Lakeview-Gavilan surface (2,100 feet of elevation).

18.7 Riverside County fire station.

19.5 On left are dissected Pleistocene fan deposits of red-brown alluvium overlying the buried channel.

20.9 For next several miles the road continues through dissected Pleistocene alluvium. View to the northeast of the Perris surface.

22.2 Water to north and northwest is MWD reservoir Lake Mathews (Cajalco Reservoir). San Gabriel Mountains on skyline to north.

23.2 Straight ahead on skyline is Santiago Peak, the highest point in the Santa Ana Mountains (5,687 feet) on the west side of the Elsinore fault zone.

23.8 Road veers to northwest leaving the Pliocene channel.

24.5 Altered quartz monzonite. This is the start of an extensive area of rock which has been silicified and tourmalinized.

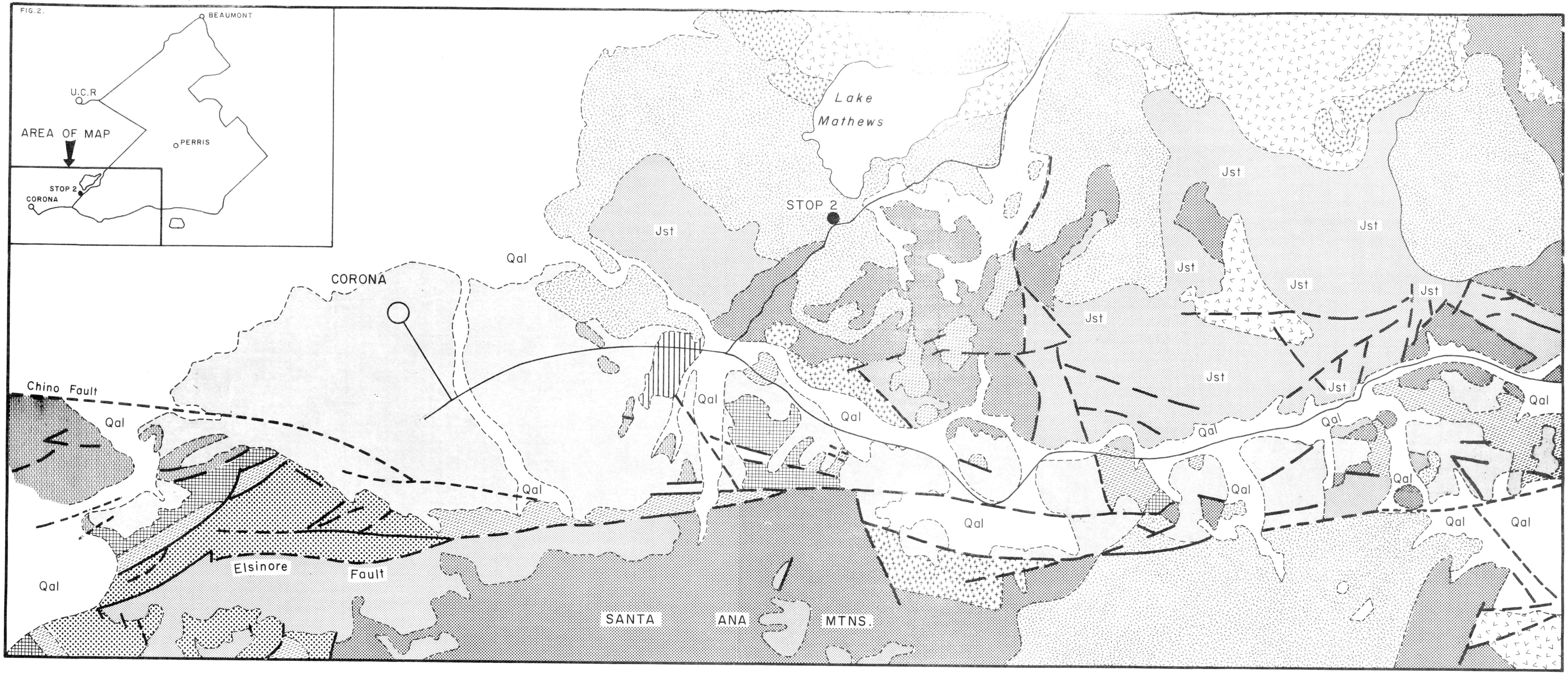
24.8 Small dark outcrops half a mile to the south (left) consist of quartz monzonite completely altered to silica-tourmaline rock termed tourmaline "blowouts." This tourmaline-silica rock is locally tin-bearing.

25.2 To right behind fence is prosptec for tin.

25.4 Dirt road to left leads to site of excavation just south of Cajalco Road that yielded Pliocene mammalian fauna (Proctor and Downs, 1963). At this point the channel turns to the north and extends to the reservoir.

26.0 Intersection of La Sierra Avenue and Cajalco Road; take left branch (Cajalco Road).

26.7 **Stop 2:** Park on shoulder and walk or take dirt road to right to low ridge just north of Cajalco Road (see Fig. 3). Rock is subporphyritic quartz monzonite which contains local "veins" of tourmalinized rock. Lake Mathews dam is to northeast at head of Cajalco Canyon. Numerous prospects to north and northeast explore tourmalinized rock for tin. Low, dark hill to north is Cajalco Hill, site of Cajalco (Temescal) tin mine. Tin was discovered in the area around 1853. The main mining activity was between 1869 and 1892, 1928-29, and 1942. The Cajalco mine, the only producer, had a total production of about 130 long tons of tin (Gray, 1957).



Qal — Alluvium

Older Alluvium (includes terrace deposits)

Undifferentiated marine Pliocene and Puente Formation

Topanga Formation

Undifferentiated Vaqueros, Sespe and Santiago Formations

Silverado Formation

Ladd and Trabuco Formation

Undifferentiated granitic rocks

Quartz diorite (primarily Bonsall tonalite, quartz diorite of the Lakeview Mtns. pluton

Gabbro and diorite

Santiago Peak volcanics

Jst — Temescal Wash quartz latite porphyry

Bedford Canyon Formation

0 1 2 3 4 5

MILES

N

Fig. 3. GEOLOGY OF PART OF THE ELSINORE FAULT ZONE.

by

D. M. MORTON and G. H. GRAY.

1971

27.5 Dark colored tourmalinized rock on left in the road cut is in mixed granitic rock and Bedford Canyon Formation (?).

27.8 Road cut on left is in Bedford Canyon (?) rock. Here it is predominantly siliceous with some phyllite.

28.2 Elsinore trough (fault zone) straight ahead. From here to the trough the predominant rock type is Bedford Canyon Formation (?).

28.6 Quarry in red rock to left is mostly weathered Bedford Canyon Formation (?) with some sediments of the Silverado Formation.

29.0 Road cut in Pleistocene (?) older alluvium.

29.3 Road crosses Santa Fe tracks. Railroad cut to right is in Bedford Canyon Formation (?) overlain by terrace deposit.

29.6 Intersection Cajalco Road and Temescal Canyon Road. Turn right onto Temescal Canyon Road for Corona Skyline Drive side trip. Turn left on Temescal Canyon Road for continuation of trip.

CORONA SKYLINE DRIVE SIDE TRIP

(0.5) International Pipe & Ceramics Corporation, Corona Plant (Interpace) (formerly Gladding, McBean & Company). Produces red-burning heavy clay products (e.g. sewer pipe, drain tile, and conduit). Plant uses local clays and filler clays, mostly from Paleocene Silverado Formation.

(0.6) Brown- to dark-gray, sandy, older alluvium containing angular cobble clasts.

(0.8) El Cerrito Hills. Exposed on both sides of highway is white to buff and brown sandstone of the middle Miocene Topanga Formation. Some of the Topanga is buff and brown siltstone and shale; in places Topanga strata are diatomaceous.

(1.3) Temescal Canyon Road changes to Ontario Avenue. Ahead to right is operation of Minnesota Mining & Manufacturing Company. Large quarry is developed in Temescal Wash Quartz Latite Porphyry of probable Jurassic age. Rock is crushed, screened, and colored with a sub-vitreous, bonded, ceramic-type glaze and used as granules for roofing materials. This operation produces most of the granules used for processed roofing materials on the west coast; shipments are made as far north as Vancouver, British Columbia. This operation has been active since 1948, although the quarry, Temescal Rock Quarry, was opened and produced rock for macadamizing streets in Los Angeles and area in 1888. Quarry operation in the early 1920s was by tunnel or coyote system which brought down 600,000 to 1,500,000 tons of rock in each blast which used 45 to 125 tons of powder (Gray, 1961). Some of these large blasts in more recent years have been used by seismologists for refining seismic travel times (Richter, 1958).

(1.6) On north side of road are outcrops of granitic rocks (quartz monzonite and hornblende granodiorite porphyry).

(2.0) Is small road cut and along north side of highway is undifferentiated Puente Formation of upper Miocene age. In this area the Puente is mostly white to greenish-gray, thin-bedded, diatomaceous siltstone; some buff to gray siltstone and shale, and brown to buff sandstone, with local conglomerate lenses.

(2.2) Road crosses north end of short stretch of the Corona Freeway (State Highway 71) and joins Highway 71 (Ontario Avenue).

(4.4) Intersection with Main Street. Proceed ahead on Ontario Avenue. The nearby citrus acreage and the town of Corona are developed on a surface of Quaternary older alluvium, the Corona compound alluvial fan.

(5.4) Intersection of Ontario Avenue and Lincoln Avenue; turn left onto Lincoln Avenue.

(6.4) Turn right onto Chase Drive. To the west and south the break in slope in Quaternary older alluvium may be the surface expression of the Chino fault. Further southeast anomalous scarplets and benches in the older alluvium, as well as a definite scarp at the contact between Quaternary terrace deposits and older alluvium, apparently mark the trace of the Chino fault.

(6.8) Oak Avenue. Road cut at left in Quaternary older alluvium.

(7.0) Intersection Chase Drive and Skyline Drive; turn left (south) onto Skyline Drive.

(7.2) Cleveland National Forest Boundary sign and end of pavement. To left (east) is Paleocene Silverado Formation capped by flat-topped Quaternary terrace deposits. Terrace deposits here are at two different elevations that are attributed to erosion, rather than faulting.

(7.4) To left (east) Silverado sandstone and conglomerate capped by brown Quaternary terrace deposits along lower Hagador Canyon.

(7.6) Junction of Hagador and Tin Mine Canyons; keep right along Tin Mine Canyon.

(7.8) To right (north) is white to buff sandstone and conglomerate of the Silverado Formation.

(8.0) Northwest-striking fault along bare cliff faces juxtaposes upper Cretaceous Ladd Formation (Baker Canyon Conglomerate Member) and Paleocene Silverado Formation. Just to west is reef-type deposit in the Baker Canyon containing abundant oyster debris. Channel to left (Tin Mine Canyon bottom) contains boulders derived from the Ladd Formation (Baker Canyon Conglomerate Member) a short distance to the northwest on the brush-covered slope. These boulders contain numerous *Actaeonella oviformis* Gabb and are from a highly fossiliferous, generally hard, sandstone layer that crops out discontinuously over about one and a half miles from Tin Mine Canyon northwest to Mabey Canyon. In places this sandstone contains abundant *Trigonarca californica* Packard and other material that indicates a *Glycymeris pacificus* fauna.

(8.1) Draw on skyline to northwest (right) is contact between the Cretaceous Trabuco Formation (red, buff, and grayish-green massive conglomerate, minor sandstone, probably nonmarine) and Ladd Formation (Baker Canyon Conglomerate member).

(8.3) Road leaves canyon bottom and starts upgrade. Cars can be left here and the remaining trip (0.8 mile) made on foot, or there is a more narrow parking area 0.7 mile further on. Rock exposed in road cut is Jurassic Santiago Peak Volcanics—just west of the Elsinore fault.

(8.4) Road crosses the northwest-striking and steeply south-dipping Elsinore fault and passes back from Santiago Peak Volcanics into Trabuco Formation.

(9.1) Switchback. Turn around here (if driving). The switchback is essentially on the Elsinore fault which again separates Santiago Peak Volcanics on the west from Trabuco conglomerate (note clasts of weathered biotite granodiorite). The switchback is in Santiago Peak Volcanics and immediately below and above the switchback, the contact between the Santiago Peak Volcanics and Trabuco conglomerate can be seen. Up the road 0.1 mile, the fault zone is well exposed in the road cut. The switchback turn out provides a vantage point for a sweeping view of the general area to the south and east.

South across Tin Mine Canyon the bare scar high on the brush-covered slope is an old gypsum working (active in the 1920s) in altered Santiago Peak Volcanics. To the southeast (south side of Tin Mine Canyon) the Elsinore fault crosses the low, rounded, brush-covered landslide debris. Here the fault is at the break in slope between nearby flat-topped areas, which developed through landsliding, and Santiago Peak volcanics. The scars along this trace also are old gypsum prospects. Fault crosses the far ridge, with the line of eucalyptus trees, at the break in slope between this flat-topped ridge (Silverado Formation capped by Quaternary terrace deposit) and the abruptly rising, steep, brush-covered hills to the south (Santiago Peak Volcanics and Bedford Canyon Formation). Continuing to the southeast the Elsinore fault is essentially at the break in slope and separates the Silverado Formation from Santiago Peak Volcanics and Bedford Canyon Formation.

Below, in lower Tin Mine Canyon, the bare hill at left is sandstone of the Baker Canyon Conglomerate Member in fault contact with Silverado sandstone and siltstone. Brushy hills north of Skyline Drive and toward the observer are Cretaceous sandstone and conglomerate (Trabuco Formation and Baker Canyon Conglomerate Member).

Retrace route to intersection Cajalco Road and Temescal Road.

29.6 Proceed southeastward on Temescal Canyon Road.

30.0 Butterfield Stage Station Historical marker. Ahead is spoil bank from Owens-Illinois glass sand operation.

30.3 At left, under the two tanks, terrace deposits overlie Silverado Formation. To right is the glass sand pit of Owens-Illinois in essentially flat-lying Silverado. Farther to the right the freeway traffic is essentially along the contact between the Silverado and the overlying undifferentiated Sespe and Vaqueros Formations (upper Eocene to lower Miocene) which is also essentially flat lying. The Elsinore fault is located along the base of the high hills (Santa Ana Mountains) which are underlain predominantly by Jurassic Bedford Canyon Formation.

30.5 Owens-Illinois glass sand plant. This is the oldest continuously operating and principal source of silica sand in southern California. The sand is obtained from a quartz-rich facies of the Silverado. In the quarry some 120 feet of usable sandstone is exposed; well data, however, indicates locally the sandstone is nearly 300 feet thick. Yearly production exceeds 100,000 tons of finished sand, of both flint and amber, with some monthly production more than 20,000 tons. To left are silt-clay waste ponds from Owens-Illinois operations. This material has been used by several companies in the manufacture of clay products.

32.0 At left San Marcos Gabbro and Bedford Canyon Formation form the low part of the hills. Overlying the basement rocks are both residual clay deposits and Silverado Formation.

33.1 Temescal (Harrington and Atlas) clay pits are to the left (east). Both residual and sedimentary clays of the Silverado Formation are mined.

33.5 Stop Sign. Proceed southeastward on Highway 71.

33.7 To right is Mission Clay Products which produces sewer pipe. Hills to left are Quaternary terrace deposits capping clay deposits of residual clay derived from the Bedford Canyon and Silverado Formations.

33.9 Turn right onto Lawson-Hunt Road.

34.1 Terrace deposits on right. Sag pond to left developed on north branch of Glen Ivy fault, part of the Elsinore fault zone. The road follows along the trace of this fault with a southwest facing scarp.

34.6 Light colored sediments in road cut are probably part of the Silverado Formation brought up along the Glen Ivy fault.

34.7 Lawson Road-Hunt Road intersection. To the northwest the trace of the fault is marked by saddles and aligned gullies in several ridges. Retrace route along trace of Glen Ivy fault to Highway 71.

35.5 Rejoin Highway 71 and turn right.

35.7 Dense vegetation at right marks the position of the Glen Ivy fault.

36.0 Entrance to Glen Ivy Resort. The south branch of the Glen Ivy fault goes through the resort but its trace is masked by recent alluvial deposits.

36.5 To the left are Holocene terrace deposits.

37.0 Santa Fe Railroad underpass. Hill straight ahead (Estelle Mountain) underlain by intermediate composition batholith rock and Temescal Wash Quartz Latite Porphyry.

37.3 Steep walled gorge ahead is superposed meander of Temescal Wash. The stream is believed to have cut a cover of sedimentary rocks which formerly filled the valley (Dudley, 1936).

38.0 Highway 71 ascends terrace deposits which cover fossiliferous Silverado Formation. The obvious break in slope paralleling and just to the left of the road is a modified fault scarp. Rock on the east side of fault is the Temescal Wash Quartz Latite Porphyry.

38.6 Highway 71 crosses fault separating Silverado Formation from Temescal Wash Quartz Latite Porphyry.

38.9 Upper end of the superposed drainage.

39.0 South end of Lee Lake, a reservoir for Temescal Water Company. This is a good vantage point from which to view the steep walled gorge. To the southwest terrace deposits cap Silverado Formation beyond the railroad tracks.

39.4 Dissected alluvial fan deposits capping Silverado Formation.

41.0 Alberhill turnoff.

41.7 Santiago Peak volcanics (Jurassic age) are exposed in road cut on left. To the right is the operation of Pacific Clay Products and the community of Alberhill which developed around the clay mining industry. The clay deposits in the Alberhill area are of both residual and sedimentary origin and are restricted to a zone within (or just below) the Paleocene Silverado Formation. Residual clay deposits, which attain a thickness of 130 feet, have been developed from the Bedford Canyon Formation, Santiago Peak Volcanics, Temescal Wash Quartz Latite Porphyry and dioritic-gabbroic rocks. The sedimentary clay is the product of local erosion of the clay which developed on the weathered basement. Sedimentary clay averages 80 feet in thickness with a maximum of about 150 feet. Two main types of clay products are produced: red burning clay is used to make heavy clay products (e.g., brick, sewer pipe and tile); white burning clay is used to produce refractory clay products (e.g., firebrick and flue lining material). In the early 1880s both coal and clay were mined at Alberhill. Mining at the time was by underground methods. The coal, lignite, was of low grade and soon constituted only a nuisance to clay mining. Between 1895 and 1955 almost six million tons of clay had been mined in the Alberhill area. By 1955 as much as 800 tons of clay was being mined each day (Engel *et al.*, 1959, pp. 77-97).

42.7 Hill to right is Bedford Canyon Formation overlain by Silverado Formation which is in turn covered by Quaternary terrace deposits and dumps from the clay mining. The road follows Walker Canyon which is apparently a superposed drainage.

45.2 Elsinore City limits.

45.3 Exposures of Bedford Canyon Formation.

45.8 Closed depression to right of highway. At this site earlier (1926) was a fissure at least an eighth of a mile in length which later formed a trench in places more than ten feet deep and averaging two or three feet in width. According to local residents this feature developed at the time of the 1918 San Jacinto earthquake (Engel, 1959, p. 52).

46.1 State Park turnoff. The broad valley to the right is underlain by Silverado Formation.

46.9 Junction with Highway 74. Low hills ahead and to left are underlain mostly by rocks presumed to be equivalent to Bedford Canyon Formation. To the right on the west side of the low hills is trace of the Glen Ivy fault.

48.1 Turnoff to downtown Elsinore and San Juan Capistrano.

48.4 Boulders of dioritic rock to left.

48.8 Hills straight ahead on skyline are at the northern end of the Paloma Valley ring-complex.

50.0 Railroad Canyon Road. At this point the San Jacinto River enters the Elsinore

Valley (trough) from the Perris block. The Elsinore trough here constitutes a closed depression and is filled by ephemeral Lake Elsinore. In historic times only during a few prolonged periods of wet years, the last being 1916-17, has the lake overflowed entering Temescal Wash which drains northward to Santa Ana Canyon and ultimately the Pacific Ocean. A recent gravity investigation indicates the valley to be underlain by four to 8,000 feet of sediments (Ghaeni, 1967).

51.0 Road cuts in old dissected alluvial fan.

51.8 To the right in the Elsinore trough is a low hill, Rome Hill, which is bounded on both sides by faults of the Elsinore fault zone. The fault on the north is generally termed the Wildomar fault, the fault to the west, the Willard fault, the frontal fault of the Santa Ana Range in this area.

53.1 Turn left onto Bundy Canyon Road. On the skyline to the northeast is a contact between San Marcos Gabbro to the right, which constitutes the interior rock of the Paloma Valley ring-complex, and granodiorite to the left, which is the outer part of the Paloma Valley ring-complex. Immediate hills on both sides of the road are granodiorite of the Paloma Valley ring-complex which contain blocks of gabbro. This composite ring-complex consists of an older, singular ring-dike, with two subsidiary shorter-arc inner dikes; and a younger set of thin, shorter-arced dikes, largely inside the older ring-dike. The older ring-dike is granodiorite (Woodson Mountain Granodiorite of Larsen, 1948), has nearly vertical walls, and is elliptical in plan with its long axis (nine miles) oriented west-northwest. This dike was emplaced in, and contains numerous inclusions of, gabbro. Largely within the older ring-dike are more than 200 younger, shorter-arced dikes, half a foot to three feet thick. These dikes, of granitic composition, define a ring-structure which cuts older-dike rock as well as gabbro. The structure is of a classical form with moderately- to steeply-dipping margins and a horizontal center. Spatially associated with the younger dikes are a number of bodies of fine-grained granophyre. The older ring-dike appears to have resulted from vertical ring-fracturing and emplacement by magmatic stopping. Granitic magma was emplaced along a younger set of domal ring-fractures. Granophyre resulted from "pressure quenching" of part of the magma which formed the younger ring-dike (after Morton and Baird, 1971).

53.7 Decomposed granite quarry with gabbro blocks within granodiorite.

54.0 Contact of the inner side of the ring-dike (granodiorite to gabbro).

54.5 Hills ahead and to right are underlain by gabbro which is intruded by granitic dikes which form an annular pattern.

55.0 Bundy Canyon Road reaches the Perris surface. The red-brown soil is characteristic of decomposed gabbro.

55.5 Granitic dikes of the ring-dike in gabbro.

55.8 To the north is the contact between gabbro and older ring-dike rock.

56.0 To the north (left) is an exposure of a finger of metamorphic rock which interrupts the otherwise continuous outer ring-dike. Note that the metamorphic rock weathers similarly to the gabbro giving rise to smooth slopes devoid of prominent outcrops.

56.6 Road cut in San Marcos Gabbro.

57.3 At this point contact between gabbro and outer ring-dike rock is just north of the road.

57.5 Intersection with Murietta Road. Exposed in road cut to left is migmatitic rock consisting of gabbro partly digested by ring-dike rock. This is essentially at the contact of the gabbro and ring-dike.

57.8 Bundy Canyon Road crosses back into the ring-dike (granodiorite) which here strikes northwest. Hill on skyline to the south (right) is at the structural center of the ring-dike complex. Top of hill is a body of granophyre.

58.1 **Stop 3:** Road cut in weathered San Marcos Gabbro with kernels of fresh rock.

59.8 Intersection with US 395. Continue straight across and continue east on Scott Road.

59.9 Boulders of ring-dike rock protrude above valley floor (Paloma surface of Woodford *et al.*, 1971).

60.6 Northeast end of Paloma ring-dike complex.

61.8 **Stop 4:** Intersection of Scott Road and Briggs Road. The road cut is in phyllitic quartz-rich metamorphic rock correlated with Bedford Canyon Formation. Hills to the left, underlain by phyllite and slate, contain a few gold-bearing quartz veins. Small building at the base of the hill is the Leon gold mine.

62.3 Hills to right are underlain by San Marcos Gabbro.

63.0 Road crosses contact between San Marcos Gabbro and granodiorite of the Domenigoni Valley pluton. The discontinuously exposed Domenigoni Valley pluton is elliptical in plan (4 x 8 miles) and oriented slightly west of north; similar rock occurs west of the pluton. The pluton invades country rock of the Bedford Canyon and French Valley Formations. The pluton, partly discordant and partly concordant, is composed of homogeneous appearing granodiorite-quartz diorite. In all but its southernmost part the plutonic rock is massive,and contains abundant unoriented inclusions. In its southernmost part the pluton is faintly foliated and contains inclusions parallel to the margin of the pluton. Two relatively consistent, steeply-dipping joint sets are present; one strikes northeast, the other northwest. A dike swarm, principally of quartz latite composition, occurs in the northwest-striking joint set. Most of the dike rock is porphyritic with a foliated structure and with a lineation produced by micaceous streaks and oriented hornblende and plagioclase crystals, on S-surfaces of the foliated rock. This lineation is strikingly consistent in orientation; it trends southeast and plunges at moderate angles to the southeast. Field evidence suggests most of the pluton was passively emplaced. Movement within quartz latite dikes after they were largely crystallized produced cataclastic texture (after Morton, unpublished mapping, 1970).

64.4 To the left is outcrop of resistant foliated quartz latite dike rock in granodiorite.

64.8 Hills on skyline to east are underlain by metasedimentary rocks of the French Valley Formation (Schwarcz, 1969).

65.0 Intersection with Winchester Road. Turn left.

65.8 Skyline to west and north is underlain by Domenigoni Valley pluton rock cut by abundant foliated quartz latite dikes.

67.0 Ahead and to left are wall-like masses of resistant quartz latite.

67.6 **Stop 5:** Road cut affords excellent exposure of granodiorite cut by foliated quartz latite dikes.

67.8 To right at base of low hills is seen the contact between the pluton and the French Valley Formation.

68.4 Road cut shows typical rock of the pluton with abundant unoriented equidimensional dark inclusions.

68.6 To the east on the far hillside is the open pit working of the old Winchester magnesite mine developed in a metaserpentine body.

68.8 Hills on skyline ahead are underlain by French Valley Formation and cut by granitic dikes. To the northwest is the contact between the Domenigoni pluton to the west, and French Valley Formation rocks to the east.

69.6 Downtown Winchester.

70.3 **Stop 6:** Cordierite-bearing biotite schist of the French Valley Formation.

71.1 Hills to right are underlain by San Marcos Gabbro which is here primarily olivine gabbro. Bouldery hills straight ahead are part of the Lakeview Mountains pluton.

71.8 Low hills to right are quartz diorite and migmatitic quartz dioritic rock that surround the Lakeview Mountains pluton.

72.2 Intersection with Highway 74. Turn left.

72.6 Workings on hill to right are feldspar-quartz prospects in pegmatite dikes in the Lakeview Mountains pluton.

73.0 Road cuts in foliated quartz dioritic rock.

73.5 **Stop 7:** Exposures of foliated quartz dioritic and migmatitic rock.

74.5 Turn right onto Juniper Flats Road.

75.1 Cross contact between foliated quartz dioritic rock and Lakeview Mountains pluton.

75.6 **Stop 8:** Outcrops to left contain abundant schlieren which are characteristic of rock of the Lakeview Mountains pluton. This pluton is a steep-walled body tear-shaped in ground plan, exposed discontinuously over an area of 60-80 square miles. Located at an abrupt local deflection of the northwest-striking regional grain, it is concordant with the enclosing rocks, which consist of varied granitic and mixed granitic-metamorphic rocks. The pluton is almost entirely coarse-grained hornblende-biotite-quartz diorite that lacks potassium feldspar. Schlieren are ubiquitous, as are lenticular inclusions, which parallel the schlieren. Schlieren, which impart to the rock an extreme small-scale mineralogic heterogeneity, geometrically fall into three orientation groups with the most pronounced concordant to the outline of the body. The other two groups, which are discordant, strike northwest and northeast. Granitic pegmatite dikes, hypersthene gabbro masses, and both mafic and leucocratic quartz diorite are concentrated in the geometrically and structurally deduced center of the pluton. It is believed the pluton was emplaced forcefully producing the deflection in the regional grain. The pegmatite dikes represent the fugitive constituents of the pluton-forming magma and their concentation in the center of the pluton marks the last part of the pluton to crystallize. An extensive chemical study shows the pluton is highly homogeneous on a large scale and extremely heterogeneous on a small scale. However, a weak, but consistent, zonational chemical pattern parallels the walls of the pluton. This zonation shows the pluton has a relatively basic and dense core and implies the last rock to crystallize was more basic than rock formed earlier (after Morton, 1969; Morton *et al.,* 1969).

75.9 Quarry in partly decomposed quartz diorite. Note the numerous schlieren.

76.5 Road reaches the 2,100 ft. Lakeview-Gavilan surface.

76.9 Thin veneer of gray bedded sediments on Lakeview-Gavilan surface.

77.8 Turn left.

78.0 Flat skyline to west and east are remnants of a 2,500 foot surface (Magee surface of Woodford *et al.,* 1971). To the north is seen a continuation of the Lakeview-Gavilan surface.

78.2 Road cut in typical rock of the pluton with abundant schlieren. Northward towards the center of the pluton granitic pegmatite dikes become common to abundant.

79.3 To the northeast is a good view of the Lakeview-Gavilan surface.

80.1 Road cut in old red alluvium.

81.4 Low hills on skyline straight ahead are the northwest part of the Lakeview Mountains pluton. Higher hills, Bernasconi Hills, are underlain by a variety of granitic rock and schist.

81.9 Turn right onto Hansen Avenue.

84.0 Community of Lakeview. Turn right onto Ramona Expressway.

84.2 Hill to the left is schist of unknown age intruded by quartz diorite. Straight ahead the higher hills are mostly metamorphic rock and the lower hills, the San Timoteo Badlands, Pliocene-Pleistocene sediments. The San Jacinto fault bounds these hills on the southwest.

86.7 In the small canyon to the south is located the contact between the Lakeview Mountains pluton to the west and foliated granitic rocks to the east.

88.0 Line of cottonwood trees to the left marks the Casa Loma fault. An 8,000-foot deep sediment-filled graben is located between the Casa Loma fault and the San Jacinto fault (Fett, 1968).

89.0 Low hill to the left, Casa Loma Hill, is a tectonically produced feature along the Casa Loma fault (Proctor, 1962).

89.5 Road crosses Casa Loma fault scarp.

89.8 West side of the high hills ahead is the modified fault scarp of the San Jacinto fault. These hills are covered by extensive landslide deposits.

91.2 Turn left onto Sanderson Avenue.

92.1 San Jacinto River.

92.9 Road crosses San Jacinto fault. Note fault scarp which produced southwest-facing break-in-slope in alluvium to northwest.

93.1 The road crosses the Gilman Springs Road. Continue straight ahead on Highway 79 (Lamb Canyon Road) entering the Badlands.

93.2 Road cut in coarse clastic red beds of Pliocene age.

93.9 **Stop 9:** Road cut affords excellent view of a minor reverse fault. Here schist of unknown age has been thrust over Pliocene red beds.

94.0 Depositional contact of red beds over gneiss. The road for a short distance to the north skirts this depositional contact.

94.3 Road cut in schist.

94.7 **Stop 10:** To the right is schist and marble of unknown age. Just north of the road is a depositional contact between these rocks and Pliocene sediments. The Pliocene sediments contain lenticular beds of monolithologic conglomerate with clasts of quartz diorite as much as 20 feet in diameter.

95.1 To left are beds of boulder conglomerate.

95.4 Prominent red bed to the left is the approximate top of the red beds in this sequence. Above this marker unit gray to tan, finer grained clastic rocks predominate.

97.0 Bouldery hill to the north is quartz diorite. Lithologically it is the same as the clasts in the conglomerate to the south and may have been the source for the clasts.

97.7 Contact between sediments and quartz diorite.

97.9 Contact between quartz diorite and sediments.

98.4 Contact between Pliocene-Pleistocene sediments and Pleistocene red alluvium.

98.8 Road cut in red alluvium. Straight ahead on the skyline is San Gorgonio Peak—high point of the San Bernardino Mountains, 11,502 feet.

99.7 Southern Pacific Railroad and the town of Beaumont.

99.9 Left turn onto Interstate Highway 10 towards Los Angeles. Enter left lanes to take Highway 60 to Riverside.

100.7 Take Highway 60 west towards Riverside.

102.3 Road cuts in red alluvium.

103.1 Road crosses contact back into Pleistocene sediments.

103.4 Jack Rabbit Trail turnoff.

103.8 Terrace deposits to the right are of old red alluvium.

104.5 Recent terraces to the right have been cut by San Timoteo stream.

105.2 Re-enter San Timoteo Badlands. Highway is essentially normal to the length of the Badlands and predominant structure which, in a gross form, is a northwest-trending anticline.

106.2 Eastward-dipping coarse clastic Pliocene-Pleistocene sediments.

107.7 Westward-dipping Pliocene-Pleistocene sediments on the south flank of the anticline.

109.4 Hemet—San Jacinto turnoff.

110.1 Highway crosses San Jacinto fault.

110.4 Smooth-topped hills to the northwest are underlain by quartz diorite and separated from the Badlands to the east by the San Jacinto fault.

115.0 To the northeast is Pigeon Pass Valley. Exposed on both sides are rocks of the Box Springs complex. Note the eastward dip of the rocks on the west side of the valley and the westward dip of the rocks on the east side.

119.2 San Diego turnoff onto US 395.

119.5 Junction with US 395.

122.6 University Avenue turnoff. Bear to the right to return to Ramada Inn.

123.8 Parking Lot, Ramada Inn, Riverside. End of trip.

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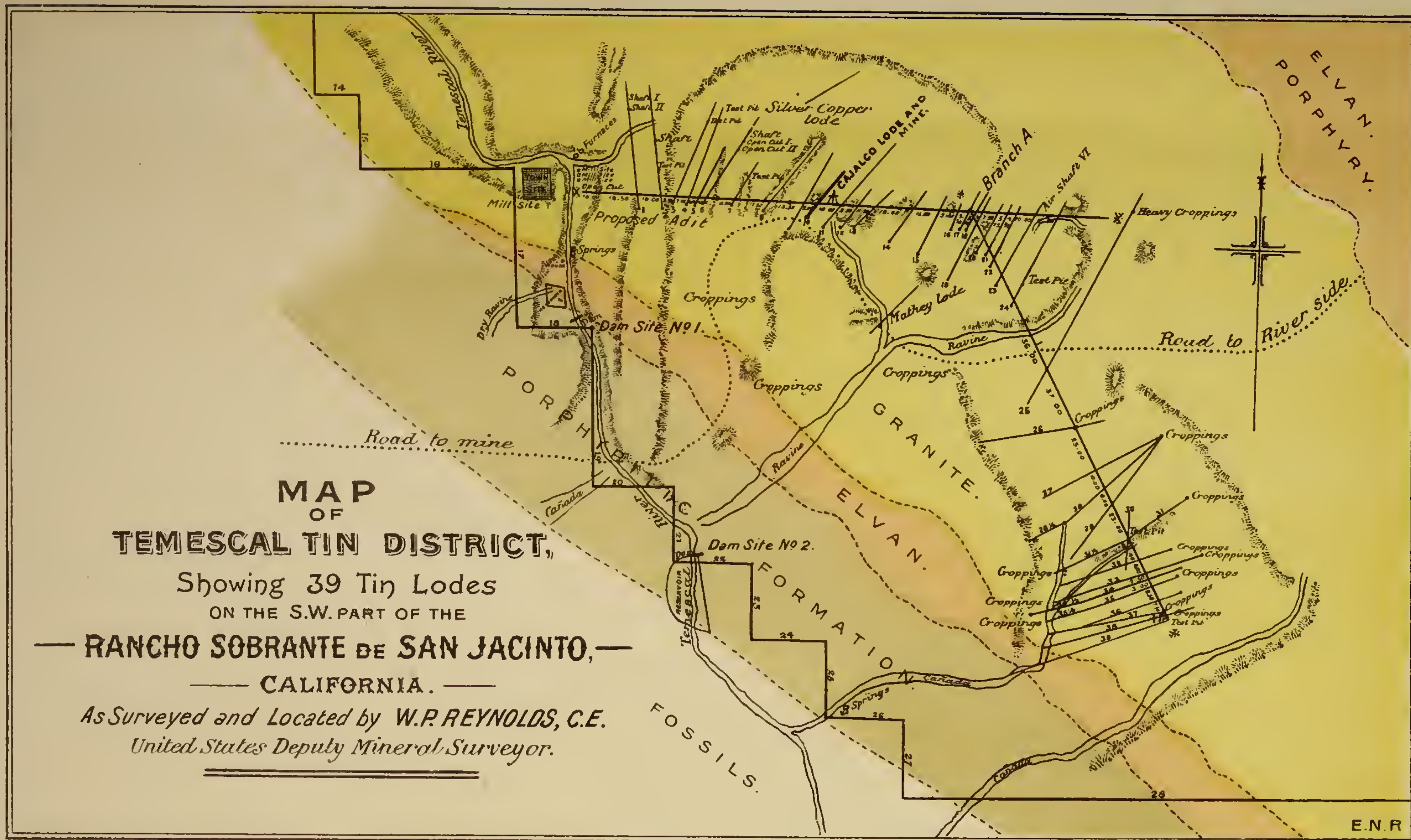
MAP
OF
TEMESCAL TIN DISTRICT,
Showing 39 Tin Lodes
ON THE S.W. PART OF THE
— RANCHO SOBRANTE DE SAN JACINTO, —
— CALIFORNIA. —
As Surveyed and Located by W.P. REYNOLDS, C.E.
United States Deputy Mineral Surveyor.
ELVAN. PORPHYRY.
Silver Copper lode
CAJALCO LODE AND MINE.
Branch A.
Heavy Croppings
Proposed Adit
Mill Site
Springs
Croppings
Mathey Lode
Test Pit
Dam Site No 1.
Road to River side.
Ravine
GRANITE.
ELVAN.
Road to mine
PORPHYRITIC
FORMATION
Dam Site No 2.
Temescal River
Cañada
FOSSILS.
E.N.R

Map D