

THE
STRUCTURAL
AND
INDUSTRIAL
MATERIALS
OF
CALIFORNIA

ISSUED BY THE
CALIFORNIA STATE
MINING BUREAU

LEWIS E. AUBURY
STATE MINERALOGIST



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STATE MINERALOGIST.

RELIEF MAP

OF

CALIFORNIA

BY

N. F. DRAKE

DEPARTMENT OF GEOLOGY, LELAND STANFORD JR. UNIVERSITY

Accompanying Bulletin No. 38

Structural and Industrial Materials of California.

ISSUED BY THE

STATE MINING BUREAU

FERRY BUILDING,

SAN FRANCISCO.



LEWIS E. AUBURY,

State Mineralogist.

1905.



PACIFIC OCEAN

RELIEF MAP

CLAY COUNTY



1891

W. H. HARRIS

AMERICAN

Geographical Institute

9

САМЪ РИЛЕНЪ

АЛМСОФИЛА

ИЗДАНИЕ ПЕРВОЕ

ВЪ ПЕЧАТНІИ ДРУЖЕСТВА

ВЪ МОСКВѢ ВЪ ПЕЧАТНІИ ДРУЖЕСТВА

САНКТИИ

1861

ДАВАНІЕ СВИДѢТЕЛЬСТВЪ

О СЛУЖБѢ

ОБЪЯВЛЕНІЕ

ОБЪЯВЛЕНІЕ

ОБЪЯВЛЕНІЕ

ОБЪЯВЛЕНІЕ

1861





ILL No. 1. COMPOSITE ARCH, CONSTRUCTED OF CALIFORNIA GRANITE, SANDSTONE, MARBLE, TERRA COTTA, SLATE, TILING, PRESSED AND GLAZED BRICK, AT THE ST. LOUIS EXPOSITION, UNDER THE DIRECTION OF LEWIS E. AUBURY, STATE MINERALOGIST.

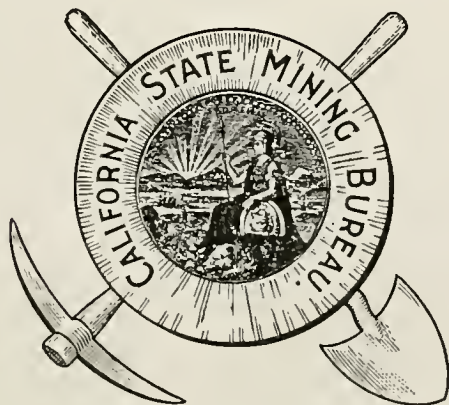
BULLETIN No. 38.

SAN FRANCISCO, JANUARY, 1906.

THE
STRUCTURAL AND INDUSTRIAL MATERIALS
OF CALIFORNIA.

ISSUED BY THE
CALIFORNIA STATE MINING BUREAU,
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UNDER THE DIRECTION OF
LEWIS E. AUBURY, State Mineralogist.



W. W. SHANNON, SUPERINTENDENT STATE PRINTING, SACRAMENTO.

1906

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LETTER OF TRANSMITTAL.

SAN FRANCISCO, January 2, 1906.

To HON. GEORGE C. PARDEE, Governor of the State of California, and to the Honorable Board of Trustees of the State Mining Bureau,

GENTLEMEN: I have the honor to transmit the work of the State Mining Bureau in the investigation of the Structural and Industrial Materials of California, as incorporated in Bulletin No. 38 of this department, and which have not been fully reported upon in previous bulletins, named below and issued under my direction.

For information on mineral substances not herein noted, and which might be classed as industrial materials, references are made particularly to the following bulletins issued by the State Mining Bureau: Bulletin No. 23, "Copper Resources of California"; Bulletin No. 24, "Saline Deposits of California"; Bulletin No. 27, "Quicksilver Resources of California"; Bulletin No. 32, "Production and Use of California Petroleum"; Bulletin No. 37, "Gems and Jewelers' Materials and Ornamental Stones of California."

It was considered advisable to issue the bulletin at this time, owing to the rapid increase in building operations in California within the past few years. The great demand for building stones, marble, clay products, etc., together with the phenomenal strides made in the various industrial pursuits, which are to a very great extent dependent upon the mineral industry of this State, has created a demand for an official bulletin wherein would be found a description not only of the developed but also of the undeveloped mineral resources of the State, on which this bulletin treats.

The field work was commenced on this bulletin in July, 1904, and it has been carried on as rapidly as conditions would permit. The investigation of the subjects contained in the publication has extended over large areas, as all counties in California, with one or two exceptions,

produce or contain structural or industrial materials in commercial quantities.

California offers exceptional opportunities to the investor, particularly in the many mineral substances of economic importance. A large percentage of these materials is imported from other states or foreign countries, even though the raw materials are here, not only in abundance, but in many cases of superior quality, and only awaiting the capital necessary to develop them.

In this bulletin it may be found that there are omissions, and lack of descriptions of some mines or quarries. Wherever practicable, mines or quarries were visited by a field assistant, but in some instances they were found to be closed down, with no one in charge at the time of the visit of the field assistant. In such cases, it was impossible to secure necessary data or any information as to the name of owner, address, etc.

Employed as field assistants in the work of collecting data for this bulletin were Mr. William Forstner, Prof. T. C. Hopkins, Mr. C. Naramore, and Mr. L. H. Eddy.

Many courtesies were extended to the field assistants by the owners of the different mines and quarries, and much assistance was rendered generally by persons interested in California's mineral development. To this large number of persons who extended information and courtesies to the field assistants, and to those who aided in this work, I herewith wish to extend the thanks of this department.

Very respectfully,

LEWIS E. AUBURY,
State Mineralogist.

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STRUCTURAL AND INDUSTRIAL MATERIALS OF CALIFORNIA.

PART I.

BUILDING STONES.

GENERAL ECONOMIC FEATURES OF THE BUILDING STONES OF CALIFORNIA.

INTRODUCTORY.

California has now reached a period in her history when the building-stone resources of the State have greater economic importance than ever before. In the period of the first settlement in any country the demand is for cheap building material, and especially for one that can be handled rapidly and will facilitate the quick construction of buildings. After the first mushroom growth, industries and settlements begin to take on an air of stability and permanence, due to the establishment of settled industries, such as agriculture, manufactures, and mining; wealth begins to accumulate in cities, and in the hands of capitalists; then a desire arises for buildings, both private and public, which show stability, durability, architectural skill, and beauty. Each year finds additional inquiries for good building and ornamental stones of different kinds.

That there is a great wealth of valuable stone in California has been known for many years. It is equally well known that much of it is still undeveloped, a very considerable portion of the building and ornamental stones used in California being imported from other states and from European countries. It is the object of this Bulletin to give such particulars as could be obtained concerning this very important one of the resources of the State.

USES OF STONE.

Stone is used in substructures almost universally. Wood, brick, and iron are frequently used as a substitute in superstructures, but whatever may be the material used in the upper building, stone is almost always used for the foundation and basement. In superstructures where first cost can be subordinated to architectural effect, stone will in most cases be used.

For monuments there is no satisfactory substitute for stone. For this purpose the stone is often shipped long distances, in order to get one that has an established reputation. Many of the monuments in this State are of stone from New England, Indiana, Georgia, or Europe, and often a large part of the cost of the monument is in railroad or steamship transportation charges. One of the objects of this Bulletin is to show where good stone for monuments, architectural, and other uses can be obtained in this State.

Some of the other uses of stone are in the construction of breakwaters, bridge abutments, culverts, curbing, fences, flagstone, hitching posts, macadamizing, paving blocks, piers, retaining walls, reservoirs, sewers, sluiceways, etc.

CLASSIFICATION OF BUILDING STONES.

Rocks are commonly divided into two, sometimes three, great classes: the unstratified, or igneous; the stratified, or sedimentary.

The first class may be subdivided into the granitic or crystalline rocks, and the volcanic or glassy and stony rocks. The granitic class includes granite, syenite, etc.; the volcanic class includes basalt, trachyte, tuff, etc.

The sedimentary rocks include those formed in water, such as sandstone, limestone, etc.

The third class includes the metamorphosed forms of the other two classes. They may be formed from the igneous rocks, as gneiss, some of the schists, serpentine, and talc; or from the sedimentary rocks, such as marble, which is metamorphosed limestone; quartzite, which is metamorphosed sandstone; or slate, which is metamorphosed clay or shale.

KINDS OF BUILDING STONES IN CALIFORNIA.

Nearly all of these classes of building and ornamental stones occur in California, as will be seen in the following pages.

Granite is quarried in the following counties: Los Angeles, Madera, Nevada, Placer, Riverside, Sacramento, San Bernardino, San Diego, Tuolumne, and Tulare. Undeveloped masses of it occur in other counties.

Limestone is quarried in Amador, Calaveras, Colusa, Napa, Santa Barbara, Butte, El Dorado, Contra Costa, Los Angeles, Kern, Mono,

Monterey, Placer, Riverside, San Bernardino, Inyo, Santa Cruz, Santa Clara, Shasta, Sonoma, and Tuolumne counties.

Marble is quarried in Amador, Riverside, San Bernardino, Inyo, and Tuolumne counties.

Sandstone quarries are in operation in Colusa, Los Angeles, Santa Barbara, Santa Clara, Ventura, and Yolo counties.

Slate is quarried in El Dorado County, but occurs in several other counties.

Serpentine occurs in a great many counties in large quantities, but has been quarried only on a small scale in a few places. It is quarried on Santa Catalina Island, and as Verde Antique in San Bernardino County.

Rubble and broken stone for macadam are quarried in a score or more counties.

Porphyry is quarried for building stone at San Luis Obispo.

Volcanic Tuff is quarried at several places in Calaveras, Napa, San Luis Obispo, and Sonoma counties.

REFERENCES ON CALIFORNIA BUILDING STONES.

1. Tenth Census Report U. S., Vol. X, p. 279.
2. Mineral Resources U. S. 1893, p. 560.
3. Neues Jahrbuch für Min. N. S. W., 1887, Bnd. V., pp. 451-578.
4. Sixth Report of State Mineralogist, Pt. I, p. 16.
5. Seventh Report of State Mineralogist, p. 205.
6. Eighth Report of State Mineralogist, p. 885.
7. Ninth Report of State Mineralogist, pp. 53, 209, 224.
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9. Eleventh Report of State Mineralogist, p. 602.
10. Twelfth Report of State Mineralogist, pp. 379-411.
11. Thirteenth Report of State Mineralogist, pp. 612 et seq.
12. U. S. Geological Survey, Geological Atlas, Folio V.
13. Geological and Industrial Resources of California. By Philip T. Tyson. Baltimore, 1851.
14. Special Report U. S. Census Office, Mines and Quarries, 1902, pp. 180 et seq.

A short discussion of the general properties of building stones and some of their commercial features is here inserted before taking up the discussion of the different quarry regions of the State.

POINTS TO BE OBSERVED IN SELECTING A BUILDING STONE.

In selecting a building stone for any purpose, there are a number of different things to be considered, among the most important of which are (1) Adaptability, including the architectural effect; (2) Cost, and (3) Durability.

Adaptability is the point that is frequently overlooked or receives but hasty consideration in selecting a building stone. A stone that may be very desirable in certain places for certain uses is quite unsuitable for other uses in other places. The selection of the stone is largely a matter of taste, and as the selective taste is good or bad, so in large measure is the resulting structure. The stone should harmonize with its surroundings in its use, color, grain, and structure, as well as in the shape and size of the building.

Cost.—The principal items affecting the cost of a building stone are thickness of the bed, its position, the thickness and kind of material overlying the stone, the workability of the rock, remoteness of the quarry, and the transportation facilities. There are many other items, such as the price of labor, the cost of fuel, the equipment of the quarry, the skill in planning work, the climatic conditions, etc., that often materially affect the price of any given building stone.

The thickness of the overburden, the material of which it consists, the contour of the surface, and other local conditions affect the cost of the stripping. It is just as expensive to remove the waste from a thin bed as from a thick one. While it might not pay to remove 20 feet of waste from a bed of stone 5 or 10 feet in thickness, it might pay to do so from a bed from 50 to 100 feet thick. It also makes a difference whether there is scattered through the bed much waste material that must be thrown out in quarrying. In some quarries lack of uniformity (due to the presence of foreign material), change in color, or defect in structure means a corresponding increase in cost of quarrying, because of the expense in handling the defective or waste stone.

Having opened the quarry, the cost of removing the stone is often influenced greatly by the hardness, structure, grain, and rift of the stone, which properties are included under the general term "workability."

In many cases the principal item of cost in a building stone is that of transportation. It must be a very desirable stone that could be quarried with profit remote from railway or water transportation. It is frequently necessary to ship stone a long distance in order to get the kind required for a particular use; but the waste comes in when shipping from a distant country a stone of average quality, because it has been exploited and is well known, instead of using a stone from near-by deposits which is equally as good, or perhaps better, but which has not been developed.

The durability of a building stone, or its ability to withstand the action of weather and other agencies, is one of the most important properties to be considered in selecting a stone. No difference how pleasing the color, how cheaply it may be quarried, how small the

transportation charges, if the stone will not stand intact in the wall it is dear at any price. There are many different points to be considered in determining the durability of a certain stone. Too frequently the selection is made or not made on some point of minor importance, which, in some instances, leads to the selection of an inferior stone, and in other cases to the selection of a stone from a distant locality, which means an enormously high freight bill, when a good, or perhaps better, stone was near at hand and condemned on insufficient evidence.

The factors influencing durability may be divided into two classes: internal and external.

INTERNAL FACTORS AFFECTING THE DURABILITY OF A STONE.

The chemical composition, and more directly the mineral composition and texture, are important factors in the durability of a stone. Thus one with a high percentage of soluble substances, such as the alkalies, the haloids or sulphates, is not as promising as one without these substances.

It also makes a difference in what mineral forms the elements are combined. Thus, soda, combined with silica and alumina, in the fresh feldspars is quite a different substance from soda carbonate or chloride.

The texture is an important factor in the durability. Thus, a finely crystalline rock is likely to be more durable than one very coarsely crystalline. A finely porous stone will likely prove to be less durable than one which is not so porous, especially in a cold climate. A homogeneous texture will generally prove to be more durable than one that is coarse in one place and fine in another.

EXTERNAL CAUSES AFFECTING THE DURABILITY OF BUILDING STONES.

The external agencies affecting the durability are: (1) Temperature changes; (2) Chemical agencies; (3) Vegetation; (4) Abrasion; (5) Method of quarrying and dressing; (6) Seasoning; (7) Position in the wall.

(1) **Temperature Changes.**—The climatic and weather changes are among the most important agents in disintegration. Probably the most important of these is the action of frost, or the freezing of water, in the pores and cavities of the rock. Each ice crystal formed in the rock acts as a little wedge to push apart the grains or burst it asunder. This is a consideration that becomes of great importance in the mountainous districts of this State and in the more rigorous climates of northern and northeastern United States.

The expansive force of the heat of the sun is less conspicuous than the frost action, but it is a powerful agent of disintegration, everywhere active. The expansion caused by the heat of the sun on the surface while the interior of the stone remains cool produces a great differential strain on the surface layers both in the expansion under the heat and in the contraction from the cold at night or by the sudden cooling from a shower of rain. Rocks deficient in elasticity suffer the most in this way. In some instances it produces checking, or incipient cracks, on the surface: sometimes it causes chips to split off from the surface, and sometimes even splits asunder large masses. The expansion under the bright sun is said to be sufficient to cause a perceptible motion of such structures as the Bunker Hill and Washington monuments.

That frost is a more active agency of injury than sunshine is indicated by the obelisk known as Cleopatra's Needle, which was brought from Egypt to New York City. The stone that stood uninjured for many centuries in the dry, equable climate of Egypt began to crumble in a few years in New York by the frost splitting off chips from the surface of the stone.

(2) **Chemical Agencies.**—There are several more or less active chemical agencies in the atmosphere that are nearly as destructive as the frost and sunshine. They are more active in warm than in cold climates. The presence of moisture increases their activity. Water itself is a solvent of the materials in the ordinary building stone to such a very slight degree that it could be ignored except as a carrier to bring the more destructive agents into contact with the stone. The acids of the atmosphere, such as sulphuric, nitric, hydrochloric, and the less active but more abundant carbonic and organic acids, are all agents of disintegration, serious in proportion to their quantity. They are more abundant and hence more active in cities and manufacturing centers than elsewhere, due to the combustion of greater quantities of fuel. They are less active in a dry climate.

(3) **Vegetation.**—While vegetable growth may exercise a protective effect at times, it is likewise an active, though generally slow-acting agent of injury or destruction. The mosses and lichens that grow on the rock-surface gather dust and disfigure the wall. Both the living and decaying portions produce some vegetable acids, which act as corroding agents. The plants also catch and hold moisture, which acts as an agent of injury, as already described. It should be stated, however, that while the lichen growth may injure the stone on which it is growing, it is at the same time an indication of a durable stone, as the lichens and mosses do not ordinarily start to grow on an inferior or rapidly weathering stone.

(4) **Abrasion.**—The greatest wear on a building stone from the friction of feet and other agencies will be in walks, steps, and sills, and stones for such places should be selected with this in mind. A stone that might last indefinitely in the wall of a building might wear away rapidly in the steps.

Wind-blown sands and dust are very often important agencies of injury. These are generally most injurious in a dry, windy climate, such as the Basin region between the Rocky Mountains and the Sierras; but are often conspicuous elsewhere, as on the monuments and the fronts of many buildings in our large cities subject to the sweep of winds through the streets.

(5) **Methods of Quarrying and Dressing.**—The durability of a building stone may be very materially affected by the methods of quarrying and dressing. Thus, stone quarried by the careless use of powder in which it is subject to violent jars or explosions will be injured. Stone has a life which may be destroyed by the shock from heavy explosions, and the dead stone will crumble more rapidly than before. This inherent life or texture of the stone may be destroyed by heavy sledging or hammering, which loosens the grains and forms incipient cracks, in which moisture, frost, and other agents of destruction gain a foothold and hasten the disintegration. Sometimes the stone is quarried at the top of a hill or mountain, and intentionally or accidentally sent tumbling down the slope by force of gravity alone, in which operation the stone bounds from ledge to ledge, striking with terrific impact, and shattering it as badly as a powder explosion. Hence, the keynote to successful quarrying and dressing of stone is to avoid explosions, concussions, and jars that will injure the grain or life of the stone.

(6) **Time of Quarrying.**—It is pretty generally recognized that building stones, like lumber, should be seasoned before being placed in the wall. The necessity for seasoning is greater with some rocks than with others, and greater in some climates. In a rigorous climate no building stone should be quarried in the winter or late fall. The reason for the need of greater care in cold climates is the liability to injury from frost. All freshly quarried (green) stone contains some water, known as quarry sap, or quarry water, similar in many ways to the sap in timber, which when once evaporated can never be replaced. The green stone is softer, weaker, and more susceptible to injury than the seasoned stone, hence the desirability of getting rid of the greater part of this quarry sap before the stone is subject to freezing or to heavy strains in the building. Many of the fragmental stones are so soft and friable in the green state that they lack the strength to support the overlying material in the wall, but after seasoning they are quite firm and strong. Such stones should be dressed ready for the wall when first quarried,

while they are soft and easily cut, but should be well seasoned before being placed in the wall, unless it be a very mild climate, where the seasoning may be done in the wall.

(7) **Position in the Wall.**—Stratified rocks should be placed in the wall in their natural position, that is, with the lamination or bedding planes horizontal. Stone in this position will withstand the action of the weather and crushing forces much better than the same stone on edge. The effect of this principle is shown in many sandstone buildings, notably the brownstone fronts of our Eastern cities.

METHODS OF ASCERTAINING THE DURABILITY.

(1) **Observation.**—Careful study of a building stone on the outcrop, in the quarry, and in the buildings and monuments where it has been used, is probably the best means of ascertaining its durability. In a new country or with an undeveloped stone there would be no opportunity to study the stone in buildings or monuments, and observations on the outcrop become all the more important. Some experience and good judgment, combined with some knowledge of minerals and the principles of geology, are necessary to interpret what may be seen on the outcrop. It involves so many and varied local conditions that no very specific directions can be given for the guidance of the inexperienced, and almost any general rules might lead to mistakes if interpreted too literally.

To the experienced eye a study of the outcrop often shows the uniformity, or lack of it, in the color, texture, and structure of the stone. It also indicates the possible changes of color which the stone is likely to undergo in the wall. The relative durability of the stone is indicated by its influence on the topographic relief. Cross-grain, lamination, unequal disintegration, and presence of clay or other deleterious substances are some of the other points shown by a study of the outcrop.

In the observation of buildings and monuments care is necessary to avoid wrong conclusions about the strength and durability of a building stone. If the stone has been injured in the quarrying or dressing, as indicated above, or wrongly placed in the wall, it may appear to have rapidly deteriorated from exposure, while the fault was in the handling. Likewise, care in selection may not have been used, and the stone may have been badly injured when first placed in the wall. If the stone has been quarried, dressed, selected with care, and properly placed in the wall, then the effect of time on it after many years is one of the best and most rigid tests that can be applied to any building stone.

(2) **Laboratory Tests.**—Some of the laboratory tests which are more or less helpful in determining the durability and strength of a stone are the chemical analysis, microscopical examination, specific gravity, absorption, acid, freezing, and crushing tests.

Chemical analysis indicates whether or not there are soluble constituents in the rock. The microscopical examination, which is much more useful, indicates not only the elements of the rock, but also the separate minerals which compose it. It also shows the condition of the minerals, whether fresh or partly disintegrated, and the texture of the rock, whether the minerals are interlocked in a manner that is productive of strength. The microscopic examination, if properly interpreted, often proves more serviceable than any other laboratory test.

The specific gravity and porosity tests, if properly made and interpreted in the light of other tests, may prove very helpful. There are several ways in which the specific gravity may be determined, with different results in each case, which must be taken into account in making comparisons between the different stones. The porosity is a more important factor in cold climates, as the stone which absorbs and holds much water is more liable to injury from frost than a non-absorbent stone, or one that dries quickly. To ascertain the strength of a stone in resisting the action of frost, the attempt is made to subject a sample to repeated freezings and thawings in the presence of moisture. A modification of this test is sometimes made with a saturated solution of some salt, like sodium sulphate, which will crystallize in the pores of the rock and exercise an action similar to that of frost.

(3) **Crushing and Transverse Tests.**—One of the most common laboratory tests is the crushing of a small cube, and measuring the force necessary to crush it. The result is generally given in the number of pounds pressure per square inch of surface necessary to destroy the stone. Nearly all the rocks are much stronger than required by any stress ordinarily placed upon them in any common building. It is only in such extraordinary structures as the Washington monument that actual danger from crushing is at all imminent; but if the result of the test is properly interpreted in the light of the chemical analysis and other examinations, it is helpful as indicating the strength of the rock and the uniformity of texture, or the lack of it.

The transverse test gives a clew to the relative value of the stone for lintels, jambs, water tables, etc., where it will be subject to transverse strains.

The modulus of elasticity, if properly determined, gives a clew to the strength of the stone in resisting the extremes of heat and cold.

ARTIFICIAL PRESERVATIVES.

Where a stone is found to be giving way, various devices have been tried and substances used to protect the surface from further decay. The principle underlying most of these attempts is to waterproof the stone, or to put something on the surface which will prevent moisture from penetrating the pores. Paint has been used, but it is very objectionable from an artistic standpoint, as it destroys and mars the grain and natural beauty of the stone. Paraffine has been used with some success, as it does not entirely destroy the natural texture and luster of the stone, although it does mar it to some extent. Another process that has met with some success is the use of water glass, or an alkaline silicate in solution, followed by a solution of some salt like aluminium chloride, which forms an insoluble silicate in the pores of the stone. It gives the stone a glassy luster, which detracts from its value, and it is too expensive. In foundations and substructures the rock is often coated with asphalt or tar to protect it from moisture, but as yet no very satisfactory process has been found for protecting the stone in superstructures—a process that is not too expensive and does not disfigure nor mar the beauty of the stone.

THE SELECTION OF A QUARRY SITE.

In selecting a site for opening a quarry the following points should be considered:

(1) **The Overburden or Waste Material to be Removed.**—In a rolling or hilly country the stone to be quarried will generally outcrop in many places under different thicknesses of overlying material. The removal of the waste is expensive, whether it be soil, disintegrated or fresh rock, and the aim should be to avoid as much expense of this kind as possible; but in doing so care is necessary not to incur a still greater expense, since a layer of soil or clay overlying a quarry stone protects it in part from disintegrating agencies so that practically all of the bed, after the removal of the overburden, is available for dimension stone, while the portion of the ledge not so protected may be so injured by the weather, either by discoloration or partial disintegration, that a large part of it must be discarded. Hence, where there is little or no overburden it is advisable to note carefully the condition of the rock before selecting it.

(2) **The Drainage.**—Frequently the removal of water from a quarry is a great expense that might have been avoided with proper care in selecting the opening where there would be natural drainage.

(3) **The Disposition of the Waste and Ease of Quarrying.**—The outcrop on a cliff, for instance, already has one side free, and hence there will

be much less expense in removing the stone than on a flat area, where the quarry must be sunk down through the solid bed, and where the first blocks, inclosed on all sides, are difficult to remove. The waste material in the latter case must be carted far away, or it will have to be moved again on extending the quarry, while the quarry on the cliff may dispose of its waste by dumping it over the cliff, where it is disposed of cheaply and for all time.

(4) **Transportation.**—The cost of transportation of stone, great enough at best, may be greatly increased by a lack of discretion in selecting the quarry site. The site should not only be near the railway or water-way, but care should be taken to avoid up-grades wherever possible.

GRANITE.

The term "granite" is used in the stone trade, ordinarily, to include all the massive crystalline igneous rocks, which the petrographer subdivides into several different classes and sub-classes. Sometimes the term is used to include the volcanic and intrusive rocks as well. The other crystalline igneous rocks are syenite, diorite, diabase, gabbro, and peridotite. The true granite is a crystalline rock, containing more than 65 per cent of silica, and is composed of quartz and orthoclase feldspar, with generally some plagioclase and biotite, muscovite, hornblende, or augite, one or more of them, and frequently smaller quantities of one or more of the following: apatite, zircon, tourmaline, garnet, sphene, magnetite, and pyrite. The materials in the last list, except tourmaline and garnet, are generally present only in microscopic crystals, and ordinarily do not greatly affect the value or use of the stone. Pyrite is sometimes present in sufficient quantities to discolor the stone on exposure to the weather, and occasionally in sufficient quantities to be an element of weakness.

The strength and durability of the granite are dependent upon the size and arrangement of the crystals, the relative amounts of the different minerals, and the state of their preservation. If the minerals have undergone incipient decay, they will not be as strong nor last as long as fresh minerals. Large crystals, or large quantities of biotite, in a rock will prove to be a factor of weakness. The close interlocking of medium-sized feldspar crystals which inclose the quartz in the interspaces gives the texture desirable for a good building granite.

The orthoclase feldspar and the quartz alone form the graphic granite or pegmatite (sometimes called binary granite), which commonly occurs in vein-like bands, from a few inches to many feet in width, in the

midst of other rocks, and which may locally be much enriched with other minerals such as tourmaline, garnet, or mica. It is quite common in San Diego County.

Most of the granites of California that are used for building stone are true granites. At Penryn, a gabbro is quarried in small quantities, and the stone at Rocklin has been classed as a granodiorite.

METHOD OF QUARRYING AND DRESSING THE GRANITE.

In the smaller quarries the drilling is done by hand, but in most of the larger ones steam or electric drills are used. In many of the quarries the blocks are loosened from the bed by driving wedges, plugs, or feathers in the drill holes. In some of the quarries the Knox* blasting system is used, and in some the rocks are blasted without any system.

The Raymond Granite Company uses a quarry bar to cut out the ends of the quarry. In many of the granite quarries in the Eastern States channeling machines are used for this purpose.

In the smaller quarries the stone is dressed by hand, by means of hammer and chisels and the bush hammer. In the larger quarries this part of the work is facilitated by machinery. Rock planers, polishing machines, surfacing machines, and pneumatic surfacing tools are in quite general use at the largest quarries. Lathes are used also for turning and polishing columns, pillars, and round monuments.

PRODUCTION OF GRANITE IN CALIFORNIA IN 1904, USED FOR BUILDING AND MONUMENT STONE.

	Cubic Feet.	Value.
Madera County.....	113,627	\$93,083
Nevada County.....	2,335	5,395
Placer County.....	84,796	110,371
Riverside County.....	250,055	195,364
Sacramento County.....	5,164	4,458
San Bernardino County.....	250	250
San Diego County.....	7,760	7,851
Tulare County.....	7,000	16,000
Tuolumne County.....	9,700	9,700
Total.....	480,687	\$447,472

Besides this there was produced \$1,388,961 worth of rubble and paving blocks, which is nearly all of igneous rocks, mostly granite, with some basalt, etc.

*The Knox blasting system (patent) consists of drilling an oval-shaped hole, elongated in the direction of the desired break, and putting in a small quantity of black powder, leaving an air space between the powder and the covering. The expansion of the air on the explosion of the powder acts as a great force to split the rock.



ILL. No. 2. RAYMOND GRANITE QUARRY, MADERA COUNTY.
Showing use of quarry bar.



ILL. No. 3. VIEW OF STONE PLANER, BLY BROS.' STONE COMPANY, LOS ANGELES.

According to the mineral resources of the United States, published by the U. S. Geological Survey for 1902, California stood sixth in the list of granite-producing states.

GRANITE PRODUCED IN THE UNITED STATES IN 1902.

New Jersey.....	\$753,005
Massachusetts.....	427,035
Pennsylvania.....	386,774
New York.....	318,003
Connecticut.....	295,063
California.....	266,103
Total for United States.....	\$3,211,780

THE GRANITE QUARRIES AND QUARRY DISTRICTS IN CALIFORNIA.

Granite and the closely associated granitic rocks (granolites) form part of the Gavilan and Santa Lucia ranges of the coast south of San Francisco bay; farther south they form the principal part of the mountain ranges in the western part of southern California, connecting with the large exposure of granitic rocks of the Sierra Nevada range, which runs from Tehachapi northward to the recent volcanics, in Lassen County. Considerable exposures of granitic rocks are also found in northwestern California in the eastern portion of the Klamath mountain region.

The accompanying sketch map gives the general outline of the granite formations in California.

BUTTE COUNTY.

Granitic rocks form the core of the Sierra Nevada range, and large bodies of those rocks are found in the eastern part of Butte County. As yet, lack of transportation facilities has prevented their commercial use. The principal and most approachable exposures are:

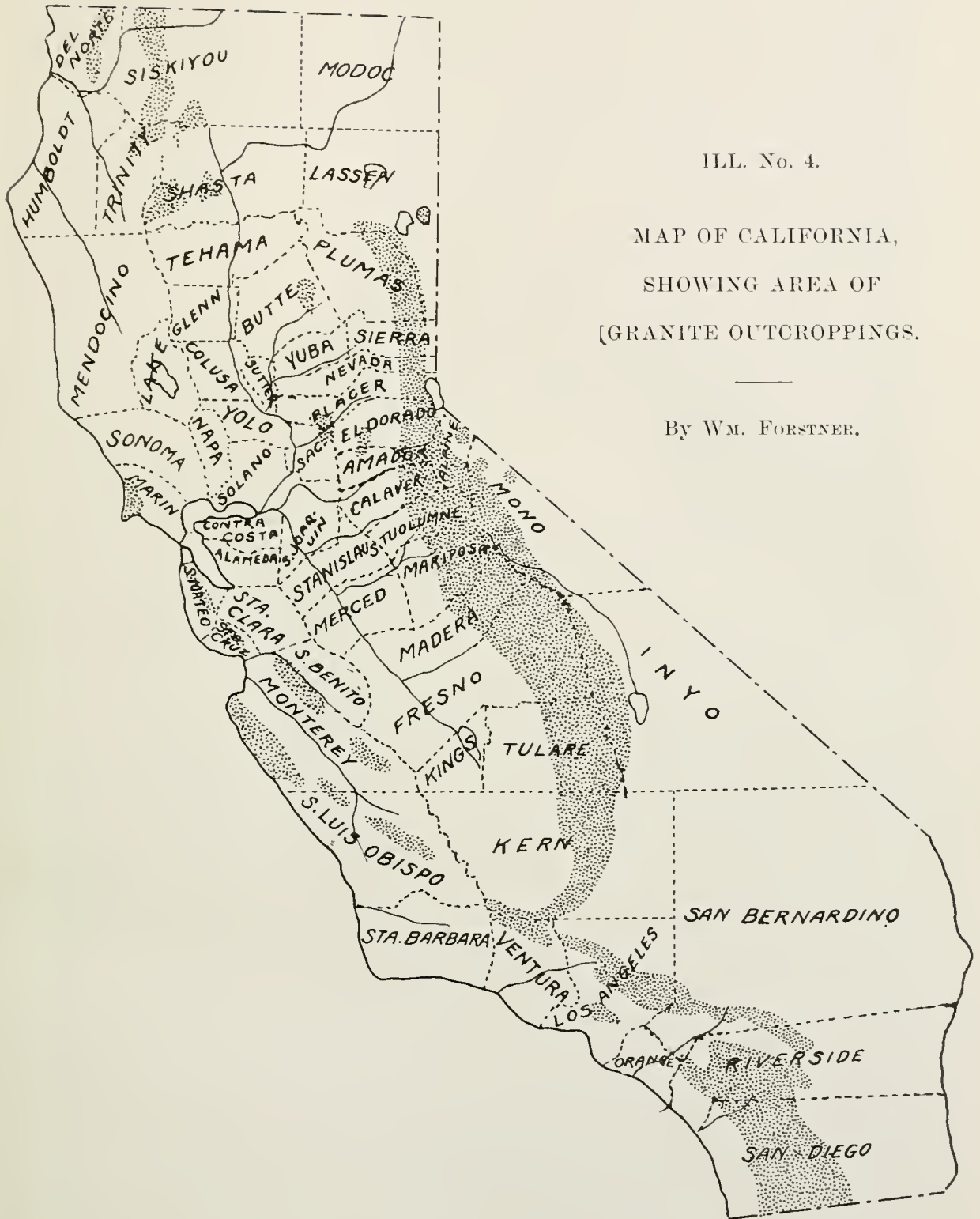
Bald Rock.—Middle Fork of Feather River, Sec. 27, T. 21 N., R. 6 E.

Big Bend.—North Fork of Feather River, Sec. 3, T. 21 N., and Sec. 33, T. 22 N., R. 5 E.

Stirling.—Sec. 31, T. 24 N., R. 4 E. Diamond Match Company, owner.

FRESNO COUNTY.

Academy Granite Company.—Sec. 13, T. 12 S., R. 22 E., M. D. M. J. S. Williams, M. F. Marshall, and Mr. Dubois, Fresno, owners. The rock is a dark, medium-grained granite, and is quarried from large boulders. Its dark color makes it a pretty trimming stone for structures of other stones.



ILL. No. 4.

MAP OF CALIFORNIA,
SHOWING AREA OF
[GRANITE OUTCROPPINGS.

By WM. FORSTNER.

GLENN COUNTY.

Talbott Granite.—In Sec. 8, T. 18 N., R. 4 W., 10 miles southwest of Willows. James Talbott, Willows, owner. Syenitic granite is exposed in the form of a dike intruding through the sandstone formation, within 8 miles of the Southern Pacific Railroad. At the point of chief exposure, the granite stands from 10 to 15 feet high and is exposed along the surface of the western slope of the hill for a width of about 40 feet. The dike strikes north 14 degrees west, and follows the general trend of the sandstone. This granite is hard, fine-grained, and of even fracture, as has been shown by rifting large pieces from the main body.

LOS ANGELES COUNTY.

At Devil's Gate, near Pasadena, the San Pedro, Los Angeles and Salt Lake Railway Company quarries granite boulders. This granite is crushed and used for ballast on its roadbed.

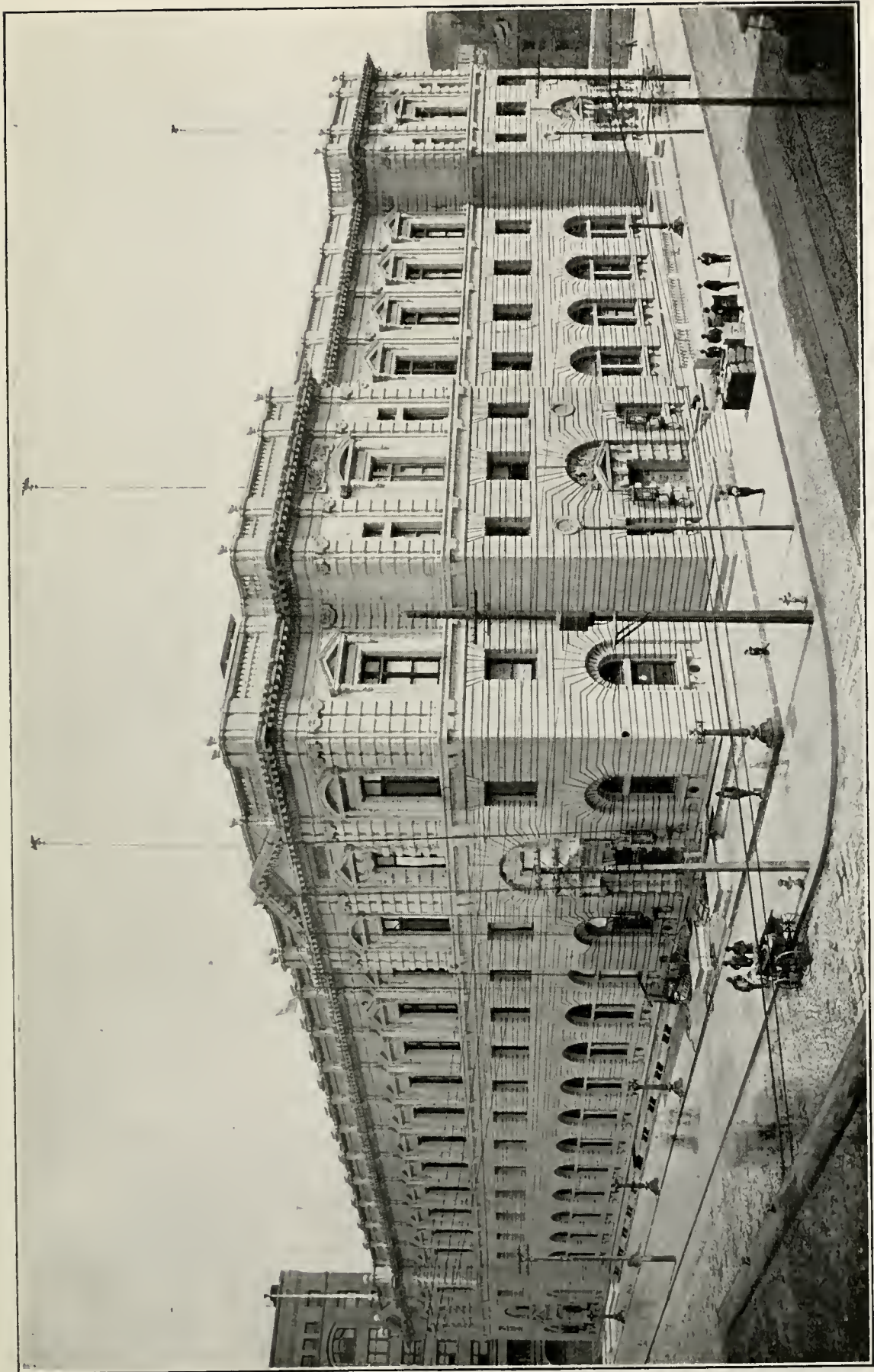
E. M. Ross, Glendale. On the Glendale ranch, Verdugo Cañon, 8 miles from Los Angeles, and three fourths of a mile from railroad, is a body of very dark hornblende biotite granite, somewhat banded (gneissic), taking a very high polish, and very well adapted for monument work and for trimming of the light-colored granites and marbles. No development work.

MADERA COUNTY.

The granite quarries near Raymond are at present large producers. There are two quarries in operation (September, 1904), employing about 300 men, and at times it is said as high as from 400 to 500 men. The quarries are located about 2 miles southeast of the village of Raymond, on a spur of the Raymond branch of the Southern Pacific Railroad. The two quarries are about half a mile apart, on the east side of the little valley in which they occur.

There is an extensive granite area covering many square miles in the vicinity of Raymond. Near the town it is a hornblende biotite granite, but at the quarries there is almost no hornblende except an occasional crystal. In many places the granite is disintegrated to a depth of many feet, while over limited areas it outcrops firm and solid on the surface. It is on such areas that the quarries should be located. The weathering of the granite is mainly by slow disintegration over the surface and along the joint planes. There are very few of the round residual boulders so conspicuous in many places. Most of the surface boulders are angular.

Among the many structures built of Raymond granite may be mentioned the new postoffice in San Francisco, which was furnished



ILL. No. 5. SAN FRANCISCO'S NEW POSTOFFICE. EXTERIOR OF RAYMOND GRANITE.

\$425,000 worth, with only one small stone needing replacement; the Fairmount Hotel was furnished about 20,000 cubic feet; the Dewey Monument, in Union Square; the Mercantile Trust Company, of San Francisco, on California street, and numerous others.

The Hall Quarry, located about 2 miles north of the McClellan quarry, near the Raymond-Berenda Railway, was opened a number of years ago, and furnished stone for a San Francisco contract, but was then abandoned and has not been operated for ten years or more.

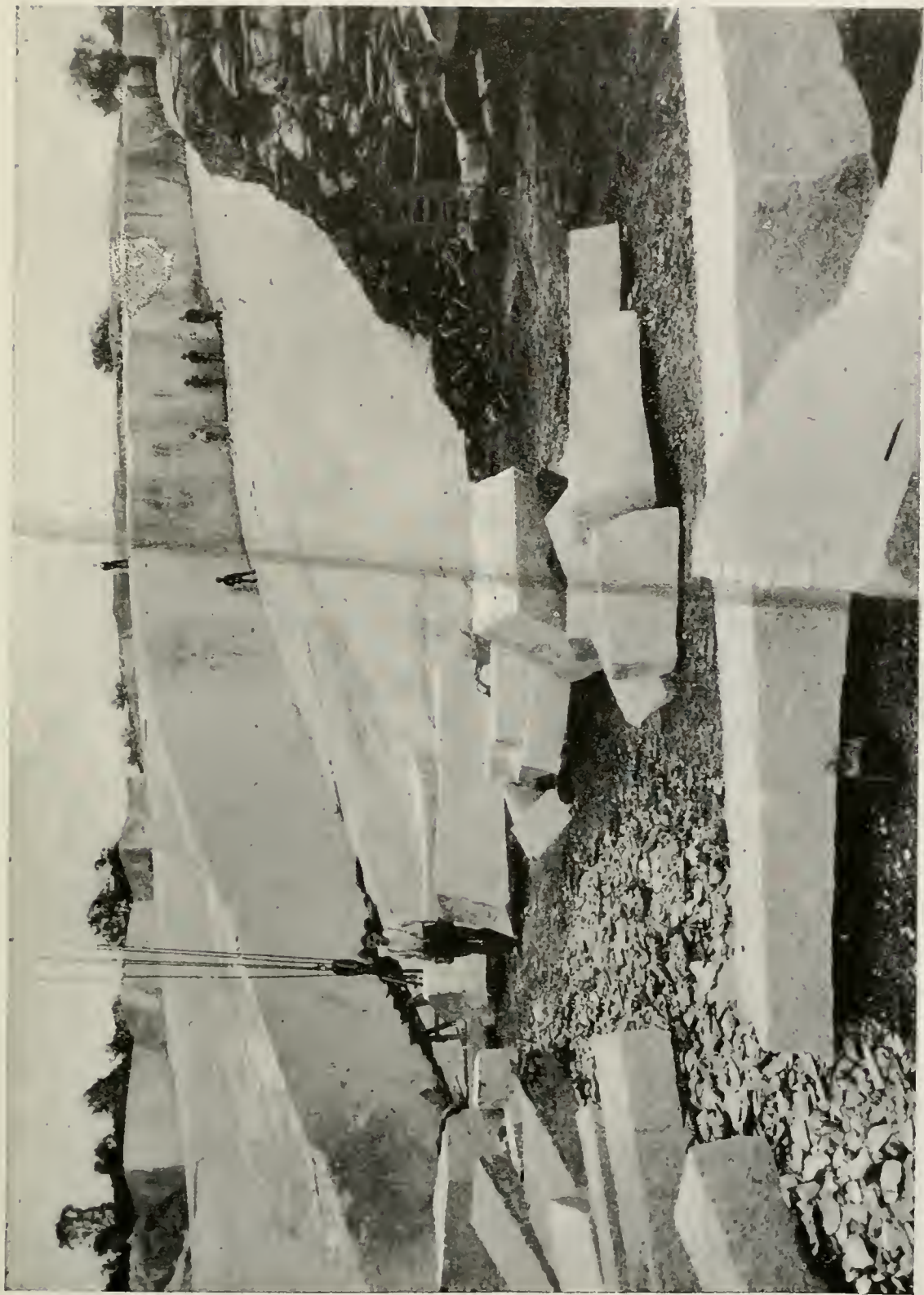
The Knowles Quarry, operated by the Raymond Granite Company, S. E. Knowles, president, Tenth and Division streets, San Francisco, has been open for seventeen years, and is well equipped with modern machinery for taking out and handling large quantities of stone. The outcrop of the granite at this point is something like a portion of the surface of a huge globe, about 300 feet or more in diameter, partly buried in the earth. Where it projects above the surface it is almost entirely bare of any soil, vegetation, or other material. It is apparently barren of seams, except the curved exfoliation seams parallel with the surface, and which are partly at least the result of weathering. In places there are remnants of these layers of exfoliation only a few inches in thickness, but the underlying layers, which are the ones worked in the quarry, vary from 1 or 2 feet to 25 feet in thickness. The quarry opening is on the northwest side of the sphere, and the quarry floor, which follows the foliation cleavage, is inclined from 20 to 30 degrees to the northwest.

The three large cutting sheds are located below the quarry opening, and an inclined tramway is run up to the quarry floor, down which the blocks are carried into the cutting sheds.

Hand and steam drills and the quarry bar are used in quarrying the stone. The quarry bar is used for cutting out the sides and ends of the quarry and also for drilling the large blocks in cutting dimension stone.

The stone is easily split and has a straight, even grain. It is split from the thin layers by drilling shallow holes and driving in wedges or plugs and feathers. From large layers the blocks are split off by drilling deeper holes and using the Knox blasting system, which leaves an even surface. The thickest layer exposed is about 25 feet thick, but most of that part quarried is much thinner, from 4 to 10 feet. As the quarry opening is carried deeper the succeeding layers will probably become thicker, that is, the joints will be farther and farther apart.

Nearly all the stone is cut and dressed at the quarry for building stone, or for monuments and cemetery work. After loosening the blocks from the quarry face and splitting them to the required dimen-



ILL. No. 6. RAYMOND GRANITE QUARRY, MADERA COUNTY.

sions by plugs and feathers, they are taken to the cutting sheds, where they are handled by steam-power overhead traveling cranes, and the surfaces are finished, either tool-dressed, rock-faced, or polished, as is desired, by hand or machine. The company has two of the heavy Barre granite surfacing and polishing machines and about ten of the lighter Concord surfacing machines. There are also a dozen or more pneumatic and surfacing tools for surfacing and carving, besides a hundred or more stonecutters and finishers at work with hand tools.

The finished stone is placed on the railway car in the cutting shed and run down the inclined track to the base of the hill, where it is taken to market over the Southern Pacific Railroad.

The supply of stone at this quarry is almost inexhaustible; it lies in admirable position for quarrying with a minimum amount of waste, and the facilities for handling the stone are excellent, all of which favor the large stone industry which has grown up at this place.

The stone is a biotite-muscovite light-gray granite, with the biotite mica in excess of the muscovite, and an occasional crystal of black hornblende. It has a medium-fine grain and is remarkably uniform in color and texture throughout the mass. Over the entire quarry area only one small dark blotch was observed. Some of the biotite crystals are idiomorphic, six-sided prisms.

The McClellan Quarry, owned and operated by the Wilson-Lyon Construction Company, office 220 Market street, San Francisco, lies on the same hillside, about one half mile south of the Raymond Granite Company's quarry. It has been in operation for nine years, and produces a stone similar to that from the Raymond Granite Company's quarry, except the rock is to some extent more deeply weathered.

The company has two quarry openings, with a large derrick in each, and a large circular cutting shed, with derrick in the center, at each quarry. The one quarry is about 50 feet square and works two layers, each 4 to 5 feet thick. The other quarry has a face about 100 feet long and from 25 to 40 feet high, with many vertical weather seams, but good granite between the seams. A branch railway spur connects this quarry with the same branch that leads to the other quarry. This stone, like that from the other quarry, is used largely for building and monument purposes. They are at present (September, 1904) preparing the stone for the McKinley memorial monument in San Francisco.

About one half mile southeast of the village of Raymond there is a small quarry with a face of about 18 or 20 feet, of a spotted gray granite, with large black crystals of hornblende and biotite. In places it approaches a syenite in character. A few feldspar veins occur and numerous dark blotches of segregated mica. There are a number of joint planes, yet blocks of large dimensions can be obtained. The



ILL. No. 7. FAIRMOUNT HOTEL, SAN FRANCISCO, THREE LOWER FLOORS OF RAYMOND GRANITE.

greatest drawback is the large dark blotches, which mar the beauty of the stone; but where it can be obtained free from blotches, it is one of the prettiest granites in the State.

NEVADA COUNTY.

Granite production in Nevada County forms only a local industry and is confined chiefly to quarrying and working the massive boulders at Nevada City, Grass Valley, and Rough and Ready, and the heavier deposits at Graniteville. The character is somewhat marred by intrusions of syenite, known to stonecutters as "black knot," especially in regard to the value of the stone for monument purposes. The granite at Rough and Ready contains fewer of these intrusions than that at Nevada City and Grass Valley. The principal employment of the granite of these sections is in the cutting of posts, copings, stoops, and bases for monuments. The chief color is blue. The weight varies from 165 to 198 pounds to the cubic foot.

T. J. Ahearn, Grass Valley, obtains blue granite from boulder cropings and ledge formation southwest of Rough and Ready, in Sec. 26, T. 16 N., R. 7 E.; but quarried none in 1904, it is reported, owing to his inability to secure competent labor.

Charles Bouchard & Son, yards one mile northwest from Grass Valley, obtain blue granite from the boulder quarries at Rough and Ready, and black granite from Sec. 20, T. 16 N., R. 7 E., south of Deer Creek. This black granite occurs only in boulders. It is of fine grain and produces handsome monument work.

E. D. Bridges, at Pine Grove Quarry, in Sec. 8, T. 16 N., R. 9 E., on the Masonic cemetery site in the eastern edge of Nevada City.

D. C. Morrison, Rough and Ready, quarries and dresses for monument and other uses fine-grained black and blue syenite granite at his quarry in Sec. 24, T. 16 N., R. 7 E. The granite occurs only in boulders, which have been his source of supply for the past twelve years.

PLACER COUNTY.

Emigrant Gap. T. 17 N., R. 12 E. There is a large exposure of granite in the extreme northwestern part of Placer County; reported to be of excellent building variety. This material was used in the construction of the dam that forms Lake Spaulding, which has an area of 240 acres and conserves 52 feet of water above the gate.

The Griffith Quarries and Polishing Works. Sec. 35, T. 11 N., R. 7 E., M. D. M. David Griffith, Penryn, owner. This is one of the pioneer granite quarries of the State. Mr. David Griffith formerly worked in the famous slate quarries in Penrhyn, Wales. He quarried granite at Folsom, but in 1864 he came to Penryn,* which he named after his Welsh home. Here he remained, and he and his descendants have quarried granite from that time until the present. David Griffith, a nephew of the first quarryman, now has charge of the business. The quarry was opened about the time the Central Pacific Railroad was being constructed in this region, and Penryn stone was used in the



ILL. No. 8. MANTYLA'S GRANITE QUARRY, ROCKLIN, PLACER COUNTY.

construction work on this line. Many Government contracts were filled in former years, and at times there have been 200 men or more employed in these quarries, although at present there is less than a score.

The stone is a dark gray biotite granite, rather uniform in color, but varying somewhat in texture in the different quarry openings. The only variation in color is the occasional occurrence of a dark blotch where the biotite crystals have segregated into a small irregular mass in a partially glassy groundmass. Care in selecting the stone avoids

*The *h* was dropped from the name of the California town by decree of court a few years ago.

the occurrence of any of these blotches on the exposed faces of stone in use.

The granite outcrops in rounded knolls and prominences in many places along the rolling area immediately east and south of Penryn. The largest and oldest quarry opening lies about one quarter of a mile east of the town, and a few hundred feet east of the shop where the stone is cut and dressed. This opening has been, at least temporarily, abandoned and they are now quarrying stone from large residual boulders a half mile south of the town on each side of the wagon road. Some of these boulders are quite large and contain many tons of good stone. Some rest on solid granite in place and some on disintegrated rock material and occur as residual boulders lying on and in the débris of the decayed rock, of which they formed part of the mass. Some of them are firm and solid on the surface, others are exfoliating and covered with partially disintegrated concentric shells of stone. This concentric weathering is shown both in the surface of the loose boulders and on the projecting knobs of the massive granite.

Quarry openings and road and railway cuttings show the granite in some places to be disintegrated to a depth of 20 feet or more, where it consists of nothing but a loose granular mass of mica scales, quartz grains, and crumbling feldspar grains. It frequently retains its original joint planes and gross structure, but is so disintegrated that a blow with a hammer or the foot causes it to crumble to grains.

There is a small quarry opening on the east side of the town of Penryn. This is said to have been opened by a San Francisco company, but only a very small quantity of stone was removed when the quarry was abandoned.

Besides the gray granite, Mr. Griffith quarries some very dark stone, known as "black granite," which is used for certain lines of work. It occurs about one mile east of Penryn. The quantity produced is small compared with that of the gray granite. This rock is classed as a gabbro in the United States Geological Survey Atlas. It differs from a typical gabbro in having considerable orthoclase feldspar along with the plagioclase, and biotite and hornblende nearly as abundant as augite.

The stone is used largely for monuments for cemeteries and for building purposes. Both the gray and the "black" granite dress nicely, and take a brilliant polish. The "black" stone is a favorite for name blocks in front of ranches or fruit farms, as well as in cemetery monuments, as the letters cut in the dark polished faces are so distinct.

At **Loomis Station**, 3 miles south of Penryn, about midway between Penryn and Rocklin, is a granite quarry operated by the **Rocklin Granite Company**, S. L. Delano, president, Builders' Exchange, San Francisco. The quarry is on a short spur of the Central Pacific Rail-

road, about half a mile south of the town of Loomis, and on the east side of the railway and wagon road. The quarry opening is on a nearly level area, and is about 100 feet long, 50 feet wide, and from 50 to 60 feet deep.

The west end of the quarry is a massive block of granite, about 50 feet square, which forms the side wall of the quarry. There are no vertical seams, except those on each side of the mass, and no horizontal seams except a few cracks not continuous but indicating a cleavage in that direction. The east end of the quarry shows several vertical seams 10 to 12 feet apart.

The Loomis stone is a biotite granite that has less biotite (black



ILL. No. 9. EUREKA GRANITE QUARRY AT ROCKLIN, PLACER COUNTY.

mica) than the Penryn stone, and hence a lighter color. In color and texture, as well as in geographic position, it stands between Rocklin and Penryn granite, being coarser and darker than the Rocklin, but not so coarse or dark as the Penryn stone. Like the others, it has a straight cleavage, and splits with an even, regular surface.

In places in the Loomis region solid granite occurs on the surface, but in most places the solid rock is covered with a varying thickness of disintegrated material, which at the quarry opening is from 3 to 10 feet deep. The concentric weathering of the stone is indicated not only in the rounded residual boulders over the surface, but in places on the quarry walls the concentric weather seams may be seen several feet

below the surface. The quarry at Loomis, it is said, is not in operation continuously, but is worked at intervals to fill special orders. At present the owners are shipping stone to San Francisco for the extension which is being made to the Hibernia Bank Building.

Rocklin is the principal granite-producing point in the Sacramento Valley. The first quarry was opened in 1863, and the stone was used in construction work on the Southern (then Central) Pacific Railroad. Brigham & Hawes operated the same quarry later and took out stone for the State Capitol at Sacramento. This quarry, after changing hands several times, came into possession of Degan & Brady, who took out the stone for the Hibernia Bank and the Crocker Building, San Francisco, since the completion of which this quarry has been idle.*

The Rocklin quarries are comparatively close together. They occur on an area probably less than a mile square, on a gently rolling plain, which borders the railway and extends from 1 to 2 miles on each side to the bottom of a bluff 200 feet or more in height, which marks the border of the upland mesa.

In most places over the quarry area the granite occurs at the surface. In some places there is a very light soil-covering, and in others the surface is covered with huge residual boulders. The stripping is very slight over the entire area.

In going northward through Penryn and Newcastle, the Rocklin plain becomes narrower and gradually disappears in the low rounded granite hills, which become higher and more rugged as one follows the railway north and east into the Sierras.

The granite area is many miles in length and width, but the quarries above mentioned are the only ones on the area in Placer County that have more than local importance.

The Rocklin stone is a biotite granite, bordering on monzonite. It contains some plagioclase and a little augite, but the prevailing feldspar is orthoclase, and biotite is in excess of muscovite. Some of the orthoclase shows a zonal structure and other portions show partial disintegration, most marked in the central portions of the crystals. In places on the weathered surfaces the biotite is partially disintegrated.

There are fifteen quarries in operation (August, 1904), and several others idle. Most of the quarries are small, employing from 3 to 10 men. The largest quarry is working 33 men, but at times employs as many as 50. Most of the smaller quarries are operated by Finns, Russians, and Italians. The following is a list of the operators in August, 1904, as nearly correct as could be obtained. Some of the men speak very broken English, if any at all, and a few of the names may not be spelled correctly: (1) The Rocklin Granite Company, I. L. Delano,

* Historical information furnished by A. W. Grindell of Rocklin.

president, Builders' Exchange, 106 Jessie street, San Francisco; (2) Adolph Penru; (3) August Martin & Co.; (4) Band Granite Company; (5) Nikolai Naykki; (6) John Pisili; (7) Holowen & Co.; (8) A. O. Wickman; (9) John Kannasta; (10) Henry Hebeck Granite Company; (11) Pete Johnson; (12) Matt Johnson; (13) Oskar Kesti; (14) John Mantyla; (15) Janhiala Company.

Nos. 1 and 14 are the largest quarries. The Allen quarry; owned by Myers, now idle, had been quite productive in the past.

The most northern and the largest quarry in the Rocklin area is owned by the *Rocklin Granite Company*. Like all the other quarries in this



ILL. No. 10. ROCKLIN GRANITE COMPANY'S QUARRY, PLACER COUNTY

locality, it is in a rectangular pit, sunk in the surface of the rolling plain. The opening is about 100 feet deep, 100 feet wide, and 250 feet long. The rock has a remarkably straight grain and regular cleavage. Curbing slabs, from 10 to 20 feet long, are split with surfaces almost as regular and even as those cut with saws. Numerous slabs up to 16 by 20 feet surface, and from 10 to 12 inches thick, have been removed from the quarry. These large slabs, like the smaller ones, are nearly all split from the ledge by use of plugs and feathers. The large slabs are used in construction of cemetery vaults. The quarry is well equipped with machinery for handling and dressing the stone. It is provided with large derricks and steam hoists, an overhead steam traveler in the

cutting sheds, and several polishing and surfacing machines. Compressed air is used in the cutting shed for drilling and surfacing. Steam and hand drills are used. The quarry was opened in 1877 by Mr. Marine. From 1878 to 1889 it was operated by Mr. G. Griffith. Since 1889 it has been operated by the Rocklin Granite Company. It has furnished large quantities of building and ornamental stone in that time.

Compression tests made on the Rocklin granite at the Watertown Arsenal December 24, 1896, gave the following results:

No. 1.	3.96" x 3.96" x 3.96".	First crack, 332,000 lbs.; ultimate strength, 342,000 lbs.
No. 2.	3.94" x 3.97" x 3.96".	First crack, 329,000 lbs.; ultimate strength, 340,900 lbs.
No. 3.	3.96" x 3.96" x 3.97".	First crack, 271,000 lbs.; ultimate strength, 311,400 lbs.

No. 1.	Ultimate strength per square inch.....	21,817 lbs.
No. 2.	Ultimate strength per square inch.....	21,686 lbs.
No. 3.	Ultimate strength per square inch.....	19,809 lbs.
	Average for the three.....	21,104 lbs.

About three hundred yards south of the Rocklin Granite Company's quarry is another opening on similar granite, which belongs to *Adolph Penru*. It is 50 feet deep and about 50 feet square, and is supplied with a large derrick at the quarry and another at the cutting shed. The work is done entirely by hand.

Besides the quarries above mentioned which were in operation part or all of the time during the year 1904, there are several others which were not operated. The largest one of the abandoned quarries is that known as the *Allen quarry*, now owned by *Myers*. It is about 300 feet west of the property of the Rocklin Granite Company. There are two other abandoned quarries of considerable extent near the south end of the area.

Much of the work in the different quarries is done by hand. The larger quarries are supplied with steam drills and surfacing and polishing machines, but in the smaller quarries the drilling, surfacing, and polishing are done by hand. There are nineteen steam-power derricks, mostly at the larger quarries, and fourteen horse-power derricks used at the smaller quarries. Blasting is carried on to some extent, but most of the stone is split with wedges, or by use of plugs and feathers. Each of the quarries has a railway spur to the quarry, all connecting with the Southern Pacific Railroad at Rocklin.

RIVERSIDE COUNTY.

Granite is pretty widely distributed over Riverside County. It has been quarried on a large scale for rubble for use in the San Pedro break-water, at Casa Blanca, and for building and ornamental purposes at Corona, Riverside, and Temecula. At Porphyry and Riverside it has been quarried for broken stone.

Corona.—East of Corona, on the north side of the Southern Pacific Railroad, and a half mile from the railway, are several productive granite quarries. There are a number of more or less regularly rounded hills or buttes that occur at this place, over the tops and slopes of which the granite outcrops in rounded ledges in the midst of a multitude of large rounded boulders. Many of the boulders, as well as the projecting ledges, have a smooth, hard, firm surface. Some of them are even polished by the winds carrying dust, which has worn away the disintegrated surface as fast as it has been formed. A large part of the granite has been quarried here from the boulders, as these are more



ILL. No. 11. GRANITE QUARRY, CORONA, RIVERSIDE COUNTY.

easily worked into dimensions than the massive bedrock. The boulders are especially sought in making the Belgian paving blocks, which are made here in large numbers.

Besides the use for paving stone, the Corona granite is used to some extent for building stone, and in considerable quantities for monuments, in Los Angeles, Riverside, and other places in southern California.

The stone from all the quarries is hauled by wagon to the railroad at Hammer switch, about a mile east of Porphyry station.

The monument dealers in the different towns nearly all speak highly of the Corona granite for monuments, thus giving it a growing reputation in that field. Its nearness to Los Angeles and Riverside also favors the use of this stone for Belgian blocks.

A microscopic examination of the granite from Mayer's quarry at Corona shows it to consist of orthoclase feldspar, with a little microcline and albite, quartz, biotite, and muscovite—the constituents of typical granite.

Temecula.—There are two granite quarries about two miles south of Temecula, near the junction of Temecula Creek and the San Jacinto River. One quarry is owned and operated by F. L. Fernald, and the other by Patrick Quinn. The quarries are both worked by hand, and the stone is largely quarried from boulders. The solid ledges are exposed in a number of places, but in most places the surface is covered



ILL. No. 12. STONE-SAWING MACHINE. BLY BROS. STONE COMPANY, LOS ANGELES.

wholly or in part with large rounded boulders of disintegration. Nearly all the work has been done on boulders, because they are more readily split and cut to the desired shape. The rock has a remarkably even fracture, one large boulder having been split with a single drill hole, leaving the fractured surface more than 200 feet square, almost as regular as a sawed surface. Some of the boulders are partially disintegrated to a depth of several inches, and sometimes discolored slightly to a depth of a foot from the surface. The interior of the stone has a rich, light gray color, with a faint rose tint which makes it very attractive. Part of the stone is made into Belgian blocks, and part is cut into dimension stone. They now have two contracts of 30,000 blocks each. Its smooth fracture makes it a desirable stone for paving blocks, as they

can be made more rapidly and more regular than from a stone with a rough fracture. It is also adapted for curbing and flagging for the same reason. It has a local use for fence posts, where the stone has been split out in pieces about 4 by 8 inches and 5 or 6 feet long, and barbed wire fastened to them after they have been put in place.

There is a hand derrick in each quarry, and two derricks are at the railway station, used in loading the stone. The railway formerly extended down the valley near the quarries, but the part south of Temecula is now abandoned and the stone is hauled by wagon from the quarries to Temecula, two miles distant.

The microscope shows the Temecula stone to be a biotite granite, with



ILL. No. 13. MACHINE SURFACING GRANITE AT BLY BROS.' STONE YARDS, LOS ANGELES.

a very little hornblende and muscovite. There is a little soda feldspar and some microcline, but the prevailing feldspar is orthoclase, some of it perthite.

Bly Brothers, 720 Alameda street, Los Angeles. Two quarries: one in the N. W. $\frac{1}{4}$ of Sec. 2, T. 2 S., R. 6 W., S. B. M.; the other in the S. E. $\frac{1}{4}$ of same section. (Formerly belonged to the West Riverside Granite Company.) This quarry produces a large quantity of fine granite used for building purposes in Los Angeles and vicinity. This firm has in Los Angeles one of the best equipped stone yards for handling and dressing the stone that there is in southern California. There are saw gangs for sawing the stone, as they handle considerable sandstone and

marble in their contracts. They have stone planers, surfacing machines, steam drills, pneumatic drills, and surfacing tools. There is also a large force of stonecutters, as much of the cutting and finishing of granite is necessarily done by hand.

The stone from Bly Brothers' Deeleez quarry is a typical granite, composed of quartz, orthoclase feldspar, and muscovite and biotite mica, with a small percentage of the soda feldspar, albite. It has a light gray color and medium-grained texture. Physical tests made on this stone by L. D. Hunt, Engineer at the University of California, gave the following results:

Dimension of sample, 3.02" x 3.03" x 3.01".
Crushing load, 201,120 pounds.
Crushing strength per square inch, 21,980 pounds.
Weight of stone per cubic foot, 167 pounds.

It will be seen that in both specific gravity and crushing strength, as well as in mineral composition, it is an average granite. Because of the uniformity of its pleasing light gray color, it will no doubt continue to be a popular building stone.

Casa Blanca Quarries, in Sec. 10, T. 3 S., R. 5 W., and Sec. 15, T. 3 S., R. 5 W., S. B. M. Two large granite quarries owned by the *Southern Pacific Railroad Company*, and operated by the *California Construction Company*. The quarries are about half a mile apart north and south, and about a mile southeast of the Casa Blanca railway station, and located at the base of the granite buttes of the vicinity. The rock is a medium dark gray granite of rather uniform texture and color, except the occurrence of the dark blotches scattered through the mass. The blotches, which vary from a fraction of an inch to several inches in diameter, consist in part of glass, which for some reason did not crystallize equally with the surrounding portions, and which injure the stone for monument purposes, but do not affect the durability or strength of the rock, as the dark patches are even more durable than the surrounding rock. They are more abundant in the north quarry than in the south one. The north quarry has an opening about 100 feet square, with a face of from 50 to 60 feet. The joints cut the mass into layers, which range from 4 to 15 feet thick. The stone is loosened from the bed by blasting.

The south quarry is 100 feet long by 30 feet deep, with a face of from 30 to 40 feet. The stone has fewer dark spots than that of the north quarry and a more even fracture. The regularity and evenness of the surface along the lines of the fracture are remarkable. Ill. No. 15 shows a surface about 30 feet square, from which a huge block has been broken off by only a few drill holes, and the face is as regular as if it had been tool-dressed. There are very few seams, and almost no waste in quarry-



ILL. No. 14. CASA BLANCA GRANITE QUARRY, RIVERSIDE COUNTY.



ILL. No. 15. CASA BLANCA QUARRY No. 2 (GRANITE), RIVERSIDE COUNTY.

ing. Excellent bridge and building stone could be quarried advantageously at this place. The rock shows concentric weathering on a large scale. The entire end of the hill on which the quarry is located is rounded off like the surface of a great boulder.

The rock is a biotite-hornblende granite, bordering on a granodiorite, as it contains much plagioclase and runs low in quartz.



ILL. No 16. H. W. HELLMAN BUILDING, LOS ANGELES. FIRST TWO STORIES CONSTRUCTED OF RIVERSIDE GRANITE.

A spur from the Santa Fé Railroad extends into both of the Casa Blanca quarries, and the stone is shipped by rail as rubble to the great San Pedro breakwater. Excellent granite for building purposes could be obtained at these quarries.

Fairehild-Gilmore-Wilton Company, 516-517 Pacific Electric Building, Los Angeles. The quarry is located in Secs. 8 and 17, T. 3 S., R. 6 W., S. B. M. This is a contracting company, and uses large

quantities of building granite, as well as paving blocks, and broken stone for ballast and concrete.

Besides the granite quarries at Hammer switch, this company operates a large quarry at Porphyry station. The stone is used for concrete, macadam, and railway ballast.

F. L. Fernald, Temecula. See page 42.

M. J. Mayer, Corona. The quarry is in the low foothills, close to the track of the Santa Fé Railroad, near Porphyry station, a couple of miles east of Corona. Mr. Mayer is working the outcropping granite boulders into paving stones in several places.

Peerless Quarry, J. B. Lane, 910 South Main street, Los Angeles. The product of this quarry is shipped to the stone yard of Lane Bros. in Los Angeles, where it is made into monuments.

Patrick Quinn, Temecula. See page 42.

Rock Mine, Stephen Connolly, Elsinore.

Rubidoux Hill Quarry, very near and west of Riverside; owned by the Riverside Water Company. A small opening on the northwest side of the city, where the stone is a gray granite, partially disintegrated to a depth of several feet. It has apparently been used for building stone, probably for foundations.

Sierra Grande Quarries, M. J. Mayer, Corona, Sec. 16, T. 3 S., R. 6 W., S. B. M., manufacture large numbers of Belgian blocks for Los Angeles streets, and also ship considerable granite to the monument dealers in different towns.

SACRAMENTO COUNTY.

Folsom State Prison Granite Quarry; State of California, owner; Represa P. O.; Brainard F. Smith, clerk. In Sec. 25, T. 10 N., R. 7 E., on the east bank of the American River, one mile east of north from the town of Folsom. The quarry is operated with convict labor; the product is principally used in prison and other State construction. The macadam quarry, situate in the same quarter-section, and farther south, is described elsewhere.

The exposure of granite on the prison lands is at the southeasterly end of the granite formation that extends in a northwest course from the northeast corner of Sacramento County to Rocklin, in Placer County. Paralleling the granite is a gray diorite, exposed in large masses in the prison macadam quarry.

The material produced in the prison quarry is a biotite granite of good building quality that has improved with depth from 170 pounds to 178 pounds to the cubic foot. In December, 1904, the working face of the quarry had a north and south length of 300 feet, 65 feet vertical depth, and a width of 100 feet from the edge of the river bed. The granite has a regular cleavage, the dimension stone quarried averaging 2 feet by 2 feet by 6 feet; the irregular shapes of smaller sizes are graded as rubble rock.

Electric power, furnished by the Sacramento Electric, Gas, and Railway Company, is used for the compressed air drills, hoisting engines, and rock-crusher in the quarries.

The production in 1904 was 5170 cubic feet of dimension stone and 7760 tons of rubble rock.

SAN BERNARDINO COUNTY.

Granite occurs over considerable areas in San Bernardino County, but is quarried only at Delez, Oro Grande, and Victorville.

The Delez Quarries, owned by the Southern Pacific Railroad Company, and leased to the California Construction Company, 324 East Market street, Los Angeles, are in Sec. 35, T. 1 S., R. 6 W., S. B. M. At Delez, on a spur of the Southern Pacific Railroad, about 1 mile south of Delez station on the main line, and 9 miles west of Colton. The stone is a rather dark-colored biotite granite, which has a gneissoid structure in places. There are a number of feldspar veins from 2 to 4 inches wide, which consist principally of orthoclase feldspar, but in a few places contain large biotite crystals. The rock is partially disintegrated for a few feet from the top, but below this comparatively thin weathered portion it is bright and fresh, and below the few feet of weathered stone the rock could be quarried in blocks large enough for dimension stone, and good building and monument stone could be obtained. At present nearly the entire output is used for rubble in the Government breakwater at San Pedro. Dynamite is used to loosen the stone from the bed, and the large irregular blocks are loaded on the cars at the quarry and taken to the breakwater at San Pedro. The drilling is done with steam drills, and seven large steam-power derricks are used to handle the stone.

The Oro Grande Quarries have furnished considerable granite in the past few years, but they were not in operation during the summer of 1904. About two miles south of Oro Grande the Mojave River cuts a narrow cañon through the granite rock, which forms rocky hillsides on each side of the river. On the west side of the river the granite is deeply disintegrated, and except on the river bluff no solid rock appears on the



ILL. No 17. DECLEZ GRANITE QUARRY, DECLEZ, SAN BERNARDINO COUNTY.



ILL. No. 18. FARMERS AND MERCHANTS NATIONAL BANK BUILDING, LOS ANGELES.
 The Granite in this building was quarried in Bly Brothers' Quarry,
 Declez, San Bernardino County.

surface. On the east side of the river the solid granite in rounded ledges and rounded boulders of disintegration covers an area of more than a square mile. In several different places over this area small granite quarries have been operated, the product being mostly Belgian blocks. The quarries are in Secs. 28 and 29, T. 6 N., R. 4 W. Most of the work has been done on the surface boulders, but in a few places some work has been done in the solid ledge underneath the boulders. The quarrying has been done almost entirely by hand, and most of it



ILL. No. 19. GRANITE QUARRY AT ORO GRANDE, SAN BERNARDINO COUNTY.

has been on paving blocks, although some building and monument stone has been shipped.

Near Victorville several quarries are in operation, also principally producing paving blocks.

Brownstone Quarry No. 4, in Sec. 34, T. 6 N., R. 4 W., S. B. M.; J. W. Auchinachie, Victorville, owner. This quarry is in the northern part of a narrow and low granite ridge, running about north and south, through which the Mojave River cuts just above Victorville, forming the Upper Narrows, and on which all the granite quarries near Victorville are located. The surface boulders in this quarry have a less banded structure than those in the quarries south of and nearer Victorville. The solid granite lies in beds dipping very slightly to the north-

east, from 6 to 8 feet thick. The granite breaks regularly and readily. It is medium-grained, of a very even, light-gray color. It is used for building and monument purposes. The county jail in San Bernardino is built of this granite. Through the quarry run seams of rhyolite, and in places masses of segregated quartz are found.

Corona Quarry, in Sec. 3, T. 5 N., R. 4 W., S. B. M.; Fairchild-Gilmore-Wilton Company, Nos. 516-517 Pacific Electric Building, Los Angeles, owner. Granite boulders are worked in this quarry. The granite has a yellowish cast. Paving blocks are shipped from this quarry.

Leahy & Turner Granite Quarry, in Sec. 28, T. 6 N., R. 4 W., S. B. M.; P. H. Leahy and J. C. Turner, Victorville, owners. It is on the southwest slope of Silver Mountain, north of Victorville, three fourths of a mile from the Santa Fé Railroad. The granite lies in nearly horizontal beds from 6 to 15 feet thick. It is medium-grained and hard, and is broken down by hand drilling and blasting with black powder, and further split with plugs and feathers. It has been used in the Ferry Building, San Francisco, the Simpson Tabernacle, Los Angeles, and other structures. This quarry was formerly known as the Leahy, Storan & Rodgers quarry.

Scheerer Quarry, in Sec. 29, T. 6 N., R. 4 W., S. B. M.; Clemens Scheerer, San Bernardino, owner. It is close to the preceding quarry and in similar material.

St. John Quarry, at Victorville, on the Upper Narrows of the Mojave River; Hesperia Land and Water Company, owner. This quarry has been idle for several years.

Victor Quarry, in Sec. 3, T. 5 N., R. 4 W., S. B. M.; T. H. Hargraves, Victorville, owner. Principally boulders are worked in this quarry. The material is similar to that of the Corona quarry in same section. Paving blocks and curbstones are shipped.

White Granite Quarry, in Secs. 22 and 23, T. 6 N., R. 4 W., S. B. M.; George E. Hunt, Victorville, owner. It is on the south slope of Silver Mountain, northeast of the Leahy & Turner quarry. The granite is stated to be bedded nearly horizontally and to be a rather fine-grained material of good quality for dimension stone. Very little work has as yet been done.

SAN DIEGO COUNTY.

There is a broad, irregular belt of granite running through San Diego County west of the middle of the county. With the exception of a little stone quarried at different points for local use, the only quarries now producing granite are those at Foster and Santee, on the San Diego, Cuyamaca and Eastern Railway, and at the Sweetwater Dam.

A. E. Babcock, Lawyer's Block, Fourth and E streets, San Diego. At Foster, the terminus of the San Diego, Cuyamaca and Eastern Railway, granite is quarried for rubble and shipped to the San Diego breakwater.



ILL. No. 20. SANTEE GRANITE QUARRY, SAN DIEGO COUNTY.

A spur is run from the railway into the quarry, which is located near the railway station, and the rock loaded by derrick directly on the cars.

Simpson-Pirnie Granite Company, James Simpson, president, San Diego. At Santee, a station on the San Diego, Cuyamaca and Eastern Railway, 3 miles north of El Cajon and 25 miles north of San Diego, is a granite quarry that has been operated for several years. A short railway spur extends from Santee to the quarry, which is on the east side of a small granite butte that stands close to the hills on the north side of the El Cajon Valley. The granite is quarried by hand. The stone is a bright-colored, light-gray, biotite-augite granite, which

has a reddish to a brownish tint on the weathered outcrop. In some places this brownish discoloration from the oxidation of the iron extends several feet below the surface, while in other places it is a mere shell on the surface. In the middle of the quarry face is a dike-like band that shows several open vertical joint seams, but elsewhere on the face the rock is massive and almost free from open seams. It has a remarkably straight fracture, and is easily obtained in regular rectangular blocks as large as can be handled. There is comparatively little stripping to the granite mass and no expensive waste in quarrying. As the quarry is at the base of the butte, the height of the quarry face will increase as it is worked back toward the center of the hill. The stone is quite uniform in texture and color, with the exception of a few small dark blotches caused by a local segregation of the dark mica flakes. It is used largely for monuments, and for this purpose it is cut and dressed at the company's yard in San Diego and shipped in considerable quantities to Los Angeles and other points in southern California. It also makes an excellent building stone, for which it is used to some extent.

Sweetwater Dam Quarry, E. A. Hornbeck, National City, general manager. This granite quarry is some miles southwest of San Diego, and the product was used entirely in the construction of the reservoir dam.

Mrs. W. S. Waterman, Hawthorn and Albatross streets, San Diego. The quarry is in the cañon about a mile west of Foster. The granite is hauled by wagon to Foster, where it is loaded on cars for shipment. The product is used for building and monument stone. The four Government buildings at Fort Rosecrans, on Point Loma, erected in 1903-04, are constructed of granite from this quarry. The stone is light-colored and very fine-grained, bordering on a felsite in places.

SHASTA COUNTY.

The granite in Shasta County is principally a hornblende granite. It contains, as a rule, relatively little hornblende and biotite and is of light color. Where not decomposed, the rock is much jointed and cross-jointed, showing the effect of strong pressure. These fracture planes and the quartz seams cutting through the rock are the cause of its not being used for building or monument purposes.

Masterson Brothers, Redding, formerly quarried the granite in Sec. 25, T. 31 N., R. 6 W., and Sec. 20, T. 32 N., R. 6 W., but have abandoned their quarries.

SIERRA COUNTY.

Granite and granitic rocks occupy a prominent place in the geological structure of Sierra County, especially in the eastern and south-central portions. No exploitation with a view to determining its structural qualification has been undertaken.

SISKIYOU COUNTY.

There is a great amount of granite and granodiorite in Siskiyou County. The greater portion is, however, too much shattered to be used for monument or building purposes.

On Craggy Mountain, about in Secs. 22 and 23, T. 41 N., R. 8 W., there is a large body of granite from which blocks of any desired size can be obtained. It is used for building purposes and coping.

In Scott River cañon, between Fort Jones and Scott's Bar, is a granodiorite, mostly dark colored, sometimes grayish, which is sufficiently massive to be used. It is of very good quality and very easily worked.

Southeast of Etna, on Mill Creek, about in Sec. 1, T. 41 N., R. 9 W., there is a large body of very fine-grained granite, closely resembling Berry granite (Vermont), taking a fine polish and used for monument work.

A similar grade of granite is found southwest of Callahan, in the southwest corner of T. 40 N., R. 8 W., and the southeast corner of T. 40 N., R. 9 W.

At the head of Park's Creek, in T. 41 N., R. 6 W., another body of gray granite of good quality is found.

TRINITY COUNTY.

The granite in Trinity County is the same material and occurs in the same manner as in Shasta County.

In Rush Creek, in Sec. 26, T. 34 N., R. 9 W., M. D. M., the hard boulders found in the soft mass of weathered granite were formerly quarried by Masterson & Armstrong of Redding, but at present this quarry is abandoned.

Better quarries could be opened in the county, provided transportation facilities to bring the material to market were at hand.

TULARE COUNTY.

Mr. Bartlett, of Porterville, is quarrying granite for building purposes in the foothills of the Sierra Nevada Mountains, 3 miles northeast of Porterville. The stone that is quarried for building purposes is obtained in a gap of the ridge close to the north end of the granite outcrop. The mountain on the south side of the gap is all granite; on the

north side the granite extends probably a third of the distance up the hill, where it meets the magnesite-bearing serpentine. (See under Magnesite, page 333.) The granite is quarried on both sides of the gap from the surface boulders, most of which are rounded by concentric weathering. Some are partially disintegrated over the surface, while others are sound to the surface, but all are sound in the interior. The rock is a biotite granite of medium-coarse grain. It has a fairly straight cleavage and takes a nice polish. The rock mass is intersected by a great many joint planes, hence the stone does not occur in large dimensions, but blocks large enough for ordinary building purposes are



ILL. No. 21. SHED AND YARD AT ROCKY POINT GRANITE QUARRY. TULARE COUNTY.

obtained. The supply of granite here is practically unlimited. The stone is now being used in the construction of a bank building in Porterville.

Rocky Point Granite Quarry, in Sec. 8, T. 19 S., R. 27 E.; Griffith & Owens, of Exeter, owners. The granite is a gray syenitic rock, of very uniform texture and color, which splits readily in any direction and takes a fine polish. It occurs in large detached masses and flattened beds; the pitch of the latter is a little east of north, at an angle of about 30 degrees. These beds or layers vary from 2 to 25 feet in thickness, and are so situated that a back of any required height may be obtained to the quarry. The "rift" appears to be east and west. All drilling

is done by hand. Powder is used only to break the larger pieces, while the dimension stone is split by plugs and feathers. Any desired size of building stone is obtainable. The company also operates a yard in Exeter for dressing and polishing the stone before shipping. (See XIIth Annual Report of California State Mining Bureau, 1894, page 387.)

TUOLUMNE COUNTY.

Phoenix Lake Granite Quarry, in Sec. 23, T. 2 N., R. 15 E.; J. M. Phillips, general manager, Builders' Exchange, 26 Jessie street, San Francisco. The quarry is located at the head of Phoenix Lake, about 7 miles northeast of Sonora. The granite is hauled by wagon to a siding of the Sierra Railway Company, about 2 miles above Sonora. The stone is a very fine-grained granite, a sprinkling of small crystals of biotite giving it a gray color.

YUBA COUNTY.

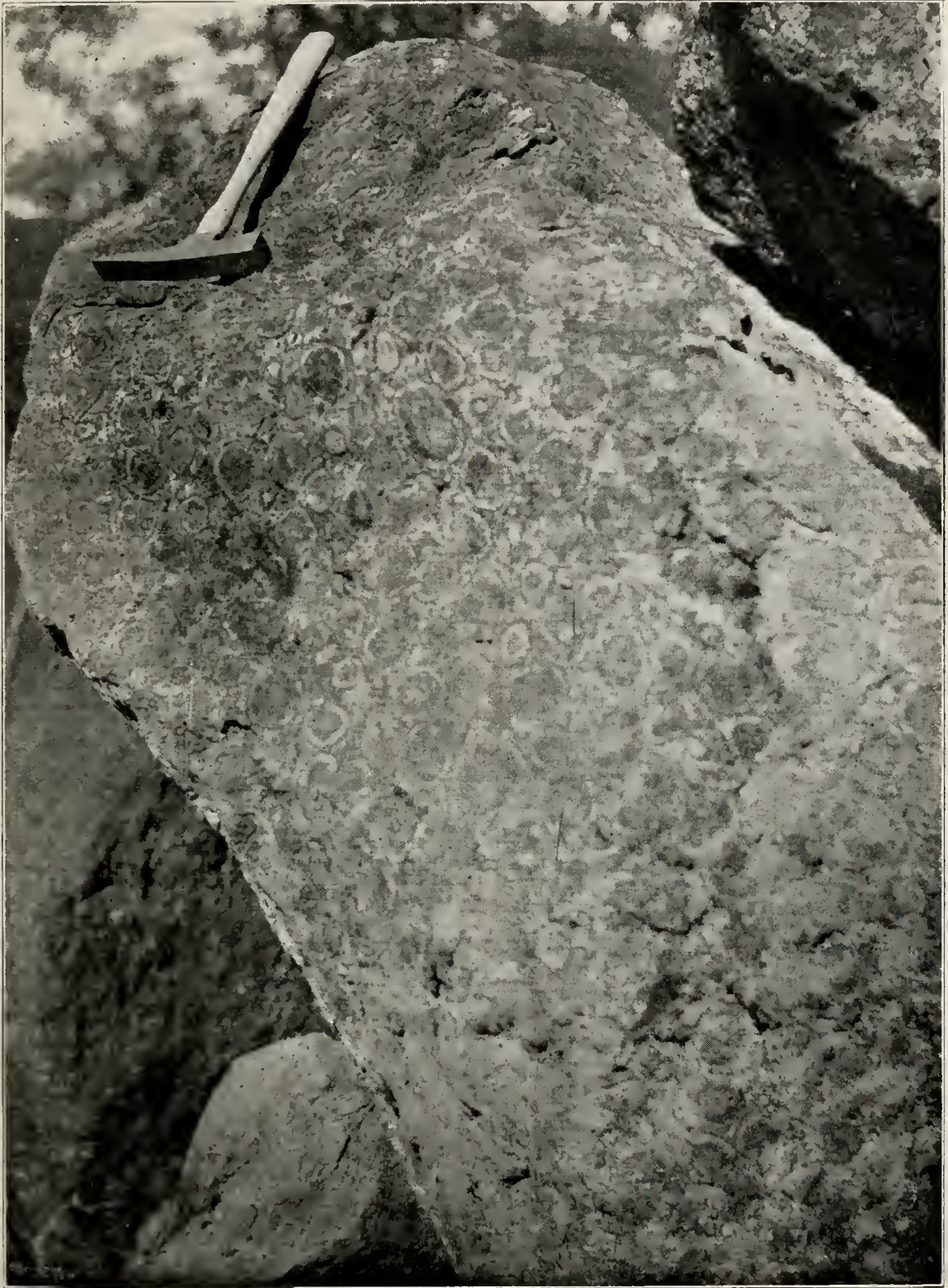
Granite, of a quality suitable for structures, occurs in Yuba County on the east side of Willow Creek, in Sec. 9, T. 18 N., R. 8 E., 2 miles by wagon road southwest from Camptonville. Willow Creek, from this point southwest and west to its confluence with the North Yuba River, appears to mark the northern end of the granite belt which extends west to the North Yuba River.

GRANITIC ROCKS.

SAN DIEGO COUNTY.

Dehesa Quarry, N. Kessler and Marion Powers, Dehesa, owners. On the north side of the Sweetwater River, a few miles east of El Cajon, is a large mass of gabbro, portions of which are orbicular and are highly ornamental on a polished surface. This rock is mentioned in the XIth Annual Report of the State Mining Bureau, page 95, by H. W. Fairbanks. The orbicular rock was first discovered by Marion Powers, of Dehesa. Prof. A. C. Lawson, of the University of California, gave a short description of it in "Science" (Vol. XV, p. 415), and a more extended description of it in Bulletin No. 17, Vol. III, Department of Geology, University of California. See also Bulletin No. 37, "Gems, Jewelers' Materials, and Ornamental Stones," State Mining Bureau. W. H. Kessler and W. R. Hamilton, of Stanford University, made a study of this rock and published an excellent illustrated description of it in

the American Geologist for September, 1904. The Mining Bureau is indebted to these gentlemen and to the American Geologist for the cuts



ILL No. 22. BOULDER OF ORBICULAR GABBRO.

of the orbicular gabbro shown in this Bulletin. Free use of both of the above papers has been made in the following pages.

The gabbro occurs apparently as an intrusive boss in the midst of

the granites. It outcrops over an area of about a square mile on the hill at Dehesa, and is said by Fairbanks to extend 4 or 5 miles southeast. The hill on which it occurs extends about 1200 feet above the river and 1800 feet above sea level. On the slopes in the central portion of the gabbro mass there are scattered boulders of the orbicular



ILL. No. 23. SECTION OF ORBICULAR GABBRO, SHOWING GENERAL APPEARANCE.

White minerals are feldspars. Dark minerals are olivines, hornblendes and hypersthene. Thickness, about 2mm. Natural size.

rock. The boulders vary in size, some of the larger ones being several feet in diameter. The orbicular rock has not been found in place.

There are several varieties of the orbicular rock, based on variations in texture. The most common variety is one in which there is a ring of feldspar around the outside, surrounding the nucleus composed of a crystalline aggregate, much like the groundmass of the rock. Another

variety consists of spheroidal bodies which do not show either concentric or radial structure. They appear to be harder and of firmer texture than the surrounding material, and on the disintegration of the rock by weathering, the rounded balls remain like pebbles in the residuum. A third variety has both radial and concentric structure.

The rock is composed of plagioclase feldspar, hornblende, hypersthene, and iron oxide. It varies considerably in texture outside of the spheroidal masses, portions of the mass being a rather finely crystalline aggregate, with parts quite coarsely crystalline. Some of the hornblende crystals in place along joint planes are several inches in length. The basic character of the orbicular portions is shown by the analysis of the orbule, one of the round portions of the mass.

Analysis* of Orbule of the Orbicular Gabbro.

	I.	II.
Silica (SiO ₂)	40.50	39.76
Aluminum (Al ₂ O ₃)	23.01	22.71
Iron (FeO)	11.96	11.96
Magnesia (MgO)	12.24	12.56
Lime (CaO)	11.44	11.39
Soda (Na ₂ O)	1.19	1.33
Potash (K ₂ O) .....	.40	.37

Analysis† of the Feldspar of the Orbicular Gabbro.

Silica (SiO ₂)	44.39
Aluminum (Al ₂ O ₃)	36.55
Lime (CaO)	18.67
Soda (Na ₂ O) .....	.83

Analysis indicates anorthite or nearly pure lime feldspar.

The orbicular gabbro is adapted to interior decoration, because of its variegated texture and coloring. Without being gaudy or bizarre, it has a rich coloring and a unique configuration that will catch and please the eye.

No very definite estimate could be made of the quantity of this stone available. It occurs on the surface only in boulders, and these form but a small percentage of the boulders on the hillside. The occurrence of the boulders is such as to leave one in doubt as to whether they came from a single dike or vein-like portion of the mass, or from several separated portions of the whole mass.

The number and size of the boulders scattered over the surface indicate that there is considerable stone here for commercial purposes, and exploitation may at any time reveal the rock in place. If it should be found in place in sufficient quantities to furnish a constant supply to the market, and to fill any orders in reasonable time, it ought to readily find a place among ornamental stones. It is almost unknown as a

* University of California, Department of Geology, Bulletin No. 17, Volume III, p. 394. Analysis made by James W. Howson.

† Analysis by W. T. Schaller.

commercial product, so that architects would be slow to use it until assured that it is obtainable in quantity.

Orbicular gabbro occurs elsewhere in California. There is a specimen in the museum of the State Mining Bureau from Rattlesnake Bar, El Dorado County, which was sent in by John Muir, and labeled "Orbicular Diorite (Napoleonite)."

Orbicular gabbro from Sierra County and norite from Plumas County are described by Turner.* His description indicates that, while part of the stone is similar to that at Dehesa, there are some varieties which



ILL. No. 24. ORBICULAR DIORITE MINE, DEHESA, SAN DIEGO COUNTY—NEAR VIEW OF OUTCROP.

have not been observed at the latter point. He says that not many of the orbicules are strictly orbicular, but that one of the finest is kidney-shaped, $4\frac{1}{2}$ inches long and $1\frac{3}{4}$ inches wide. (See photograph in 17th Annual Report, U. S. Geological Survey, pl. 30.) There is nothing in Turner's description to indicate the quantity of the orbicular stone in the above localities, nor whether it occurs in boulders or ledges, nor the possible sizes obtainable.

Orbicular granite is said to occur in Rhode Island and in Ontario, but so far as known, no commercial use has been made of it in either

*14th Report U. S. Geological Survey, Pt. II, p. 474, and 17th Report U. S. Geological Survey, Pt. I, p. 642.

place. The same is true of the locality in Davie County, North Carolina.*

Persons desiring further information on orbicular gabbro, diorite and granite are referred to the papers by Kessler and Hamilton, by Lawson, by Adams, and by Watson, each of which contains a bibliographical list of references to the papers on this subject.

LIMESTONE AND LIME.

LIMESTONE.

Distribution of Limestone in California.—Limestone is pretty well distributed over the State of California; no very large area is entirely without it, yet the deposits are not continuous over large areas. The stone is in some places several hundred feet thick, but, as a rule, it extends only a short distance on the surface.

Uses of Limestone and Lime.—Limestone is used for building and ornamental purposes, mostly, however, in the metamorphic form—marble. It is further used to burn lime. The lime burned at Suisun, Napa Junction, and Colton is principally used in the manufacture of cement, and in the near future much of that from other points will be so used, as the cement industry is increasing very rapidly.

The numerous large beet-sugar factories in the State use large quantities of lime, several of the productive quarries being operated for the sugar factories alone. The manufacture of beet-sugar is an industry that is liable to increase greatly in the near future of California, and hence an increased demand for lime for this purpose.

The remainder of the product is used for furnace flux, as a fertilizer, for mortar and plaster in building operations, in glass manufacture, and other minor industries.

The California limestones belong in several different geological periods, were formed under different conditions, and hence differ considerably in structure, texture, and composition. The limestones of Santa Cruz, Kern, San Bernardino, and San Diego counties are all highly metamorphosed and associated with granites. Their geological age is indefinite, but is probably as old as the Paleozoic. The deposits at Suisun and Concord are travertine, and probably of recent age.

*Orbicular gabbro, diorite from Davie County, N. C., by Thos. L. Watson, *Journal of Geol.*, Vol. XII, p. 294.

PRODUCTION OF LIME AND LIMESTONE IN CALIFORNIA FOR 1904.

COUNTIES.	LIME.		LIMESTONE.	
	Barrels.	Value.	Tons.	Value.
Amador	1,700	\$1,700		
Calaveras			3,500	\$5,500
Contra Costa	12,187	10,359		
El Dorado	12,864	7,075		
Kern	178,038	172,000		
Los Angeles	10,000	10,000		
Mono	215	850		
Monterey	3,240	3,240	4,550	21,500
Riverside	20,000	20,000		
San Bernardino	25,000	21,500	28,421	42,575
Santa Barbara			6,000	12,000
Santa Cruz	293,207	306,775		
Shasta	18,000	10,500		
Sonoma	1,500	2,250		
Unapportioned			1,236	11,132
Totals	565,951	\$566,249	43,707	\$92,707

Total value of lime and limestone, \$658,956.

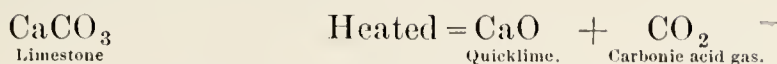
From this it will be seen that the total value of the lime produced in one year is \$566,249, and of the lime and limestone nearly \$660,000. Lime is produced in twenty counties. The limestone is given as used for furnace flux, beet-sugar manufacture, and paving. The part that is used in the sugar factories is first made into quicklime, and that used for furnace flux is reduced to lime in the furnace; hence, all the limestone quarried in the State is used for lime except the little that is used for paving and concrete. The above table does not include the large quantities that are used in the manufacture of Portland cement, nor does it include that used for marble and onyx.

LIME.

Lime is the oxide of the metal calcium (CaO), and in some form is the basis of all the mortars and cements used in building operations. In a comparatively pure form it is common lime, caustic lime, or quicklime. When mixed with a considerable percentage of clay or silica it forms poor or meager limes, and with the increase of clay it forms hydraulic lime, and when mixed with clay in proper proportions it forms cement. Lime combined with sulphuric acid forms calcium sulphate, which forms the plaster of paris cements.

Burning.—Lime is produced commercially by heating common limestone in heaps or in specially constructed furnaces known as limekilns. Limestone consists of the carbonate of lime, which when heated at high

temperature loses the carbonic acid, which passes off as a gas, and the oxide of lime for quicklime remains.



Limestone begins to lose its carbonic gas at about 750° F., but requires a temperature of over 1300° F. before it is all driven off. In chemically pure lime carbonate, there are 56 per cent of lime and 44 per cent of carbonic acid, but there is nearly always present a considerable percentage of moisture and organic matter, which are driven off, and generally a varying percentage of clay, magnesia, iron oxide, etc., which are not driven off, in the burning. So the actual percentage of lime may vary from 55 per cent or more to 30 per cent or less of the stone. The moisture in the stone facilitates the burning, so that a freshly quarried moist stone is more readily reduced than a dry stone. Hence a dense, compact stone is reduced with greater difficulty than a porous one, but the quality of lime is better.

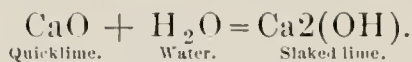
It is desirable to have the lumps of stone of a nearly uniform size as they are put into the kiln. If there are a few large pieces, either they will not be calcined to the center and hence will not slake, or there will be a waste of fuel in heating the smaller pieces after they have been calcined.

The burning may be done in open fire where a small quantity of lime is wanted for local use. Where any considerable quantity of lime is desired, kilns are constructed.

Limekilns.—There are two classes of kilns in general use: the intermittent kiln, which is used only when a small quantity of lime is wanted, and the continuous kiln, which is the kind in general use. There are many different types of the continuous kiln, which resemble each other in that the burning process is a continuous one from the time the fire is started until it is extinguished for repairs, or for some other purpose. In the first class the fire is intermittent, as the name indicates. The kiln is filled or partially filled with stone, and what is estimated to be sufficient fuel to drive off the carbonic acid is put underneath and mixed with the stone and fired. The kiln is permitted to cool after the fuel is burned and the lime is drawn.

There are many different kinds of continuous limekilns, some of which are covered with patents. They may all be divided into two classes, in one of which the fuel and limestone are put in the kiln in alternate layers, and in the other, the fuel is burned in furnaces and only the flames enter the kiln. The objection to the first class is that the ashes of the fuel are mixed with the lime and injure it more or less. So serious is this objection that kilns of this type are gradually being replaced by the shaft kiln.

Slaking Lime.—When water is added to quicklime, it combines with it chemically and forms the hydrate, the hydroxide, or slaked lime; thus,



This process is accompanied by the evolution of heat, which is most prominent in the rich or fat limes and decreases with the increase of impurities. As the change from lime carbonate to the oxides causes a decrease in bulk (usually about 6 per cent) and a decrease in weight (about 40 per cent), so the addition of water causes an increase in both weight and volume.

Uses of Lime.—Probably more lime is used in mortar than for any other purpose. For this it is first slaked and then mixed with sand, when used for binding masonry together and for wall plaster. It is also used without the sand for whitewashing.

Some of the other purposes for which lime is used are: (1) dehydrating alcohol; (2) disinfectant; (3) dyeing; (4) fertilizer for agricultural purposes; (5) flux and glaze in pottery manufacture; (6) furnace flux; (7) furnace hearths; (8) furnace linings where the basic steel process is used; (9) insecticide; (10) manufacture of aqua ammonia; (11) manufacture of boneash; (12) manufacture of calcium carbide; (13) manufacture of gas; (14) manufacture of glass; (15) manufacture of paper; (16) manufacture of potassium dichromate; (17) manufacture of soap; (18) manufacture of soda; (19) molds and crucible; (20) oxy-hydrogen light; (21) polishing material; (22) refining beet-sugar; (23) tanning, in removing the hair from the hides.

ALAMEDA COUNTY.

J. D. Collins, Livermore, owner; in Sec. 30, T. 2 S., R. 3 E. A small outcrop of crystallized limestone occurs on summit of hill, 6 miles north-east of Livermore. Undeveloped.

AMADOR COUNTY.

Amador County Limekiln; **J. H. Bonham**, Ione, proprietor; **Theo. Gebhart**, Ione, manager. Situated about 4 miles by wagon road north of east of Ione. The lime is burned in an intermittent stone kiln erected by Mr. Bonham in 1859, which has been in operation ever since that time. They first gathered up the limestone boulders over the surface, and later opened two quarries, one at the kiln and another some distance southeast of the kiln.

The stone at the kiln is a compact, blue-gray, stratified limestone, which is quarried by hand and lifted by a derrick to the top of the kiln. It is burned with wood obtained in the vicinity of the kiln. It appears

to be a comparatively pure carbonate of lime, which gives good satisfaction for plaster and mortar. It is used almost exclusively in the buildings in Amador County, and is delivered by wagons from the kilns. None of it is shipped out of the county. The production was 1700 barrels of lime in 1904.

The deposit at the quarry shows a thickness of more than 100 feet, and as the contact on either side is not exposed, the total thickness of the bed is not shown, but from the scattered outcrops in the vicinity of the quarry it appears to be quite heavy and apparently inexhaustible.

The numerous fissures and joints in the stone prohibit the quarrying of dimension stone for building purposes, but it is admirably adapted for use as quicklime.

BUTTE COUNTY.

The limestone deposits of Butte County are described under the headings "Cement" and "Marble."

CALAVERAS COUNTY.

Genelli Ranch.—At the Genelli ranch, one mile north of Vallecito, some marble has been burned in a crude kiln for use as lime in that vicinity, but only at intervals and not for shipment. There is an unlimited supply of limestone in this vicinity.

Mereer's Cave, in Sec. 31, T. 4 N., R. 14 E., M. D. M.; W. J. Mercer, of Murphys, owner. This wonderful work of nature lies just off the Sierra road, $1\frac{1}{4}$ miles northwest of Murphys, and was discovered in 1885 by the owner. It occurs in the limestone belt that passes through Murphys, and consists of several chambers, which are connected by stairways and lighted by electricity. The first room is 200 feet long, 60 feet wide, and 58 feet high, with thousands of stalactites hanging overhead and on the walls in the most fantastic shapes. The entire cave is 362 feet long and about 150 feet deep.

Markwood Quarry, in Sec. 32, T. 5 N., R. 11 E.; George Markwood, Sr., Fosteria, owner. The rock is occasionally quarried for use as flux at the smelter at Campo Seco.

McNamara Quarry, in Sec. 32, T. 5 N., R. 11 E.; Charles McNamara, Fosteria, owner. The limestone occurs in highly tilted slates. It is operated intermittently to furnish stone for fluxing purposes at the smelter at Campo Seco.

Plaza Limestone Quarry, in Sec. 32, T. 5 N., R. 11 E.; Penn Chemical Works, Campo Seco, owner. The entire output is used for flux at the company's smelter at Campo Seco.

Young's Quarry, in Sec. 4, T. 4 N., R. 11 E.; A. & D. Young, Fosteria, owners. This is the largest limestone quarry in the vicinity. Formerly the owners burned some lime, but of late years the quarry has been idle except when rock was sold to the smelter at Campo Seco for use as flux. The limestone croppings extend for about three fourths of a mile in a general northwesterly and southeasterly direction.

The limestone in the quarries near Fosteria is a compact, fine-grained, dark blue rock, colored by carbon, which readily burns out, producing a good lime.

COLUSA COUNTY.

Lambert Ranch, in Sec. 20, T. 16 N., R. 5 W.; J. T. Rathbun, College City, owner. A deposit of limestone, from which lime was burned about fifteen years ago.

Manzanita, in Sec. 29, T. 14 N., R. 5 W.; G. V. Northey, Sulphur Creek, owner. Lime is produced from coarse crystalline limestone deposits, for retorting and local use. Only a small quantity has been marketed.

CONTRA COSTA COUNTY.

Col. Coates, in Sec. 15, T. 1 N., R. 1 E., M. D. M. Limestone occurs on the property of Col. Coates, in Oil Cañon. The outcrop is similar and adjoins the deposit belonging to Mr. Harkinson.

Henry Cowell Lime Company's lime quarries lie 3 miles south of Concord, in the foothills on the northwest end of Mount Diablo. The rock is a travertine, which outcrops over a considerable area in the vicinity of the quarries. It varies in character, a large part of it being a very compact drab-colored stone, very faintly banded. In places it is bluish colored, and brecciated. Part of the stone is a snow white, porous, light tufa, which is irregularly mixed through the other rock. The compact rock, because of its high specific gravity, is thought to be aragonite.

There are two quarry openings. The one now in operation is an irregular, funnel-shaped opening, about 50 feet deep and covering probably about half an acre at the top. The other quarry is on the point of the hill, about one eighth of a mile south of west from the first mentioned and 50 feet or more above it, and has a face of 50 feet of limestone. The only covering over this stone at either opening is a thin layer of dark-brown adobe. The stone is cut by numerous seams and cracks, which cause it to come from the quarry in such small dimensions that there is very little of it that needs further breaking for the limekiln.

The stone is hauled by wagon from the quarry to the kiln on the railroad at Concord, where it is burned ready for shipment. At present (August, 1904) some unburned stone is being shipped.

Harkinson Lime Deposit, in Sec. 16, T. 1 N., R. 1 E., M. D. M.; R. Harkinson, Antioch, owner. The deposit, which is about 7 miles southwest of Antioch, in Oil Cañon, has been developed by a tunnel. The



ILL. No. 25. LIMESTONE QUARRY OF HENRY COWELL LIME AND CEMENT COMPANY, CONCORD, CONTRA COSTA COUNTY.

rock is an amorphous, compact, bluish-gray, fossiliferous limestone. Very little of the rock has ever been shipped.

EL DORADO COUNTY.

Alabaster Cave, W. T. Holmes Lime Company, 24 Sacramento street, San Francisco, owner, is about 7 miles east of Newcastle, on the east side of the American River, and about three fourths of a mile above the suspension bridge. It occurs in a crystalline, granular, white, and clouded white and blue limestone, which lies in a stratum about 50 feet thick, inclosed by mica-schists. The limestone layers are standing vertical and have a north and south strike parallel with the cleavage of the schist. It forms a bold outcrop on each side of a small cañon that cuts through it. The Alabaster cave from which the place is named is

on the roadside on the north side of the cañon. A lime quarry was opened on the hill immediately above it, and a stone kiln in which the lime was burned is on the roadside, but they have not been used for several years.

On the south side of the cañon and a few hundred feet from the cave is a large stack kiln, in which is burned the lime from the stone quarried just above it. This quarry has been worked to a depth of 50 feet, about 300 feet long, and to the full width of the limestone. The lime rock is brought on tram-cars to the top of the kiln, which stands on the hillside below the level of the quarry.

The stone at the above quarry is a compact, heavy, medium-coarse, crystalline limestone, free from impurities, except a few parallel bands of schist which are inclosed in it. Some of these schist bands are disintegrated to the depth of the quarry opening, and the rotten schist is easily separated from the limestone; but some of the schist is not disintegrated and is not so easily separated from the limestone, and hence causes some waste in the quarrying.

The stone is burned with wood in the kiln at the quarry and hauled in rawhide sacks by wagon 7 miles to Newcastle, on the Southern Pacific Railroad. It is mostly shipped to Sacramento and handled by the Sacramento Lime Company.

At **Cave Valley**, east of Auburn, is another limestone quarry and limekilns.

Henry Cowell Lime Company.—It is reported that about 2 miles north of Cothrin station, on the Placerville branch of the Southern Pacific Railroad, the Henry Cowell Company owns and operates a large lime quarry and kilns. The lime is shipped from Cothrin station.

Limestone is said to occur in small, isolated, lenticular masses in a number of places in the county. The limestones are thought by Mr. Lindgren to be of Carboniferous age.*

FRESNO COUNTY.

Limestone is found in large quantities in T. 12 S., R. 26 E.; T. 12 S., R. 27 E.; T. 12 S., R. 29 E. It extends for several miles in length, with an average width of $1\frac{1}{2}$ miles. The limestone in this section is of good quality and years ago considerable of it was burned, but nothing is being done with it of late years, owing to its distance from a market.

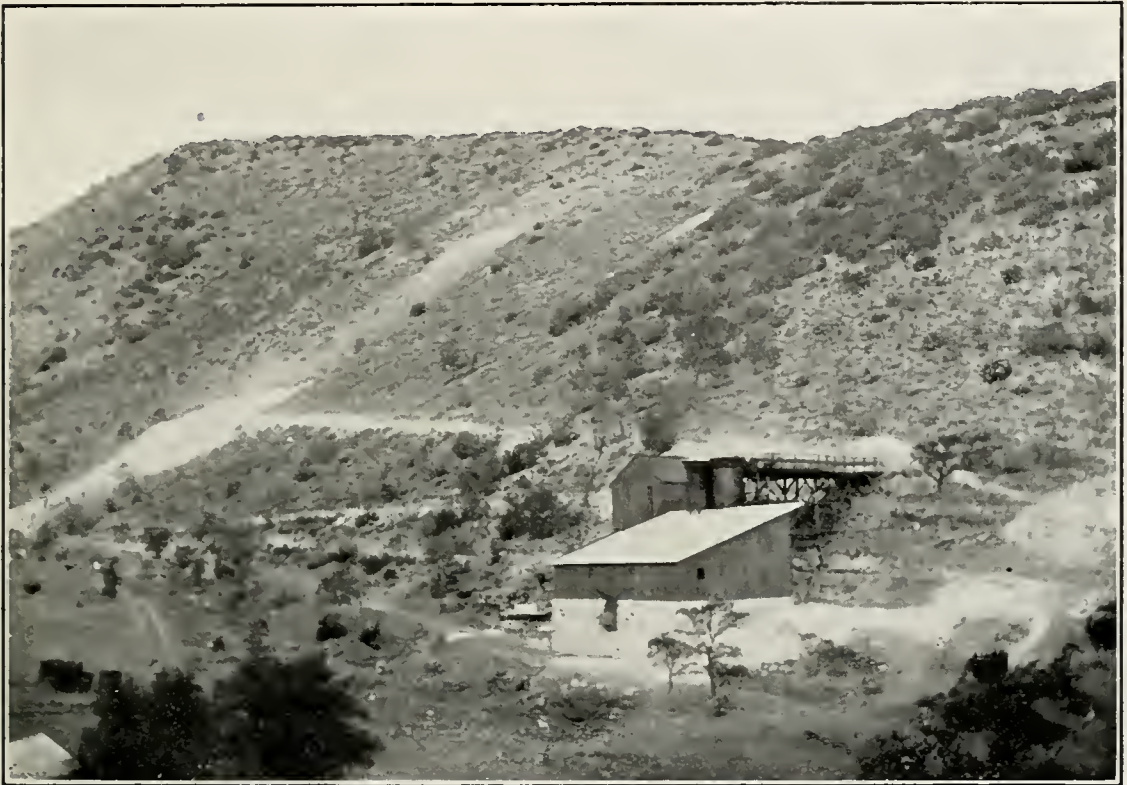
Dunlap.—An undeveloped vein of calcite, 30 feet wide, is found near Dunlap.

Sampson's Flat.—A heavy ledge of blue limestone, suitable for the production of lime, is found at Sampson's Flat, on Kings River.

*Sacramento, Folio No. 5, U. S. Geological Atlas.

KERN COUNTY.

The lime industry is a large and important one at Tehachapi, Kern County, on the Southern Pacific and Santa Fé railroads. The industry began a great many years ago by burning the lime for local use, and then for shipment to other points, until now the Tehachapi lime is known all over southern California. The first lime was burned in the rudely constructed "pot kilns," built of stone, some of them brick-lined. At present the lime is all burned in modern kilns. Sometimes oil and sometimes wood is used for fuel. The oil is the cheaper fuel, but it

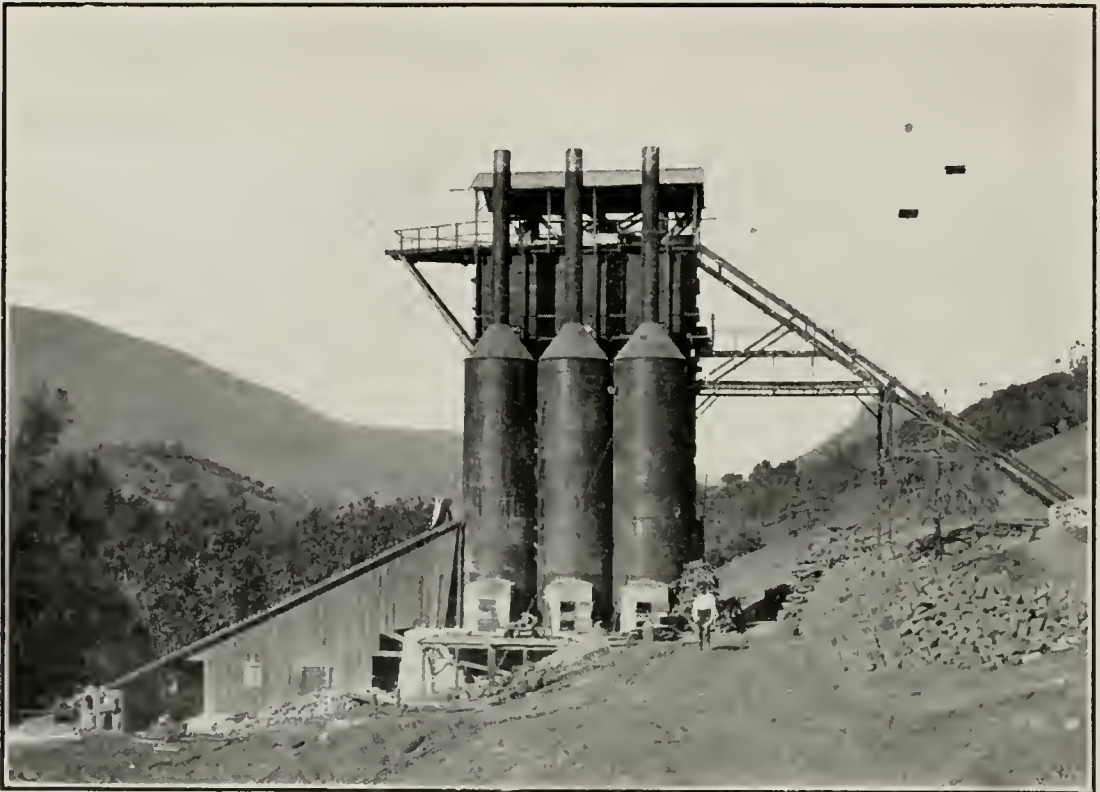


ILL. No. 26. JAMESON LIME COMPANY'S KILNS, TEHACHAPI, KERN COUNTY.

is claimed that for certain purposes the lime made with oil is inferior to the wood-burned lime, hence part of it is burned with wood. The wood is obtained on the hills about the quarries, where it grows in considerable quantities.

Limestone outcrops at many other points in this area, where it is possible to open quarries in the future. There have been a number of small quarries opened at different points, where the lime has been burned, mostly for local use, but from some of the quarries it has been shipped to different points. None of these were in operation in 1904. From one of these quarries in the vicinity of Tehachapi some marble is said to have been quarried and shipped a few years ago.

Jameson Quarry, Jameson Lime Company, Tehachapi, owner. On the north side of the great Tehachapi Valley is a broad belt of limestone that forms the bordering hills of the valley. The quarry is located in a small cañon about half a mile from the border of the valley. The hillside on which the quarry is located is 400 feet or more in height, and shows limestone outcroppings all the way to the top. The opening from which the stone is taken at present (July, 1904) is about 100 feet above the bottom of the cañon, and several other smaller openings have been made at different heights on the hill. The hill is apparently all limestone, except



ILL. No. 27. MOUNTAIN SUMMIT LIME COMPANY'S KILNS AT KEENE, KERN COUNTY.

a few small clay seams in places and some chalcedonic chert near the middle of the slope. The slope on the south end of the hill and the talus slope below contain a great quantity of chert fragments which are remnants from the weathered limestone, and appear as a rusty brown mantle on the surface.

The limestone is coarsely crystallized and of a prevailing blue color, but portions of the deposit are white and in places white and blue banded. The rock is much fractured and weathered on the surface. The limestone, as exposed over a belt more than half a mile in width and at least several hundred feet in thickness, with practically no overburden, shows an unlimited available supply.

Two modern kilns, constructed in the summer of 1903, are in opera-

tion. The lime is burned mostly with oil, but some wood is used. It is put in barrels at the kiln and transported by wagon to the railway at Tehachapi.

Mountain Summit Lime Company, 324 Requiena street, Los Angeles, owns a large lime quarry at Keene station, 8 miles northwest of Tehachapi. Large quantities of lime are burned and shipped to various points. The limestone and the resulting lime are said to be similar to that at Tehachapi.

Union Lime Company, 203 San Pedro street, Los Angeles; A. L. Foster, Tehachapi, superintendent. The quarries are on the south side of the val-



ILL. No 28. QUARRY AND KILNS OF THE UNION LIME CO., TEHACHAPI, KERN COUNTY.

ley. The limestone occurs in heavy beds, with more or less inclusions of schist. The biotite mica in the schist is frequently badly disintegrated and stains the adjoining limestone with iron rust. The rocks are sharply folded and much shattered, so that large dimension stone is not available. The limestone is all crystallized; in some places coarse-grained and elsewhere fine-grained. It varies from white to light blue in color, the prevailing color being a bluish gray. In one place in the quarry of the Union Lime Company the stone is finely banded, blue and white, with a fine, compact, saccharoidal texture. It might be quarried with profit to a limited extent, in slabs of several square feet, utilizing the fragments for the limekiln. These slabs could be used for interior decoration and for cabinet and panel work.

The limestone lies apparently in a closely compressed syncline, which has a general trend or strike about N. 75° W. Both strike and dip vary in direction as well as in angle.

There are several quarry openings scattered along the hillside over a distance of half a mile or more. In one of the largest is a quarry face of about 300 feet which is worked at several levels. The stone is quarried by blasting and is run from the quarry to the kilns on tram-cars. It is needless to add that there is an unlimited amount of limestone available at this locality.

There are at least two other ledges of limestone south of the Union Lime Company's quarry, one of which, about one mile south in a side cañon to the west, was quarried some years ago and the lime burned in a pot-kiln at the quarry. The limestone at this point is only about 10 feet thick and dips 45° N. 40° W., which soon carried it so deep into the hill that it became expensive removing the overburden. The associated rocks are granite, schist, and porphyry.

The company has five kilns at the railway track one half mile below the station, and four more at the quarries 3 miles south of Tehachapi.

Pomona Lime, Cement, and Stone Company, Pomona, has a quarry in a body of crystalline limestone at Spadra, on the San Pedro, Los Angeles and Salt Lake Railroad, about 4 miles west of Pomona. This limestone is burned in a kiln close to the quarry.

MONTEREY COUNTY.

A belt of limestone shows in several places on the west slope of the Santa Lucia range, not very far from the coast line. Its most northern outcrop is on Long Ridge, in Sec. 9, T. 18 S., R. 1 E. It runs in a southern direction to Sec. 36, T. 18 S., R. 1 E., and Sec. 31, T. 18 S., R. 2 E. Another conspicuous outcrop of limestone is found in Sec. 30, T. 19 S., R. 3 E. Farther down the coast, in the southern part of the county, the limestone forms very steep escarpments along the shore. Another belt of white, coarsely crystalline limestone is found at the foot of the west slope of the Gabilan range, especially east of Salinas. These limestone exposures are remnants of a thin bed overlying the granite.

Henry Cowell Lime and Cement Company, 211 Drumm street, San Francisco, owns the former Rockland Lime and Lumber Company's plant at Rockland Landing, in Sec. 22, T. 22 S., R. 4 E. Formerly four continuous limekilns were in operation, but the plant has been idle for a number of years. (See also VIIIth Report of California State Mining Bureau, p. 480; XIIth *ibid.*, p. 392; and XIIIth *ibid.*, p. 629.)

Monterey Lime Company, Mills Building, San Francisco, owns limestone quarries and limekilns on Bixby Creek, about 3 miles from the

coast, in Sec. 16, T. 18 S., R. 1 E. Two quarries are opened on the north side of the creek. The limestone is much shattered and decomposed to considerable depths along the fissures. Where fresh, the rock is a white crystalline limestone, with grayish-blue streaks, closely approaching to marble. The surrounding rock is granite. The property is equipped with two patent continuous kilns of a daily capacity of 70 barrels, which were started in August, 1904; a similar kiln of 80 barrels capacity is under construction. The company produces two grades of lime, the Diamond M and common lime.

Spreckels Sugar Company, Salinas, owns several limestone quarries east and southeast of Salinas, located principally along Alisal Creek in the Rancho El Alisal and Rancho Cienega del Gabilan, about 6 miles from Salinas, in the belt west of the Gabilan range above described. The limestone is used in the beet-sugar factory. The rock is a very white, coarsely crystalline limestone, which makes an attractive white building stone, of which some rubble masonry has been made in Salinas.

An extensive deposit of limestone is reported in the Gabilan range, at the head of Chalone Creek, in the southeast corner of T. 17 S., R. 7 E., about 6 miles (air line) east from Metz, a station on the Southern Pacific Railroad.

Los Vergeles Rancho.—In lots 1 and 3 of the Los Vergeles Rancho; Mrs. J. H. Wythe, corner of Minnesota and Lincoln avenues, San José, owner; about 12 miles northeast of Salinas, on the San Juan road, several deposits of limestone occur, two of which are quite extensive. The stone ranges from a coarsely crystalline white and bluish-white calcite to a very compact, holocrystalline, fine-grained marble. It all averages very high in lime content and is suitable for cement and sugar purposes. Preparations are being made to open a quarry.

NEVADA COUNTY.

Formerly considerable lime was produced in Nevada County, but at present the supply is chiefly from outside sources.

Limekiln Smith's Property, in Sec. 4, T. 14 N., R. 8 E., Hull & Mitchell, Grass Valley, owners, was formerly a large producer of lime.

In Sec. 2, T. 15 N., R. 9 E., lime was formerly burned from a limestone ledge near the east bank of Greenhorn River.

ORANGE COUNTY.

Capistrano.—Sec. 31, T. 7 S., R. 7 W., S. B. M.; R. Egan, Capistrano, owner. A deposit of fossiliferous limestone, used by the padres to burn lime for the mission buildings.

El Toro.—A similar limestone was burned about 1888, but the kiln was abandoned after a campaign not lasting two years.

William Moulton.—Extensive beds of this fossiliferous limestone are found on Moulton's ranch, south of El Toro. (See Cement.) The following analysis of this limestone is reported: carbonate of lime, 96 per cent; silica, 2.5 per cent; alumina, 1 per cent; iron oxide, 0.5 per cent.

PLACER COUNTY.

Holmes Limekilns, in Sec. 33, T. 15 N., R. 9 E.; The Holmes Lime Company, 24 Sacramento street, San Francisco, owner. The works are on the east bank of Bear River, 2 miles west of Colfax. The quarry was operated for eight months in 1904, burning lime in one of the two kilns. This limestone was first quarried in 1870 for marble. (See under "Marble.") The exposure in the quarry is 200 feet wide and 50 feet high. About 2000 feet north the ledge crops for a length of 100 feet over a width of 40 feet. The general dip is to the east. There are 46 acres in the holding, including quarry, kilns, tramway, Pelton wheelhouse, reservoir tank, and storage house. The kilns are updraft. of 6 tons daily capacity each, though they have not been operated beyond 5 tons. Wood is used for fuel. The tramway for carrying the lime from the kilns to the storage house is 1000 feet long, at an inclination of 40 degrees, and operated by a 24-inch Pelton waterwheel.

Pacific Lime and Plaster Company, in Clipper Gap district; limekilns at Benicia, Solano County; D. Edward Collins, Oakland, president; W. O. Badgley, Oakland, general manager, with head office in San Francisco. The company, which began operations in January, 1905, at Clipper Gap, 5 miles northeast of Auburn, purchased 1353 acres within Secs. 16, 20, 21, 29, and 30, T. 13 N., R. 9 E. The extensive limestone deposits lie on the west side of the North Fork of the American River, following the southwesterly course of the river for a distance of 4 miles, extending in some occurrences to the bank of the river and in others a mile to the westward. Mr. Badgley states that the company decided upon the location of the kilns at Benicia because of economy in transportation of the rock, having both rail and water facilities for shipment of the product, and the availability of oil for fuel.

The same limestone belt is exposed near Murderers' Bar, on the American River. A kiln was erected at the deposit a number of years ago, but was never used.

PLUMAS COUNTY.

Limestone of a good lime-producing quality occurs in a great ledge extending half a mile north from the Last Chance mine, in Sec. 35, T. 23 N., R. 9 E., and south from the same point into Sec. 5, T. 22 N., R. 9 E., crossing Onion Valley Creek. Along this course the ledge varies in width from 100 to 300 feet. It extends also farther south through Secs. 17 and 20, but is not of equal body.

RIVERSIDE COUNTY.

Chino Quarry, in Secs. 2 and 3, T. 2 S., R. 5 W., S. B. M.; American Beet-Sugar Company, Chino, owner. A white marble found in boulders, with a great amount of waste, partly clay, partly débris. Has not been operated for the past ten or twelve years.

Sky Blue Marble and Onyx Company, E. W. Tucker, Eighth and Walnut streets, Riverside, general manager, operates a limestone quarry at West Riverside, about 5 miles northwest of the town of Riverside, in Secs. 2 and 3, T. 2 S., R. 5 W., S. B. M. The limestone occurs in one of the numerous buttes found in the northern part of Riverside and the southern part of San Bernardino counties, which are generally granite. This limestone butte at Riverside resembles in some respects the one at Colton. Both are mixtures of blue and white calcite, but the Riverside stone has a particularly deep and rich blue color. There are two beds of the limestone separated by granite and quartzite. The strata dip 25° N. 25° E., and at the north end of the mountain the limestone is underlaid by granite, which is followed by quartzite, and that in turn by another bed of limestone. The contact of the limestone with the granite and with the quartzite is quite sharp.

Analysis of Riverside Blue Marble.*

Lime (CaO).....	55.85
Equivalent to lime carbonate	99.73
Magnesia.....	0.30
Iron.....	trace.

The chemical analysis shows it to be a remarkably pure carbonate of lime, which verifies the appearance of the stone in the quarry.

Some of the limestone has been used for building purposes in Riverside and in Los Angeles, and some has been used for ornamental purposes in San Francisco.

There are two kilns at the quarry; the product is put on the market under the name of "Lily White" lime. About 75,000 barrels of lime have been burned at this quarry.

* John A. Wesener, analyst; copy of analysis furnished by the company.

By utilizing the small dimensions for quicklime, the quarry can be profitably worked and a variety of marble obtained different from that in any other known quarry in the United States.

The durability of the Riverside limestone is indicated by its strong topographic relief, where it stands up in prominent knobs in the midst of granite and quartzite.

Ferdinand Snyder owns a productive lime quarry 7 miles north of San Jacinto, on a branch of the Santa Fé Railway. The stone is coarsely crystallized limestone, and is said to make an excellent lime for the sugar refineries. There are two kilns in use, in which the lime is burned with wood, and shipped to different points in southern California. The quarry has been in operation for eight years.

SAN BENITO COUNTY.

A belt of white crystalline limestone runs along the east slope of the Gabilan range, in places forming the main ridge. (See XIth Report, California State Mining Bureau, p. 370, and Monograph XIII, U. S. Geological Survey, p. 181.)

M. Barbe, San Juan. Several exposures of this limestone in Secs. 9 and 15, T. 13 S., R. 4 E., and in the northern part of the Rancho Cienega de Gabilan. At present under bond to J. C. Kemp van Ee, San Francisco.

Henry T. Cowell, and the Holmes Lime Company, No. 22 Sacramento street, San Francisco, own large limestone quarries, near Cienega, along Thompson Creek, and in its vicinity, in Secs. 28, 29, 30, and 32, T. 14 S., R. 6 E.; also Secs. 14 and 24, T. 14 S., R. 5 E. This property was owned formerly by the Cienega Lime Company, which had several limekilns on Thompson Creek. Idle for the last six years. (See VIIIth Report, California State Mining Bureau, p. 488; XIth *ibid.*, p. 370; XIIth *ibid.*, p. 393; and XIIIth *ibid.*, p. 629.)

U. G. Harlan, Hollister, owns a limestone deposit in Secs. 23 and 24, T. 14 S., R. 5 E., on which he has a pot-kiln of 250 barrels capacity, and it is claimed burns a fair quality of lime for local use.

S. Lavagnino, San Juan, owns the old Twitchell kilns in the upper part of the Rancho Cienega del Gabilan, which have been idle for several years.

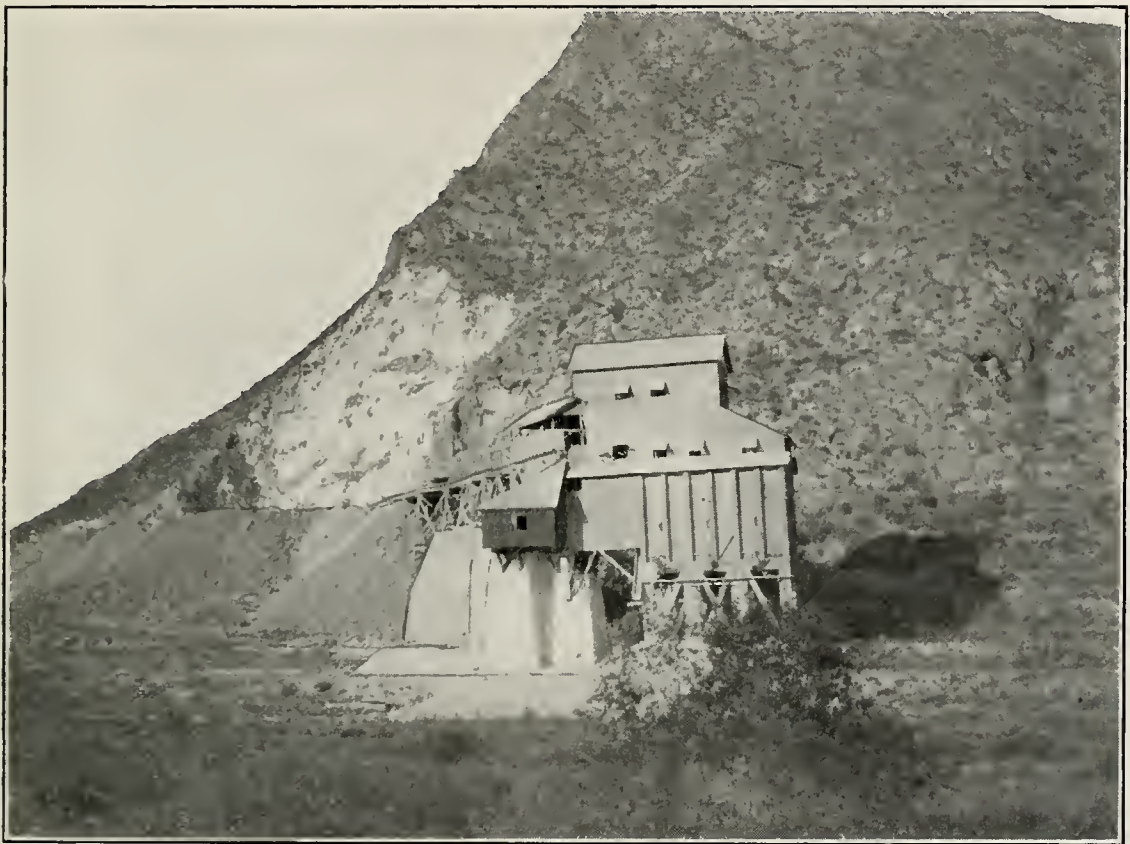
Los Vergeles Rancho, near San Juan. See Monterey County.

A. F. Underwood, San Juan, owns a limestone deposit in the northern part of the Rancho Cienega del Gabilan, adjoining the property of M. Barbe; under bond to J. C. Kemp van Ee, San Francisco.

SAN BERNARDINO COUNTY.

Mrs. O. Burns, San Bernardino, and Rev. P. J. Stockman, Santa Barbara, own a limestone deposit in Sec. 33, T. 1 S., R. 5 W., S. B. M., about $3\frac{1}{2}$ miles southwest of Slover Mountain. The exposure of limestone is small—not over 30 feet high and covers only a few acres. The limestone is white, coarsely crystalline, thinly bedded, and dips 45 degrees north-easterly. It is quarried and burned in a small kiln on the Santa Ana River, close to the hillock, but in Riverside County.

California Portland Cement Company, No. 401 Trust Building, Los Angeles, T. J. Fleming, general manager, owns Slover Mountain, in



ILL. No. 29. ROCK-CRUSHER AT COLTON LIMESTONE QUARRY, SAN BERNARDINO CO.

Secs. 19 and 30, T. 1 S., R. 4 W., S. B. M. This mountain is an isolated knoll of crystalline limestone, about 500 feet high. The limestone is generally very pure, especially the coarser crystalline variety, which runs $98\frac{1}{2}$ to 99 per cent of calcium carbonate. The lime burned from this limestone slakes very quickly and flashy, but must be slaked with a great amount of water to prevent it from being burned. The burned coarse variety shows small black specks (locally called fly-bitten rock). The fine-grained limestone is not so pure, but makes a better plaster. (See Marble and Cement.)

Oro Grande.—The limestones are interstratified with reddish-brown quartzites and brown shale. In the quarries the limestone varies from

60 to nearly 200 feet in thickness, but the total thickness or the total extent of the limestones in this region is not known. In the area surrounding the quarries are isolated outcrops of smaller lenticular masses of limestone. About 3 miles east of Victorville is another outcrop of massive, crystalline white and clouded limestone that would make a handsome marble.

The limestone is a hard, coarsely crystalline rock, mostly of a dark blue color, with numerous iron stains; but in the large quarry nearest the railway there is much white limestone stained with dendrite along the surfaces in the joint and cleavage planes.

In several places in the upper quarries there are great clusters of



ILL. No. 30. LIMESTONE QUARRY, ORO GRANDE, SAN BERNARDINO COUNTY.

calcite and aragonite crystals, which occur in long prisms, sometimes 4 or 5 inches long. The crystals have a brownish-yellow color from the iron stain. There is also considerable pyrite, in places some bornite, along the joint seams, the weathering of which gives rise to free sulphur in a number of places, and in places stains of yellow-brown iron rust. The impurities are not in sufficient quantity to materially injure the quicklime, but they are sufficient to disfigure it for use as a building stone.

The rock is so much fractured that no large dimension stone is available; but this texture is an aid for lime quarrying, where the stone

is used in small dimensions and must be broken up artificially if not done by nature. The quarrying is done by hand-drilling and blasting.

The quarries are located well up on the hillside, east of the railway, and northeast of the town of Oro Grande, in T. 6 N., R. 4 W., near the middle of the township. It is down grade, part of it quite steep, to the railroad. Some of the limekilns are located on the railway, several north and one south of the town of Oro Grande, and two of the kilns are on the hillside half a mile east of the railway. The stone is hauled by wagons from the quarries to the kilns. The quarries opened up in the vicinity of Oro Grande are:

Hoey Quarry; American Beet-Sugar Company, Oxnard, Ventura County. Idle last year.

Oro Grande Lime Company's Quarry; N. L. Morrow, 116 S. Avenue 20, Los Angeles. Idle for many years.

Summit Quarry; Oro Grande Lime and Stone Company (formerly Stimson & Fleming), Third and San Pedro streets, Los Angeles. This company manufactures the Red Star brand of lime, and ships limestone to the beet-sugar factories.

Superior Quarry; American Beet-Sugar Company, Chino, Los Angeles County.

SAN JOAQUIN COUNTY.

California Lime and Cement Company's Quarry, located about three fourths of a mile south of Carnegie. The company's offices are at 328 Montgomery street, San Francisco. The quarry was opened in 1900 and the lime was originally burned in an open kiln at the quarry, but at present the rock is hauled to the railroad siding at Carnegie and burned in a continuous oil-burning kiln, with a capacity of 200 barrels per day. The lime is only burned as it is needed for building purposes at Tesla and Carnegie. Some lime rock is shipped to the glass works at Stockton. The rock occurs in a series of aragonite veins, varying in width from 3 inches to 3 feet and dipping to the northeast at an angle of about 65 degrees. It is overlaid with crushed shales stained with iron. The quarry was opened for about 75 yards, with a face averaging about 40 feet high. Four prospect tunnels further developed the deposit and exposed considerable serpentine inclusions, which cause much waste in quarrying.

SAN LUIS OBISPO COUNTY.

A. Dubost, Adelaide. In Secs. 18 and 19, T. 26 S., R. 10 E., M. D. M., on the old Tartalja place, is a large exposure of limestone. Formerly A. Gould burned lime here. Idle for the last few years.

Dawson Lowe, San Luis Obispo. In the northwestern part of T. 32 S., R. 16 E., and eastern part of T. 32 S., R. 15 E., M. D. M., 15 to 18 miles east of Arroyo Grande, in the Huasna country. An extensive deposit of buff-colored limestone.

J. D. Morgan, Arroyo Grande. In Sec. 36, T. 32 S., R. 14 E., M. D. M., near the Loma Pelon, is a limestone cropping from 30 to 40 feet wide, which can be traced for a considerable distance in isolated patches along the highest points of the ridges. The rock is of a dark gray color. Several years ago some lime was burned in a kiln on Section 35 of same township. (See also VIIIth Report, California State Mining Bureau, p. 522.)

Miss Julia Newsom, Newsom Springs, Rancho Santa Manuela, $2\frac{1}{2}$ miles east of Arroyo Grande. The limestone crops out along the hillside, from 35 to 50 feet above the cañon, in a flat bed 5 to 6 feet wide. It is light colored, and mixed with clay. Some lime was burned here several years ago.

Mrs. R. Porter, Santa Barbara. In the Huasna country. (See D. Lowe, above.)

In the **Huasna Country**, on Government land, the same limestone is found. (See D. Lowe, above.)

In **Lopez Canon**, in the northern part of T. 31 S., R. 14 E., M. D. M., about 18 miles from Arroyo Grande, are extensive limestone deposits. The rock is coarsely crystalline, white colored, containing in places some clay and inclusions of shale.

Near **Oak Flat**, west of Paso Robles, an exposure of limestone is reported. (See Xth Report, California State Mining Bureau, p. 584.)

SANTA BARBARA COUNTY.

T. C. Lind, Lompoc, owns a limestone deposit on the south side of San Miguelito Cañon, opposite that on the property of the Union Sugar Company (see below), but whether it is part of the same reef is doubtful. Undeveloped.

Loma Blanco Lithographic Stone Company, Judge E. M. Ross, president; A. M. Cates, 310 Currier Building, Los Angeles, secretary. A deposit of fine-grained limestone, claimed to be appropriate for lithographic work. On the Moraga ranch, Secs. 4 and 5, R. 26 W., S. B. M., near the summit of the Santa Ynez range, in a very unapproachable country.

Th. W. Moore, Santa Barbara. On Las Positas ranch, on the Arroyo Burro, 3 miles from Santa Barbara. A slightly yellowish colored,

coarsely crystalline limestone. (See also VIIIth Report, California State Mining Bureau, p. 538.)

Union Sugar Company, Betteravia, Santa Barbara County, owns a deposit on the north side of San Miguelito Cañon, about 6 miles southwest of Lompoc, elevation 1150 feet, which has been leased for the last six years by W. O. Badgeley, 236 Bacon Building, Oakland; G. E. Badgeley, Lompoc, superintendent.

The stone is quarried and hauled by wagon 6 miles down grade to Lompoc, where it is shipped by rail to the large sugar factories at Santa Maria and Oxnard, being there calcined for use in refining the sugar.



ILL. No. 31. LOMPOC LIMESTONE QUARRY, SANTA BARBARA COUNTY.

The limestone occurs in a heavy ledge which dips northeast. The quarries are on the projecting knobs on the north side of the valley.

The rock is a soft, fossiliferous limestone, chalky in places. The upper part of the deposit is a coarse limestone conglomerate, with numerous siliceous pebbles. The stone has been badly shattered and broken in the uplift and contains many slickensides surfaces along the cracks and fissures. The limestone is of Tertiary age, as shown by the many fossil shells which it contains.

There are three quarry openings. The most northern one shows from 30 to 35 feet of white limestone overlaid by 25 feet of siliceous limestone conglomerate. The south opening shows about the same

thickness of limestone, which is stained yellowish brown in spots from the infiltrating iron-bearing waters. The middle opening shows from 10 to 15 feet of white limestone.

There is no building stone available at this quarry, owing to the friability of the limestone. It is adapted to use for quicklime because of the ease with which it can be quarried.

SANTA CLARA COUNTY.

El Dorado Sugar Company's Quarry, in Sec. 18, T. 7 S., R. 2 W.; Granite Rock Company, owner; Mr. Wilson, Watsonville, manager. This quarry is located on Black Mountain, 9 miles by wagon road from Mountain View, on the Southern Pacific Railroad.

The limestone is hauled by wagon to Mountain View, where it is shipped by rail, at the rate of 30 to 60 tons per day during the dry season, to the sugar factory at Alviso, where it is burned into quicklime and used in the factory. The quarry has been in operation for three years.

The limestone is thinly bedded and much shattered, compact to finely crystalline, of a gray to nearly black color, of the variety known as anthraconite; containing considerable organic matter and numerous small veins of white calcite. The strata are highly inclined, the dip being 55° N. 10° E. at the quarry. The limestone contains considerable dark gray to black chert, in seams 2 or 3 inches thick and in small irregular lenses. In places the limestone is shaly and contains much clay. In quarrying, the very thin layers break up into pieces too small for use. Hence the waste from the chert, the clay, and the small fragments causes considerable extra expense in the quarrying. The stone, however, when freed from the chert and the shale is said to make a most desirable lime for the use of the sugar-maker.

The stone has been quarried in several places. The present workings on the east side of the cañon near the base of the mountain have a face of about 35 or 36 feet, the upper 10 or 12 feet of which contain much black shale. The limestone extends to the top of the mountain, several hundred feet above the quarry.

The outlines of the limestone area, as that of other neighboring small patches, are shown on the U. S. Geological Survey Atlas sheet of this region.

The stone would make a good road material, as it is already in such small dimensions that there would be little expense for further crushing.

Los Gatos Lime Quarry; J. W. Taylor, San Francisco, owner. Located on the mountain 2 miles southeast of Los Gatos. There is a good road, all down grade, to Los Gatos, where the stone was hauled and burned

in kilns located on the bank of the creek in the town. The quarry has been idle for a number of years.

There are three quarry openings, exposing a total thickness of more than 100 feet of limestone. The rock is in thin layers from a few inches to 30 inches thick; the strata are more or less crumpled. The stone occurs in fragments of such small dimensions that no building stone could be obtained, but which adapts it to use for macadam or lime burning.

The limestone is very compact, fine-grained and quite brittle, with a flinty fracture, and locally contains many fine white calcite veins, also considerable inclusions of chert ("flint"), partly in continuous bands and partly in irregular lenses.

SANTA CRUZ COUNTY.

There are extensive beds of limestone northwest of the city of Santa Cruz. Four quarries are now operated in these deposits. The stone is a coarsely crystalline blue, and in places white limestone, much broken and shattered, and is overlaid by a dark brown and in places black adobe clay. In places the limestone appears on the surface through the adobe. The limestone is generally stained yellow and brown on the surface along the fissures by the clay and iron carried down by the percolating waters. With the exception of this surface stain, the stone appears to be a quite pure carbonate of lime. The texture is more variable than in many other localities; part of it is quite coarsely and part of it finely crystalline.

The stone has been used to some extent for rubble work in retaining walls and foundations and for macadam in the streets of Santa Cruz, but more of it has been burned into quicklime and shipped to San Francisco and elsewhere, besides that used locally.

Henry Cowell Lime and Cement Company, 211 Drumm street, San Francisco. The limekilns are located on the north side of the wagon road about one half mile west of Thurber's. There are three pot-kilns in use, in which the lime is burned with wood, and another stone kiln which is not in use. The lime is packed in barrels at the kilns and hauled by wagon to Santa Cruz, where it is shipped by rail or steamer.

Limestone was formerly quarried at the kilns, but at present most of the stone is hauled from a large quarry about half a mile up the cañon. This quarry, covering an acre or more, has a face of about 150 feet. There is a tramway from the quarry to the kilns, but for some reason this has been abandoned and the stone is hauled to the kilns by wagon.

Besides the large quarry, there are numerous smaller quarry openings along the sides of the cañon, from which large quantities of limestone

have been removed. The stone outcrops in the walls of the cañon in many places for more than half a mile above the quarries. It would appear from the outcrop in this cañon and at the quarries southeast and west, that a large part of this great peneplain is underlaid by crystalline limestone. As the adobe covers the surface everywhere except at the quarries and the outcrops along the cañon walls, the total extent of the limestone beds was not determined, but the quarries and outcrop clearly show several very heavy limestone beds, with a general dip to the northwest and separated by beds of schist and granite.

The same company has other kilns and quarries in a cañon about



ILL. No. 32. H. COWELL & CO.'S LIMESTONE QUARRY, $3\frac{1}{2}$ MILES NORTHWEST OF SANTA CRUZ.

2 miles west of those above mentioned, and about $3\frac{1}{2}$ miles from Santa Cruz. There are three large quarry openings, one of which has been abandoned, and several smaller openings. There are three large pot-kilns in use, in which the lime is burned with wood cut from the neighboring hills. The barrels are made in a cooper shop at the kilns, and the lime is barreled and hauled by wagon to Santa Cruz for shipment. The large quarry opening has a face of about 150 feet of comparatively pure, coarsely crystalline, white and blue limestone, overlaid by a few feet of dark brown adobe, which has washed down the numerous cracks, staining the surface of the stone. The next opening immediately adjoining the above mentioned on the west has a face of about 50 feet, and contains several pockets of clay. The next large opening

west has been abandoned and the lower level filled with water and waste material. In the cañon walls in the vicinity of these quarries are large exposures of limestone that have not been worked. The beds are very extensive, and are admirably exposed for quarrying by the deep cañon that has been cut down into them. The strata have a dip west of north, and the underlying rocks are exposed down the cañon.

Felton, a station on the Narrow Gauge Railway, 6 miles north of Santa Cruz, is the center of an important lime industry. Two separate beds of limestone, having a northeasterly dip and northwesterly strike,



ILL. No. 33. I X L LIMESTONE QUARRY, FELTON, SANTA CRUZ COUNTY.

form bold projecting ridges on the face of the mountainside west and northwest of Felton.

Holmes Quarry; The Holmes Lime Company, 24 Sacramento street, San Francisco, owner. Located on the mountain 2 miles northwest from Felton. The limestone is exposed from the base to the top of the mountain, a height of probably 1000 feet, along the strike, and a quarry face of this height could be obtained if desired. Mica schist occurs in considerable quantities in the limestone, both as continuous bands from 6 to 10 feet thick and in irregular patches. It is readily separated in the quarrying, and the only serious drawback connected with its occurrence is the expense in handling it. In some places there will be a

thickness of from 50 to 60 feet of limestone free from other rock, while elsewhere from 10 to 20 feet will be followed by a layer of schist of nearly equal thickness.

The principal workings are at two levels, one about half way up the mountain, the other near the top of the mountain. There is an incline railway extending from the kilns to the top of the mountain, and the stone is transferred from the quarries to the kilns on this track by gravity. At present, much of the stone is obtained at the head of the incline, where several openings are being made on both the north and south sides of the gulch.



ILL. No. 34. SANTA CRUZ LIMESTONE QUARRY, 18 MILES N. W. OF SANTA CRUZ.

There are two quarry openings on the mountainside a quarter to half a mile south of the large quarry.

Part of the stone is shipped in the rough blocks as it comes from the quarry, but the greater portion is burned to lime in the pot-kilns at the foot of the incline, or in the kilns near the town of Felton, to which the stone is run on a tramway. The burning is done with wood obtained from the neighboring mountainside. The lime is barreled at the kilns in barrels made on the spot. These quarries have been in operation forty years or more.

I X L Quarry; Henry Cowell Lime and Cement Company, 211 Drumm street, San Francisco, owner. Located about half a mile north of the

Holmes quarry above mentioned. There are three pot-kilns in use, with a capacity of about 250 barrels per day. The lime is barreled at the kilns in the barrels made at the works and hauled by wagon to Felton station, about $2\frac{1}{2}$ miles. The quarry is at the confluence of two deep cañons, with one opening in the steep hill between the two cañons and another opening on the point immediately west. The limestone stratum at the quarry is nearly vertical, and extends from the base to the top of the mountain, with no covering except a little vegetation in the irregularities of the surface. The present quarry face is about 200 feet, but may increase to 400 feet or more as the quarry is worked back,



ILL. No. 35. KILNS AND COOPERAGE OF THE SANTA CRUZ LIME COMPANY.
18 miles N.W. of Santa Cruz.

before any stripping is necessary. The thickness of the stone exposed at the quarry is nearly 300 feet, but the entire bed is probably considerably thicker, as the contact with the granite is not shown on either side. The greater comparative durability of the limestone over the granite is shown by the projecting ridges of limestone in the midst of the granite mass, both here and at the Holmes quarry. The wood for burning the lime is obtained from the hills in the immediate vicinity of the kilns.

Santa Cruz Lime Company; Charles Moore, manager. The quarry of the Santa Cruz Lime Company is about 18 miles northwest of the city of Santa Cruz, and 4 miles inland of the beach. The landing place is

some distance north of the mouth of San Vicente Creek. The quarry is on the west side of a deep cañon in the Coast mountains. A little railway track is cut into the steep rocky side of the cañon, and the stone is carried on small tram-cars about a quarter of a mile north of the quarry to the limekilns. There are two large stack-kilns, which produce from 90 to 100 barrels of lime each per day, and three pot-kilns in use. A cooper shop is located at the kilns, where the barrels are manufactured. The lime is barreled as it is drawn from the kilns and then hauled by wagon $4\frac{1}{2}$ miles to the beach, where it is loaded on boats and shipped by water to San Francisco and points along the coast. The quarry has been in operation about five years and produces about 300 barrels of lime per day.

The stone is a coarsely crystalline blue limestone, similar to that at the other quarries in the Santa Cruz region. It is much broken and shattered and comes from the quarry in large, irregular blocks, which are broken up by blasting and by sledges into pieces small enough for the kiln. The present quarry face is nearly 100 feet high. The company is now starting a new opening on the upper side of the road, much nearer to the kilns.

The limestone occurs here in great abundance and outcrops in a number of places in the cañon. In the vicinity of the quarry there is a heavy growth of redwood and other trees, which are being cut to furnish wood to burn the lime and make barrels.

Thurber Quarry; S. L. Thurber, 465 Pacific avenue, Santa Cruz, owner. The quarry is located 10 miles northwest of Santa Cruz, and is worked through a large, irregular, shallow cut. (See Macadam.)

SHASTA COUNTY.

In the western half of Shasta County limestone is found mainly in three almost parallel belts, having a general north and south direction. (See also on this subject: J. S. Diller, U. S. Geological Survey, Bulletins No. 196, p. 64, No. 213, p. 365, and No. 225, p. 176, and American Journal Science, 4th Series, Vol. 15, pp. 342 et seq.; J. S. Diller, Ch. Schuchert, American Journal of Science, 3d Series, Vol. 47, pp. 417 et seq.; H. W. Fairbanks, XIth Annual Report, California State Mining Bureau, p. 48, and XIIth *ibid.*, p. 395; American Geologist, Vol. 14, p. 26; Prof. James Perrin Smith, Journal of Geology, Vol. 2, p. 592.)

The most eastern belt, Triassic limestone, is found on Cedar Creek, east of the Afterthought mine, in the southern portion of T. 34 N., R. 1 and 2 W. A subordinate exposure is found on the east slope of Bear Mountain, in the northeastern part of T. 33 N., R. 3 W., north of Pit River, the Triassic limestone forms Brock Mountain and may be traced

for several miles, crossing Squaw Creek. This limestone has been referred to as the Hosselkus limestone beds, belonging to the Upper Trias. It is an extensive exposure, and shows a great thickness of limestone, covering Secs. 7 and 8, T. 34 N., R. 2 W. The lower part has a dark gray color, is rather thinly bedded, and is cut by numerous seams of calcite; while the upper portion is more massive, contains less calcite seams, and has a lighter gray color. The limestone contains many fossils.

Limestone is quarried from the lower or thin-bedded portion of this deposit for use as furnace flux at the Bully Hill copper smelter. The quarry is worked by hand-drilling.



ILL No 36. McCLOUD LIMESTONE BLUFFS, FROM U. S. FISHERIES, SHASTA COUNTY.

The analysis of this limestone as given by Mr. J. B. Keating, general superintendent of the Bully Hill mine, is: CaO, 52 per cent; SiO₂, 5.5 per cent; organic, 1.5 per cent.

Mr. Diller, in Bulletin No. 225, U. S. Geological Survey, page 187, remarks that the lower beds probably contain some clay. He suggests that this limestone might be suitable for the manufacture of hydraulic cement, mixed with the Tuscan tuffs found on Stillwater and east of Millville. Judging by its appearance, however, its value for the production of lime appears doubtful.

About 6 or 7 miles west of this belt of Triassic limestone a prominent belt of Carboniferous limestone occurs, in places showing a thickness of

2000 feet. The most southern exposure of this belt is near Lilienthal, in Sec. 26, T. 33 N., R. 4 W. From there it can be traced along Rancheria Creek to the Grey Rocks, south of Pit River, in the northeastern part of T. 33 N., R. 4 W. North of Pit River and east of McCloud River it forms the McCloud Bluffs (photograph by Capt. Lambson and Sketch D, Ill. No. 37), and can be traced north as far as Grizzly Peak, on the divide between McCloud River and Kosk Creek, in Siskiyou County. Wherever stratification can be observed in the limestone it shows a northwesterly dip. In places the limestone is highly metamorphosed.

The limestone in this belt has as yet not been used for burning lime. Some was quarried near Potter's Creek, in Sec. 24, T. 34 N., R. 4 W., and used for flux at the Bully Hill smelter. Its analysis as given by Mr. J. B. Keating is: lime, 54.5 per cent; insoluble, 3 per cent.

West of this belt, between the McCloud and Sacramento rivers, are sporadic limestone exposures, indicating a limestone belt intermediate between the Carboniferous McCloud limestone and the Devonian limestone west thereof. Where examined the limestone has a dark gray color.

The most western belt of limestone in Shasta County is of Devonian age. It crops out in isolated patches along the eastern slope of the range dividing the Klamath and Sacramento river drainage. In the northern part of the county, in T. 37 N., R. 4 W., the same limestone belt crops out on Hazel Creek and Soda Creek, east of the Sacramento River. The limestone in this belt is more compact and has a more bluish gray tint than the Carboniferous limestone; occasionally seams filled with large calcite crystals are found. The limestone is of uneven quality; in places it is very good, showing on the fracture a very fine-grained, very light gray or whitish material, and when burned produces very nearly pure lime. In other places, it is somewhat impure, showing dark gray spots, burning to lime of a less pure grade. The limestone lies generally in contact with shales, although most of the country rock surrounding the deposits on Backbone Creek is of igneous character. In the new quarry of Holt & Gregg on the south side of the divide between the two Backbone creeks, in Section 34, the relation of the limestone, the underlying shales, and intrusive diorite can be seen. (Section on Sketch D.)

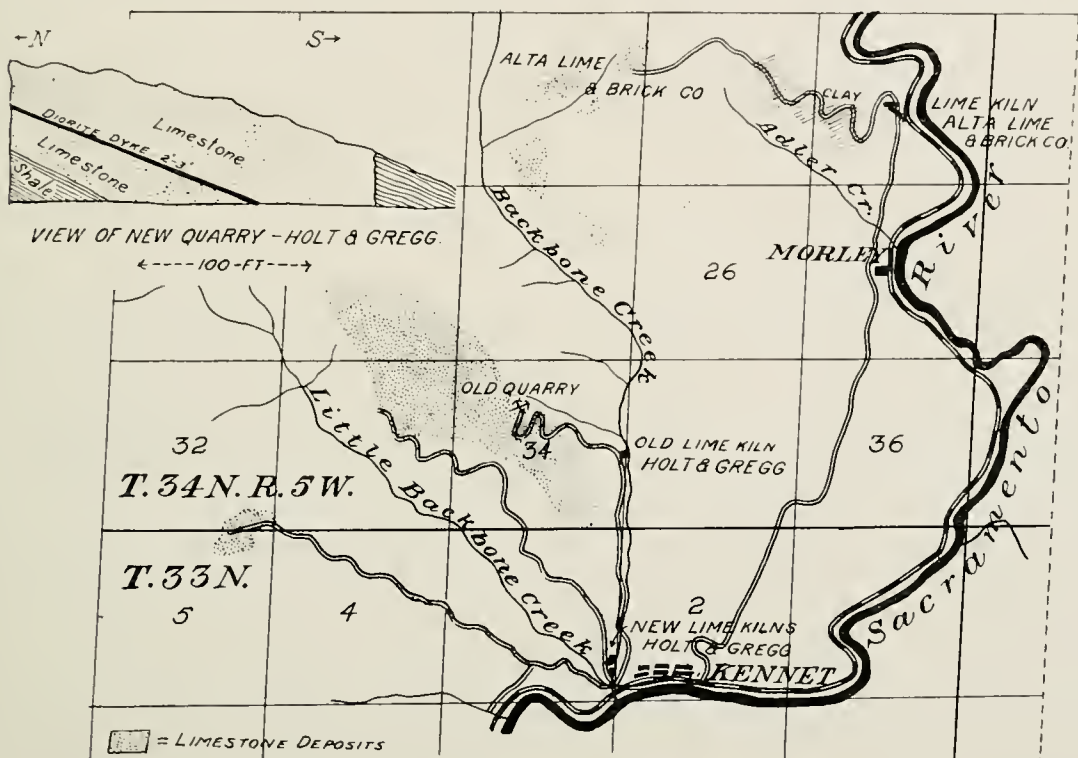
The limestone deposits in Sec. 22, T. 34 N., R. 5 W., are owned by the Alta Lime and Brick Company, Redding. This company started operations about January 1, 1904, and is building a road from its limekiln in Section 24, same township, near the railroad, to the mine. The limekiln is under construction, and will have a capacity of 8 tons per twenty-four hours.

The limestone in Sec. 31, T. 31 N., R. 5 W., Dr. Th. R. Heintz, Red-

ding, owner, forms a prominent bluff on the north side of Clear Creek, from 60 to 70 feet high and 300 feet long. The limestone can be traced farther up the hill to about 110 feet above its lowest exposure, where it is overlaid by black shales. Mr. J. S. Diller (Bulletin U. S. Geological Survey, No. 213, page 365) classified this limestone as Devonian.

There is a small outcrop of the same limestone just opposite on the south side of Clear Creek. The remnants of an old limekiln are found at the foot of the bluffs; formerly a great amount of lime was burned here and was shipped as far as Colusa.

The deposit in Secs. 28 and 34, T. 34 N., R. 5 W., Holt & Gregg, Redding, owners, was formerly quarried on the north side, on the Big Back-



ILL. No. 37. SKETCH D, SHASTA COUNTY.

bone side (see Sketch D), and burned in kilns in Section 34, in Big Backbone Cañon. The new quarry is on the south slope toward Little Backbone and the kilns at Kennett. The quarry is worked by hand-drilling; the blocks are sledged down to pieces from 12 inches to 4 inches; pieces below 4 inches are thrown over the dump. At the kiln the stone is further broken to pieces running from 6 inches to 3 inches. The kilns are modified patent shaft kilns, with iron sheeting, having a capacity of $7\frac{1}{2}$ tons of lime per twenty-four hours, using wood as fuel. The lime is used all over northern California.

The deposit in the S. E. $\frac{1}{4}$ of Sec. 32, T. 34 N., R. 5 W., Mountain Copper Company, Keswick, owner, was quarried some years ago, and used for flux in the smelter at Keswick.

SIERRA COUNTY.

Three distinct ledges of limestone occur in the central part of the county, between Downieville and Sierra City. The first is encountered about 3 miles east and northeast of Downieville, extending from Sec. 13, T. 20 N., R. 10 E., in a southwestern course through Secs. 19, 30, 32, T. 20 N., R. 11 E.; the second, 2 miles farther east, has a north and south course through the W. $\frac{1}{2}$ of Sec. 27, T. 20 N., R. 11 E.; the third is between Loganville and Sierra City, extending in a southeasterly course from the center of Sec. 30, through Sec. 29 and into Sec. 32, T. 20 N., R. 12 E. This last named is the most important of the three ledges in point of quality. In November, 1904, lime was being burned from the limestone taken from this ledge for structural use in the construction of a cyanide plant for the Sierra Buttes mine. Thirty years ago lime was burned from the limestone taken from the ledge nearest Downieville.

SISKIYOU COUNTY.

Limestone is found in Siskiyou County in great abundance, not only in belts of large, disconnected exposures, some of which are very extensive, but also in small patches scattered between other formations, especially the schists. Sometimes it has the laminated structure of the schists to such a degree that a superficial examination of hand specimens does not disclose their mineral character.

One belt of limestone runs from a little west of Etna in a general northwesterly direction, along the eastern slope of the Salmon Mountains, forming farther north part of the Marble Mountains, and of the Grider Mountains, showing north of the Klamath River on Thompson Creek and running farther north into Oregon. The limestone of this belt is nearly all altered into marble, and is described under that heading. In the other limestone belts of this county the alteration has not been so complete, although marble is found in nearly all the limestone deposits.

East of Scott River there are a number of separate exposures of limestone, some of which are here mentioned. As, so far as known, no positive data regarding the age of these limestones have been ascertained, it is not possible to state whether they all belong to one belt or not.

Farmington Quarry, in Sec. 7, T. 40 N., R. 8 W.; S. Farmington, Callahan, owner.

The limestone was burned in a rock kiln. The lime was used in the neighborhood and marketed as far as Yreka (over 40 miles distant) and in Trinity County. It is claimed to have been of very good quality. The kiln has not been used since the fall of 1903.

The limestone is of a very dark bluish-gray color, and is traversed by a great number of thin veins of calcite; it is very even and fine-grained. The general trend of the limestone belt is nearly north and south; it is about 200 feet wide, and cut by several dikes of basic igneous rock, not over 10 feet wide, having a similar strike, which, however, have not altered the limestone.

Greenhorn Quarry, in the southwestern part of T. 45 N., R. 7 W.; L. E. Gilbert, Yreka, owner. A ridge of limestone, on the north side of the Greenhorn, from which lime was burned occasionally, and used in Yreka. The last lime was burned in 1902.

Oro Fino Quarry, in Sec. 19, T. 43 N., R. 9 W.; L. C. Wilson, Etna, owner. A small detached exposure of limestone, about 200 feet wide, having a length of about a quarter of a mile on its east and west strike. The limestone lies in the basic igneous rocks of which the Oro Fino Mountains consist, and is altered into a very fine and even-grained pure limerock of a very light gray color. It is rather thinly bedded and dips nearly vertical. This rock is burned in a small rock kiln, producing a good quality of lime, used in Scott Valley and in Yreka. The kiln was used in the fall of 1904. Harris Brothers of Greenview have a ten years' lease on the property.

Quigley Quarry, in Sec. 2, T. 46 N., R. 9 W.; W. Quigley, Walker P. O., owner. North of the Klamath River a bluff of limestone about 50 feet high rises above the surrounding serpentine, from which in former years some lime was burned.

SONOMA COUNTY.

Sonoma County Lime Company's Plant, in T. 11 N., R. 9 W., on L. S. Black's ranch; A. H. Ingham, 525 Seventh street, Santa Rosa, owner. The quarry is 6 miles northeast of Geyserville, on the Little Sulphur Creek. It was first opened in 1884, and reopened in April, 1901. The rock is a hard, compact, drab-colored limestone, with pure white streaks of micro-crystalline limestone through the mass. An analysis of the rock shows the following:

Carbonate of lime.....	95.20
Silica	1.27
Peroxide of iron and alumina	0.43
Oxide of manganese.....	0.18
Magnesia and loss.....	1.32
Water	1.60
Total	100.00

The deposit occurs in the form of a boulder 150 feet long, 70 feet wide, and outcropping 30 feet above the inclosing rock, which is a chert. It is burned at the quarry in a continuous kiln, with a capacity of 50

barrels a day. Wood is used as fuel. An abundant supply of live oak occurs in the immediate vicinity of the kiln. The plant is worked extensively during the summer, but is idle during the rainy season, because, with the present condition of the roads, it is too expensive to haul the lime to Geyserville for shipment.

TRINITY COUNTY.

Limestone is found in many places in Trinity County. There are: (1) A belt of Devonian limestone, showing in separate lenses for over 100 miles, running about parallel with the South Fork of Trinity River from its source to Hoopa Valley, for the most part intimately associated with igneous rocks; (2) A parallel belt of Devonian limestone running to the northeast of the preceding; and (3) A belt of Carboniferous limestone, entering Trinity County from the southeast near the Hall City mine, in the northeast corner of T. 29 N., R. 10 W., M. D. M., running northwest along the Hayfork River, disappearing north of Hayfork and showing farther north on New River, near Patterson's. (See J. S. Diller, *American Journal of Science*, 4th Series, Vol. 15, pp. 342 et seq.) Northeast of these belts numerous limestone exposures are found. The great amount of metamorphism in Trinity County has altered much of the limestone into marble.

On **Brown Mountain**, in Sec. 21, T. 33 N., R. 9 W., M. D. M., owned by the Southern Pacific Railroad Company, is a belt of limestone having a nearly north and south trend. It was quarried years ago, and burned in a limekiln of which the remnants are still visible. The lime was used in the piers of the bridge formerly crossing Trinity River at Lowden's and in the masonry of the courthouse at Weaverville. The limestone is coarsely crystalline. The quarry excavations are shallow and caved in, and it is impossible to determine the size, dip, or bedding of the limestone.

At the **head of Oregon Guleh**, in Sec. 3, T. 33 N., R. 10 W., M. D. M., there is a body of limestone from which in 1856 lime was burned, which was used in several buildings in Weaverville.

In the **vicinity of Hayfork**, in T. 31 N., R. 11 W., M. D. M. (unsurveyed), are found several detached exposures of limestone, which are typical of similar exposures through the county.

TULARE COUNTY.

Lemon Cove Lime Quarry, in Sec. 35, T. 17 S., R. 27 E. This small quarry lies $1\frac{1}{2}$ miles north of Lemon Cove (formerly Limekiln). The stone is a white, coarsely crystalline calcite, and occurs in an irregular pocket formation. The limestone extends for about 40 feet across

the face, with perpendicular side walls of clay shale. A dike of slaty schistose material, 4 feet in width, extends diagonally across the present face of the quarry. The stone was trammed about 100 yards to the intermittent open field kilns, two of which have double draws and one is a single draw. Willow wood cut in a nearby creek furnished fuel. The plant has been idle for the past two years.

TUOLUMNE COUNTY.

G. Engler Lime Company, in Sec. 27, T. 2 N., R. 14 E.; G. Engler, Sonora, owner. This plant is located about $2\frac{1}{2}$ miles north of Sonora, near Shaw's Flat, and supplies a local demand for lime. The stone is quarried from the numerous outcrops, exposed by the early placer workings, which extend for several miles through this district. The rock is burned in two intermittent field kilns, of about 400 barrels capacity. Wood is used for fuel.

MARBLE.

Marble is a metamorphic, crystalline limestone, distinguished from other limestones principally by its adaptability to receive a polish. It is used as an ornamental building stone, also for decorative and monument purposes.

The production of marble in California, as indicated below, is not very large, but a study of the deposits in the State justifies the conclusion that more deposits could be opened, and the ones already opened could be operated more extensively. Large quantities of marble are shipped into California from Vermont, Georgia, Tennessee, and Italy, which indicates a demand greater than the supply, a demand that could and should be met, in a large measure, from the home quarries.

So far as observed, California produces no bright-colored marbles that could replace the red Tennessee and red Vermont variegated marbles for interior decoration; but there is a sufficient supply of white, clouded, and colored marbles and onyx marble to more than supply the home demand.

Some of the limestone and marble deposits of California are shattered and have many cracks and seams, and in some cases poor judgment has been used in quarrying and in selecting some of the marble that has been put on the market. Besides, the use of heavy charges of powder will cause seams and cracks in the marble, however sound the

stone may have been at first. All these reasons have to some extent been detrimental to the general impression regarding the marble resources of the State.

The published reports for 1904 show that marble was produced in five different counties in California, but good marble is known to exist in several other localities where it is not quarried.

MARBLE PRODUCTION IN CALIFORNIA IN 1904.

	Cubic Feet.	Value.
Amador County	4,785	\$6,558
Inyo County	3,000	3,000
Riverside County	5,000	2,500
San Bernardino County.....	31,116	53,400
Tuolumne County.....	11,500	28,750
Totals	55,401	\$94,208

REFERENCES ON CALIFORNIA MARBLES.

1. Eleventh Census Report on Mineral Industries, p. 626, Washington, D. C.
2. Tenth Report of State Mineralogist, California, p. 584.
3. Eleventh Report of State Mineralogist, California, pp. 312, 363, 506.
4. Twelfth Report of State Mineralogist, California, pp. 391-96.
5. Thirteenth Report of State Mineralogist, California, pp. 627-633.
6. Mineral Industry, N. Y., Vol. VIII, 1899.
7. Annual Report of Arkansas Geological Survey, 1890, Vol. IV, p. 175.
8. California Marble, Stone, Vol. VIII, p. 254.
9. California Marble, Stone, Vol. XXI, 1903, p. 28.

Onyx Marbles of California:

1. Tenth Report of State Mineralogist, California, p. 584.
2. Twelfth Report of State Mineralogist, California, p. 403.
3. Thirteenth Report of State Mineralogist, California, p. 641.
4. Bulletin No. 37, State Mining Bureau.
5. Twentieth Annual Report of U. S. Geological Survey, Pt. VI cont., p. 287.
6. Stone, N. Y., November, 1898.
7. The Tenth Census, Vol. X.

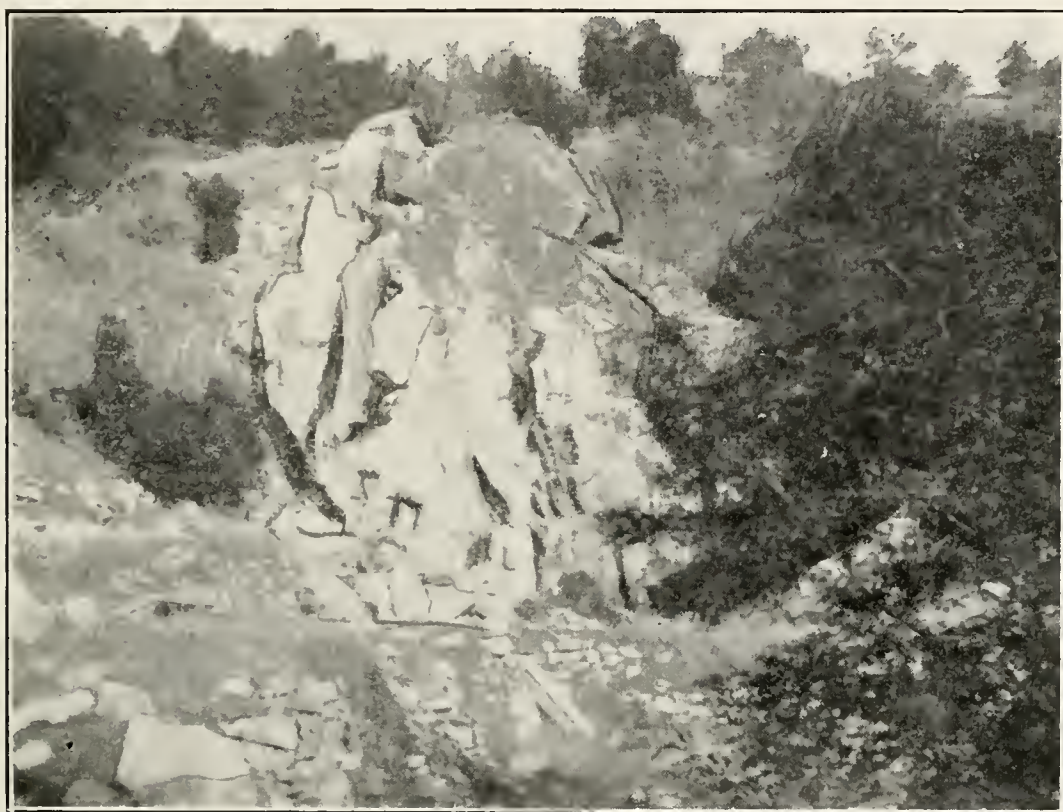
AMADOR COUNTY.

Amador Marble Quarry; D. E. Collins, California Bank, Oakland, president. Idle for the last few years. The marble was used for monument and building purposes.

Carrara Marble Quarry; C. Dondero, room 617, 456 Montgomery street, San Francisco. The quarry is located in Sec. 29, T. 7 N., R. 12 E.,

M. D. M. The principal product is white marble with black streaks; also white and ash-colored marbles are available. Used in rotunda of City Hall, and entrance to Native Sons' Building, San Francisco; also in rotunda of Museum Building, Stanford University.

Oleta Quarry, M. Zwischenbach, owner. Two and a half miles east of Plymouth, on the south side of the Oleta-Plymouth stage road, is a marble quarry, now idle, which some years ago was worked as the demand required. The marble occurs in a heavy ledge, about 100 feet thick, lying in the midst of blue schists. There is a small parallel bed



ILL. No. 38. OLETA MARBLE QUARRY, PLYMOUTH, AMADOR COUNTY.

of marble, about 10 feet thick, 100 feet west of the quarry, and several heavier beds east of the quarry, probably 200 feet or more of marble in all. The quarry has been opened more than two thirds of the way down the steep slope on the north side of the cañon about 200 feet below the Oleta road. The quarry face is a little over 100 feet in height and about 100 feet wide. The stone is a light gray and blue clouded marble. It has a medium-fine grain, and is comparatively pure and free from foreign material. Blocks 6, 8, and 10 feet long, and in one place nearly 30 feet long, and from 4 to 10 feet thick, are obtainable. If the smaller blocks could be worked into tiling, mosaic, marble dust, etc., the waste would not be excessive.

BUTTE COUNTY.

Marble of blue, black, and white varieties occurs in Butte County. No commercial production has been essayed.

Big Bend Marble Quarry, in Sec. 32, T. 22 N., R. 5 E., M. D. M.; John A. Clark, Yankee Hill, owner. Two ledges of limestone marble occur in the Big Bend of the North Fork of Feather River. The main ledge is a blue limestone, striking northwest and crossing the river; it is exposed 1200 feet south of the river, and extends southeast about 2000 feet. It has been prospected by an open cut from 20 to 50 feet wide. Northeast of this exposure occurs a ledge of white marble of fair quality. More attention has been given to the development of the blue ledge, from which samples have been shown to sustain a high polish.

Marble Creek.—In Sec. 10, T. 22 N., R. 6 E., M. D. M., a heavy cropping of white marble occurs on the west bank of Marble Creek, crossing the creek on its northwest and southeast strike. Some local use has been made of the marble in interior structural work.

Mooretown Marble.—Sec. 24, T. 20 N., R. 6 E., M. D. M.; Golden West Mining Company; R. M. Green, Oroville. A ledge of white marble is exposed on the north side of Sucker Run Creek for about 40 feet above the surface of the stream and from 20 to 30 feet wide. The north extension of the ledge was traced for about 100 feet.

Pentz Marble.—In N. W. $\frac{1}{4}$ of Sec. 8, T. 21 N., R. 4 E., M. D. M.; J. G. Curtis, Pentz, owner. Several years ago Mr. Curtis burned lime from this deposit. A handsome black mottled marble slab 4 feet long, 1 foot wide, and 4 inches thick, from this quarry has been exhibited in San Francisco and Oroville as a demonstration of the value of the limestone for marble, but no extensive quarrying for marble has been done. The ledge extends for a mile northwest and southeast through the center of Section 8, and is exposed for a width of 300 feet.

CALAVERAS COUNTY.

White, gray, and banded marble is found in many places in Calaveras County, but is not quarried. The belt passes from Tuolumne County northward through Calaveras County, and is found near Vallecito, Murphys, and Cave City. (See also XIIth Report of California State Mining Bureau, page 391.)

Caldwell Marble Quarry, in Sec. 35, T. 4 N., R. 11 E., M. D. M.; Edward J. Caldwell, Valley Springs, owner. Located about 4 miles southeast of Valley Springs, on Bear Mountain. The specimen in the Mining Bureau museum shows it to be a dark variegated limestone,

capable of receiving a high polish. No marble has been shipped, merely development work having been done.

Hertzig Marble Quarry, in Sec. 29, T. 4 N., R. 12 E., M. D. M.; M. Hertzig, San Andreas, owner. A compact, gray building marble.

Treat Marble Quarry, in Sec. 16, T. 14 N., R. 12 E., M. D. M.; J. F. Treat, Sr., San Andreas, owner. Located $1\frac{1}{4}$ miles east of San Andreas. The quarry lies on the hillside, and the marble is very easily quarried. The stone was used in erecting the Hall of Records in San Andreas. It is a very compact, finely crystalline marble, and both white and variegated varieties are available.

GLENN COUNTY.

Alexander Brown, Oakland. In the northwest corner of T. 18 N., R. 6 W., a cropping of a ledge of serpentine is exposed. The material has the texture, solidity, and luster requisite to the production of a good quality of serpentine marble. No prospecting or development work.

H. A. Daniels, Stonyford, Colusa County; Sec. 21, T. 18 N., R. 6 W., M. D. M. Several years ago a ledge of marble of the white or alabaster limestone variety was prospected by W. H. Wilton of San Francisco, to a distance of about 40 feet into the exposure. The ledge may be traced for about a mile north and south along the east side of Stony Creek.

INYO COUNTY.

Inyo Marble Company; M. J. McDonald, Mills Building, San Francisco, president. The quarries are situated at the base of the Inyo range, between Keeler and Lone Pine. They are scattered along the base of the range for several miles, but the point at which most of the work has been done is about 5 miles north of Keeler. The marble from these quarries is a dolomite, is generally fine-grained and quite hard, takes a good polish, and is a durable and handsome stone. A specimen of the pure white dolomite was analyzed, with the following results: carbonate of lime, 54.25 per cent; carbonate of magnesia, 44.45 per cent; iron and silica (clay), 0.60 per cent. A little south of the original quarry face a bed of fancy and variegated marble was opened. It is mottled (white, yellow, gray, and black), and is penetrated by beautiful dendritic markings of manganese. The white quarries furnish any desired size of blocks; pieces of from 15 to 18 tons weight have been obtained. There is a quarry of beautiful yellow marble about half a mile north of the main workings. A deposit of black marble is utilized for floor tilings. The company ships the rough-dressed marble to its

mills on the Truckee River, 18 miles west of Reno, where it is sawed and dressed ready for shipment. This company furnished the stone for the Mills Building, both inside and out, and many other buildings in San Francisco.

KERN COUNTY.

Antelope Valley Marble Quarry, in Sec. 2, T. 9 N., R. 17 W., S. B. M.; Southern California Marble Company, J. T. Houx, Call Building, San Francisco, owner. Near Neenach, on the south slope of the Tehachapi range. A large body of fine-grained marble, consisting of a number of beds of various colors, dipping at an angle of about 35 degrees into the mountain. In the quarry is found white marble with reddish-brown veins, and with heavy blue veins. This marble has been used in the Stimson Block, Los Angeles, in the Spreckels band stand, Golden Gate Park, and Goldberg & Bowen's store, Sutter street, San Francisco, etc. (See also XIIIth Report of California State Mining Bureau, p. 629.) This quarry has been idle for the past two years.

MARIPOSA COUNTY.

A belt of crystalline limestone, some of which would make handsome structural and ornamental marble, occurs on the south side of the South Fork of Merced River, near Hite's Cove, where it is exposed on the grade road. No effort has ever been made to develop it.

NEVADA COUNTY.

Marble, though at present not productive, is a prospective industry in Nevada County. There are two distinct occurrences of marble in the county, which have been prospected in a small way.

Bear River.—In Sec. 22, T. 15 N., R. 9 E., marble occurs near Bear River, the dividing line between Nevada and Placer counties. This exposure, which is prominent, is an apparent extension of the large bodies of marble in Section 35, same township and range, on the Placer County side of Bear River. These ledges extend north and south.

South Yuba.—In Secs. 13 and 18, T. 17 N., R. 9 E., J. C. Martens, W. Calenberger, W. C. Harmon and A. L. Martens, of North Bloomfield, made locations in 1894. The marble ledge is exposed in the bed and on the banks of the South Yuba River at elevations of from 1000 to 2000 feet, with croppings at still higher points, having a northwest and southeast course. Lesser occurrences of limestone are found some 4 or 5 miles farther west and downstream, from which lime was burned five or six years ago, but from which no marble has been quarried. These marble deposits are situate about 15 miles northeast of Nevada City, by wagon road.

PLACER COUNTY.

Marble occurs in Placer County in several localities.

Auburn Quarry, in Sec. 14, T. 12 N., R. 8 E.; W. S. Davis, Auburn, owner. A somewhat shattered white marble, although masses of considerable size have been quarried. It is exposed for a height of about 25 feet, over a distance of about 100 feet.

Holmes Lime Company's Quarry, in Sec. 33, T. 15 N., R. 9 E.; Holmes Lime Company, San Francisco, owner. (See Limestone.) Thirty-five years ago marble was sawed and polished from this limestone ledge by a man named Pritchard, who made the marble columns for the entrance way to the Napa Insane Asylum and tiling for the floor of the San Francisco branch mint building.

Hotaling Quarry, in Sec. 16, T. 13 N., R. 8 E. White marble occurs near Hotaling, 5 miles north from Clipper Gap. It has been used only as flux for the smelting of iron by the California Iron and Lime Company.

John McAninch.—A deposit of verde antique marble is reported near the Butcher Ranch, on land owned by John McAninch.

Verde Antique.—In Sec. 1, T. 13 N., R. 9 E.; Mr. Dunning, Oakland, owner; about 16 miles northeast from Auburn. The serpentine marble, or verde antique, is exposed for 100 feet or more in height and between 400 and 500 feet wide, on the northerly slope of the hill that looks down upon the American River. The deposit is not extensive east and west, and appears to be a series of ledges. Some prospecting has been done, and small pieces of ornamental design have been polished by Joseph Boleres of Forest Hill. It is a beautiful stone, green and blue in color, and if found compact in sufficiently large masses would prove a profitable property.

PLUMAS COUNTY.

There are large bodies of marble in the southwestern part of Plumas County. Marble Cone is a great mountain of marble situated in Sec. 8, T. 22 N., R. 8 E., on the south side of Middle Feather River. Marble ledges also occur on the north side of the river, in Sections 5, 6, and 7. This ground is unsurveyed. Locations were made some twelve years ago by Judge C. E. McLaughlin of Quincy, James Jones of La Porte, and others, and samples of the marble were polished, presenting a handsome face and evidence of fine quality; but the locations were abandoned, owing to failure of the extension westward of the Beckwith Pass Railway.

RIVERSIDE COUNTY.

Sky Blue Marble and Onyx Company's Quarry, in Secs. 2 and 3, T. 2 S., R. 5 W., S. B. M.; E. W. Tucker, Eighth and Walnut streets, Riverside, manager. (For description of quarry, see Limestone, page 75.) This limestone takes an admirable polish, with a dark blue color, making a very desirable material for ornamental purposes, and for trimming with lighter colored marbles.

SAN BERNARDINO COUNTY.

Nearly all the limestone found in San Bernardino County may be classified as marble. In many quarries the material is used both for burning lime and for building and monument purposes.

J. D. Aekerman, 602 Commercial street, San Francisco, and **J. Scheerer**, San Bernardino, have located a deposit of white crystalline limestone in Secs. 23, 24, 25, 26 and 35, T. 6 N., R. 4 W., S. B. M., about $3\frac{1}{2}$ miles northeast of Victorville.

Barstow Lime Quarry, C. M. LeStrange, Barstow, owner, 3 miles northwest of Barstow. The material is stated to be a fairly good marble. Not in operation.

Black Hawk Mountains, 30 miles east of Victorville, contain white marble of excellent quality. Not worked. (See XIIIth Report of California State Mining Bureau, p. 630.)

Bonanza King Quarry, in T. 10 N., R. 3 W., S. B. M., 1 mile north of Hinkley, on the Santa Fé Railway. Claimed to be very pure limestone.

Cadiz.—On the north side of the Santa Fé Railway, extending from near Cadiz to Bengal, is a range of limestone hills, in which large deposits of marble are said to occur. Specimens said to have come from near Cadiz show a handsome variegated, dark-colored, nearly black marble, not often found on the American market. Lighter-colored marbles are said to occur in the same region. A brief description of this marble area is given in the Mining Review, Los Angeles, July, 1904.

California Portland Cement Company, 401 Trust Building, Los Angeles, owns several quarries on Slover Mountain, near Colton, as follows:

(1) **Colton Cement Works Quarry**. (See Lime and Limestone, and chapter on Cement.)

(2) **Crusher Plant Quarry**, on the northwest corner of the mountain, about 200 yards from the cement works. The limestone is similar to that in the quarry of the Colton Cement Works, only the inclusions of

hornblendic rock are larger. The rock is crushed in a spindle crusher to a size about 2 inches in diameter, and is used for concrete.

(3) **Marble Dust Quarry and Plant**, on the west side of the mountain. The limestone is purer, without inclusions of the hornblendic material. The rock is broken down by hand in the quarry, then crushed in a Potts crusher to $\frac{1}{2}$ inch in size, from which it passes through a 30-inch Sturtevant mill, and then through four screens. The grit is used for coating tar roofing paper; the finer material passes through a 36-inch

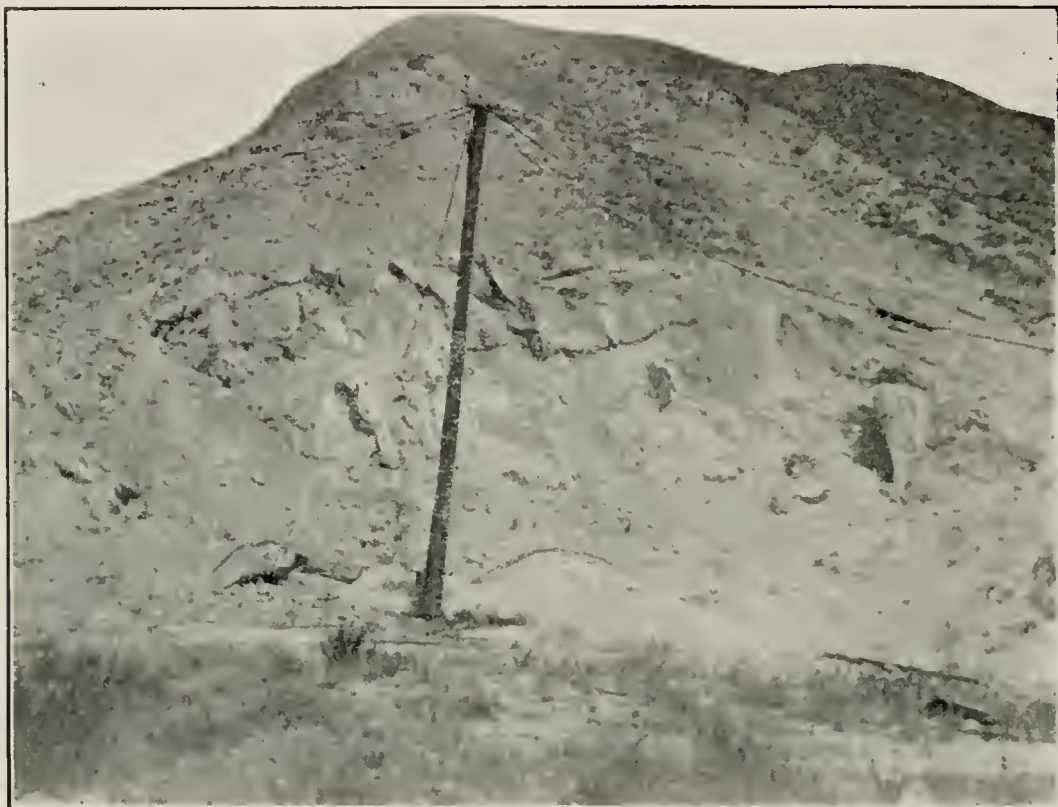


ILL. No. 39. MARBLE MILL AND YARD, COLTON, SAN BERNARDINO COUNTY.

Sturtevant mill, where it is ground to an impalpable dust. This material is used as mixture with asphalt for street paving.

(4) **Colton Marble Works** are leased by the California Portland Cement Company to the Colton Marble Company, W. A. Berrin, Colton. They are located on the south side of Slover Mountain, and use marble from two quarries. The lower quarry, about 30 feet above the works, is the larger. The dark bluish-gray limestone dips at a slight angle, not over 10 degrees, northwesterly. In the upper quarry, 160 feet above the works, the limestone has a very light color. The beds are from 5 to 7 feet thick. The rock is broken down by hand-drilling, the holes having the depth of the beds, with about 5 feet face, blasting being done with black powder. The marble is principally used for ornamental

building purposes, but some monument work is turned out. It has been used in the Academy of Sciences, Crossley, and Rialto buildings, San Francisco, in the latter being trimmed with the verde antique marble (see Mojave Consolidated Development Company); also in the Lankershim Hotel, Los Angeles, and will be used in the new Bishop Building, San Francisco. It is mostly cut to 1-inch stock. The plant is equipped with six gang-saws, one 14-foot ribbing bed, two polishing machines, one counter sinking machine, one tile machine, and one machine for cutting plumber's slabs, etc. Power is furnished by a



ILL. No. 40. COLTON MARBLE QUARRY, COLTON, SAN BERNARDINO COUNTY.

100-horsepower boiler using oil as fuel, one 50-horsepower steam engine, and one 50-horsepower electric engine.

J. B. Cook, 209 Laughlin Building, and **L. A. Porter**, Figueroa and Twenty-first streets, Los Angeles, own a deposit of white marble in Sec. 33, T. 10 N., R. 2 W., S. B. M., west of and near Barstow, having a northwesterly course, dipping steeply northeast, and stated to have an outcrop over 100 feet wide and to be three fourths of a mile long. Little development work has been done on this deposit.

M. L. Cook, San Bernardino, and **J. B. Devore**, Pullman Building, Chicago, own a small body of crystalline, flinty limestone in T. 2 N., R. 5 W., S. B. M., west of Cable Cañon. G. Wilson of Colton had a limekiln on this deposit, which is now abandoned. This deposit belongs

to a series of detached bodies of limestone found along the foothills on the south slope of the San Bernardino range.

M. L. Cook, San Bernardino, in Secs. 15, 16, 21, and 22, T. 2 N., R. 5 W., S. B. M., on the north side of Cajon Cañon, about 2 miles from the Santa Fé Railroad. A body of limestone similar to that above mentioned. J. Hansome formerly burned lime on this ground.

In **Holecomb Valley**, San Bernardino Mountains, near Metzger's gold mines, it is stated that a wide reef of white marble is found.



ILL. No. 41. MOJAVE CONSOLIDATED DEVELOPMENT COMPANY'S VERDE ANTIQUE MARBLE QUARRY, VICTORVILLE, SAN BERNARDINO COUNTY.

In **Lone Pine Canon**, Sec. 15, T. 3 N., R. 7 W., S. B. M., near Swartout Valley, is an old limestone quarry and kiln. Unappropriated Government land.

Mojave Consolidated Development Company; J. P. O'Brien, 175 Crocker Building, San Francisco. This company has been organized to operate the marble quarries formerly known as the "Gem Quarries" (Alamo Consolidated Marble Company) and the "Verde Antique," in Sec. 28, T. 7 N., R. 2 W., S. B. M. (See IXth Report of State Mining Bureau, p. 363, and XIIIth Report, *ibid.*, p. 630.) See chapter on Serpentine.

Muscapabia Land and Water Company, M. S. Severance, San Bernardino; Sec. 6, T. 1 N., R. 4 W., S. B. M., in Devil's Cañon. A deposit of

limestone, similar in character to that described above in Cable Cañon and Cajon Cañon. Lime was also burned here in former years.

G. E. Otis, Farmers' Exchange Building, San Bernardino, owns a deposit of rather fine-grained marble, white, blue-veined, and bluish-mottled, in Sec. 12, T. 1 N., R. 6 W., S. B. M. This deposit has an east and west course, is about one eighth of a mile wide, and can be traced for a considerable distance, occasionally interrupted by outcrops of presumably eruptive rocks.

W. E. Van Slyke, 716 Fifth street, San Bernardino. In the north-



ILL. No. 12. MOJAVE CONSOLIDATED DEVELOPMENT COMPANY'S VERDE ANTIQUE MARBLE QUARRY, SAN BERNARDINO COUNTY. (FROM $\frac{1}{2}$ MILES DISTANT.)

eastern part of T. 1 S., R. 1 E., S. B. M., at the head of Mill Creek, is an exposure of marble of various colors, red and mottled blue and white.

Stevens Deposit; **R. H. Greer**, 469 Belmont avenue, and **J. M. Day**, 3102 Hobart avenue, Los Angeles; $2\frac{1}{2}$ miles northeast of Barstow. The deposit is claimed to be of considerable extent, of white and pure marble, in a schistose country rock. The material is, however, stated to be somewhat shattered. Very little development work.

Northwest of Victorville, 22 miles west of Northcamp, is stated to be a large reef of white marble about 150 feet wide and 1000 feet long. Unappropriated Government land.

A similar reef is stated to exist in the northern part of T. 6 N., R. 2 W., S. B. M., 3 miles south of the Verde Antique marble mines.

SAN DIEGO COUNTY.

San Diego Desert Marble Company owns several claims in T. 16 S., R. 9 E., S. B. M., on the most eastern extremity of the Coyote Mountains, Colorado Desert. Many blocks measuring from 10 to 20 feet in diameter have been taken out, ready for transportation, from two quarries. The marble is fine-grained and exceptionally hard, usually of a gray or black and white color, with strata of pink, yellowish, and reddish marble. Nothing but assessment work has been done.

SHASTA COUNTY.

In Sec. 3, T. 33 N., R. 4 W., M. D. M., **H. H. Rosemann**, Bayha P. O., has opened up a marble body by an open cut 35 feet long, with a height of 20 feet at breast. The marble is still broken up, but promises to produce a good material in depth. Through it are boulders of aragonite (onyx marble) of various colors.

SISKIYOU COUNTY.

A belt of marble runs from a little west of Etna in a general northwesterly direction along the eastern slope of the Salmon Mountains, forming farther north part of the Marble Mountains, and in the Grider Mountains showing north of the Klamath River on Thompson Creek, and running farther north into Oregon.

Marble Mountain, in Secs. 16, 19, 20, and 21, T. 43 N., R. 12 E., H. M.; a very large body of marble is in this belt. It is very circumstantially described by Mr. T. A. Reynolds in his history of Siskiyou County, pages 36 and following. The limestone is metamorphosed, producing all varieties and colors of marble, but principally pure white marble.

R. McDaniels, Etna, owner. In Sec. 6, T. 41 N., R. 9 W., M. D. M., on the road from Etna to Sawyer's Bar, is exposed marble similar to that described in Sec. 32, T. 42 N., R. 9 W., hereinbelow, except that there are more numerous seams of diabase through the marble, and the pure white marble does not occur in such large bodies.

Alex. Parker, Jr., Etna, owner. In Sec. 32, T. 42 N., R. 9 W. This marble quarry was formerly worked. The elevation is 4025 feet. The belt is from 100 to 150 feet wide. The marble is heavily bedded; in places it is perfectly white and fine-grained; in other places it carries dark gray veins, with seams of diabase. Some of the marble is pink-colored, carries some iron pyrite, has inclusions of diabase, and is very coarsely crystalline. The workings are not very extensive, but if

pushed away from the diabase intrusions will probably, owing to the heavy bedding, show fine bodies of workable marble.

Very close to and southeast of Oak Bar, in Secs. 7 and 18, T. 46 N., R. 9 W., on the ridge to the south of the Klamath River, is a small exposure of limestone. The marble is fine-grained, with dark gray seams. No work has been done on this deposit.

J. C. Woods, Woods P. O., owner. In the northern part of T. 17 N., R. 8 E., on the east side of Thompson Creek, about 900 feet above the creek, and opposite the head of the Minetta ditch, is a cropping of rather fine-grained marble, having apparently formed the rim of a water-course. No work has been done on this deposit to determine the extent of the limestone.

SOLANO COUNTY.

Pacific Portland Cement Company.—In Sec. 17, T. 5 N., R. 1 W., M. D. M., at Cement (see chapter on Cement, page 185), is a deposit of travertine, through which occur vein-like and pocket-like deposits of a dark brown, banded stone—the so-called Suisun marble. Has been used for decorative purposes in San Francisco.

TULARE COUNTY.

Robert James, Porterville, owner. A deposit of dark gray marble, claimed to be suitable for building purposes; located 8 miles southeast of Porterville, on the road to the South Tule Indian Reservation.

At Three Rivers, 25 miles east of Visalia, is a deposit of a blue-black marble, suitable for burning lime and for building purposes.

TUOLUMNE COUNTY.

Columbia Marble Company's Quarry, in Sec. 34, T. 3 N., R. 14 E.: Columbia Marble Company, D. Hearfield, manager, Rialto Building, San Francisco. The quarry and works are located about $2\frac{1}{2}$ miles north of Columbia, about 800 feet above the Stanislaus River. The Stanislaus River has uncovered the marble ledge, showing it to extend for a depth of 800 feet below the present quarry level. This marble strip is 150 feet wide. The quarry face has been sufficiently opened to allow large quantities of any desired size of stone to be readily taken out. The pure white and variegated varieties have been developed more especially. The marble is a compact, fine-grained, holocrystalline dolomite, free from iron and flint, and weighs 182 pounds to the cubic foot. It is quarried by channeling three sides of a block, and breaking the bottom by the plug-and-feather method. The channeling



ILL. No. 43. EAST SIDE OF MARBLE MOUNTAIN, SISKIYOU COUNTY.



ILL. No. 44. WEST SLOPE OF MARBLE MOUNTAIN, SISKIYOU COUNTY.

machines and drills are driven by compressed air. The stone is loaded by derrick on to car trucks, which convey it to the mill, where six gang-saws (with automatic screw feed) cut it into slabs and panels ready for shipment. The plant includes a 50-horsepower Ingersoll-Sergeant air-compressor. Electric power is used, but a steam boiler and engine are ready for emergencies. The marble is hauled $7\frac{1}{2}$ miles to Sonora by traction engine when the road permits, otherwise by wagon. A 60-horsepower traction engine hauls four cars, each of 10 tons capacity. About a carload is shipped every week the year round. About 800 tons of this stone was used in the Merchants' Exchange Building, on Cali-



ILL. No. 45. COLUMBIA MARBLE COMPANY'S QUARRY, TUOLUMNE COUNTY.

fornia street, San Francisco. The pavements and stairways of the Palace Hotel are also of this marble.

YUBA COUNTY.

A large marble exposure is reported in Sec. 15, T. 19 N., R. 8 E., 8 miles west of north of Camptonville, on the south side of North Yuba River.

Another marble exposure is reported in Sec. 9, T. 19 N., R. 8 E., on the north side of the North Yuba River.

Marble is reported to occur on Oregon Creek, in Sec. 11, T. 18 N., R. 8 E.

ONYX MARBLE.

The term "onyx" signifies a banded variety of quartz, highly prized as an ornamental stone. "Onyx marble" is a commercial and not a scientific term; it covers such calcareous deposits as have the texture and beauty fitting to serve as ornamental stone. The requisite qualities are: perfect homogeneity of texture, microcrystalline structure, translucency, and beauty of color. (See Twentieth Annual Report of U. S. Geological Survey, Part VI cont., page 286.) Much of the finest and best onyx marble is composed of aragonite, and some writers limit the term onyx marble to such varieties, but considerable quantities of the onyx marble of commerce are calcite.

Some of the onyx marbles are deposited by hot springs, some by cold springs, and some are cave deposits. The spring deposits are thought by some to furnish a finer grade of onyx than the cave deposits. The finer grades of this stone command fancy prices in the market, and are among the most costly stones used in architectural work.

Onyx marble occurs in a number of places in California. Probably the largest and finest deposit is the Kessler, described below, which consists of aragonite.

SAN LUIS OBISPO COUNTY.

Kessler Onyx Deposit, in Secs. 9 and 16, T. 31 S., R. 15 E., M. D. M.; F. A. Kessler, administrator, 325 Fair Oaks street, San Francisco; 5 miles north of Musick P. O., and 17 miles northeast of Arroyo Grande, the nearest railway station. A deposit of beautiful onyx marble, discovered more than twenty years ago. About 1890, Mr. Kessler built a wagon road at considerable expense from Musick, and during the 90's it is said that more than 1000 tons were shipped from this quarry. None has been shipped during the past five years, as the estate has been in the probate court.

Onyx marble has been quarried at two different points. The main opening lies on the east side of the hill near the head of a small cañon, about one mile east of the county road. The opening is about 50 feet long and 20 feet high, and the total thickness exposed is about 15 feet.

The onyx marble occurs in somewhat irregular layers, from 1 inch to 8 or 10 inches, and in one place 30 inches in thickness. In places it is banded or variegated, and in some layers it is a white, massive, compact stone. It is true aragonite, and hence has a higher specific gravity than ordinary limestone. The stone is translucent and takes a brilliant polish. On the outcrop it has a yellowish-brown surface stain. In a few places the seams are filled with red hematite, which occasionally impregnates the stone, making bright red blotches or bands. Portions of the stone are banded with a dark green color. In parts of the deposit

the stone contains small cavities up to an inch in diameter, which disfigure the marble, but most of it is solid between the seams. It has been broken out in blocks from 3 to 6 feet square, but blocks with a much larger surface could be obtained by careful quarrying.

There are a great many tons of good, sound onyx marble exposed at this point, and the supply beneath the surface is probably considerable, but there is nothing to indicate the depth to which these layers extend.

There is a smaller opening on the west side of the hill, about half a mile west of the main opening. At this point the stone is white, with a very faint banding, and occurs in two layers varying from 1 to 6 inches thick, averaging about 3 inches.

Onyx marble in irregular masses is also exposed at the mineral spring on the hill between the two quarry openings. In several places aragonite is in process of formation in cavities in the shales and sandstones through which the mineral water trickles. In several places in the shales there are incrustations of *flos ferri*, a delicate, coral-like form of aragonite.

The onyx marble in this locality has been formed by the mineralized water that seeps out near the top of the hill and trickles down over the shales and sandstones. The water is now highly charged with sodium chloride and other salts, and during the dry season forms an extensive deposit along the several watercourses that radiate from the high land on which the springs are located. There are several small springs or seeps in this area, from all of which comes a mineral water strong with different salts in solution. The water has been shipped in barrels to some of the hospitals in the State, because of its great curative properties.

Many polished specimens of the Kessler onyx marble are on exhibition in the museum of the California State Mining Bureau and in the Golden Gate Park museum. A chemical analysis of the stone shows it to be fairly pure carbonate of lime.

Chemical Analysis of San Luis Obispo County Onyx Marble.

Lime carbonate (CaCO_3).....	93.86
Magnesia carbonate (MgCO_3)	1.43
Iron carbonate (FeCO_3)	3.93
Manganese carbonate (MnCO_3) .....	.06
Lime phosphate ($\text{Ca}_3\text{P}_2\text{O}_8$).....	.25

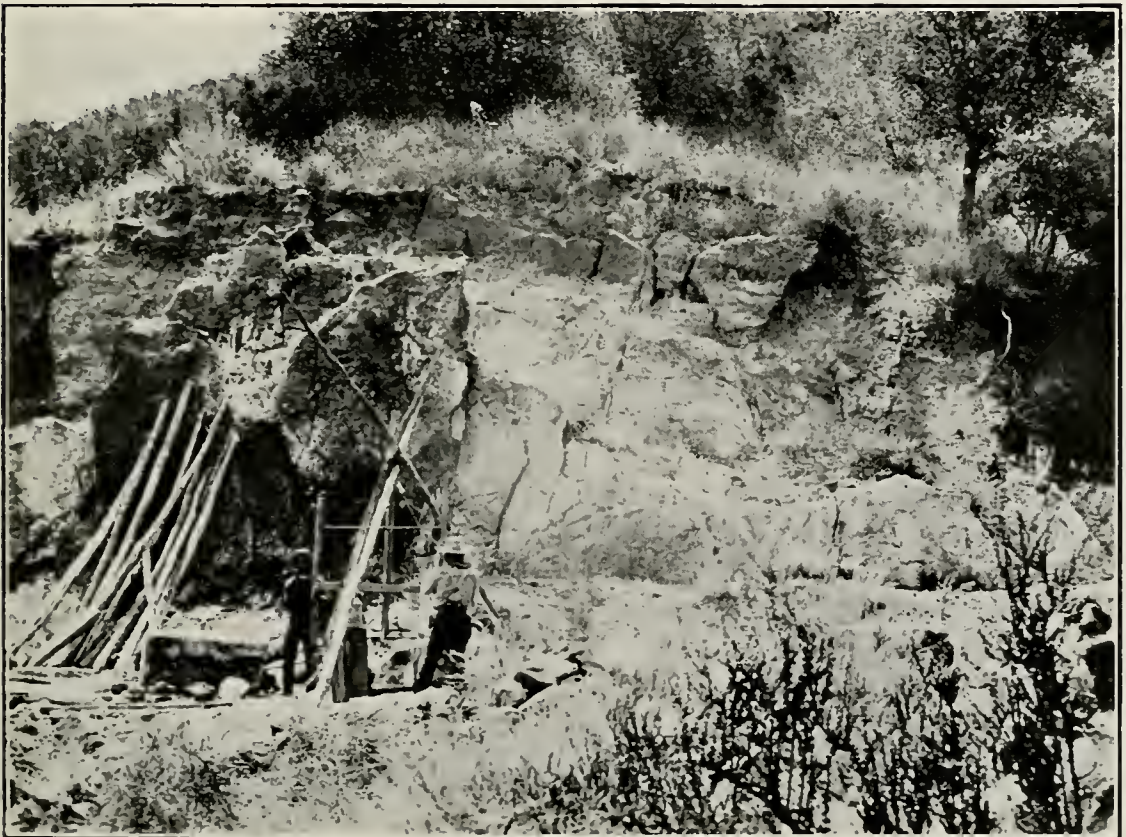
This onyx is considered by experts to be superior to any other onyx mined in the world.

SISKIYOU COUNTY.

Some onyx is occasionally found in the vicinity of Dunsmuir, but only as relatively small boulders; also boulders of aragonite, or onyx marble, generally of a light greenish color, associated with hot springs, which are depositing onyx marble and porous travertine. (See U. S. Geological Survey, Twentieth Annual Report, Pt. VI cont., page 288.)



ILL. No. 46. ARAGONITE QUARRY (KESSELER'S ONYX MARBLE), SAN LUIS OBISPO CO.



ILL. No. 47. ARAGONITE QUARRY (KESSELER'S ONYX MARBLE), SAN LUIS OBISPO CO.

SONOMA COUNTY.

Healdsburg Marble Company's Quarry, in Sec. 31, T. 9 N., R. 11 W.; George Madeira et al., Healdsburg, owners (formerly the Gray-Madeira onyx claim). Located 16 miles west of Healdsburg, at the head of Gillam Creek, a tributary of Austin Creek. The aragonite found here is green, and has filled a number of parallel fissures in a belt of serpentine, which courses northwest and dips 70 degrees. Some specimens show cavities lined with milky chalcedony; others have seams of chalcedony between the crystals of aragonite, so as to give it a banded structure. The inclosing silicified serpentine is most beautifully veined with yellow and brown opal, chalcedony, and jasper. It is very hard and can be had in large blocks, making it a valuable material for table tops and mantels. This claim has never been developed, owing to the distance from a railroad.

Besides the above-described localities, onyx marble occurs at the following points:

Gravelly Valley, Mendocino County.

Near Bridgeport, Mono County; California Travertine and Onyx Company, San Francisco, owners.

Some onyx marble has been quarried near Tolenas and Suisun, Solano County.

The verde antique marbles of California are described under Serpentine, page 147, which see.

SANDSTONE.

Sandstone is a sedimentary rock composed of sand grains cemented together. The bulk of the rock consists of the grains, which vary considerably in size and composition. When the quartz grains are very minute and the cementing material is prominent and of a clayey nature, sandstone gradates into shale, and when the size of the grains increases to that of pebbles the rock becomes a conglomerate. (See A. Geikie, Text-book of Geology, pages 161 and 164.) The bulk of the grains in nearly all sandstones consists of quartz. However, a small but variable percentage is composed of other minerals, among the most common of which are feldspar, muscovite, biotite, iron oxides, and hornblendes.

The *cementing* substance of sandstone forms a much smaller percentage of the rock mass than the grains, but it is a much more important part in governing its value as a building stone, since both the color and the strength of the sandstone are dependent on the cementing substance. The most common cements in sandstones are iron oxide, clay,



ILL. No. 48. VIEW OF ARCHES OF INNER QUADRANGLE, STANFORD UNIVERSITY.
BUILT OF SANDSTONE FROM GOODRICH QUARRIES, SANTA CLARA COUNTY.



ILL. No. 49. IONE RED SANDSTONE QUARRY, NEAR IONE, AMADOR COUNTY.

quartz, and calcite; sometimes one only, but frequently two or more of these cements are present. Crystalline quartz cement alone or in excess forms a quartzite metamorphic sandstone, an extremely hard rock and one difficult to work. Calcite cement alone makes a hard rock and one difficult to work. An excess of clay cement forms a stone that crumbles easily in a cold climate. Most of the sandstones that are strong enough for a good building stone and at the same time soft enough to be economically quarried and dressed, have as cementing substances either iron oxide—the yellow, red, and brown sandstones—or clay with a little calcite or silica in addition—the gray, blue, and buff sandstones.

Certain sandstones more nearly approach a true fireproof stone than any other class of building stones. The ease with which sandstones can be worked, together with the variety of pleasing colors, and the fact that in grain and texture they harmonize so well with bricks and other stones, makes them one of the most desirable of the building stones. That California is well supplied with good sandstones for building purposes is shown on the following pages.

SANDSTONE PRODUCTION IN CALIFORNIA FOR 1904.

Colusa County.....	\$290,000
Los Angeles County.....	13,145
Orange County.....	200
San Bernardino County.....	2,000
San Luis Obispo County.....	45,000
Santa Barbara County.....	3,600
Ventura County.....	3,500
Yolo County.....	720
Unapportioned.....	209,106
Total.....	\$567,181

SANDSTONE PRODUCTION IN CALIFORNIA SINCE 1887.

Years.	Value.	Years.	Value.
1887.....	\$175,000	1896.....	\$28,379
1888.....	150,000	1897.....	24,086
1889.....	175,598	1898.....	46,384
1890.....	100,000	1899.....	103,384
1891.....	100,000	1900.....	254,140
1892.....	50,000	1901.....	192,132
1893.....	26,314	1902.....	142,506
1894.....	113,592	1903.....	585,309
1895.....	35,373	1904.....	567,181
Total since 1887.....	\$2,869,378		

ALAMEDA COUNTY.

At present all of the sandstone produced in Alameda is used as macadam, rubble, or concrete. Years ago two quarries produced building stone, but they have been abandoned.

Altamont Sandstone Quarry, in Sec. 28, T. 2 S., R. 3 E.; H. T. Knowles, 30 California street, San Francisco, owner; one quarter of a mile

southeast of Altamont station. It was operated until 1888, the principal shipments being to San Francisco, where it was used in the Odd Fellows' cemetery. The stone is a massive, buff-colored sandstone, with occasional hard nodules in face.

Farwell Sandstone Quarry; Wm. Farwell, Berkeley, owner. In Rocky Brook Cañon, a tributary of Niles Cañon. Idle since 1898. The rock is shattered and broken, and much waste resulted in quarrying. Last used in foundation of Masonic Home, between Niles and Decoto.

AMADOR COUNTY.

O'Neal Sandstone Quarry, in Sec. 27, T. 5 N., R. 10 E.; Thomas Barnett, Ritchey P. O., owner; about 8 miles south of Ione. This red sandstone quarry was opened by David O'Neal about twenty years ago and was worked for a number of years. It has not been quarried for ten years or more. Stone from this quarry was used for the entrance and trimmings of the beautiful Preston School buildings at Ione, in the California Bank Building at Sacramento, and in the Chronicle Building at San Francisco. The stone was hauled by wagon to Ione, the nearest railway point, from which it was shipped by rail. It has a warm, rich, bright red color, and even, rather fine grain, and works nicely under the hammer. When first quarried it is soft, but hardens on seasoning. The quarry face shows a maximum thickness of from 18 to 20 feet of red sandstone in one massive bed, which lies with a slight dip to the north, and will probably show a greater thickness back from the present quarry face. The sandstone at the north end of the quarry opening is of a quality inferior to that farther south along the face, as it contains many spots and blemishes of the yellow iron oxide.

About 100 yards north of the red sandstone quarry, and from 30 to 40 feet higher on the hill, a small opening has been made into a massive *snow-white sandstone*. The thickness of this stone exposed in the opening is about 10 feet, but the total thickness of the bed is probably much greater. The white sandstone is a beautiful building stone and it is pure and free from iron, so that the waste from the building-stone quarry could all be used in glass or pottery works.

CALAVERAS COUNTY.

Late Sandstone Quarry, in Sec. 23, T. 4 N., R. 10 E.; Miss E. E. Late, Valley Springs, owner. A small quarry has been opened on a bold outcrop, which is plainly visible from the road. The stone is a medium-grained, white sandstone, occurring in thick beds, which have a slight dip to the north and into the hill. The stone in place is fractured and cross-seamed, so that no large dimension stone is visible, but this might



ILL. No 50. KOHL BUILDING, CORNER OF CALIFORNIA AND MONTGOMERY STREETS,
SAN FRANCISCO. BUILT OF COLUSA SANDSTONE.

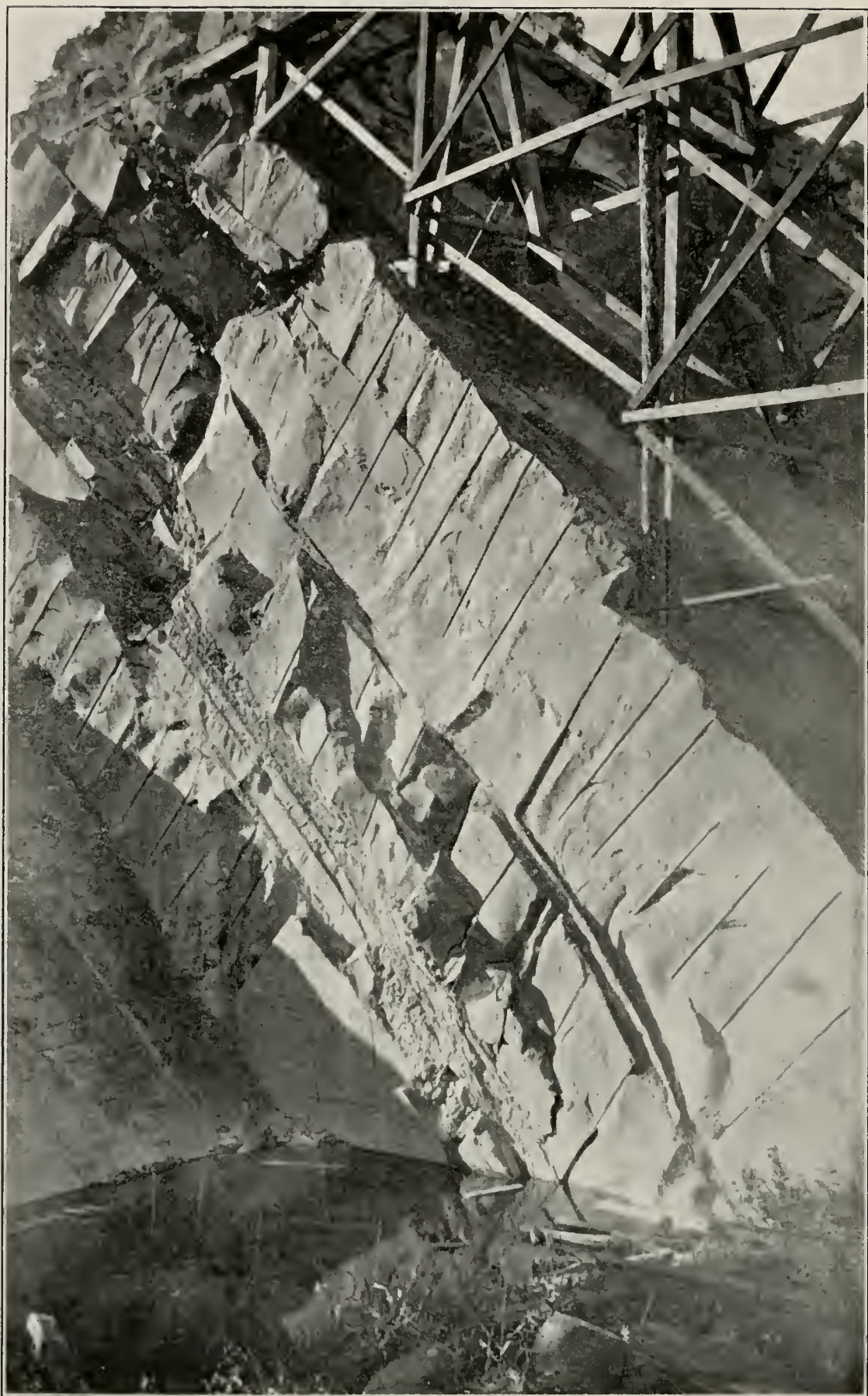
have resulted from careless blasting. The quarry has been idle for many years. The stone was used, rough-hewn, in building the residence of the owner in 1870, and some has been shipped to Stockton and used as a decorative stone in brick buildings.

Wildermuth Quarry; Isaac Wildermuth, Valley Springs, owner; about 3 miles northeast of Valley Springs, and about one quarter of a mile east of Campo Seco reservoir. The stone is a soft, coarse-grained, dark-gray sandstone, and is not very compact. It has been used in constructing the residences and buildings on the place, but is hardly suitable for large buildings. A quarry was opened years ago on the bold outcrop which occurs near the home, and extends for about 150 feet along the face with a 20-foot elevation.

COLUSA COUNTY.

A great belt of sandstone and shale extends from the northern boundary of the county for 20 miles to the south; in this belt occur massive ledges of the building stone character for a distance of 8 miles north and south, from Sec. 17, T. 16 N., R. 4 W., to Sec. 8, T. 17 N., R. 4 W., with a width of three fourths of a mile. The first extensive use of this sandstone for the construction of large buildings was in the Union Depot and Ferry Building at the foot of Market street, San Francisco. The most recent is the James Flood Building, at Market and Powell streets, San Francisco.

These ledges of sandstone have an average dip of about 50 degrees to the northeast. The beds vary from 18 inches to 18 feet, and average 4 to 6 feet in thickness. In the Colusa Sandstone Company's quarry, one bed measures 35 feet in thickness, which in its southern extension in the McGilvray quarry is 45 feet thick. It is difficult to ascertain the precise length of these ledges, but they have been exposed by the quarrying operations for an unbroken length of 230 feet in each of the two quarries. As to their thickness, they vary from 125 to 225 feet, measuring from the apex to the floor of the narrow valley that skirts the westerly side of the series. The quarries are being operated from the easterly side of the series of ledges, driving westerly and northerly. Measured by observations taken through Stone Corral ravine, the operations may extend from one fourth to one half mile westward on the valley floor level, and still be within the series of massive ledges. The stone is blue-gray and buff in color, weathering to light brown; compact, and measures 12 cubic feet to the ton, and has an even rift. The blocks are quarried to any desired length and width. Holes are drilled by hand or machine, from 2 to 3 feet apart, $1\frac{1}{2}$ inches in diameter, with a V-shaped half-inch ream on two sides. They are shot by battery. Wadding is placed in each hole 2 or 3 feet below the collar and the



ILL. No. 51. COLUSA SANDSTONE QUARRY. VIEW FROM SOUTH END OF QUARRY.
(120)



ILL. No. 52. ST. FRANCIS HOTEL, SAN FRANCISCO. COLUSA SANDSTONE.

DEWEY MONUMENT. RAYMOND GRANITE.

space above tamped with soil. The air in the chamber between the wadding and the bottom of the hole when compressed by the explosion of the powder serves as a force in splitting the rock. Both quarries are operated with steam-power hoists and derricks, and masses measuring 20 feet long, 10 feet wide, and 6 feet thick are handled with ease and quickness. The stone is shipped over the Colusa and Lake Railroad, a narrow-gauge system that connects with the Southern Pacific at Colusa Junction, and extends from the town of Sites to Colusa. At Colusa Junction the stone must be transferred to the standard-gauge cars of the Southern Pacific. The market has been so far confined to the California coast and the Hawaiian Islands.

Colusa Sandstone Company, F. E. Knowles, president; Thomas Bradbury, secretary. Offices and works, corner Potrero avenue and Tenth street, San Francisco. Quarries are located three fourths of a mile east of Sites, Colusa County, in the S. $\frac{1}{2}$ of the S. E. $\frac{1}{4}$ of Sec. 20, T. 17 N., R. 4 W. J. D. Martin, superintendent.

The ledges within this company's holdings extend north and south one quarter of a mile along their trend, and nearly half a mile east and west across the series. The present quarrying is being prosecuted at about the center of the holdings on the north side of Stone Corral Creek. Two quarry faces are exposed east and south. The east face is 225 feet long by 100 feet high. The south face is about 100 feet long, across twelve beds, and to a height equal to that of the east face. The stone is of the same quality and character as the stone in the McGilvray quarry. The stone for the San Francisco Ferry Building was obtained from this quarry.

The following shows the analysis and tests of this stone:

BOARD OF STATE HARBOR COMMISSIONERS,
10 CALIFORNIA STREET,
SAN FRANCISCO, May 6, 1897.

R. W. GORRILL, *President Colusa Stone Co.,*
San Francisco, Cal.

DEAR SIR: With regard to your inquiry as to whether we have made any tests of your sandstone, I will state that I have had both physical and analytical tests made, which are as follows:

May 14, 1896.

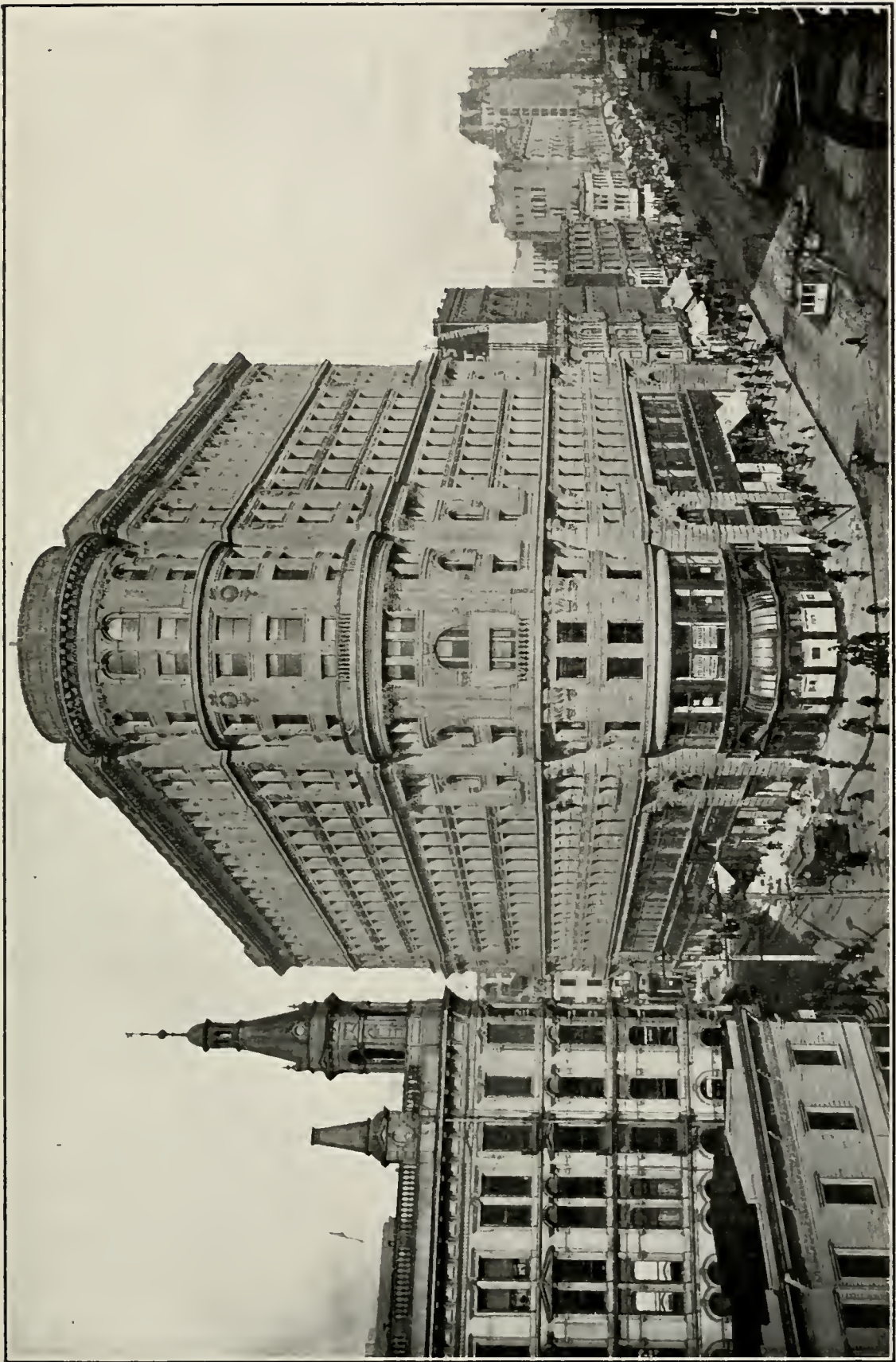
Analysis of sample of Colusa sandstone, from Sites Quarry, received from the Board of State Harbor Commissioners:

	Per Cent.
Silicon dioxide.....	85.99
Aluminum oxide.....	4.82
Iron oxide.....	4.49
Calcium carbonate.....	1.87
Magnesium oxide and alkalies.....	0.76
Moisture.....	0.69
Water of combination, organic matter, and loss.....	1.38

	100.00

Specific gravity, 2.558.

Water absorbed in twenty-four hours, 3.025 per cent.



ILL. No. 53. JAS. L. FLOOD BUILDING, SAN FRANCISCO. CONSTRUCTED OF COLUSA SANDSTONE.

When heated to a red heat and plunged into water, the stone neither splinters nor cracks. It resists, without fusion, the temperature of a full white heat, not even the sharp edges of the stone being blunted. Plunged into water, after being subjected to a full white heat, the stone assumes a light brown color.

We regard this as a very superior building stone.

The grains are small and uniform in size, thus forming a very compact rock, and one exceptionally well adapted for general use as a building material.

(Signed)

THOMAS PRICE & SON, Analytical Chemists.

SAN FRANCISCO, CAL., May 8, 1896.

MR. HOWARD C. HOLMES, *Chief Engineer, Board of State Harbor Commissioners, San Francisco, Cal.*

DEAR SIR: We have tested the three one-inch cubes of Colusa sandstone brought to us by Mr. S. G. Hindes, with the following results:

No. 1 broke at 8,940 pounds; No. 2 broke at 8,440 pounds; No. 3 broke at 8,880 pounds. All of which shows remarkably well.

Yours very truly,

(Signed) PACIFIC ROLLING MILL COMPANY,
By P. Noble, Manager.

Hoping that this may be what you require, I remain,

Yours very truly,

HOWARD C. HOLMES, Chief Engineer.

McGilvray Stone Company, John D. McGilvray, owner. Offices and works, Townsend street, between Seventh and Eighth, San Francisco. Quarries, three fourths of a mile east of Sites, in Sec. 29, T. 17 N., R. 4 W.; H. Sturrock, superintendent. The ledges in their general north and south course extend for the full length of the holding three fourths of a mile, with a width of one fourth of a mile. The quarrying was begun in about the center of the east side, driving westerly across the ledges. The face is 230 feet long north and south, and 220 feet high. The surface exposure of the sandstone extends to about 400 feet in height. The general character and quality of the stone is, however, the same. The operations in March, 1905, had reached a depth of more than 30 feet, cutting one bed 4 feet, one 6 feet, and one 18 feet thick. The latter bed has not been cut through its full thickness; it is estimated to be 20 feet thick.

Some of the prominent buildings in San Francisco which have been constructed of the McGilvray Stone Company's Colusa sandstone include: The Kohl Building (formerly the Haywards Building), corner Montgomery and California streets; F. W. Woods Building, Geary street; Miller, Sloss & Scott Building, corner First and Mission streets; Mutual Savings Bank Building, Market and Geary streets; Park Emergency Hospital; St. Francis Hotel; Flood Building, Powell and Market streets; Italian-American Bank, Montgomery street; Sherrith Israel Synagogue, corner California and Webster streets; Shreve Building, corner Grant avenue and Post street; W. P. Fuller Building, corner Mission and Beale streets.



ILL. No. 54. A PORTION OF THE FACE OF THE MCGILVRAV SANDSTONE QUARRY, COLUSA COUNTY.



ILL. No. 55. FRANKLYN SANDSTONE QUARRY, CONTRA COSTA COUNTY.
Wilson-Lyon Construction Company.

CONTRA COSTA COUNTY.

Franklyn Sandstone Quarry, in Sec. 24, T. 2 N., R. 3 W.; Wilson-Lyon Construction Company, 220 Market street, San Francisco, owner; William Haley, superintendent. It is $3\frac{1}{2}$ miles southwest of Martinez, in Franklyn Cañon, just east of Franklyn station, on the Santa Fé Railway. The stone is fine-grained, light blue in color, and is very soft when green, but upon exposure it seasons well and makes a very firm building stone. It occurs in beds about 26 feet thick and dipping in a general northerly direction at an angle of 45 degrees. At present the quarry face is nearly 100 feet from crest to bottom. The Santa Fé Railroad Company has run a switch to the quarry and the cars are loaded by means of an electric hoist and derrick. The waste rock is used for ballast and rubble. Any sized dimension stone is obtainable, but considerable waste is entailed in taking out large pieces. This stone was used in two new buildings in Martinez, and in the new schoolhouse in Redwood City. Twelve men are employed in the quarry.

Martinez Quarry; Mrs. S. E. Rankin, Martinez, owner. About three fourths of a mile south of west of Martinez, in a small ravine in the rear of the residence. The quarry was last worked about fifteen years ago, when some stone was taken out for use in the buildings of the Napa Asylum. The stone is rather fine-grained and buff-colored. It is soft when green, but hardens upon seasoning, and occurs in beds which dip at a high angle in a general southwest direction. These beds range from 1 to 8 feet in thickness, and are somewhat broken up, probably from careless blasting. Only a small quarry face was opened and not enough development work has been done to prove the quantity of stone available, but the outcrop which extends across the cañon would indicate a considerable body.

GLENN COUNTY.

Sandstone beds extend in a west of north course from the southern to the northern boundary of the county. In T. 18 N., R. 4 W., the beds maintain an average thickness of from 2 to 4 feet, and though broken on the surface by numerous small valleys and ravines are of sufficient continuity of length to insure the quarrying of masses equal to any but an extraordinary demand. In the central portion of the county greater thickness and continuity of the beds were observed in the exposures in T. 20 N., R. 6 W., where Stony Creek cuts through the sandstone for a width of about 1000 feet. In T. 20 N., R. 4 W., are exposures of massive beds lying close to the surface; and in the northern part of the county the sandstone series are clearly marked by exposures along the southern slope of the foothills east of Newville.



ILL. No. 56. GREEN SANDSTONE QUARRY OF THE KERN DEVELOPMENT SYNDICATE, KERN COUNTY.



ILL. No. 57. RED SANDSTONE, KERN COUNTY. KERN DEVELOPMENT SYNDICATE.

KERN COUNTY.

Kern Development Syndicate Quarries, in Sec. 14, T. 32 S., R. 34 E., M. D. M.; Kern Development Syndicate, 202 Wilcox Building, Los Angeles, owner; Robert Lewis, manager. These quarries are 6 miles south of Tehachapi and 3 miles from Erie station, on the Southern Pacific and Santa Fé railroads, and 112 miles from Los Angeles. The sandstone is of many colors—green, blue, red, tan, and drab. The formation lies at an angle of about 10 degrees, and varies in thickness from 3 to 30 feet. It is in unlimited quantity, covering several sections of land, all owned by this company. The Pasadena library building, and the Date and Fish blocks of Los Angeles, were constructed of stone from these quarries.

LOS ANGELES COUNTY.

Chatsworth Park Quarry, 200 acres in Sec. 13, T. 2 N., R. 17 W. S. B. M.; California Construction Company, 324 East Market street Los Angeles, owner. About 1½ miles west of Chatsworth, a station on the Southern Pacific Railroad. The quarry is connected by a branch line with the main road.

The stone is rather heavily bedded arkose sandstone. Near the surface it has a tawny color, but when fresh is of a bluish-gray color. This weathering takes place to irregular depth, but the line of demarcation between the weathered and fresh stone is very distinct. The stone is moderately fine-grained. When quarried for dimension stone it can be split regularly along the run, but when quarried for large blocks, as is done in this quarry for the substructure of the San Pedro breakwater, it breaks along uneven surfaces. It resists exposure to the atmosphere satisfactorily. Near Garvanza is a church (Holy Angels), built in 1887, of the tawny-colored stone, showing no signs of deterioration. The Courthouse in San Bernardino, the Public Library in Santa Ana, and the California Club in Los Angeles are all built of the tawny variety of this sandstone, taken from near the surface. At the land end of the Southern Pacific Railroad pier at Santa Monica some of this sandstone has been used for rip-rap. Below the level of high tide, where moistened by seawater, it is quite hard, but above high-water line the exposed stone is rather soft and somewhat disintegrated.

It may be mentioned here that extensive comparative tests made by the U. S. Engineer Corps, at Humboldt Bay, California, have proven that sandstone under seawater, or regularly moistened by sea tide water, will harden and not disintegrate by any chemical action of the salt water, but that the same sandstone exposed to the atmosphere on the shore will disintegrate. If slightly moved by the wave action, the stone will suffer some abrasion.



ILL. No. 58. PUBLIC LIBRARY BUILDING, PASADENA, LOS ANGELES COUNTY.
Constructed of Nile-green sandstone, and trimmed with red sandstone from Kern County.



ILL. No. 59. SANDSTONE QUARRY, KERN COUNTY. KERN DEVELOPMENT SYNDICATE.

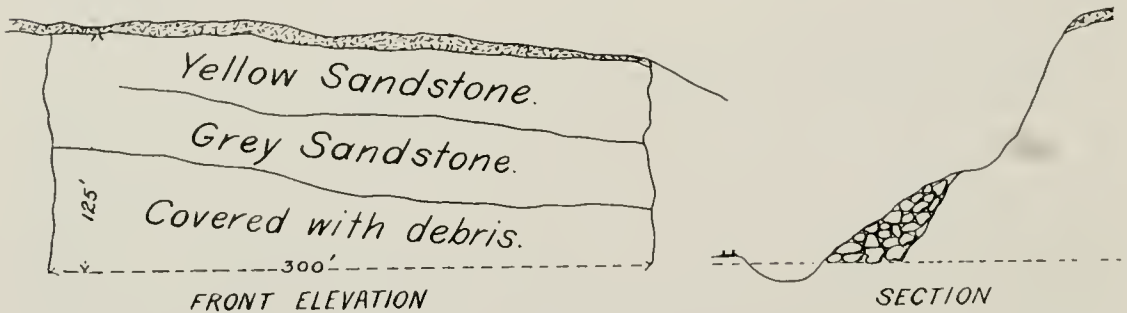
The blocks that form the San Pedro breakwater are broken down by churn-drilling (three men to the drill) rows of holes, having an average depth of 25 feet, with 20 feet face, and blasting with black powder, tamping solid without an air chamber above the charge. It is estimated that of the rock thus broken down: 20 per cent is débris, under 100 pounds, thrown over the dump; 15 per cent is small blocks, from 100 to 1000



ILL. No. 60. CHATSWORTH PARK SANDSTONE QUARRY, LOS ANGELES COUNTY.

pounds; 20 per cent is blocks from 1000 to 4000 pounds; and 45 per cent large blocks over 4000 pounds. (See sketch of front elevation of quarry.)

The quarry is equipped with four steam derricks, using oil as fuel.



ILL. No. 61. CHATSWORTH PARK SANDSTONE QUARRY, LOS ANGELES COUNTY.

Capacity, from 500 to 700 tons per day of random stone of large size for San Pedro breakwater. About fifty men are employed.

O. A. Charlton, in Sec. 7, T. 2 N., R. 16 W., S. B. M., on Sugar Loaf Hill, has quarried some boulders of sandstone similar in character to that in the other quarries near Chatsworth.

H. Clement & Co., 2124 Bay street, Los Angeles, lease part of the quarry of the California Construction Company in Sec. 13, T. 2 N., R. 17 W., S. B. M., west of the main quarry. They produce dimension

stone. The stone is similar in character to that in the quarry of the California Construction Company. The bed worked at present is from 20 to 25 feet thick, dipping about 20 degrees northwesterly. The rock is worked with plugs and feathers. The gray rock has not as yet been reached in this quarry.

Southern Pacific Railroad Quarry, in Sec. 12, T. 2 N., R. 17 W., S. B. M., near the eastern end of the middle tunnel; leased to C. Bertelson, 1307 West Ninth street, Los Angeles; produces dimension stone similar in character to the Chatsworth sandstone. The stone is broken down by hand-drilling and blasting with black powder and split with wedges. It is rather coarse-grained, heavily bedded. The gray stone has not been reached in this quarry. The quarry is equipped with a derrick, moved by horse-power. Capacity, 25 tons (one carload) per day. Nine men are employed.

MERCED COUNTY.

Dickenson Quarry, in T. 9 S., R. 16 E.; S. W. Dickenson, owner. A small quarry of a medium-grained, gray sandstone, which has been developed only in a small way.

MONTEREY COUNTY.

A belt of sandstone runs along the east slope of the Santa Lucia range, from Reliz Cañon, T. 21 S., R. 7 E., in a northwesterly direction past Tassajara Springs into T. 19 S., R. 3 E. Near these springs, in Sec. 36, T. 19 S., R. 4 E., this sandstone, which is a gray and olive in color, has been quarried and used for building the hotel. (See XIIIth Report, California State Mining Bureau, p. 636.) It is, however, too far from a railroad to be, as yet, of commercial importance.

NAPA COUNTY.

Gardner Sandstone Quarry, in Sec. 22, T. 6 N., R. 3 W.; Mrs. Sara T. Gardner, Napa, owner. Located 12 miles northeast of Napa, in Wooden Valley. The stone is a light buff, fine-grained sandstone. It occurs in beds dipping slightly to the north, and ranging from 2 to 4 feet in thickness, as is shown in exposures in the creek bottom. About 600 tons of this sandstone has been used in building bridges in the vicinity; it was taken from small outcroppings only, and no regular quarry face has been opened.

Maxwell Cañon.—About 15 miles from Rutherford, on the Maxwell ranch, and also on the Hardin ranch, in Maxwell Cañon, in Pope Valley, there is an abundance of sandstone which can be readily taken out in any desired dimensions. It is a fine, even-grained, com-

paet, light gray sandstone, and works well. It has been used in the cemeteries at Napa and St. Helena. No regular quarry face has been opened as yet, owing to the long wagon haul to railroad or water.

Napa Sandstone Quarry, $5\frac{1}{2}$ miles west of Napa, in Park Cañon, on the Brown Valley road; D. L. Beard, Napa, owner. It was first opened in 1901, and the stone was used in the construction of the Behlow Block in Napa. No large dimension stone is obtainable, as the beds are extensively fractured.

Pheland Quarry, about 4 miles south of Monticello, on the west side of Berryessa Valley. The stone is a bluish-gray sandstone, and was used in the construction of the bridge across Putah Creek, 2 miles south of Monticello. This bridge has three 75-foot spans and cost \$20,000.

ORANGE COUNTY.

Santiago Sandstone Quarry, in Sec. 17, T. 5 S., R. 7 W., S. B. M.; Rev. C. Gruen, 814 Rose street, Santa Ana, owner. This quarry is situated in a side cañon of Santiago Cañon. This side cañon runs along a fault, dividing the sandstone from the shale.

The sandstone is quite hard, of a light gray color, rather coarse-grained, with inclusions of igneous material rounded and waterworn. The large blocks are broken down with powder, hand-drilling, and are split to the required dimensions by driving a few wedges. The stone is used for building purposes in Santa Ana.

SAN BENITO COUNTY.

Paicines Sandstone Quarry, in Sec. 1, T. 14 S., R. 6 E., M. D. M.; Martin Miller, Paicines, owner. Idle for years.

SAN BERNARDINO COUNTY.

There is a deposit of sandstone suitable for building purposes in the east end of the San Bernardino Valley, on Mill Creek, in Sec. 7, T. 1 S., R. 1 W., S. B. M. In former years two companies were formed to quarry this material, both of which are now out of existence.

Mentone Sandstone Company operated in the S. W. $\frac{1}{4}$ of the section. The stone was used in the Hall of Records in San Bernardino; it is a tawny-colored, medium-grained sandstone, very similar to the Chatsworth sandstone. It is claimed that the best material was found near the surface, and that in depth the shale increased. The company has quit operations for the last three years.

Southern California Sandstone Company operated in the same section. (See also IXth Report of California State Mining Bureau, page 225.)

SANTA BARBARA COUNTY.

The Santa Ynez Mountains consist of Miocene strata, which embrace a heavy body of sandstones, conglomerates, and shales at the base. (H. W. Fairbanks. Bulletin Geological Society of America, Vol. VI, p. 39, and Journal of Geology, Vol. VI, pp. 561 and 574.) Partly, as near Refugio Cañon, the shales form the main body of the range, with a sandstone capping, dipping southeasterly; while in other places, as for instance near Santa Barbara, the range consists apparently of massive sandstones, dipping northward, the underlying shales being found in the foothills.

As near as can be judged from the broken boulders, the stone is a light buff-colored, rather coarse-grained and not very compact arkose. It is used for building purposes. As yet only the large boulders have been quarried.

F. R. Angulo, Santa Ynez (844 E. Carillo street, Santa Barbara). A quarry of boulders in Sec. 12, T. 5 N., R. 31 W., S. B. M., on the summit of the Santa Ynez Mountains, at the head of Refugio Cañon, 8 miles by wagon road from Orella, a station on the Southern Pacific Railroad. The abutments of the railroad bridge over the Refugio, and the church at Naples were built of this stone. Some is shipped to Los Angeles.

Erickson Quarry, in T. 9 N., R. 34 W., S. B. M.; J. B. Arrellanes, Santa Maria, owner. A sandstone quarry, about 5 miles south of Santa Maria, from which some good building stone has been quarried. (See XIIIth Report, California State Mining Bureau, p. 637.)

Near Gaviota Pass there is a blue stone of very fine grain that has been used in limited quantities for monuments by the Santa Barbara Marble Works.

Mission Cañon, near Santa Barbara; principal owner, the Roman Catholic Church. A number of buildings in Santa Barbara are built of this stone.

James Waring, Santa Barbara, owns a quarry in Sec. 6, T. 4 N., R. 26 W., S. B. M.; between Cold Stream and Hot Springs creeks, near Santa Barbara.

SANTA CLARA COUNTY.

Cassell Quarry, on the Bear Creek road, 10 miles from Los Gatos; John Cassell, Los Gatos, owner. A buff-colored sandstone, similar to that in the Goodrich quarries (see below). The Carnegie Library in Santa Cruz is built of this stone.

Goodrich Quarries, Jos. Maddox, owner; operated by the McGilvray Stone Company, Second and King streets, San Francisco. At Gray-

stone station, 9 miles south of San José, on a spur of the Narrow Gauge Railroad running from San José to Santa Cruz. An extensive body of buff-colored sandstone, which has been quarried in this locality for many years by several different parties.

The sandstone occurs in beds from a few inches to 10 feet or more in thickness. The present (August, 1904) quarry face shows beds 10 feet, 3 to 4 feet, 10 feet, 6 feet, $6\frac{1}{2}$ feet, and 4 to 6 feet thick, respectively. About 50 feet of sandstone are exposed below the bottom of the present quarry, and about 100 feet on the outcrop above the quarry, while a still greater thickness is exposed on the hills immediately adjoining on the northeast and northwest. The strata dip 25° N., 75° W., in the quarry opening, but this varies somewhat over other portions of the outcrop.

Like many sandstones, it is quite soft when first quarried, but indu-



ILL. No. 62. CARNEGIE LIBRARY, SANTA CRUZ.

Constructed of Sandstone from John Cassell's Quarry, near Los Gatos, Santa Clara County.

rates on exposure until it has a quite firm, hard surface. In grain, color, and texture the stone is fairly uniform. In a few places some of the iron has been leached out by the surface waters, leaving the stone a mottled yellow and gray; however, only a comparatively small part of the stone is thus affected. In some of the abandoned quarry openings the stone contains iron oxide concretions, which disfigure the stone, but none of these are visible in the present working.

The freestone character of the rock adapts it to carved work, as is so well shown in the elaborate and intricate carving on and in the costly chapel at Stanford University, Palo Alto.

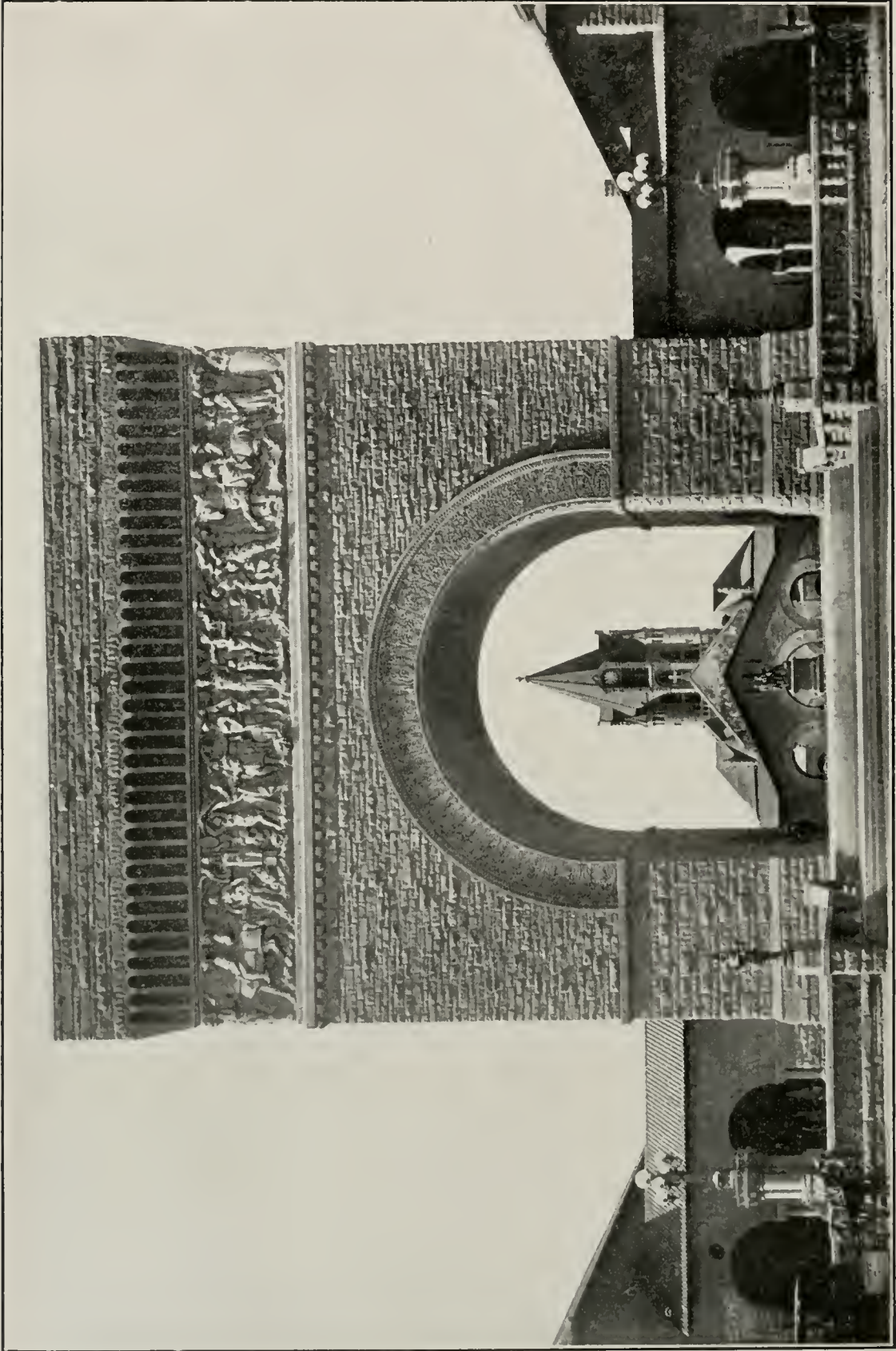
The stone is quarried by hand, loaded with steam-power derrick on small tram-cars, and sent down an inclined track about 800 feet to the stone mill and cutting yard near the railway track. The mill is supplied with two gang-saws for cutting dimension stone, and a large crew of stonecutters is at work finishing the stone.



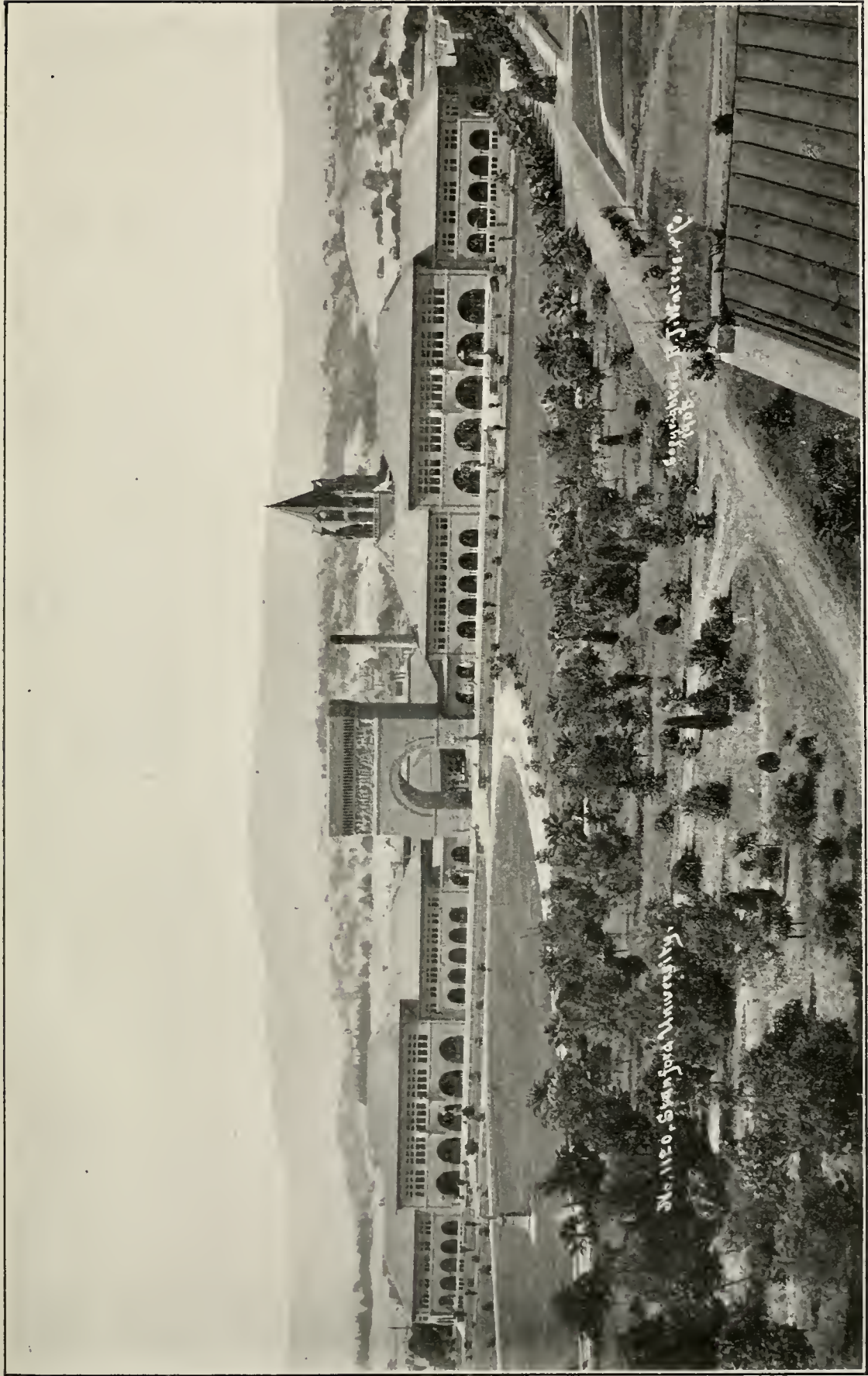
ILL. No. 63 STANFORD QUARRY, SANTA CLARA COUNTY.
(Goodrich Sandstone Quarry. McGilvray Stone Company.)



ILL. No. 64. STANFORD SANDSTONE QUARRY, SANTA CLARA COUNTY.
(McGilvray Stone Company.)



ILL. No. 65. MEMORIAL ARCH, WITH CHURCH IN BACKGROUND, STANFORD UNIVERSITY, SHOWING TYPES OF CARVED WORK WITH THE SANDSTONE.



ILL. No. 66. GENERAL VIEW OF QUADRANGLE BUILDINGS, STANFORD UNIVERSITY, CONSTRUCTED OF SANDSTONE FROM GRAYSTONE QUARRIES.

The stone has been used for building purposes in San José and nearby towns for many years, but the greatest and most elaborate monument to the architectural value of this stone is to be found in the many costly buildings of Leland Stanford Junior University, which, with the exception of one or two cement and one or two brick buildings, are constructed of this buff sandstone.

Laboratory Tests of the Graystone Sandstone.*—Specific gravity, 165 pounds per cubic foot. Absorption of moisture, 1.23 per cent; of water, 5.13 per cent. Loss in carbonic acid solution, 0.42 per cent. In the acid fumes, the color was leached out one fourth inch deep and fissure-joints were developed. In the muffle-furnace the stone suffered no change up to a bright red heat, except the change in color from yellow to red. Immersion in water while hot failed to crack the stone. The crushing strength indicated by a single specimen was 2400 pounds per square inch. The microscope shows that quartz is the leading constituent. Orthoclase and plagioclase are present, the first in excess and both much decomposed. The cement is a film of kaolin impregnated with carbonate of lime. The yellow ochre coloring matter is not distributed uniformly, but is in small particles and patches scattered between the granules.

SHASTA COUNTY.

A few miles northeast of Redding, the Cretaceous Chico sandstone forms the surface rock of Secs. 7 and 18, T. 32 N., R. 4 W. The tawny-colored sandstone occurs in thick horizontal beds, enabling the quarrying of large blocks. It makes a fairly good building stone, and has been used in many of the prominent buildings in northern California. Two quarries have been worked on this sandstone:

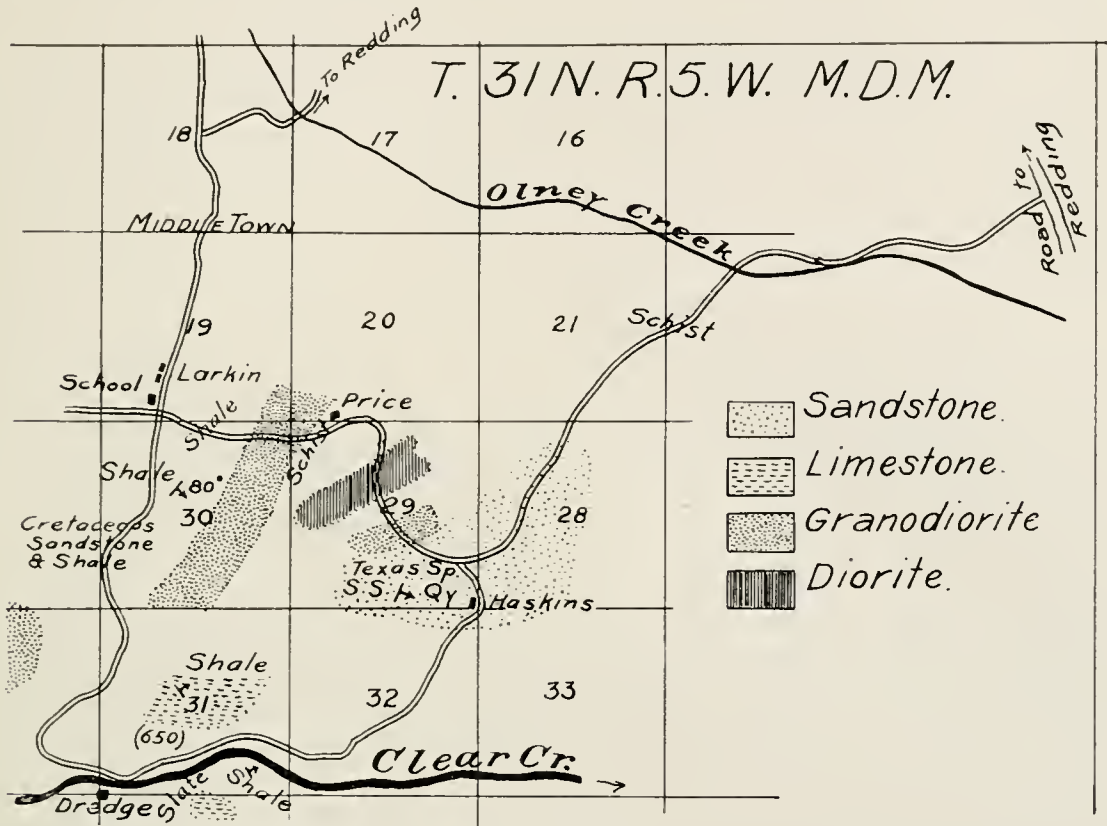
Sandflat Quarry, in Section 18; A. Dutton, Redding, owner.

Stillwater Quarry, in Section 7; F. H. Dakin, 104 Sutter street, San Francisco, owner.

Texas Spring Quarry, in Sec. 29, T. 31 N., R. 5 W.; California Sandstone and Construction Company, 16 Post street, San Francisco, owner. The Chico sandstone lies at the surface on a considerable portion of Sections 28 and 29 (see sketch C); thin beds are also found overlying the shales in Section 30, on the Horsetown road. At the Texas Spring quarry the sandstone is yellow and hard on the exposed faces; gray and softer when fresh; thickly bedded, dipping slightly a little north of east. One bed more than 7 feet thick was worked in the quarry.

* Made by Prof. A. W. Jackson, University of California, Berkeley. VIIIth Report State Mineralogist, p. 890.

The sandstone contains a number of concretions (niggerheads) and very thin lenses, carrying considerable fossils. On account of these inclusions and niggerheads, the stone, otherwise a good building material, is not well suited for that purpose.



ILL. No. 67. SKETCH C. SHASTA COUNTY.

SISKIYOU COUNTY.

A very extensive bed of sandstone runs along the east side of the Kildall hills, Black Mountain range, and Cottonwood Mountains, into Oregon. Its southern extremity is about in Sec. 4, T. 44 N., R. 6 W. It is found east of Yreka in two large exposures. The most southern runs from the southern extremity of the belt to Secs. 25 and 26, T. 45 N., R. 7 W., along the eastern rim of the Kildall hills. It forms a narrow ridge, with steep slopes on both sides.

North of this ridge the sandstone crops out again in Sec. 13, T. 45 N., R. 7 W., where it forms another ridge having a northeasterly direction, also forming the rim of the Shasta River Valley.

The same sandstone crops out a few miles south of Ager, along the east side of Black Mountain range, where a coal mine has been worked in the sandstone at the Herr ranch.

The same belt shows in the vicinity of Hornbrook in the ridges surrounding the valleys of the Klamath River and the lower part of Cottonwood Creek.

West of Hornbrook and Henley, along the rim of the Cottonwood Mountains, runs a belt of fine-grained gray sandstone, not over a quarter of a mile wide. It forms a landmark, as its surface sloping east forms for a greater portion the bare lower slope of the mountains, its gray color being distinguishable from a long distance.

The sandstone is very fine-grained, compact and hard. It consists of small granules of quartz, with some small ones of hornblende, and is known as the *Henley sandstone*. The relation of this sandstone to that east of the valley is not clear. Whether it underlies the latter or does not persist farther than exposed at the surface has not been determined as yet.

D. C. Earhart, Hornbrook, owns a quarry in Sec. 20, T. 47 N., R. 6 W., near Henley, on the Henley sandstone.

Fioch Brothers, Yreka, own a quarry in Sec. 13, T. 45 N., R. 7 W., near Yreka, where considerable stone has been taken out. The face of the quarry shows massive sandstone, nearly horizontal, dipping slightly east. The upper bed is at least 8 feet thick, and coarse-grained. Only very few niggerheads occur and the sandstone is very uniform in texture, of a tawny color. Underlying this, but without any parting, is a bed of dark gray sandstone, under which shows again tawny sandstone, which forms the present floor of the quarry.

G. B. Russell, Yreka, owns a quarry in Sec. 7, T. 45 N., R. 6 W. The stone is a fine-grained, bluish-gray sandstone. It is used for building and monument work and for flagstones; it resists weathering very well, showing no deterioration after an exposure of over forty years.

Mr. Russell has two quarries in Sec. 30, T. 45 N., R. 6 W. In the quarry on the west side of the ridge the coarser-grained tawny sandstone is cleared off to reach the underlying fine-grained gray sandstone, which is similar to the Henley sandstone. The overlying sandstone cuts in blocks up to 8 feet long, and from 12 to 18 inches wide. In the quarry on the east side of the ridge the sandstone is very hard. It is worked by plugs and feathers, and breaks in blocks and rifts with the grain almost equal to lumber.

Southern Pacific Railroad Company has several quarry openings on the Henley sandstone in Sec. 29, T. 47 N., R. 6 W., near Henley. It uses the stone principally for bridge abutments. The quarries are worked by plug-and-feather work. The sandstone breaks in large square blocks, some weighing over 5 tons. In a quarry on Rock Creek, a parting of shale about 1 foot thick is found in the sandstone. The sandstone was used in the Horn and Jones buildings, Hornbrook, built in 1888, and shows no signs of weathering.

SOLANO COUNTY.

The northwest portion of Solano County is closely related in topography and geology to the southwest portion of Yolo. The sandstone croppings can be followed from Putah Creek for a distance of 12 miles to Vaca Valley.

The only practical exposures of sandstone beyond the surface of the croppings in Solano County have been made by two small quarries or open cuts necessitated by the opening of public roads and to supply a small local demand.

F. Frietas, Vacaville, in Sec. 11, T. 6 N., R. 2 W., toward the southern extremity of the belt.

F. B. Kington, Vacaville, in Sec. 35, T. 7 N., R. 2 W., 2 miles north of the first named.

The sandstone is gray of color, fine of texture, and said to weigh 185 pounds to the cubic foot; it has been used principally in culvert construction.

SONOMA COUNTY.

Coast Bluffs.—Along the coast from Fort Ross to Stewart's Point sandstone has been quarried and proved to be a good building material. The bluffs can be approached by schooners. (See XIIth Report State Mineralogist, p. 400.)

In the hills just east of Freestone, along the county road to Sebastopol, there are many places where freestone can be quarried. It is easily cut with a saw when green, but seasons fairly well. It is not suitable for large buildings.

A small quarry face has been opened on the property of Mary E. Roberts, on the south side of Jonive Creek, in the Jonive Grant, one mile northeast of Freestone.

STANISLAUS COUNTY.

Wright Ranch, in Sec. 21, T. 1 S., R. 12 E.; G. W. Wright, Knight's Ferry, owner. Stone has been quarried from this locality at different times for the last fifty years, furnishing material for all the principal buildings in the vicinity of Knight's Ferry. The entire hill is composed of bedded sandstone, the beds ranging in thickness from a few inches to several feet, and dip slightly to the southwest. The stone is a light buff-colored sandstone, and contains some mica flakes. No regular quarry has been developed, but stone has been taken out at intervals along the roadside. Much waste rock covers the small faces and only a small amount of dimension stone is exposed at present, the result of very careless quarrying by divers persons.

VENTURA COUNTY.

Sandstone has been quarried at different points in Sespe Cañon by various parties for a great many years, but nearly all the stone (except a little in Razzle Dazzle Cañon) has been quarried by hand from surface boulders. Scores of immense boulders, some of them hundreds of tons in weight, offer inducement for inexpensive quarrying. A further inducement is found in the position of these boulders at the base of the hill, while the ledges are generally high up on the mountainside, where considerable expense would be involved in bringing the quarried blocks to the roadway in the bottom of the valley.

The Los Angeles Brownstone Company quarried rock in this cañon for several months, in 1888, and then left the work. Several other parties have quarried stone here, some for a few months, some for a few years, but only one party is quarrying stone at present.

In the XIIIth Report of the State Mineralogist, in 1896, two companies are mentioned as then in operation: The Mentone Sandstone Works, at Brownstone spur, employing 18 men; the Razzle Dazzle Sandstone Quarry, $3\frac{1}{2}$ miles north of the works, and owned by the same company; and the Henley Brothers, operating the Phœnix Sandstone Quarry.

Sespe Canon Brownstone Quarry, in Sec. 35, T. 5 N., R. 20 W., and Secs. 1 and 2, T. 4 N., R. 20 W., S. B. M.; George J. Henley, Sespe, owner. This is the only quarry at present in operation; it is located from 5 to 6 miles from Brownstone, a station on the Southern Pacific Railroad. Most of the stone is loaded for shipment at Brownstone. It was used in the State Insane Hospital at Patton. Four men are employed.

In this locality the Sespe River cuts across the "Coldwater Anticline," with its axis nearly east and west, dipping toward the east. The brown sandstone is exposed on the crown and on both sides of the axis on both sides of the river. It is also exposed in the several small tributary cañons, such as Coldwater Cañon, east of the river. In places, as at the "Devil's Gate," and below, the shearing planes developed by the folding are more prominent than the bedding planes and in places cut the stone into small dimensions. On the north side of the axis the stone does not appear to be at all shattered, and occurs in heavy massive beds, with two sets of nearly rectangular joint planes, so that it lies in huge cubical blocks which have a gentle dip to the north and east.

The brownstone beds are underlaid by a series of oil-bearing gray sandstones and gray and red variegated shales. Overlying the brownstone is another oil-bearing series of gray sandstones and shales.

The brownstone series consist of sandstones, shales, and conglomerates, with a total thickness of 800 feet or more. The lower portion of the series is prevailingly conglomerate, quite coarse in places, with some sandstone and shale intermingled. The upper part of the series consists of brown shales with alternating beds of sandstone. The middle portion of the series, several hundred feet in thickness in places, is almost entirely brown sandstone. While this is the general relation of the beds, there are local variations.

The most favorable location for a quarry opening would be where the greater part of the overlying shales has been eroded, exposing the sand-



ILL. No. 68. VIEW IN SESPE CAÑON, VENTURA COUNTY, SHOWING "COLDWATER ANTICLINE."

stone of the middle portion of the series over an area sufficiently large for quarry operations.

On the west side of the river, just north of the axis, the shales have been eroded, exposing the top of the sandstones over a large area, probably 100 acres or more. Several small perennial watercourses have cut deep tributary cañons into this hill, exposing the edges of the sandstone layers from 15 to 20 feet thick, and in places forming perpendicular cliffs from 30 to 50 feet in height, and in one place more than half a mile long. Good quarries of excellent brownstone could be opened at many places in this hill.

The stone has such a straight fracture and even grain that it could be most economically quarried by wedging or with the Knox blasting

system. The evenness of the fracture and the regularity of the joint planes are indicated by the huge talus blocks, which are, in places, as rectangular and as square-cornered as though they had just come from the hands of the stonecutter.

No stone has yet been quarried on this hill, because of the difficulty in getting it to railroad. There probably are good quarry sites in the brownstone area, other than the one described.

The stone is a typical brownstone; the coarser-grained varieties have a rich purplish-brown color, and the finer-grained stone has a light reddish-brown color. The stone is free from the "iron balls," "iron blisters," or "liver spots," too common in many of the Eastern brownstones; in fact, it is remarkably free from defects of any kind. In many places, most prominent in the finer-grained varieties, there is a faint banding parallel with the bedding, which is perceptible on a rock- or sand-rubbed surface. It works readily under the stonecutter's tools, and is adapted to carved and dressed surfaces as well as rock-faced work. Blocks several feet in diameter are split straight and even by plug-and-feather in 3-inch hand-drilled holes.

The durability of the stone is indicated by the steep mountain slopes on which it occurs, and by the bold outcropping ledges and the sharp corners and fresh surfaces of the talus blocks. It is rarely discolored, even on the long-exposed outcrop. The conglomerate beds are likewise for the most part quite durable and might be safely used for bridge abutments, foundations, retaining walls, and similar uses. The shaly layers and the very fine-grained stone should be avoided where great durability is important.

Laboratory Tests on Sespe Brownstone.*—The specific gravity of the stone is 2.65, hence the weight of one cubic foot is 165.6 pounds. The absorption of moisture is 0.76 per cent; absorption of water equals 1.53 per cent; loss in carbonic acid gas solution, 0.24 per cent. Exposure to strong acid fumes changed the shade to a lighter tone, corroded the stone somewhat, leaving it slightly crumbly on the surface, resulting in a loss by disintegration of 2.37 per cent, 2.05 per cent of which was lost quietly in the exposure chamber. This test works unfairly against this stone, as compared with one containing no visible carbonate of lime in the cement, such as, for instance, the Angel Island sandstone, because while fairly indicating relative tendencies to *chemical* disintegration, it gives no measure of the *mechanical* disintegration to which the loosely aggregated argillaceous sandstones of the Coast Range are particularly liable. On account of the firmness, this brownstone would unquestionably resist the combined agencies of chemical and mechanical disintegration indefinitely longer than the Angel Island and similar

* Made by Prof. A. W. Jackson, University of California. VIIIth Report State Mineralogist, p. 888.

sandstones. In the muffle-furnace the brownstone changed its color at full red heat to a light brownish red, and developed one crack clear through the cube parallel to the bedding. The rest of the cube was entirely unaffected, neither cracking, scaling, nor becoming crumbly on the surface. Immersion in cold water while still hot failed to affect the stone in the least.

The crushing strength determined on a bed-cube 1.507 in. by 1.534 in. by 1.435 in. (ht.) equaled 4122 pounds per square inch, and on an edge-cube 1.472 in. by 1.618 in. by 1.595 in. (ht.) yielded 3892 pounds per square inch.

References on the Sespe Brownstone.—1. Eighth Report, State Mineralogist of California, pp. 676, 687, and 888.

2. Tenth Report, State Mineralogist of California, p. 761.

3. Thirteenth Report, State Mineralogist of California, p. 638.

4. U. S. Geological Survey, Mineral Resources of the United States, 1893, p. 560.

5. Merrill, Building and Ornamental Stones, p. 252.

6. Bulletin No. 11, California State Mining Bureau, p. 26.

7. Bulletin No. 19, California State Mining Bureau, p. 94.

Buildings Constructed wholly or in part of Sespe Brownstone.—Bryson Block, Los Angeles, first story and superstructure trimmings; Y. M. C. A. Building, Los Angeles, front façade; Burdick Block, Los Angeles, first story and trimmings; Drew Block, San Bernardino, trimmings; Opera House, South Pasadena, trimmings; People's Bank, Pomona, trimmings; Orphan Asylum, Los Angeles; Shatto pyramid, Rosedale Cemetery, Los Angeles; Briswalter monument, Courier Building, Los Angeles; Bradbury Building, Los Angeles; Van Nuys Hotel, Los Angeles, two doorways; Old Chamber of Commerce Building, Los Angeles; Methodist Episcopal Church, Pasadena; Torrence Building, Pasadena; Academy of Sciences Building, San Francisco; Pacific Insurance Building, San Francisco; Whittier State School, Whittier; Chico High School, Chico; Sherman Indian School, Arlington; Gay residence, San Diego; Highland Insane Asylum, near San Bernardino.

In most of the above mentioned buildings the brownstone is used for doorways or trimmings, or both.

YOLO COUNTY.

Sandstone deposits crop out along the west boundary of Yolo County on the eastern slope of the mountain ridge that divides the county from Napa, at some points reaching an elevation of 2000 feet above the levels of Cache and Putah creeks. Between these two streams the ledge is apparently unbroken. At the south end the stone is of a bluish color

that is reputed to be strongly resistant to the elements. The same character of formation may be traced across and beyond Putah Creek into Solano County. Except for local uses this sandstone has been quarried on a comparatively small scale, considering the vast deposits indicated by the croppings.

Putah Stone Quarry, in Sec. 29, T. 8 N., R. 2 W.; E. F. Searles, San Francisco, owner; B. Berthelot, Winters, lessee. In the extreme southwest corner of Yolo County, 9 miles by wagon road from Winters; 15 miles by wagon road from Vacaville, Solano County. This deposit of sandstone is situate on the north bank of Putah Creek, and is exposed in heights varying from 50 to 200 feet for a width of one quarter to one half mile. The formation extends east to south across Putah Creek into Solano County. The exposed material at the Putah quarry is shattered but massive. It is blue and gray in color, takes a fine finish, and averages 174 pounds to the cubic foot.

SERPENTINE.

Serpentine is a hydrous silicate of magnesia ($3 \text{ MgO}, 2 \text{ SiO}_2, 2 \text{ H}_2\text{O}$) that occurs in rock masses, and is sometimes used as a building or ornamental stone. It usually has a green color—sometimes dark, sometimes light, and sometimes yellowish green. It is thought to be in all cases a secondary rock; that is, it is formed from some other rock by a gradual change in the mineral character. The most common minerals which are known to change to serpentine are chrysolite, hornblende, and augite.

Serpentine forms extensive rock masses in the Coast Mountains and occurs in numerous small areas in the Sierras, but in most places it lacks sufficient brightness of color to be a desirable ornamental stone, and has too many cracks, fissures, and mineral impurities to make a good building stone. It has been quarried for both building and ornamental stone in small quantities at some localities in California.

Despite the fact that serpentine is a durable stone and occurs in large quantities in different parts of the United States, it has not been used for either building or ornamental purposes in quantities at all comparable with many of the other classes of building stone. The reasons for this are probably twofold: first, the color is not a favorite one; and second, the great quantity of waste necessary to handle, because of the numerous fissures and cracks, makes the quarrying expensive. Large dimensions are scarce in all serpentine quarries.

Verde Antique.—When serpentine is mixed irregularly with considerable quantities of calcite, it is called verde antique marble, or ophiocalcite, and is highly prized as an ornamental stone. One large deposit of verde antique marble, noted below, has been quarried in California.

AMADOR COUNTY.

A yellowish-green to dark olive-green serpentine has been quarried about two miles west of Plymouth. The quarry is not in operation and is said to have been idle for a number of years. The old pit is 40 by 20 by 15 feet, and was formerly owned by Dr. Thomas Boyeson.*

Folio 11, U. S. Geological Survey Atlas, states that a beautiful mottled variety of serpentine is quarried $1\frac{1}{2}$ miles west of Sugar Loaf, Amador County.

LOS ANGELES COUNTY.

Banning Company, 593 Pacific Electric Building, Los Angeles, owns a quarry in a belt of serpentine, at Empire Landing, Santa Catalina Island, on the east coast, about 12 miles from Avalon. The serpentine is very dark green and occurs in that part of the island in bunches, in conjunction with soapstone and steatite, from which a very good material for ornamental, sanitary, and electrical purposes is obtained. It can be worked out into very thin slabs and even used for open work, and takes a very fine polish. (See XIIth Report, California State Mining Bureau, p. 402; also XIIIth *ibid.*, p. 639.)

SAN BERNARDINO COUNTY.

Mojave Consolidated Development Company, J. P. O'Brien, 175 Crocker Building, San Francisco, organized to operate the *Verde Antique Marble quarry*, formerly known as the Gem quarry (Alamo Consolidated Marble Company), or the Kimball mine, in Sec. 28, T. 7 N., R. 2 W., S. B. M., on the Mojave Desert, about 16 miles N. 25° E. from Victorville, a station on the Southern California Railway. It was opened a number of years ago by Frank Kimball of National City, San Diego County, and has been worked at several different times. It is idle this year (1904). More than 400 tons of marble have been hauled from this quarry to Victorville, and shipped by rail to Colton, where it was sawed, polished, and prepared for use. It has been used for interior decoration in a number of buildings in Los Angeles and San Francisco. Some very handsome stone has been obtained from this quarry, probably as fine as any in the United States, and it seems unfortunate that more of it is not put on the market.

* Twelfth Report of State Mineralogist, 1894, p. 402.

While the long distance from the railway makes the marketing expensive, the beauty of the stone is sufficient to command a price that would pay for the transportation.

The quarry opening is from 60 to 100 feet long, with a face of about 75 feet. It is in what appears to be a large dike or intrusive mass of serpentine and calcite, in the midst of a granitic porphyry. The metamorphism is now so complete that it would require a more detailed study of the rock and the locality to determine the nature of the original rock from which the serpentine and calcite were derived. The rock is quite heterogeneous in structure. In some places the pure serpentine is from 5 to 10 feet thick; elsewhere the serpentine occurs in patches and bands of limestone, which alternates in white and blue. In places the limestone is from 10 to 20 feet thick, without any serpentine. The serpentine varies in color from a light yellow-green to a dark green. The handsomest stone is that in which the bright yellow-green occurs banded with dark green and white limestone.

Both the limestone and serpentine contain many cracks and weather seams, so that there is a large quantity of waste material to be handled. The method of quarrying by blasting has caused additional waste.

There are two derricks in the quarry and another one at the base of the hill. The stone is dragged from the quarry to the base of the steep part of the mountainside, where it is loaded on wagons to be hauled to the railway.

It is to be hoped that this quarry may soon be again in operation, and that it may be worked more systematically and on a larger scale.

The serpentine outcrops again about half a mile S. 70° E. from the quarry, but it is not certain that this mass is connected with that at the quarry.

SISKIYOU COUNTY.

Most of the serpentine found in Siskiyou County has a conchoidal fracture. A belt of it runs along a part of the main ridge of the Cottonwood Mountains, forming there "Shafts Rock," a prominent landmark at the head of Bogus and Dutch creeks. Samples show that it takes a fine polish, and breaks so as to form blocks which can be used as structural material.

SLATE.

Running through El Dorado and Amador counties is a great belt of black slate that has been exploited in a small way in a score or more places. Many of the openings, however, are not deep enough to show whether a good material is present or not. The belt forms part of the Mariposa slate belt, which is of Jurassic or early Cretaceous age. It will be strange, indeed, if other first-class slate does not occur in this extensive range, and other quarries will no doubt be opened in the future when better railway facilities are afforded.

PRODUCTION OF ROOFING SLATE IN CALIFORNIA, 1889-1904.

Year.	Squares.	Value.	Year.	Squares	Value.
1889.....	4,500	\$18,089	1898.....	400	\$2,800
1890.....	4,000	24,000	1899.....	810	5,900
1891.....	4,000	24,000	1900.....	3,500	26,250
1892.....	3,500	21,000	1901.....	5,100	38,250
1893.....	3,000	21,000	1902.....	4,000	30,000
1894.....	1,800	11,700	1903.....	10,000	70,000
1895.....	1,350	9,450	1904.....	6,000	50,000
1896.....	500	2,500			
1897.....	400	2,800	Total...	52,860	\$357,739

The figures show a marked increase in production during the past five years. The fact that California is at present the only slate-producing State on the Pacific Coast gives additional interest. It has recently shipped slate to the insular territories of Hawaii and Guam.

REFERENCES ON CALIFORNIA SLATE.

1. Eighth Report, State Mineralogist of California, p. 199.
2. Ninth Report, State Mineralogist of California, p. 283.
3. Twelfth Report, State Mineralogist of California, p. 400.
4. Thirteenth Report, State Mineralogist of California, p. 639.
5. Eleventh Census, volume on Mineral Industries, p. 662.
6. Bulletin No. 225, U. S. Geological Survey, pp. 417-421.
7. E. C. Eckel, Journal of Geology, Vol. 12, February, 1904, pp. 15-29.
8. Proceedings of the California Miners' Association for 1903, p. 134.

AMADOR COUNTY.

On Lane Ranch, Mr. Yager, owner, $1\frac{1}{2}$ miles east of Ione, some preliminary work was done a few years ago in opening a slate quarry. Two openings have been made; the south one shows only little promise of good slate in large dimensions. The north opening, about 250 yards

down the gulch, appears to be free from quartz veins, and promises a good quality of slate, but the opening is not yet deep enough.

The thick belt of Mariposa slate, the same that has been quarried in El Dorado County, crosses the county and is promising at sufficient depth in a number of places, but the above are the only openings as yet made in Amador County.

EL DORADO COUNTY.

California Slate Quarry, in Secs. 23 and 25, T. 11 N., R. 10 E., M. D. M.; F. S. Chadbourne, 121 New Montgomery street, San Francisco, owner. It is located on the north side of the American River. The material contains much iron pyrites. The trimmed slabs left in the yard are nearly all iron-stained, and some of them crumbling by the disintegration of the pyrite since their exposure to the air. The pyrite appears to be much worse on the west side of the quarry opening than on the east side. It is probably confined largely to certain layers of the slate, and the quarry opening unfortunately struck one of these bad streaks. The quarry has not been operated in the last few years.

Chili Bar Slate Quarry, in Sec. 36, T. 11 N., R. 10 E., M. D. M.; J. G. Mothersole, Placerville, owner. On the south side of the American River. It is said to be the oldest quarry in the district, but has been idle since 1897.

Eureka Slate Company, Wm. J. Dingee, president, Crocker Building, San Francisco, is operating the only quarry that is producing any slate at present in California. It is located at Slatington, one mile south of Kelsey, and between 7 and 8 miles north from Placerville, the nearest railway station and the shipping point of the slate. The quarry has been in operation for fifteen or twenty years. The present company has operated it only about two years and a half, and has put in large improvements, among others an extended wire cable-way 3 miles long, of the Bleichert system, for transporting the slate across the American River, with a clear span across the river-valley of 2400 feet, at an elevation of 600 feet above the river, and operated by water-power. From the south end the slate is hauled by wagon to the railway at Placerville.

The Eureka slate has a blue-black color, which weathers brown in some places, and greenish-gray in other places. It is for the most part free from impurities in the deeper portion of the quarry, but in a few places there is iron pyrite along the seams and a few small quartz and calcite veins, which add to the waste that is always an important part of every slate quarry.

The quarry is located in the bottom and on both sides of a small

cañon. The steep slope for several hundred feet below the quarry opening gives an excellent dumping ground for the waste product. The quarry opening on the north side of the cañon has been abandoned. On the south side of the cañon the quarry has a face over 200 feet long, and about 70 feet high at one end, and about 200 feet at the other. The west end of the quarry has been sunk 90 feet below the bottom of the cañon. The deep portion is about 100 feet square, and it is from this opening that the greatest quantity of good slate, with the least waste, is now obtained. The east end of the quarry is within 40



ILL. No. 69. EUREKA SLATE QUARRY, SLATINGTON, EL DORADO COUNTY.

feet of the bottom of the cañon. From both places large quantities of good roofing slate are quarried.

The strike of the cleavage is south 25 degrees east. To a depth of nearly 40 feet in places, there are numerous joint-planes cutting the slate into small dimensions. Below this the joints rapidly disappear, and in the bottom portions there are very few—not enough to interfere with taking out blocks as large as can be quarried and handled. The blocks are loosened by hand work, by drilling and wedging, and are then lifted by the cable-hoists and placed on cars on the tracks on the upper floor. The same hoists are used to lift the fragments and waste. The blocks taken out vary from 300 to 3000 pounds in weight.

The marketable slate is run to the sheds, where the splitters and the blockmaker reduce it to the standard size for roofing. The finished

slate is placed in small iron carriers on the cable-way. The present output is 1000 squares per month.

The entire product is used for roofing slate, for which purpose it gives good satisfaction and the demand keeps pace with the shipments. The slate unit is the square which is sufficient to cover 100 square feet of roof, and weighs about 600 pounds.

Running through the body of the slate are numerous narrow ribbons of a material more siliceous than the adjoining slate, which are separated in the quarry operation and thrown out in the waste. These ribbons do not follow the cleavage of the slate, but indicate the original bedding of the slate mass, which does not vary greatly at this point from the cleavage plane.

Eureka Green Slate.—There is a green-colored belt of slate several feet in width, crossing the black slate, that is thought by Mr. Eckel* to be an altered intrusive dike of igneous rock. This is indicated by the fact that it is not parallel to the ribbons and hence is not interstratified material, and further by the chemical composition (see accompanying analysis), which shows it to be quite unlike the black slate and much like certain basic igneous rocks of the district. The green slate is not quite so smooth as the black, but works very well and is used with the black for lettering and trimming.

Analyses of Eureka Slate, Slatington, California.

	Black Slate.	Green Slate.	Green Slate.
Silica (SiO ₂)	63.52%	45.15%	47.30%
Alumina (Al ₂ O ₃ and TiO ₂)	16.34	16.33	15.53
Iron oxides (FeO, Fe ₂ O ₃)	6.79	8.42	8.00
Lime (CaO) .....	.98	6.42	7.83
Magnesia (MgO)	2.50	8.72	7.86
Carbon dioxide (CO ₂) and water	4.86	11.28	9.92

GLENN COUNTY.

Slate of good roofing quality may be developed in Glenn County. Some of the following deposits may be worthy of future investigation:

Alder Spring road, T. 21 N., R. 7 W.

Grindstone Cañon, T. 22 N., R. 6 W.

Kilgore road, T. 22 N., R. 7 W.

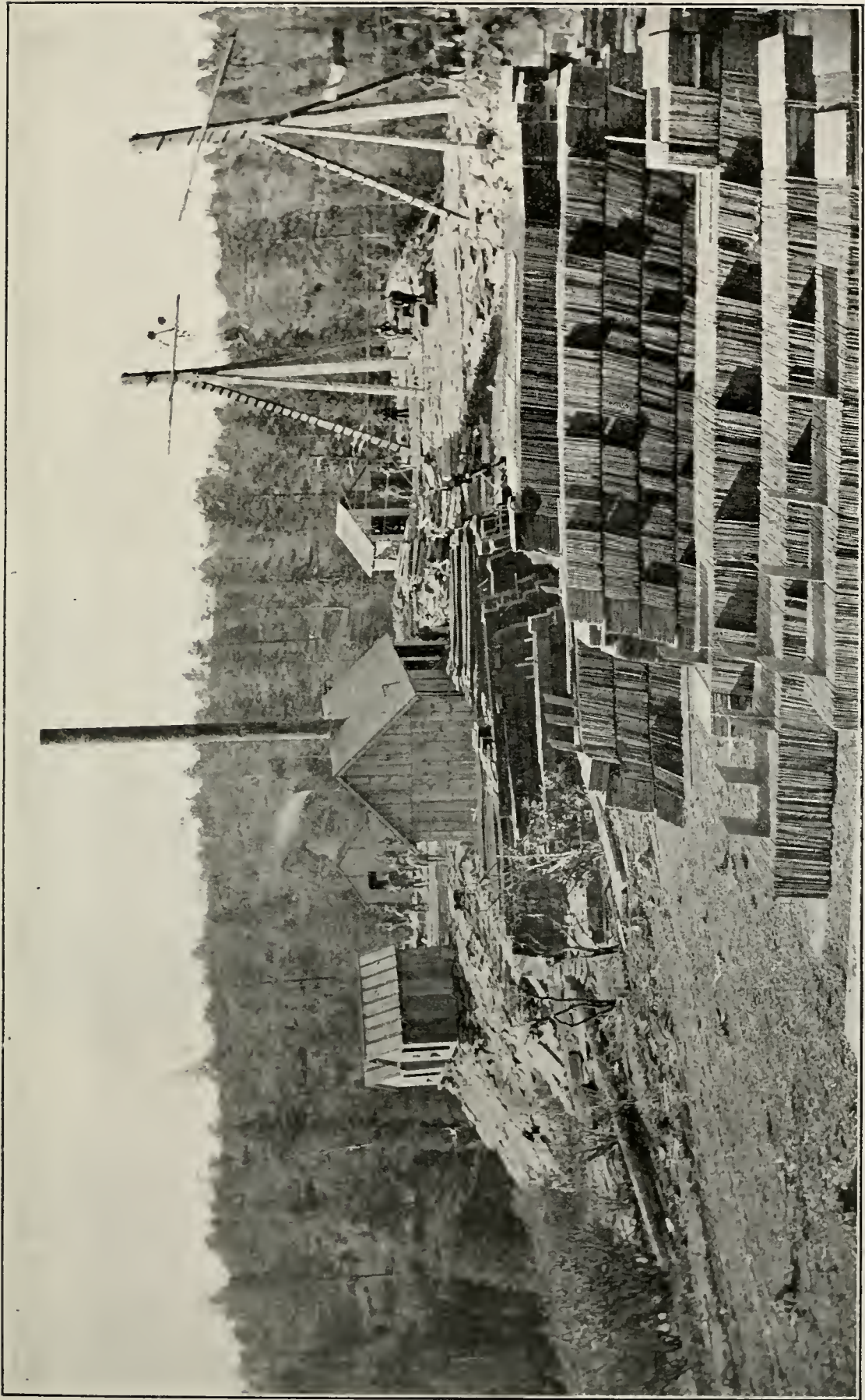
J. Shelton ranch, T. 22 N., R. 6 W.

Stout ranch, Sec. 20, T. 20 N., R. 7 W.

MARIPOSA COUNTY.

Pacific Slate Company's Quarry, in Sec. 6, T. 6 S., R. 16 E., M. D. M.; Pacific Slate Company, owner; C. G. Kocher, Merced, secretary. The quarry was first opened about 1897 and operated intermittently for a

* Bulletin No. 225, U. S. Geological Survey, p. 419.



ILL. No. 70. VIEW IN YARD NEAR QUARRY OF THE EUREKA SLATE COMPANY, EL DORADO COUNTY.

time, but it has been idle for the last three years. The slate is of good quality, with a straight, even cleavage, and was used in roofing the county jail at Merced. An 18-mile haul over rough roads is the main item of expense.

PLACER COUNTY.

In Sec. 31, T. 16 N., R. 12 E., south of Emigrant Gap, an exposure of slate is found which is claimed to contain a good quality of roofing material.

VOLCANIC AND INTRUSIVE ROCKS.

BUTTE COUNTY.

Curtis Ranch, in Sec. 7, T. 21 N., R. 4 E.; J. G. Curtis, Pentz, owner. Volcanic tuff of coarse grain and dark color has been quarried for local building purposes; it is easily worked and hardens with exposure.

CALAVERAS COUNTY.

Several quarry faces have been opened at different times on the steep cliff on the north side of the lower road to Murphys (by Vallecito), about 2 miles northeast of Angels, in Sec. 26, T. 3 N., R. 13 E. The stone is a trachytic tuff and can be obtained in any desired amount, but no very large dimension stone can be quarried because of the numerous seams and cracks.

GLENN COUNTY.

A belt of tuff runs along the foothills in the western part of Glenn County. It is the southern continuation of the belt of similar material found in Tehama County. The tuff is quarried for local purposes, and also used for the manufacture of ollas (water jars).

INYO COUNTY.

A soft volcanic tuff occurs in Sec. 14, T. 6 S., R. 32 E., M. D. M.; A. M. Strong et al., Bishop, owners; 6 miles from Laws, on the Carson and Colorado Railroad. It has been used for building purposes in Bishop and Independence.

LOS ANGELES COUNTY.

On Santa Catalina Island, bluffs of trachyte come to the water's edge on the east coast, between Avalon and Empire Landing, in places to a height of 800 feet. This trachyte has been used in the old breakwater

from Terminal Island to Deadman's Island, San Pedro harbor, and formerly in the Government breakwater at San Pedro, but in the latter its use was abandoned on account of the difficulty in obtaining the large blocks required, weighing over 4000 pounds. (See also Xth Report, California State Mining Bureau, p. 279, and XIth *ibid.*, p. 404.)

NAPA COUNTY.

Brown Quarry; Mrs. Marguerite Myers, Fairfield, owner; 2 miles southeast of Calistoga. There are two quarry faces; the older one was abandoned, as it became too soft. The new face is one fourth of a mile



ILL. No. 71. ST. HELENA PUBLIC SCHOOL.
Constructed of Trachytic Tuff from Moffat Quarry, near St. Helena Napa County.

nearer town and is more uniform in character, being a hard, coarse, yellowish trachyte. It outcrops in large boulders and larger stone is obtainable. It has been used to a considerable extent locally as a building stone.

Davis Quarry; Dr. C. E. Davis, St. Helena, owner; 2 miles north of St. Helena, on the Sanatorium road. The stone is a hard reddish trachytic tuff, showing flow structure, and is quarried from the outcrops. It was used in the construction of the Hunt Block in St. Helena.

Dr. Davis also has an exposure of soft buff-colored tuff at the bridge on the Sanatorium road, 1 mile north of St. Helena.

Howell Mountain Quarry; H. Overacker, Jr., St. Helena, owner. This quarry is about 3 miles northeast of Calistoga. The stone is a light yellow trachytic tuff, and occurs in large boulders. It can be obtained in large pieces and is suitable for large buildings. It was used in the front wall of the postoffice at St. Helena.

Jursch Quarry (formerly the Carver Quarry); G. O. Jursch, St. Helena, owner; about 1½ miles northeast of St. Helena, on a private road off the Howell Mountain road. The stone is a light yellow trachytic



ILL. No. 72. NEWMAN'S TRACHYTE QUARRY, 2 MILES SOUTH OF NAPA.

tuff, and has been used in a number of buildings in St. Helena and also in some bridges in the county.

Linscott Quarry; Mr. O. H. Linscott, Calistoga, owner; 2 miles southeast of Calistoga, on the St. Helena road. The rock is a light yellow trachytic tuff, and grades from a fine-grained, nearly white rock on the north side of the quarry to a coarse, yellowish stone on the south side. It furnishes a very good stone for bridge or foundation work, but a large amount of waste is necessary in getting out building stone, and no very large dimension stone is obtainable.

Moffat Quarry; James Moffat, 915 Geary street, San Francisco, owner; D. Brusk, superintendent; about 2 miles northwest of St. Helena, near the reservoir. The stone is a light buff trachytic tuff; it can be quarried

in large pieces, and is uniform in color. It was used in the construction of the beautiful new school building at St. Helena.

Newman Quarry; operated by J. B. Newman, Napa; about $1\frac{1}{2}$ miles southeast of Napa, on the Soscolor Vallejo road. The stone is a light-gray trachyte and grades into a bluish, close-grained basaltic trachyte, showing flow structure. It occurs in a bedded deposit, and the rock varies within a few feet. It is used as a building stone for bridges and foundation work.

In the field adjoining the State Hospital grounds on the south side, there are numerous low outcrops of a wine-colored trachytic tuff which are being dug from the earth and split into small building stones,



ILL. No. 73. WING'S TRACHYTE QUARRY, NAPA.

principally used as a decorating material in buildings constructed mainly of lighter colored tuffs.

Pickett Quarry; C. N. Pickett, Calistoga, owner; about $1\frac{1}{4}$ miles east of Calistoga. The rock is a light-yellowish trachyte and has been used as a building stone in Calistoga.

Rose Quarry; Dave Willis, Calistoga, owner; 2 miles east of Calistoga. The stone is a trachytic tuff and has been used in bridge construction, but is rather too soft, tending to flake when exposed to the action of frost. It is suitable for foundation construction where protected from the weather.

Salmina Quarry, in Secs. 9 and 10, T. 6 N., R. 4 W.; 7 miles north of Napa. The stone is a soft, light-yellow tuff, and is easily sawed or cut and readily dressed. It makes a very pretty stone for interior decorations, especially for fireplaces, and is used very successfully as firebacks in stoves, being very refractory when dry.

Taplin Quarry; W. H. & J. O. Taplin, St. Helena, owners; about $2\frac{1}{2}$ miles southeast of St. Helena, on the east side of the road. This quarry formerly furnished considerable rock for building purposes in St. Helena, but has not produced much of late. The stone is a trachytic tuff.

Wing's Quarry, in Sec. 19, T. 6 N., R. 3 W.; H. W. Wing, Napa, owner; 4 miles northeast of Napa, on the Berryessa road. The rock is a hard, light gray to a yellowish trachyte, with a close, even texture. It is used for bridge and foundation work. Mr. Wing used it in the construction of the bridge on Brown street, for the city of Napa. The rock is rather seamy and very much waste is entailed in securing large dimension stone.

Zollner Quarry; J. F. Zollner, Napa, owner. This quarry is located $2\frac{3}{4}$ miles south of Napa. The rock is a smooth, even-grained basalt, and is dark blue to black in color. On the west side of the quarry a very hard gray trachyte is quarried for building purposes by H. W. Wing of Napa.

PLACER COUNTY.

Rhyolite of good building quality is reported to occur in Blue Cañon, in Sec. 14, T. 16 N., R. 11 E.

Tuffs of good building quality are abundant in the Forest Hill district, T. 14 N., R. 10 E. Some occur at Dutch Flat. The old hydraulic mine workings have exposed large quantities of this material of varying quality. A local building erected in Forest Hill about forty years ago still stands as evidence of the imperviousness of this material to the elements. It is light of weight and color, and of finer grain than that at Dutch Flat. Similar occurrences are noted at Chalk Bluff, between Sugar Pine Mill and Damascus, in T. 15 N., R. 11 E.

SAN LUIS OBISPO COUNTY.

A line of buttes of igneous rock runs in a northern direction west of the Santa Lucia range from San Luis Obispo to Morro. These rocks are of a grayish color, and have been classified by Mr. H. W. Fairbanks, *Journal of Geology*, Vol. VI, page 567, as dacite granophyre and andesite granophyre. These buttes afford very good quarry sites.

Another belt of igneous rock (tuff) is found in the southwestern part of the county, running from near Arroyo Grande in a southeastern direction past Los Berros Creek. The belt is over a mile wide, and the tuff has been quarried in several places.

Bishop's Peak (Cerro Obispo) Quarry, in Sec. 21, T. 30 S., R. 12 E., M. D. M.; Dr. G. B. Nichols, San Luis Obispo, owner; J. W. Wyley,

superintendent. There are two quarries on this property. From the old quarry at the southwest corner of the butte large blocks were taken by A. A. Polhemus and the City Improvement Company of San Francisco for the Government breakwater at Port Harford, but lately this quarry has not been used. The present quarry is in the southeast corner of the butte, elevation 1000 feet. As yet only boulders have been quarried, the face having just reached the solid rock, which has a porphyritic character, and breaks easily, requiring very little powder. The rift is not appreciable, the fracture occurring generally on a curved plane, which, however, is very smooth. The rock can be easily dressed and takes a good polish. It is used for rubble masonry,



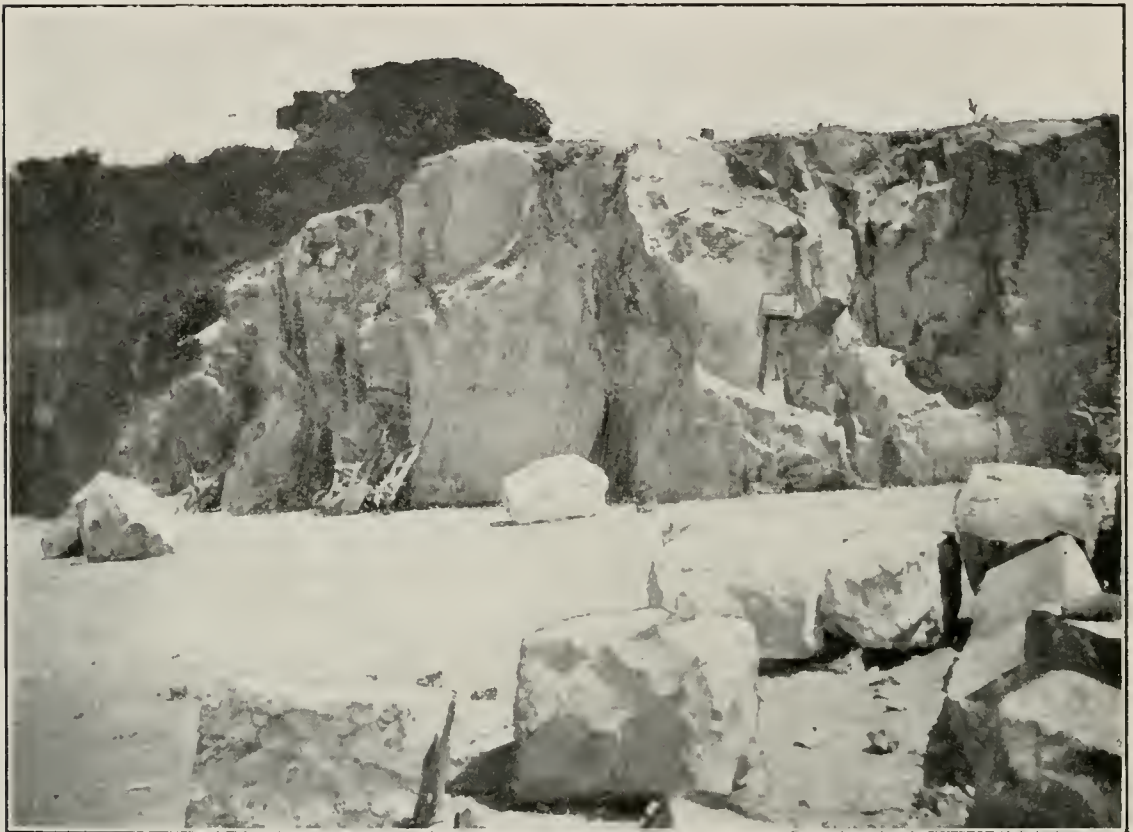
ILL. No. 74. WYLIE'S RHYOLITE QUARRY, SAN LUIS OBISPO COUNTY.

coping stone, curb stone, etc. It was used in the Presbyterian Church, and the basement of the Free Library, San Luis Obispo.

In 1896 Mr. William Ireland made an analysis of the rock from the old quarry, giving it silica, 64.15 per cent, and a specific gravity of 2.58, equal to 161 pounds per cubic foot.

Caen Quarry, in Sec. 36, T. 32 S., R. 13 E., M. D. M., and Sec. 26, T. 12 N., R. 35 W., S. B. M.; Los Berros Stone Company, Los Angeles, owner. It is also known as the Houghton quarry, and is about 3 miles south of Arroyo Grande. The tuff is uneven in character, containing in places considerable iron. It has generally a high yellow color, but with white patches and seams containing some lime.

Lee Quarry, in Sec. 17, T. 30 S., R. 12 E., M. D. M.; Elena Hansan, San Luis Obispo, owner. At the north foot of the Cerro Omaldo, near Chorro Creek; elevation, 625 feet. The rock is of a character similar to that in the Bishop's Peak quarry, only the groundmass has a much lighter and duller gray color. The quarry is in the solid rock, in beds from $1\frac{1}{2}$ to 3 feet thick, dipping easterly 45 degrees, which have very smooth planes, in places showing slickensides. This rock was used in the construction of the Southern Pacific railroad, near San Luis Obispo. Has been idle since 1891. (See also XIIIth Report, California State Mining Bureau, p. 623.)



ILL. No. 75. VOLCANIC TUFF QUARRY, LOS BERROS, SAN LUIS OBISPO COUNTY.

Moore Quarry, in Sec. 31, T. 12 N., R. 35 W., S. B. M.; P. Moore, Arroyo Grande, owner; leased to the Los Berros Stone Company, Los Angeles. It is on the south side of Los Berros Creek. In the quarry two distinct flows of tuff are readily distinguished. The upper flow, from 10 to 12 feet thick, thins out toward the west. It lies without any parting on the smooth surface of an older flow, dipping slightly eastward. The upper tuff is of more regular character and harder than that at the Caen quarry. It breaks in large but irregular blocks. The lower tuff is much harder than the upper, has a metallic ring, and breaks in small blocks with curved faces like glass. In Los Berros Creek a small gang-saw has been erected. The tuff is sawed here and

used for building purposes in Arroyo Grande and San Luis Obispo, and some carloads have been shipped via Port Harford to Los Angeles.

Morro Rock Quarry, in Sec. 26, T. 29 S., R. 10 E., M. D. M.; Morro Bay, United States Government Reservation. The most northern of the line of buttes above described. Used by A. A. Polhemus for the breakwater at Port Harford. (See also XIIIth Report, California State Mining Bureau, p. 623.)

SHASTA COUNTY.

A belt of tuff extends from Clover Creek to Bear Creek, a distance of 5 miles.

In Sec. 18, T. 31 N., R. 2 W., in the forks of Old Cow Creek and South Cow Creek, east of Millville, a bluff of Tuscan tuff rises with steep sides from 30 to 50 feet high. In the road the underlying Chico sandstone is found, nearly horizontal; dip S. 50° W., at an angle of about 10°. The tuff has a light gray color, and contains a great number of inclusions of various sizes and hardness, some even of a soft, talcose material. The rock is rather soft and easily cut to any desired form, but hardens on exposure. Being light, it makes a good building material for a temperate climate.

SIERRA COUNTY.

Basaltic lava occurs in Sec. 29, T. 21 N., R. 10 E., 2 miles east of Morristown; also in Sec. 34, T. 22 N., R. 10 E., at Mount Filmore, in the northwestern part of the county; also in Sec. 27, T. 19 N., R. 14 E., at Weber Lake, in the central part of the county. This stone is adapted for building purposes, resisting exposure to the weather, and may be secured in massive sizes. It can be worked with the ordinary stone-cutter's tools, takes a fine polish, and has been employed in local construction and for monument work in local cemeteries.

SISKIYOU COUNTY.

In Sec. 10, T. 44 N., R. 5 W.; E. C. Hart, Roselawn P. O., owner. A prominent bluff of tuff, rising from 30 to 40 feet above the surrounding country, has been quarried and used in Yreka for building purposes. The rock is light yellowish, with narrow bands of light brown and white colors, rather coarse-grained. When fresh it is not very hard and can be easily dressed, but on long exposure to the air the outer coating becomes very hard. This quarry is from 7 to 8 miles by wagon road from Montague, a station on the Southern Pacific Railroad.

In Sec. 17, T. 45 N., R. 4 W.; S. F. Terwilligen, Little Shasta P. O., owner. On the north bank of Little Shasta River there is a consider-

able area of similar rock, only somewhat finer grained. It can be trimmed easily and takes a fine polish. This same belt runs north to the Klamath River near the mouth of Bogus Creek, where it has been used by the Klamath Lake Railroad in its bridge abutments.

In Sec. 16, T. 45 N., R. 4 W.; S. F. Terwilligen, Little Shasta P. O., owner. On the north bank of Little Shasta River, for a distance of about a hundred yards, a brick-red rhyolite rock is exposed; in places it is light bluish gray. The rock has been quarried and used in Yreka for building purposes. This quarry is about 12 miles from Montague, on the Southern Pacific Railroad.

About half a mile up the river there is a large bluff of the same material, of a grayish-green color.

Vesuvianite.—In Sec. 12, T. 18 N., R. 6 E., H. M., on the north side of the South Fork of Indian Creek; A. E. Heighway, 52 Nassau street, New York, owner. Some work has been done on large boulders of a hard stone, varying from olive to almost grass-green. This rock was at first supposed to be jade, but proved upon analysis to be a form of vesuvianite, called by Mr. G. F. Kunz californite. It takes a fine polish, and can be used for ornamental work. (See American Journal of Science, 4th Series, Vol. XIV, 1903. Bulletin No. 37, California State Mining Bureau.) These boulders lie in serpentine, dipping northwesterly into the mountain. Whether the vesuvianite occurs as a bed in the serpentine, or only as boulders, is as yet undetermined. Large boulders are found in the creek bed.

SOLANO COUNTY.

Tuff deposits occur in the northwest corner of Solano County. The belt has a northwest and southeast trend, crossing Putah Creek into Yolo County. The tuff is white, light of weight, and hardens on exposure to the atmosphere. It has been used for building purposes, and as firebacks.

Secs. 31 and 32, T. 8 N., R. 1 W., M. D. M.; Sackett Bros., Winters, Yolo County, owner.

Sec. 36, T. 8 N., R. 2 W., and Sec. 1, T. 7 N., R. 2 W.; D. L. Tucker and Sarah L. Taylor, Winters, Yolo County, owners.

SONOMA COUNTY.

Aguillon Quarry; C. Aguillon, Sonoma, owner. Located one half mile north of Sonoma, adjoining the Vallejo estate. The rock is a light-colored trachyte, and is suitable for a building stone. Idle.

Lounibos Quarry (formerly the Cady Quarry); Mr. Lounibos, El Verano, owner. A series of small quarry faces along the road between

El Verano and Agua Caliente, near the latter place. It has been operated for building stone, paving blocks, and curbings. Idle.

McDonald Quarry. (See Paving Blocks, page 344.)

Santa Rosa Bank Quarry; operated by P. Maroni; located 2 miles north of Santa Rosa, on the Sonoma road. The stone ranges from a light to a dark gray trachyte, and is used for building stone and paving blocks.

Stony Point Quarry; Petaluma and Santa Rosa Interurban (electric) Railroad, owner; R. J. Evans, superintendent; located on the rail-



ILL. No. 76. CARNEGIE LIBRARY, PETALUMA.
Constructed of Trachytic Tuff from Stony Point Quarry.

road, about 9 miles south of Sebastopol. The rock is a trachytic lava, showing occasional flow structure, with small pebble inclusions, and occurs as a capping on a low hilltop. The drainage on either side of the hill has eroded down through it. When green, the stone breaks with a fairly even face and is easily dressed, resembling the San José sandstone so much that it is erroneously called sandstone by the people of Sonoma County. When seasoned, it becomes nearly white in color, very hard and refractory. The stone stands well, as is shown by the Phoenix Building, in Petaluma, which was erected about 1862. It has been used in other buildings in Petaluma, and recently in the Carnegie Library, which is now nearing completion (November, 1904).

At present the quarry face is being opened with a view of later taking out building stone for shipment to bay points by rail and water. Both electric and steam power are available. About 85 men are employed, and the quarry is operated day and night, the rock being used principally for ballast on the railroad bed.

On the north side of the same hill P. Maroni has been endeavoring to take out some suitable stone for the erection of the new bank building in Sebastopol. The stone occurs in pentagonal columns averaging about 5 feet in thickness, dipping N. 30° E. at an angle of about 70°. On account of cross fractures or seams, it is very difficult to obtain dimension stone more than 5 or 6 feet in length. Another small opening near the crest of the hill shows similar columns.

Vallejo Estate Quarries, in the foothills one half mile north of Sonoma, on the old Vallejo rancho. One quarry furnishes a dark red rhyolitic tuff, which has been used considerably in the buildings of Sonoma, especially for trimming buildings constructed of the dark blue basaltic rock of this locality.

Paving blocks are obtained from a quarry face on same property.

SUTTER COUNTY.

In Sec. 32, T. 16 N., R. 2 E., 3 miles west of Sutter City, is a quarry of rhyolite, used locally for building stone.

TEHAMA COUNTY.

About 20 miles west of Red Bluff, between Thomes and Elder Creek, there is a considerable exposure of a light reddish tuff, which Mr. Diller in Bulletin 196, U. S. Geological Survey, page 39, refers to the Tuscan tuffs. The tuff is very soft, can be cut with a saw, and resists exposure and heat very well; it is used all through the vicinity for building purposes, especially chimneys, etc.

Rice Quarry, in Sec. 12, T. 24 N., R. 6 W., M. D. M.; H. W. Rice, Paskenta, owner; a small quarry on Headquarters Creek.

YOLO COUNTY.

Tuffs suitable for building purposes occur in the eastern margin of the foothills of western Yolo County; and along the northern bank of Putah Creek, in T. 7 and 8 N., R. 1 and 2 W., on lands owned by Sackett Brothers Company, and by W. H. Gregory, Winters P. O. The formation extends into Solano County. No development work has been done, and only small local use is made of the material.

ARTIFICIAL STONE (CEMENT PRODUCTS).

Artificial stone is now made in several different ways. The sand-lime bricks form a very good artificial stone. Another artificial stone that is meeting with much favor both in California and elsewhere in the United States is made by mixing sand with Portland cement, using cement in place of lime as a bond for the sand grains. It is a special form of concrete, in which sand is used in place of broken stone. Instead of being made in the wall or structure in which it is to be used, it is made in a factory into desired forms, such as bricks, building stone blocks, arches, columns, etc.

There are several different methods of its manufacture, some portions of which are said to be covered with patents. In one method the sand and cement are mixed into a liquid mortar, which is poured into specially designed molds and permitted to harden. Another process consists in mixing the sand and concrete in a moist condition and packing it into molds and then drying. A great many factories in different parts of the United States are now engaged in making artificial stone or concrete blocks, and several manufacturers are engaged in making machinery for molding the bricks. By means of pigments the color of any sandstone can be duplicated, and any stone in rock face or tool-dressed face can be duplicated by making with metallic lead a cast of the face of a block of the stone it is desired to imitate, and using this as a mold for the concrete block. By a little experimenting with pigments the color is duplicated, and having the mixture and mold, any desired number of blocks can be made.

In a similar manner, large columns, arches, and carved blocks are reproduced. Doorways and gateways of the finest brownstone or red sandstone are made in this way, and so closely do they resemble the natural stone that it is not easy to distinguish one from the other. One can easily see the great possibilities in this line. There can be little question that the artificial stone when carefully made is superior in some ways to the natural product. In the natural stone, nature cements the sand grains by iron oxide, clay, carbonate of lime, or silica, aided to some extent in places by pressure. In the artificial stone, man adds the Portland cement to hold the grains together, and it is stronger and more durable than some of the natural cements.

The same process might also be used in making conglomerate, especially where a supply of bright-colored pebbles is available.

A strong point in favor of the artificial sandstone over the natural in carved and ornamental work is that the projecting and weaker parts

can be strengthened internally by wires and steel rods, also the large arch blocks and columns can be made with a sunken iron loop to aid in handling them, and thus avoid disfiguring the face of the stone.

CONTRA COSTA COUNTY.

There are two companies manufacturing sand-lime bricks at Antioch. Each of the plants has a short spur connecting with the A. T. & S. F. Railway, and a tunnel underneath the sand dune to the river bank, where they have a dock with deep water, so that they can ship either by water or by rail. Both companies get their sand from the sand dune at the works and lime from kilns at Concord.

Holland Sandstone Brick Company, office 18 Fremont street, San Francisco; F. W. Moller, superintendent; has a plant one mile east of Antioch, on the north side of the Santa Fé Railroad. It uses the un-slaked process, in which the lime is ground as quicklime and mixed with the screened sand and slaked in the mixing process. The lime and sand are first thoroughly mixed in a pugmill, with sufficient water to slake the lime, and the mixed material runs into large bins, holding enough for several thousand bricks, where the slaking process is completed. The sand is well screened, the coarse and the very fine materials being separated and thrown out before it is mixed with the lime in the pugmill. The mixed materials while still warm are run into another pugmill, in which more water is added, and after another thorough mixing, they pass still warm into a Kormick brick machine having a capacity of from 10,000 to 12,000 brick per day, where the bricks are molded under high pressure, loaded on the cars, and run into the steam boilers still warm. There are three boilers, each about 30 feet long, and each holding 7,000 bricks, where the bricks are kept under steam pressure of 120 pounds for about ten hours, when they are removed on cars and run into the yard, where they are stored and permitted to further season before shipping. The bricks are made of a standard size, weigh 5 pounds each, and have a bright, light gray color when finished.

The Holland Company began working in June, 1903, but its plant was not in operation the first four months of 1904, so that it had not put many bricks on the market at that time.

Golden Gate Sandstone Brick Company.—This company manufactures by a little different process, in which the lime is slaked before mixing with the sand. The slaking is done in iron pots with steam, in the same boilers in which the bricks are afterwards steamed. As this plant was started about the same time as the other, both are too new as yet to tell which process will give the better results. The Golden

Gate Company uses an American-made machine, which molds six bricks at a time, instead of one, as in the German machine. The company has one large steam boiler, about 60 feet long, and is now (August, 1904) putting in a second smaller boiler about 30 feet long, which, when complete, will give them practically the same boiler capacity as the Holland Company.

Pacific Stone Company, office 208 Crossley Building, San Francisco, is putting up an extensive plant at Black Diamond, Contra Costa County, to manufacture "litholite" by the Stevens process. This process is somewhat different from the one described above, and the company objects to calling it an artificial stone, but uses the more classic name, litholite.

The company will use crushed granite, basalt, quartz, and other rocks, which, after being crushed into fine fragments, are mixed with cement into a thin mortar or slip, and poured into sand molds. The sand absorbs the excess of moisture, part of which it gives back when the stone begins to set. In an above mentioned process the semi-dry materials are tamped in the mold and then removed and air-dried. In this process there is no pressure, and the cement sets in the presence of excess moisture. It takes about thirty days from the time the materials are mixed until the stone is ready for use in the building. The granite used by this company is a light gray and the stone produced is normally a light gray concrete, but by using pigments any desired color may be made.

A letter from this company dated October 24, 1904, says: "We expect to start the wheels turning to-morrow." The present capacity of its plant is 300 cubic feet of building stone per day, and it has been constructed with a view to future enlargement. It is located on deep water on the San Joaquin River, and has a siding from both the Santa Fé and Southern Pacific railroads, so that shipping facilities are of the best.

The plant is equipped with crushers, rolls, conveyors, elevators, screens, mixers, and overhead carriers, which are operated by electric motor with power from the wires of the Bay Counties Power Company.

At the beginning of 1904 there were in the United States and Canada twenty different factories making stone by this process, most of them in the East, five of them being in New York State. The Pacific Stone Company claims to be the only one on the Pacific Coast.

KERN COUNTY.

Bakersfield Sandstone Brick Company, John Curran, superintendent, began operations in August, 1903. This company uses the Kommick system of manufacture, the same as the Holland Sandstone Brick Com-

pany at Antioch. It uses river-sand from the bed of Kern River, and lime from Tehachapi. This sand is obtained up the river from Bakersfield and is brought to the plant on railway cars. The works have been in operation almost continuously since they started in 1903, except when delayed by waiting for supplies. Several large business blocks and some private residences have been constructed of this light-colored brick in Bakersfield, which has a larger percentage of houses of this material than any other town in the State. The greater part of the product is used in Bakersfield, where it is apparently growing in favor. Since they are sold about as cheap as red bricks, they will probably be used even more extensively in the future.

LOS ANGELES COUNTY.

California Concrete Building Block Company; H. C. Turner, general manager, 510 Douglas Building; works, 2522 East Ninth street, Los Angeles. Various building materials are made from gravel, sand, and cement. The forms are pressed in Palmer hollow-block machines and pressed-brick machines. The plant is equipped with an 8-horsepower gasoline engine. Employs 8 men.

California Ornamental Brick Company, 1030 East First street, office 215 Mason Opera House Building, Los Angeles, uses the second method described (on page 165), by mixing sand or gravel with the cement in a moist condition, and turns out quite a variety of products. The company manufactures many bricks of standard size, also many different kinds of sandstone in form, dimensions, and color to suit the customer. The factory stands on the river bank below First street, and an endless wire cable, with sand buckets attached, elevates the sand and gravel of the river-bed to the top of the building, where they are automatically dumped into screens, which separate, first, the coarse gravel used for concrete; second, the finer gravel used in mixing with tar in roofing buildings; and third, the sand used in making the brick and sandstone as described above.

Some of the buildings in Los Angeles in which the artificial stone and brick made by the Pacific Stone Company have been used are: Evening Express Building, Home Telephone Building, Bryson Block, Congregational Church, Pruess Block, McBurney Building, Emergency Hospital, St. Joseph's Church, Synagogue, Weinshank Building, and Bacon Block.

Ornamental Stone and Brick Company; F. A. Parker, president, Fourth and Alamitos streets, Long Beach; J. H. Dovey, superintendent. Manufactures hollow concrete blocks of various forms and dimensions for building purposes, and intends to manufacture pressed building bricks.

Gravel is used, the pebbles being crushed and mixed with cement. The mixture is pressed moist in forms, then slowly dried in the air, being moistened every day. Started operations September, 1904. Employs 7 men.

Pacific Sandstone Brick Company has a sand-lime brick plant one mile north of Redondo, on the coast, near Los Angeles. During the summer of 1904 the company remodeled its plant and put in new machinery. The works are close to one of the great oil fields of the State, and are



ILL. No. 77. PACIFIC SANDSTONE BRICK COMPANY'S PLANT, REDONDO, LOS ANGELES COUNTY.

favorably located for fuel and raw material. The rapidly growing city of Los Angeles, and other neighboring towns should offer a good market.

MONTEREY COUNTY.

Monterey Brick and Stone Company, 320 Crossley Building, San Francisco; Wm. Quinton, Alvarado street, Monterey. It contemplates erecting a plant to make sand-lime brick by the Schwartz system from the Monterey beach sand.

The T. A. Work Company, Pacific Grove, makes at Monterey and Pacific Grove, hollow building blocks out of the beach sand and California Portland cement, in the ratio of 5 to 1; for the facing blocks the ratio is 2 to 1. The material is mixed dry, and tamped dry into a

Hayden automatic block machine. The blocks are moistened twice a day for four or five days, then left to dry in the air, and within ten or twelve days are ready for use. The works were started in October, 1904.

SANTA BARBARA COUNTY.

Leslie Conklin, Santa Barbara, is now (July, 1904) erecting a small factory on Castillo street, Santa Barbara, for the purpose of making artificial stone. He has been experimenting for some time and reports that his experiments have been very successful. He expects to use sand from nearby deposits and cement in the proportion of about 8 to 1. He has ordered machinery for molding the blocks, and estimates that he can manufacture bricks in this way cheaper than ordinary red bricks can be sold.

SANTA CLARA COUNTY.

San Jose Cement Block Company is operating a plant at the corner of Fourth and Virginia streets, San José. J. H. Kircher is superintendent, with offices in Room 40, Auzerais Building. Stone copings, hollow concrete building blocks, chimneys, gravestones, and other cement products are manufactured.

SONOMA COUNTY.

Sonoma Stone and Construction Company has a plant at 121 Fifth street, Santa Rosa, and manufactures various products, including cement sewer pipe, pressed sand bricks, artificial stone, cemetery ornaments, copings, curbings, cement shingles and tiling, etc., using California Portland cement as a binder. Ten men are employed.

VENTURA COUNTY.

H. Roberts, Ventura, manufactures hollow building blocks from beach sand and California Portland cement.

ARTIFICIAL MARBLE.

A number of handsome marbles now on the market are partly artificial; that is, other rocks, such as gypsum and slate, are put through a process in which they are made to resemble marble.

PART II.

PORTLAND CEMENT INDUSTRY IN CALIFORNIA.

Cement, as used in building operations, signifies a compound of lime and other substances that hardens under water or in contact with water. It is a mixture of lime, or lime and magnesia, with clay or silica, or both. It differs from common quicklime in that it does not slake, expand, crumble, nor give off heat when wet, but chemically combines with part of the water into a firm, solid rock. There are two principal classes of cement: the natural rock, or Rosendale cement; and the artificial product, or Portland cement; to which may be added a third, the Pozzolana, or slag cement.

NATURAL ROCK CEMENT.

A limestone which in nature contains sufficient clay or other substance, mixed with the carbonate of lime, that it only requires proper burning and grinding to form a cement, is called a waterlime or natural cement rock, and the product is natural or Rosendale cement, sometimes called Roman cement. Natural cement rock was discovered accidentally in the United States in 1818, near Chittenango, N. Y. Later it was found in large quantities in Pennsylvania, Indiana, Kentucky, and elsewhere. Ulster County, New York, and Louisville, Kentucky, have always been the centers of this important industry. The natural cement is generally inferior to the Portland cement, and in some places, especially in a few localities in New York State, its market is being gradually taken by the artificial product.

The only natural cement rock known in this State comes from Orange County, where a body of it, claimed to be of good quality, is found.

PORTLAND CEMENT.

Portland cement may be defined as a compound consisting chiefly of silicates and aluminates of lime, produced by the calcination to incipient vitrification of a mechanical mixture of calcareous and argillaceous materials, the clinker thus produced being subsequently ground to a more or less impalpable powder. The exact chemical composition of Portland cement varies considerably; its principal constituents are lime, silica, alumina, and oxide of iron, which are found, roughly, in

the following proportions: lime, 60 to 64 per cent; silica, 20 to 24 per cent; alumina, 6 to 10 per cent; iron oxide, 3 to 5 per cent. These four constituents, as a rule, amount to about 96 per cent, the remainder consisting of small quantities of sulphuric anhydride, magnesia, alkalies, etc. (See Portland Cement, D. B. Butler, page 10. Geological Survey of Ohio (4th series), Bulletin No. 3, The Manufacture of Hydraulic Cements, by A. V. Bleining. A paper by same writer in the Transactions of the American Ceramic Society, 1903. Chemical and Engineering News, 1898, Vol. IV, page 5, etc.) The use of Portland cement is principally based on its characteristic quality to harden rapidly under water or in a moist atmosphere.

Portland cement was first manufactured and so named in 1824 by Joseph Aspdin,* who took out a patent for it as "an improvement in the modes of producing an artificial stone." The growth of the industry was very slow at first. It was not until 1851 that it was first brought prominently before the world, and soon after its manufacture began in Germany, France, and elsewhere on the continent. The increase in the output was rapid from this time, especially in Germany and England, both of which countries exported large quantities to the United States.

In the United States the first Portland cement was manufactured in 1875, by Mr. Saylor, at Siegfried, in eastern Pennsylvania. A second factory was soon afterwards established in western Pennsylvania. For nearly twenty years the growth of the industry was very slow indeed, but during the last decade of the nineteenth century there was a phenomenal increase in the product. This was brought about by the greatly increased use of cement, which without any marked decrease in importation raised the home production in one decade more than 1200 per cent. The following figures indicate the great increase in the domestic production and the growing commercial importance of the industry:

Domestic Production, Imports and Exports of Portland Cement, 1890-1903.

	1890	1900.	1902.
Production of Portland cement in the United States, in barrels.....	335,500	8,482,000	17,230,644
Number of works in the United States....	16	50	65
Imports of Portland cement into the United States	1,940,186	2,386,683	1,961,013
Production of natural rock cement in the United States.....	7,082,204	8,383,519	8,044,305

The enormous increase in the domestic production of Portland cement is a matter of surprise, and yet when one looks at the varied uses to which it is put and the many other places where it might be used, it will be a matter of great surprise if the increased rate of production does not continue for many years.

* While Aspdin is usually credited with inventing the Portland cement, it is thought that he originated the name only, as the cement which he made was a Rosendale or Roman cement, and not a Portland cement.

Uses of Portland Cement.—Because of the ease with which it can be molded or put into desired shapes, its hardness and durability when placed, and its resistance to the action of moisture and vermin, Portland cement will continue to increase in importance in structural and engineering work. It is not only replacing the ordinary lime mortar in masonry, especially in foundations, but is even replacing stone and brick, and for many uses wood and iron, in the structures.

Cement is used both in the manufacture of artificial stone, and in concrete, which material is much used for monolithic structures, in walls (*e. g.* the Museum of Fine Arts at the Stanford University), foun-



ILL. No. 78. SANTA ANA VIADUCT, ON THE S. P., L.^oA. & S.^oL. R. R., CROSSING SANTA ANA RIVER, NEAR RIVERSIDE.

dations, bridge construction (*e. g.* the bridge of the Salt Lake Railway at Riverside), reservoir dams, etc.

The following list, arranged alphabetically, indicates the more important present uses of Portland cement: abutments, arched culverts, artistic tile, artificial stone, bank vaults, breakwaters, concrete in many places, curbs and gutters, dams and wheel-pits, dry docks, engine beds, fence posts, fireproof floors, etc., fortifications, foundations and walls, foundations for brick and asphalt pavements, irrigation flumes, linings of war vessels, locks of canals, pavements, piers, piling, pipe mains, railway ties, reservoirs, retaining walls and embankments, sea walls, sewers, shingles, stucco, telephone conduits, terra cotta blocks, tombstones, tunnel linings, and burial tombs. The list is capable of indefinite extension, as possibly no other modern product commends itself so readily to so many different uses.

The quantity of Portland cement used in California is far in excess of that manufactured in the State. With large deposits of limestone and clay quite widely scattered over the State, and a large fuel supply, it would seem as though the cement industry ought to increase quite rapidly. The State should be exporting rather than importing cement. For many years the development of the cement industry, like many other manufacturing industries in California, was hindered by the high price of fuel, but with the opening of the great oil fields this difficulty has been overcome.

Tests of Portland Cement.—The tests recommended by the American Society of Civil Engineers for Portland cement are: (1) *For fineness*—Cement shall be ground to such fineness that 95 per cent by weight will pass through a standard sieve of 50 meshes per inch (2500 meshes per square inch), and 90 per cent will pass through a standard sieve of 100 meshes. (2) *For soundness*—The cement shall endure the hot-water test at 25° F. for twenty-four hours without cracking or blowing. (3) *For initial set*—Neat cement shall not set to support $\frac{1}{4}$ pound on $\frac{1}{2}$ -inch wire in less than fifteen minutes for natural cement, and twenty-five minutes for Portland cement. (4) *For tensile strength*—Portland cement briquettes of neat cement mixed three minutes, put in molds with thumbs and trowel, and kept at a temperature of 65° to 70° for one day in moist air and six days in water, shall show a least average tensile strength of 400 pounds per square inch. Briquettes of three parts by weight of standard crushed quartz and one part by weight of Portland cement, mixed in same manner and kept seven days under same conditions, shall show a least average tensile strength of 125 pounds per square inch. Briquettes like the last, kept twenty-eight days under the same conditions, shall show a least average tensile strength of 220 pounds per square inch. (5) *For tensile strength, American natural cement*—Briquettes of neat natural cement, mixed three minutes, put in molds with thumbs and trowel, and kept at a temperature of 65° to 70° for two hours in moist air and twenty-two hours under water, shall show a least average tensile strength of 60 pounds per square inch. Briquettes of natural cement and standard crushed quartz in equal parts by weight, mixed and handled in the same manner and kept at same temperature for one day in moist air and six days in water, shall show a least average tensile strength of 65 pounds per square inch. Briquettes similar to last, and kept twenty-eight days under same conditions, shall show a least average tensile strength of 150 pounds per square inch.

The standard crushed quartz used in the tests shall pass a sieve of 20 meshes per inch, and shall stop on one of 30 meshes.

Portland cement is to a great extent bought on the reputation of the

brand, hence the importance to the manufacturer of keeping up the regularity of quality of his product.

The **Composition of Portland Cement** is already given above. The varying amounts of the different constituents influence the character of the cement to a certain extent. Cements rich in lime set more slowly, but harden better than those poor in lime. Cements rich in silica set more slowly than those rich in alumina, but they are better for use under salt water.

An addition of 0.33 to 0.75 per cent of fluorspar is helpful in making the materials clinker more easily.

Gypsum or sulphate of lime in small quantities delays the setting of the cement somewhat, and adds to its final strength. More than 4 or 5 per cent is injurious, and many specifications require that less than 2 per cent be added.

In this country limestone, marl, chalk, and travertine are used in making Portland cement.

ANALYSES OF RAW MATERIALS AND THE CEMENT, COLTON, CALIFORNIA.*

	Limestone.	Clay.	Clay.	Cement.
Lime (CaO).....	55.216	2.900	2.300	60.648
Magnesia (MgO).....	.000	1.016	1.873	.378
Silica (SiO ₂).....	.550	49.300	50.100	22.250
Alumina (Al ₂ O ₃) and Ferric oxide (Fe ₂ O ₃) ---	.850	20.100	29.700	-----
Carbon dioxide (CO ₂).....	43.384	Undet.	3.854	-----
Sulphate of lime (CaSO ₄).....	-----	-----	-----	2.000
Alkalies.....	-----	-----	-----	1.524
Moisture and organic matter.....	-----	-----	12.300	-----

MANUFACTURE OF PORTLAND CEMENT.

The successive steps in the process of manufacture are the preparation of the raw materials, the mixing, burning, grinding and bolting.

Mixing.—There are two general methods of preparing and mixing the raw materials. One is known as the wet process, and the other as the dry or semi-wet process.

In the wet process, the mixing is done in water. Sometimes it is necessary to grind the materials first, but as this method is commonly used with chalk or marl, the preliminary grinding is often unnecessary. The mixing is done in large tanks resembling the plungers used in clay-washing plants. In the center of the tank is a vertical rotating shaft, carrying a framework with scrapers, that keeps the materials constantly agitated. Water is let in continually during the mixing, and as it flows out it carries the materials as sediment to the settling tanks, where after the settling of the solids the clear water is drawn off. One of the objections to this process is that clay and chalk, having different specific gravities, tend to separate in the settling tank. Another objec-

*Annual Report of State Geologist of New Jersey, 1900, p. 24.

tion is the length of time required to dry the materials or get rid of the excess water.

In the dry or semi-wet method, the raw materials are ground dry separately and mixed with only enough water to form a paste or slurry, which is then molded into bricks to facilitate the charging into the kilns. Where the rotary kiln is used, the forming into bricks is unnecessary. Sometimes the dry-press is used in forming the bricks, thus saving the expense of evaporating the excess water. In all the California cement works the rotary kiln is used, and hence the briquetting is unnecessary.

Burning.—After the materials are mixed in the proper proportions, the next step is the burning in kilns, of which there are different types in use in this country.

The rotary kiln is the only one in use in California, and is now almost universally used throughout the United States, while rapidly growing in favor abroad. It consists of a steel cylinder lined with firebricks. The first rotary kilns were 40 feet long, but this was soon changed to 60 feet, which has been the standard length for several years. Recently Edison constructed a kiln 150 feet long, which shows a considerable saving in fuel and an increased output. This result has already induced several manufacturers to lengthen their kilns, but the 60-foot kilns are still in use in California. The cylinders are slightly inclined and revolve upon two, sometimes three tires, resting on idlers, and are turned by steam power. The upper end of the kiln projects into a brick flue, which is generally surmounted by an iron stack. The lower end of the kiln is closed by a firebrick hood. The raw material is fed into the upper end and the fuel burned at the lower end. The material works slowly down the interior of the kiln into gradually higher temperatures. First the moisture is driven off, next the carbonic acid, and next there is a partial fusion into yellow balls, which finally change to a greenish-black slag or clinker; when the burning is complete the clinker drops through the opening in the hood into the clinker pit. Each of these processes takes place at a different temperature, but the last one requires the greatest care, as either overburning or underburning injures the value of the cement.

The first work done with the rotary kilns was with oil for fuel, but in eastern Pennsylvania, coal, which is cheaper there than oil, replaced the oil and is used by first crushing it to a powder and then blowing it into the kiln. In California, however, oil, being much cheaper, is used exclusively, and aside from cheapness is preferable to coal.

The clinker is cooled in several ways. Some use rotary coolers, some vertical coolers, and some cool in the pits or on the floor. Water is generally sprinkled on the clinker, which helps cool it and also aids in seasoning it.

Grinding.—After cooling, the clinker is ground to a fine powder either in the Griffin mill or in the ball and tube mills, such as are used for grinding the raw materials. The cement is ground until a large percentage of it (90 per cent or more) will pass through a 100-mesh screen, and a smaller but still large percentage would pass through a 200-mesh sieve. Many contracts call for a specified degree of fineness.

The cement should be stored for several weeks, or better, several months, before using. This is usually done in large bins in the storage warehouse. When sent to market, it is shipped in either bags or barrels. Nearly all the California product is shipped in bags holding 95 pounds each.

The Griffin mill, which is the kind used at Colton, is an American invention, and is used extensively in the cement works in the eastern United States. It consists of a revolving pendulum, with a ball at the lower end, which in its rotation strikes the inner side of a steel ring, the grinding being produced partly by the blow and partly by the peculiar rubbing motion.

The ball and tube mills are used at Suisun and Napa Junction. The *ball mill* is a short cylinder, having heavy perforated steel plates inside of screens near the outside cylinder. It is charged with quite hard steel balls from 3 to 5 inches in diameter, and when the cylinder is rotated the balls drop with considerable force on the rock material below. The ball mill is quite effective in crushing the material to about 20-mesh size. The *tube mill* is used to continue this process until extreme fineness is produced. It consists of a tube usually about 22 feet long and 52 inches in diameter, although the size is not always uniform. It is charged with well-rounded pebbles, usually imported from Norway or Sweden. The Suisun factory uses some pebbles from the American River. After the cement to be ground is placed in the mill, rotation is started and the rolling and running action of the pebbles reduces the cement to extreme fineness. The expense of keeping these mills in repair is said to be very great, not infrequently the annual cost of repairs being equal to one third the original cost of the mill.

ANALYSES OF PORTLAND CEMENT.

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃
<i>German—</i>						
Dyckerhoff	20.64	7.15	3.69	63.06	2.33	1.39
Germania	22.08	6.84	3.36	63.72	1.32	1.82
<i>French—</i>						
Boulogne.....	22.30	7.00	2.50	64.62	1.04	.75
Candelot	22.30	8.50	3.10	62.80	.45	.70
<i>American—</i>						
Saylor's	22.68	6.71	2.35	62.30	3.14	1.88
Giant.....	19.92	9.83	2.63	60.32	3.12	1.13
Alpha	22.62	8.76	2.66	61.46	2.92	1.53
Atlas	21.96	8.29	2.67	60.56	3.43	1.43
<i>California—</i>						
Colton.....	22.25	— 12.70 —		60.65	.38	1.18
“Standard,” Napa Junction	21.42	7.40	3.20	63.08	1.02	1.07
Golden Gate, Suisun	22.55	7.25	3.50	62.60	1.20	1.20

PORTLAND CEMENT FACTORIES IN CALIFORNIA.

At present (1904) there are three cement factories in operation in California, located at Napa Junction, Napa County; at Colton, San Bernardino County; and at Cement, near Suisun, Solano County. At other places cement works are projected in the near future. The oldest factory is that at Colton. The one at Suisun began in 1902, and the one at Napa Junction in 1903.

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BUTTE COUNTY.

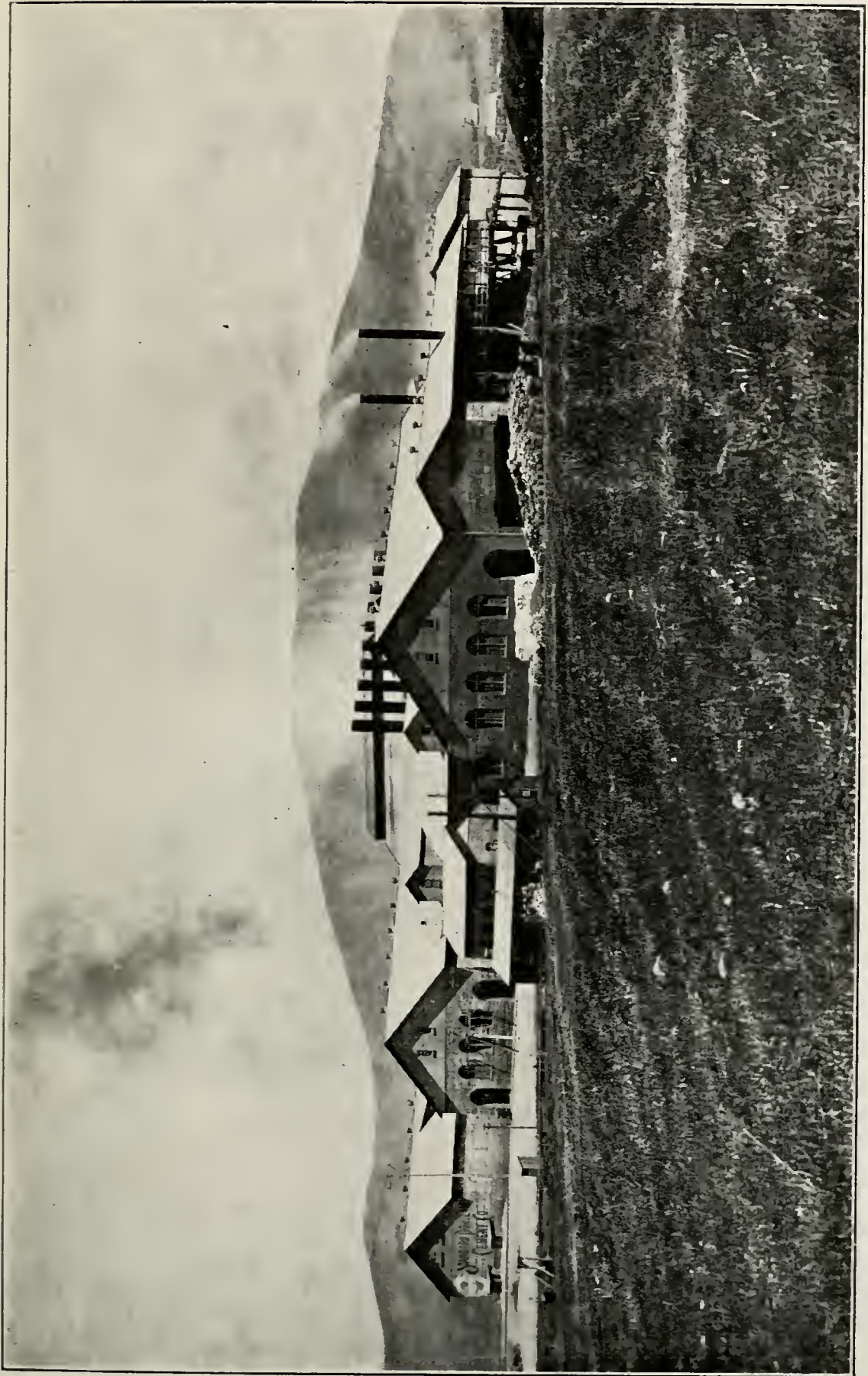
There is a possibility that cement may be manufactured in the near future at the limestone quarries in Secs. 7, 17, 18, and 20, T. 21 N., R. 4 E., M. D. M. L. M. Hancock, Fortuna, Humboldt County.

LOS ANGELES COUNTY.

Los Angeles Fireproof Cement Company, J. E. Brown, 318 Grant Building, Los Angeles, manufactures a cement out of sawdust, sand, and Portland cement. The works are located in Garvanza. The material is mixed by hand. Capacity, about 20 tons per day.

NAPA COUNTY.

Standard Portland Cement Company.—The works of this company are at Napa Junction, Napa County; office, Crocker Building, San Francisco. The company began operations in February, 1903, with eight rotary kilns, which were soon increased to ten, each having a capacity



ILL. No. 79. WORKS OF THE STANDARD PORTLAND CEMENT COMPANY AT NAPA JUNCTION.

of 200 barrels per day, or a total capacity at present of 2000 barrels of cement per day.

The plant is close to the Southern Pacific Railroad, at the junction of the roads to Vallejo and Benicia. Two spurs from the railway extend into the works, and a tramway runs to deep water on Napa Creek, about a mile distant, so that cement may be shipped either by rail or by water.

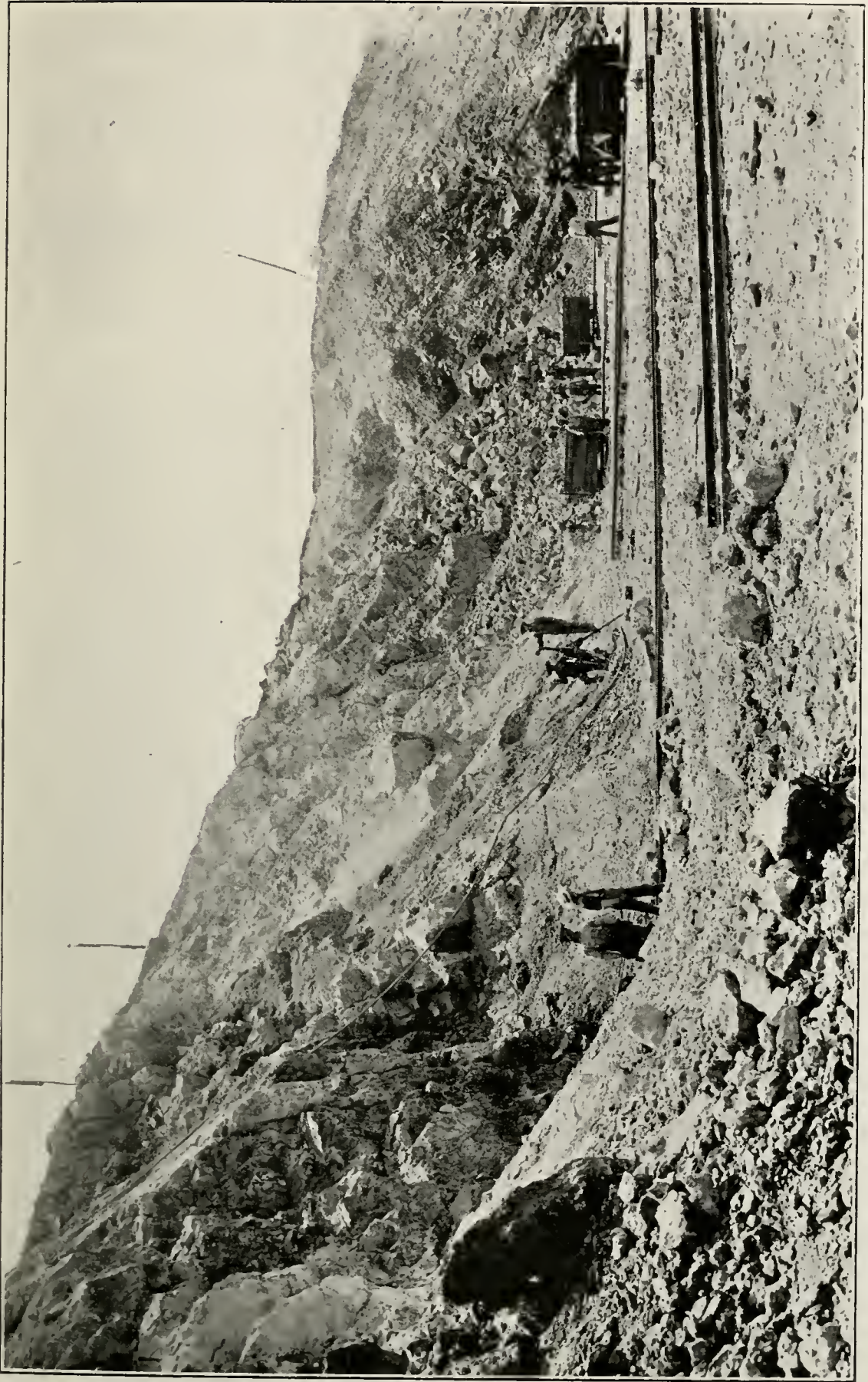
The cement is manufactured in large fireproof buildings. The building for holding the stock is over 200 feet long and has a capacity of 200,000 barrels. The cement is usually shipped in sacks of 95 pounds each; when so desired, it is shipped in barrels. The company has its own cooper shop.

The works are well equipped with modern machinery. The company has its own machine shop. Electrical power is used throughout the plant, and the material is all handled by machinery from the time it is put on the car in the quarry until it is placed in sacks for shipment. The only manual labor required is in quarrying and loading the raw materials, and in loading the cement on the cars.

The raw materials, both the limestone and the clay, are quarried close by the mill and loaded on small dump-cars, which are pulled into the works by a wire cable. Each car is weighed as it comes in, and the materials are properly proportioned, so that the limestone and clay when dropped into the rock-crusher are in the right proportion for cement. From the crusher the material passes to two large rotary dry kilns heated by oil flame. From the dry kilns part of the product goes to storage bins, where a supply is kept to meet demands. The other portion from the dry kilns passes to the ball and tube mills; there are six of each for grinding the raw materials, and the same number for grinding the clinker. The fine material is then conveyed to ten large rotary kilns, where it is burned with oil fuel to a clinker, which as it comes from the kilns is caught in iron buckets on a vertical belt and carried to the top of the cooling chamber, where it is cooled by air-currents. The cooled clinker is next passed to the ball and tube mills, where it is thoroughly pulverized ready for use, and then taken by an overhead tube to the stock room, and stored in large bins awaiting shipment.

The raw materials consist of crystalline limestone and a calcareous clay, both of which are obtained from the same pit. The limestone occurs in regular beds from 1 to 4 feet thick, which dip to the north at an angle of 40 degrees. It is partly crystallized and very fossiliferous, being composed largely of a mass of broken shells, not many of which are preserved entire. It is probably of Lower Cretaceous age.

The limestone is overlaid by a yellow calcareous clay. The quarry face shows a thickness of about 100 feet of limestone and 50 feet of clay. Drill records, it is reported, indicate a thickness of at least 200 feet of



ILL. No. 89. LIMESTONE QUARRY OF STANDARD PORTLAND CEMENT COMPANY AT NAPA JUNCTION.

limestone at the quarry. Steam drills and dynamite are used in quarrying the limestone, and a steam shovel for loading the clay is soon to be added.

A fault-plane runs through the quarry and shows quite prominently on the south wall, where a crumpled, blue-black, pyritiferous shale has been thrust up over the limestone.

The clay at the east end of the quarry is very calcareous, and merges into limestone, but at the extreme west end it is more argillaceous. Overlying all is a bed of dark brown adobe.

Analyses of Cement Materials and Cement of the Standard Portland Cement Company, Napa Junction.*

	High-Grade Material.	Low-Grade Material.	Cement.
Silica (SiO ₂)-----	6.63	20.23	21.42
Alumina (Al ₂ O ₃)-----	3.61	8.68	7.40
Iron oxide (Fe ₂ O ₃)-----	1.26	3.11	3.20
Lime carbonate (CaCO ₃)-----	85.17	65.23	-----
Lime (CaO)-----	-----	-----	63.08
Magnesia carbonate (MgCO ₃)-----	1.83	1.72	-----
Magnesia (MgO)-----	-----	-----	1.02
Sulphuric anhydride (SO ₃)-----	.91	.25	1.07
Ignition-----	-----	-----	1.46

Physical Tests of the Standard Portland Cement Company, Napa Junction.

Fineness—100-mesh-----	94.8 per cent.			
200-mesh-----	75.0 per cent.			
Initial set-----	2 hours.			
Final set-----	6 hours.			
<i>Tensile strength</i> —	—7 days.—		—28 days.—	
	Neat.	Sand.	Neat.	Sand.
No. 1-----	647	265	840	387
No. 2-----	653	294	798	396
No. 3-----	628	273	834	412
No. 4-----	643	277	824	398

This plant is admirably located for the production of cement in large quantities. Good rail and water transportation, and an abundant supply of raw material at the works, are certainly strong points in favor of a stable industry. Gypsum and fuel are the only substances not obtained close at hand. The gypsum is shipped from Nevada, as is nearly all that substance used in central California. The fuel is oil, but much of the power is electric, brought by wire from the American River.

ORANGE COUNTY.

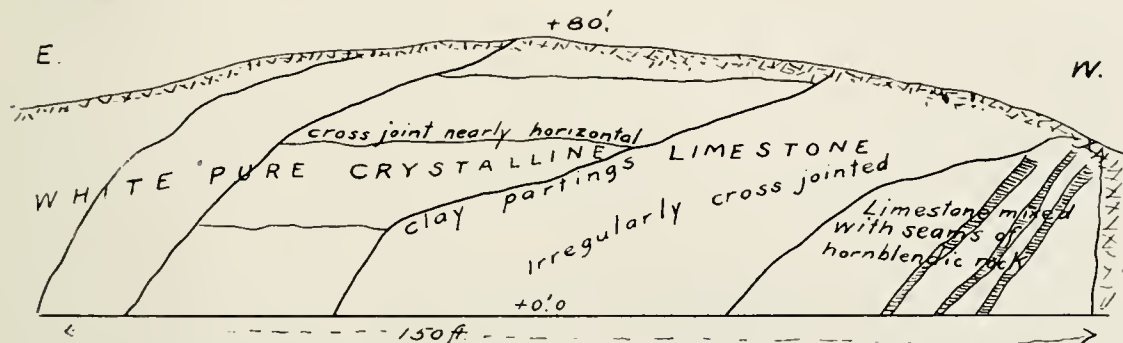
Some years ago tests in the manufacture of cement were made by using clay and the fossiliferous limestone found on the ranch of William L. Moulton, near El Toro. The product was of satisfactory quality, but the high cost of fuel at that time prevented the manufacture from a commercial standpoint. With the present supply of oil as fuel, cement could probably be produced commercially with the limestone and clay found on this property.

* Analyses and tests made by the company in their laboratories.

SAN BERNARDINO COUNTY.

Colton Cement Works, in Secs. 19 and 30, T. 1 S., R. 4 W., S. B. M.; at Colton; California Portland Cement Company, 401 Trust Building, Los Angeles, owner; T. J. Fleming, general manager. Preliminary work was begun about 1892, and in 1894 the works were producing about 50 barrels per day and employing 25 men.* In 1896, the capacity of the plant was 200 barrels per day and 75 men were employed.† Since that time the capacity of the plant has been increased nearly threefold.

The works are located about $1\frac{1}{4}$ miles west of Colton, on the south side of the Southern Pacific Railroad, and at the north end of Slover Mountain. This mountain, which is nearly all pure limestone, is about a mile in length, more than a half mile wide, and 500 feet high. (See Limestone and Marble, pages 77 and 102.) Near the summit of the mountain, on the northeast side, is the quarry from which the cement



ILL. No. 81. ELEVATION OF LIMESTONE QUARRY OF COLTON CEMENT WORKS, SAN BERNARDINO COUNTY.

rock is obtained. The limestone is here very coarsely crystallized, some of the calcite rhombs being more than an inch in diameter. Analyses of this stone show it to be a remarkably pure carbonate of lime. One analysis gave: lime, 55.216 per cent; carbonic acid, 43.384 per cent; silica, 0.55 per cent; alumina and iron oxide, 0.85 per cent. The composition of the stone in the quarry is said to be remarkably uniform, as its appearance would indicate. A tunnel has been cut through the mountain from the level of the quarry floor to a point directly above the cement works. The broken stone from the quarry is run through the tunnel on small tram-cars and dumped into a rock-crusher. After crushing it is sent by gravity down a long chute to the cement mill, where it is finely pulverized in a Griffin mill, and then thoroughly mixed with the clay in a mixer. The mixed product is fed into three rotary kilns, where it is burned to a clinker with an oil fire. The superintendent has patented an appliance for spraying the oil into the kilns, which is said to be a great aid in burning. The clinker is removed

*Twelfth Annual Report of State Mineralogist, 1894, p. 380.

† Thirteenth Annual Report of State Mineralogist, 1896, p. 612.

by wheelbarrow from the kilns to the drying floor, where it is spread out and sprinkled with water for the double purpose of cooling and seasoning it. It is then ground in the Griffin mill and sacked ready for shipment.

The clay is obtained from Alberhill, Riverside County, and is shipped in by rail. The gypsum is obtained from Arizona.

Besides cement, this company produces crushed stone, marble, plaster of paris, lime, and marble dust for making carbonic acid gas for soda fountains.

SANTA CRUZ COUNTY.

Several years ago a Santa Cruz company was organized to manufacture Portland cement from material obtained in a little gulch at a place known as Wagner's Park, one mile north of Santa Cruz. A reverberatory furnace, a kiln, and the necessary grinding machinery were installed, and some cement was produced, which, reports say, was good; but as the price of imported cement had been reduced to a figure below the cost of local production, a cessation of operations resulted. The material used in the manufacture of this cement was taken from a bed of calcareous travertine (a deposit from springs), and was ground with some clayey material found in a neighboring bluff.

SAN BENITO COUNTY.

Chittenden Cement Plant; Mr. Bauman of New York and Mr. Kemp Van Ee of San Francisco, owners until the company is regularly organized. The company has completed plans for the erection of a large cement plant near Chittenden, a small station on the coast line of the Southern Pacific Railroad, in the southeast corner of Santa Cruz County. The company claims to have about 700 acres of limestone from $1\frac{1}{2}$ to $2\frac{1}{2}$ miles west of San Juan, and an immense hill of shale at Chittenden. The plans call for a plant with a daily capacity of 3200 barrels, with facilities for enlarging. Buildings are to be of steel and reinforced concrete. The plans also include a broad-gauge electric railroad to tide water at Watsonville Landing. Oil from the nearby wells will be used as fuel.

SAN DIEGO COUNTY.

At Jamul, 18 miles southeasterly from San Diego, hydraulic cement was manufactured on a small scale a number of years ago. The reason commonly assigned for abandoning the industry at this point is that it is too far from the railway. The plant was designed, it is said,* to produce 200 barrels per day.

*Ninth Annual Report of State Mineralogist, 1889, pp. 139 and 309. Twelfth *ibid.*, 1892, p. 383.

SOLANO COUNTY.

James Clyne, Benicia, owner; extensive deposits of rock in Sec. 33, T. 3 N., R. 3 W., M. D. M., on the hills back of the town of Benicia, and in fact within the limits of the town, which until 1890 was used in making cement. The article was once in demand, and pronounced equal to the best imported. It is stated that 130,000 barrels were used in the construction of the New City Hall in San Francisco.*

Pacific Portland Cement Company ("Golden Gate Cement") has a plant in Sec. 17, T. 5 N., R. 1 W., M. D. M., at Cement, 2 miles north of Tolenas, a station on the Southern Pacific Railroad, 5 miles northeast of Suisun; office, Rialto Building, San Francisco.

This company began operations in 1902. The plant has been enlarged once, and is now being enlarged a second time, to meet the constantly increasing demand. At present the company is some months behind on its orders.

There are eight large rotary kilns, with a rated capacity of 200 barrels each per day, eight tube and ball mills for grinding and mixing the clay and stone, and eight others for grinding the clinker.

The limestone and clay quarries are above the mill, so that everything is moved by gravity from the quarries into the mill, and through the mill until it comes out finished cement at the base of the hill, where it is stored in a large warehouse ready for shipment. The company has its own locomotive and side track connecting with the Southern Pacific Railroad at Tolenas; also a machine shop, a carpenter shop, and a chemical and testing laboratory at the works, besides a restaurant and dormitories for the men. About 160 men are employed.

The limestone used is a porous travertine, which has been subject to uplift since it was deposited. There is almost no soil-covering over the stone, which outcrops on the surface over a large area. The limestone is a comparatively pure lime carbonate, as shown by the following analysis:

Average Analysis of Travertine Limestone Used by the Pacific Portland Cement Company.

	Per Cent.
Lime (CaO).....	53.65
Loss on ignition (mostly CO ₂).....	43.40
Magnesia (MgO).....	.55
Silica (SiO ₂).....	1.25
Alumina (Al ₂ O ₃) and Ferric Oxide (Fe ₂ O ₃).....	1.00
Total	99.85

The travertine is said to be very uniform, and to vary but little from the average assay.

* Twelfth Annual Report of State Mineralogist, 1893-94, p. 380.

It was from this travertine deposit that the so-called Suisun marble has been taken in limited quantities at different times.

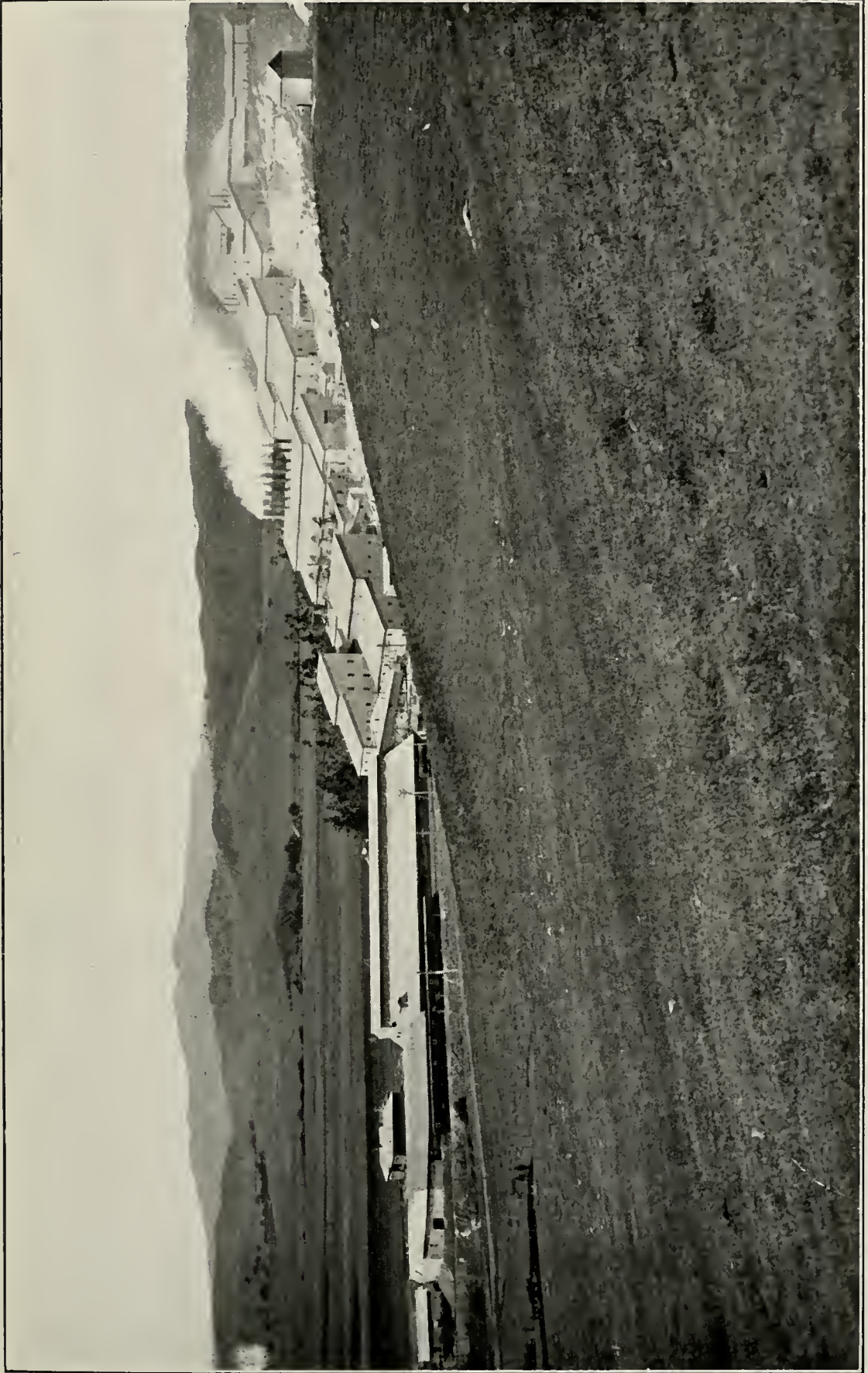
The extent of the deposit is not less than one quarter of a mile wide and a mile in length, and it may be even larger. The present quarry face shows from 30 to 60 feet of stone, and it is said to persist 60 feet below the bottom of the quarry. How much deeper it goes is not known. The deposit resembles in many ways the large deposit at Tivoli, near Rome, from which the stone was named. Hand samples of the two rocks look very much alike.

The clay used by the Pacific Portland Cement Company is a laminated



ILL. No. 82. SECTION OF FACE OF LIMESTONE QUARRY OF PACIFIC PORTLAND CEMENT COMPANY, CONS., AT CEMENT, SOLANO COUNTY.

gray to buff clay, shaly in places, and containing some interstratified shaly sandstone. The deposit is probably late Tertiary in age. The clay is free from fossils, but some of the sandstone layers contain many fossil fragments. The clay beds have been elevated and crumpled somewhat. At the clay pit where they are working the strata stand vertically. The clay crumbles and slakes rapidly on exposure to the air, so it is customary to plow it up and leave it exposed to the air and sun a week or more, after which it is moved by scrapers down grade to the loading platform, where it is loaded through a hopper into small cars which run by gravity into the mill and dump it at the mixing machine.



ILL. No. 83. PLANT OF THE PACIFIC PORTLAND CEMENT COMPANY, CONS., AT CEMENT, SOLANO COUNTY.

Analysis of Clay Used by the Pacific Portland Cement Company.

	Per Cent.
Silica (SiO_2)	58.65
Alumina (Al_2O_3)	18.25
Loss on ignition (mainly water with a little organic matter).....	10.00
Iron oxide (Fe_2O_3)	7.35
Lime (CaO)	2.15
Magnesia (MgO).....	1.15
Alkalies	2.05
Sulphuric anhydride (SO_3).....	.50
Total	100.10

Aside from the thin sandstone layers, which are thrown out in the quarrying, the clay is remarkably free from quartz and contains no perceptible grit. It is a smooth, plastic clay that would fuse at a moderately low temperature.

Analysis of Golden Gate Cement made by the Pacific Portland Cement Company.

Lime (CaO)	62.60
Silica (SiO_2)	22.55
Alumina (Al_2O_3)	7.25
Iron oxide (Fe_2O_3)	3.50
Magnesia (MgO).....	1.20
Sulphuric anhydride (SO_3)	1.30
Loss on ignition .....	.75
Alkalies by difference .....	.85
Total	100.00

The above is the analysis of the cement made at the works in August, 1904. For comparison with the other cements, the table on page 177 should be consulted.

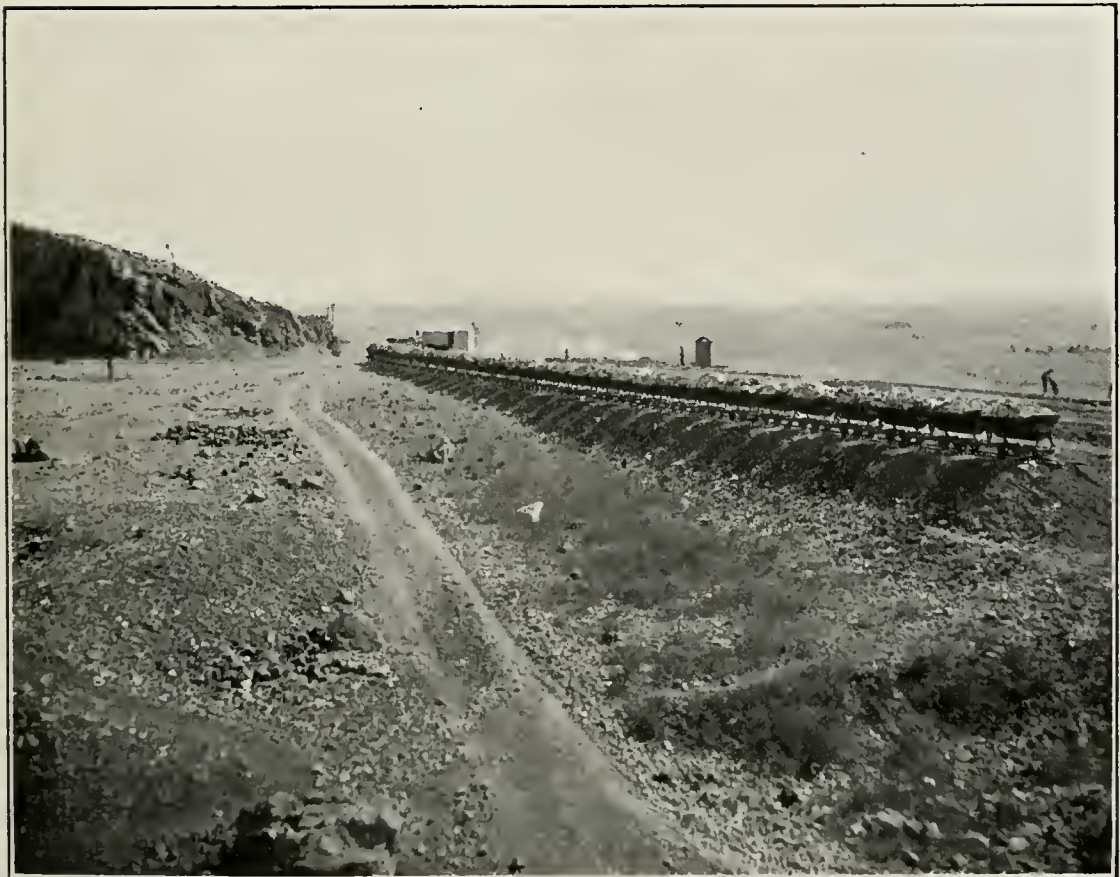
Physical Tests* of the Golden Gate Cement, July 10, 1904.

Fineness—100-mesh	90.5 per cent.				
200-mesh	70.0 per cent.				
Set—Initial	2 hours, 40 minutes.				
Final	6 hours.				
<i>Tensile strength—Neat:</i>	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
1 day	320	310	305	310	320
3 days	520	545	490	580	545
7 days	710	650	665	600	650
28 days	820	800	800	750	800
<i>Tensile strength—Sand:</i>					
3 days	120	140	125	100	140
7 days	210	200	205	200	225
28 days	370	340	340	370	395

*Tests for tensile strength were made in a Fairbanks standard machine.



ILL. No. 84. STEAM SHOVEL AT WORK IN CLAY PIT, PACIFIC PORTLAND CEMENT COMPANY, CONS., SOLANO COUNTY.



ILL. No. 85. CARS LOADED WITH LIMESTONE TO SUPPLY THE CRUSHER AT PLANT OF THE PACIFIC PORTLAND CEMENT COMPANY, CONS., AT CEMENT, SOLANO CO.

PART III.

CLAYS AND CLAY INDUSTRIES IN CALIFORNIA.

1. DEFINITION OF CLAY.
 2. ORIGIN OF CLAYS.
 3. CHEMICAL COMPOSITION OF CLAYS.
 4. PHYSICAL PROPERTIES OF CLAYS.
 5. USES OF CLAYS.
 6. HIGH-GRADE CLAYS:
 - China Clay.
 - Potter's Clay.
 - Fire Clay.
 - High-Grade Clay Industries in California.
 7. LOW-GRADE CLAYS:
 - General Features.
 - Red Brick and Tile Works in California.
-

Clay is one of the most useful substances in nature. Besides forming a large and important part of all the soils, it adapts itself to so many and varied uses that it is almost indispensable to man in all stages of development.

DEFINITION OF CLAY.

Clay is one of the common, everyday words that possibly can not be accurately defined in technical terms, and yet it has been adopted into technical literature as a convenient word, and ordinarily does not lead to confusion except when one seeks a definition.

There are so many varieties of clay, which differ so widely in chemical and physical properties, that it is difficult to give a satisfactory definition that will include all of them. The Standard Dictionary says that clay is "A common earth of various colors, compact and brittle when dry, but *plastic* and tenacious when wet," which is fairly descriptive of nearly all clays; but to see that it is not inclusive, one needs only to turn to another page of the same dictionary, where it is stated that "Fuller's earth is a *non-plastic* clay used in fulling cloth." The so-called flint fire clay is not at all plastic in its native condition.

Clay is sometimes defined from a chemical standpoint as an earthy substance composed essentially of the mineral kaolin, a hydrous silicate of alumina. But some persons challenge this with the pertinent statement that it has not been proved that kaolin is the essential base, or that it is always present.

One recent writer on the subject makes the definition include "all earthy or stony substances which are or may be used in the manufacture of clay wares."

Mr. Jefferson Middleton, in a special report of the Census Office, "Mines and Quarries," 1902, page 861, gives the following popular definition of the term clay: "Any earthy substance which, if mixed with water and molded, will retain its shape after drying, and which upon subjection to high temperature loses its plasticity and becomes hard and brittle."

ORIGIN OF CLAYS.

The ultimate origin of the silicate of alumina, which appears to be an important part of all the clays, is to be sought in the aluminous minerals of the igneous rocks, especially the feldspars. In the weathering processes, the alkalies are separated and combine with carbonic or other acids, and are carried away in solution. The remaining alumina and part of the silicate frequently combine with some water, forming kaolin.

The hydrous silicates of alumina seem to be exceedingly stable compounds at ordinary temperatures. The elements may not always combine in the same ratio as in crystallized kaolinite, yet they remain in some form and constitute an important part of nearly all clay, shale, and slate deposits, and hence a very material portion of the surface rocks of the earth.

When this hydrous silicate of alumina or clayey material is segregated and forms a considerable portion of any deposit the product is called clay, but it also occurs in large quantities mixed with other materials in other rocks, as with sand in the sandstones, with gravel in the conglomerates, and with the carbonate of lime in the limestones. When the clayey limestones disintegrate by the carbonated waters dissolving the lime carbonate and carrying it away in solution, the insoluble silicate of alumina is left behind as residual clay. The disintegration of the sandstones and shales forms a mixture of clay and sand, which when carried away by the rains and streams is frequently separated into sand and clay deposits.

Thus the clays may be divided, on the basis of origin, into *residual clays*, or those occurring in the place of the original rock from which they have formed, and *transported clays*, or those which have been deposited by water which has transported them from their original position.

The *glacial clays* (boulder clay or till) is a special class of transported clay in which the agent has been ice. Besides the clay of disintegration that has been picked up by the glacier, the glacial clay consists in part of finely-ground, fresh-rock material, which was formed by the rock-shod mass of ice pulverizing the rock over which it passed.

CHEMICAL COMPOSITION.

Technically, pure clay or kaolinite, which is the basis of all clay, is a hydrated silicate of aluminum ($\text{Al}_2\text{O}_3, 2 \text{SiO}_2, 2 \text{H}_2\text{O}$). All clay in its natural state contains more or less impurities, the kind and quantity of which determine its character; from purest varieties, called kaolin, clays range through all stages of impurity down to a point where the material contains so little kaolinite that it can not be classified as clay at all. (Mines and Quarries, above mentioned, page 861.)

The foreign material of the clay is frequently divided into the fluxing and non-fluxing constituents, depending upon whether or not they increase the fusibility of the clay. The most common fluxing constituents are lime, magnesia, potash, soda, lithia, iron, and manganese. The fusibility of the clay is as well affected by the physical condition of these fluxing constituents as by their quantity. For instance, a small percentage of iron oxide very finely divided and intimately diffused through the clay mass will prove to be a more active flux than twice the amount scattered through it in coarse grains.

The common non-fluxing constituents are silica, titanio acid, water, and organic matter. This classification is not wholly free from criticism, as silica may slightly increase the fusibility.

These constituents may be present in quite a variety of mineral forms.

PHYSICAL PROPERTIES OF CLAYS.

Some of the properties which make clay so valuable to mankind are: (1) Plasticity and mobility when wet; (2) Retention of the molded form when dry; and (3) The hardness and great durability when burned. Plasticity when wet is a property common to all clays but the flint fire clay. *

The plasticity is a result of the microscopical texture of the clays. (See IXth Report, California State Mining Bureau, page 287.) The kaolinite, which is formed *in situ*, and composed of crystalline scales, is only slightly, if at all, plastic, while kaolin, which has been transported, and composed of infinitesimal globular particles, makes a highly plastic clay. Flint clay becomes plastic when finely ground, but quartz does not, because the resulting particles are so hard that they will not flatten, however small.

In *drying*, the clay loses part of the interstitial water, and in burning it loses the remainder and part of the water of crystallization. The hardening of the clay from high temperature is a permanent one, the nature of the material is changed, and it will no longer become plastic on the addition of water.

* Possibly some persons would add fuller's earth to the exceptions, but it need not be classed with the clays at all.

Shrinkage.—All clays that are molded wet, shrink on drying—*air shrinkage*—and undergo a further shrinkage when burned—*fire shrinkage*. The shrinkage is probably due, in great part at least, to loss of water. The water exists in the clay as water of crystallization, as a film around the particles, and inclosed between them.

The *air shrinkage* is due largely to the loss of the second part as indicated by the fact that the shrinkage is from 2 to 10 per cent, while it takes from 14 to 35 per cent to make the clay plastic. The difference indicates in a general way the volume of the interstices.

Clays differ greatly in the amount of shrinkage. In general, the more plastic and purely argillaceous clays shrink more than the sandy, siliceous ones. Hence, if the brickmaker has a clay that is too “fat,” he adds sand to it. Clay that has been burned once undergoes no further shrinkage on subsequent burning, hence burned clay is frequently used as a “grog” to lessen shrinkage, especially in refractory products, where sand might lower the fusing point.

The *fire shrinkage* is probably caused, in part at least, by the loss of the water of crystallization along with the remaining interstitial water. It is also affected by the amount of organic or other volatile matter present. Moreover, some substances expand on heating, and if present in the clay may more than counterbalance the shrinkage of the argillaceous part.

It is important to know the shrinkage of any given clay that is to be used for products of definite dimensions, so that the molds may be made the proper size. Laboratory tests made on a large number of different kinds of clay gave the following results, each being the average of several specimens of that kind:

Laboratory Tests on Shrinkage.

	Air Shrinkage. Average.	Fire Shrinkage. Average.
Flint fire clay.....	3.5%	9.9%
Kaolin.....	5.0	8.8
Potter's clay.....	7.0	5.4
Brick.....	5.5	4.5
Shales.....	6.0	4.6
Gumbo.....	9.0	1.5

Fusibility of Clays.—The clay manufacturer must necessarily know the fusing temperature of the clay he is using, in order that he may not injure or destroy his ware by overburning or underburning. The term “fusibility” as applied to clays has a significance a little different from that as applied to metals. When clay is heated beyond red heat, it shrinks and becomes close-grained and harder. It finally reaches a point where shrinkage ceases and it becomes very hard and strong, and the individual grains are no longer recognized. This is called *incipient vitrification*. On further heating, the density and hardness are still further increased. This is called *complete vitrification*, although the clay still retains its form and shape. If the temperature is further

increased, the clay begins to warp and sag, and blister, and becomes scoriaceous, which stage may be called *scoriaceous vitrification*. A further increase in temperature may produce a complete vitrification to a molten stage, from which it cools to a hard, glassy, rock-like slag.

The temperatures at which the various stages of vitrification are produced are different in the different clays, and are functions largely of the chemical and physical composition of the clay.

The clays which resist vitrification at high temperatures are called fire clays or refractory clays. The line of separation between refractory and non-refractory clays is an arbitrary one. (See Fire Clay.)

Color.—Clays may be white, black, red, yellow, brown, blue, or variegated. The white clays are free from metallic oxides and frequently among the purest forms of kaolin. The black clays are generally colored by the carbonaceous material diffused through them, and are frequently made white by burning. The yellow, brown, red, and frequently the blue colors are due to iron in some form; in the yellow clay the iron is in the form of the hydrous oxide, the common bog ore; in the red, the color is due to anhydrous iron oxide, or hematite; the blue color may be caused in part by iron carbonate, silicate, or sulphide, and sometimes wholly or in part by organic matter.

The color of a clay after burning is frequently quite different from that before burning. They may be divided into three classes: Those which burn (1) white, (2) buff, (3) red. The color of the burned clay is influenced not only by the amount of iron in the clay, but also by the physical and chemical condition of the iron, the other elements associated with the iron, the temperature and length of time in burning, and the character of the gases in the kiln. The color of the burned product is thus very largely influenced by the skill of the burner.

In the finer grades of ware, the desired color or colors are obtained by mixing the proper pigments. Almost any desired color or shade of color, except white, can be obtained in this way. For white wares, clay free from metallic oxides is necessary. (See "The Rôle Played by Iron in the Burning of Clays," by Professor Orton, in the "Clayworker," for April, 1904.)

USES OF CLAY.

The uses of clay are so many and varied that it is impossible to enumerate them all, especially in view of the fact that almost every day new uses are found for it.

VARIETIES OF CLAY.

The varieties of clay are almost endless, and the methods of classification are almost as many. The commercial clays are conveniently divided into high-grade and low-grade, although the line of separation is not a sharp one.

HIGH-GRADE CLAYS.

CHINA CLAY, PORCELAIN CLAY OR KAOLIN EARTH.

This is the purest known form of clay; a white-burning, non-plastic, highly refractory, residual clay, used in the manufacture of china and other white wares. It must be practically free from iron. The kaolins are friable in the hand and meagre to the touch. In the natural condition they always contains more or less impurities, which are removed by washing.

China Clay (J. H. Collins, "Engineering and Mining Journal," June 8, 1905) is a commercial term for the purest and whitest variety of kaolin. It is obtained by washing a variety of decomposed and often disintegrated granite, called "carlazite." In this the feldspar crystals have been more or less completely converted into kaolin. When the kaolinization is complete, or nearly so, the rock is called "clay"; when less complete, if there is an absence of objectionable elements in the other components of the rock, the mass is called "chinastone" or "petunzite." The kaolinization is closely associated with veins of quartz and black tourmaline or schorl. Sometimes china clay can be traced for long distances, with a breadth of only a few feet, or even a few inches, in the direction of those veins; occasionally the width may reach several yards. These wide masses of china clay are found associated with a number of more or less parallel veins of the kind mentioned. The breadth of the decomposition is apparently independent of the size of the veins, but the direction of the decomposed land is distinctly governed by that of the vein. The limit of the persistence in depth of the china clay is as yet unknown; at one place it was found at a depth of 900 feet below the surface.

From a chemical standpoint the china clays are more valuable the nearer they approach kaolinite in composition, namely, 46.3 per cent of silica, 39.8 per cent of alumina, and 13.9 per cent of water. The physical properties are often as important as the chemical ones, and are not always governed by the chemical composition. The following table, compiled from many analyses, indicates the wide range in chemical composition of china clays:

Range in Composition of Chinaware Clays.

	Per Cent.
Silica	45 to 85
Alumina	5 to 40
Water	2 to 14
Iron oxide	0 to 2
Lime	0 to 2
Magnesia	0 to 2
Alkalies	0 to 3
Titanic acid	0 to 3

Ball Clay is a white-burning, plastic, refractory clay, free from metallic oxides or other coloring material. It is used with kaolin in the manufacture of white ware, and often incorrectly called kaolin; its distinguishing characteristic is its plasticity.



ILL. No. 86. HIGH-GRADE CALIFORNIA CLAY PRODUCT. HAND-CARVED.
(Courtesy of Mrs. L. V. Irelan.)

POTTER'S CLAY.

Potter's clay is a term rather loosely used. The most general idea conveyed by the term, probably, is that of smooth, plastic clays, too fusible for highly refractory purposes and containing less iron than the

ordinary brick clay. Adapted to the manufacture of stoneware, earthenware, terra cotta, and sewer pipe. Wares manufactured from potter's clay are usually light buff in color, and when burned to incipient vitrification are strong and slightly porous, requiring a glaze to render them



ILL. No. 87. HIGH-GRADE CALIFORNIA CLAY PRODUCT. MUSHROOMS
MODELED BY HAND. (Courtesy of Mrs. L. V. Irelan.)

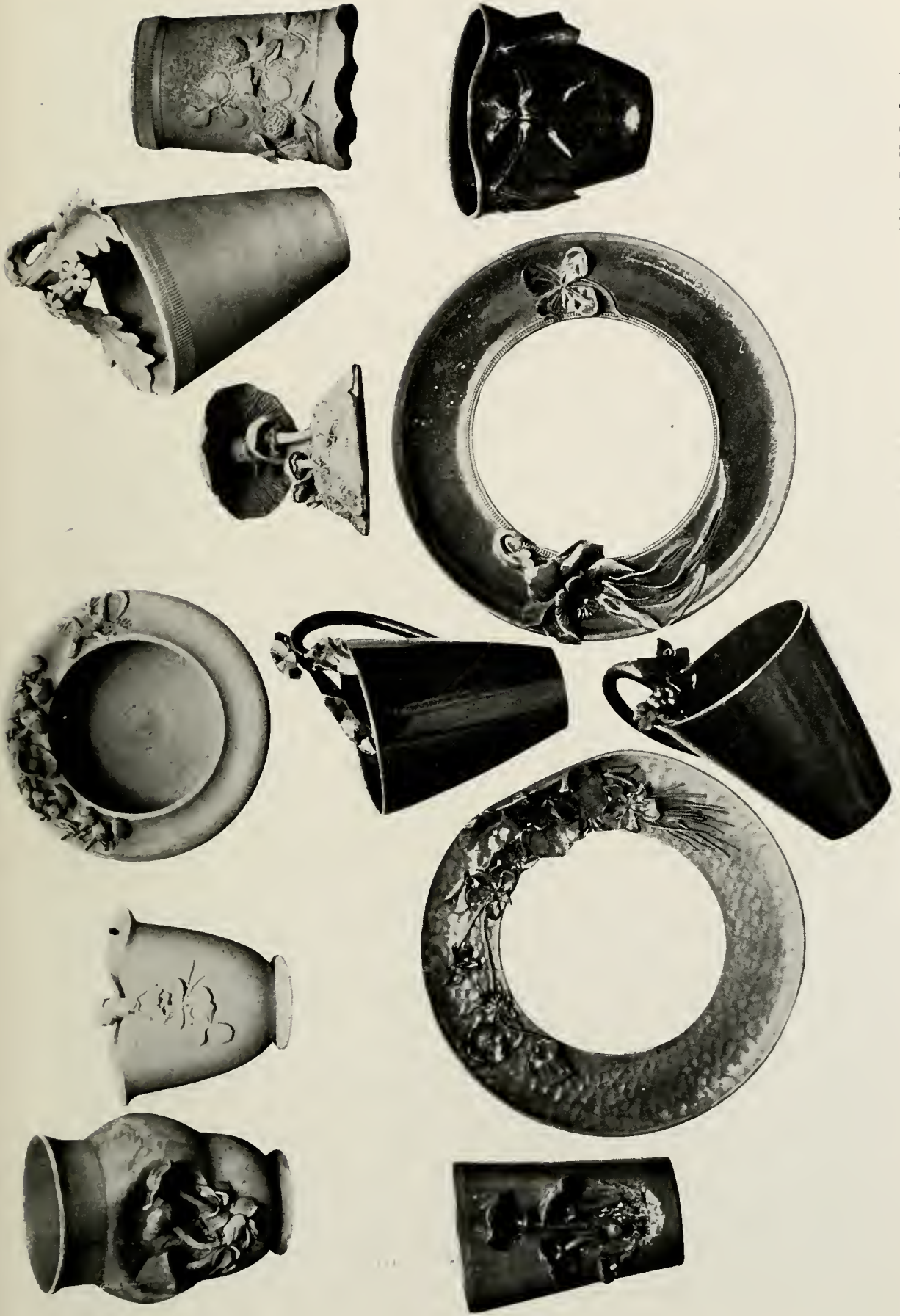
impervious to liquids. The stoneware glazes are commonly either a salt glaze or one formed by slip clay. Much stoneware is made with a brown slip glaze on the inside, and a blue-gray salt glaze on the outside. The requisites of a good stoneware clay are: (1) It should be emi-

nently plastic, so that it may easily be molded and turned into the thin walls of the vessels required, and yet retain its shape without injury. To mold readily, it should be high in clay base, that is, a "fat" clay. (2) It should be low in iron, as a light-colored ware is more desirable. (3) It should be free from coarse sand or other coarse material. It is frequently necessary to remove such material by a process of washing, in which the coarse materials are separated by gravity. The washing process will also remove the iron if it should be present in crystals or lumps, the condition in which it causes the greatest injury. (4) It



ILL. No. 88. HIGH-GRADE CALIFORNIA CLAY PRODUCTS, "THROWN" AND HAND-MODELED. (Courtesy of Mrs. L. V. Irelan.)

should be fusible enough to vitrify at a moderate temperature, less than 2000° F. If the vitrifying point should be too high, the burning would be too expensive. (5) The clay should have a range of at least 200°, and better 300°, between incipient and complete vitrification, as it is not easy to control the temperature of the furnace within narrower limits, and all the ware in the kiln should pass the stage of incipient vitrification, but should stop short of complete vitrification. If it has not reached the first stage it will be soft, porous, and lacking in strength, and if completely vitrified it would be glassy and brittle, and likely be out of shape. (6) It should be capable of drying at moderate speed without checking or cracking, otherwise there will be increased storage and drying room required, increased stock, hence more capital and



ILL. No. 89. HIGH-GRADE CALIFORNIA CLAY PRODUCTS, "THROWN" AND HAND-MODELED. (Courtesy of Mrs. L. V. Irelan.)

greater expense. (7) It should be free from salts that are liable to cause blisters in burning.

Yellow or Rockingham Ware is a class of pottery that differs from stoneware in the manner in which it is burned. In stoneware, the burning is complete in one operation, while yellow ware is first burned in the biscuit kiln to form the body, and then burned again to develop the glaze. A less refractory clay may be used in the yellow ware, but since the glazes fuse at lower temperatures the same clay may be used for either stoneware or yellow ware.

Earthenware is the lowest form of pottery, and can be made with proper precautions from almost any common yellow clay. It is softer and more porous than stoneware or yellow ware.

SLIP CLAY.

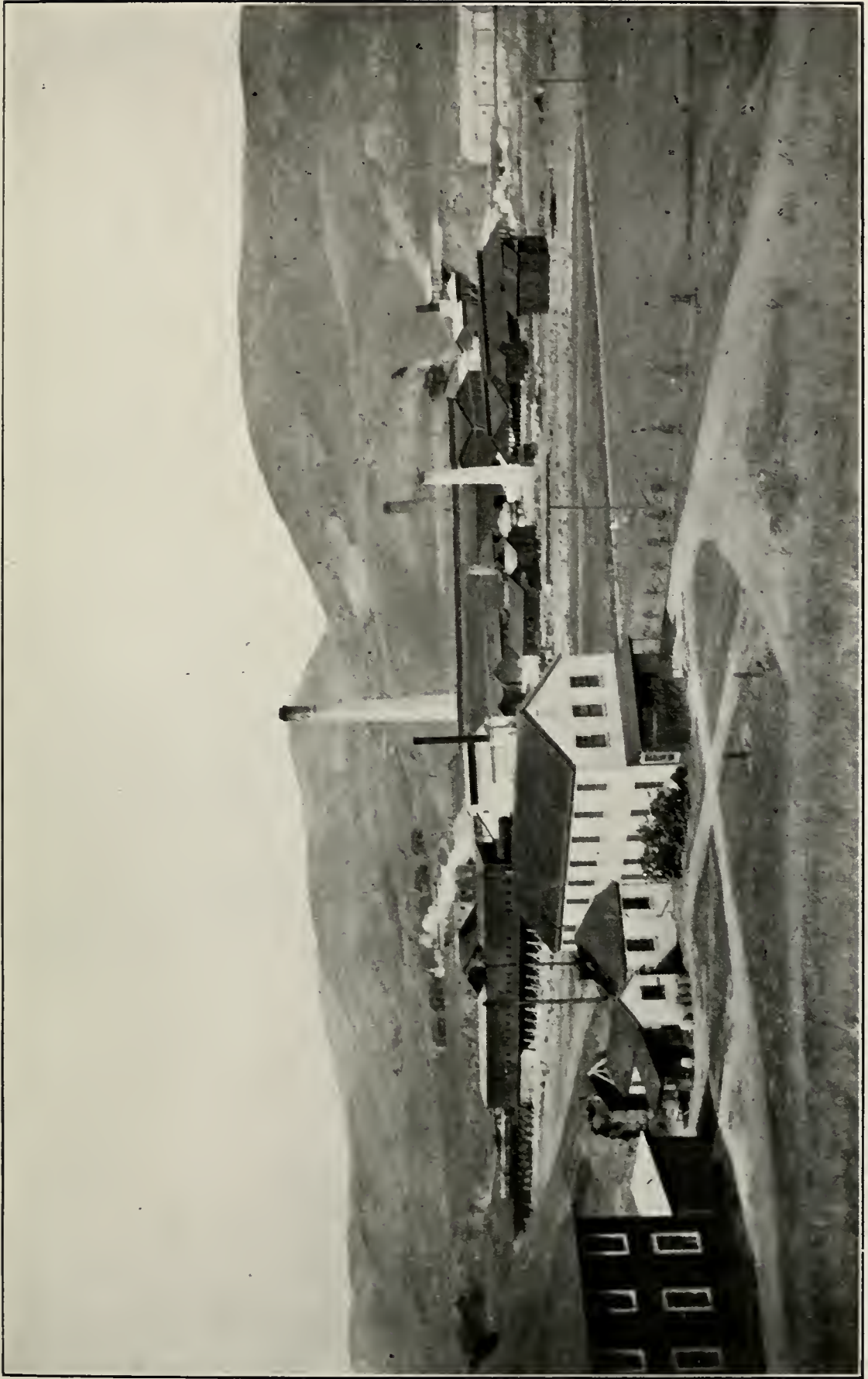
Slip clay is a variety that runs very low in fusibility, and is used in forming the glaze in stoneware and earthenware. The following copy of an analysis of a slip clay shows the composition of one of the best known and most widely used clays of this class in the United States:

Analysis of Albany Slip Clay.	Per Cent.
Silica (SiO_2).....	56.75
Alumina (Al_2O_3).....	15.47
Iron (Fe_2O_3).....	5.73
Lime (CaO).....	5.78
Magnesia (MgO).....	3.32
Alkalies.....	3.25
Water.....	8.87

Much of the slip clay used in California is obtained from Albany, New York.

FIRE CLAY.

Fire clay is, as the name signifies, one that resists high temperatures, and hence is more refractory than the common clays. It has a lower percentage of the fluxing substances, such as alkalies, iron, and manganese. It is most commonly associated with coal-beds or other vegetable deposits, and it is thought, in some instances at least, to owe its existence to the vegetable matter which has extracted the fluxing constituents, such as the alkalies and alkaline earths, from the clay. There are two classes of fire clays: the soft or plastic, and the hard or flint. The latter occurs in hard rock masses, which do not slake in water, and are not plastic in their natural condition. They are frequently more refractory than the plastic clays. Fire clays are used for making firebricks, stove and furnace linings, gas retorts, glass pots, and for other refractory purposes. They are also used for making high-grade building bricks, and some low-grade fire clays are used for making paving bricks.



ILL. NO. 90. POTTERY AND LIMEKILN AT CARNEGIE, CORRAL HOLLOW, SAN JOAQUIN COUNTY.

HIGH-GRADE CLAYS AND CLAY INDUSTRIES IN CALIFORNIA.

ALAMEDA COUNTY.

California Pottery and Terra Cotta Company.—S. W. Winsor is proprietor of these works, which are at the corner of East Twelfth street and Park avenue, at Twenty-third street station, Oakland. The pottery was opened about 1876. Sewer and chimney pipes, flue linings, flower-pots, bean-pots, and fancy vases are manufactured. The equipment includes one 12-foot and three 20-foot kilns, one wet pan, and one new 7-foot dry pan. The clay is obtained from Carbondale, Amador County, and loam is secured locally. The market is mostly local and central California points. The annual output averages about \$30,000. Oil fuel is used throughout in boilers and kilns. About 10 men are employed.

Carnegie Brick and Pottery Company's Sewer-pipe Factory.—It is $1\frac{1}{2}$ miles down Corral Hollow, east of Tesla, in S. $\frac{1}{2}$ of Sec. 30, T. 3 S., R. 4 W. The office is at 328 Montgomery street, and the city yard is at Tenth and Channel streets, San Francisco. It is a modern and complete plant for manufacturing sewer pipe. The equipment includes two wet pans and two sewer-pipe presses, one capable of making 36-inch pipe. Eight 30-foot kilns are in operation, and the stack is built to accommodate eight more kilns. Each kiln is turned over once every fourteen days. The clay is obtained from the mines at Tesla.

N. Clark & Sons' Pottery; Albert V. Clark, president, 17-19 Spear street, San Francisco; George D. Clark, secretary and treasurer, and superintendent at pottery, Alameda. The works are located in the city of Alameda, at the corner of Fourth and Pacific streets. It is a very extensive plant, manufacturing large quantities of vitrified sewer and water pipes, chimney pipes and tops, fire-proofing flues, architectural terra cotta work, faced brick, etc. The equipment includes eight 20-foot, one 14-foot, and two 16-foot kilns, and one 22-foot "brick" kiln. The main building is 300 by 130 feet, four stories, of brick. The terra cotta building is a two-story brick structure, 100 feet square. The clay is obtained from their own pits at Carbondale, Amador County. (See page 207.) Oil fuel is used throughout for kilns and boilers. From 80 to 90 men are employed.

East Ninth Street Pottery, C. Anderson, proprietor, at 1333 East Ninth street, Oakland, manufactures stoneware, flower-pots, fancy pots,



ILL. No. 91. N. CLARK & SONS' POTTERY AT ALAMEDA POINT, ALAMEDA COUNTY.

and crocks. There is one 12-foot kiln, using oil fuel. The clay is from Amador County. About twelve kilns are burned a year.

Novelty Pottery Company; N. S. Clark, manager. The works are on Clay street, between Second and Third, Oakland. The pottery was started in May, 1904. At present the company manufactures a patent bread-toaster, with a fire-clay body, the rest being a secret formula. It is expected to make other clay novelties. One 9-foot kiln is in use, using oil fuel.

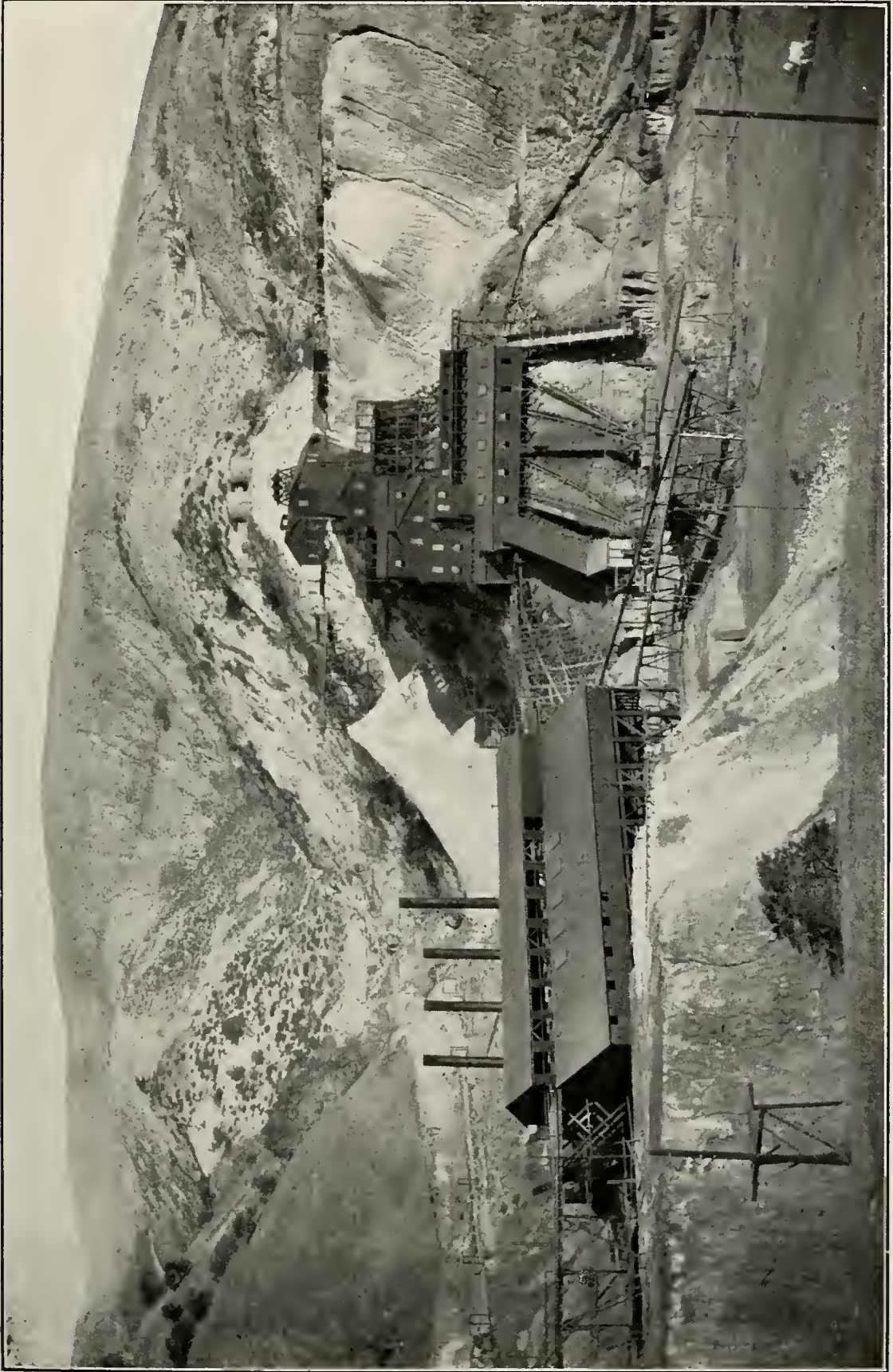
Oakland Art Pottery, James Miller, 1125 East Twelfth street, proprietor; on East Twelfth street, between Twenty-second and Twenty-third avenues, Oakland. Manufactures various sorts of ornamental vases, flower-pots, sewer pipes, chimney pipes and tops, tiling, water-coolers, and general terra cotta wares. One 12-foot and two 20-foot kilns are operated, using oil fuel. The clay is obtained from Carbon-dale, Amador County.

Rose Firebrick Company, office, 604 Merchants' Exchange, San Francisco. The American Magnesite Company plans to deliver the crude magnesite to the above company's plant in Oakland, on the old Session Tract, in Oakland Creek. The ore is to be calcined in three large rotary calciners (each 100 feet long and 8 feet in diameter). The magnesia will be used by the Rose Firebrick Company in the manufacture of firebrick, and the carbonic acid gas will be delivered to the adjoining plant of the Pacific Carbonic Gas Company, where it will be liquefied and prepared for shipment for use by refrigerating plants, soda-water manufactories, ice factories, breweries, etc.

San Francisco and San Joaquin Coal Company, 328 Montgomery street, San Francisco. The land holdings of this company average 2 miles in width and extend for about 7 miles east and west along Corral Hollow, partly in Alameda County and partly in San Joaquin County. Its plants are connected with Stockton by its own broad-gauge railroad (Alameda and San Joaquin Railroad).

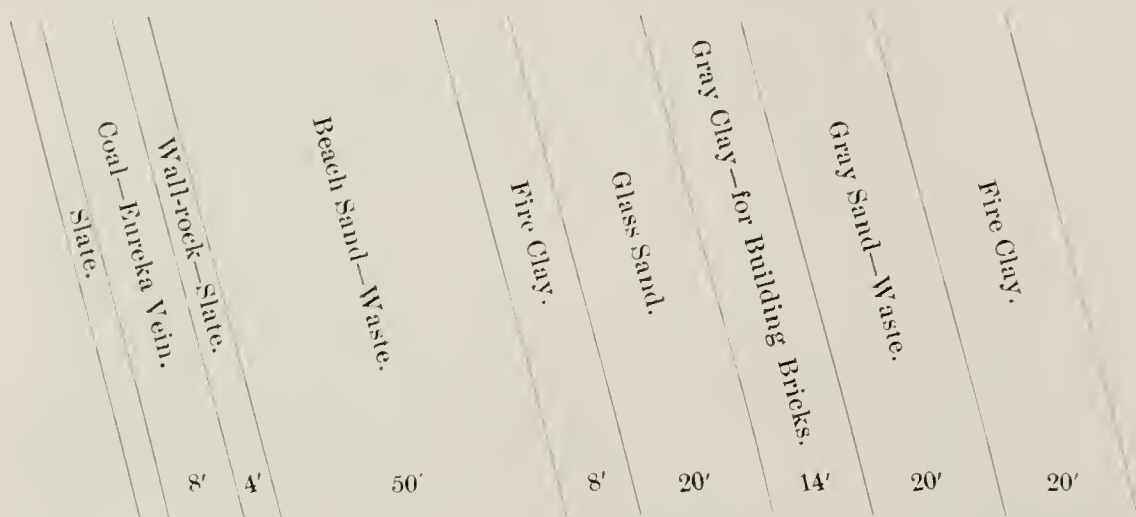
The hills on either side of Corral Hollow, in the vicinity of Tesla, are studded with prospect tunnels, ranging from 50 to 800 feet in length. Some of them were put in as early as 1863 in quest of coal. Most of them are caved at present.

The only producing mine is at Tesla, in S. E. $\frac{1}{4}$ of Sec. 26, T. 3 S., R. 3 E., where, in opening up the coal deposits, immense beds of clay have been developed, which will furnish an unlimited supply of high-



ILL. No. 92. HOISTING WORKS AND PLANT AT TESLA COAL AND CLAY MINE, ALAMEDA COUNTY.

grade pottery and fire clays. The accompanying sketch roughly shows a cross-section of the beds, which dip N. 70° W. at an angle of about 60°.



These clays are of various grades, from nearly pure kaolin to ordinary sewer-pipe clay, and are mined from the different tunnels and stored in bins above the railroad siding at mine. They are shipped down the cañon 2 miles to the Carnegie Brick and Pottery Company's sewer pipe factory (see page 202), and 4 miles to brick and terra cotta plant (see page 227), as is needed.

At the **Tesla Mine**, in Corral Hollow, in the same series as the clay beds, there occurs a ledge of soft, sandy material, which is used as a refractory mortar in the construction of the many kilns at the potteries at Carnegie. The ledge is from 12 to 15 feet thick, and furnishes an inexhaustible supply. It is developed by a 500-foot shaft. By washing this material and freeing it from the sand, a very high-grade kaolin is secured.

AMADOR COUNTY.

Carbondale.—In the area about Carbondale, and between Carbondale and Ione, are extensive deposits of high-grade clays. Fine plastic potter's clay and fire clays occur in unlimited quantities. There is also a highly sandy clay, and associated with these are plastic variegated clays adapted to terra cotta, sewer pipe, drain tile, and similar uses.

A large part of the extensive clay area around Carbondale occurs in an old Spanish grant of 34,000 acres, which is now controlled by the Pacific Improvement Company, from whom the clay lands are leased.

The following analyses of Carbondale clays were made in the laboratory of the State Mining Bureau a number of years ago. No. 1 is from the pit of N. Clark & Sons. No. 2 was made in 1889, and is marked

Carbondale, but the pit is not designated. No. 3 is marked from Carbondale, and said to contain quartz grains:

Chemical Analyses of Carbondale Clays.

	No. 1.	No. 2.	No. 3.
Silica (SiO_2)	60.00	57.02	48.90
Alumina (Al_2O_3).....	30.29	31.06	38.18
Iron (Fe_2O_3).....	2.27	0.53	2.40
Lime (CaO).....	.28	trace	.50
Magnesia (MgO).....	trace	trace	.09
Alkalies.....	1.02	2.32	1.85
Water.....	8.05	8.95	8.65



ILL. No. 93. CLAY PIT OF N. CLARK & SONS, NEAR IONE, AMADOR COUNTY.

N. Clark & Sons, 17 Spear street, San Francisco, obtain clay for their factory in Alameda from the large pit on the Ione-Sacramento road, $2\frac{1}{2}$ miles north of Ione; W. R. Bacon is their superintendent at Ione. The clay is soft, smooth, plastic, and free from grit. It has a light blue color in the interior of the bed, but changes to snow-white when dried. It occurs in a massive bed, from 18 to 20 feet thick, on the back wall of the pit, and is overlaid by from 3 to 10 feet of variegated yellowish, red and white sandy clay that is stripped off and thrown on the waste. Around the greater part of the pit there is a thin layer, one or two inches thick, of red hematite, which has been carried down the joint-planes by the percolating waters and forms red blotches on the clay along the joints. The white clay can be quarried here in large

quantities at very little expense. During the summer a sufficient quantity is stored in the large shed at the railroad to keep up the shipments during the months when the roads are impassable.

N. Clark & Sons also obtain a gray clay from a pit a mile north of east of the siding, which contains considerable sand and is stained with iron oxide. It lies near the surface, with from 2 to 10 inches of reddish-brown gravel and sand overlying it. The vegetation growing over the surface has sent many fine roots down into the clay, some extending to the bottom of the clay deposit. These decaying roots, along with the iron that has been carried in from the overlying red gravel, have changed in places the original white color to gray and brown, and where the roots are abundant to even a black color. This clay, because of its burden of sand, is used in mixing with other clays for certain classes of work.

N. Clark & Sons also obtain a "fire sand," a white clay with a large percentage of sand, from a pit about 1 mile north of Carbondale.

Mr. Fred Hammer operates a small pottery at May P. O., a half mile north of Carbondale, which has been in operation since 1877. From clay obtained about a half mile east of the pottery, Mr. Hammer makes sewer pipe, drain tile, chimney tops, jugs, and jars. The ware is turned by hand, and burned in the single kiln with wood.

King & Enos, Carbondale, work one clay pit about 200 yards west of Carbondale. A side track from the railroad extends alongside the storage shed at the clay pit. An inclined track runs from the pit to the shed, and the loaded cars are hauled into the shed and dumped by a steam-hoist. They have a large storage shed, which at the end of the dry season contains about 5000 tons of clay ready for shipment during the wet season. The shipments from this pit average about 15 carloads per month during the year.

The pit furnishes a soft, plastic, refractory clay, free from grit, having a light blue color when first dug, which changes to white when dried. It occurs in a bed from 6 to 14 feet thick, underlaid by quicksand and overlaid uncomformably by from 1 to 6 feet of yellow, sandy clay, containing a few scattered boulders. This overburden is stripped off and thrown in the waste. Only the white clay is shipped.

King & Enos, for Steiger Terra Cotta and Pottery Works, room 45, Mills Building, San Francisco, work a large clay pit on Irish Hill, about 3 miles east of the railroad. The clay is hauled by wagon to the large storage shed located at the coal mine at the Yarn switch, about a mile south of Carbondale.

The clay on Irish Hill is white plastic, similar to that in the pit at Carbondale. It occurs in a massive bed from 15 to 25 feet thick, and



ILL. No. 94. CLAY PIT, IRISH HILL, NEAR IONE, AMADOR COUNTY.



ILL. No. 95. CLAY PIT OF THE STEIGER TERRA COTTA AND POTTERY COMPANY,
AT CARBONDALE, AMADOR COUNTY.

is or was overlaid by a heavy bed of auriferous red gravel, which, over a large area along the brow of the hill, was removed by hydraulic mining some years ago. Clay is quarried from this area exposed by the hydraulic washing and which contains thousands of tons, as the gravel-bed back is from 20 to 40 feet thick—too great a thickness to remove to obtain the clay. The greatest expense in handling the clay is the 3-mile haul by wagon to the railroad. The purity of this clay, together with the great thickness of the bed and the slight stripping required, are points which make the deposit a valuable one.

King & Enos, for Steiger Terra Cotta and Pottery Works, room 45, Mills Building, San Francisco, also operate a clay bank about half a mile east of the Yarn switch, to which the clay is hauled by wagon. This clay is quite gritty, and contains a great many quartz grains scattered through it. It is used for mixing with other clays, and is said to be very refractory. It occurs in a bed from 3 to 10 feet thick, and has been dug over an area about a quarter of an acre in extent. It is overlaid by a layer of reddish gravel from 6 inches to 2 feet in thickness, which is stripped off as the clay is quarried.

Lambert & Seams operate a small pottery similar to Hammer's, located about 2 miles north of Carbondale. They make similar wares for the local trade.

J. W. Orr, as early as 1859, put up the Michigan Bar pottery at Michigan Bar. In 1862 it was moved out 3 miles on the Ione road. In 1865 A. M. Addington, now postmaster at May P. O., purchased this pottery and operated it until 1884, when he sold it to Mr. Williams, who owned it until it was abandoned in 1896. Stoneware and sewer pipe were the principal products.

A. E. Smith, Carbondale, quarries, about 3 miles north of Carbondale, white, refractory, plastic clay, similar to that described, which he hauls by wagon to Carbondale, and ships to Sacramento, where it is made into firebricks by the Southern Pacific Company.

Steiger Terra Cotta and Pottery Works, at South San Francisco, office 45 Mills Building, San Francisco, obtain clay from three pits in the vicinity of Carbondale, all of which are operated by King & Enos, who also run the coal mine near Carbondale.

There were other small potteries scattered over the area years ago, but like most of the small potteries of the United States they could not compete with the large ones where the ware was made by machinery, and as a result were closed, except a few scattered ones more or less remote from the railroad, which still supply the local trade.

BUTTE COUNTY.

In Butte County are many clay deposits of varied character. The principal ones are in T. 21 N., R. 3 and 4 E.; T. 20 and 19 N., R. 4 E.; T. 18 N., R. 2 and 3 E.

Bohannon Ranch, in Sec. 4, T. 21 N., R. 5 E.; T. Bohannon, Yankee Hill, owner. A considerable body of a plastic yellow clay was observed. It is tenacious, plastic and refractory. No effort has been made to develop it, or to demonstrate its value.

In Secs. 19 and 30, T. 18 N., R. 3 E., about 2 miles southeast of Biggs, is a light brown or white brittle clay-bed, about one-half mile wide. Max Brooks of San Francisco and Mr. Reed of Biggs, owners.

Coal Canon.—In Sec. 12, T. 20 N., R. 3 E.; Charles F. Lott, Oroville, owner. A stratum of clay occurs in the coal mine.

Durbin Ranch.—In the S. W. $\frac{1}{4}$ of Sec. 13, T. 21 N., R. 3 E., on the Durbin ranch (A. M. Smith, Oroville, owner), there is a large deposit of clay of a refractory character and of low plasticity, overlying or making into a more plastic material. Both contain fine grit, and taken together were traced to a depth of about 100 feet.

Clay shale occurs in vertical ledge form about half a mile northeast from the lower clay exposure just mentioned. It is of low plasticity, refractory, and may be employed for firebacks, and when reduced to liquid form applied as a whitewash.

In the N. E. $\frac{1}{4}$ of Sec. 13, T. 21 N., R. 3 E., there is another exposure of clay west of a heavy slate formation, trending north and south. It is of a lighter color than that in the southwest quarter of the section, and of higher plasticity.

Oroville.—In Sec. 22, T. 19 N., R. 4 E., about 3 miles southeast of Oroville, clay occurs on lands owned by John M. Ward and James McPherson, the latter known as the Garden ranch, and extends into the Richardson ranch in Section 15. There has been no effort at development, and the material is exposed only by cuts made in road building.

Snow Ranch.—In the S. W. $\frac{1}{4}$ of Sec. 31, T. 24 N., R. 4 E.; A. Snow, Lovelocks P. O., owner. Occasional occurrences of light-colored clays of medium plasticity in Section 31.

CALAVERAS COUNTY.

Penn Chemical Works.—This company mines about 100 tons of high-grade fire clay each year for its own use at the smelter at Campo Seco. The pit is in the clay beds which overlie croppings of copper ore.

Valley Springs Clay Pit.—It is located about one fourth of a mile northeast of Valley Springs, on the Mokelumne Hill road, and has been idle for nine years. The clay was formerly used by a Stockton pottery. It is a plastic yellow clay, somewhat stained by iron in the open pit, and is capped by a gravel deposit.

CONTRA COSTA COUNTY.

Mount Diablo Pottery and Paving Brick Company; Hon. C. M. Belshaw, Antioch, owner. This large pottery is located one mile south of Antioch, on the Southern Pacific Railroad. The plant was opened about 1896 and operated only about one year, and has been practically aban-



ILL. No. 93. E. M. HAMILTON'S CLAY DEPOSIT, NEAR ROSAMOND, KERN COUNTY.

doned. The clay was obtained from the various tunnels at the coal mines at Stewartsville, which were connected with Antioch by a narrow-gauge railroad. The company has torn up the rails and stopped all work at the mines.

KERN COUNTY.

Los Angeles Pottery Company, 625 Griffin avenue, Los Angeles, owns a large deposit of pottery clay in Sec. 11, T. 9 N., R. 13 W., S. B. M., about 4 miles northwest of Rosamond station. Some clay, it is stated, has been shipped during the past fifteen years to the factory in Los Angeles.

The clay pit lies near the northeast end of one of the many felsite porphyry buttes on the south side of Antelope Valley, in the midst of the felsite porphyry, and appears to be a local decomposition product of the same. It is plastic, has a smooth, even texture, and shows no evidence of stratification. It contains numerous small and some large boulders of partially disintegrated felsite of the same color and appearance as the inclosing clay, except their hardness, and apparently are residual boulders of disintegration. At one point there is a disintegrated granite mass with many quartz grains. For the most part the clay is quite free from quartz and very plastic. There is a slight red coloring near the surface, probably from the overlying surface fragments of red porphyry, but otherwise the clay has a uniform pale blue-green color.

Most of the clay is taken from an open pit on the hillside, in the face of which a tunnel has been run about 200 feet back into the hill. The tunnel shows the greenish clay to continue about 25 feet in from the face of the pit, where it is followed by a light gray, more or less sandy clay, with many rock fragments, and stained yellow-brown along the many seams with iron oxide.

LOS ANGELES COUNTY.

Anderson & Sandquist East Main Street Pottery Company, 2009 East Main street, Los Angeles. Use local clay from Boyle Heights; manufacture flower-pots and ollas.

California Clay Manufacturing Company, 235 South Los Angeles street; works, Central avenue, Los Angeles. Use plastic clay from Alberhill, and fire clay from Elsinore, Riverside County. Manufacture firebrick and vitrified pipe.

The works are equipped with a Brewer wet-mud brick machine, and a Berg press for dry-pressed brick, each with a daily capacity of about 20,000 bricks; a Barber pipe press; and 8 downdraft kilns, varying from 30 to 16 feet in diameter, using oil as a fuel. Employ about 30 men.

J. Dodson, San Pedro. In Lot M, Los Palos Verdes ranch, west of San Pedro, are a series of surface exposures running northwesterly in the terrace southeast of the San Pedro Mountains, noticeable by lack of vegetation. In a shallow cañon the formation is exposed over a thickness of about 25 feet, showing beds of a light gray clay, with narrow streaks of brown, probably due to iron, dipping southeasterly. The material is very light, and has the appearance of diatomaceous earth. It is, however, unctuous to the touch and plastic, hardening in the fire with a gray color. Conformable with these beds are seams, not over 3 inches wide, of a disintegrated volcanic ash.

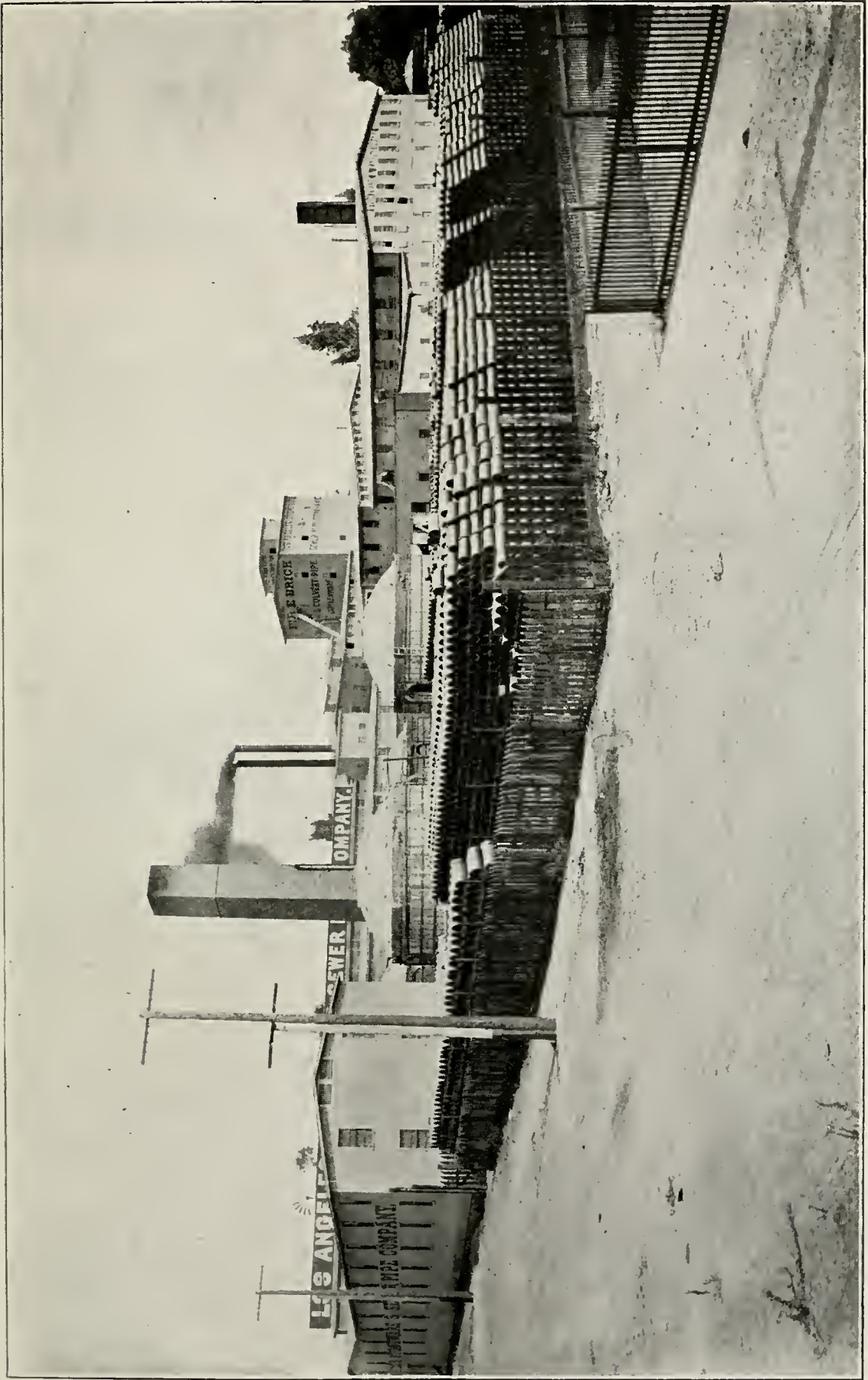
Los Angeles Pottery Company, J. M. Matthews, Los Angeles, uses principally local clays from Boyle Heights at 625 Griffin avenue and Alhambra street, Los Angeles. Principal product, flower-pots.

Los Angeles Pressed Brick Company, 105 South Broadway, works at Alhambra avenue and Date street, and at Colorado avenue, Los Angeles, has a large and well-equipped factory for making fine pressed building brick, firebrick, and refractory linings of different kinds. The plant has been in operation for several years, and the business has been constantly increasing from the start, as there is a very active demand for high-grade brick. The company is also trying to meet the demand for refractory furnace linings, which is caused by the increase in manufacturing industries and the increased use of oil fuel. For the refractory ware this company uses a black flint fire clay from Gypsum station, near Corona, which is similar to that at McKnight's clay pit (see page 224). The bricks and tiles made from this clay are said to give satisfaction. The building bricks are made of white clays from their pits near Alberhill, Riverside County. This company has also a large plant for the manufacture of red brick at Colorado avenue and Twenty-fifth street. The combined capacity of its two plants is 20,000,000 bricks per year.

Los Angeles Stoneware and Sewer Pipe Company, Arch. Douglas, president; 423-527 North Avenue 26, Los Angeles. Manufactures all kinds of stoneware, earthenware, firebrick; vitrified, salt-glazed sewer and water pipe, from 3 to 36 inches in diameter; conduits of underground electric wires, terra cotta chimney pipes, flue linings, etc.

It uses the following materials: For stoneware: clay from Alberhill Coal and Clay Company, Elsinore, Riverside County; Rosamond, Antelope Valley, Kern County (kaolin). For sewer pipe: clay from Alberhill Coal and Clay Company, Elsinore, Riverside County; local clay, in northeastern part of Los Angeles city. For firebrick: fire clay from Alberhill Coal and Clay Company, Elsinore, Riverside County. For flower-pots: local clay. For glazing purposes: clays from Albany, N. Y., and from Michigan; imported feldspar, flint, china clay, and English ball clay.

The clay, duly mixed, according to the product to be manufactured, is passed through a dry-pan crusher, then washed, blunged and passed through a press filter. The firebrick material passes through a pug-mill, a Giant auger, 12-brick wire-cutter, and an Eagle represser. The sewer-pipe material passes through a wet-pan crusher, and two presses, according to the dimension of the pipes, one making those from 3 to 16 inches in diameter, the other those from 18 to 36 inches in diameter. The pottery material goes to a pottery pugmill, where it is brought to the required plasticity. The green products are dried in large



ILL. No. 97. LOS ANGELES STONEWARE AND SEWER-PIPE COMPANY'S PLANT.

rooms, slightly heated by the exhaust from the kilns. The time required for drying depends on the weather; in summer from eight to ten days are sufficient.

The plant has seven downdraft kilns, using oil as fuel—three with an inside diameter of 30 feet, one with an inside diameter of 25 feet, two with an inside diameter of 20 feet, and one with an inside diameter of 12 feet.

Power is furnished by a 250-horsepower boiler, using oil as a fuel, and a 200-horsepower engine.



ILL. No. 98. SILICA FROM THIS CROPPING WAS USED BY THE TROPICO WORKS, LOS ANGELES COUNTY, FOR GLAZING TILES.

Southern California Pottery Works, Tomaseck Sons, 828 East Fourth street, Los Angeles; works, 448 East Twenty-eighth street, Los Angeles. Use clay from Corona and Elsinore, Riverside County, but principally local clays from Boyle Heights. Manufacture earthenware, stove linings, flue thimbles, assayers' furnaces and muffles.

St. Louis Firebrick and Clay Company, T. C. Mitchell, 123½ West Third street, Los Angeles; works, 2464 East Ninth street, Los Angeles. Uses clay from Corona and Elsinore, Riverside County. Manufactures pressed brick. The bricks are made in a 4-mold Berg brick machine, and burned in downdraft kilns, using oil as fuel. Idle at present.

Standard Pottery Company, F. G. Barnard, 411-415 North Avenue 20, Los Angeles. Uses clay from Corona, Riverside County, and local clay

from Boyle Heights, Los Angeles. Manufactures flower-pots, ollas, stove thimbles, etc. The clay is mixed in a clay-grinder. The pots are made in a stamp pot machine, of a capacity of 2000 pots per day. The plant is equipped with a 12-horsepower gasoline engine. Employs 6 men.

Western Art Tile Works, successor to the Pacific Art Tile Company, has a commodious and well-equipped factory on the Southern Pacific Railroad at Tropic, 6 miles north of Los Angeles, and has been in active operation since August, 1904.

They manufacture floor, wall, mantel, and art tiles; plain, ornamental, and embossed vitreous china; sanitary ware, plumbers' earthenware, and other clay goods.

The factory started about two years ago as the Pacific Art Tile Company. The works were closed several weeks during the summer of 1904. It is said to be the only factory of its kind west of the Rocky Mountains, and its progress will be watched with some interest. Many of its products require the finest quality of clays, which at present are imported from Europe. The ground silica and feldspar are also shipped from the Eastern States. These materials occur in California, but the known deposits are so remote from the railway that it is found to be cheaper to import them than to mine the home products.

MERCED COUNTY.

Goldman Deposit; M. Goldman, Merced, owner. A clay which the owner claims is suitable for manufacturing pottery occurs in large beds on the south bank of the Merced River, near the Merced Falls. No practical tests have been undertaken as yet to determine the quality of this clay.

NEVADA COUNTY.

Kaolin has been uncovered in three different places in Nevada County, but has been persistently prospected in only one.

De Golia Ranch, Rev. Dr. Meyer, Chicago Park, owner; in Sec. 3, T. 15 N., R. 9 E., 6 miles north of Colfax. There are two exposures of clays on the section. A bed of kaolin or clay 12 to 24 inches thick forms both banks of a small stream, underlying a capping of 2 to 3 feet of blue shaly clay, plastic and gritty, that crumbles on exposure to the atmosphere. These clays are exposed for a distance north and south of about 100 feet, and dip to the east. Three hundred feet west another deposit of clay, which is capped by 2 to 3 feet of red soil, is exposed by an open cut.

Last Chance Mine, Andrew Berg, Nevada City, owner; in Sec. 29, T. 17 N., R. 9 E., 5 miles northeast from Nevada City, on the North Bloomfield road. There has been uncovered in two tunnels on the Last Chance mine a considerable deposit of fire clay and kaolin lying alongside of a deposit of blue lava ash, extending east and west, and dipping to the south. There are occasional intrusions of iron.

William Walker, of Biggs, Butte County, reports kaolin in the white clay on Union Hill, 2½ miles east of Grass Valley. He states that in the manufacture of bricks on Union Hill several years ago he found white clay, kaolin, galena, and copper.

ORANGE COUNTY.

Fire clay is claimed to be found in the foothills of the southwest slope of the Santa Ana Mountains, and to be used for the manufacture of fire-bricks in the plant of the Orange County Tile Works.

It is also claimed to be found in Hicks Cañon, in the S. E. ¼ of Sec. 2, T. 6 S., R. 7 W., S. B. M.; G. F. Haven of Santa Ana and A. B. Joplin of Trabuco, owners.

Also in Bell Cañon, in the northeastern part of Sec. 24, T. 6 S., R. 7 W., S. B. M.; J. B. Joplin, Santa Ana, owner.

On the ranch of Luis Moulton, south of El Toro, on Aliso Creek, a good grade of bluish clay is found. (See Cement, page 182.)

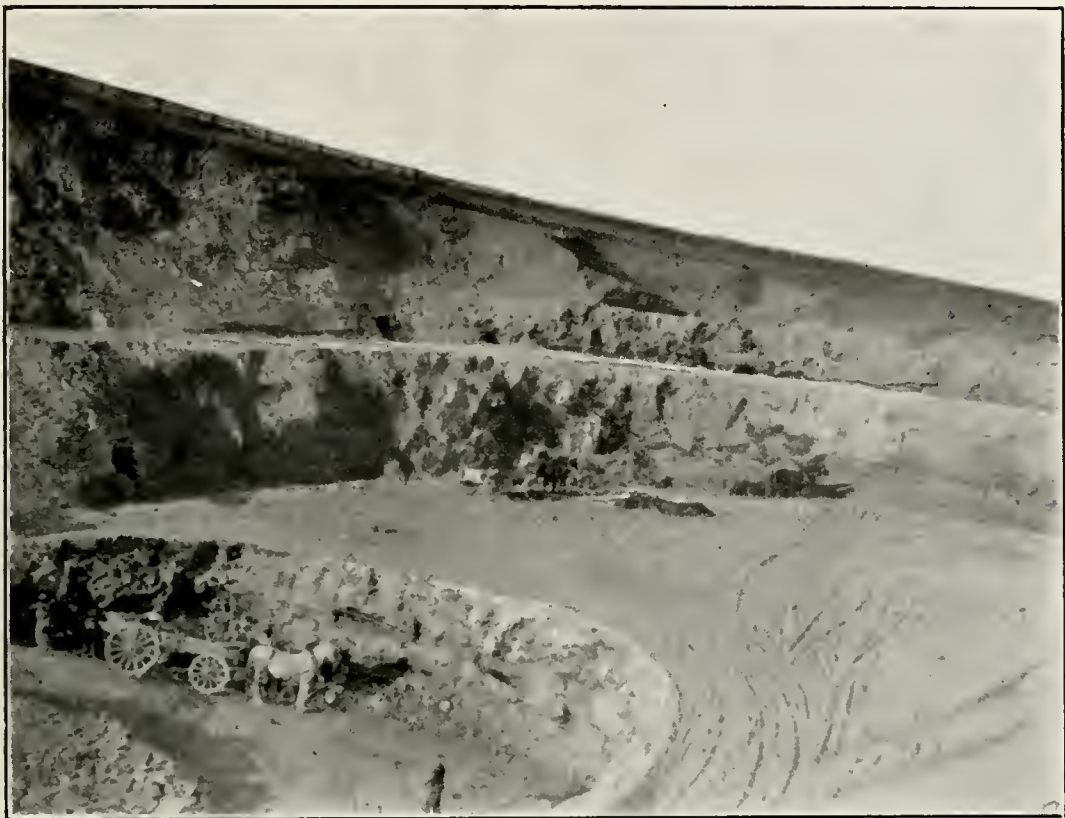
PLACER COUNTY.

Clays in Placer County, besides those mined and worked by the Gladding & McBean Pottery at Lincoln, are similar to those in other counties where hydraulic mining has been in vogue.

A pronounced occurrence of varied clays was observed along the southernmost tier of sections of T. 16 N., R. 10 and 11 E., from Dutch Flat to Shady Run, lying between Bear River on the west and the north fork of the north fork of the American River on the east.

At Dutch Flat, in Sec. 35, T. 16 N., R. 10 E., there occurs a tenacious yellow clay, plastic and containing no perceptible grit, that is unlike other clays found in Placer County. Its value for pottery uses can be determined only by practical test. In the eastern part of Sec. 35, and the western half of Sec. 36, T. 16 N., R. 10 E., the clays exposed by the railroad cut are white, soft, and plastic. In Sec. 31, T. 16 N., R. 11 E., through which Cañon Creek flows in a southwest course, there is a decided change to a chocolate or dull white clay that lies between two strata of blue sand, overcapped by some 10 feet of soil and coarse brown sand. These chocolate clays extend southwesterly to the railroad cut.

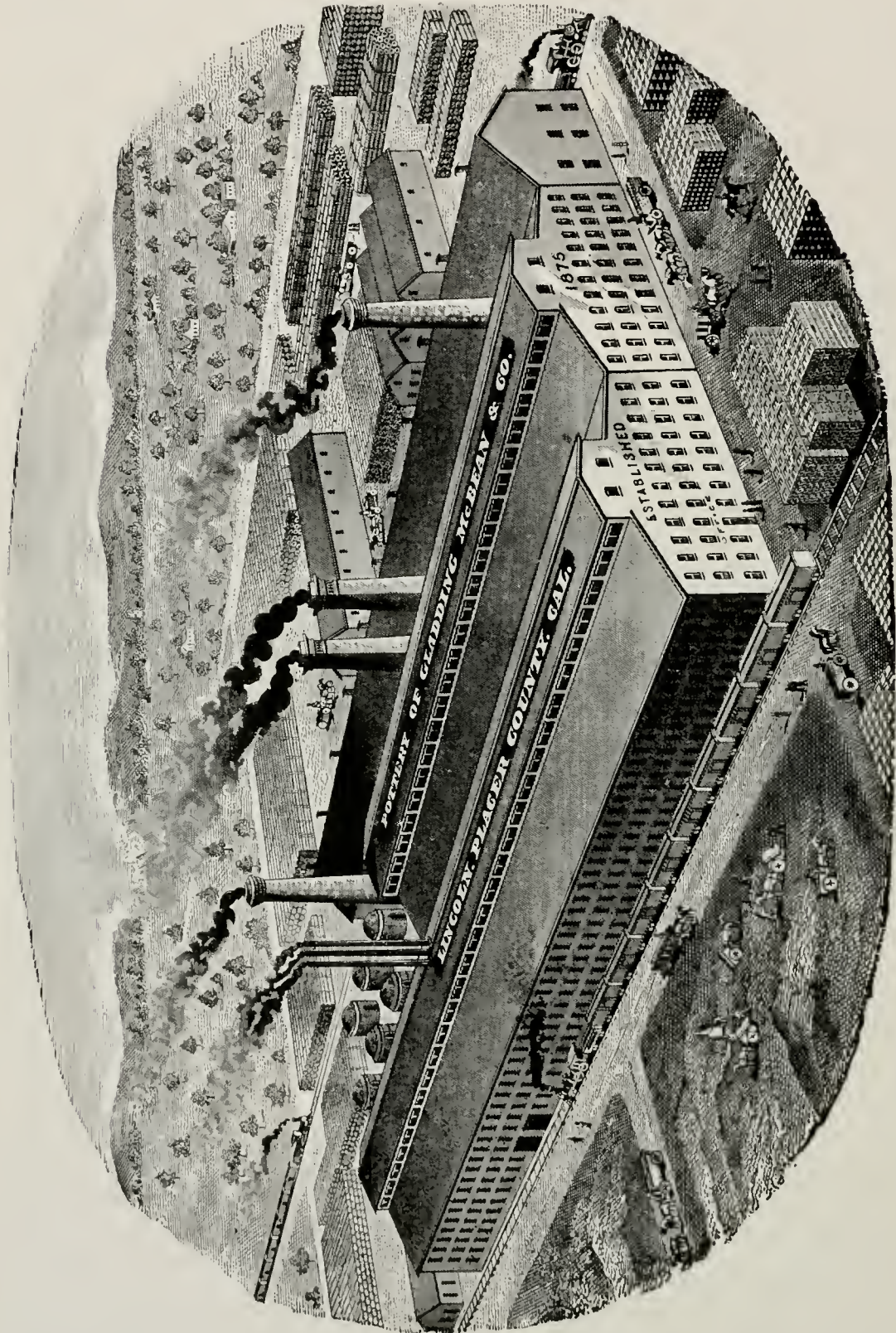
Cedar Creek Mine; A. Roger, Towles, manager; in the eastern edge of Sec. 32 and the western edge of Sec. 33, T. 16 N., R. 11 E., a white fire clay, plastic and containing an almost imperceptible grit, is exposed in the mine workings. The clay lies under a capping of red surface soil containing white quartz gravel; it occurs in the east side of the channel, coursing north and south 3500 feet. On the west side of the channel the clay is yellow and coarser, but possesses similar qualities, being locally employed for firebricks. No effort has been made up to the present time to work the fire clay to commercial advantage.



ILL. No. 99. CLAY PIT OF GLADDING, McBEAN & CO., AT LINCOLN, PLACER COUNTY.

Gladding, McBean & Company's Pottery; located at Lincoln; main offices, in the Rialto Building, San Francisco; Gladding, McBean & Co., owners. This large plant covers about 27 acres, and includes about 25 kilns of various types and ranging from 18 to 30 feet in diameter. Everything in the line of clay products is manufactured, including architectural terra cotta, sewer pipe, water and drain pipes, tiles, crocks, brick (fire and enameled), etc. The plant uses electricity, steam, and air for power, and oil for fuel. The clay is obtained from the beds about 1 mile north of Lincoln, where there is an abundance of very fine clay occurring in the Ione formation and overlying a vein of lignite. The clay has been excavated by a series of benches for about 50 feet in depth. In the XIIth Report of the State Mining Bureau, 1896, page

616, mention is made of a hole being bored 60 feet deep in the bottom of the pit without going through the clay bed. (See State Mining Bureau Reports for 1889, 1892, 1894, and 1896.)



ILL. No. 100. GLADDING, McBEAN & CO.'S POTTERY AT LINCOLN, PLACER COUNTY.

Rich Flat.—In Sec. 15, T. 12 N., R. 8 E., one mile south of Auburn, on Rich Flat, in an open cut at the breast of an old drift, there is exposed a variety of clays in small occurrences. The colors are white

and light brown, some containing fine, grit-like volcanic ash; others, pure clay or kaolin. These clays occur in a low hill extending south and rising from 150 to 200 feet, cropped with scattering boulders of lava.

RIVERSIDE COUNTY.

Extending in a general west of north and east of south direction from Elsinore on the south to Corona on the north is a great belt of clays of superior quality. In many places these clay deposits resemble the famous white, gray, black, red, and parti-colored clays of New Jersey and eastern Pennsylvania. Like the Eastern deposits, these California clays are subject to great local variations in color, thickness, and other properties. A score or more of openings have been made at different points in these beds, from which clay has been taken for the factories at Elsinore and Corona, and for shipment to the factories at Los Angeles.

In the region about Alberhill and Elsinore different parts of the clay area are overlaid by a layer of disintegrated granite, which varies from a few inches to many feet in thickness.

South of Corona the exposures indicate that the clays lie along a great anticline, the top of which has been removed by erosion, exposing the kaolin on each side of the axis. Along the greater part of this area the clays are concealed by a layer of granitic sand and boulders similar to that occurring at Alberhill. In places this sand-covering is absent, leaving the clays exposed over limited areas. The Corona clay beds are quite variable in character, at different points containing white plastic clay, red and mottled plastic clay, and gray and black flint fire clay.

The extent of these Corona-Elsinore clay beds, together with the great thickness and great plasticity of some and high refractory properties of others, will tend to increase the output in the future. The deposits will have an additional importance as the population increases in southern California.

Alberhill Coal and Clay Company, Elsinore, is (1904) shipping clay from three different openings at Alberhill, the terminus of the railway spur from Elsinore Junction. At the coal tipple of the coal mine is a clay pit covering an area of about 100 feet long by 50 feet wide, with a face of about 30 feet. The upper portion of this deposit consists of 10 feet of red and gray variegated clay, underlaid by from 6 to 8 feet of a mixed fire clay and granitic sand, underlaid in turn by a gray to black clay with thin streaks of coal, and at the base, underlying the coal streaks, is a bed of blue plastic fire clay, 3 to 4 feet exposed.

About half a mile east of south of the above pit and about 200 feet higher on the hill, another pit has been opened, from which the clay is

hauled by wagon to the railway. In this opening a high-grade plastic fire clay is obtained. The deposit is from 4 to 5 feet thick, and is overlaid by from 5 to 10 feet of a greenish-colored plastic clay that is not used, but which must be removed in order to get the fire clay. Overlying the green clay in most places is a layer of sand containing polished granite boulders. Despite the considerable expense of quarrying the clay at this pit, it has been removed in large quantities. The present openings cover an area of probably four or five acres.

A quarter of a mile south of the above pit is another one from which red and white mottled plastic clay is obtained. The bed varies from 25



ILL. No. 101. HARRINGTON CLAY PIT, 10 MILES SOUTH OF CORONA, RIVERSIDE COUNTY.

to 40 feet in thickness in different portions of the pit, which extends over an area of about half an acre. This clay is at present (June, 1904) being shipped in larger quantities than from any of the other pits.

California Fire-Proof Construction Company has a factory 3 miles north of Elsinore, where it manufactures sewer pipe, earthenware, and hollow bricks, sewer pipe being the chief product. At present the company is getting its clay from Alberhill (described above). On the hillside at the factory are two clay pits from which the clay was formerly mined.

Ch. P. Carter, Elsinore, owns a deposit of kaolin about 2 miles east of Wildomar, said to be of considerable extent and to contain some material of very good grade.

Corona Pressed Brick and Terra Cotta Company operates a factory one half mile west of Corona, on the south side of the Santa Fé Railway. The company manufactures white, buff, and spotted pressed brick. Both hand and steam-power repressing machines are used, and a beautiful high-grade building brick is produced. Los Angeles is the chief market.

Harrington Clay Pit, leased for ten years to M. W. Finley, Corona, is about 10 miles east of south from Corona. It lies on the mountainside, about 300 feet above the valley floor, on the east side of the valley. A section of the face of the pit shows several grades and varieties of clay, as follows: from 2 to 6 feet of sand and boulders at the top, underlaid by from 10 to 20 feet of red and white mottled plastic clay, then by from 4 to 10 feet of white plastic refractory clay, and then at one end of the quarry by a red clay with a pisolitic structure and resembling a ferruginous bauxite in appearance. The clay from this pit is hauled in wagons to Corona, for shipment to Los Angeles.

George W. Lord, Corona. In Sec. 14, T. 4 S., R. 7 W., S. B. M., is a body of light grayish, fine-grained fire clay, in which a ledge of ochre is found.

Los Angeles Pressed Brick Company, 105 South Broadway, Los Angeles, operates a large clay pit about one mile north of west from Alberhill, and hauls the clay in wagons to the railway at Alberhill, whence it is shipped to Los Angeles. The clay deposit at this point is quite extensive, probably not less than 60 feet in thickness, but varies somewhat in character. The beds are stratified and show a dip of 30° S., 10° W. The bulk of the deposit exposed in the pit consists of white and gray plastic fire clay. There is some red and variegated clay at the top of the deposit, and in several places the clay contains some coarse sand, resembling disintegrated granite. The clay pit is about 200 feet long, 60 feet wide, and from 25 to 35 feet deep. A shaft sunk in the floor of the pit is said to be 40 feet deep in clays, differing somewhat in kind, but all high grade. These clays are used in Los Angeles in the manufacture of terra cotta and light-colored building bricks.

McVicar Pit; W. G. McVicar, Corona, owner; in Sec. 4, T. 4 S., R. 7 W., S. B. M. An extensive deposit of clay, covering about 100 acres. The clay is of various colors—light brown, dark and light gray. It was formerly shipped to the California Clay Manufacturing Company, Los Angeles. Not operated in 1904.

Pacific Clay Manufacturing Company, 235 South Los Angeles street, Los Angeles, owns and operates a large clay pit in the valley about a mile southwest of the Harrington pit. The clays are somewhat similar

to those in the Harrington pit, but are arranged in a little different order. There is a thickness of from 5 to 25 feet of sand and boulders overlying the clays. On one side of the pit the sand is underlaid by white plastic clay from 15 to 25 feet thick, which is underlaid by red mottled clay; on the opposite side of the pit the sand rests on red mottled clay, a portion of which has a pisolitic texture. Both the red and white clays are very smooth and plastic, but in places contain diffused sand or quartz grains, which are sufficient to prohibit their use in fine ware, unless carefully selected in quarrying, or the coarse particles removed by some system of washing.

This company also owns the quarry 3 miles southwest of Corona, formerly owned and operated by Mr. McKnight. It produces a black flint fire clay in large quantities, besides some of the blue refractory clay. This clay lies on the top and south side of the low hill in a bed which dips 35 degrees south. The clay has been removed by tunneling at the base of the hill. The black flint clay shows a thickness of about 20 feet, and is overlaid by 10 feet of blue clay and about 20 feet of reddish-colored plastic clay, which is followed by a coarse, granitic quartzose sandstone. Large quantities of highly refractory clay are obtained here for use in the works at Corona.

This company also owns the clay pit formerly owned by W. G. McVicar, near Elsinore.

The works of this company are situate one mile west of Corona, on the north side of the Santa Fé Railway. They manufacture sewer pipe, water pipe, both salt-glazed and unglazed tiles, flue linings, chimney pipes, firebrick, conduits for electric wires, and terra cotta. The firebrick is made from the refractory clay of the McKnight quarry, previously described. The different kinds of pipe, etc., are made from the clay obtained 10 miles south of Corona. The factory is well equipped with machinery. There are eight round, downdraft kilns in use, in which the products are burned with oil fuel.

Thomas Parks, Corona, has a clay deposit in Temescal Cañon.

Near Perris, $1\frac{1}{2}$ miles southeast, is a large deposit of clay along the San Jacinto River, traversed by the Santa Fé Railway. It was formerly used by the Colton Cement Works. Its analysis as given by the chemist of those works is: silica, 15.10 per cent; alumina and ferric oxide, 29.70 per cent; carbonate of lime, 4.14 per cent; carbonate of magnesia, 3.02 per cent; water and organic matter, 12.30 per cent.

Pipe and Tile Works, near Elsinore; Dolbeer estate, San Francisco, owner; G. Ross, superintendent. Manufacture principally sewer pipe. Use clay from the neighborhood of Alberhill.

SACRAMENTO COUNTY.

Bundoek Stoneware Works, Oak Park postoffice station, Sacramento; G. F. Bundoek, owner. The works are located in the eastern suburb of Sacramento. The products are butter-jars, churns, bean-pots, jugs, milk-crocks, poultry-fonts, water-jars, and flower-pots. Two varieties of pottery clay are employed: "fat" clay of light brown color, "lean" clay of white or cream tint. From 85 to 90 tons of the clay are consumed in a year. The clay banks (4 acres in area) are owned by the proprietor of the works, and are situate in the N. E. $\frac{1}{4}$ of the S. E. $\frac{1}{4}$ of Sec. 2, T. 7 N., R. 8 E., on the north side of the Cosumnes River, 2 miles east of Bridge House. The clay when first removed from the banks weighs 170 pounds to the cubic foot and shrinks to 87 pounds when dried by exposure to the atmosphere. The ware is burned in an updraft kiln, having a capacity of 2000 gallons.

Capital Sewer Pipe Works, at Thirtieth and L streets, Sacramento; Muddox Brothers, owners. The works have been established and in operation for a number of years. Formerly the products included stoneware and firebricks, but for the past five years the output has been restricted to sewer pipe and terra cotta chimneyware. The material used is pottery clay obtained in Amador County near Ione, and loam. The plant consists of a Vaughn sewer-pipe press of an average daily capacity of 1200 pieces, and two downdraft kilns 18 to 20 feet in diameter. Ten to fifteen men are employed.

Southern Pacific Firebrick Works, a department of the Southern Pacific shops system at Sacramento; H. S. Becker, manager. This company makes no commercial bricks, the product being restricted to its own requirements. The product is chiefly of three classes of firebricks: keyed bricks, employed in the construction of coal-burning locomotive fireboxes; small plain bricks for stationary coal-burning furnaces; and special sizes and shapes for rolling-mill arches. The clay used is of two varieties, white and blue, obtained from the Al Smith clay banks near Ione, in Amador County. The blue clay is considered the better material, owing to its greater plasticity. The process adopted is the burning in a kiln of a quantity of the clay and grinding it to a powder. This is mixed with an equal quantity of fresh clay and allowed to weather in the open during the winter months. Then the mixture is ground in the pugmill, and molded by hand in pattern molds of the required shapes and sizes; then the bricks are burned in open updraft kilns. The better bricks are made by substitution of ground "grog" for the ground clay. The ground substance serves the purpose of quartz sand; the oftener it is used the stronger it becomes. The ground clay and the ground grog—two parts grog and one part

clay—are mixed and used as a mortar for setting the firebrick in the oil-burning fireboxes and rolling-mill arches. The plant consists of a pugmill and two updraft open kilns, using wood fuel. The time required for burning the bricks is 168 hours. The aggregate annual capacity of the two kilns is 150,000 bricks.

SAN BENITO COUNTY.

The large valleys of the San Benito and its tributaries in the northern part of San Benito County, and their surrounding foothills, undoubtedly contain extensive deposits of clays, of which some might prove valuable upon investigation. Deposits of very plastic clay are found in one section of the San Juan hills, and probably over a much larger area in those hills than as yet ascertained.

R. W. Chappell, Hollister, owns, in the southern part of the San Justo ranch, in the eastern part of the San Juan hills, 3 miles south of Hollister, 160 acres of tableland, upon which is a bed of clay, exposed to a considerable depth in the several gulches. A well was sunk 80 feet without reaching the underlying rock. The clay is light gray in color, very plastic, without any grit, burns to a cherry red, and tests have proven it suitable for potter's ware.

In some places near the top of the deposit a horizontal bed of clay, about one foot thick, of a light yellow color, due to iron oxide, more indurated, somewhat gritty and only slightly plastic, crops out in the slopes of the gulches, but is apparently not continuous over the entire deposit.

SAN BERNARDINO COUNTY.

R. H. Atwood, Oro Grande, owns a clay deposit in T. 6 N., R. 4 W., S. B. M., about 4 miles east of Oro Grande. It consists of disconnected bodies of kaolin, lying in a decomposed material. Through the kaolin are found narrow seams of selenite. A drift of about 100 feet long has been run in this deposit, known as the Excello mine.

About 15 miles north of Barstow large clay deposits are reported; the beds are said to contain several different varieties of clays. Have not been utilized as yet.

C. F. Blackburn, Victorville, has located a clay deposit of a character similar to that of the Atwood deposit, and about 2 miles E. N. E. therefrom, one mile west of the Snider wells, covering about five acres, and claimed to be from 30 to 40 feet thick.

California Portland Cement Company, 401 Trust Building, Los Angeles, owns an extensive clay deposit in Rechie Cañon, southeast of Colton, in Sec. 35, T. 1 N., R. 4 W., and Sec. 2, T. 1 S., R. 4 W., S. B. M. This

clay bed has a strike about N. 20° W., and dips about 30° northeasterly; is exposed along the cañon for a height of about 50 feet, and has a width of about 100 feet. It is a rich clay, with few small pebbles; color light gray, showing on the exposures in places efflorescence of alkalis, and on the fracture planes a thin brownish coating of iron oxide, probably due to percolation from the surface soil. Intercalated in the clay are some beds of a sandy material not over a couple of feet wide. The clay was formerly used by the California Portland Cement Company in the manufacture of cement at the Colton Cement Works, but is now replaced by clay from Alberhill, Riverside County.

Near Daggett a clay deposit is mentioned in the IXth Report of the California State Mining Bureau, page 303. The material is described as a soft, white, very plastic clay, containing a large percentage of alumina, and claimed to be a pure kaolin, combined with aluminum hydroxide.

J. B. Friend, Victorville, has covered by location a clay deposit of 180 acres in T. 6 N., R. 3 W., S. B. M., 10 miles easterly of Victorville. The clay is from 1 to 5 feet thick, partly of a bluish tint, partly white. When burned it has a brownish tint. This clay is stated to have been tested for the manufacture of firebrick, pressed brick, and tiles. Some was shipped to Tropic, Los Angeles County, in former years. None was shipped in 1904.

Near The Needles clay deposits are reported, but as yet have not been developed.

SAN DIEGO COUNTY.

Very near the summit of El Cajon Mountains, about 25 miles east of San Diego, there is a deposit of kaolin, claimed to be about 75 feet wide. A shaft has been sunk through apparently pure kaolin.

Three miles northeast of Otay there is a deposit of montmorillonite (mineral soap), a massive, clay-like variety of kaolin, containing a great amount of combined water. (See IXth Report of the California State Mining Bureau, p. 139.)

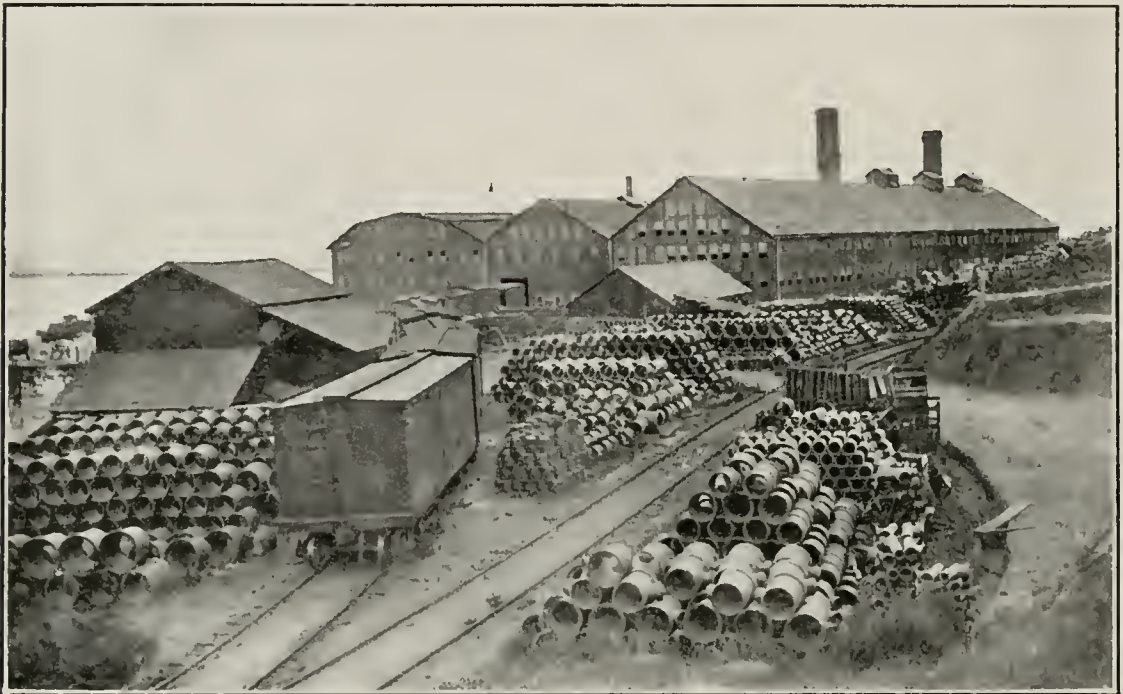
East of Warner there is a deposit of ochre, which as yet has only been slightly prospected. F. L. Hahn, 1650 North Main street, Los Angeles, owner.

SAN JOAQUIN COUNTY.

Carnegie Brick and Terra Cotta Pottery; Carnegie Brick and Pottery Company, 328 Montgomery street, San Francisco, owner. This plant is situated at Carnegie, in Corral Hollow, 4 miles below Tesla. In November, 1904, twelve 32-foot kilns were already completed in the brick department, each kiln with a capacity of 110,000 bricks. The output of

the plant is 100,000 bricks per day. Inside drying tunnels use the waste heat from burned kilns, and season 100,000 bricks in ten hours. At present the plant makes everything in the line of bricks except common brick, including faced, fire, paving, glazed, etc.; also fire blocks for locomotives, etc. The terra cotta works are in course of construction.

Carnegie Shale Pit; Carnegie Brick and Pottery Company, 328 Montgomery street, San Francisco, owner. Shale quarried one half mile from Carnegie, in a small cañon on the east side of Corral Hollow, is mixed with clay from the Tesla mine, and used in the manufacture of the Carnegie paving brick. These hard clay shales are permeated with



ILL. No. 102. STEIGER TERRA COTTA AND POTTERY COMPANY'S PLANT AT SOUTH SAN FRANCISCO, SAN MATEO COUNTY.

manganese stains, and extend for over 200 yards into the hill, as is shown by a development tunnel. It is claimed that these "pavers" were subjected to a rattling test of 2000 revolutions with a loss of only 6.7 per cent, and a crushing test of 8000 pounds per square inch. They are to be used in paving San Pablo avenue, in front of the City Hall, in Oakland.

SAN MATEO COUNTY.

Steiger Terra Cotta and Pottery Works; offices, 45 Mills Building, San Francisco. Works are at South San Francisco, San Mateo County, located on the bay shore, so that shipments may be made by water as well as by rail. This extensive plant, including yardage, covers eight acres of ground, and includes three 16-foot muffle kilns and seven brick and sewer-pipe kilns, ranging from 25 to 30 feet (inside diameters):



three dry pans; three wet pans; two sewer-pipe presses (capable of making 30-inch pipe); two brick presses; and all the necessary machinery for a complete plant. Steam is used for power and oil for fuel. The clay is mined in their own pits in Amador County (see page 210). The company manufactures everything in the line of pottery and terra cotta wares. Illustration No. 103 represents a two-thirds life size terra cotta figure, entitled "The California Poppy," now in the National Museum at Washington, D. C.

SANTA CLARA COUNTY.

Garden City Pottery; T. C. Barnett, South First street, San José. At present (December, 1904) it is located at the corner of Park avenue and East streets, San José, but new buildings and machinery are being erected at the corner of Sixth and Jackson streets. The present small experimental plant was installed merely to prove up the clays to warrant further buildings. The clays, from the banks of Coyote Creek, have proven suitable for the work desired, and the larger plant has been started. Flower-pots, sewer pipe, water-jars, etc., are manufactured.



ILL. No. 103. TERRA COTTA WARE. BY STEIGER
TERRA COTTA AND POTTERY WORKS, OF SAN
FRANCISCO.

SHASTA COUNTY.

Holt & Gregg, Redding, have, in Sec. 34, T. 34 N., R. 5 W., M. D. M., on the road from the old limestone quarry to the old kilns on Backbone Creek, a bank of clay used for fire-clay lining in the limekilns. It is claimed to be equal to fire clay shipped in from other points.

SISKIYOU COUNTY.

A. H. Denny, Etna, owns the coal mine in Sec. 26, T. 46 N., R. 6 W., M. D. M. Fire clay is found in the roof and on the floor. The clay in the roof is generally about 5 feet thick. The thickness of that on the floor is not known. This clay has been used in the boiler furnace at the mine and has given good satisfaction. In the coal are two partings of clay, from 1 to 4 inches thick. This clay has been used and found to be good fire clay. The mine is at present idle, and the workings are inaccessible.

Melvin Hovey, Gazelle, owner, in Sec. 8, T. 43 N., R. 6 W., has found a body of yellowish clay about 16 feet wide, and traced for over half a mile, which has been used as refractory material. Molded forms, baked in fire, make very compact and consistent articles.

YUBA COUNTY.

Durst Ranch Loam Deposit; **D. P. Durst** and **R. H. Durst**, Wheatland, Yuba County, owners; in Secs. 10, 12, and 18, T. 14 N., R. 5 E., on Bear River, half mile east of Wheatland. There are 400 acres of land in the holding, 75 acres of which contain loam. Four acres have been worked off since the beginning of the present production in 1896. The material is a black clay loam, occupying a depth of 6 feet, overlaid by 18 inches of soil. The product shipped is the subsoil, which has a depth of 3½ feet. The output is 375 tons annually, disposed of at \$2 per ton, and used for tempering various pottery clays at the Gladding-McBean pottery works, Lincoln, Placer County, a distance of 10 miles by rail.

LOW-GRADE CLAYS.

The low-grade clays include the adobe clays and the common red brick and tile clays and shales.

ADOBE CLAYS.

Adobe clays of California are similar in many respects to the gumbo clays of the Mississippi Valley. They are extremely strong, plastic clays



ILL. No. 104. ADOBE HOUSE, SHOWING USE OF ADOBE BRICKS.
SAN BERNARDINO COUNTY.

that slake readily when wet, to a very sticky, pasty mass and become very hard on drying. They are used in the manufacture of sun-dried bricks which were, in former times, generally used in the construction of the pioneer homes. The bricks are made from 18 to 24 inches wide and from 5 to 6 inches thick, but shrink on drying. Then, after the walls are constructed, they are plastered over with clay.* Adobe bricks form cool and comfortable buildings in warm climates, but can not resist heavy rainfall or constant moisture.

*Geology and Industrial Resources of California, by Phil T. Tyson, Baltimore, 1851, p. 41.

RED BRICK AND TILE CLAYS AND INDUSTRY.

The low-grade clays used in the manufacture of red brick and red tile are so abundant, and hence so cheap, that they can not profitably be transported far, so that the brick and tile factories are located at the clay deposits, and the two are considered together.

In the value per ton the brick clays rank among the lowest; in the total or aggregate value they probably stand at the head of all the clay industries. The statistics for the United States, as given by the U. S. Geological Survey for the year 1902, show that of the \$122,169,531, the value of all the clay products, \$24,127,453 represents the value of the varied pottery industries, and \$98,042,078 the value of the brick and tile industries, of which \$48,885,869, or 40 per cent of the total, represents the red brick and tile.

In the list of states California ranks eleventh in the value of its clay products, with 89 firms operating and \$2,253,096 the value of the product for 1902; and sixteenth in the value of the common brick and tile, valued at \$1,291,941. Thus the red-brick product in California has a greater aggregate value than that of all the other clay products. It is likewise more widely distributed over the State. The pottery industry is limited to a very few counties, while the common-brick industry is represented in nearly every county of the State.

The clays or materials used in making common red bricks consist of a clay base, with a mixture of sand and other materials. There are so many and such varied mixtures used for the manufacture of brick that the impression is often gained that "anything will do to make brick." But such is not the case. There is a wide range in the composition of the materials from which good bricks may be manufactured, but there is a limit beyond which the quality of the bricks rapidly deteriorates. The following analyses show the average and the maximum and minimum of the ingredients commonly occurring in brick clays. A clay in which the percentage of any one or more of the ingredients mentioned is much above the maximum given or below the minimum will prove an inferior, if not worthless, clay for even common brick.

Chemical Analyses of Common-Brick Clays.

	Average.	Minimum.	Maximum.
Silica (SiO_2), combined.....	15.0%	12.0%	30.0%
Silica sand.....	55.0	20.0	60.0
Alumina (Al_2O_3).....	14.0	11.0	25.0
Water (H_2O), combined.....	4.0	3.0	9.0
Water moisture.....	2.0	0.0	6.0
Iron oxide (Fe_2O_3).....	4.0	2.5	8.0
Lime (CaO).....	1.5	0.5	7.0
Magnesia (MgO).....	1.5	0.3	7.0
Alkalies (K_2O , Na_2O).....	3.5	2.0	7.0

Increase of sand decreases the shrinkage and facilitates the drying.

Decrease of sand, with increase of alumina and water, increases the shrinkage and generally increases the plasticity of the clay. The iron gives the red color to the brick. The original clay before burning may be blue, black, yellow, or gray, but in the burning the iron is turned to the red or anhydrous oxide, one of the most durable forms of iron to resist the action of the atmosphere. Lime and magnesia, in large amounts, tend to form buff and cream colors with the iron.

As might be expected from the great range in composition, there is a wide range in plasticity and other properties. Those with a high percentage of coarse sand are very lean and difficult to mold. Those with less sand, or very fine sand, are generally highly plastic. The hydrous silicate of alumina is assumed to be the base in all cases.

The brick clays of California are the residual, alluvial, lacustrine, and marine clays, with the second class greatly in excess.

An abundant supply of fairly good clay for red brick is found in all parts of the State where it is needed. The two chief centers of the industry are San Francisco and Los Angeles. Several varieties of clay and shale are used at both places, as described later.

THE MANUFACTURE OF BUILDING BRICK.

Weathering the Clay.—When, as is often the case, the clay coming directly from the bank slakes very slowly upon being immersed in water, time is saved and better bricks are manufactured if the clay is allowed to weather before being used. Often, however, this is neglected, and the clay is removed directly from the bank to the pugmill.

Soaking and Mixing the Clay.—The proportions of clay and water required in the manufacture of brick vary with the different clays and processes used. Clay soaked from twelve to forty-eight hours in a vat should absorb sufficient water so that no additions will be necessary during pugging. This soaking before mixing is very beneficial and frequently necessary, as there are very few clays that can absorb water with such rapidity that it will be equally distributed throughout the clay in the time that it passes from one end of the pugmill to the other.

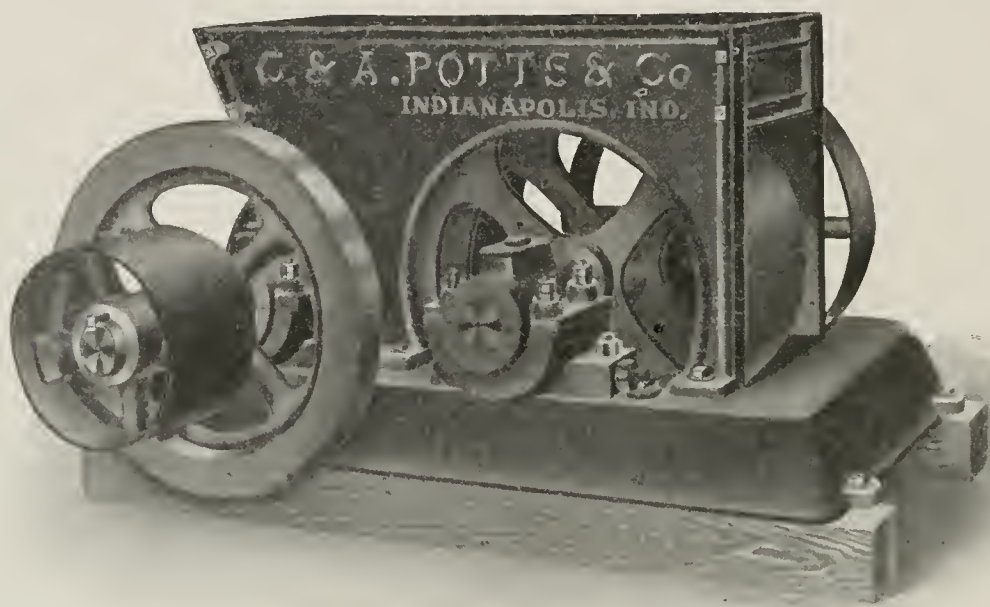
Clay is mixed by using a tempering wheel. After the clay has soaked over night, a wrought-iron wheel, consisting of one or two rims, turning on a horizontal shaft, is revolved through the mud, changing its position every revolution. This mixing continues for about six hours, the time required depending on the character of the clay. Sometimes the tempering is done in upright pugmills.

Grinding the Clay.—Shales are sometimes so hard that they have to be reduced in a reducer, crusher, disintegrator, pulverizer, dry pan or wet pan, before they can be suitably tempered or soaked with water.

In some instances clay contains gravel or other nodular substances that must be removed or pulverized before the clay is in condition for manufacturing purposes.

Hand-made Brick is a hand-molded brick, generally sun-dried and burned in open kilns. This primitive method of manufacture is now only used in places where a very limited and intermittent output can be marketed.

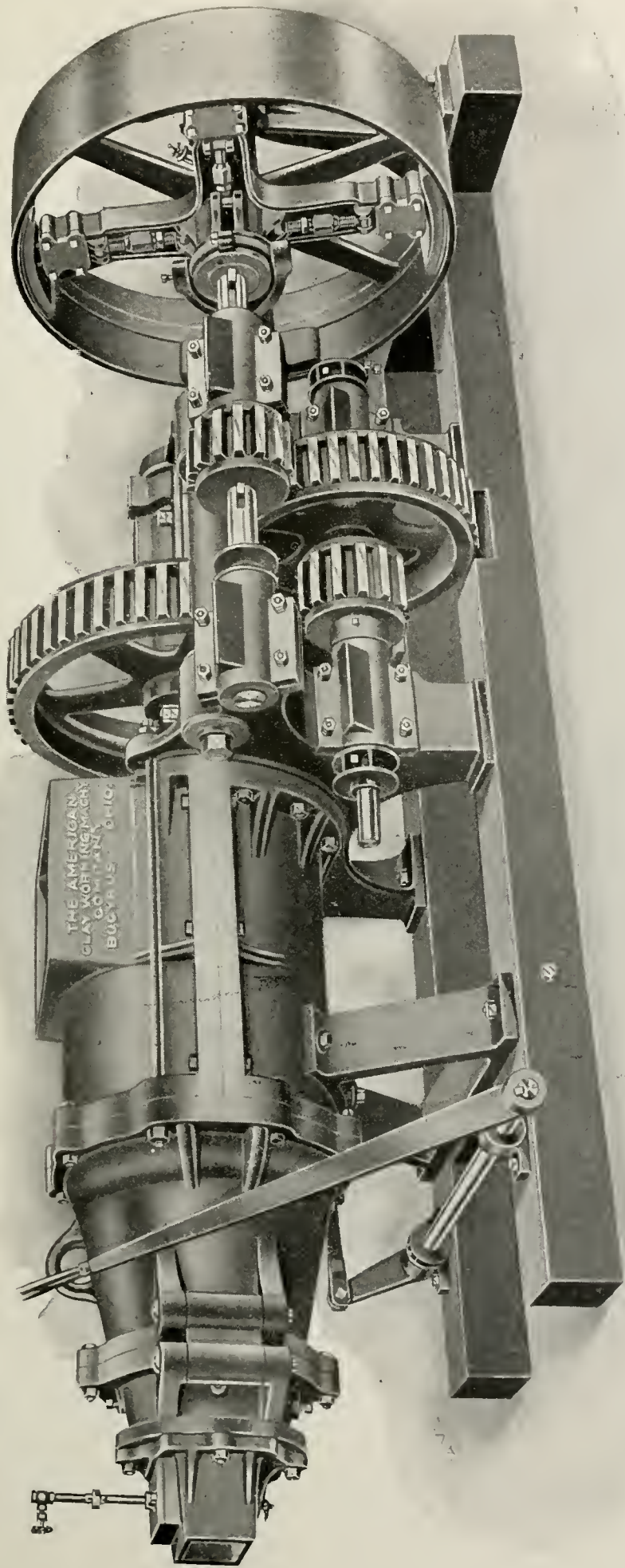
Machine-molded Brick.—Nearly all the bricks now made in California are machine-molded; the common red brick either by the soft-mud or



ILL. No. 105. POTTS DISINTEGRATOR.

by the stiff-mud process; and the high-grade front brick by the dry-process or the semi-dry process.

The *soft-mud process* is adapted to the highly siliceous clays that can not be worked satisfactorily by the other methods, as well as to any plastic clays that can be dried without cracking. The machines which are commonly used in the soft-mud process have a capacity of from 15,000 to 40,000 bricks per day. The clay is ground and tempered in a vertical pugmill, from which it is forced by a plunger into the molds. The molds are taken away, emptied, and returned to the machine. The drying is usually started on a sand floor in the open air, when, after partial drying, they are removed to drying racks under cover, and further dried by the air, or they are sometimes dried in artificially heated drying-chambers before being put in the kiln. Bricks made by the soft-mud process, unless repressed, are apt to be imperfect in shape and irregular in size. Sometimes when drying in the yard they are exposed to the action of a rainstorm and the edges and corners washed off and the bricks destroyed. If, however, the corners are uninjured



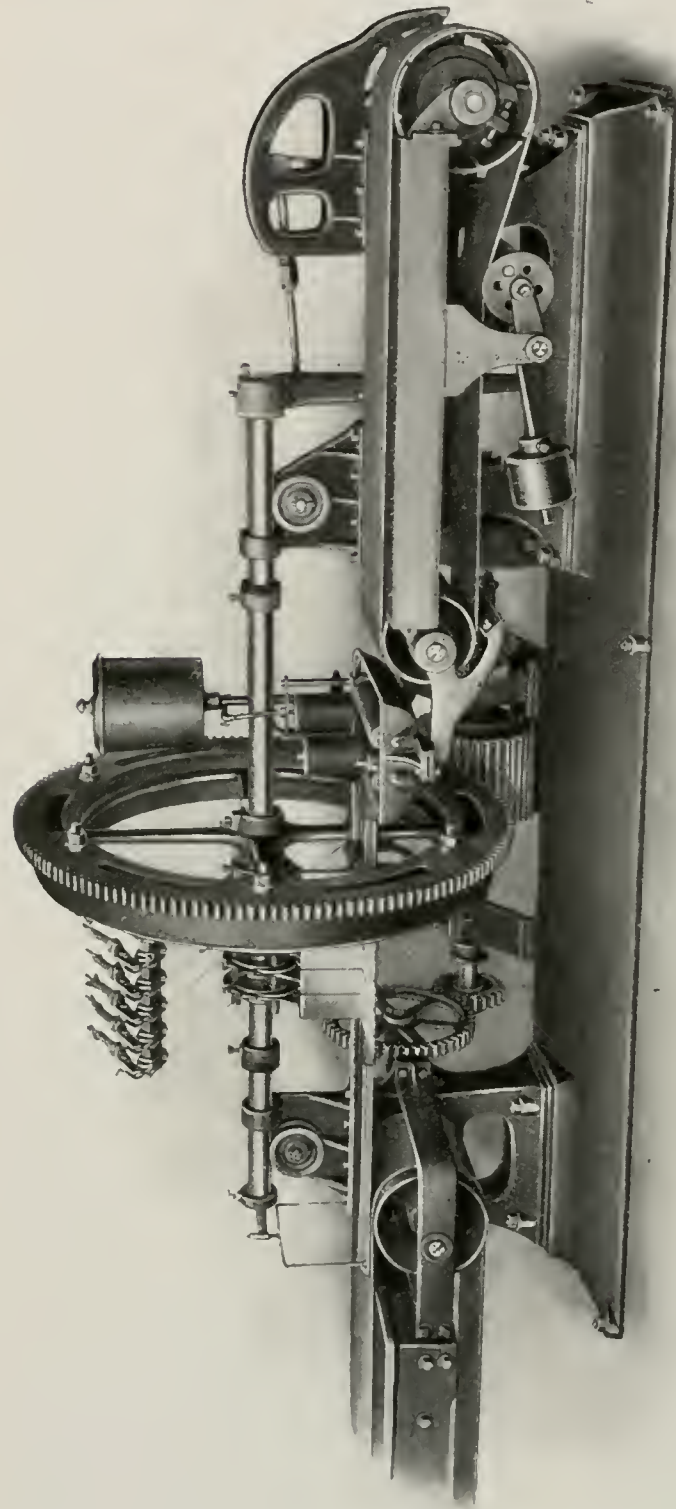
ILL. No. 106. AUGER STIFF-MUD BRICK MACHINE, OF THE AMERICAN CLAY-WORKING MACHINERY COMPANY.

and the surface merely spotted with the rain, they find a ready market in some localities as "washed" or "rain-marked" brick, which were so popular at times that they were produced artificially by sprinkling

the green bricks with water from a hose.

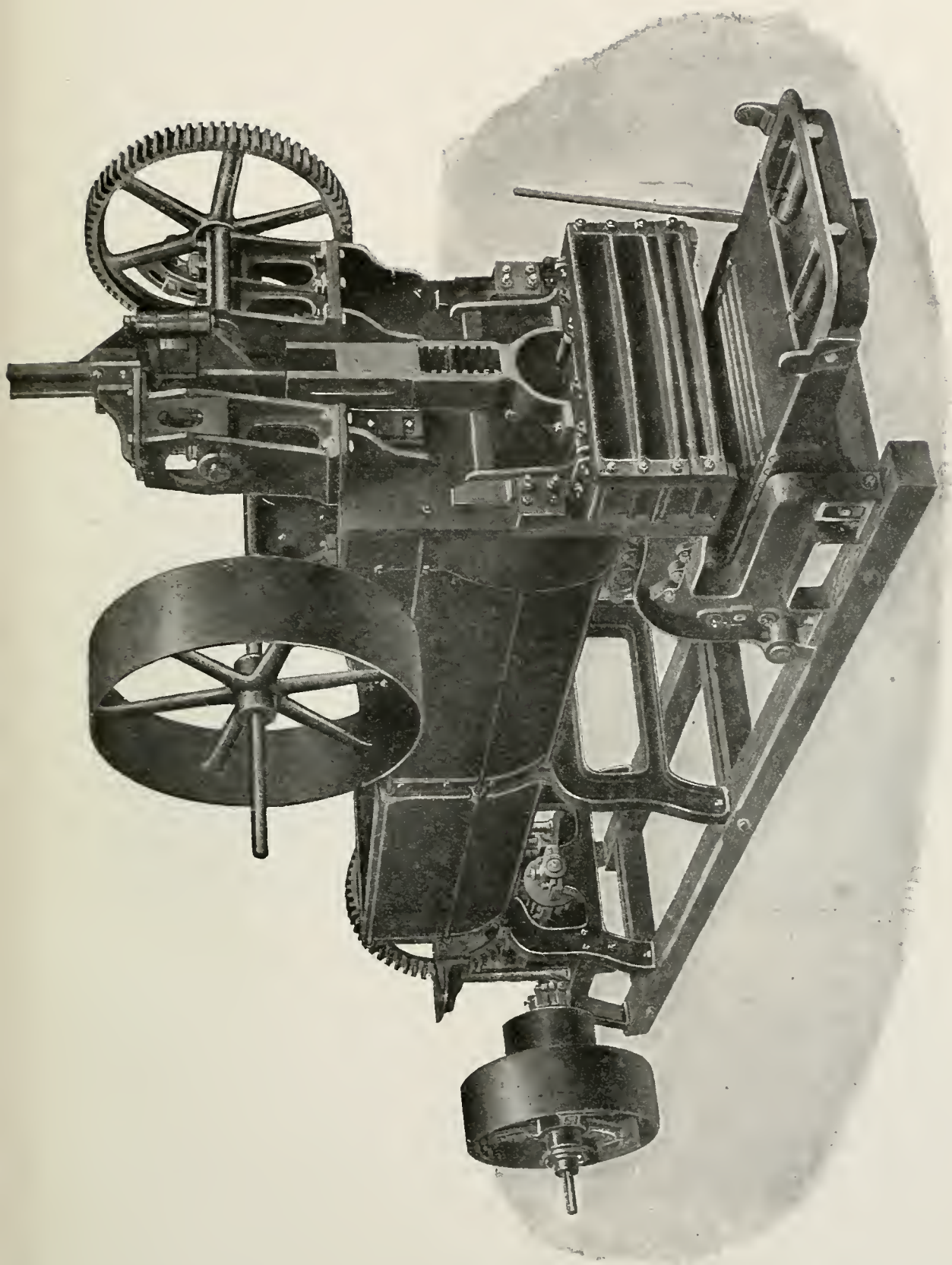
If stock or face brick is desired, the molded bricks are allowed to partially dry out and then they are repressed in a hand press, which removes the inequalities and produces a smooth surface and sharp corners.

The *stiff-mud process* requires a plastic clay and one capable of drying in a reasonable time without cracking. In this process the clay is tempered with less water to a stiff mud in a pugmill, and is then fed into an auger machine or plunger machine. In the auger machine the clay is forced through the die to the cutting table in a continuous bar (see Ill. 106), which is cut into brick size by wires operated



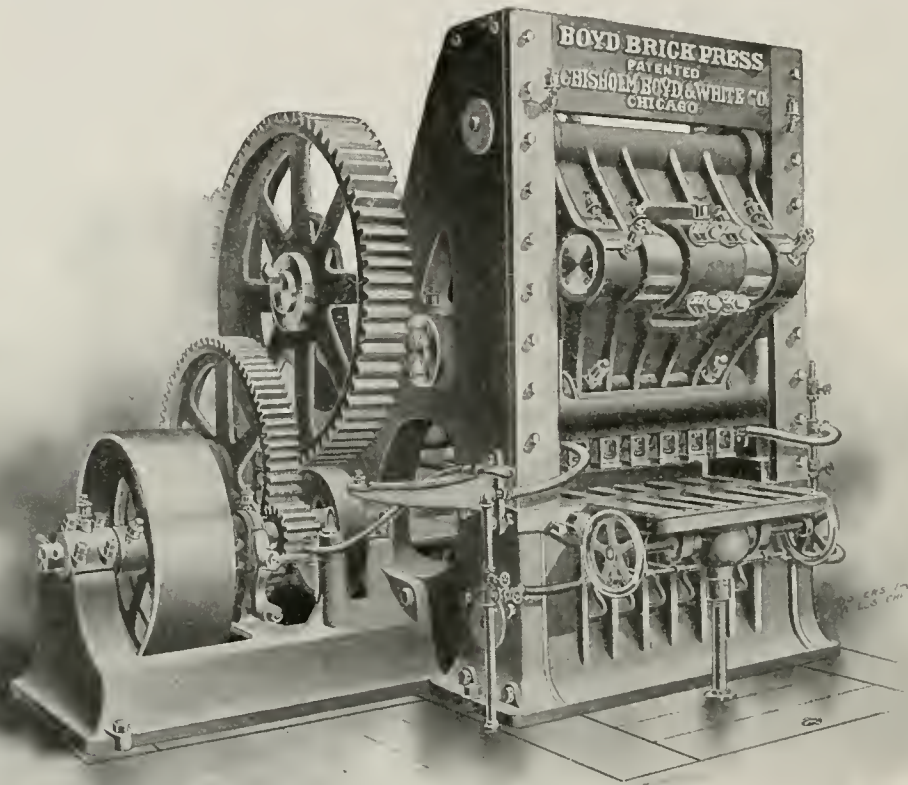
ILL. No. 107. ROTARY AUTOMATIC WIRE CUTTER OF THE AMERICAN CLAY-WORKING MACHINERY COMPANY.

either by hand or automatically. The wires are so arranged as to cut any number of bricks from two to twenty-four or more at once. By using different dies the same machines can be so set as to cut the bricks



ILL. No. 108. POTTS HORIZONTAL BRICK MACHINE.

at the end, the side, or the edge. By changing the die, hollow bricks may be made on the stiff-mud machine. Sometimes two or more bars of clay are delivered from the machine at the same time, and the capacity thus doubled. In one type of the machine the bricks are delivered on a board after cutting. In another, the bricks are delivered on a moving belt, which carries the bricks from the machine. From the belt they are removed by hand and then transferred to the driers, either in the open air or in drying tunnels. The plunger machine differs from the auger machine in forcing the clay through the die by a plunger or piston, and hence the stream or bar of clay is not continuous. This

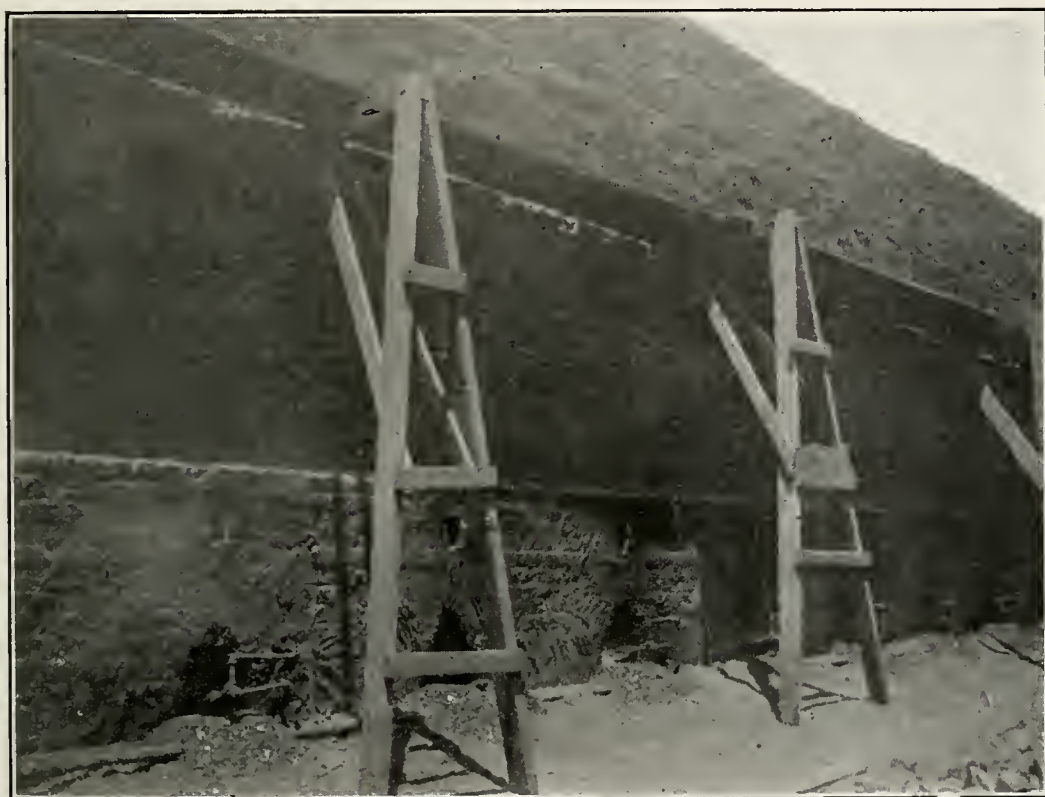


ILL. No. 109. SIX-MOLD BRICK PRESS. MADE BY THE CHISHOLM, BOYD & WHITE CO.

type of machine is passing out of use and giving way to the auger machine. Bricks made by the stiff-mud process are liable to more or less injury in the handling, so that when a better grade of brick is desired they are repressed, as in the other processes.

The *dry-press method* can be used for quite a variety of clays, from very fat, aluminous clays to very siliceous ones, if they are not too coarsely sandy. In this method the clay, instead of being mixed into a plastic mass with water, is molded dry, or with only sufficient moisture to permit it to cohere when pressed together. The clay should be stored several weeks or months before using. When ready for use it is pulverized in a disintegrator, and screened to secure uniformity. It is then pressed into molds and put in the kilns and burned without the prelim-

inary drying necessary in the other method. It must be water-smoked or heated at a low temperature for several days before burning at high temperature. A special and valuable variety of the dry-press brick is the hydraulic pressed brick, in which the pressure is applied by a pair of hydraulic rams, which first give a pressure of 240 pounds to the square inch, followed directly by a pressure of 3700 pounds, or about forty tons to the brick. The enormous pressure greatly increases the hardness and density. The hydraulic pressed brick is a patented product, and the output in the United States is controlled by a single great corporation, with plants in different cities. The ordinary dry-press brick is



ILL. No. 110. FIELD BRICK KILN, SHOWING METHOD OF BURNING WITH OIL.

made in many localities. The advantages claimed for the dry-press brick are smooth face, sharp edges, and freedom from defects. They generally command a much better price than the common brick.

Drying.—The bricks molded by hand and by the soft-mud process are commonly dried in the sun in open yards or in the pallet-driers, which consist of covered frames for holding pallets or boards on which the bricks are carried from the machine. Both these methods are common in California.

The bricks from the stiff-mud machine are commonly dried in the drying tunnel with artificial heat. The bricks are piled on iron or steel cars, which are pushed slowly through the drying tunnel and emerge at the opposite end. The tunnels are heated sometimes by

steam and sometimes by hot-air flues. The cars from the drying tunnels are run into the kilns, where the bricks are stacked for burning.

Burning.—There are several types of kilns in which bricks are burned.

Updraft Kilns.—The bricks at the small yards are almost invariably burned in updraft kilns of the stove type, commonly called the open kiln or field kiln. The bricks are set in rectangular masses, from 36 to 54 bricks high, and built with a series of arches running through the mass. After the bricks are set, they are surrounded by a wall of old bricks, which is daubed with mud on the outside. After the burning



ILL. No. 111. INTERIOR OF A CONTINUOUS BRICK KILN (HOFFMAN TYPE).

the walls are torn down and the bricks removed from any part of the kiln.

The permanent updraft kiln, or Dutch kiln, differs from the above in having permanent side and back walls; it is far more preferable and produces a better and more uniformly burned brick.

Downdraft Kilns.—In the downdraft kilns the heat enters through openings in the walls near the top, and is carried down through the bricks stacked in the kiln and out through one or more flues at the bottom, which are connected with a chimney or chimneys on the exterior. A much more uniform heat can be maintained in a downdraft kiln than in an updraft kiln. There are two common types of downdraft kilns: the round and the square. In California the former type is more generally in use.

Continuous Kilns.—There are several kinds of continuous kilns, of which the most common is the Hoffman kiln (see Ill. 111), which consists of an oval ring, surrounding a central space, the chimney. The oval ring is divided into a series of chambers, with either permanent or temporary walls. The bricks are stacked in some of these chambers and the heat is led through several ahead before it reaches the chimney; the fuel is fed through small apertures at the top, and the fire progresses from one part of the kiln to the other, creeping gradually ahead as the fuel is fed farther and farther in front. The fire is never allowed to go out, and there are sufficient chambers so that the brick may be burning in one, drying in another, and being taken out of a third at the same time. There are a large number of these kilns in California.

The face-brick and all the other high-grade bricks are burned in either a downdraft kiln or in a muffle kiln.

CLASSIFICATION OF BRICK.

In the market the bricks are commonly classified as follows: (1) *Common bricks* are those used for all building purposes, except fine fronts or facings. They are graded, mainly on the basis of the hardness of burning, into salmon brick, which are the underburned ones from the top of an updraft or the bottom of a downdraft kiln, and are the lowest grade of brick, being used for backing or inside work, where not exposed to the weather. Light red, medium red, dark red, hard red, straight hard, and rough hard are the other grades.

(2) *Stock bricks* are those more carefully made, having perfect shapes and edges, and selected. They command a price two or three times that of common bricks.

(3) *Pressed bricks*, or *face bricks*, are a finer grade and command higher prices.

(4) *Roman brick* is the name of a special size now used extensively all over the United States for front and face brick; 12 by 4 by $1\frac{1}{8}$ inches is a standard size for the roman brick. They are most commonly buff, gray, or spotted; rarely are they made of red color.

(5) *Ornamental brick* is the name given to many shapes, colors, and sizes that are used for decorative purposes.

(6) *Enameled or glazed bricks* are used largely in hallways, bathrooms, and subways, where a light-reflecting or sanitary lining is needed.

(7) *Buff and spotted bricks* are used in large quantities. A clay that will burn to a light color is used for the buff and light-colored bricks. The colored and spotted bricks are produced by the use of pigment,

such as iron ore and manganese oxide. These bricks are made by at least eight firms in California almost entirely by the dry-press process.

(8) *Fire bricks.* See chapter on high-grade clays.

(9) *Vitrified bricks.* See chapter on high-grade clays.

ALAMEDA COUNTY.

Remillard Brick Company; E. R. Sinard, Pleasanton, vice-president and superintendent; J. P. Gelinas, Second and Clay streets, Oakland, secretary. The plant of this company is located in Livermore Valley, on the Southern Pacific Railroad, 1½ miles northeast of Pleasanton; it includes two 16-compartment Hoffman kilns of 20,000 daily capacity each. Coal is used as fuel. Only common bricks are made. They are manufactured from a superficial deposit of sandy loam, 25 feet thick, which is near the kilns. The company employs 100 men during the summer, and 50 in winter.

BUTTE COUNTY.

T. Bordenheim, Doons. In Sec. 32, T. 24 N., R. 4 E. Burned 170,000 bricks in 1904.

Ophir Hardware Company, Oroville. Burned 500,000 bricks in 1904.

William Walker, Biggs. In Sec. 30, T. 18 N., R. 3 E. Idle since 1903.

COLUSA COUNTY.

George Smith, Colusa. The yards have been in operation since 1892, producing 1,800,000 bricks, the most of which were used by the maker in construction work. The clay employed at present is from a tract of thirteen lots containing a sandy soil about 4 feet in depth. The Quaker brick machine and the common kilns are used.

CONTRA COSTA COUNTY.

Richmond Brick Company, office 126 Davis street, San Francisco. The plant is located one mile west of the town of Richmond. The company has a patent kiln of its own design, with a capacity of 800,000 bricks. It averages about 30,000 bricks a day. Shipments are made by rail.

FRESNO COUNTY.

C. J. Crayeroft & Son Brick Company. One plant is located about one mile south of Fresno, where bricks were formerly burned in a 16-compartment Hoffman kiln, but this yard was not worked during 1904. A second plant is located one quarter mile south, where the bricks are made in soft-mud machines, sun-dried, and burned in open kilns, using oil as fuel. The plant is operated during the summer months. Both common and pressed bricks are made.

Fresno Brick and Tile Company, Fred Prescott, manager, corner of H and Mono streets, Fresno. This plant is located about 3 miles north of the city. Both common and pressed bricks are manufactured and burned in open kilns, using oil as fuel.

GLENN COUNTY.

Brick clays are abundant in Glenn County in T. 19 and 22, N., R. 3 W. These clays are chiefly sandy loam. No bricks have been made in the county in the past nine years. Previous to that time the local demand required the operation of several yards.

HUMBOLDT COUNTY.

(See Supplement.)

KERN COUNTY.

(See Supplement.)

KINGS COUNTY.

W. D. Trehitt Brickyard, S. P. Brownlee, manager, Hanford. This plant is located one half mile west of Hanford, on the Southern Pacific Railroad. The bricks are made in a stiff-mud machine, sun-dried, and burned in open kilns, using oil as fuel.

LOS ANGELES COUNTY.

The clay deposits within the limits of Los Angeles consist principally of loam (clay in which there is a considerable proportion of sand) which contains numerous inclusions of pebbles. In Chavez Cañon, in the northern part of the city, a bank of shale over 100 feet high is used. These shales occur in narrow beds dipping into the hill, some of which are highly plastic, separated by narrow beds of sand, and make a very workable material. In the northeastern part of the city the clays are underlaid by sand. In the eastern part, on Boyle Heights, the clay forms the upper stratum, from 5 to 10 feet thick, containing, however, numerous inclosures of sandy material. It is underlaid by sand and gravel. In the southeastern part, a bank of clay from 25 to 50 feet high, running a little north of west, and inclosed on both sides by arkose beds, is worked by the Southern California Brick Company. Near Inglewood, southwest of the city, the clay is intermingled with lenses of sand and some fine gravel, and is underlaid by coarse gravel. West of Los Angeles, near Santa Monica, is found the best clay in this vicinity. It is presumably underlaid by gravel.

Berg & Oxby, 615 Lankershim Building, Los Angeles. Clay bank covering 6 acres, at College and New Depot streets, Los Angeles. The bricks are made in a stiff-mud, wire-cutting brick machine, dried in

steam-heated driers, and burned in open kilns, using oil as fuel. The yard is equipped with a 60-horsepower boiler, a 40-horsepower engine, and a blower. Employs 30 men.

Hubbard & Chamberlain, R. M. Hubbard, West Pico street, Los Angeles. Clay bank covering 7 acres on Pico Heights, Los Angeles. The clay is ground by a disintegrator. The bricks are made in a Potts soft-mud brick machine, air-dried, and burned in open kilns, using oil as fuel. The yard is equipped with a 50-horsepower boiler and a 30-horsepower engine. Capacity, 40,000 bricks per day. Employs 30 men.

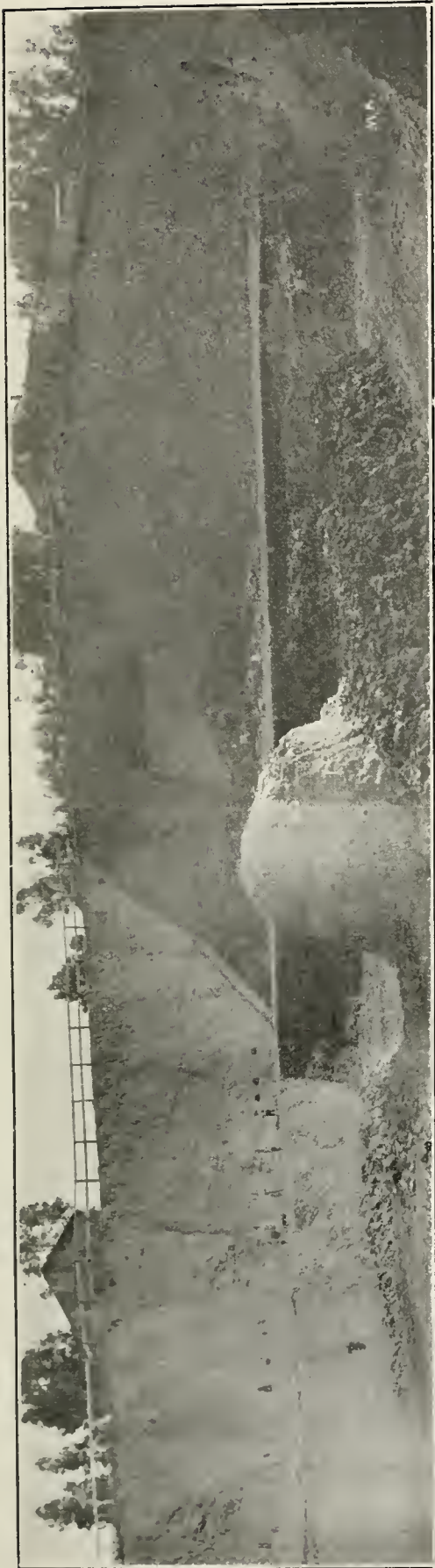
Independent Brick Company, M. Flint, president, 607½ South Broadway, Los Angeles. Clay bank at Inglewood, 12 miles southwest of Los Angeles, on the Santa Fé Railway. The clay is from 10 to 13 feet deep, intermingled with bodies of sandy and sometimes gravelly material. The clay is ground in a Raymond roller-crusher, and the bricks are made in a Freese stiff-mud, wire-cutting brick machine, having a capacity of 50,000 bricks per day. They are dried in a steam-heated tunnel drier, with a capacity of 250,000 bricks, and are burned partly in open kilns and partly in downdraft kilns, having a diameter of 25 feet, with ten heating flues, using oil as fuel, and two sets, of two flues each, under the floor, running to two outside stacks. The capacity of each kiln is about 60,000 bricks. Employs about 30 men.

J. Jenson, Los Angeles. Clay bank covering 8 acres on Pico street, Pico Heights, Los Angeles. The clay is ground in a disintegrator. The bricks are made in a Potts soft-mud brick machine, air-dried, and burned in open kilns, using oil as fuel. The yard is equipped with a 15-horsepower gasoline engine. Capacity, 40,000 bricks per day. Employs 20 men.

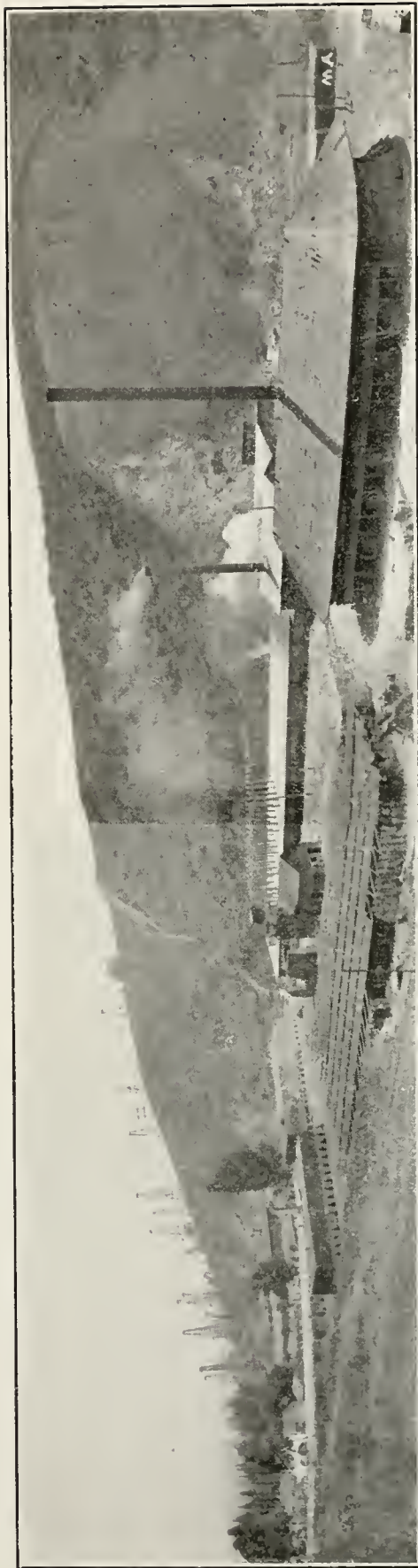
K. & K. Company—Keller & Kubach, 409 Stimson Block, Los Angeles. Clay bank covering 38 acres on Bishop street, Boyle Heights, Los Angeles. The bricks are made in a Raymond brick machine and Tate wire-cutter, dried in a steam-heated drier, and burned in open kilns, using oil as fuel. The yard is equipped with a 250-horsepower boiler and 200-horsepower engine. Capacity, 75,000 bricks per day. Employs 34 men.

Lordsburg Brick and Construction Company, J. D. McCoy, Lordsburg.

Los Angeles Brick Company, W. F. Botsford, president, 301 Trust Building, Los Angeles. This company has five brickyards. One brickyard is on Mission avenue, near the County Hospital. The clay bank is from 25 to 30 feet thick, underlaid by 5 or 6 feet of sand. The clay is ground in a pugmill, and then passes through a roller-crusher. The



ILL. No. 112. BERG & OXBY CLAY PIT, LOS ANGELES.



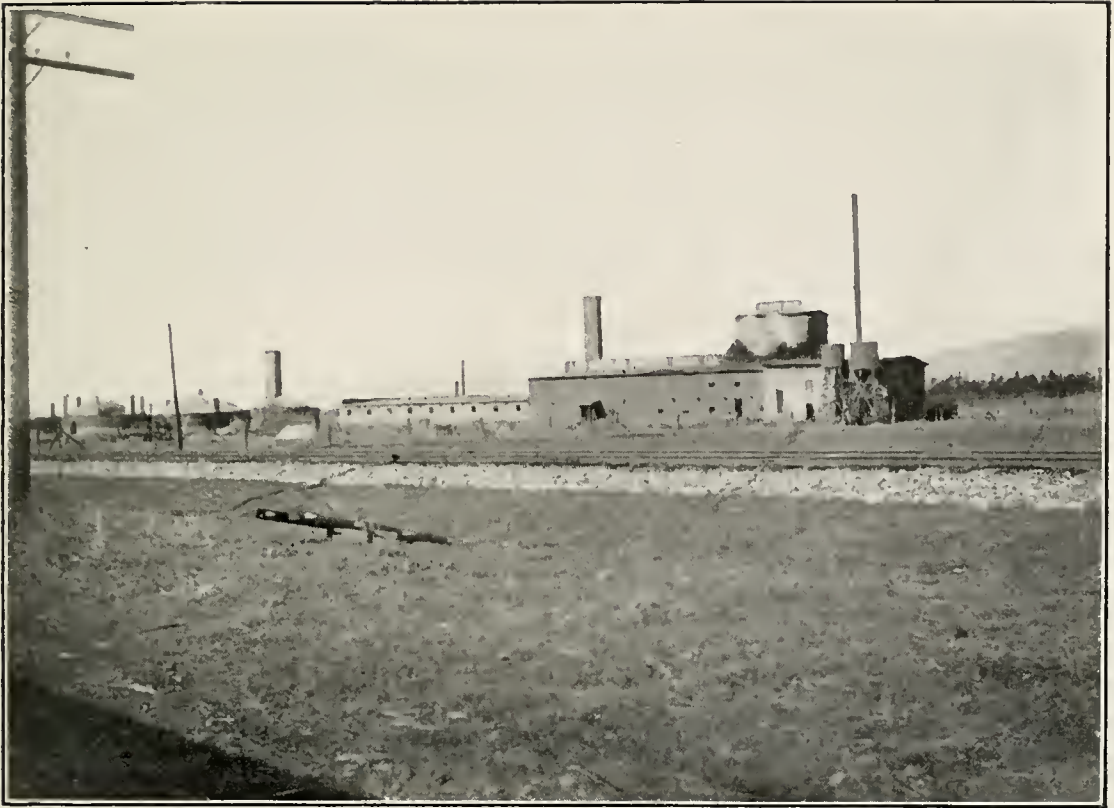
ILL. No. 113. WORKS OF LOS ANGELES BRICK COMPANY, SHOWING CLAY PIT AND CONTINUOUS KILN. LOS ANGELES CITY.

bricks are made in a Potts soft-mud brick machine, driven by electric power; air-dried, and burned in a continuous kiln—an ellipse, 175 feet long and 52 feet wide; the outside ring, 12 feet wide, and the chambers (distance between the flues near the bottom to the smoke-room) 12 feet long; the firing flues, 4 by 4 inches, are placed in rows $3\frac{1}{2}$ feet interdististant, five in a row. The fuel used is fine coal. The bricks can be burned in from fifteen to seventeen days. Capacity, 25,000 to 30,000 bricks per day.

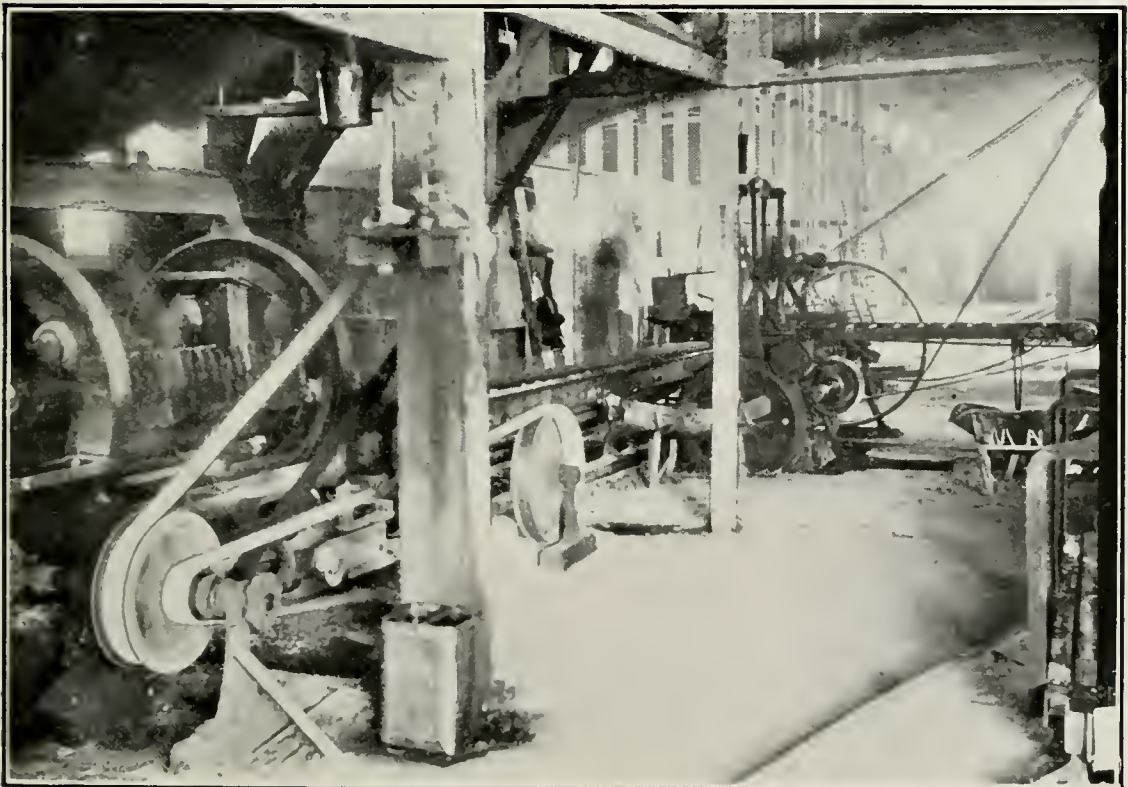
Three brickyards are in Chavez Cañon. The clay used is the shale forming the southwest bank of the cañon, as above described (see page 243). This material is ground in a dry-pan grinder of special construction. The ground clay falls on a belt, which passes under the center of the grinder and delivers it to another belt, which conveys it to the brick machines. In this way the scrapers ordinarily used under the grinder are omitted, reducing the amount of power required and the cost of repairs in handling this rather stiff material. In one yard the bricks are made in a combined stiff-mud brick machine, having a 12-foot pug and a 22-brick wire-cutter. In the other two yards the bricks are made in Potts soft-mud brick machines. The bricks are dried in steam-heated driers, and burned in three continuous kilns and in open kilns. The motive power is furnished by steam. The combined capacity of the three yards is 147,000 bricks per day. They employ about 90 men.

The fifth yard is on Seventh street, near Boyle avenue. The clay is obtained from the upper part of the Boyle Heights terrace formation. (See general description, page 243.) The bricks are made in a Potts soft-mud brick machine, air-dried, and burned partly in a 150 by 50 feet continuous kiln and partly in open kilns, using oil as fuel.

Los Angeles Pressed Brick Company, C. Frost, 105 South Broadway, Los Angeles. The works at the brickyard at Santa Monica have been recently erected, and are yet in course of completion. The territory covers about 60 acres, of which about one acre has been excavated. The clay bank is from 10 to 35 feet thick, dipping northwest, and increasing in depth in that direction, presumably underlaid by gravel. The clay is of better quality than most of the deposits in the vicinity of Los Angeles; it makes a good, hard brick, being mixed in dry-pan crushers and a 14-foot pugmill. The bricks are made in a special Giant, stiff-mud, 18-brick, wire-cutting brick machine. They are dried in tunnel driers, heated by the exhaust heat from the downdraft kilns. The blower is so located that in case this source be insufficient, steam heat can be provided. The bricks are burned in eight downdraft kilns, of 30 feet diameter, with eight or ten firing flues, using oil as fuel; also in open kilns. The downdraft kilns will burn common bricks in



ILL. No. 114. PLANT OF THE LOS ANGELES PRESSED BRICK COMPANY AT SANTA MONICA, LOS ANGELES COUNTY.

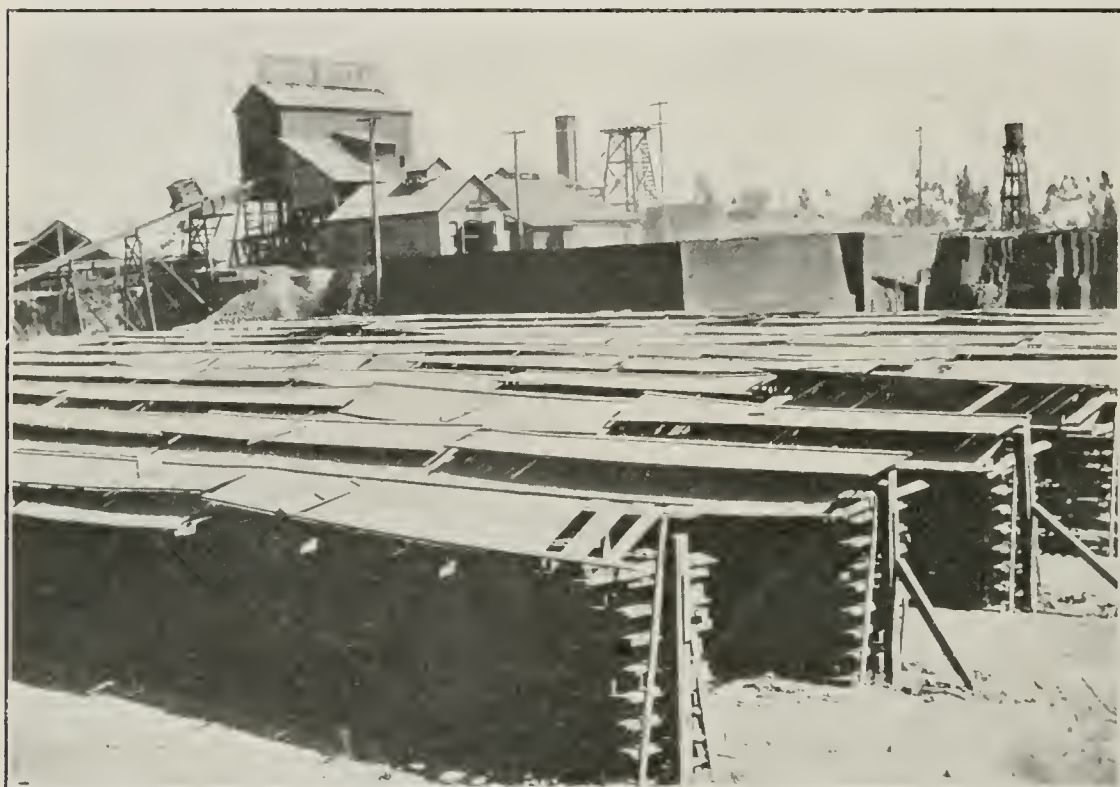


ILL. No. 115. WIRE-CUTTING AND PRESSED BRICK MACHINE, LOS ANGELES PRESSED BRICK COMPANY.

six days, hard bricks in seven to eight days. The works manufacture building brick, hard brick (vitrified), repressed brick, paving bricks, and paving blocks. The yard is equipped with 300-horsepower boiler and a 250-horsepower engine. Its daily capacity is 90,000 bricks.

R. Loynes, Long Beach. Clay bank east of the Anaheim road, north-east of the city limits, covering 10 acres. The bricks are burned in open kilns, using oil as fuel.

Pomona Brick Company, McMullin & Gamble, West Ninth street, Pomona.



ILL. No. 116. SIMONS BRICK COMPANY, LOS ANGELES.

Simons Brick Company, R. Simons, 123 West Third street, Los Angeles. This company manufactures common building brick and pressed brick, and is operating three brickyards, the combined capacity of which is 145,000 bricks per day. From 175 to 200 men are employed.

One yard is located at 23 South Boyle avenue, Los Angeles. The clay bank forms the upper portion of the Boyle Heights terrace formation. (See general description, page 243.) It is excavated by a steam shovel. The bricks are made in stiff-mud and soft-mud brick machines, air-dried, and burned in open kilns, using oil as fuel.

Another yard is on South Franklin avenue, Pasadena. The clay bank covers an area of 22 acres, of which 12 are worked out, and is from 10 to 15 feet thick—18 feet at the deepest point—underlaid by

from 12 to 14 feet of sand and gravel; then come from 20 to 30 feet of good clay, but containing a great amount of iron, which causes considerable shrinkage in the bricks when burned; this clay stratum is underlaid by coarse gravel. The bricks are made in a Potts soft-mud brick machine, air-dried, and burned in open kilns, using oil as fuel. The yard is equipped with a 36-horsepower electrical engine. Capacity, 36,000 bricks per day. From 35 to 40 men are employed.

The third yard is near Inglewood, where the bricks are burned in a continuous kiln.

The company is opening a new brick yard near Santa Monica.

Southern California Brick Company, J. H. Marks, 304 Hellman Building, Los Angeles. The clay bank covers 12 acres, on Stephenson avenue, Boyle Heights, Los Angeles. The bricks are made in a soft-mud brick machine, air-dried, and burned in open kilns, using oil as fuel, and in a continuous kiln.

Standard Brick Company, R. G. Simons, 101 and 102 Stimson Block, Los Angeles. The yard is on Seventh street, Boyle Heights, Los Angeles. The company manufactures common brick and repressed brick. The clay is ground in a dry-pan crusher. The bricks are made in a Potts soft-mud brick machine, air-dried, and burned in open kilns, using oil as fuel. The yard is equipped with a 30-horsepower engine and boiler. Capacity, 36,000 bricks per day. Employs 35 men.

MADERA COUNTY.

J. Dyer Brick Company (formerly the Dyer & Craycroft Company), J. Dyer, Madera, owner. This plant is located half a mile south of the depot at Madera. The bricks are made in molds by hand and burned in open kilns, using oil as fuel. They are made for the local trade, only a small number being shipped.

MARIN COUNTY.

McNear Brickyard, The McNear Brick Company, Builders' Exchange, San Francisco, owner. This plant is situated on the bay shore at McNear's Point, 3½ miles southeast of San Rafael. Both common and pressed brick are made; the former are used locally as firebrick for lining oil-burning fireboxes.

The clay banks are composed of a mixture of sandy shale, plastic clay, and streaks of sandstone, and furnish an unlimited supply of brick-making material. The plant includes two dry-pans, one stiff-mud machine (capacity 100 bricks a minute), one 20-compartment Hoffman kiln, burning coal screenings, and two 5-compartment downdraft kilns, burning oil. Power is furnished by a 100-horsepower motor. The output of the plant is 10,000,000 bricks a year.

Patent Brick Company, 328 Montgomery street, San Francisco. The plant is located $4\frac{1}{2}$ miles north of San Rafael, on the road to Petaluma. It includes two soft-mud brick machines (capacity 40,000 bricks per day each); a tunnel drier (capacity 100,000 bricks per day); three 16-compartment Hoffman kilns, with burning capacity of 25,000 bricks per day each. At the present time (November, 1904), the company is erecting a new plant with a stiff-mud machine capable of making 100,000 bricks per day. Only common bricks are made. The material used is a mixture of loam, clay, and disintegrated shales and sandstone, and is obtained from the low hills in rear of plant. The output averages about 50,000 bricks per day, the bulk of it being shipped on schooners loaded at the side of the kilns. The company has operated for thirty years.

Remillard Brick Company, corner of Second and Clay streets, Oakland. This company has a plant at Greenbrae, on the California Northwestern Railway, 2 miles south of San Rafael, on the San Quentin road. Only common bricks are manufactured in soft-mud brick machines. They are burned in a 16-compartment Hoffman kiln. The clay is obtained from pits in rear of plant. The deposit of disintegrated shale and sandstone is practically inexhaustible. The plant was idle during 1904, merely shipping brick from reserve. The schooners are loaded directly in front of plant on the Corte Madera canal.

MERCED COUNTY.

Merced Brickyards, W. H. McElroy, Merced, owner. This plant is located about one quarter of a mile west of the Southern Pacific Company's depot at Merced. The bricks are molded in a soft-mud brick machine, sun-dried, and burned in open kilns, using oil fuel. The plant is operated intermittently as bricks are needed.

MONTEREY COUNTY.

S. Pierce, Main street, Salinas, owns a brickyard at the southern end of Abbott Creek, near the cemetery. The bank shows 10 feet of clay, of which the lower 4 feet is a rich plastic material. The clay is mixed in upright pugmills, moved by horse-power; the bricks are hand-made, air-dried, and burned in open kilns, and are of good quality.

NEVADA COUNTY.

Brick clays are abundant in Nevada County. Two and a half miles east of Grass Valley, on Union Hill, there is a brick clay from which William Walker of Biggs, Butte County, made some 2,000,000 bricks in the time of his operations at Grass Valley. But none have been made in the past four years.

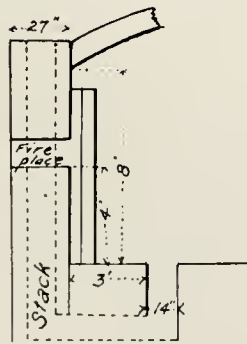
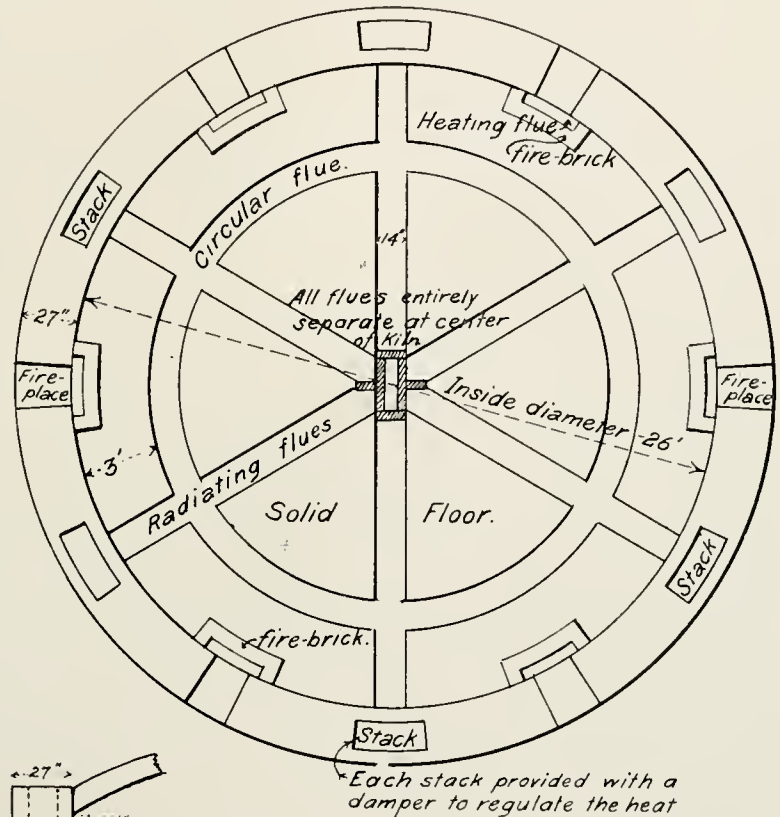
An apparently good quality of clay is uncovered by the Cement Hill ditch, in Sec. 6, T. 16 N., R. 9 E., near the Reddik and Odin mines, long ago abandoned. It is yellowish white, plastic, and contains fine grit. The locations and sections here named, and those under the heading of "Kaolin," are worthy of the attention of prospectors for clays.

ORANGE COUNTY.

Near Capistrano brick was burned in former years.

On the ridge west of the Santa Ana River, south of Wintersburg, is

found a deposit of good clay, which is used for the manufacture of tiles, etc.; this ridge is about 30 feet above the lowlands, to the east thereof, which are partly peat land, partly a clay soil, but principally a sandy loam soil. The clay in this ridge has been opened up in Sec. 35, T. 5 S., R. 11 W., S. B. M., on both sides of the branch line of the Southern Pacific Railroad from Newport to Smeltzer. The clay is very compact, of a dark gray color, in places tinted slightly red by iron oxide. While good for tiles, it requires an admixture of more sandy material to make brick. Two plants are working on this material.



GROUND PLAN SHOWING FLUES
DOWNDRAFT KILN
ORANGE COUNTY TILE WORKS
SMELTZER, ORANGE CO.

ILL. No. 117.

La Bolsa Tile Company, H. S. Hazeltine, president; E. R. Bradbury, general manager, Santa Ana. The plant is in Sec. 35, T. 5 S., R. 11 W., west of the above-mentioned branch line of the Southern Pacific Railroad to Smeltzer. This company manufactures tiles from 3 to 16 inches in

diameter, hollow building blocks, and bricks. The capacity of its plant is about 25,000 linear feet of tiles per month. Employs 8 men.

The plant is equipped with a 60-horsepower engine and a 70-horsepower boiler. The clay is ground in a dry-pan crusher; it is then conveyed by a vertical elevator into a hopper, which discharges it into a short pugmill, from which it passes into a lower pugmill provided with an auger which forces the clay through the die upon the wire-cutting table. The tiles up to 8 inches in diameter are cut to the length of 13 inches; those of larger diameter to that of $27\frac{1}{4}$ inches. The drying sheds are heated by hot air forced by a blower through flues under the floor. This hot air is obtained either from the exhaust of the kilns or by forcing air through a coil stove heated by the exhaust steam from the boiler. These works are located a short distance from the ocean, where drying without heat would require too long a time and spoil the paste, while sun-drying would in summer be too sudden and crack the tile. The smaller-sized tiles are dried in twenty-four hours or more; the larger tiles require sixty hours. The plant is equipped with two downdraft kilns of 24 feet diameter, with six fires, using oil as fuel, having one main flue and one stack.

Orange County Tile Works, J. B. Rain and A. Bailey, Post Route No. 5, Santa Ana. In Sec. 35, T. 5 S., R. 11 W., S. B. M., to the east of the branch road of the Southern Pacific Railroad from Newport to Smeltzer. The clay has been described above. These works make tiles, hollow building blocks, and bricks from this clay, and firebricks from the clay obtained from the Trabuco hills, in Orange County. The clay-working machinery is very small and old, but the installation of larger and better machinery is under way. There are two downdraft kilns, one of which, of a new design, is under construction. (See Ill. No. 117, page 251.)

Santa Ana Brickyard, on Hickey street; C. Grouard, 612 Olive street, Santa Ana, owner. The clay deposit covers about 11 acres, of which 3 to 4 acres are worked out. The clay is from 8 to 10 feet deep, and is underlaid by gravel. It is used as excavated. The bricks are made in a Quaker brick machine moved by horsepower, sun-dried, and burned in open kilns, using oil as fuel. The yard is working about six months of the year.

RIVERSIDE COUNTY.

Hancock Brickyard, C. P. Hancock, North Market street, Riverside, owner. The clay deposit covers an area of 6 acres; thickness, about 5 feet. The clay may be classed as loam. The bricks are made in a Potts soft-mud brick machine, air-dried, and burned in open kilns, using oil as fuel. The yard is equipped with an 80-horsepower boiler and a 35-horsepower engine. Capacity, 36,500 bricks per day. Employs 30 men.

Lewis Brickyard, E. N. Lewis, Corona, owner. The clay deposit lies in the northwestern part of Corona, and covers an area of 5 acres; thickness, about 8 feet. The material is a rich clay, which is mixed in a Quaker pugmill. The bricks are hand-made, air-dried, and burned in open kilns, using wood as fuel. Capacity, about 15,000 bricks per day.

SACRAMENTO COUNTY.

Sacramento Transportation Company, Sacramento County; principal place of business, Sacramento; James O'Neil, superintendent of the brickmaking department. This company is the sole maker of building bricks in the county and has been making bricks for twenty-two years, other makers having abandoned the production a few years ago. The present operations of this company are confined to one yard 6 miles south of Sacramento, on the east side of the Sacramento River. In ordinary years the production of bricks by this company averages 16,000,000 per annum. In 1904 the output was reduced to 5,000,000, owing to the flooding of the yards by the heavy rains and overflow of the river in the early part of the year. The yard, including material and plant, has an area of 182 acres; material from 10 acres has been consumed in the manufacture of bricks. It is composed of three strata: a dark soil overlying a strong giant clay, beneath which is a deep bed of sharp river sand. The plant consists of a steam shovel for cutting out the material; a railway train and locomotive for conveying the material one fourth of a mile to the operating yards at the edge of the river; pugmills; five soft-mud Monarch brickmaking machines; and two continuous downdraft kilns. The material is cut out in the winter and used in the following spring. The capacity of the plant is equal to 18,000,000 bricks per annum. In the making season the machines turn out 70,000 bricks per day, each kiln discharging and receiving 35,000 each day. The finished bricks are wheeled from the kilns to the company's barges on the river, ready for direct transportation to the principal market at San Francisco. Sacramento and other valley towns also offer a market for bricks made by this company. An average of 100 men are employed.

SAN BERNARDINO COUNTY.

Taylor Brothers Brick Company, J. Taylor, president, Room 12, National Bank Building, Redlands. Owns two clay deposits. One is in Redlands, on West Olive avenue, about one mile west of the center of the town, and covers about 5 acres, of which about one acre is worked out. The clay has a depth of from 3 to 5 feet and is underlaid by sand. The material is a sandy loam. The bricks are made in a Potts soft-mud brick machine, air-dried, and burned in open kilns,

using oil as fuel. The yard is equipped with an 80-horsepower boiler and a 35-horsepower engine. The capacity of the yard is 42,000 bricks per day, employing 23 men.

The other deposit is in San Bernardino, on G street, south of the Highlands branch of the Santa Fé Railway, and covers about 30 acres. The material is a sandy loam. The method of manufacturing the brick, the equipment, and the capacity of the yard are similar to those of the Redlands brickyard.

SAN DIEGO COUNTY.

Harbour & Peterson operate a brickyard at Imperial.

Hubbard Brickyard, B. M. Hubbard, 1048 Fourth street, San Diego, manufactures common red brick. The plant is equipped with a gasoline engine; crude oil is used as fuel for burning the bricks. Capacity, 20,000 bricks per day.

Rose Cañon Brick Company, J. S. Ackerman, 1311 E street, San Diego.

SAN FRANCISCO COUNTY.

Bay City Brick Company owns a yard on the Corbett road, opposite the end of Twenty-fourth street. The clay is obtained at side of its 12-compartment kiln. Oil was used as fuel. The bricks were seasoned in a 5-compartment drier. The plant is idle.

San Francisco Brick Company, Wells-Fargo Building, San Francisco. This large plant is on State street, near Douglass. The bricks are made in a stiff-mud machine, seasoned in steam-heated driers, and burned in a 28-compartment Hoffman kiln.

Simons-Fout Brick Company, box 153 Builders' Exchange, San Francisco. This plant is on the Corbett road, opposite the end of Twentieth street. The bricks are made in a stiff-mud machine, which averages 30,000 per day. They are dried by live steam and burned in a 20-compartment Hoffman kiln, using coal as fuel. Only common bricks are made.

SAN JOAQUIN COUNTY.

Roberts Island Brick Company, A. Kunz, manager, Stockton. The plant is being erected about 6 miles southwest of Stockton, on Roberts Island, one fourth of a mile inland from the Stockton Brick Company's kiln. The clay will be handled by a steam shovel. The bricks will be made in a soft-mud machine, sun-dried, and burned in a 16-compartment Hoffman kiln.

San Joaquin Brick Company, I. F. Stein, secretary, corner of Channel street and Weber Point, Stockton. The plant is located about $5\frac{1}{2}$ miles west of south of Stockton, on the San Joaquin River, on the east side of Roberts Island. The clay is dug by means of a steam shovel, and the bricks are made in a soft-mud machine with a capacity of 40,000 per day. They are sun-dried and burned in a 16-compartment Hoffman kiln. The plant is operated five months during the year, and the bricks are shipped on barges, which are loaded at side of kiln.

Stockton Brick Company, E. Lanzoni, Stockton. The plant is located about 6 miles west of south of Stockton, on the San Joaquin River, on the east side of Roberts Island. The clay is a sort of sandy loam, a bottom land deposit, and is kept dry enough to work by taking it from the pits in a series of benches, and draining the water from the lowest bench. A cable tramway takes the clay from the pits to the plant, which includes one stiff-mud machine (a continuous cutter), with a capacity of 40,000 bricks per day; two driers, with a capacity of 90,000 bricks per day each, using both live and exhaust steam; and one 16-compartment Hoffman kiln. The plant is operated the year round, and employs 26 men. The bricks are shipped on barges, which load at side of plant.

SAN LUIS OBISPO COUNTY.

Ah Louis, San Luis Obispo, northwest of the city, on the road to Bishop's Peak quarry. The clay is of good quality. The bricks are hand-made, air-dried, and burned in open kilns, with wood as fuel.

P. Olohan, Arroyo Grande. Clay bank 6 to 7 feet thick, one mile east of the town, underlaid by gravel. The bricks were hand-made, air-dried, and burned in open kilns, with wood as fuel. Idle for the last four years.

P. S. Pickering, Paso Robles. A clay bank in Wells Addition, northern part of Paso Robles, in the Salinas River bottom; about 6 feet of fairly good clay, underlaid by sand and gravel. The bricks were hand-made, air-dried, and burned in open kilns, with wood as fuel. Idle since 1900.

SAN MATEO COUNTY.

Baden Brick Company, Mr. Weaver, superintendent; offices, 106 Jessie street and 927 Market street, San Francisco. The plant is located about $1\frac{1}{2}$ miles east of South San Francisco, on the bay shore, in a little inlet known as "Snug Harbor." The bricks are made from a light yellow clay which has considerable grit. It is elevated by a tramway from the clay pit to the bins. The bricks are made in a stiff-mud machine (continuous cutter), with a capacity of 75,000 bricks per day. Waste

and live steam are used in the driers, which average about 25,000 bricks per day. Both common and repressed bricks are made, and occasionally some hollow brick. At present one 16-compartment Hoffman kiln is used, and another is being erected. The bricks are shipped on schooners, which load almost at side of kiln.

SANTA BARBARA COUNTY.

The valley of the lower part of the Santa Ynez River, in the neighborhood of Lompoc, is covered with a bed of clay about 12 feet thick, underlaid by quicksand. This clay is used, where needed, for burning brick, producing a very fair quality. It is claimed that potter's clay has been found here.

T. Connor, Santa Maria, is making preparations to again start up the brick kilns at Santa Maria.

Grant Brothers, Santa Barbara, operate a brickyard on land belonging to J. C. Mahon, at the west end of Montecito street. The clay is excavated to a depth of 5 feet, over an area of about one acre. It is of fairly good quality. The bricks are hand-made, air-dried, and burned in open kilns, using oil as fuel.

Martin Kelsch, Santa Barbara, has a brickyard at Haley and Milpitas streets, in the eastern part of the town. The clay bank varies from 4 to 10 feet in thickness, in places containing considerable gravel, underlaid by sand. The bricks are made in a horse-power Damon machine, air-dried, and burned in open kilns, using oil as fuel.

SANTA CLARA COUNTY.

(See Supplement.)

SHASTA COUNTY.

The Sacramento River Valley bottom below the mountains contains extensive clay banks, and on the higher tablelands debris accumulation has in places formed clay deposits.

In the southern part of the county, in the Sacramento Valley, a number of deposits of siliceous white clay are found; apparently a pottery clay, but mixed with too much silica to allow its use in the manufacture of pottery. (See IXth Annual Report of California State Mining Bureau, pp. 287 et seq.)

Alta Lime and Brick Company, Redding, owns the clay bank in Block 29, Redding Grant, about $1\frac{1}{2}$ miles south of Redding, in the Sacramento River bottom, formerly known as the Coleman & Hill Brickyard. The clay is tawny-colored, and from 5 to 6 feet thick. The upper 4 feet is a plastic clay, which grades into and rests upon a bed of sand, underlaid in turn by gravel. In former years a great many bricks of fairly good quality were burned in this yard.

In Sec. 24, T. 34 N., R. 5 W., the same company has superficially opened a clay bank just above its limekiln, but has not performed enough work to prove its extent. This clay is of a bright red color, and most probably is a remnant of an old deposit in the Sacramento River Cañon.

Holt & Gregg, Redding, own a brickyard about a mile south of Redding, on both sides of the railroad, containing similar clay to that in the old Coleman & Hill pit. Several years ago they abandoned this yard, and concentrated all their brick kilns near Anderson.

The same company owns an extensive clay bank 2 miles north of Anderson, very near the railroad, also in the Sacramento River bottom, on which two pits are worked in proximity to each other. The clay bed in the northern pit is from 12 to 15 feet thick, and of slightly different quality from that of the southern pit, where the bank is 8 feet high and contains a little more sand. The clay is brought in carts from the pit to the dump, and thence conveyed on a belt to the crusher, which feeds the Potts soft-mud brick machine. The bricks are sun-dried in about four days, and burned in open kilns. The plant employs about 40 men, and has a capacity of 36,400 bricks per twenty-four hours.

In Sec. 19, T. 32 N., R. 4 W., owned by the Southern Pacific Railroad Company, is a bed of clay outcropping on both sides of a low hill topped with gravel. This clay bed probably underlies the entire knoll, covering a surface of about 40 acres.

In the Reading Homestead, owned by R. L. Reading, directly east of Cottonwood, on the Sacramento River, is an extensive clay deposit, about one mile long and one-quarter mile wide. The clay is about 30 feet thick, and is capped by from 5 to 15 feet of gravel. It has not been developed.

SISKIYOU COUNTY.

T. T. Garvey, Yreka. In Sec. 27, T. 45 N., R. 7 W., M. D. M., are large banks of clay of a reddish color, containing some minute quartz pebbles. A good quality of brick, used in Yreka, is manufactured.

T. Hamilton, Fort Jones. In Sec. 2, T. 43 N., R. 9 W., M. D. M. Formerly brick was burned here from the surface clay.

T. A. Reynolds, Fort Jones. In Sec. 11, T. 43 N., R. 9 W., M. D. M. An old brick kiln, which used surface clay.

Peter Smith, Etna. In Sec. 21, T. 42 N., R. 9 W., M. D. M., is a bank of clay of good quality, apparently 4 feet thick, from which bricks were burned and used in buildings at Etna.

J. Walker, Greenview. In Sec. 32, T. 43 N., R. 9 W., M. D. M., is a deposit of grayish-colored clay of good quality, from which formerly a good grade of brick was burned.

SOLANO COUNTY.

Clay shales occur in Solano County along the San Pablo Bay shore at Vallejo and Benicia, and between those points. This material was several years ago employed in the manufacture of bricks; it was also used, in connection with other purer clays, in the manufacture of terra cotta ware and pottery. No bricks or other clay goods have been made at Vallejo or Benicia for several years, owing to the competition of large operators in other counties.

SONOMA COUNTY.

California Pottery and Brick Company; T. T. Mangle, manager, Glen Ellen. The plant is located in the northern portion of Glen Ellen, on Sonoma Creek. A soft, white, plastic clay occurs in a bed about 8 feet thick and overlies a bed of sandy clay, with which it is mixed by loading onto a belt conveyor in proper proportions. A 200-foot belt conveyor takes the clay from the pit direct to the bins. The bricks are made in a four-cut, stiff-mud machine and seasoned in a drier, with a capacity of 20,000 bricks per day. They are burned in field kilns, using oil as fuel. At present only common bricks are manufactured for the trade.

Healdsburg Brick Company; W. Burgett, Healdsburg, owner. This plant is situated in the northern portion of Healdsburg. The bricks are made in hand molds and burned in a Stewart kiln, with wood as fuel. The kiln capacity is 30,000 bricks. The output of the plant is about 175,000 bricks a year. The clay is obtained from an 8 to 9 foot bank of sandy loam and clay mixture.

Hilton Brickyard; T. P. Brown, Hilton, owner. This yard is located at Hilton station, 19 miles northwest from Santa Rosa. Mr. Brown manufactures both common and pressed brick, and burns them in a kiln of his own design.

Sonoma Brick Company.—This company's plant is located on the east bank of the Sonoma Creek, at Glen Ellen. The bricks are molded in a Martin soft-mud machine, and burned in field kilns, using wood as fuel.

TEHAMA COUNTY.

There are undoubtedly several clay deposits in the Sacramento River bottom lands of Tehama County, but very few have been used for the manufacture of brick.

O'Connor Brothers, Red Bluff, own a clay deposit in the Reed tract in Sec. 29, T. 27 N., R. 3 W. The deposit covers an area of over 19 acres. About a couple of acres have been worked by pits, showing a good quality of brick clay for a depth of from 8 to 11 feet, underlaid by gravel. The bricks are made in a soft-mud machine worked by horse-power. They are sun-dried, and burned in open kilns. When running full capacity the brickyard can produce about 16,000 bricks per day, employing 14 men. The bricks are mostly used locally.

TULARE COUNTY.

Pioneer Brick Company; B. Heberling, secretary, Heberling Planing Mill, Visalia. The plant is located on Center street, Visalia, near the eastern city limits. The bricks are made in a soft-mud machine, seasoned in racks, and burned in field kilns, using oil as fuel. Most of the output consists of the common red brick, but a few pressed bricks are made each year.

VENTURA COUNTY.

Brunson & Carter, Santa Paula. Hand-made bricks, burned in open kilns.

F. Jochueh, Montalvo. Hand-made bricks, burned in open kilns.

People's Lumber Company; D. T. Perkins, president, Ventura. Hand-made bricks, burned in open kilns, using oil as fuel.

Ventura Mill and Lumber Company; H. A. Giddings, president, Ventura. Bricks are made in a Damon soft-mud brick machine moved by horse-power, and are burned in open kilns, using oil as fuel.

YOLO COUNTY.

Bricks have been made in Yolo County, chiefly at Woodland and Winters (as recorded in Xth Report of California State Mining Bureau, 1890, p. 791), of good quality of clay and clayey loam, principally by hand methods and open kilns; but the demand was limited.

YUBA COUNTY.

Bricks are made in Yuba County only at Marysville. The supply of brick clays is not limited nor confined to the Marysville district, but the small demand does not justify their exploitation. Until a few years ago the manufacture of bricks had been a thriving industry at Marysville for nearly fifty years, being conducted by J. B. McDonald, a pioneer brickmaker. Since the introduction of wooden houses and concrete sidewalk paving, the industry has declined from an output of from 1,000,000 to 2,000,000 per year to a demand for about 400,000 bricks annually.

PART IV.

MISCELLANEOUS INDUSTRIAL PRODUCTS.

ANTIMONY.	MACADAM, RUBBLE, ETC.
ASBESTOS.	MAGNESITE.
BARYTES.	MANGANESE.
BAUXITE.	MICA.
CALCAREOUS TUFFA.	MINERAL PAINT.
CHROMITE.	ONYX.
CONCRETE ROCK (see Macadam).	PAVING BLOCKS.
FULLER'S EARTH.	PLATINUM.
GLASS-MAKING MATERIALS.	PYRITES.
GRAPHITE.	RUBBLE (see Macadam).
GYPSUM.	QUARTZ-CRYSTALS.
INFUSORIAL OR DIATOMACEOUS EARTH.	SOAPSTONE—TALC.
IRON ORE.	SULPHUR.
JASPER.	TUNGSTEN.
LITHIA.	ZINC.

ANTIMONY.

Inyo, Kern, and Riverside counties, see Supplement.

SAN BENITO COUNTY.

The antimony deposits are situated on the main ridge of the Mount Diablo range, in the extreme northeastern corner of the county, slightly extending into Merced County. The mineral-bearing zone is about 8 miles long north and south, and from 2 to 3 miles wide, containing principally antimony and quicksilver. The developed deposits of antimony cover, however, an area not over 3 miles long and 1 mile wide.

The deposits are in altered slate, and they have a quartzose gangue. On the west slope stibnite (sulphide of antimony) prevails, while on the east slope cinnabar is the predominant mineral, with stibnite as an accessory.

In former years these antimony mines were worked, and a furnace was erected in Sec. 8, T. 12 S., R. 7 E., M. D. M. This furnace is now abandoned, and the workings are all caved in. The principal mines were the Ambrose and the Appeal, in Sec. 30, T. 11 S., R. 7 E., M. D. M.; the Gleason, in Sec. 6, T. 12 S., R. 7 E.; the Schriver, in Sec. 31, T. 11 S., R. 7 E.; and the Eureka and the Star, one fourth mile from the Schriver. The territory covered by these mines is now owned by T. H. French, in Sec. 31, T. 11 S., R. 7 E.; J. Gleason, in Sec. 6, T. 12 S., R. 7 E.; and the Stayton Mining Company, all of Lone Tree P. O. (See also VIIIth Report of California State Mining Bureau, p. 485; Xth *ibid.*, p. 515; and XIth *ibid.*, p. 371.)

ASBESTOS.

Two distinct minerals are known in the markets as asbestos. One is a variety of actinolite, or tremolite, which are varieties of hornblende. It is a silicate of lime, magnesia, and iron $[\text{Ca}(\text{MgFe})_3, (\text{SiO}_4)_3]$, and has fine, soft, flexible fibers like cotton. Most of the commercial asbestos, however, is a variety of serpentine, called chrysotile or amianthus, a hydrous silicate of magnesia ($3 \text{ MgO}, 2 \text{ SiO}_2, 2 \text{ H}_2\text{O}$), and contains about 14 per cent of water. Although in many respects the two varieties are similar in physical properties, the chrysotile variety is superior in both strength and elasticity to any amphibole asbestos, while the heat-resisting properties of both varieties are about equal. Consequently, for all purposes in which non-conductivity of heat and not strength of fiber is the important factor, as in fireproof paint, wall plaster, boiler covering, fireproof packing of safes, etc., both varieties can be used. Infusorial earth, talc, and mica are, however, strong competitors of asbestos in these lines of manufacture.

Where strength of fiber is essential, as well as non-conductivity, as in the manufacture of cloth, rope, felt boards, tubes, washers, and blocks of various shapes, only the chrysotile variety can be used. The fibers of chrysotile are seldom over $2\frac{1}{2}$ inches long, and usually from $\frac{1}{2}$ to $1\frac{1}{2}$ inches in length.

The mill fiber, a paper stock, is the minute fibers of asbestos which have become broken and are not capable of being used for weaving.

Asbestic is the final waste material, which contains a small amount of minute fibers and a considerable amount of the crushed serpentine rock. (See Bureau of Census, Mines and Quarries, 1902, p. 973.)

Nearly all the high-grade asbestos used in the United States is imported, most of it from Canada.

AMADOR COUNTY.

F. Mace, $2\frac{1}{2}$ miles east of Ione, on Sutter Creek. Some veins and stringers of the chrysotile asbestos in a dark green serpentine along the contact with black slates. Formerly several small openings were made on this asbestos, but they are all caved in.

BUTTE COUNTY.

A wide belt of serpentine runs from the southwestern corner of Sierra County, through Yuba, into Butte. A number of surface exposures of asbestos are found in this belt, but no asbestos of commercial

value has, as yet, been developed in this region. The most prominent surface indications are located in:

Sec. 14, T. 19 N., R. 5 E. Mrs. L. M. Power, Oroville.

Sec. 7, T. 21 N., R. 6 E. Edw. Martin, Brush Creek.

Sec. 3, T. 21 N., R. 5 E. John A. Clark, Berry Creek.

Sec. 34, T. 21 N., R. 4 E. United Gold and Copper Company, Cherokee.

Sec. 7, T. 21 N., R. 4 E.

The south half of T. 23 N., R. 4 E.

In the Mining Bureau Museum are specimens of asbestos from Forbestown, Oroville, and Red Hill.

EL DORADO COUNTY.

El Dorado Copper Mining Company; W. E. Everson, manager, F. W. Blodgett, secretary, 204 Bacon Block, Oakland. Mine near Georgetown. Shipped 10 tons of asbestos in 1904.

FRESNO COUNTY.

Hogue & Phillips Claim, R. L. Hogue of Fresno and Mr. Phillips of Letcher, owners. This deposit lies about 12 miles north of Sanger, in T. 13 S., R. 23 E. They are sinking on a small ledge, and find that the asbestos becomes less siliceous and of longer fiber as they get farther down. It is merely a prospect.

In the Mining Bureau Museum is a specimen of asbestos from near Coalinga.

In the Mining Bureau Museum are specimens of asbestos from **INYO COUNTY;** **MADERA COUNTY,** from Fine Gold Gulch and from near Fresno Flats; and **MARIPOSA COUNTY,** from two localities near Bear Valley.

PLACER COUNTY.

Washington Consolidated Mine, S. M. Sprague & Co., Newcastle, owners; in Sec. 33, T. 15 N., R. 10 E., Iowa Hill district. Ten carloads of asbestos were shipped to San Francisco from this mine, at \$35 per ton, delivered at the railway at Colfax, 9 miles west. The mine has been idle for three years, but the company contemplates resuming operations. The asbestos was quarried out with soapstone, which lies east of a quartz ledge that has serpentine for the west wall.

Surface indications are found in:

• Sec. 36, T. 14 N., R. 10 E., near Forest Hill.

Sec. 29, T. 14 N., R. 11 E., in Lady's Cañon.

Sec. 13, T. 13 N., R. 9 E., in Gas Cañon.

RIVERSIDE COUNTY.

Asbestos is reported from:

East of Indio. (See XIth Report of the California State Mining Bureau, p. 383.)

Near Palm Springs, in the San Jacinto Mountains. (See XIth Report of the California State Mining Bureau, p. 383.)

F. A. Stephens, 3 miles south of Winchester. (See XIIIth Report of the California State Mining Bureau, p. 642.)

Up to the present time none of these deposits have, however, produced a material of commercial value.

SAN BERNARDINO COUNTY.

Fire-Proof Mine, J. B. Friend, Victorville, locator. This mine is situated about 4 miles west of Cottonwood, a station on the Santa Fé Railway, probably in the southern part of T. 9 N., R. 4 W., S. B. M. The asbestos is stated to occur in a seam in a shale country rock, from 5 to 6 feet wide. A small portion of the asbestos is claimed to be of rather good quality. None has been shipped. This is probably the same mine as mentioned under the name of Scorpion in the IXth Report of the California State Mining Bureau, p. 236.

In the Mining Bureau Museum is a specimen of asbestos from near Barstow.

SAN DIEGO COUNTY.

Within 3 miles of the Hot Sulphur Springs, in the northeastern part of Warner's Valley, some asbestos has been found. (See IXth Report of the California State Mining Bureau, p. 148.)

In the Mining Bureau Museum are specimens of asbestos from near Elsinore and from the San Jacinto Mountains.

In the Mining Bureau Museum is a specimen of asbestos from Hazel Creek, SHASTA COUNTY.

SIERRA COUNTY.

Casserly Mine, Lee Craft, Forest City, owner; in Sec. 32, T. 20 N., R. 10 E., on west bank of Goodyear Creek, $1\frac{1}{2}$ miles north of Goodyear Bar. Asbestos, in serpentine, from 6 to 10 inches wide, was encountered by a mine tunnel 128 feet long, about 25 feet below the surface. The asbestos follows the course of the serpentine north and south, near its contact with slate.

America Excelsior Cons. Mine, Goodyear Bar. In the Mining Bureau Museum is a specimen from the above mine, donated by Mr. Robert Stuart. The vein is said to be 2 feet wide at a depth of 20 feet, where the sample was taken.

SISKIYOU COUNTY.

While many prospects of asbestos are reported, none of commercial quality has as yet been found. In the Mining Bureau Museum is a sample from near Sisson.

TRINITY COUNTY.

It is claimed that near the head of the Blythe ditch, in Sec. 28, T. 38 N., R. 6 W., M. D. M., when it was excavated over twenty years ago, a promising deposit of asbestos was uncovered, but at present only very insignificant indications of it can be found. The ditch has been largely filled up with débris.

YOLO COUNTY.

In the Mining Bureau Museum are specimens of asbestos from the Keys tunnel in the California mine.

YUBA COUNTY.

There are some surface exposures of asbestos in the belt of serpentine, already mentioned (see Asbestos, Butte County, page 261), but no asbestos of commercial value has, as yet, been developed in this region. The most prominent surface indications are located in:

Sec. 35, T. 19 N., R. 8 E. W. S. Godfrey, Camptonville.

Sec. 32, T. 19 N., R. 7 E.

Sec. 8, T. 19 N., R. 7 E. Mount Hope mine; Mrs. Blake, Woodleaf.

Sec. 29, T. 20 N., R. 8 E.

BARYTES.

Barytes are used in the paint industry; in the manufacture of paper and rope; as barium hydroxide in the sugar industry, and in tanneries. The value of crude barytes at the mines varies from \$3 to \$5 per ton.

BUTTE COUNTY.

Pinkston Mine, William Pinkston of Yankee Hill, and J. Eicher of Oroville, owners; in Sec. 8, T. 21 N., R. 4 E. Heavy spar was found in bunches and boulders, accompanied by clays and some tale, of the mineral paint varieties, and small bunches of fuller's earth, in this mine, when it was worked for its gold values.

SAN BERNARDINO COUNTY.

Barytes occur, in conjunction with copper and lead ore, on the property of George Shephard, 8 miles northwest of Barstow.

BAUXITE.

Four principal substances are prepared from bauxite, viz: (1) Aluminum sulphate, commonly known as "concentrated alum," extensively used in dyeing, paper industry, etc.; (2) Alum, also used in dyeing, paper-making, etc.; (3) Artificial emery; (4) Aluminum hydroxide, from which the metal aluminum is manufactured. Value of bauxite, about \$3 per ton.

YUBA COUNTY.

Dempsey Ranch Mine, J. M. Dempsey, Mooney Flat, owner; in Sec. 3, T. 15 N., R. 6 E., M. D. M., 2 miles southeast of Smartsville. Three occurrences of white bauxite, indicating a considerable quantity, were encountered at respective distances of 120, 180, and 210 feet by a mine tunnel driven 200 feet below the surface. The bauxite occurs within a casing of clay gouge overhanging the ledge matter carrying copper. Neither the ledge matter nor the bauxite has been further developed. Red bauxite occurs in association with ochre about 1000 feet distant from the above described workings.

CALCAREOUS TUFA.

SAN LUIS OBISPO COUNTY.

Mrs. O'Leary, Creston. In Sec. 20, T. 28 S., R. 14 E., M. D. M., east of south of Creston, a considerable area of calcareous tufa, having a great thickness, has been exposed by several gulches cutting through the tableland. In the western part the beds lie nearly horizontal with vertical joint planes, so the material can be excavated in nearly square blocks. The tufa is massive, white and light. The deposit can be traced for a considerable distance in a north and south direction. About 200 yards east of its prominent western rim a dike of silicified shales, about 10 feet wide, crops out, running in a northwesterly direction, dipping northeasterly about 30 degrees, which can be readily traced for over a mile. East of this dike comes again the tufa; but as its surface has not been carved out by gulches, as is the case on the western rim, little can be said regarding its extension. This calcareous tufa is very refractory. It has been used in fireplaces, etc.; also in dental furnaces, where it withstands perfectly a heat of over 2000° F. It is also a very strong non-conductor of heat.

CHROMITE.

Chromite is a black ore with a submetallic luster, and in appearance resembles some of the iron ores. It occurs in small octahedral crystals and granular masses in serpentine rock, and consists, when pure, of 68 per cent of chromium oxide (Cr_2O_3) and 32 per cent of iron oxide (Fe_2O_3); frequently ferric oxide or alumina replaces part of the chromium. The commercial ores commonly run about 50 per cent of chromium oxide, and are generally sold on a 50 per cent basis.

Chromite is the source of the chromium salts of commerce, which are used extensively in several different industries. It likewise enters into the manufacture of chrome steel, now used largely in making armor plate and heavy projectiles. Another important use of chromium is in the basic bricks for lining furnace-hearths, in steel-making, and in copper-smelting. Both of the last two uses require large quantities of ore, and probably will require still larger quantities in the future, thus giving interest to the California deposits, which are the most extensive in the United States.

Chromite occurs in several of the Eastern States, and was formerly mined in Pennsylvania and Maryland, but in later years, according to the Government statistics, the total domestic production comes from California. The greater part of the ore used in the eastern United States since 1895 is imported, as by the removal of the tariff chromite can be imported from Europe cheaper than it can be shipped from California. Hence the chromite industry in this State has been materially lessened during the last ten years, but it only awaits favorable trade conditions to be revived, as the ore deposits have not been exhausted.

Chromite occurs in California in several counties, which have nearly all been producers of ore in the past.

The following figures, taken from the records of the California State Mining Bureau, show the fluctuations of the industry:

Year.	Tons.	Value.	Year.	Tons.	Value.
1887.....	3,000	\$40,000	1896.....	786	\$7,775
1888.....	1,500	20,000	1897-9.....	None.	
1889.....	2,000	30,000	1900.....	140	1,400
1890.....	3,599	53,985	1901.....	130	1,950
1891.....	1,372	20,580	1902.....	315	4,725
1892.....	1,500	22,500 ^r	1903.....	150	2,250
1893.....	3,319	49,785	1904.....	123	1,845
1894.....	3,680	39,980			
1895.....	1,740	16,795			
			Total, since 1887...		\$313,570

ALAMEDA COUNTY.

Douglas Mine, Douglas Mendenhall, Livermore, owner; in N. E. $\frac{1}{4}$ of Sec. 26, T. 4 S., R. 3 E., 15 miles southeast of Livermore. About fifty tons of chromic iron ore are on the dump. Have only done assessment work since 1903.

The Jones Chrome Outcrop, in Sec. 6, T. 5 S., R. 4 E., 20 miles southeast of Livermore, on the Arroyo Mocho road. Three and one-half foot outcrop of chromite in serpentine. About twenty tons of ore have been taken from a 10-foot development shaft. No shipments have been made, and no development work has been done, since 1900.

Mendenhall Mine, A. Mendenhall, Livermore, owner; in Sec. 26, T. 4 S., R. 3 E., 15 miles southeast of Livermore. There are several tons of ore on the dump which averages about 55 per cent without concentrating other than sledging and hand-picking. Nothing more than assessment work has been done of late years. The ore deposits are variable in thickness and dip, and occur apparently in crushed and broken portions of the serpentine. Previous to 1894, about \$20,000 worth of ore was shipped to Philadelphia, where it was used for coloring pigments in woolen mills.

BUTTE COUNTY.

M. E. Strauss, Forbestown, in Sec. 7, T. 19 N., R. 7 E., owns a deposit of chromic iron, occurring in the form of a large kidney, from 10 to 100 feet wide, in serpentine. The claim has been prospected, but no shipments were made, owing to the distance (26 miles) from the railway at Oroville.

CALAVERAS COUNTY.

Chromic iron occurs 10 miles northeast of Milton, on the ranch of Capt. John Wright, in Salt Spring Valley, in the serpentine belt which skirts the western base of Bear Mountains. A similar deposit is found on the Tower ranch, near the Angels stage road, 9 miles east of Milton. Very little work has been done on either of these deposits. (XIIIth Report of the California State Mining Bureau, p. 48.)

Big Pine Chrome Mine, Penn Chemical Works of Campo Seco, owner; in Sec. 20, T. 4 N., R. 11 E. The entire output of this mine is used by the owners in lining the reverberatory furnaces at their smelter at Campo Seco.

Big Trees Mining Company, Murphy. In Sec. 2, T. 3 N., R. 14 E. A block of hematite and chromic iron. Idle.

DEL NORTE COUNTY.

Large deposits of chromite are found in Rattlesnake Mountains, from Bald Hill to the Klamath River, embedded in the serpentine country rock. They are not located, as the cost of transportation is too great to make their working profitable at present.

French Hill (Tyson) Mines, Tyson Mining Company, Baltimore, owner; in Secs. 5 and 6, T. 16 N., R. 1 E., H. M., 3 miles south of Gasquet. Kidneys of chromite embedded in serpentine. Idle.

Low Divide (Tyson) Mine, same owner; in Secs. 33, 34, and 35, T. 18 N., R. 2 E., H. M., 8 miles east of Smith River P. O. Idle.

FRESNO COUNTY.

Toll House.—Chromite occurs in a serpentine belt 6 miles southwest of Toll House, near Sentinel, in T. 11 S., R. 23 E. Some prospecting and developing were done, but the ore proved to be low grade. Considerable ore was shipped from this vicinity by the Copper King Mines Company for its own use.

GLENN COUNTY.

Black Diamond Mine, in Sec. 25, T. 22 N., R. 7 W.; Guy M. and John Luce, Newville P. O., owners. Chrome ore has been profitably mined. Up to 1893, there were 3319 tons mined and shipped 20 miles by wagon road to the railroad station at Fruto. The property has been idle for several years. At the time of the active work on this property, a number of other deposits were discovered in the vicinity. These deposits of chrome ore occur in the serpentine belt following the eastern slope of the Coast Range. The Black Diamond mine was worked by an open cut and tunnel. The workings have the form of an irregular-shaped quarry, exposing a face from 25 to 35 feet high, from 30 to 40 feet wide, and a floor depth of about 70 feet. The highest line of the ore exposure is about 10 feet below the apex of the serpentine.

MENDOCINO COUNTY.

Chromite of good quality is found in several places in the hills west of Russian River Valley. The individual deposits are not large, but there are quite a number of them. In 1895 efforts were made to develop the mines. (XIIIth Report of the California State Mining Bureau, p. 49.)

PLACER COUNTY.

Some surface deposits of chrome ore were worked in 1890 and 1891, and the product shipped to the Eastern market. These surface deposits were found in a belt running nearly north from Lady's Cañon, in Sec. 29, T. 14 N., R. 11 E., M. D. M., to Rattlesnake Den, near Dutch Flat, on Little Bear River, in the southeastern part of T. 16 N., R. 10 E., M. D. M.

Some detached surface deposits are found near Cape Horn, in Secs. 35 and 36, T. 15 N., R. 10 E., M. D. M., and near Weimar, in Sec. 21, T. 14 N., R. 9 E., M. D. M.

SAN BENITO COUNTY.

Tom Ingalls, Emmett P. O., about fifteen years ago performed some development work on a deposit of chromite, in Sec. 36, T. 14 S., R. 7 E., and it is claimed found a quantity of good ore. Since that time no further work has been done.

Near **New Idria**, on the divide between San Carlos Creek and Clear Creek, surface boulders of chromite were found in the early fifties, and in fact were the cause of prospecting which resulted in the discovery of the New Idria quicksilver mines. The chromite contains narrow green seams of rodochrome.

SAN LUIS OBISPO COUNTY.

Years ago large quantities of chromite were shipped from San Luis Obispo to Baltimore and Philadelphia. The Goldtree Brothers were the principal shippers, and most of the ore passed through their hands. The shipments were greatest, it is said, from twenty to twenty-five years ago, and continued up to about seven years ago, when they ceased, owing to removal of the tariff. A concentrating mill was erected in San Luis Obispo about the time the industry ceased, which now stands idle.

The ore occurs in irregular pockets and stringers in serpentine, which is deeply disintegrated in most places. Much of the ore was obtained from the disintegrated material.

Owing to the mode of occurrence of the ore, the mining was mostly surface work, and there were a great number of pits scattered over the area. The principal mines are about 8 or 9 miles north of the town of San Luis Obispo, in the serpentine hills of the Santa Lucia Mountains, but there are other mines west and southwest of the city in the Los Osos Mountains. In the northwestern part of the county, on the west slope of Pine Mountain, chromite occurs under similar conditions.

The ore being found in relatively small pockets disseminated through the serpentine, the cost of mining was rather high—about \$5.50 per ton, laid down at San Luis.

In 1890, Myron Angel, field assistant of the California State Mining Bureau, estimated that over 11,000 tons of chromite had been shipped from San Luis Obispo. (See Xth Report of the California State Mining Bureau, p. 582.)

J. A. Chanslor, San Luis Obispo. The Castor mine, in Sec. 29, T. 29 S., R. 12 E., M. D. M.

Charles Goetz, 735 Ellis street, San Francisco. The El Devisadero, El Salto, Primera, and La Trinidad mines, in Sec. 33, T. 29 S., R. 12 E., M. D. M.

Goldtree Brothers, 124 Sansome street, San Francisco. The London, and Pick and Shovel mines, in Sec. 33, T. 29 S., R. 12 E., M. D. M.

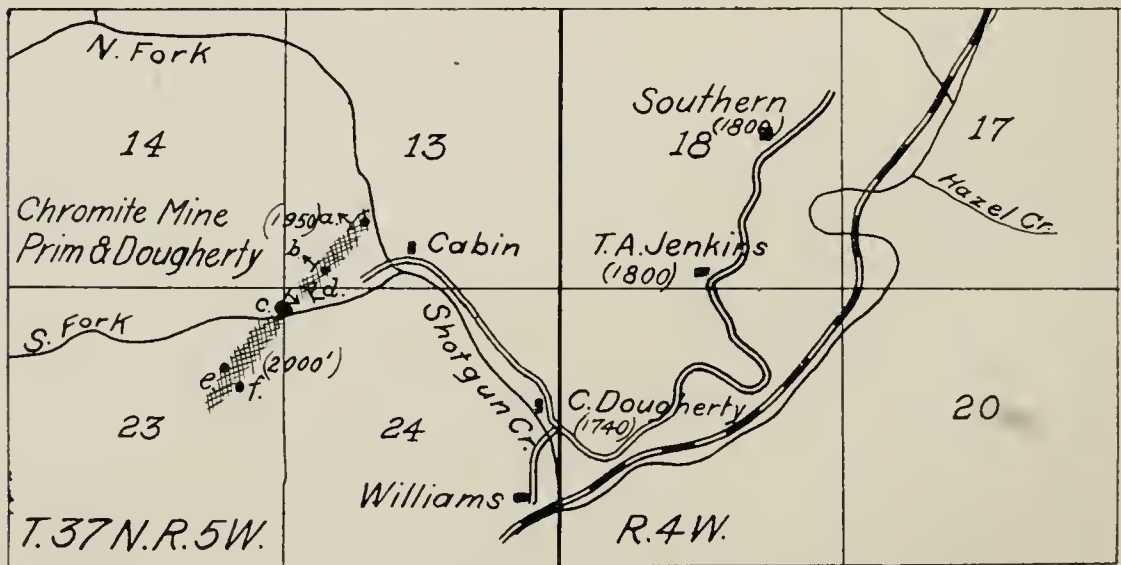
C. T. Greenfield, San Luis Obispo. A mine in Sec. 3, T. 31 S., R. 12 E., M. D. M., very near the city limits.

T. Steele, Arroyo Grande. On the Rancho Santa Manuela, about 6 miles up the Arroyo Grande Creek from Arroyo Grande, some work has been done, showing some chromite ore of a good quality. A small amount was shipped from this point about fifteen years ago.

G. Urben, San Luis Obispo. The Jasper mine, in the southwestern part of the Rancho Laguna, in the Los Osos Mountains, about 3 miles southwest of San Luis Obispo.

Several small outcrops have been found in the Los Osos Mountains on lands belonging to several parties.

On the west side of Pine Mountain lies a wide belt of serpentine, wherein are found boulders of chromite, which were mined in former years and shipped via San Simeon. These mines are located in Secs. 3 and 10, T. 26 S., R. 8 E., M. D. M.



ILL. No. 118. SKETCH A, SHASTA COUNTY.

SHASTA COUNTY.

F. P. Prim, Redding, and **C. Dougherty**, Hazel Creek, own three chromite claims in Secs. 13 and 24, T. 37 N., R. 5 W., near Sims. A belt of chromite of very good quality has been opened up over a length of about 1000 feet. The country rock is serpentine. The ore is lustrous black, carries high in chromic oxide and relatively low in iron oxide. Seams of a talcose serpentine cut through the ore bodies. At the surface the ore has the tawny, earthy appearance of the streak of chromite. The ore generally lies against more or less polished surfaces of the serpentine. No gangue or clay seam occurs on the contact. So far as

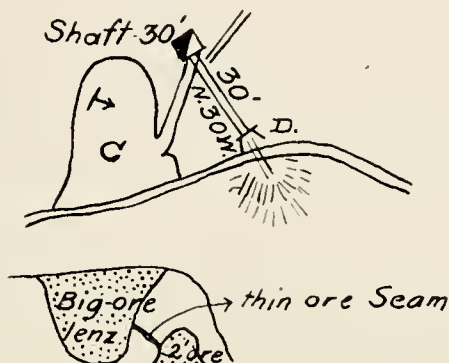
developed, the chromite occurs in lenses, connected by narrow seams, with dips reversing occasionally within a few feet. All the present workings are very near the surface.

The chromite is shipped as far as Arizona, Colorado, and Montana, and is used for furnace bottoms at the Bully Hill and Keswick copper furnaces.

The workings as indicated in Sketch A are: (a) Lens about 25 feet diameter and 15 feet deep, out of which 600 tons were taken. Ore has been left in the bottom, to be reached by tunnel *c*.

(b) A similar, but smaller lens, out of which 300 tons were taken. Here the dip of the ore body is northwest, while in *c*, not 50 feet distant, the dip is southeast.

(c) The original discovery—a large lens on the north side of the creek, out of which 1500 tons were taken, connecting by a narrow seam with another but smaller body lying to the southeast and lower. (See section over XY in sketch A.) The latter body dips under tunnel *d*.



ILL. No. 119. Detail of *c* and *d*, Sketch A, Shasta County.

(d) A tunnel run to cut the ore below *c*, *b*, and *a*. About 50 feet from the entrance, a vertical shaft about 30 feet deep was sunk, cutting the ore coming from *c*. It is claimed that there are 8 feet of ore in the bottom of the shaft. The tunnel has not yet reached either *c* or *a*.

(e) To the south of Shotgun Creek, a short tunnel has developed a small body of ore, having the form of a half-moon, out of which were taken 200 tons of very good ore. This opening lies apparently a little west of the belt in which the preceding works are located.

(f) An ore body in the line of this belt, higher up the hillside than *e*, from which 200 tons of ore were taken.

Messrs. Prim and Dougherty own another claim, in Sec. 22, T. 37 N., R. 5 W., on which very little development work has been done and from which no ore has been shipped.

E. Holden, J. Gibson, and others, of Lamoine, own eight claims in Sec. 22, T. 37 N., R. 5 W., but sufficient work has not been done to judge about their prospective value.

SIERRA COUNTY.

Brandy City.—Sec. 1, T. 19 N., R. 8 E. A deposit of chromic iron.

Luse & Co.'s Mine, in Sec. 1, T. 19 N., R. 8 E.; D. E. Luse & Co., Camptonville, Yuba County, owners. A deposit of *magno chromite* (a magnesia variety of chromite), from which a considerable tonnage has

been shipped by wagon to the railroad at Nevada City. This material is used more especially for furnace lining. There is a large body of ore in sight.

SISKIYOU COUNTY.

Considerable float of chromite is found near the top of the Forest Mountains, in the eastern part of Sec. 13, T. 44 N., R. 8 W., Southern Pacific Railroad Company, owner; and in the western part of Sec. 18, T. 44 N., R. 7 W., Wm. Ramus and Carl Hill, Yreka, owners. The country rock is serpentine; the chromite is found in relatively small pieces. No development work has been done.

Float of chromite is reported in the vicinity of the Dewey mine, about 10 miles southwest of Gazelle.

TEHAMA COUNTY.

A belt of serpentine having a general north and south trend runs through the southwestern part of Tehama County and the northwestern part of Glenn County. This belt is on the lower eastern slope of the Coast Range, called the Yallo Balloo Mountains. In this serpentine float of chromite is found in a great number of places. In Tehama County mining operations have, however, only been conducted on the north fork of Elder Creek.

J. A. Heslewood, 469 East Eleventh street, Oakland, and **P. C. Crumbo**, Red Bluff, own deposits of chromite in Sec. 16, T. 24 N., R. 7 W. They were formerly worked by the Tehama Consolidated Chrome Company of Red Bluff. (See Xth Report of the California State Mining Bureau, p. 692; XIIth *ibid.*, p. 38; XIIIth *ibid.*, p. 50.) This company mined the deposit in three places. Its last shipment was made about 1898. The ore was shipped on a basis of 47 per cent of chromium oxide (Cr_2O_3) as a minimum. It is claimed that much of the ore went considerably higher. The ore was paid for at the rate of \$9 per ton delivered at Red Bluff. The last shipments were made to John Rosenfeld's Sons, of San Francisco. The cost of hauling to Red Bluff may be placed at \$5.50 per ton. All the ore taken out was practically from the surface. No work was done to determine whether the ore persisted in depth.

TRINITY COUNTY.

It is claimed that fair chromite is found on the north fork of the east fork of Trinity River, a few miles above the point where the road from Trinity Center to Cinnabar crosses the creek, which would locate it in the northwest part of T. 38 N., R. 6 W., M. D. M. It is also claimed that a large deposit has been developed near Hayfork.

FULLER'S EARTH.

Fuller's earth is a soft, friable rock that is used in fulling wool and deodorizing and clarifying oils, fats, greases, and other fluids. It differs from other earths in its texture, which makes it so valuable in the industries. The essential properties of fuller's earth are that it falls to powder easily in water, and removes with avidity grease from cloth and coloring matter from oils. The latter appears to be the essential and characteristic quality that distinguishes fuller's earth from all others. As yet, no distinguishing definite mineralogical composition has been recognized, and just what gives it the unique filtering and absorbent properties is not clearly known.

The following analyses show the composition of several of the best known of the fuller's earths on the market:

CHEMICAL ANALYSES OF FULLER'S EARTH.

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Alka- lies.	Loss on Ignition.
English fuller's earth. (Min. Ind. N. Y., Vol. X, p. 273).....	54.20	14.30	6.30	1.25	2.72	3.79	17.44
English fuller's earth. (Jour. Frank. Inst., Vol. CL, p. 220).....	59.37	11.82	6.27	6.17	2.09	.98	13.19
Gadsden Co., Florida. (Jour. Frank. Inst., Vol. CL, p. 220).....	62.83	10.35	2.45	2.43	3.12	.94	7.72
Ocala, Florida. (Jour. Frank. Inst., Vol. CL, p. 220).....	36.73	27.78	3.21	.81	.64	.42	12.14
Fairburn, South Dakota. (Jour. Frank. Inst., Vol. CL, p. 220).....	60.16	10.38	14.87	4.96	1.72	-----	7.20
Decatur County, Georgia. (Jour. Frank. Inst., Vol. CL, p. 220).....	67.46	10.08	2.49	3.14	4.09	-----	5.61
Bakersfield, Kern County, California. (Min. Ind. N. Y., Vol. X, p. 273)...	54.32	18.88	6.50	1.00	3.22	4.21	11.86
England. (Geikie, 1893, p. 133).....	44.00	11.00	10.00	5.00	2.00	5.00	-----

One of the most striking features concerning the analyses is the variation in the composition. The value of a fuller's earth is a function of the physical texture, not of the chemical composition.

Production of Fuller's Earth in the United States.—During the past four years the production has been as follows:

	Tons.	Value.
1901	14,112	\$96,835
1902	14,100	109,980
1903	20,693	190,277
1904	29,480	168,500

The imports of fuller's earth for 1902 were 13,513 tons, valued at \$102,580.

The production of fuller's earth in the United States began in the year 1893 by accidental discovery at Quincy, Florida. Other deposits

were found later in other parts of Florida, Virginia, North Carolina, Georgia, Nebraska, Colorado, New Mexico, South Dakota, New York, and California. The market supply in the East continues to come from Florida, and in the West from California.

The American fuller's earth, it is said,* is used for filtering mineral oils, while the English earths are preferred for cottonseed and lard oils.

Preparation.—In America the earth is ground fine enough to go through a 60-mesh sieve, when it is ready for use. With the mineral oils the earth is put in long cylinders, through which the crude oil is allowed to slowly percolate. The first oil that comes through is clear, thinner and lighter than that which follows. With the vegetable oils, the oil is heated above the boiling point of water and the earth added, and the mixture stirred vigorously for some time, and then filtered through bag filters, when the coloring matter remains with the earth.

References.—1. Occurrence of fuller's earth in the United States; characteristics, uses, distribution, etc., by David T. Day. *Journal of Franklin Institute*, Vol. CL (Sept., 1900), p. 214.

2. Fuller's earth of Florida and Georgia, by T. W. Vaughan. U. S. Geological Survey, Bulletin 213, p. 392.

3. Fuller's earth of South Dakota. *Trans. Amer. Inst. Min. Eng.*, Vol. XXVII (1898), p. 333.

4. *Mineral Industry*, Vol. VII, p. 271.

BUTTE COUNTY.

Fuller's earth is found in three distinct and separate sections of the county, but in each case observed it appears to be an intrusion into the clays and of inferior quality:

In Sec. 8, T. 24 N., R. 4 E.; Diamond Match Company, owner.

In Sec. 8, T. 21 N., R. 4 E.; the barytes mine, J. C. Eicher, Oroville, owner.

In Sec. 13, T. 21 N., R. 3 E.; A. M. Smith, Oroville.

KERN COUNTY.

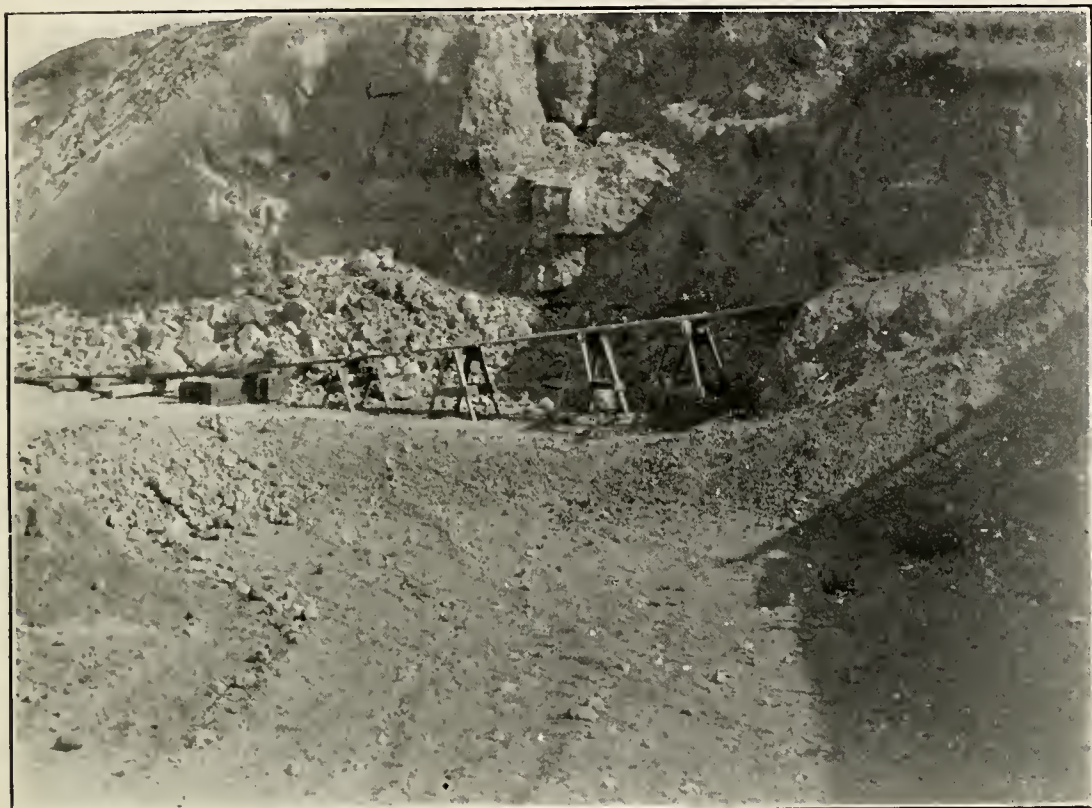
California Fuller's Earth Company; H. L. Packard, Bakersfield, manager. In Sec. 14, T. 27 S., R. 28 E., 18 miles north of Bakersfield, is a large deposit of fuller's earth, said to vary from 15 to 50 feet in depth, and many acres in extent. The fuller's earth is overlaid by a thin layer of soil, which is first removed, and then the earth is taken out in open pits. It is hauled in wagons 18 miles to Bakersfield, where it is ground and shipped principally to Kansas City and other Eastern points for refining animal and vegetable oils. This deposit was first opened in 1898, and it has produced since then.

* David T. Day, *Journal Franklin Inst.*, Vol. CL, p. 214. (September, 1900.)

The analysis of the earth shows:

	Per Cent.
Silica (SiO_2).....	54.32
Alumina (Al_2O_3).....	18.88
Iron oxide (Fe_2O_3).....	6.50
Lime (CaO).....	1.00
Magnesia (MgO).....	3.22
Loss on ignition.....	11.86
Alkalies (by difference).....	4.21

A comparative test of this earth with the English fuller's earth showed that 10 pounds of it equaled 9.75 pounds of the English earth. The



ILL. No. 120. QUARRY OF FULLER'S EARTH, KERN COUNTY.

tests were made on cottonseed oil, with 5 and 10 per cent quantities of earth at 100° C. for forty-five minutes.

SAN BERNARDINO COUNTY.

J. Reed, 428 Court street, San Bernardino, owns a deposit containing fuller's earth and claimed to be of considerable extent, about 12 miles north of Barstow. The fuller's earth occurs in sandstone and conglomerate. It has gray, red, and brown colors.

W. E. Van Slyke, 716 Fifth street, San Bernardino, has located a deposit of fuller's earth, claimed to be of considerable extent, in the northern part of T. 9 N., R. 22 E., S. B. M., on the north side of the Sacramento Wash, opposite Java, a station on the Santa Fé Railway. About four years ago some work was done on this deposit, showing a face over a length of about 80 feet.

THE GLASS INDUSTRY OF CALIFORNIA.

The glass industry is almost in its infancy in California. A few factories are in operation, making the lower grades of glass, but not enough is manufactured to supply the local demand, and very little is shipped from the State.

The Materials.—The chief materials used in bulk in glass-making are lime, silica, and soda, with smaller quantities of other materials, such as potash, lead, and alumina. Glass consists of an acid like silicic acid or boracic acid, combined with an alkaline earth, as lime, barium, or strontium, and an alkaline metal, as soda or potash. Of these materials, silica and lime are cheaper than any of the others, hence are commonly used in ordinary glass, and soda more commonly than potash.

Lime occurs pretty widely distributed over the State, and there is little difficulty in obtaining it in sufficient quantities at a moderate price. Silica occurs in large quantities in the form of sand, sandstone, and quartz veins. Many sand deposits contain, besides the quartz granules, grains of other minerals, such as feldspar, mica, tourmaline, etc., which hold in combination too many impurities for good glass-sand. Most of the sand deposits in California are of this nature. There is a large sand deposit at Monterey of sufficient purity to make good glass, and it is used for that purpose to the extent of about 5000 tons per year. At Tesla, in Alameda County, is another large deposit of sand that is used for glass-making. So far as could be ascertained there is no sandstone used in this State for the manufacture of glass.

ALAMEDA COUNTY.

At Tesla, Corral Hollow, in Sec. 32, T. 3 S., R. 1 E.; San Francisco and San Joaquin Coal Company, Safe Deposit Building, 328 Montgomery street, San Francisco, owner. The sand occurs in a 20-foot bed above the coal vein and between a bed of gray clay (used for building brick) on the hanging wall and a bed of fire clay on the foot wall. The bed dips N. 70° W., at an angle of 60°. The outcroppings are plainly visible across the hills in a general east and west direction. Sand was first shipped to Stockton in 1901. The sand was originally taken from outcroppings, but is now worked from a 500-foot tunnel. It is a fine quartz sand, and is washed by long sluice-boxes onto tables to free it from particles of light clay. It is then sacked at a siding and shipped to the glass factories. About 600 tons are shipped in a season.

LOS ANGELES COUNTY.

Quartz veins of sufficient size and purity for glass material are worked in northern Los Angeles County, and no doubt could be opened elsewhere.

C. E. Joslin, 900 Braly Building, Los Angeles, owns a quartz vein 6 miles northwest of Acton which has been opened during the present year. The vein is reported to be 30 feet thick. Analyses of two specimens gave for one 98.3 per cent of silica and 1.3 per cent of iron and alumina, and for the other 99.43 per cent of silica.*



ILL. No. 121. PLANT OF SOUTHWESTERN GLASS MANUFACTURING CO., LOS ANGELES.

Several miles out from Lancaster, Los Angeles County, is a deposit from which quartz is obtained for the glass works at Los Angeles. The quartz is hauled by wagon from the quarry to Lancaster, from which it is shipped by rail to the glass works. It is a white, milky quartz, quite free from impurities.

Southwestern Glass Manufacturing Company, G. E. Bittinger, president, 301 North Avenue 19, Los Angeles, successor to the Los Angeles Glass Company; began operations in February, 1904. The company obtains its lime from Colton and its quartz from Lancaster. Bottles, Mason jars, and packing jars are manufactured. The Mason jars are

* Analyses furnished the Bureau by Mr. Joslin.

made by machine, but the bottles and small jars are blown in molds. The glass is free from iron color, but has a smoky tint that slightly mars its beauty. Located as it is in the midst of one of the greatest fruit districts in the world, this factory should have an extensive local trade in fruit jars and bottles.

MONTEREY COUNTY.

Carmel Development Company, Mr. Devendorf, secretary. Carmel-on-the-Sea has a deposit of sand claimed to be similar to that of Lake Majella and to run 95 per cent silica.

Pacific Improvement Company, Henry Cowell Lime and Cement Company, agent. Deposit at Lake Majella, near Pacific Grove, in southeastern part of T. 15 S., R. 1 W. The sand is arkose. The grains of quartz and feldspar are mostly angular, but mixed with rounded quartz granules. The biotite and hornblende granules occur in limited quantity. The sand is shipped in bulk to the glass factories in San Francisco and Stockton. About one fourth of the output is shipped in sacks—about 50,000, weighing from 80 to 100 pounds each.

ORANGE COUNTY.

Glass sand is found in Sec. 31, T. 7 S., R. 7 W., S. B. M.; R. Egan, Capistrano, owner; about one mile northeast of town, in a cañon entering the Trabuco at Capistrano. On the west side of the creek a bed of sand is exposed over 50 to 60 feet, from 8 to 10 feet high, overlaid by recent clays. Close by, on the east side of the cañon, a similar deposit is exposed over a couple of hundred feet, having a thickness of 25 to 30 feet. This material consists of very minute, angular quartz granules and very fine scales of biotite, sometimes muscovite.

PLACER COUNTY.

Roseville Deposits, in Sec. 8, T. 11 N., R. 7 E.; Thomas Thomas, Roseville, owner. This deposit of glass sand was prospected by G. M. Hanisch, who made borings in this material to a depth of 90 feet. The sand is overlaid by 15 feet of gold-bearing gravel, and lies in a basin formed by lava on the north, black slate on the south, and granite on the east.

Lincoln Deposits, in Secs. 9 and 10, T. 12 N., R. 6 E.; Tallant Banking Company, owner. This deposit was also prospected by Mr. Hanisch; the glass sand was found at an average depth of 25 feet. (See Xth Report of the California State Mining Bureau, pp. 20, 413.) More recent borings were made on a town lot in Lincoln, owned by Frank Elder. Several tons were extracted at a depth of 30 feet.

SAN JOAQUIN COUNTY.

Pacific Window Glass Company; C. J. Hurre, manager. It is located about one mile south of Stockton, was started in 1902, and manufactures only window glass, using the cylinder window-glass process. The equipment includes one continuous melting tank, with a capacity of eighteen pots (thus accommodating eighteen blowers); two flattening ovens, and a cutting, sizing, and shipping department. The crew of skilled labor includes 18 blowers, 18 tender boys, 4 flatteners, and 4 cutters, and the balance is common labor. Ninety men are employed in the factory. Oil is used as fuel. The glass sand is shipped from Monterey County. The management claims that the glass is as good as any Eastern product, and can be furnished in any sizes ranging from 7 by 9 inches up to 50 by 80 inches.

SAN LUIS OBISPO COUNTY.

Glass sand is reported in large quantities and of a very good quality in the mountains about 40 miles east of Arroyo Grande, by J. F. Beckett, Arroyo Grande.

Glass sand is also claimed to be found in the northern part of T. 32 S., R. 13 E., M. D. M., near the Southern Pacific Railroad, 3 to 4 miles south of Edna, in the bituminous rock formation on the Rancho Corral de Piedra. (See also Xth Report of the California State Mining Bureau, p. 573.)

GRAPHITE.

Graphite is sometimes called "plumbago" or "black lead." It is a form of carbon, and occurs in two varieties, crystalline and amorphous. Crystalline graphite is usually found in a compact foliated or granular mass. Graphite is infusible and resists the corrosive action of many chemicals and molten metals, which properties render the crystalline variety with its flake-like form of great value in the manufacture of graphite crucibles. Crystalline graphite is a good conductor of heat and electricity, which renders it of special value in the manufacture of electrical appliances. Graphite is also used for stove polish, foundry facings, paint, and lead pencils; as a lubricant, and in powder glazing, electrotyping, steam packing, etc. (See Bureau of Census, Mines and Quarries, 1902, p. 1017.)

FRESNO COUNTY.

A large body of graphite is found in Drum Valley, 6 miles north of Auckland, Tulare County, on the land of William Kincaid, of Dunlap, and another body on the Reeves ranch, $3\frac{1}{2}$ miles west of Dunlap. (See XIIIth Report of the California State Mining Bureau, p. 642.) These deposits have not been operated on a commercial scale as yet.

LOS ANGELES COUNTY.

D. O. Helman, 2029 New Jersey street, Los Angeles, owns a deposit of crystalline graphite in T. 7 N., R. 15 W., S. B. M., near Elizabeth Lake. It has, however, not been sufficiently developed to prove its commercial value.

In Sec. 4, T. 1 N., R. 13 W., S. B. M., in Verdugo Cañon, 12 miles northeast of Los Angeles, an extensive deposit of graphite is found in a granite country rock. It is amorphous and soft, which renders its separation more difficult and expensive. The soft graphite can only be used for paint. (See IXth Report of the California State Mining Bureau, p. 207.)

Graphite Mine; George A. Skinner and Charles Woodin, both of Kern County, owners. It is located in the northern portion of Los Angeles County, near Saugus. The property is at present undeveloped. It is reported that there are two veins, 4 and 6 feet wide. It has been held by the present owners for about two years.

MENDOCINO COUNTY.

Western Graphite Company, Crossley Building, San Francisco, owns a deposit of graphite in Sec. 8, T. 12 N., R. 15 W., about 15 miles east of Point Arena. The graphite occurs in a blanket formation; it is mined by quarrying, then washed and puddled to free it from quartz inclusions, and later refined in San Francisco. It is marketed as a paint, a lubricant, and for foundry facings.

SAN BERNARDINO COUNTY.

W. E. Van Slyke, 716 Fifth street, San Bernardino. A deposit of graphite, stated to be near the head of the Santa Ana River, in the San Bernardino Mountains, about 15 miles from East Highlands, a station on the Santa Fé Railway. The material is claimed to carry about 50 per cent of graphite, which is apparently of the soft, amorphous variety.

SISKIYOU COUNTY.

A ledge of graphite is reported in the Siskiyou Mountains, very near the top of the ridge on the north slope, opposite the head of the eastern branch of Seiad Creek, about in Secs. 4 and 9, T. 47 N., R. 11 W.

SONOMA COUNTY.

Healdsburg Paint Company.—In excavating for the foundation of a mill at the Healdsburg Paint Company's mine, 10 miles south of Healdsburg, a deposit of graphite was exposed. It was overlooked and covered by a waste dump. The material is apparently very similar to that at the Skinner graphite mine, and to samples from Mendocino County. Small particles of quartz occur throughout the graphite.

Skinner Graphite Mine, E. Leach (care of F. A. Leach, U. S. Mint, San Francisco), owner; in Sec. 14, T. 4 N., R. 7 W., 4 miles south of Petaluma, on the San Rafael road. It was opened about 1894, and has produced \$9000 worth of mineral paint. The development works are at present inaccessible, and there is no outcropping of graphite. Mr. Skinner states "that the graphite occurs as a 40-foot bed, dipping to the north at an angle of about 45 degrees, and that 8 feet of the best material—the upper portion of the bed—averages 90 per cent." Stringers of quartz are distributed throughout the deposit. The ore was merely screened at the mine to remove the quartz, and shipped to San Francisco to be milled and bolted for paint.

TUOLUMNE COUNTY.

Morgan Graphite Mine; R. H. Morgan, Columbia, owner; in Sec. 9, T. 2 N., R. 14 E., about 3 miles west of Columbia. The graphite is said to contain some silica. A few years ago a shipment was made to England, but nothing could be learned of the returns. The works are closed and inaccessible.

GYPSUM.

Gypsum is a hydrous calcium sulphate ($\text{CaSO}_4, 2\text{H}_2\text{O}$), which, proportioned by weight, contains 20.9 per cent of water, 32.5 per cent of lime, and 46.6 per cent of sulphur trioxide. The color is usually white when pure, but sometimes it is gray, yellow, red, brown, or black. It occurs massive, granular, fibrous, and crystallized, in large solid crystals, or in lamellar or scaly crystal masses and sheets. The fine fibrous forms are called *satin spar*, from its satin-like luster, and the transparent crystal forms are called *selenite*. A compact, granular, translucent variety of gypsum is called *alabaster*, and is used for ornamental purposes.

Calcium sulphate occurs in nature without the water of crystallization in the mineral anhydrite (CaSO_4). It occurs associated with lime-

stone and other rocks, sometimes with beds of rock salt, but is not so common or abundant as gypsum.

Calcium sulphate occurs in large quantities in solution in many springs and streams, and in still larger quantities in sea-water.

Uses of Gypsum.—Gypsum has a large number of varied uses in the industries. It is used in the form of plaster of paris. It replaces quicklime in wall plaster, and is frequently used for the hard finish on lime plaster. It is used for making plaster boards and for the smooth finish put on the surface. Large quantities enter into the manufacture of fertilizers, although less than formerly. It is used as a retarding ingredient in Portland cement. It is further used in the paper, the glass, the dyeing, and in many other industries; also as an adulterant for food products.

The researches of Professor Hilgard of the University of California have shown that gypsum is one of the most valuable materials for reclaiming the black alkali lands of central California. There are a number of small gypsum quarries where the product is used locally for this purpose.

The increased demand for gypsum along the different lines is in excess of the supply in California, and a considerable portion of that used is shipped in from other states. The large cement works, potteries, and plaster works in the vicinity of San Francisco obtain gypsum from Nevada.

Methods of Manufacture of Plaster or Plaster of Paris.—In the manufacture of plaster, the gypsum is heated or cooked in large kettles up to a temperature of 177°, when it is withdrawn from the fire. If all the water is driven off, the plaster becomes "dead burned" and refuses to set. If the gypsum is properly burned and ground, when water is added to it a hard, compact material is formed. With the pure gypsum this process takes place quite rapidly—in six to eight minutes.

In its use as wall plaster and for some other purposes it is desirable to have the plaster set slowly. This object is commonly attained by mixing with it some substance which has the property of delaying the final set. Such substances are called retarders and are of different materials, such as sawdust, pulp, fiber, lime, slag, sugar, alkalies, acids, glue, and glycerine.

Sometimes it is desirable to hasten the time and have the plaster set as quickly as possible, which is accomplished by adding what is called an accelerator. Alum or borax is frequently used for this purpose.

It is possible, by adding certain chemicals to the plaster, to make a harder product. Even the natural gypsum rock may be hardened artificially.

Distribution.—Gypsum occurs widely distributed in nearly all localities where the Tertiary rocks occur; that is, in the Coast Ranges, in the Great Valley, and in southern California; but only in few localities does it occur in beds of sufficient size or purity and convenient to transportation to be worked profitably.

The only counties reporting to the Mining Bureau in 1903 were: Kern, 1000 tons, and Los Angeles, 5914 tons, all valued at \$46,441. There was probably a considerable production from small quarries for local use which was not reported.

References on Gypsum Deposits.—1. The VIIIth, Xth, and XIIth Reports of the State Mineralogist of California.

2. Bulletin No. 223, U. S. Geological Survey. Gypsum deposits in the United States.

3. Bulletin No. 11, Vol. III, 1893, N. Y. State Museum.

4. Iowa Geological Survey, Vol. XII, 1901.

5. University Geological Survey of Kansas, Vol. V.

6. Geological Survey of Michigan, Vol. V, Pt. II, 1893.

BUTTE COUNTY.

Gypsum occurs in Butte County in the St. Clair hydraulic mine (long ago abandoned), in Sec. 19, T. 21 N., R. 4 E. It is exposed in the face of the workings in small horizontal ledges or layers, from 3 to 5 feet apart, and extending for about 100 feet across the face.

COLUSA COUNTY.

Gypsum occurs in various sections in the western side of Colusa County, but none has been developed in commercial quantity. It is reported in the Sulphur Creek district, in Sec. 31, T. 17 N., R. 7 W., and in the Ruby King copper mines.

FRESNO COUNTY.

About 9 miles north of Coalinga, in Fresno County, is a gypsum deposit, which occurs in two beds interstratified with clays and shales which dip 20 degrees to the southeast. The product was used for fertilizer in Tulare and Fresno counties.

Paoli Mine.—Professor Hilgard gives a description of this deposit in the XIIth Report of the State Mineralogist, 1894, p. 323. It is located in the ridge bordering the west side of the Great Valley, about 18 miles southwest from Mendota. The gypsum crops out along the crest of several ridges, with a gentle dip toward the valley. The deposit on the crest of the main ridge, where most work has been done,

shows a thickness of at least 30 feet, but its lower limit has not been exposed. The deposit is a very large one, sufficient to supply the needs of the San Joaquin Valley for a long time to come.

Samples collected from croppings by Professor Hilgard show the material to be very nearly uniform from top to bottom; a yellowish-white chalky mass, easily crumbled, and therefore readily put in shape for farmers' use. Eight samples were selected to represent the outcrops in several places. The analyses of four gave the following results:

	Gypsum.	Clay.	Sand, Moisture, and Carbonate of Lime, etc.
No. 1, from summit of main ridge	95.24%	1.98%	2.78%
No. 5, from second spur, middle of crest	94.74	1.52	3.74
No. 6, from third spur, in cañon	92.90	2.60	4.50
No. 7, from fourth spur, near road	82.20	8.21	9.59

KERN COUNTY.

California Gypsum and Mineral Company; J. M. Anderson, Tulare. The deposit is located near McKittrick.

Cottonwood Creek, 5 miles north of Pampa, and 8 miles from Wade, on the Southern Pacific Railroad. The gypsum is stated to occur both as surface crust and in interstratified beds. The material is shipped from Wade, and used for fertilizing purposes. (See Bulletin No. 223, U. S. Geological Survey, p. 121.)

Western Petroleum Company; McKittrick. Sec. 20, T. 30 S., R. 22 E., M. D. M.

LOS ANGELES COUNTY.

Alpine Plaster Company; main office, 720 East Colorado street, Pasadena; branch office, 302 Douglas Building, Los Angeles; David Lang, manager at the works at Palmdale. The gypsum occurs in large quantities in the low foothills about half a mile to the south, and is manufactured into plaster at the factory, which is located near Palmdale, a station on the Southern Pacific Railroad. At present the material is transported in wagons from the quarries to the mill.

The gypsum outcrops for several miles east and west in the low foothills along the south side of the great Antelope Valley, interstratified with conglomerate, sandstone, and shales. The general dip of the strata is to the south. So far as known, the total thickness of the gypsum beds has not yet been ascertained, but there is sufficient showing on the outcrop to furnish a supply for many years to come. Part of the gypsum occurs in fibrous layers one eighth to one half of an inch or more thick, alternating with thin layers of clay and shale. The banded layers are in places rather sharply folded, and in places faulted. (See

Ill. 122.) In other places along the outcrop the gypsum is more massive, shows little crystallization, and contains more or less white and yellow clay diffused through the mass.

The better grades of the gypsum now being quarried, it is stated, run over 80 per cent in calcium sulphate. The workable beds vary in thickness from 2 to 30 feet or more. The present quarry (July, 1904) contains from 4 to 5 feet of commercial product, with almost no stripping. All of the quarrying so far has been on the outcrop along the brow of the low hill. A dozen or more small quarry openings have been made.

The mill has been in operation three years, manufacturing two grades



ILL. No. 122. GYPSUM QUARRY OF THE ALPINE PLASTER COMPANY AT PALMDALE, LOS ANGELES COUNTY. Light bands are gypsum.

of plaster—No. 1, white for finishing; and No. 2, wall plaster. The product is principally used in Los Angeles and Pasadena, and the demand is stated to be steadily increasing. There are two pots in operation, with a capacity of 40 tons of plaster per day, using oil as fuel.

(See XIth Report of the California State Mining Bureau, p. 248; XIIth *ibid.*, p. 324; XIIIth *ibid.*, p. 504.)

Fire Pulp Plastic Company, 750 South Alameda street, Los Angeles, owns a gypsum deposit at the head of San Francisquito Creek, about 13 miles from Castaic. The gypsum is of good quality; it occurs, however, in relatively small pockets and layers within the inclosing country rock.

About two miles north of Lang, a station on the Southern Pacific Railroad, in Sec. 30, T. 5 N., R. 14 W., S. B. M., there is a deposit of gypsum, nearly 8 feet wide, almost perpendicular. (See IXth Report of the California State Mining Bureau, p. 195.)

ORANGE COUNTY.

In Gypsum Cañon, Orange County, on the west slope of the Santa Ana range, is a deposit of white crystalline gypsum, said to be from 8 to 10 feet in thickness. It occurs in sandstone strata, thought to be of Cretaceous age. (See Bulletin No. 223, U. S. Geological Survey, p. 121.)

RIVERSIDE COUNTY.

Adams-Blakely Deposit; H. R. Adams and T. A. Blakely, Braly Building, Los Angeles, owners; in T. 3 S., R. 18 E., S. B. M., in the Old Ironwood Mining District, a deposit dipping at an angle of 45 degrees, reported as about 2 miles long and 1 mile wide. The greater part is granulated gypsum, and runs from 96 to 99 per cent pure. Stone gypsum or alabaster occurs intermediary in dikes. At present the deposit is too distant from the railroad to be worked commercially, but the new Santa Fé cutoff from Parker to Bengal will make it accessible.

Banning Station, near the Southern Pacific Railroad. (See Bulletin No. 223, U. S. Geological Survey, p. 120.)

George W. Lord, Corona. In Secs. 14 and 15, T. 4 S., R. 7 W., S. B. M. The gypsum occurs in a brown ferruginous shale, partly as crystals, partly as fibrous gypsum, and partly as thin flakes crystallized in the seams of the rock. It has been worked by the Standard Fertilizing Company, which took out 250 tons of gypsum in 1901, and about 150 tons before that date; but has not been worked since then.

SAN BENITO COUNTY.

In Bitterwater Creek Cañon a number of detached gypsum deposits are found, running from Lewis Creek, in Sec. 5, T. 19 S., R. 10 E., M. D. M., to Sec. 17 or 18, T. 18 S., R. 9 E. The quality of the gypsum differs materially in the various exposures. (See also Bulletin No. 223, U. S. Geological Survey, p. 120.)

F. Q. Alvarez, Bitterwater P. O. In Sec. 5, T. 19 S., R. 10 E., and Sec. 32, T. 18 S., R. 10 E., on the east side of the Lower Bitterwater. The gypsum lies in, or in close contact with, a belt of serpentine which runs along the east rim of Bitterwater Valley. It is mixed with clay and often of a grayish color; some boulders of white gypsum are, however,

found on the surface. Several years ago some was excavated and hauled to San Francisco, but in later years the deposit has been idle.

Mrs. S. Chambers, Bitterwater P. O. In Sec. 15, T. 18 S., R. 9 E., on the west side of Bitterwater Valley, some gypsum boulders were excavated some years ago. In a well dug near the house a bed of gypsum about 3 feet thick was passed through.

Three hundred yards northeast of the house some open cuts have exposed two beds of a fair quality of gypsum. The country rock is shale, but the gypsum is accompanied by a light gray sandstone containing inclusions of gypsum.

J. F. Dunn, Hollister. On the Topo ranch, in Sec. 17 or 18, T. 18 S., R. 9 E., on the divide west of Bitterwater Valley, a deposit of gypsum lying in a horizontal bed, 3 to 4 feet thick, has been opened for about 100 feet. It has only a soil overburden of $2\frac{1}{2}$ to 3 feet, and is underlaid by shale. The gypsum is of fairly good quality. The deposit is 12 miles from railroad. (See XIIIth Report of the California State Mining Bureau, p. 504.)

J. C. Tully, Bitterwater P. O. In Sec. 32, T. 18 S., R. 10 E. (See Alvarez deposit, of which it forms part.)

R. R. Tully, Bitterwater P. O. In Sec. 11, T. 18 S., R. 10 E. Some detached bodies of grayish-colored gypsum, somewhat mixed with clay.

Estate of T. Williams (deceased), 1003 First street, San José. In the southwestern part of T. 19 S., R. 12 E., and the northwestern part of T. 17 S., R. 12 E., M. D. M., on Silver Creek, indications of gypsum have been found.

SAN BERNARDINO COUNTY.

San Bernardino County contains gypsum beds of promise in many places on the desert, especially in the eastern part, in Amboy sink. They are associated with salt beds and overlaid by a thin layer of clay. They have not been developed.

Near Camp Cady, a gypsum deposit has been located by Willam Hale, 310 D street, San Bernardino, and F. Deming and J. Ackerman, Daggett, one mile from the San Pedro, Los Angeles and Salt Lake Railroad, in the northern part of T. 10 N., R. 5 E., S. B. M. The deposit is stated to be uncovered along a low ridge about 300 feet long, and 100 feet high at the highest point. Very little work has been done on the deposit.

Beds of Selenite (gypsum) also occur associated with salt beds at Danby dry lake, 32 miles southeast of Danby, on the Santa Fé Railway.

SAN LUIS OBISPO COUNTY.

White and gray gypsum occur in irregular, bunchy veins on Alamo Creek, 16 miles from Santa Maria, but very little of it has been used.

SANTA BARBARA COUNTY.

Charles D. Fox, Room 21, Curtaz Building, San Francisco. An extensive deposit in Santa Barbara Cañon, in T. 8 and 9 N., R. 25 W., S. B. M., about 5 or 6 miles south of Quartel P. O., in the Cuyama Valley. It is claimed to contain a very fair grade of gypsum, also alabaster. (See Bulletin No. 223, U. S. Geological Survey, p. 123.) This deposit can be reached by wagon from Santa Maria and from Bakersfield.

Stevenson & Marshall, Casmalia P. O., own a gypsum deposit near Point Sal, on the coast of Santa Barbara County. It has produced considerable gypsum in the past, but has been idle for a number of years, with no prospect of producing again. The gypsum was hauled to Point Sal landing for shipment by water. There are said to be two beds of gypsum occurring in black clay, all dipping down at a high angle. Six different openings were made, and the most accessible part of the deposit has apparently been exhausted. (See also VIIIth Report of the California State Mining Bureau, p. 583; Xth *ibid.*, p. 601; Bulletin No. 223, U. S. Geological Survey, p. 122.)

Selenite is found among the surface débris near Santa Barbara, but no regular deposit has as yet been discovered.

TULARE COUNTY.

California Gypsum and Mineral Company; J. M. Anderson, Tulare; works at McKittrick. In Sec. 21, T. 30 S., R. 22 E., M. D. M. Specially for fertilizer, etc.

Dudley Mine; M. Dickson, McKittrick, Kern County, owner. Idle for several years.

VENTURA COUNTY.

J. F. Dennison, Nordhoff. On the Dennison ranch, about 3 miles east of Nordhoff, a little to the south of the main road to Santa Paula, a gypsum deposit was worked to a small extent more than ten years ago, but not since. (See Bulletin No. 223, U. S. Geological Survey, p. 122.)

INFUSORIAL EARTH.

Infusorial earth or diatomaceous earth, sometimes known as tripoli or tripolite, the German *kieselguhr*, consists of siliceous material secreted by microscopic plants called diatoms. When pure it is generally white or nearly white in color, and consists essentially of opal or colloidal silica and water, but frequently contains as impurity a small percentage of other constituents such as alumina, iron oxide, lime, and magnesia, as shown by the following analyses:

ANALYSES OF DIATOMACEOUS EARTH.

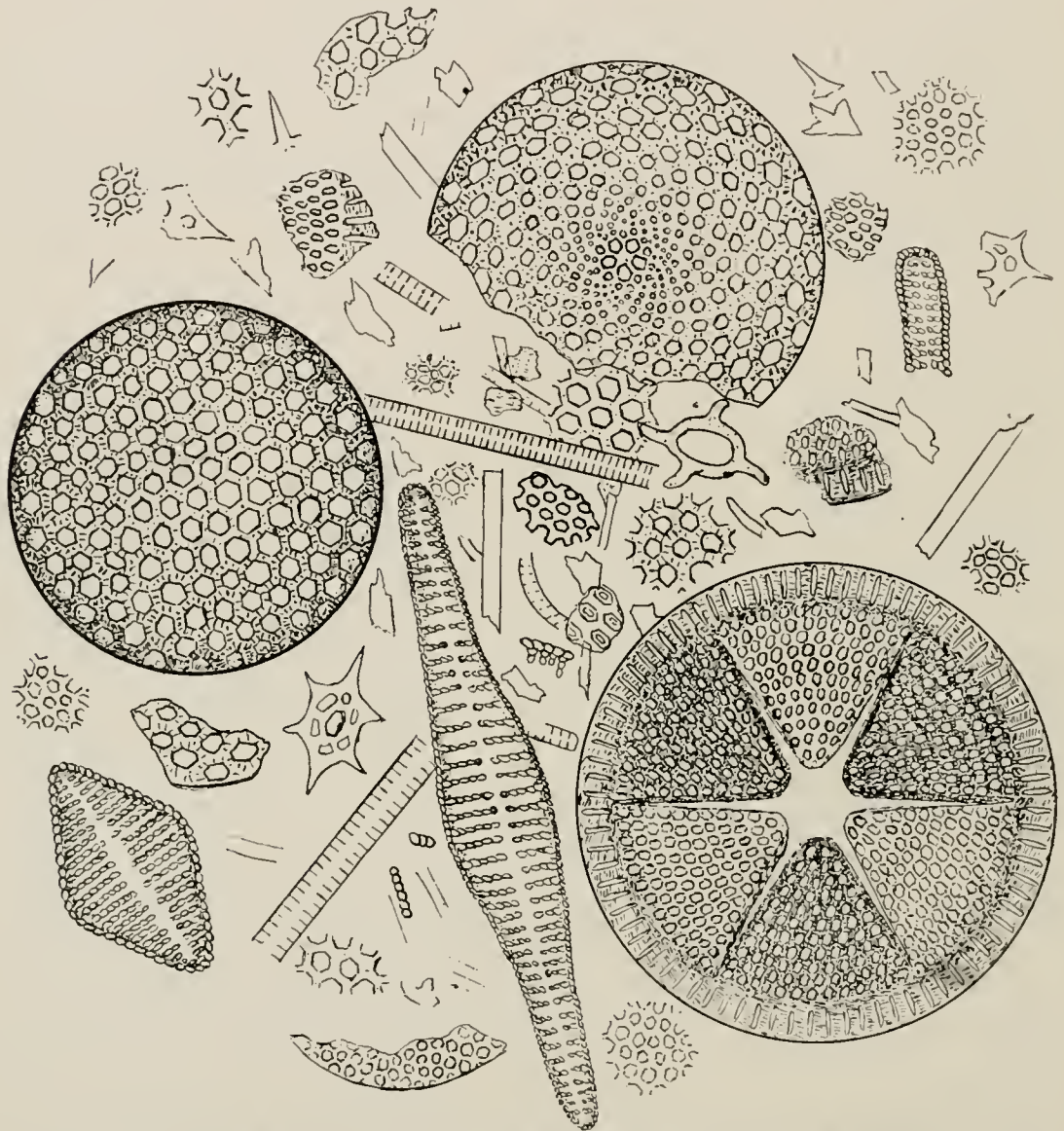
	Silica	Water	Iron Oxide	Alumina	Lime	Magnesia	Alkalies	Totals
White Lake, New York	86.52	12.12	.37	.45	.12	---	---	99.58
Richmond, Virginia	75.83	8.37	2.92	9.88	.29	1.63	---	98.95
Morris County, New York	80.66	14.01	---	3.84	.58	---	---	99.09
Pope's Creek, Maryland	81.53	3.47	3.33	3.43	2.61	5.63	---	100.00
Storey County, Nevada	81.08	18.44	---	---	---	---	---	99.52
Pollet Lake, Canada	80.49	13.33	.95	3.15	.34	.28	---	98.54
Auvergne	1.20	10.00	---	2.00	---	---	---	99.20
Tuscany	79.00	12.00	3.00	5.00	---	---	---	99.00
Aberdeen	95.34	.03	3.65	---	---	---	---	99.02
Hanover	84.15	10.40	.70	1.40	1.75	1.10	---	99.50
Little Truckee River, Nevada	91.43	3.80	.66	2.89	.36	.25	.95	100.34
Fossil Hill, Nevada	86.90	5.99	1.26	4.09	.14	.51	1.18	100.07

The diatom plants are exceedingly minute; there are a great many kinds and varieties, some of which inhabit fresh water and some salt water. The marine forms are very widely distributed; in places they make up the bulk of the ooze of the deep sea, where it is called diatom-ooze. The diatoms are very abundant in many fresh waters; they accumulate in great quantities in some of the fresh-water lakes. (See further, *Mineral Resources*, 1901, p. 798.) Probably the largest deposits in the world occur in California.

The Eleventh Census Report, *Mineral Industry*, page 707, states that the first development of infusorial earth in California was made in 1889, near Calistoga, Napa County.

Infusorial earth is not soluble in acids, but is soluble in alkalies and has great absorptive powers. Its specific gravity is about 0.25; when saturated it has a density of 1.24. After calcining, the specific gravity is increased about 50 per cent. This excessive porosity, together with the hardness of the constituent particles, gives the earth its economic value. It is used as an absorbent for nitro-glycerine in the manufacture of dynamite. It is one of the best non-conductors, and is used

extensively for packing boilers and steampipes; also in the manufacture of fire-proofing and building and refractory brick, which are used where lightness is important. It is further used extensively as a polishing powder, and in the manufacture of scouring soaps. It is a superior filtering material for many purposes, because of its porosity. A new



ILL. No. 123. DIATOMACEOUS EARTH FROM LOMPOC. HIGHLY MAGNIFIED. THE MICROSCOPE SHOWS ITS REMARKABLE PURITY AND POROSITY.

use introduced in Germany is for cleaning and scouring wool by forcing it through the wool by air blast.

The production of diatomaceous earth in the United States is as follows:

	Tons.	Value
1898 -----	1,392	\$11,002*
1899 -----	3,000	30,400*
1900 -----	3,615	24,207†
1901 -----	4,020	52,950†
1902 -----	5,655	59,808
1903 -----	9,219	76,273

* Min. Ind., Vol. VII, p. 607.

† Min. Res., p. 799.

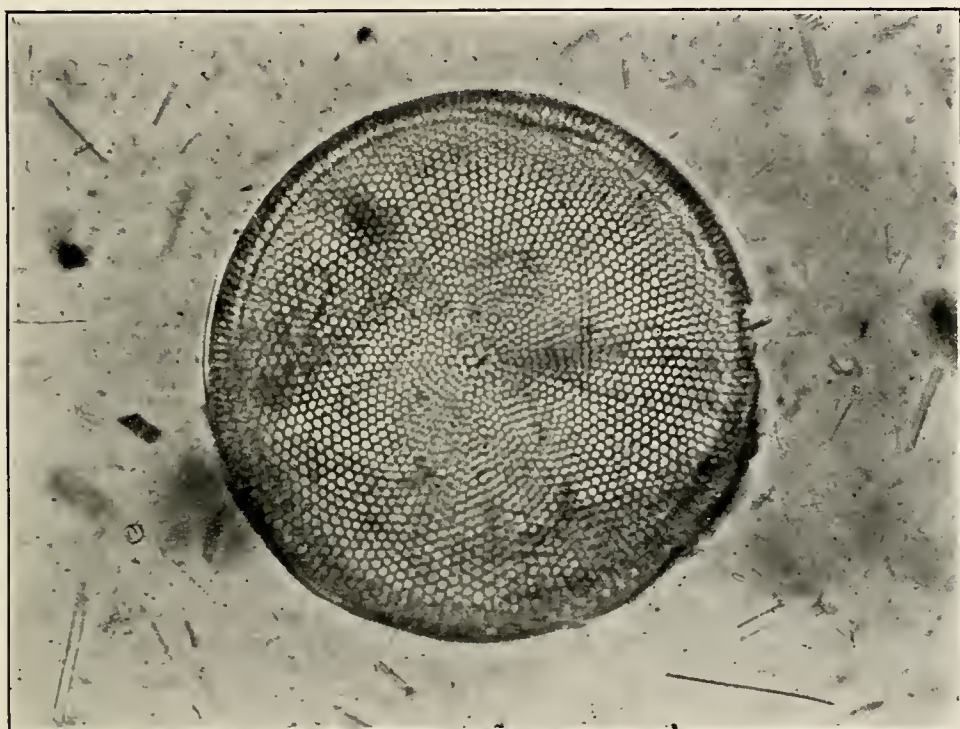
The product in California in 1902 was 422 tons, valued \$2,532; in 1903, 2703 tons, valued at \$16,015; in 1904, 6950 tons, valued at \$112,282.

The Eleventh Census Report, Mineral Industry, page 707, gives the value of the diatomaceous earth in the United States for 1889 as \$23,372, distributed as follows: California, \$8,000; Connecticut, \$422; Maryland, \$10,700; New Hampshire, \$2,750; and New Jersey, \$1,500.

References.—1. Mineral Industry, N. Y., Vol. VII, p. 606.

2. American Jour. of Sci., 1854, Vol. XVII, p. 179. J. W. Bailey.

3. American Jour. of Sci., 1891, Vol. XLII, p. 369. A. M. Edwards.



ILL. No. 124. PHOTOMICROGRAPH OF DIATOM FROM THE LOMPOC DIATOMACEOUS EARTH. ENLARGED 235 DIAMETERS.

4. Eighth Report of the California State Mining Bureau, p. 532.
 5. Tenth Report of the California State Mining Bureau, p. 583.
 6. Thirteenth Report of the California State Mining Bureau, p. 643.
 7. Bulletin No. 28, California State Mining Bureau.
 8. Bulletin Santa Barbara Soc. Nat. Hist., No. 1, 1887, pp. 8-11.
- W. W. Finch.

LOS ANGELES COUNTY.

Banning Company, 593 Pacific Electric Building, Los Angeles, owns a deposit of infusorial earth on Santa Catalina Island, from which considerable amounts have been shipped. (See XIIth Report of the California State Mining Bureau, p. 406; XIIIth *ibid.*, p. 643.)

J. Bixby, Currier Building, Los Angeles. On the Los Palos Verdes ranch, San Pedro Mountains, are several exposures of infusorial earth

of a very chalky character. None, however, has been developed to any extent.

At **Point Duma**, northwest of Santa Monica, there is a large deposit of infusorial earth. (See IXth Report of the California State Mining Bureau, p. 208.

MONTEREY COUNTY.

A belt of infusorial earth runs along the eastern foothills of the Santa Lucia range, from the southern boundary of the county, in T. 24 S., R. 10 E., in a northwesterly direction to the Arroyo Seco, in T. 19 S., R. 6 E., and then shows again, in the same general direction, in Secs. 36 and 26, T. 15 S., R. 2 E. West of Bradley, in the northern portion of T. 24 S., R. 10 E., some work has been done on this belt.

B. J. Riewerts, Bradley. Sec. 4, T. 24 S., R. 10 E. The infusorial earth shows along the slope of the cañon, running in an east and west direction; it has been opened over a length of 300 feet, showing a thickness of from 10 to 15 feet, but is probably thicker. The infusorial earth is very light, white or very light gray, and is cut by seams of silicified clays. It forms a very refractory material. Three carloads were shipped in 1904—one to the Yeso Manufacturing Company, San Francisco.

This deposit continues in Section 9, same township, on land belonging Mr. Leprosy, San Francisco; and in Section 10, on land belonging to O. P. Spencer, Bradley.

ORANGE COUNTY.

Around Alisos Creek, south of El Toro, a great amount of infusorial earth is found scattered among the surface débris and clays. As far as could be observed, it is not very pure. No efforts have been made to open up any of these deposits.

SAN BENITO COUNTY.

A. Leonard, San Benito. In Secs. 20 and 28, T. 16 S., R. 8 E., between Bear Valley and the San Benito, deposits of infusorial earth are claimed to be found.

SAN BERNARDINO COUNTY.

A small deposit of infusorial earth is claimed to occur in the northern part of T. 2 N., R. 9 E., S. B. M., about 12 miles from Twenty-nine Palms, and 40 miles from Palm Station. It is stated to be about 2 feet thick. Unappropriated Government land.

SAN LUIS OBISPO COUNTY.

The belt of infusorial earth running through the southern part of Monterey County continues into San Luis Obispo County, showing in detached exposures along a general southeastern direction from T. 25 S., R. 10 E., to T. 28 S., R. 14 E., M. D. M. Some deposits of infusorial earth are also found in the belt of bituminous rock south of San Luis.

J. F. Beckett, Arroyo Grande. North of the town, close to the Pacific Coast Railroad, is an undeveloped deposit of infusorial earth.

Frank Silva, Verde. In Verde Cañon, about 3 miles north of Arroyo Grande, is an exposure of very white infusorial earth.

J. Tognizi, Edna. West and close to the Southern Pacific Railroad, opposite Edna, infusorial earth shows for a couple of hundred feet in a slide on the hillside, about 35 feet above the railroad track.

In Sec. 23, T. 26 S., R. 10 E., M. D. M., in the Rancho Corral de los Mulos, an exposure of infusorial earth is found in a gulch, near the road from Oak Flat to Adelaide. (See also Xth Report of the California State Mining Bureau, p. 583, where its analysis is given as follows: SiO_2 , 70.23 per cent; Al_2O_3 , 16.55 per cent; CaO , 1.06 per cent; MgO , 0.59 per cent; K_2O , 11.32 per cent.)

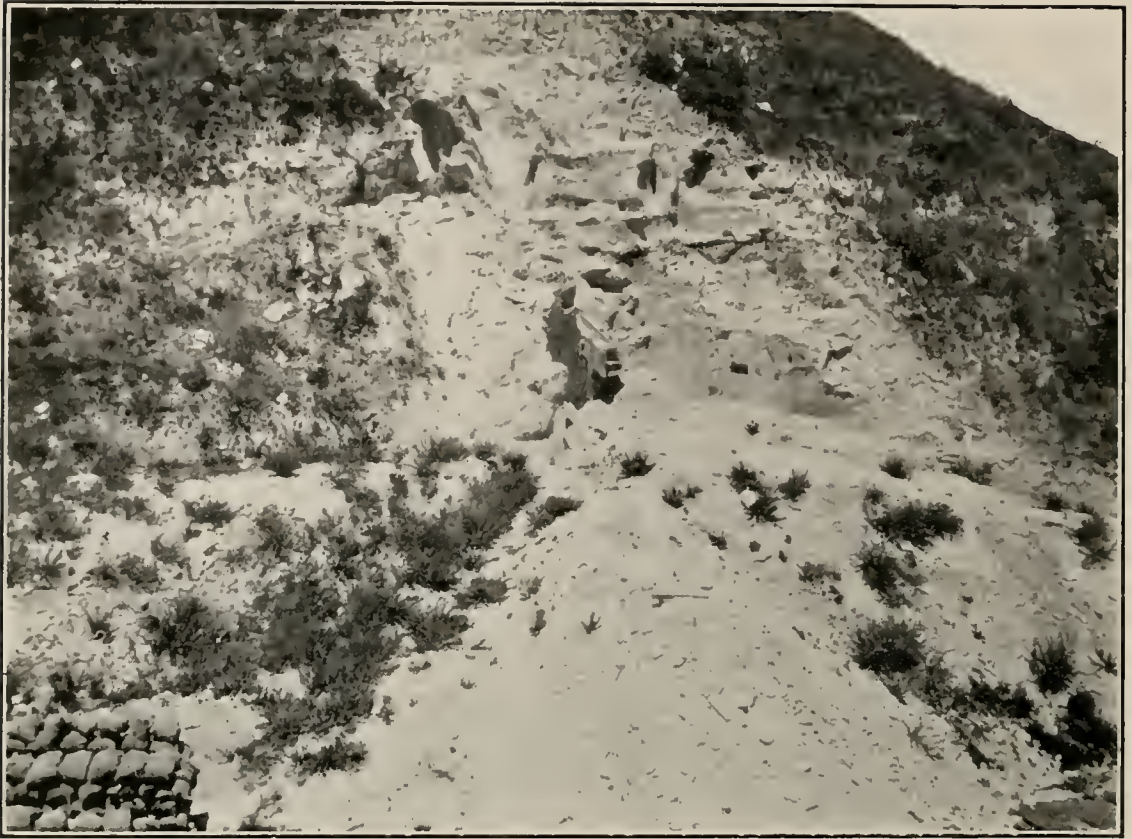
In Sec. 11, T. 25 S., R. 10 E., M. D. M., another small exposure of infusorial earth is found.

SANTA BARBARA COUNTY.

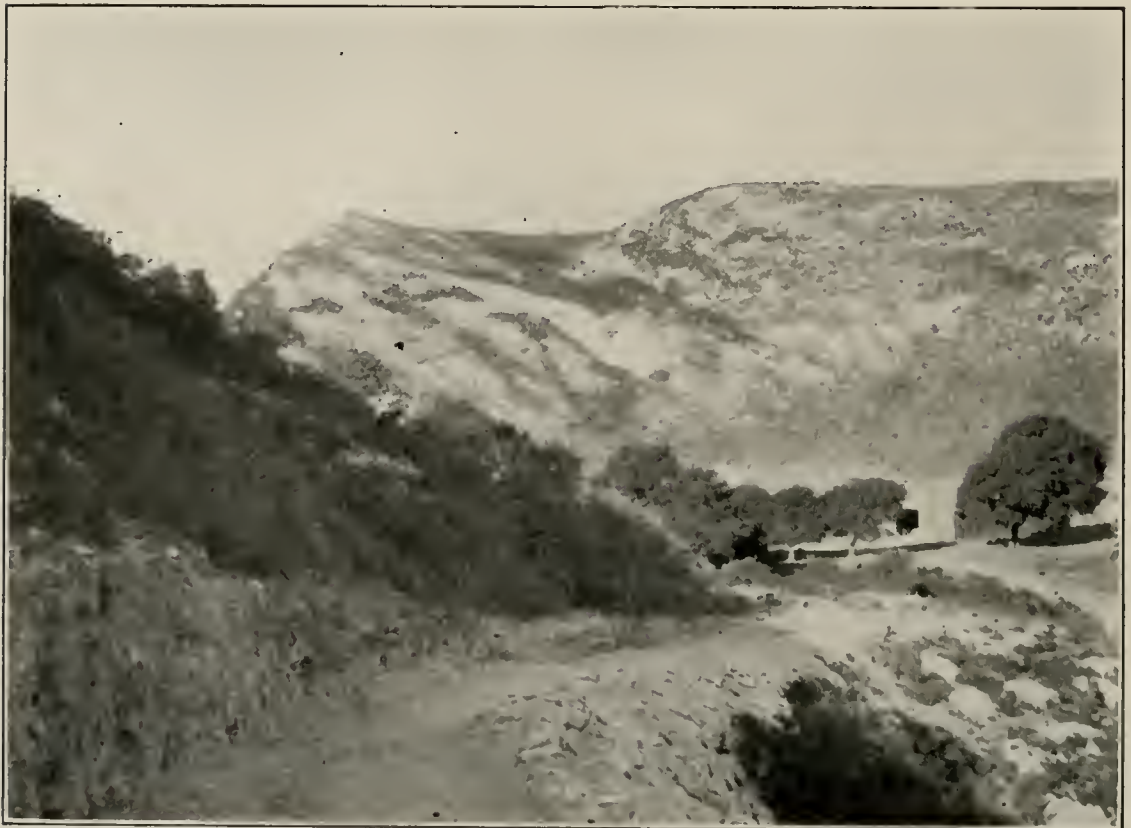
The Lompoc infusorial earth is undoubtedly the best quality found as yet in the State.

Balaam Mine; Balaam Brothers, Lompoc, owners; H. F. Kidwell, Lompoc, superintendent. In an eastern side cañon of the San Miguelito, about 2 miles south of Lompoc; elevation, 575 feet. A very light (26 pounds per cubic foot), flaky and white infusorial earth. The strata dip south about 30 degrees, conformable with the underlying shales, and show on both sides of the cañon to a thickness of about a couple of hundred feet. The deposit consists of very thin, regularly bedded layers of the material, with occasional narrow, conformable seams, from 1 to 2 inches wide, of a dark brown siliceous shale. The face of the quarry is about 30 feet high.

This material is used as a boiler and pipe covering; as furnace lining, by adding some gypsum as a hardening ingredient; in the beet-sugar factories, replacing limestone; and more especially in the manufacture of fireproof plaster at the Fireproof Plaster Works at Emeryville, Umthard Brothers, 514 Twelfth street, Oakland.

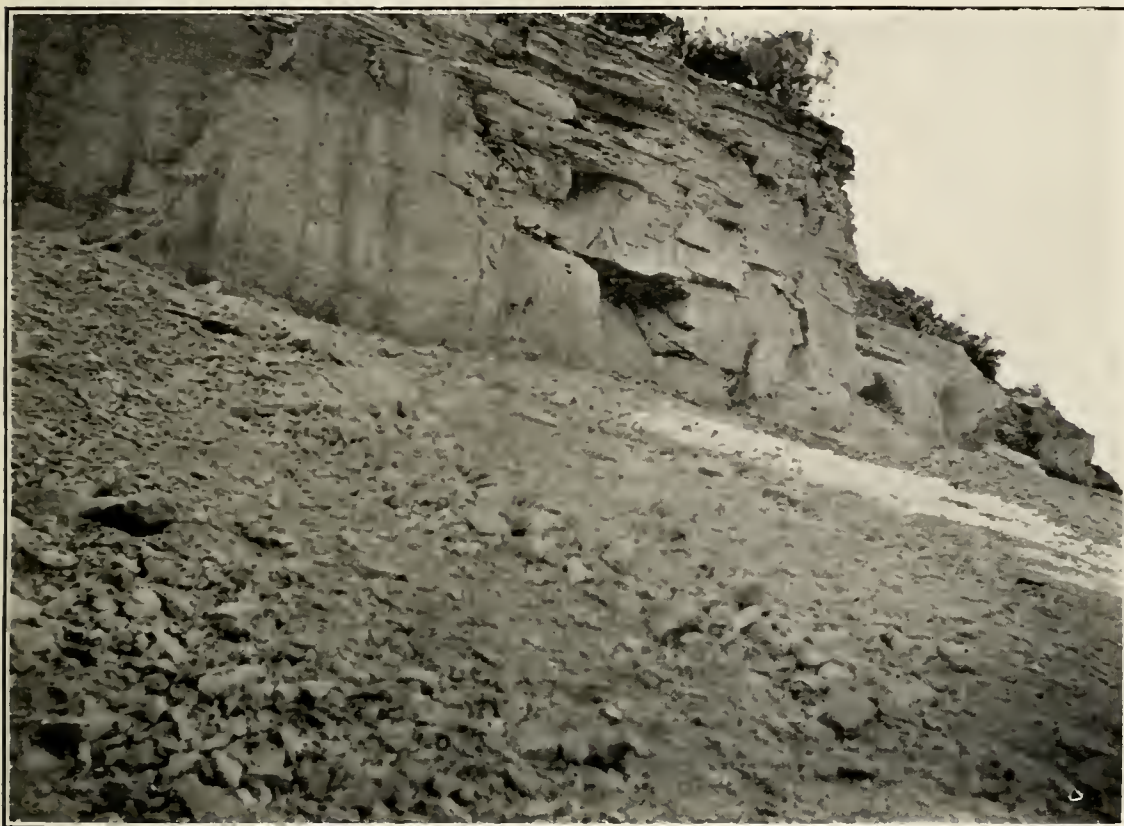


ILL. No. 125. QUARRY OF INFUSORIAL EARTH AT LOMPOC, SANTA BARBARA COUNTY.

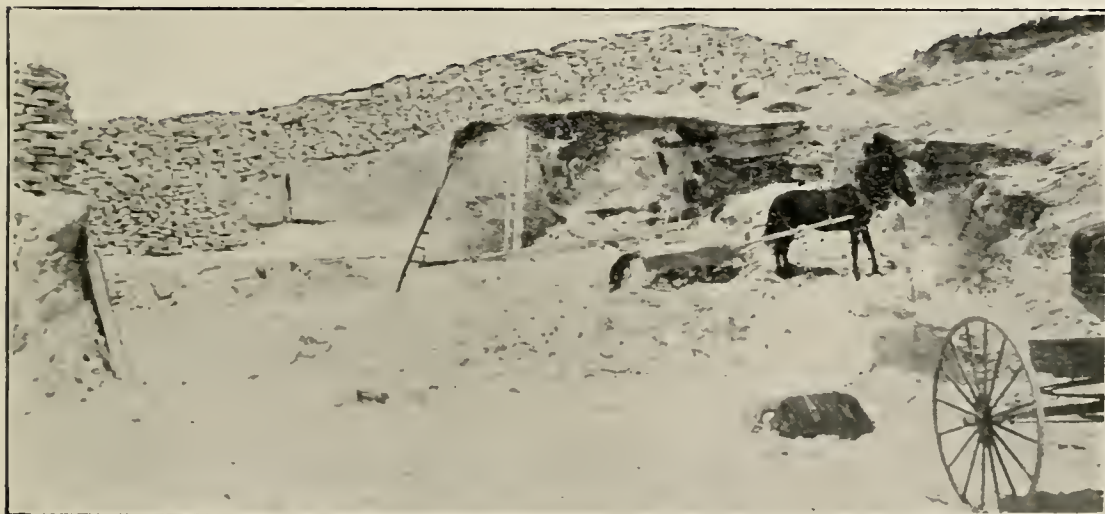


ILL. No. 126. OUTCROP OF INFUSORIAL EARTH OPPOSITE BALAAM BROS.' QUARRY,
LOMPOC, SANTA BARBARA COUNTY.

Bank of Lompoc.—On the Santa Rita ranch, on the north bank of the Santa Ynez River, about 5 miles in an air line east of Lompoc, is an undeveloped deposit of infusorial earth of considerable size. This



ILL. No. 127. BALAAM BROS.' QUARRY OF INFUSORIAL EARTH, LOMPOC, SANTA BARBARA COUNTY.



ILL. No. 128. "MAGNE SILICA QUARRY," INFUSORIAL EARTH, NEAR LOMPOC, SANTA BARBARA COUNTY.

deposit is cut by the Santa Ynez River; the portion south of the river lies in the Salsipuedes Ranch (see below). It lies evidently in the trough of the underlying shales.

Dimock Mine, Magne Silica Company (Harriman & Hanimore), Los Angeles, owner. It is at the head of an eastern side cañon of the San Miguelito, about three fourths of a mile south of Lompoc; elevation, 900 feet. A very large body of infusorial earth, in very thin layers, but somewhat more compact than in the Balaam mine; and in places light gray. The beds are nearly horizontal. A tunnel about 150 feet is run into the hill; near its breast a raise over 100 feet high runs through the material to the surface. The earth is sacked for shipment and used by the company in its works at Los Angeles.

The same company also owns part of the Moody property, adjoining the Balaam mine to the south, on which it is claimed an extensive deposit of infusorial earth is found, as yet undeveloped.

Salsipuedes Ranch, Hollister Estate, Santa Barbara, owner. (See Bank of Lompoc, above.)

Sunnyside Mine, M. M. Telford; owner. In a side cañon of the San Miguelito, between the Dimock and Balaam mines. Idle for the last few years.

Along the south slope of the Santa Ynez Mountains, in the vicinity of Santa Barbara, are a number of patches of more or less impure infusorial earth.

SHASTA COUNTY.

In the northeastern part of the county, but more especially along both banks of Pit River, near the mouth of Hat Creek, and up that creek for about 5 miles, several exposures of infusorial earth, locally called chalk, are found in beds of varying thickness. Only a relatively small part of these beds is pure, the greater portion being mixed with sand. The pure beds are seldom over 10 feet thick, and are interbedded with tuffs and basaltic débris.

T. W. Brown and Mrs. E. Ray, Carbon, owners. In Secs. 7 and 18, T. 36 N., R. 4 E., M. D. M., along Hat Creek.

Mrs. E. Ray and W. Tyrrel, Carbon, owners. In Sec. 7, T. 36 N., R. 4 E., M. D. M., along the north bank of Pit River.

Above the Farmers' bridge a ridge of infusorial earth shows, both north and south of Pit River, in Section 17.

Another ridge shows also on both sides of the river in Section 16. The exposure south of the river is the largest in this region—the so-called chalk-slide, on the Winters road. It is at least 100 feet high, but the infusorial earth is not of as good a quality as that in Hat Creek, and is interbedded with sandstone.

TEHAMA COUNTY.

Near Lassen Butte, in the northeastern part of the county, considerable deposits of infusorial earth are said to be found.

IRON.

BUTTE COUNTY.

Diamond Match Company, Chico, owner. Sec. 5, T. 25 N., R. 4 E., M. D. M. The iron occurs chiefly in the form of float, on a plateau, at an altitude of about 6000 feet. An open cut 12 feet deep was made several years ago, cross-cutting the supposed ledge.

Heavy iron float is also found in Secs. 7 and 27, T. 23 N., R. 4 E., belonging to the same company.

John Morrison, Sec. 30, T. 25 N., R. 5 E., M. D. M. Heavy iron float.

J. F. Nash, Stirling, and **J. C. Burden**. Secs. 5 and 8, T. 25 N., R. 4 E., M. D. M. Locations.

J. H. Rempel. Secs. 5 and 8, T. 25 N., R. 4 E., M. D. M. Locations.

CALAVERAS COUNTY.

Big Trees Iron Mine, Willard Sperry, Gridley, Butte County, owner. In Sec. 32, T. 4 N., R. 14 E., M. D. M., about $1\frac{1}{2}$ miles north of Murphys. It has been idle for several years, but considerable work was done years ago in the nature of open cuts, drifts, and some shafts. The iron (limonite) forms a capping of the entire hill.

Detert Iron Mine, Mr. Detert, Jackson, Amador County, owner. In Sec. 11, T. 4 N., R. 10 E., M. D. M., $1\frac{1}{2}$ miles north of Valley Springs, at the head of Skunk Hollow. Only assessment work has been undertaken.

EL DORADO COUNTY.

Reliance Mines, Reliance Mining and Smelting Company, owner; L. W. Simmons, president, 2695 Howard street, San Francisco. In Sec. 18, T. 10 N., R. 9 E., M. D. M., 8 miles northeast of Folsom. The ore is stated to be a magnetite, occurring in two $4\frac{1}{2}$ -foot veins, cropping out over a considerable distance, with a decomposed hanging and a granite foot wall. Developed by three shafts, 50, 218, and 312 feet deep, respectively.

LOS ANGELES COUNTY.

John Carroll, Fourth and Junipero streets, Long Beach, and **J. D. Rivard**, 2915 Downey avenue, Los Angeles. A deposit of magnetite within 200 yards of the Southern Pacific Railroad, at Russ Station (Soledad Cañon). Only a little development work has been done. Some years ago a small furnace, using oil as fuel, was erected at the deposit, but proved a failure.

The Iron Maek, H. Reblick, Acton, and E. L. Baker, 713 West First street, Los Angeles, owners. In Sec. 36, T. 6 N., R. 14 W., S. B. M., at the head of Mint Cañon, about 10 miles northwest of Acton. A deposit of low-grade material, containing some small pockets of magnetite, accompanied by some manganese ore. From a pit less than 10 feet deep, some ore was shipped a few years ago.

MADERA COUNTY.

Minaret Iron Mines.—In the eastern portion of Madera County, near the Mono County line, on the south slope of the Minaret Mountains, about twenty-nine locations were made on the belt of iron ore, which extends for about 2 miles in a general northwest and southeast course, with an exposure of ore averaging 300 feet in width. Some prospecting was carried on during 1891–92, but since then they have been idle. The ores are hematite and magnetite.

Mount Raymond Iron Mines, T. G. Hart, 1924 Tulare street, Fresno, in charge. In Secs. 9, 10, 14, 15, 22, and 23, T. 5 S., R. 22 E., on the west slope of Mount Raymond and about 33 miles east of Raymond Station, a little development work has been done on some large bodies of magnetite and hematite ore. Large quantities of limestone are close at hand, but, as in other California iron mines, the question of fuel is the hindrance to development.

NEVADA COUNTY.

There are two distinct exposures of iron croppings in this county, indicating an iron belt extending from T. 15 N., R. 7 E., to T. 14 N., R. 8 E. No persistent prospecting of Nevada County iron has been done.

Indian Springs Deposit, M. C. Taylor, San Francisco, owner. In Sec. 4, T. 15 N., R. 7 E. A tunnel has been driven on this property about half a mile east of the heavy croppings, which stand 300 feet high by 150 feet long and 100 feet wide. The outer or upper cropping is a heavy gossan. The main body is hematite.

Niekerson Ranch Deposits, J. R. Niekerson, Wolf P. O., owner. In Secs. 33 and 34, T. 15 N., R. 7 E., and in Sec. 7, T. 14 N., R. 8 E., are indications of iron ore.

PLACER COUNTY.

Hotaling Iron Mines.—Iron in commercial quantity and quality was mined and smelted in Placer County several years ago, in Sec. 15, T. 13 N., R. 8 E., at Hotaling, by the Phoenix Iron and Lime Company. Several thousand tons of hematite iron are still on the dump, and the remains of the smelting furnace and buildings are on the ground.

Weimer Deposits.—In Sec. 21, T. 14 N., R. 9 E., near New England Mills (or Weimer), iron croppings are visible and are traceable in a northwest course to Bear River. Very little prospecting has been done, and these iron deposits have only been operated in former years by the Phoenix Iron and Lime Company.

PLUMAS COUNTY.

Iron (magnetite), said to be of fair quality, occurs in T. 22 N., R. 9 E.; undeveloped.

SAN BENITO COUNTY.

Quilty Iron Mine, J. S. Hawkins, Hollister, owner. In Sec. 6, T. 15 S., R. 6 E., M. D. M. Has been idle for many years. (See also VIIIth Report of the California State Mining Bureau, p. 490.)

Estate of T. Williams (deceased), 1003 First street, San José. In T. 17 S., R. 12 E., M. D. M., on Silver Creek. Indications of iron ore are found on this property. (See VIIIth Report of the California State Mining Bureau, p. 490.)

Numerous surface indications of iron ore are found on the Mount Hamilton range of mountains, in the northwestern part of the county, between Stayton and the Panoche Pass, but no iron ore in place has as yet been discovered.

SAN BERNARDINO COUNTY.

Alarm Iron Mine, The California Industrial Company, owner; S. T. Merrill, secretary, East Fourth street, Los Angeles. In Sec. 1, T. 5 N., R. 4 E., S. B. M., 16 to 20 miles from railroad. A deposit of Bessemer ore. This mine forms a part of two groups, known as the San Bernardino iron mines.

Cave Cañon Group, owned by Eastern parties. In Secs. 12 and 13, T. 11 N., R. 7 E., S. B. M.; patented. Located very near the Salt Lake Railroad. Reported to be an extensive deposit of Bessemer iron ore.

Iron Age Mine, A. R. Rhea et al., owners, 545 East Third street, Los Angeles. Three patented claims in Sec. 29, T. 1 S., R. 13 E., S. B. M., near Dale. The ore is claimed to average 67 per cent of iron, carrying some phosphorus, but no sulphur.

Iron Mountain Group, Colorado Fuel and Iron Company, Denver, Colo., owner. In Secs. 11, 12, 13, and 14, T. 15 N., R. 6 E., S. B. M. Reported to be a large deposit of Bessemer iron ore.

Iron Mountain, in Secs. 27 and 28, T. 6 N., R. 4 E., S. B. M.; Mrs. Phœbe Owens, 1225 San Bruno avenue, San Francisco, and E. S. Lake, Los Angeles, owners. Contains two well-defined parallel veins of iron

ore, course about N. 20° E., and dipping 30° northwesterly. The Tip Top is the most northerly vein, from 30 to 150 feet wide. The ore is both hematite and magnetite. The hanging wall is a dolomite, bounded on the north by granitic rocks. The foot wall is a body of syenite, about 150 feet wide, which forms the hanging wall of the Dick Turpin vein, containing very pure magnetite ore. In the same vicinity is the Bessemer vein, course north and south, reported free from phosphorus and sulphur.

Four miles southeasterly is another body of magnetite ore, varying in width from 20 to 100 feet, course north and south.



ILL. No. 129. IRON VEIN, SAN LUIS OBISPO COUNTY.

Kingston Mountain and **Resting Springs** are also reported to contain magnetic iron ore. (See J. H. Crosman, IXth Report of the California State Mining Bureau, pp. 235 and 236; also XIth *ibid.*, p. 349.)

SAN DIEGO COUNTY.

A little north of the Gold King mine, about in Sec. 10, T. 13 S., R. 4 E., S. B. M., a belt of iron-ore boulders is found. (See IXth Report of the California State Mining Bureau, p. 144.)

In Eagle Peak Cañon, near the south corner of Secs. 34 and 35, T. 13 S., R. 2 E., S. B. M., a vein of hematite iron ore is found. A. Juch, Julian. (See IXth Report of the California State Mining Bureau, pp. 144 and 154.)

SAN LUIS OBISPO COUNTY.

H. B. Perfumo, San Luis Obispo, owns an extensive deposit of iron ore in Sec. 1, T. 31 S., R. 11 E., and Sec. 6, T. 31 S., R. 10 E., M. D. M. The vein has been traced by its outcrop about $1\frac{1}{2}$ miles, in a direction S. 73° E. The creek crosses the vein at nearly right angles, and the ore is exposed on the creek bank and on the hills on each side. In many places the vein stands out prominently 2 or 3 feet above the surface. The ore consists of limonite and hematite, and the surfaces of the numerous cracks are frequently covered with a blue-black coating suggestive of manganese. The ore is banded and intersected by many cleavage planes, so that a large block is shattered by a heavy blow with a hammer into many fragments, which generally have either a rhombohedral or hexagonal outline.

SHASTA COUNTY.

The most prominent deposits of iron ore in Shasta County are found in close proximity to the McCloud Carboniferous limestones on both sides of the Pit River.

North of Pit River and east of the McCloud River there are extensive surface indications of iron ore bodies, and in Sec. 26, T. 34 N., R. 4 W., M. D. M., a great number of openings, distributed over a considerable area, have been made on the surface croppings, but in no place has enough work been done to furnish sufficient data regarding the importance and continuity in depth of these deposits. (See also J. S. Diller, Bulletin U. S. Geological Survey, No. 213, pp. 130 and 219.) A great many claims have been located on this section, the ownership of which is indicated on the detail sketch. (See Sketch B, page 302.)

In places *d*, Sketch B, inclusions of the iron ore in the limestone are found. A tunnel running under the iron ore exposure at *d* has proven that it did not persist in depth.

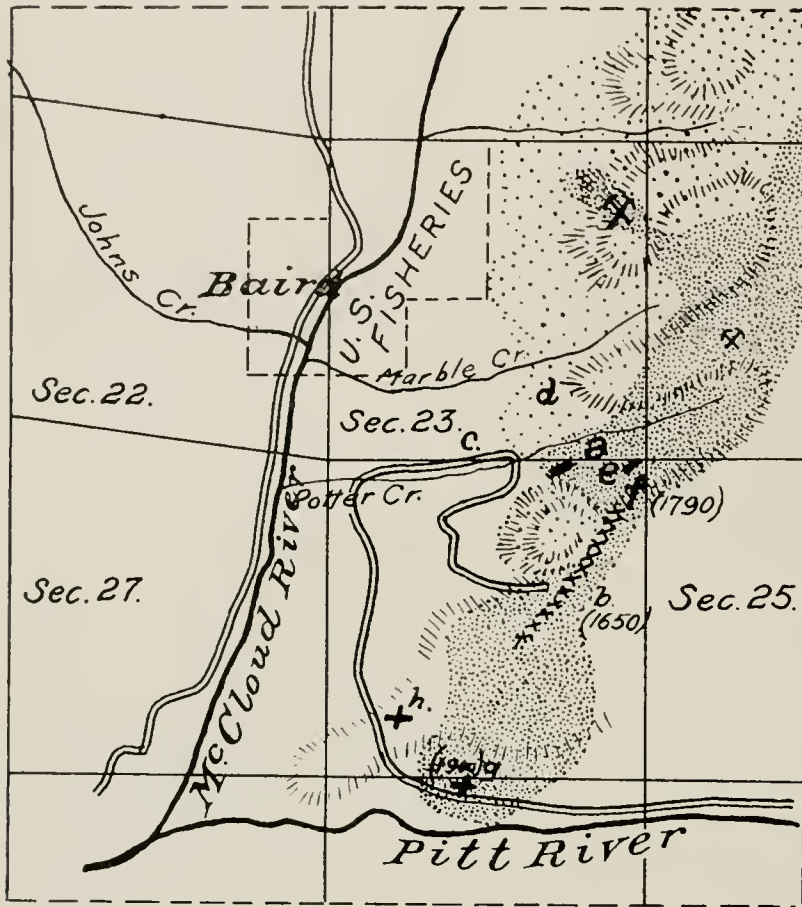
A little southwest of *d* a tunnel has been driven in hypersthene and diorite country rock. Evidently the hypersthene was mistaken for iron ore by the parties running this tunnel.

South of *c*, on the south side of Potter Creek, in the northeast corner of Section 26, there is a large lump of iron ore (*a*), mostly limonite. The country rock is here very much altered. Along the west side of the limestone knoll, in the northwest quarter of Section 26, a number of shallow openings between *a* and *b* show similar iron ore.

A continuous ore cropping, having a northeasterly direction and running on the south side of the same knoll, can be traced for a considerable distance. On this deposit is the largest opening on this section (*b*), which is about 40 feet wide and 15 feet deep. The opening is entirely in ore, principally magnetite. To the northwest lies the limestone

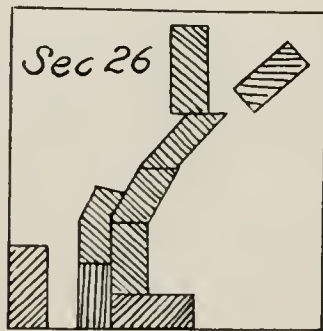
knoll; to the southeast the altered igneous rocks (metarhyolite) of the Bully Hill copper belt. The beds lie dome-like, and apparently the iron ore is a replacement product.









At *f* the magnetite is to a certain extent in a state of magnetic



polarity, forming loadstone. The distance from *f* to *b* is about 250 feet, and *f* is about 140 feet above *b*. The croppings between these two points are continuous, but nothing as yet developed would justify the assumption that at *f* the ore body would have a depth of 140 feet. Northeast of *f*, between *f* and *e*, and southwest of *b*, for about 300 feet iron ore croppings are found, but they do not follow the limestone exposures.

At *g*, not far from the center of the south line of Section 26, near Pitt River, on the road to Copper City, iron ore is exposed over a distance of about 100 feet. Several hundred tons of this ore were used as a flux in the Bully Hill copper



-  Lime.
-  Igneous, Metarhyolite.
-  Baison Radcliff.
-  Shasta Iron Co.
-  Calif. Cons. Iron Mine.
-  T. L. Bass, Balrd.
-  Copper.
-  Iron.

ILL. No. 130. SKETCH B, IRON DEPOSIT NEAR BAIRD, SHASTA COUNTY.

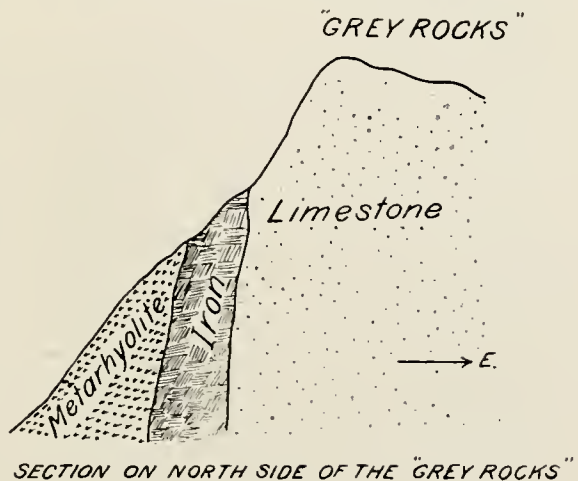
furnaces. This deposit is entirely in the igneous rock, and no limestone exposure is found in its vicinity. There are strong indications of sulphur in the water flowing out of the excavation, which is the more noteworthy as not over 600 feet west, and at a lower elevation

near the river, Mr. T. L. Bass has run a tunnel wherein he found iron ore carrying considerable sulphide of iron. This would lead to the supposition that the deposits of iron oxides, uncovered, are only superficial and will in depth change into sulphides.

At *h* are a number of shallow cuts on another iron ore body, which lies in line with the *f*-*b* deposit, and may be its continuation.

While the ores so far uncovered are principally oxides, limonite, hematite, and magnetite, the association of sulphur with the deposit *g*, the occasional presence of sulphides, as also the character of the deposits in the vicinity of the Grey Rocks, would tend to lead to the supposition that the original ores were sulphides. Mr. J. S. Diller is of the opinion that the ore bodies are a contact phenomenon of the McCloud limestone with dioritic and diabasic masses which cut the limestone. (Bulletin U. S. Geological Survey, No. 225, p. 178.) While this is possible, even probable, the occurrences as above described do not absolutely establish the fact.

To the south of Pit River, on the north and west side of *Grey Rocks*, in the N. $\frac{1}{2}$ of Sec. 3, T. 33 N., R. 4 W., R. H. Roseman, Bayha P. O., has opened up iron ore bodies on the contact of the limestone. On the north side of the Grey Rocks the iron ore dips nearly vertical. It is from 10 to 15 feet wide. The ore is a magnetite and contains bunches of copper ore, carbonates and sulphides. Adjoining the iron ore are also bodies of copper ore. The west wall of these ore deposits is nearly everywhere eroded, or covered by débris, but in one place a remnant shows it to be the metarhyolite, almost vertically bedded. The east wall is limestone.



ILL. No. 131.

On the west side of the Grey Rocks, in the same north half of Section 3, the same owner has opened up a body of iron ore by a small cut and tunnel. The iron ore is partly solid iron sulphide, partly iron oxide. It lies nearly horizontal and rests on metarhyolite, approximately horizontally bedded. Strong sulphur efflorescence occurs in the opening, which is in the neighborhood of basic igneous dikes, mentioned in the description of the limestone at this point. (See Shasta County limestone, page 88.)

It must be noted that while on the north side copper sulphides are found with the iron oxide ores, on the west side no copper ore has as yet been found, but iron sulphide is found with the iron oxide.

Southwest of this a belt of limonite croppings, at least 1000 feet away from the limestone, can be followed over a considerable distance in Section 3, having a northwesterly strike and from 10 to 15 feet wide. It has been opened up in several places, but has proven not to persist in depth.

In Secs. 2 and 3, T. 33 N., R. 4 W., the Black Diamond mine, Northern California Investment Company, George Bayha, vice-president, Bayha P. O., has large bodies of pyritic iron ore, containing some copper, also in contact with the limestone.

On the northeast slope of the Hirtz Mountain, in Secs. 6, 7, and 8, T. 35 N., R. 3 W., are very superficially developed exposures of iron ore, in the shale lying to the east of the limestone. These openings are found on a series of claims, mostly located on Section 7, by J. J. Jennings, of Portland, Oregon. The section belongs to the Southern Pacific Railroad.

SIERRA COUNTY.

Sierra Iron Company, Downieville, owner. In Secs. 11 and 14, T. 21 N., R. 11 E., a large deposit of magnetite at an elevation of 7000 feet. The location precludes present commercial development.

SISKIYOU COUNTY.

In Sec. 10, T. 46 N., R. 10 W., on the north side of the divide between Buckhorn Creek and the Klamath River, float of iron ore is found, partly limonite, having the structure of the schistose country rock, partly iron ore and chromite mixed. These pieces have a massive structure, and show garnets on the contact with the schist.

SONOMA COUNTY.

Fisk's Mill.—Three miles inland, on the Lancaster ranch, a body of iron ore has been slightly exploited. It is a part of an ore body running west and south along the coast for miles.

Fort Ross.—Six miles east of Fort Ross is a body of iron ore of considerable extent. It is mostly hematite, and courses north.

Noble's.—Five miles north of Mr. Noble's ranch, near the west fork of the Gualala River, is a large body of hematite.

TEHAMA COUNTY.

J. A. Heslewood, 469 East Eleventh street, Oakland. In Secs. 15, 16, 21, and 22, T. 29 N., R. 8 W., M. D. M., in the vicinity of the Beegum. Important indications of iron deposits are claimed to be found.

TRINITY COUNTY.

Iron ore deposits are reported in several places in the county, but none of merit have as yet been opened up.

It is claimed that some iron ore is found at the head of Democrat Gulch.

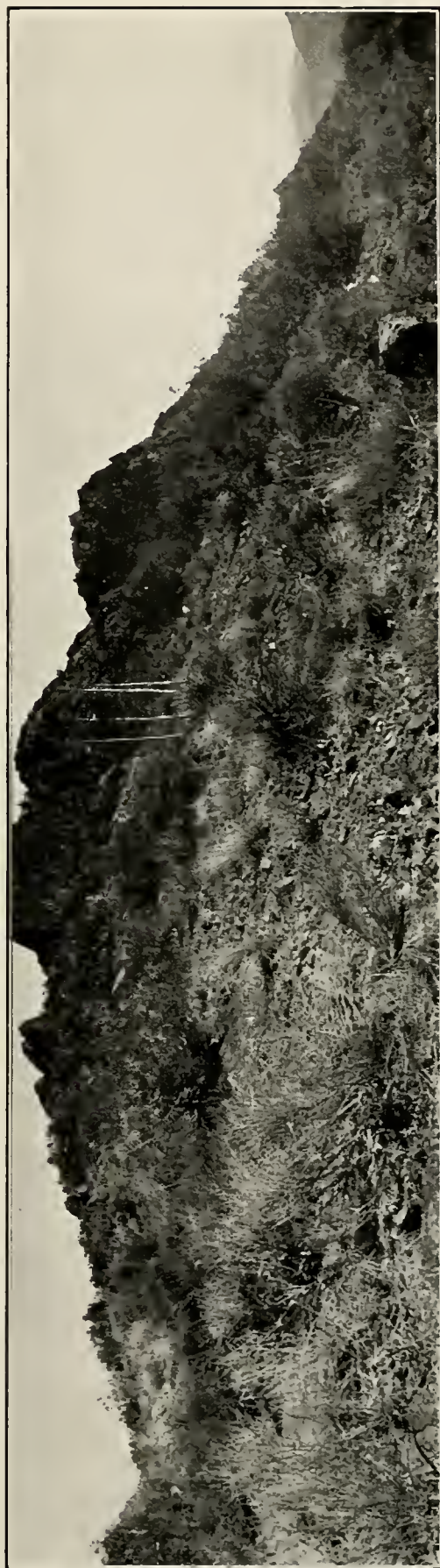
On the northwest side of Chanchelulla Peak, in Secs. 4, 5, 9 and 10, T. 30 N., R. 10 W., M. D. M., stringers of iron ore are reported to be found lying in contact with large bodies of hypersthene, and the superficial resemblance of the latter material to iron ore may have caused the claim of large outcrops of iron ore in that vicinity.

JASPER.

LOS ANGELES COUNTY.

J. Stewart, 1417 East Twenty-first street, Los Angeles. In Sec. 18, T. 5 N., R. 12 W., S. B. M., 3 miles northeast of Acton, on the Southern Pacific Railroad. The jasper forms the crest of a ridge for over a quarter of a mile, for a height of from 25 to 30 feet and from 30 to 40 feet wide. (See Ill. No. 132.) The jasper has various colors—some deep red, others bluish, others red, mottled with white. It takes a very fine polish. Only surface rock has as yet been taken out. This can be used for ornamental building purposes; it contains, however, vugs and geodes, which may prevent its use in large slabs, unless they be filled.

20—BUL. 38



ILL. NO. 132. VIEW OF JASPER CLAIM, THREE MILES N. E. OF ACTON, LOS ANGELES COUNTY.

TRINITY COUNTY.

A very prominent belt of jasper is reported on the Backbone, the divide between the North Fork of Trinity River and the East Fork of the North Fork, showing especially in Secs. 5 and 8, T. 35 N., R. 11 W., M. D. M.

Another large belt of jasper is reported on Red Mountain, situated at the head of Red Mountain and Prospect Creek, in the southwest corner of T. 29 N., and the northwest corner of T. 28 N., R. 11 W., M. D. M.

LITHIA.

Lithia occurs in nature in several different minerals, the principal ones of which are lepidolite, amblygonite, and spodumene. The first two occur in commercial quantities in San Diego County, California. A quite rare variety of spodumene, called kunzite,* occurs at the same locality as a gem-stone, but not as a source of lithia.

The chief use of lithia in the market is in the form of the carbonate, in effervescing lithia tablets, and in the preparation of mineral waters. Some of it is used as the nitrate in making red fire. The production of lithia minerals† in the United States for 1902 amounted to 1245 tons, valued at \$25,750. In 1903 the production was 1155 tons, valued at \$23,425. The greater part of this production is from San Diego County, California. Some spodumene is mined in the Black Hills region. The California lepidolite has been mined and utilized as a source of lithia for several years, but the amblygonite was first found there in 1901. The occurrence of the lithia minerals in large quantities and of good quality at Pala, and its comparative scarcity elsewhere in the United States, is likely to make this a valuable deposit.

THE LITHIA MINERALS.

Amblygonite, which is now an important source of lithia, consists of a fluophosphate of lithia and aluminum (AlPO_4LiF), containing 10 per cent of lithia. The mineral crystallizes in large, coarse crystals in the triclinic system. The hardness is 6, or the same as that of feldspar, and the specific gravity is 3.01 to 3.09. The color is white to pale-greenish, bluish, yellowish, or brownish white. The California product is almost entirely white. It fuses easily in the flame, with bubbling, and it tinges the flame red.

* See Bulletin No. 37, State Mining Bureau.

† Mineral Resources of the United States, 1903.

The mineral closely resembles some of the feldspars, many of the specimens being difficult to distinguish by the eye from feldspar. The hardness and cleavage are much the same. With the blowpipe, they are readily distinguished by the red color and the easy fusibility of the amblygonite.

As it is only recently that this mineral has been discovered in California, it has not had such an extended use as the lepidolite and spodumene, but promises to be more valuable than either, as it contains a



ILL. No. 133. ENTRANCE TO LEPIDOLITE MINE AT PALA, SAN DIEGO COUNTY—
LEPIDOLITE AND RUBELLITE.

higher percentage of lithia, and the phosphoric acid is a valuable by-product.

Lepidolite, the lithia mica, commonly occurs in sealy, granular masses, sometimes in aggregates of short six-sided prisms. The cleavage is basal, luster pearly, and color rose-red, violet-gray, yellowish, grayish white to white. It has a hardness of 2.5 to 4, and a specific gravity of 2.8 to 2.9. It fuses easily to a gray or white glass and colors the flame red. It can be distinguished from the other micas by the red flame, its ready fusion, and the reaction of fluorine.

Lepidolite has quite a complex composition. Dana gives a general formula as $\text{KLi}[\text{Al}(\text{OH}, \text{F})_2]\text{Al}(\text{SiO}_3)_3$. Analyses of a number of specimens from different localities show the percentage of lithia to range from 3.87 to 5.88.

Spodumene, another lithium mineral, occurs in California, but not as a commercial source for lithia. It occurs in prismatic crystals, often flattened, crystallizing in the monoclinic system. It has a perfect cleavage, a lamellar structure, uneven fracture, and glassy luster. In color it may be greenish white, grayish white, green, yellow, amethyst purple or violet. Spodumene is a lithia-alumina silicate ($\text{Li}_2\text{O}, \text{Al}_2\text{O}_3, 4 \text{SiO}_2$), having 8.4 per cent of lithia, 27.4 per cent of alumina, and 64.5 per cent of silica.

ANALYSES OF LITHIA MINERALS.

	Amblygonite, Pala, Cal.	Lepidolite, Pala, Cal.	Spodumene, Goshen, Mass.	Spodumene, Branchville, Mass.	Lepidolite, Paris, Me.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Lithia (Li_2O)	8.26	4.91	6.89	7.62	4.20
Silica (SiO_2)	1.99	48.61	63.27	64.25	50.92
Phosphoric acid (P_2O_5)	45.47				
Alumina (Al_2O_3)	33.09	22.36	23.73	27.20	24.99
Iron oxide (FeO)	trace		1.17	.20	.23
Potash (K_2O)		16.16	1.45		11.38
Soda (Na_2O)		.38	.99	.39	2.11
Loss on ignition, water, etc.	6.28		.36	.24	1.96
Undetermined	3.56				
Lime (CaO)	1.35	.64	.11		
Magnesia (MgO)			2.02		
Fluorine		2.05			6.29

SAN DIEGO COUNTY.

American Lithia Company, Wm. N. Crane, president, 206 Broadway, New York; L. A. Wright, superintendent, San Diego. In Sec. 23, T. 9 S., R. 2 W., S. B. M., a little over a mile north of Pala. The first mine that produced lithia on a commercial scale in the State. It is reported that the deposit was discovered and located by Mr. John Stewart twenty-three years ago; it was opened in 1891, and the first ore shipped for commercial use in 1900.

The lithia, in the form of the minerals lepidolite and amblygonite, occurs in a large pegmatite vein which forms the top of the narrow ridge. The lepidolite lies mostly *under* the pegmatite and the amblygonite in the lower portion of it. From each side of the hill a tunnel has been run, and the two are connected by a winze. Nearly all the lepidolite has been taken out from the east end and the amblygonite from the west end of the tunnel.

The amblygonite occurs mostly west of the middle of the hill and in the lower part of the pegmatite overlying the lepidolite. In places, the lepidolite projects into the amblygonite, and in a few places small masses are inclosed in it. The amblygonite is closely associated with a shattered ferruginous quartz, which occurs in large and small masses, both inclosing and inclosed in the amblygonite. The amblygonite occurs in quite irregular masses, which in some places are several feet

thick and elsewhere only a few inches. Part of the mineral has bright, reflecting cleavage-faces, and in some the faces are dull and earthy, although the interior is hard and firm. It is accompanied by a clay-like substance that apparently comes in part at least from decomposed amblygonite.

The pegmatite vein which caps the lithia deposits is 50 feet or more in thickness at this point, and dips toward the west. It forms a bold, projecting ledge on the hillside north of the lithia mine, extending N. 7° E. It consists of coarsely crystalline orthoclase and quartz, with large quantities of black tourmaline and some red tourmaline (rubellite), with a few crystals clear enough for gem-stones. Some of the black tourmalines are quite large, from 4 to 5 inches in diameter, and from 2 to 3 feet long. The tourmalines are pre-vaillingly black where they occur in the compact orthoclase, but where they project into the clay pockets they are red or green, and sometimes clear. There are scattered patches of lepidolite in the pegmatite and in the amblygonite, but the principal occurrence is at the mouth of the tunnel. Rubellite is scattered irregularly through the lepidolite mass.

Other minerals in small quantities occur in the pegmatite, but none have apparently any influence on the lithia deposits.

The red and clear tourmalines are, however, nearly always associated with albite.



ILL. No. 134. PALA MOUNTAIN—VIEW OF THE LITHIA MINE, SHOWING WORKINGS AND DUMP. LEPIDOLITE WITH RUBELLITE.

About a quarter of a mile north of the lithia mine of the American Lithia Company, another company, **Mr. Markle**, manager, is tunneling in the hillside to strike the same ledge on which the present company is working. At the present time (June, 1904) they are still passing through the country rock underlying the ledge. Several other claims have been staked out in the vicinity of the lithia mine, but no others have proved productive up to the present.

Caterina Mine, Heriart & Sickler, owners, Pala.

Ed Fletcher Mine, near Pala; Ed Fletcher, San Diego, owner. Produced in 1903.

Heriart Mine, near Pala; F. M. and M. M. Sickler, owners.

San Pedro Mine, Peiletech & Heriart, owners.

In Bulletin No. 37 of the California State Mining Bureau, "Gems, Jewelers' Materials, and Ornamental Stones of California," a detailed description of all the lithia mines in San Diego County is given.

At first the Pala lithia mine was worked for the lepidolite, from which lithia salts were manufactured. Since the discovery of amblygonite, that alone is worked, because it contains a larger percentage of lithia, is more easily changed to the carbonate, and the by-products are more valuable. An estimate made by the chemist of the American Lithia Company, previous to the recent development, indicates the products and possible profits of the industry.

Products Derived from 5000 Pounds of Amblygonite per Day, using 7000 Pounds of Caustic Soda in Reduction.

	Pounds.
Lithia carbonate.....	800
Tri-sodium phosphate.....	5,000
Sulphate of aluminum	8,000
Phosphate salt	1,000
Caustic soda (recovered at half cost)	3,000

MACADAM, RUBBLE, AND CONCRETE.

ALAMEDA COUNTY.

Berkeley Rock Company's Quarry; Berkeley Rock Co., J. T. Cochran, manager, Bacon Block, Oakland. This quarry is one quarter of a mile beyond the end of Broadway, Oakland, and is reached by College avenue. The deposit is a much altered trap-rock, and is used for concrete, macadam, and gutter rock. The company produces about 250 yards a day.



ILL. No. 135 BLAIR QUARRY No. 1 (MACADAM ROCK), OAKLAND, ALAMEDA COUNTY.

Blair Quarries; The Realty Syndicate, 1160 Broadway, Oakland, owner. On Moraga road, just east of Mountain View Cemetery, and about 4 miles from the city hall. The main quarry is located near the summit of the hill, about 100 yards up the slope north of the road. It was opened in 1901. The rock is a chert (phthanite), mostly red, some yellowish, and is extensively used as road-dressing in Piedmont district and in the cemetery. The company is opening a "blue rock" quarry, of metamorphosed sandstone, on the south side of the road, and is tunneling in quest of rock for a quarry 50 yards west of and below the larger Blair quarry. Twenty men are at work.

Blake & Bilger Company's Quarry (formerly the Oakland Paving Company's quarry); F. W. Bilger, secretary and treasurer, Central Bank Building, Fourteenth and Broadway, Oakland. Located on McAdam street, just off Broadway. It was opened about 1870, and has been operated almost constantly since. It is the largest quarry in Alameda County. The rock is typical "blue rock," as termed by the trade, and is a metamorphosed sandstone, with lime carbonate in seams. It is used for macadam, concrete, and gutter rock. Two Gates crushers handle all the rock. Two steam percussion drills are in operation. From 60 to 80 quarrymen are employed.



ILL. No. 136. BLAKE & BILGER QUARRY (FORMERLY OAKLAND PAVING CO.),
McADAM STREET, OAKLAND.

Broadway Quarry, on both sides of Broadway, near Hudson street, Oakland. The rock is a soft, friable, buff-colored sandstone, interbedded with soft, slate-colored shales. Idle in October, 1904.

Crusher Quarry; E. B. & A. L. Stone Company, 900 Broadway, Oakland. Near their crushing plant on Laundry Farm; opened about 1899. Reddish, decayed rock is hauled from face without crushing, and used for sidewalks, etc.

Curran Quarry; John Curran, School street, owner. This was formerly the O'Brien Quarry, and is on Maple avenue, Fruitvale District. The rock is termed "red cement gravel," and is a very much altered rock, recemented by a red clay. Used as a top dressing for roads and walks.

Diamond Canon Quarry (Heyland Quarry); Hutchinson Company, 401 Fourteenth street, Oakland, owner. Four miles from Lake Merritt, on Diamond Cañon road, East Oakland. There are two quarries; in the upper one the rock is a hard, medium-grained, gray sandstone; in the lower quarry face in the cañon, 100 yards below the road, is a flinty, dark-colored, metamorphosed sandstone. The crushing plant is abandoned and badly out of repair.

Easton & Wilson Quarry; Clark Avery, at quarry, owner. On Lincoln avenue, 1 mile from Diamond P. O. It was opened about 1899 and worked intermittently for two years. The rock, a blue metamorphosed sandstone, occurs in boulders. Large quantities of soft sandstone and slaty shales made so much waste that it was unprofitable to work at the time. Two other small openings show similar characteristics.

Eliot Gravel Pit; Southern Pacific Railroad Company, owner. One and three fourths miles east of Pleasanton. The pit is half a mile long and about 300 yards wide, and is operated as gravel is needed for ballast or concrete. The cars are loaded by steam shovel.

Estudillo Quarry; J. H. Ravekas, owner; at present under lease to the E. B. & A. L. Stone Company, who are preparing to reopen it. Three fourths of a mile from center of San Leandro, at southeast corner of Estudillo and Grand avenues. The stone is an altered basaltic rock, much fractured and with serpentine in seams.

Fruitvale White Gravel Mine (Packard Quarry); George Mack, in charge. A small quarry at the end of Maple avenue, Fruitvale District. A disintegrated quartz rock, with a clay cementing material in seams; used as a top dressing for roads and walks.

Hays School Quarry, near Hays school, in Brooklyn Township. It is a small quarry, the product of which is used locally for roads. The rock is much altered and contains considerable lime. It is idle at present.

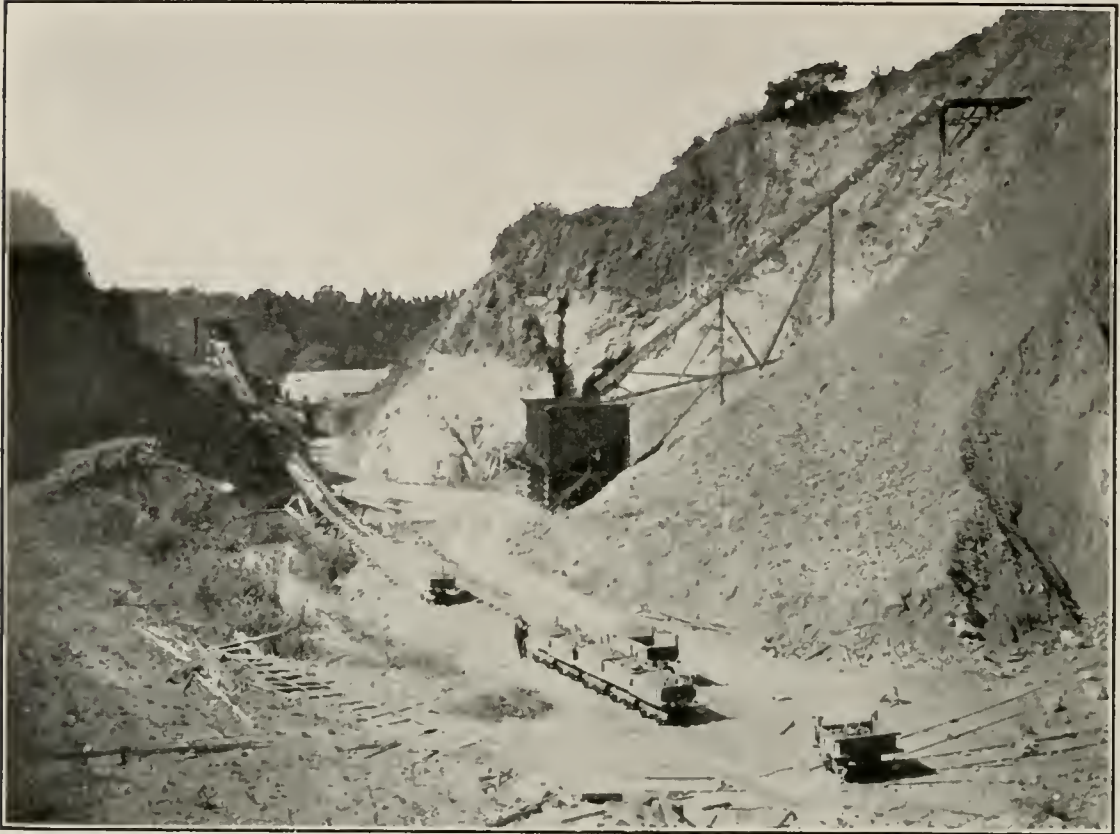
Leona Heights Quarry; E. B. & A. L. Stone Company, 900 Broadway, Oakland, owner; G. H. Luchs, superintendent. It was formerly the California Improvement Company's quarry. It is on Laundry Farm, on the summit of a prominent ridge, one mile north of Mills College. The rock is a fine-grained basalt, and is used for macadam and concrete. The quarry face is about 125 feet high. Two gravity trams, one 2500 feet long and the other 1200 feet, take the rock from the quarry to the crusher at the termini of the railroads, both narrow and broad gauge. About 300 yards a day are crushed by two Gates crushers. Electricity is used for power. Thirty-five men are at work in the quarry.

Mills College Quarry; same owner. Near the college grounds; opened about 1892. The rock is a red gravel and clay mixture, and is used as top dressing for garden and side walks, without crushing. Electric

trains, both broad and narrow gauge, enter this and the "Crusher Quarry."

Mission District Quarry; A. S. Escobar, owner, and operated by the county. On Sunol road, one mile above its intersection with Mission San José-Niles road. The rock is a black shale, recemented by lime and gypsum.

Newark Road Quarry; Realty Syndicate, owner, and operated by the county. In Sec. 34, T. 4 S., R. 2 W. The quarry was opened twenty-



ILL. No. 137. ONE FACE OF PIEDMONT PAVING COMPANY'S QUARRY, OAKLAND.

three years ago. The rock is a hard, flinty, red jasper, interbedded with soft seams of red clay. This quarry furnishes all the macadam for Newark road district.

Pacific Land and Investment Company's Quarry. In Sec. 10, T. 5 S., R. 2 W. The quarry formerly furnished a large amount of ballast for the Southern Pacific Railroad, but is idle at present. The north end of the quarry shows beds of red flinty chert, some siliceous shale, and red clay; the south end, some soft sandstone and shales; also small outcrops of manganese ore.

Piedmont Paving Company's Quarry; C. D. Bates, Jr., secretary, Macdonough Building, Fourteenth street and Broadway, Oakland. About three fourths of a mile above the head of Lake Merritt and one

fourth of a mile from Wildwood avenue. It was opened in 1878 by the Alameda Macadamizing Company, and reopened by the present management about 1892. The rock is a grained, metamorphosed sandstone, bluish in color, locally termed "blue rock." It is used chiefly for macadam, but some is utilized for rubble and ballast.

Ransome Construction Company's Quarry; office, 473 Fourteenth street, Oakland. This quarry is on the Old Fish Ranch road, about $5\frac{1}{2}$ miles from the Oakland City Hall. It was opened in April, 1904. A tramway 600 feet long carries rock from the quarry face to the crusher at side of road. The rock is a fine-grained basalt, and is used for macadam and concrete. Some gutter rocks are sorted out. The rock is hauled to Oakland and Berkeley by wagon. Eighteen quarrymen were at work in October, 1904.

San Leandro Quarry; E. B. & A. L. Stone Co., 900 Broadway, Oakland, owner. South and across the cañon from the dam at foot of Lake Chabot, and about 2 miles east of San Leandro. It was opened in 1886 by the present owner. The rock is a regular "blue rock"—a metamorphosed sandstone. At present the overburden, a red rock (jasper), covers the face of the old quarry by an immense slide. The original quarry is abandoned, only the jasper rock from the talus slope being used as a sidewalk material.

Spring Construction Company's Quarry; J. E. Porter, superintendent; office, University Savings Bank, Berkeley. Located on Greenwood Terrace, about one half mile east of the reservoir in North Berkeley. The company is driving a 250-foot two-compartment tunnel, to connect by an upraise with the present floor of the old quarry. The rock will be broken down in the quarry and transported through the tunnel to the crushing plant on the hillside below. A Gates crusher is driven by electric power. The rock in the main quarry face varies, in a short distance, from hard, siliceous shale to a highly metamorphosed rock of coarse, sandy texture. It is to be used for macadam and concrete work. Twenty-five men are employed.

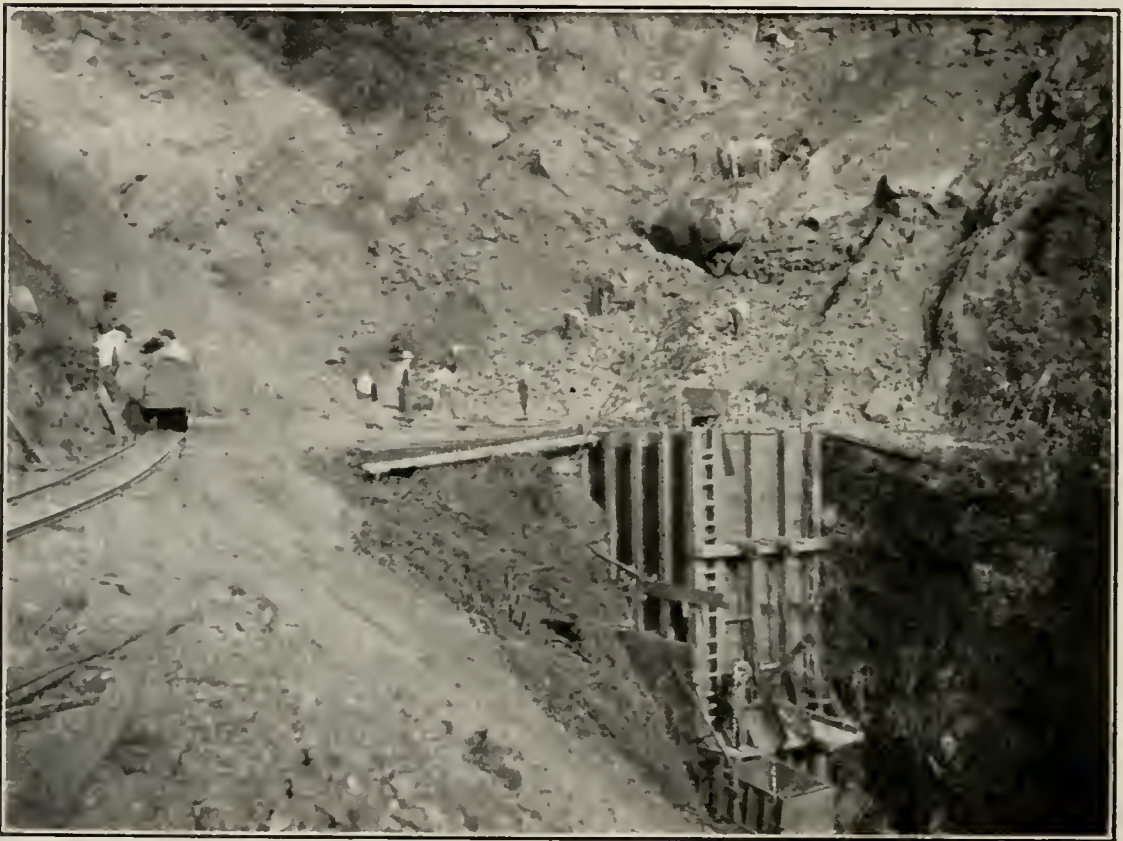
Sunol Road Quarry, $2\frac{1}{4}$ miles from Mission San José, and $3\frac{3}{4}$ miles from Sunol, on west side of road. The rock is a hard, shaly, buff-colored sandstone. The quarry is idle.

Syndicate Quarry; The Realty Syndicate, 1160 Broadway, Oakland, owner. Located on south side of Buckeye avenue, half a mile northeast of the Catholic cemetery. It was opened about 1901, and has been worked intermittently. The rock is a jasper (phthanite), similar to that in the Blair quarry.

COLUSA COUNTY.

The **Colusa Sandstone Company** crushes and delivers the sandstone macadam on board the cars of the Colusa and Lake Narrow Gauge Railroad at the nominal price of \$1 per ton. The county of Colusa could probably secure the stone for the price of haulage and do its own crushing. For railway ballast the "buff" or croppings, as well as the broken ledge material, may be used, but for wagon roads the broken ledge material is preferable; it weighs 166 pounds to the cubic foot, and crushes with uneven fracture adapted to road building.

The **McGilvray Stone Company** produces similar material.



ILL. No. 138. STEGE QUARRY, CONTRA COSTA COUNTY. HUTCHINSON & CO., OF OAKLAND, OWNER.

CONTRA COSTA COUNTY.

Antioch Quarry.—A small quarry is located about one mile south of the Southern Pacific Railroad depot at Antioch, in a bank of loosely cemented gravel, which is easily quarried and furnishes a very good macadam. It is worked intermittently as macadam is needed for the roads.

Christen Quarry (formerly the Avery Ranch); Joseph M. Christen, owner. This small quarry lies one quarter of a mile west of Pacheco. The rock is a soft, friable sandstone, formerly used for macadamizing

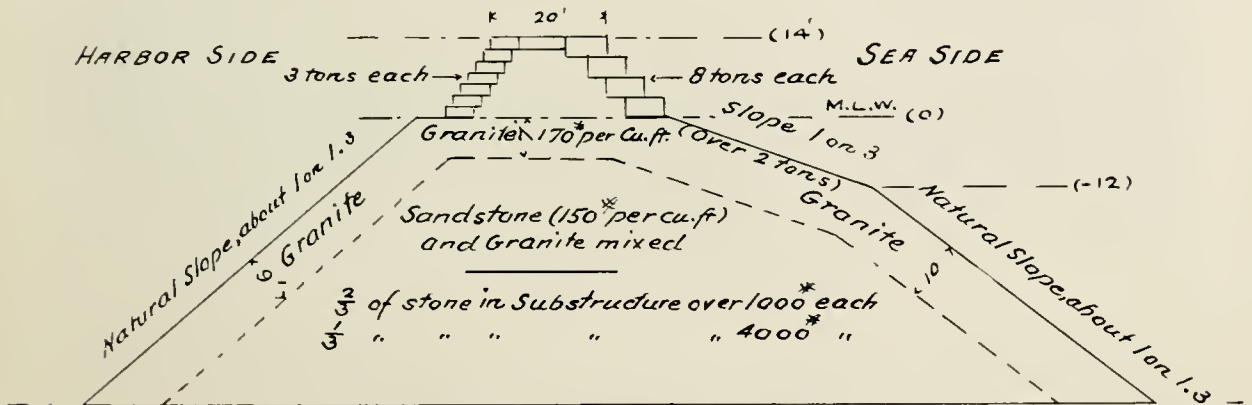
the roads about Pacheco. The quarry has been practically idle of late years, because the rock is too soft to make a good road material.

Fitzgerald Quarry, on Haven street, Martinez. The rock is a soft, friable sandstone and sandy shale, and is sold by the load for macadam purposes.

Port Costa Cut.—The Southern Pacific Railroad Company is operating a steam shovel at the foot of the steep hillside at the side of its tracks at Port Costa. The material is used for ballast. It is a friable clay shale and shaly sandstone.

Slater Quarry; A. E. Slater, owner. This quarry lies about one quarter of a mile south of Pacheco. The rock is a very soft, friable sandstone, used for macadam.

Stege Quarry; Hutchinson & Co., corner of Fourteenth and Franklin streets, Oakland, owner. It is 8 miles north of Oakland. A gravity tram, 5290 feet long, brings the rock from the quarry face to the crusher. The rock is a metamorphosed sandstone, and is used for macadam and concrete purposes.



ILL. No. 139. SAN PEDRO BREAKWATER.

LOS ANGELES COUNTY.

Home Teaming and Transfer Company, Arroyo Seco, foot of Avenue 22, Los Angeles. Crushes stone used for concrete work. The plant is equipped with a rock-crusher, using steam power, and oil as fuel. Capacity of crusher, 100 tons per day.

Parson Macadam Plant, Arroyo Seco, foot of Avenue 20, Los Angeles. A 20-horsepower gasoline engine is in use.

The San Pedro Breakwater is being constructed by the California Construction Company, 342 East Market street, Los Angeles, for the Federal Government, under supervision of the Corps of Engineers, U. S. A. The breakwater is to be 9000 feet long; the greatest depth below mean lower low water is 52 feet. The top of the breakwater, 20 feet wide, is 14 feet

above mean lower low water. The accompanying sketch gives a cross-section of the structure. The sandstone for the substructure is obtained from the Chatsworth Park quarry, Los Angeles County. The granite for the substructure and the superstructure is obtained from the Declez quarry, San Bernardino County, and the Casa Blanca quarry, Riverside County. It is estimated that about 2,370,000 tons of rock will be required to make the breakwater. Under the terms of the contract 25,000 tons per month must be deposited in December, January, and February, and 35,000 tons a month during the rest of the year. The work will probably be completed in 1907. The end of the superstructure is to be of concrete blocks 40 feet square and 20 feet high, founded 3 feet



ILL. No. 140. VIEW OF HARBOR SIDE OF SAN PEDRO BREAKWATER.
Granite blocks (over 6000 pounds each) from Casa Blanca Quarries, Riverside County.

below mean lower low water. (See Ill. No. 139.) (By courtesy of C. H. McKinstry, Captain, Corps of Engineers, U. S. A.)

MARIN COUNTY.

Bull Quarry; Bull & Gossard, Parrott Building, San Francisco, owners. Situated on the bay shore, on San Pedro Point, 4 miles east of San Rafael. The quarry was opened in August, 1904. The rock is a metamorphosed, dark-gray sandstone, extensively fractured and broken. It is loaded into three-ton skips, which are placed on barges by a 50-foot derrick. At present (October, 1904) they are shipping about 450 tons per day, to Jersey Island, in the Sacramento River, where it is used as rubble in building levees. Twenty-five men were at work in the quarry.

Forbes Quarry; E. Schwiesan, San Rafael, owner. On the hillside, in the northwest portion of San Rafael. The rock is a hard, red chert, and was used for concrete and macadam purposes. A small jaw crusher

was used. The quarry has been extensively worked, but is idle at present.

Hoffman Quarry; B. H. Hoffman, owner. A small quarry 3 miles north of San Rafael, on the Petaluma road. The rock is a siliceous shale, and is used for macadam.

Hotaling Quarry; A. P. Hotaling, San Rafael, owner. Situated at the end of Clark street, San Rafael. The rock is a hard, compact, blue sandstone, and is used for macadam and concrete. It is not worked regularly.

Marin Quarry; Gray Brothers, Mills Building, San Francisco, owners. Located on McNear's Point. The rock is a highly metamorphosed blue sandstone. It is used for rubble in seawall construction; at present being used by the State in the construction of the new mail dock, and large quantities were also used in the Santa Fé fill in China Basin. The rock is handled in skips, holding about $2\frac{1}{2}$ yards each, which are passed by four 60-foot derricks onto barges and towed to various points on the bay. Two Burleigh drills are used in the quarry. Sixty men are at work.

Mount Tamalpais Cemetery Quarry, in the upper end of the cemetery, $1\frac{1}{2}$ miles northeast of San Rafael. The rock is a hard, blue-colored, metamorphosed sandstone, comparatively free from fractures. It is used, rough dressed, in building fronts and curbing in the cemetery; it is also crushed for macadam and concrete. At the present time it is only worked as the rock is needed in the cemetery.

San Francisco Bay Improvement Company's Quarry (formerly the Jordan Quarry). This large quarry is on the bay shore at Point San Pedro, 5 miles east of San Rafael. It was opened in 1884. The rock is a grayish-blue, metamorphosed sandstone, and is used for rubble. Large quantities were used in the Santa Fé fill in China Basin. It is loaded at the quarry face into skips, which are placed on small cars and drawn out onto the wharf to be loaded on barges. The company owns five barges, each of 5000 tons capacity. The output averages 700 tons daily. Sixty-five men are employed.

Steffini-Bartini Company's Quarry, in the southwest portion of San Rafael, on Greenwood street, just above the brewery. It is a small quarry of hard, blue, metamorphosed sandstone, containing considerable lime in fractures. The rock is used, rough dressed, for foundation walls in San Rafael, and also crushed for macadam and concrete.

Tiburon Point Quarry.—The California Northwestern Railway Company operates a quarry in rear of the ferry slip at Tiburon, as it needs the rock for ballast.

NAPA COUNTY.

Herrington Quarry, one-half mile east of Napa, on the property adjoining the cemetery. The rock is a brecciated tuff, and for many years has been used for macadamizing the streets of Napa.

J. F. Zollner Quarry. (See Paving Blocks, page 342.) Mr. Errington, of Napa, hauls this stone to Napa and crushes it for macadam.

RIVERSIDE COUNTY.

Fairmount Hill Quarry and City Crusher Plant; Superintendent of Streets of the City of Riverside, in charge. In Sec. 14, T. 2 S., R. 5 W., S. B. M. The rock mass is quite varied in character, and consists of a dark-gray biotite granite, associated with gneiss, mica schist, and limestone. The rocks are all too deeply weathered to be valuable for building stone, and are used as crushed stone for macadam and concrete.

SACRAMENTO COUNTY.

Folsom State Prison Quarry; State of California, owner. In Sec. 25, T. 10 N., R. 7 E. (See also Granite, page 47.) Besides the rubble quarried with the dimension stone, there is a quarry in diorite. In 1904 the production was 63,021 tons, a small part of which was used by the prison.

SAN BENITO COUNTY.

Granite Rock Company; A. R. Wilson, Watsonville, manager. The quarry is in the northwest corner of the Rancho Las Aromitas y Agua Caliente, on the Pajaro River, at Logan, a station on the Southern Pacific Railroad. The granite is rather disintegrated, and lies in narrow beds. It is used for macadam, etc.

SAN FRANCISCO COUNTY.

Blue Rock Quarry, at corner of Twenty-sixth and Douglass streets. The stone is a hard, blue-grained, metamorphic sandstone, with a flinty fracture. All machinery has been removed, and the quarry is idle. It was formerly worked by Gray Brothers.

County Jail Quarry, on Ocean avenue, between the jail and Ingleside Park. The rock is a hard, gray sandstone, and is used for macadam. It is worked intermittently by the prisoners.

Gray Brothers Quarry, at Thirtieth and Castro streets. Admission to quarry was refused.

Lately Street Quarry.—A small quarry face at the corner of Castro and Lately streets. The rock is a hard, siliceous red and yellow chert. Idle when visited.

Lewis & Biggio Quarry; R. Biggio and Mr. Lewis, of Colma, owners. On San José avenue, just north of Ocean View. The rock, a blue metamorphosed sandstone, is crushed by a jaw crusher at the quarry and is used for concrete purposes. The quarry is worked intermittently.

Maloney Quarry.—Mr. Ed. Maloney, Builders' Exchange, operates a small quarry on Twin Peaks, at the corner of Seventeenth and Ashbury streets. The rock is a red jasper, and is used for macadam purposes.

Ocean View Quarry, Ocean View, one block west of San José avenue. It is operated intermittently by the city for street repairing. The rock is a slaty shale, occurring in contorted beds.

Quimby & Harrelson Quarry; Quimby & Harrelson, 206 Kearny street, San Francisco, owners. On Amazon street, one block off the Mission road. The rock is a gray, metamorphosed sandstone. Quimby & Harrelson have not taken out any rock for some time, but the prisoners of the county jail have quarried some for macadam.

San Francisco Construction Company, 26 Montgomery street, operates a small quarry on Twin Peaks, on Carmel street. The rock is a red chert, is crushed in a small jaw crusher, and used for macadam.

Simons-Fout Company, Box 153, Builders' Exchange, operates a quarry in connection with its brickyard on the Corbett road. Several faces have been opened in clearing the land for real estate purposes. Blue rock, red chert, and loose sand rock are quarried. The latter is used in making fills on the property, and the former is crushed for macadam, concrete, and rubble purposes. The crusher averages about 150 yards per day.

Telegraph Hill Quarry; Gray Brothers, 1122 Haywards Building, owners. At the corner of Green and Sansome streets. The rock is a highly metamorphosed blue sandstone, and stands with a nearly perpendicular face about 180 feet high. This quarry has been idle for about a year, but the crushing plant is being operated with stone brought in carts from their smaller quarry, of similar rock, at the corner of Chestnut and Montgomery streets. The face of this smaller quarry is nearly 100 feet high.

For three quarters of a mile around the foot of Telegraph Hill rock has been quarried for many years, first, to fill in the bay, and at present for seawall and other concrete construction about San Francisco.

Twin Peaks Quarries—There are numerous small quarries on the slopes of Twin Peaks, which are worked intermittently, as rock is needed in small quantities.

Vulcan Quarry, at the base of Telegraph Hill, on Francisco street, between Kearny and Dupont, in the rear of the Vulcan Iron Works. George P. Wetmore & Co. quarry the rock and haul it in carts to their crushing plant on Lombard street, near Sansome. The stone is the typical blue rock, a metamorphosed sandstone, and is extensively fractured by numerous slips. It is used for rubble, macadam, and concrete purposes.

George P. Wetmore Quarry.—This large quarry is at the corner of Lombard and Montgomery streets. The office is at this quarry. C. A. Wetmore is superintendent. They quarry a blue and gray metamorphosed sandstone, and some altered slaty rock occurs in the slips. The face is about 100 feet high. No blasting is done. The rock is barred down, and large slips often cover the quarry floor with much broken rock. This is sledged and loaded onto small skips, which are taken to the crusher by means of an aerial tramway. Rubble, macadam, and concrete rock are produced. A No. 5 Gates crusher averages about 150 yards a day.

This firm also operates a small crushing plant at Tenth and Division streets, by using the waste rock from the stone yards of the Colusa Sandstone Company and the McGilvray Sandstone Company.

SAN JOAQUIN COUNTY.

Corral Hollow Gravel Pit; San Francisco and San Joaquin Coal Company, 328 Montgomery street, San Francisco, owner. About 2 miles below Carnegie. The gravel deposit extends for a distance of nearly 4 miles down the hollow, and averages 25 feet in depth and nearly half a mile in width. The gravel is loaded on the cars direct from the bank by means of a steam shovel, and has been used extensively on the streets of Stockton.

SAN LUIS OBISPO COUNTY.

City of San Luis Obispo's Plant, on Higuero street, crushing chert rock.

SAN MATEO COUNTY.

Casey Quarry (formerly the Laurel Creek Quarry); W. W. and J. E. Casey, San Mateo, owners. Located about one eighth of a mile south of Beresford Station, on Laurel Creek. There are two faces; one is a quartz formation, with the quartz considerably fractured and colored in the seams with manganese stains; the other furnishes a red and

yellow chert and also a soft, buff-colored sandstone, which has been extensively fractured and crushed. In January, 1905, the county was operating the quarry for macadam for the roadways, using a portable crushing plant consisting of a 15-horsepower gasoline engine on trucks, and a jaw crusher and screen on another pair of trucks. This plant is taken from quarry to quarry as the roads are macadamized in different localities.

Daly's Quarry; operated by the United Railroads of San Francisco. On Daly's Hill, San José avenue. The rock is a close-grained metamorphosed sandstone, light gray in color, and extensively fractured and seamed. It is crushed by a jaw-crusher at the quarry and loaded directly from bins to electric ballast cars. The entire product is used by the railroad company as crushed rock. About twenty men are employed, and the output averages 80 yards per day.

Gardner Quarry; Dr. A. M. Gardner, Belmont, owner. One half mile west of Belmont. The rock is a folded and crushed chert. The quarry has been worked in three different faces, and is operated intermittently.

Johnson-Splivalo Quarry, half a mile northwest of Belmont. The rock is a red and white chert, and is highly stained with manganese. It occurs in folded and crumbled beds. The quarry is worked intermittently.

Jones Quarry; Fair Estate, San Francisco, owner. On the bay shore, $1\frac{1}{2}$ miles east of South San Francisco. The quarry was operated to furnish rubble for the Santa Fé Railroad Company. The rock is handled by three derricks in the face of the quarry and two on the small wharf for loading onto barges. It varies from a soft, buff-colored sandstone, associated with shale, on the north end of the quarry, to a hard, compact, light gray, metamorphic sandstone on the south end.

San Bruno Quarry, in Visitacion Valley, about 8 miles south of San Francisco, off the San Bruno road. Warren Improvement Company, owners, offices at 230 Montgomery street, San Francisco. There are two adjoining faces. The rock is loaded into boxes on car trucks and hauled 2 miles to the wharf, where the boxes are loaded onto barges and shipped to various points about the bay.

SANTA CLARA COUNTY.

Alum Rock Quarry, in Alum Rock Cañon, at end of railway track, about 100 yards above the baths. It is operated by the City of San José, for grading the roads within Alum Rock Park and the city streets. The rock is a siliceous shale, interbedded with a slaty material. It is broken down into a talus slope, and fed through a 60-foot steel-lined chute into bins which load directly to the cars.

Gay Quarry; James W. Rea & Co., corner Market and Santa Clara streets, San José, owners. On the Monterey road, one quarter of a mile south of Oak Hill Cemetery. The stone is a close-grained, igneous rock, suitable for macadam and concrete. It is a large, circular quarry, and has furnished rock for the streets of San José for many years. Idle during 1904.

SANTA CRUZ COUNTY.

De Dero Quarry, L. de Dero, Santa Cruz P. O., owner. This quarry lies about 10 miles northwest of Santa Cruz and consists of two openings, one covering a half acre or more and another closely adjoining on the north less than half as large. The stone has been quarried to a depth ranging from 8 to 20 feet on the front to 40 or 50 feet on the back face. It is overlaid by from 2 to 6 feet of brown adobe. The limestone is much shattered, and occurs in small dimensions only. There are numerous cavities, some filled with clay and some lined with calcite. The lower part of the quarry face shows an irregular bed of impure sericite schist, interlaminated with the limestone in places, and at the south end of the quarry changing into a hard blue quartzite. There is a rock-crusher at the quarry, and the stone is used for macadam and concrete.

Thurber's Quarry, the nearest one to Santa Cruz, is on the roadside about half a mile northwest of the reservoir. The stone has been quarried at three different levels. The lowest one, now abandoned, covers an area of several acres, and was quarried from 8 to 20 feet deep. The stone in the quarry face is much weathered. The second level has been worked over an area of about 500 square feet, and contains blue and gray coarsely crystalline limestone, banded in places and containing a pocket of white, yellow-stained clay. The upper level, now in operation, has been quarried from 8 to 20 feet deep over an area of a quarter of an acre. The stone in this opening occurs in larger dimensions than in any of the others. With the exception of the black adobe clay that has worked down in the fissures, it is quite pure limestone, and small pieces of good marble could be obtained. The stone is used for rubble and crushed stone. A crusher is located at the quarry.

SHASTA COUNTY.

Macadam is used for the streets of Redding. The rock quarry and crushing plant are located in the northwestern part of town. The rock is an altered, siliceous, igneous rock, quarried by hand drilling. It is crushed in a jaw crusher, and then passed over a 2-inch screen. The larger pieces are used as a foundation in the streets, the finer for top covering and for sidewalks. The crusher is driven by electric power.

SOLANO COUNTY.

The county macadam quarry is one mile north of Vacaville. The stone is a black basalt, which crushes with an uneven fracture excellently suited to the purpose of road material. Several thousand yards have been used in county road construction. The quarrying has exposed a ledge for a length and depth of about 75 feet.

Other deposits and boulders of black basalt occur on Putnam Peak and in Butte and Putah creeks.

Shale of a grade suitable for road work occurs along the eastern line of the sandstone belt within 3 or 4 miles of Vacaville, and is in considerable demand for improvement of the county roads.

The **Benicia Crushed Stone Company** owns a quarry and rock-crusher at Hoyt's siding, above Benicia, which have been operated for crushed stone, but are now (August, 1904) idle.

Cordelia Quarry; E. B. & A. L. Stone Company, 900 Broadway, Oakland, owner. In Secs. 5 and 6, T. 4 N., R. 4 W., M. D. M., in the foothills on the west side of the Suisun Valley. This company has purchased the Lord lands lying directly north, making the total holdings 400 acres. Two Gates and five Austin crushers (Nos. 8, 5, 4, and 2) were added to the plant in the early part of 1905.

There are three large quarry openings and a score or more of smaller ones extending for nearly a mile around the top of a hill about 300 feet in height. The larger openings have inclined railways to the large rock-crusher at the base of the hill, and which connects by a spur with the Southern Pacific Railroad, at the south end of the tunnel, about a mile from Cordelia.

The stone is a compact, olivine basalt. Around the south end of the hill are large quantities of tuff, which is much softer than the compact basalt. The rock outcrops over a large area, the outcrop consisting of more or less rounded boulders, varying in size from a few inches to many feet in diameter. In fact, much of the stone that has been quarried has been from boulders.

Part of the stone is made into paving blocks, and part of it is crushed for use as macadam, rock ballast, and concrete, for all of which uses it is well adapted. It has a straight, smooth cleavage, which enables it to be readily made into regular paving blocks.

The large opening in which most of the work is being done at present (August, 1904) is an acre or more in extent, with a face of about 50 feet at the back. The back wall of the quarry is in solid basalt, cut up by irregular seams, along which the stone is discolored yellow and gray from weathering. It shows concentric weathering in many places. The rounded boulders, weathering off in concentric shells, are prominent in all the quarries.

In the opening east of the one above mentioned, the stone shows the hexagonal jointing common in basalt bodies. Many of the columns are 3 to 4 feet in diameter; in a few places, smaller columns of from 6 to 10 inches in diameter occur. The stone has an especially easy, straight cleavage parallel to the base of these columns.

In several places the stone has a vesicular structure. In one of the quarry openings is a considerable quantity of dark-red stone, similar in grain and texture to the dark-colored basalt.

The supply of stone available here is unlimited, and the position is favorable for quarrying, loading, and shipping at low cost.

In excavating for the new crusher foundations, the company extracted and secured tests of three varieties of volcanic tuff—lavender, red, and gray—that underlie the basalt in the order named. The lavender-



ILL. No. 141. BASALT QUARRY AT CORDELIA, SOLANO COUNTY. E. B. & A. L. STONE CO.

colored rock showed a crushing strength of 8630 pounds to the square inch, weighing 143 pounds per cubic foot; red rock, 4020 pounds crushing strength, weight 158 pounds; gray rock, 1630 pounds crushing strength, weight 89 pounds. Like various other eruptive tuffs in Solano and other counties, this material may be easily and economically cut into desirable shapes for use as building material.

P. Siebe, Cordelia, owns a quarry-opening half an acre in extent at the station in the town of Cordelia. It is from 15 to 30 feet deep, in a weathered, light-colored volcanic tuff and breccia. It is said to have been used for road material on the streets in and around Cordelia.

SONOMA COUNTY.

J. P. Classen Quarry, $1\frac{1}{4}$ miles south of Petaluma. The rock is basalt, and is used as rubble. Worked intermittently.

McNear's Quarry, half a mile north of Petaluma, on the Santa Rosa road, just north of McNear's cemetery. It was opened about 1890.

The rock is red and gray trachyte, extensively fractured and altered, and is used for macadam and rubble. The quarry is worked intermittently.

Meachem Quarry, 5 miles northwest of Petaluma, on the Frank Meachem ranch, on the Sebastopol road. The bulk of the rock is of a basaltic nature, and is overlaid with a soft, red, disintegrated chert, which occurs in quarry face as a talus. It is used on the county roads. The quarry is worked intermittently.

Purrington Quarry, $1\frac{3}{4}$ miles southeast of Petaluma, at the end of Mountain View avenue. It is owned by the Petaluma Real Estate Association, and operated under lease by A. W. Nash. The rock is a red chert, and is extensively used in macadamizing the streets of Petaluma.

VENTURA COUNTY.

Camarillo Quarry; Southern Pacific Railroad Company, owner. In Sec. 5, T. 1 N., R. 20 W., S. B. M. A light pinkish-gray igneous rock, used for ballast on the roadbed from Burbank to north of Santa Barbara.

Santa Susanna Quarry; Southern Pacific Railroad Company, owner. In Sec. 16, T. 2 N., R. 17 W., S. B. M. The material is similar to that of the Chatsworth Park quarry, Los Angeles County. It is used by the railroad company in several places along its roadbed as rip-rap, and it is also mixed with oil for pavements.

MAGNESITE.

In the crude condition magnesite is used largely for making carbon dioxide gas; also in the manufacture of Epsom salts, of which, in 1902, at least 9000 tons were produced in the United States. Calcined magnesite (magnesia, oxide of magnesium) is used in the form of refractory bricks or concrete as furnace lining, and as non-conducting covering for boilers, steam-pipes, etc.; it is also used in the manufacture of paper stock. (See Bureau of Census, Mines and Quarries, 1902, p. 1071.)

ALAMEDA COUNTY.

American Magnesite Company. See American Magnesite Company, Santa Clara County, on page 330.

King Magnesite Claim, in Sec. 8, T. 5 S., R. 4 E. Small outcrops of magnesite are exposed by a small cut. No shipments have been made and the claim is idle.

In Sec. 16, T. 5 S., R. 4 E., are small outcroppings of magnesite.

FRESNO COUNTY.

Magnesite occurs in Sec. 5, T. 13 S., R. 24 E., about 15 miles northeast of Sanger, the nearest railroad station. There is a large deposit outcropping for several hundred feet in a course N. 10° E., and averaging 10 feet in width.

MENDOCINO COUNTY.

Vassar Magnesite Claim, 12 miles north of Cloverdale. It occurs in a serpentine formation at the crest of a steep hill 1½ miles from the California Northwestern Railway. No development work.

NAPA COUNTY.

Chiles Valley Magnesite Kiln; J. D. Phelan, San Francisco; Sec. 29, T. 8 N., R. 5 W. An old open field kiln, built of stone. The magnesite was fed in at the top and drawn at intervals from below. Heat was supplied by four separate wood-burning fireboxes, one on each side of the furnace, arranged so that only the hot gases reached the magnesite. It was operated for about eight years, and the calcined magnesite sent to San Francisco.

Fairweather Claim, owned by Mr. Duval. It adjoins the White Rock claim. (See below.)

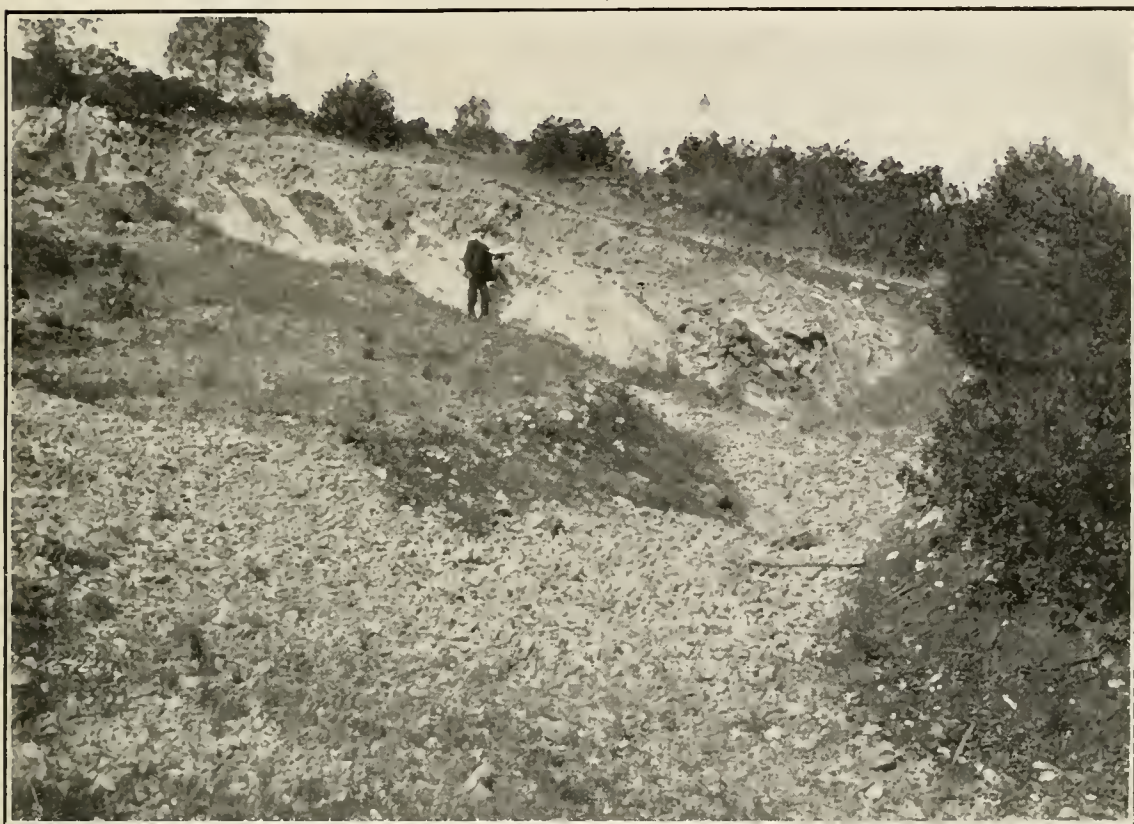
Matthai Magnesite Mines; Frank Matthai, Chiles P. O., owner. *North Mine* (formerly the Cleveland) is in Sec. 36, T. 8 N., R. 4 W., in Soda Creek Cañon, just above the road. It was worked by Bartlett & Stanley in 1895, but has been idle since. The magnesite occurs in serpentine in irregular ledges outcropping on the hillside, and was mined by means of open cuts. Merely the larger boulders and pockets near the surface were extracted without regard to development work, so that much rock remains.

South Mine, about one quarter of a mile southeast of the North Mine, just over a low ridge on the north bank of Greasy Camp Creek. Here a 5-foot ledge of very pure white magnesite outcrops along the creek for about 30 feet, and dips to the north into the hill at a low angle. Two cuts have been opened on the croppings, and a short tunnel was driven in on the ledge. There are about 100 tons of magnesite on the dump.

Priest Mine; D. C. Priest, Chiles P. O., owner. In Sec. 23, T. 8 N., R. 4 W., about 13 miles east of Rutherford, in Chiles Valley. The deposit has been opened up at four places upon the steep hillside; the lower two (large open cuts) have been idle for about five years, and are covered

up by débris. About 500 yards farther up the hill a 2-foot ledge is exposed by a 30-foot open cut, and above this, in a 30-foot tunnel, an 18-inch ledge dipping nearly perpendicular is exposed.

Russel Mine; E. T. Russel, Chiles P. O., owner. In Sec. 24, T. 8 N., R. 4 W., 15 miles from Rutherford, the nearest railroad station. The tunnel is caved and inaccessible. There are numerous surface crop-pings, on which several small open cuts have been run in on the south-



ILL. No. 142. MAIN CUT OF "WHITE ROCK" MAGNESITE MINE, POPE VALLEY, NAPA COUNTY.

west slope of the hill. The magnesite deposit is in serpentine. Only about 25 tons were shipped.

Snowflake and Blanco Mines; H. G. Staab, James Flood Building, San Francisco, owner. In Sec. 29, T. 7 N., R. 4 W., 11 miles east of Rutherford. The mines were formerly worked by the Stanley & Bartlett Company, but they have been idle for the past three years. There are eight or ten different openings from which ore was taken to the kiln, where it was calcined with wood, and shipped as magnesia from Rutherford, a station on the Southern Pacific Railroad.

The magnesite forms an irregular vein from 3 to 6 feet wide, in a dark-green, weathered serpentine. The much-shattered magnesite has been recemented in many places, forming a breccia, part magnesite and part country rock, with considerable clay and other foreign mate-

rials included. Below the more weathered portion, the magnesite forms an irregular, hard vein of snow-white color.

Many of the old tunnels have caved and but few are at present accessible, and in the latter very little magnesite can be seen in place. The outcrops have all been worked out. Similar conditions prevail in the small ravine northwest of the main workings.

White Rock Magnesite Mine; J. B. Duval, of Lidell, Pope Valley, owns a two-thirds interest and the Western Carbonic Acid Gas Company the remaining one third. In Sec. 11, T. 9 N., R. 5 W., in Pope Valley. The deposit was first developed about 1894, and about 250 tons a year were shipped for five years to the Western Carbonic Acid Gas Company. The outcroppings on the hillside, about 400 feet above the floor of the valley, dip at a steep angle to the east. The larger cut runs in on the croppings and exposes a very large face of magnesite, which has been nearly covered by talus since the works have been idle. The country rock is serpentine, which is filled with small stringers of magnesite. The formation is shown to a limited extent by a tunnel which has been driven in diagonally across several ledges, ranging from 2 to 4 feet in thickness, and numerous smaller stringers. They struck a large mass when in about 120 feet, and proceeded to drift alongside of it for some 30 feet. Most of the rock is pure white, but in the large cut considerable cream-colored magnesite makes its appearance.

PLACER COUNTY.

Snowball Mine; S. M. Sprague & Co., Newcastle, owners. In Sec. 18, T. 15 N., R. 11 E., M. D. M. It is claimed that small deposits of magnesite are found on this property.

Magnesite is reported to occur on the American River, near Bentley.

SANTA CLARA COUNTY.

American Magnesite Company.—This company holds twenty-seven claims, nineteen of which are on Red Mountain, fourteen on the Santa Clara County side, and five in Stanislaus County. The remaining eight claims are on Cedar Mountain, in Alameda County. The offices are at 604 Merchants' Exchange Building, San Francisco. H. C. Stillwell, general manager.

The extensive magnesite deposit on Red Mountain lies about 32 miles southeast of Livermore, at the head of the San Antone Valley, at an elevation of about 3350 feet. The magnesite occurs in bold outcroppings extending in a general north and south course for a distance of $1\frac{1}{2}$ miles, and ranging from 15 to 150 feet in width. The company owns 600 acres in addition and adjoining to the mineral claims for road and camp purposes.

The present workings are limited to the Alameda mine, which is being opened by a tunnel and upraise into an open quarry. The rock will be broken down through this chute into tram cars in the tunnel. These cars will convey the rock by a 2500-foot aërial tramway to the bunkers, 590 feet lower than the tunnel. It will be hauled by traction engine trains over a grade not exceeding three per cent loaded haul, to Livermore, where automatic bunkers are being erected to load Southern Pacific cars for shipment to their plant in Oakland. The aërial cable tram will use 1000-pound skips, with a capacity of 10 tons per hour. The traction engine will haul three steel wagons (capacity of 20 tons each), and will make a round trip every twenty-four hours. The company expects to begin shipping on September 15, 1905.

Cochrane Quarry; Mrs. A. F. Cochrane, Morgan Hill, owner. Four miles east of Madrone, on the headwaters of Coyote Creek. The rock outcrops at intervals on the hillside south of the creek, extending up the hill in a southerly direction, and has been opened up by small cuts in several places. No extensive body is discernible, as the adobe soil covers most of the outcrops. Much limonite and hematite float are found around the magnesite croppings. It was last worked about 1897, when Mr. Cummings of San Francisco shipped several carloads to the city.

Weber Ranch Deposit; The Bay Cities Water Company, Mutual Savings Bank Building, San Francisco, owner. On west side of San Felipe Creek Valley, near its junction with Coyote Creek. The magnesite outcrops in a bold ledge, plainly visible from the road. It has been developed to some extent, and much good stone now occurs as float rock below the workings, but at present little good rock is visible in place. The country rock is serpentine, and much of the magnesite has serpentine inclusions.

A small sheet-iron furnace lined with firebrick lies dismantled below the main cut, but no evidence remains of any magnesite having been calcined there, and it is a complete wreck now.

SONOMA COUNTY.

F. W. Brush, Cloverdale, reports that magnesite deposits are found on the Brush & Son ranch, 3 miles east of Cloverdale, but are not developed.

Creon Magnesite Deposits; Mr. J. Kolling, 2527 Bryant street, San Francisco, owner. In Sec. 32, T. 12 N., R. 10 W. The magnesite has been mined in three places. In the upper small cut a 12-inch vein, dipping north into the hill at an angle of 40 degrees, is exposed in an altered and faulted serpentine. At the lower deposits the magnesite

veins range from 1 to 18 inches in width, and cut through the light-green serpentine rocks at varying angles. The lower cuts are each about 30 feet long, and one is followed by a tunnel, which is caved at the entrance. The serpentine rock is impregnated with numerous little stringers of magnesite, extending in almost every direction. About 350 tons of rock remain on the dump.



ILL. No. 113. CREON MAGNESITE MINE, THREE MILES N. E. OF CLOVERDALE, SONOMA COUNTY.

Cummings Deposit; Pat Cummings, owner; operated by the Sotoyome Magnesite Company of Healdsburg, Tom Merchant, manager. In Sec. 23, T. 11 N., R. 11 W. The rock is a very pure-white, compact magnesite, and outcrops at intervals in a general east and west direction on the north slope, near the summit of the hill. The hill is mostly serpentine, but the magnesite outcrops in a blue adobe soil. Development work was begun in the fall of 1904. It will be necessary to build about half a mile of road to connect with the county road.

Eckert Ranch Deposit, about 2 miles southeast of Cloverdale, on the Eckert ranch, formerly the Warren Green ranch. The magnesite outcrops just above the county road, and the croppings can be followed across the ranch in a general northeast and southwest direction. Three open cuts expose a considerable body of magnesite.

Madeira Magnesite Deposit; George Madeira, Healdsburg, owner. In Sec. 31, T. 9 N., R. 10 W. Numerous croppings extend in a general northwest and southeast direction for a considerable distance up the hill and about 150 feet in width, partially covered with loose soil and low brush. The magnesite contains considerable silica. In order to develop the property it will be necessary to build about 2 miles of road to connect with the county road.

Mr. Madeira owns another deposit of magnesite, about 6 miles northeast of Cazadero, and within 2 miles of the county road. The rock is similar and occurs in larger outcrops. No development work has been done.

Sotoyome Magnesite Company; T. Merchant, Healdsburg, manager. The deposit is 10 miles northwest of Healdsburg, on the Ed. Norton ranch, on Dry Creek. The magnesite occurs in an irregular deposit, seemingly a series of loose boulders overlying a serpentine formation, and is overlaid by a clay formation, which is in turn overlaid by 2 feet of black soil. The cut exposes a boulder face of magnesite, about 16 feet wide. The magnesite at present on the dump has a considerable silica content. There is no outcrop, and it is necessary to remove considerable soil to expose the deposit.

STANISLAUS COUNTY.

American Magnesite Company. (See page 330.)

TEHAMA COUNTY.

To the east of the chromite belt (see page 272) lies one of magnesite, but this deposit has never been sufficiently investigated to determine its commercial value.

TULARE COUNTY.

Large magnesite deposits occur on the top of the first range of foothills of the Sierra Nevada Mountains, about 3 miles northeast of Porterville, on the Southern Pacific Railroad, the nearest railway point. Magnesite has been quarried and shipped from here for a number of years. Part of the magnesite is conveyed by tramway and chute to the kiln, where it is calcined and shipped as magnesia. Part of it is hauled by wagon to Porterville and shipped as magnesite. At present all the product is shipped by W. P. Bartlett, Porterville, Tulare County. A

considerable portion of it is sent to the Western Carbonic Acid Gas Company, 606 Merchant street, San Francisco.

The magnesite occurs in a schistose serpentine mass, which is impregnated with magnesite veins, and contains some basalt and diabase intrusions.

Some magnesite has been quarried from veins having a north and south trend on the hillside just above the magnesia kiln, but at present all the product is obtained from the hill one fourth to one half mile northeast of the kiln, where the serpentine is filled with a network of veins which in places form nearly half of the rock mass.

The first workings along the tramway, less than one half mile northeast of the kiln, are two tunnels on two prominent veins. The first tunnel has been run in about 300 feet north on a vein trending north and south, and another about 50 feet north of the first has been run in about 50 feet on a vein trending N. 60° W., which intersects the first vein less than 100 feet beyond the end of the tunnel. In each tunnel the white magnesite forms irregular veins from 2 to 4 feet thick in places, inclosing masses of serpentine. The wall rock on each side of the vein contains many small veins, some of which are 2 or 3 inches thick.

On the hill, from 90 to 100 feet above the level of the tunnels, an open cut has been made through the crest of the ridge on these same veins after they have united. The vein here is from 3 to 8 feet thick, inclosing some country rock in place.

For a distance of about 300 feet east from the vein above mentioned the rock contains but little magnesite in workable deposits.

From a point about 300 feet east of the vein to the east end of the hill, several hundred feet farther, the rock mass is very rich in magnesite. A large blanket vein, varying in structure at different points, underlies the whole east end of the hill, and has been quarried at a number of places; short tunnels, from 10 to 20 feet in length, have also been run into the hill. On the north side it is from 5 to 6 feet thick, inclosing a mass of dark green serpentine from 2 to 3 feet thick, which in places contains so many veins of pure magnesite that it can all be profitably quarried and hand picked.

The magnesite, being more durable than the inclosing serpentine, stands out as prominent white streaks over the surface, projecting in some places a foot or more above the surface, like quartz veins. The magnesite industry will be a profitable one here apparently for many years to come.

MANGANESE.

ALAMEDA COUNTY.

Bartlett Mine, in Sec. 6, T. 4 S., R. 4 E.; is in a small cañon branching west from Mitchell's Cañon, which is in itself a tributary of Corral Hollow. Idle for many years.

Black Jack Mine; H. J. Overacker, owner; 12 miles southeast of Livermore, on the Arroyo Mocho road, in N. E. $\frac{1}{4}$ of Sec. 14, T. 4 S., R. 3 E. It was opened in 1885, and has been worked intermittently, about 50 tons having been shipped. The ore occurs as irregular kidneys in siliceous shales, and is exposed by three short cuts and tunnels.

Fratris Mine (Estacia Mine) is 8 miles southeast of Livermore, on the Cedar Mountain road. The ore body is 8 feet wide, and is exposed by a small cut. Eight or ten tons of low-grade ore have been taken out.

Merchant Mine; Merchant Estate, Livermore, owner; operated by A. J. and J. W. Merchant. It is located 9 miles southeast of Livermore, on the west side of the Arroyo Mocho road, in Sec. 9, T. 4 S., R. 3 E. It was opened in 1888, and has been worked intermittently since. About 25 tons were taken out in September, 1904. The ore is soft and of high grade, and occurs in contorted beds of chert, dipping about 45 degrees west, with a general north and south strike. It is developed by two short tunnels, which expose a 4-foot ledge. At the surface only a 6-inch cropping is discernible. The ore has been stoped down about 25 feet.

Merchant Brothers' Mill.—A. J. and J. W. Merchant own a small mill in Livermore for grinding and concentrating manganese ore. The capacity is about 8 tons a day, and steam power is used.

COLUSA COUNTY.

Manganese was prospected about fifteen years ago by J. P. Rathbun (now resident of College City) in Sec. 4, T. 17 N., R. 7 W., M. D. M. The deposit was afterwards abandoned.

MERCED COUNTY.

Briggs Mine; N. C. Briggs, Hollister, San Benito County, owner. In Sec. 16, T. 13 S., R. 9 E., on the east slope of the Mount Diablo range. A deposit of manganese ore is claimed to show on the surface over a width of from 100 to 200 feet. Only very little development work has been done.

PLACER COUNTY.

Daniel Russell, Colfax. In Sec. 35, T. 15 N., R. 9 E., under Cape Horn. The indications of a deposit are sufficient to induce prospecting and development, but no effort has been made to expose the mineral in deposit.

RIVERSIDE COUNTY.

Charles P. Carter, Elsinore. A deposit claimed to contain high-grade manganese ore, in granite and schist country rock, about 6 miles north-east of Elsinore, near the Santa Fé Railway. To some extent developed by shafts, tunnels, and open cuts.

SAN BENITO COUNTY.

Hendricks Mine; N. C. Briggs et al., Hollister, owners. In Sec. 24, T. 13 S., R. 8 E., about 17 miles east of Tres Pinos, in the Mount Diablo range. A deposit of manganese ore, claimed to be of extensive surface area, and stated to be of fair grade, but sufficient development work has not been done to justify an opinion regarding the extent and permanency of the deposit.

SAN LUIS OBISPO COUNTY.

Antonio Staneusuch, in Secs. 6 and 7, T. 31 S., R. 12 E., M. D. M., in the Los Osos Mountains. Some deposits of manganese ore have been uncovered in the metamorphic Franciscan sandstone. Sufficient work has not been done, however, to justify an opinion regarding the extent of the deposits, but considering the small amount of work done, a satisfactory amount of a rather good grade of manganese ore has been excavated.

SANTA CLARA COUNTY.

Ala Mountain Mine; Merchant Estate, Livermore, owner. In Sec. 28, T. 5 S., R. 4 E. The vein of manganese ore is about 4 feet wide at the outcrop and dips slightly to the west, with a general northwest and southeast strike. The walls are a siliceous shale. The vein has been exposed by an open cut and a short tunnel. About 32 tons were shipped to Livermore.

Black Bear Mine; D. P. Doak, San Francisco, owner. In Sec. 34, T. 5 S., R. 4 E., near the summit of the west slope of the Arroyo Mocho Valley. Considerable development work has been done in the last few years. A small cut near the summit exposes a 3-foot vein of good ore, which has a north and south strike and dips slightly to the west. About 200 yards below these workings, another small cut exposes a 30-inch vein of ore, with an east and west strike and an almost perpendicular dip. This

vein is crossed by a vein with a north and south strike and dipping to the east. Still lower on the hillside a tunnel exposes another 30-inch vein, with an east and west strike and dipping about 60 degrees north. There are about 20 tons of ore upon the dump.

Doak Mine No. 2; same owner. On the section line between Secs. 22 and 27, T. 5 S., R. 4 E. About 25 tons were taken out by open cuts and hauled to Livermore.

Fable Mine, about 26 miles southeast of Livermore, in a small cañon tributary to the Arroyo Mocho, at Camp Jessie. The mine lies about 100 yards up this cañon from the mill, which is located on the Arroyo Mocho road. The ore occurs as a blanket vein, varying in thickness from 1 to 6 feet, and following the general contour of the hill. It occurs in contorted siliceous shales, which are extensively stained by the manganese. The blanket has been worked away for about 30 feet along the vein, by removing the overburden. Further mining was carried on by means of a tunnel, which was closed by a locked door. The ore was hauled in mine cars about 100 yards to the mill, where it was crushed before being shipped. The mill was also locked, so that the field assistant was unable to enter. The entire plant had been idle for some time.

SONOMA COUNTY.

Shaw Mine; J. E. Shaw, Cloverdale, owner; about 7 miles northwest of Cloverdale. A high-grade manganese ore (pyrolusite) outcrops about 10 feet in width, in a general northwest course. About 60 tons of ore have been extracted by means of open cuts, and it still lies on the dump. Only assessment work has been done the last few years.

MICA.

BUTTE COUNTY.

J. M. Douglass, of Merrimac, reports that mica occurs in Butte County in Secs. 16 and 17, T. 22 N., R. 6 E.

VENTURA COUNTY.

Mount Alamo Mica Company; W. Borrowe, president, 36 Geary street, San Francisco. In Secs. 12, 13, and 24, T. 17 N., R. 20 W., S. B. M. The country rock is granite, gneiss, and mica schist. The mica lies in a feldspar gangue, between a granite hanging and a mica schist foot wall. It is a muscovite. An analysis by L. Falkenau gives: SiO₂,

43 per cent; FeO, trace; Al₂O₃, 40 per cent; CaCO₃, 1 per cent; MgO, .73 per cent; K₂O, 9.3 per cent; H₂O, 5.4 per cent. As yet no large sheets have been found; some 3 by 4 inches have been mined, but the product is largely scrap mica. The material is used as follows: ground, for lubricating; in the manufacture of roofing and wall paper, rubber, etc.; also in small sheets for the manufacture of flexible mica plates, boards, washers, electrical insulation material, etc., for which purpose these small sheets of irregular form are pressed together under very high pressure.

MINERAL PAINT.

BUTTE COUNTY.

Chico Ochre and Metallic Company; Park Henshaw, secretary, Chico. In Secs. 5 and 6, T. 23 N., R. 4 E. The company has mined no ochre nor produced mineral paint for two years. Mr. Henshaw stated that the operations conducted had proven the value of the material, and also demonstrated the necessity for the practice of greater economy in production, and that it is the purpose of the company to resume operations on a more economic and extensive scale. The product brought the same price as the French ochre, and no complaint as to the quality was ever received by the producers. The market included San Francisco, Los Angeles, Portland, and Seattle.

The company owns 400 acres of ground, in which the mine is situated. The mine was worked by a tunnel 200 feet in and 400 feet below the surface, and by an open cut of 60 feet.

CALAVERAS COUNTY.

Late Ochre Mine; Miss E. E. Late, Valley Springs, owner. One half mile west of Valley Springs. The pits are on the croppings of a belt of clay ochre, occurring in upturned shales and extending in a general northwest and southeast direction across the foothills. The ochre varies in color from a light yellow to a dark reddish hue. Several carloads were shipped to San Francisco during the two seasons in which the pits were operated. The workings have been idle for about ten years.

LOS ANGELES COUNTY.

Two or three miles north of Redondo, on the coast, there are some bluffs of very fine, pure clays, of yellow, brown, and ochre tints, very suitable for mineral paints, for which they have been successfully tested by practical painters. (See IXth Report of the California State Mining Bureau, p. 298.)

NAPA COUNTY.

Carl Brown Paint Mine; Carl Brown, Calistoga, owner. Located about 2 miles south of Calistoga, on Benali Mountain. Mr. Brown has mined raw sienna, red oxide of iron, and kaolin on his place.

Paint Mine and Milling Company; Charles Hoover, Calistoga, owner. The mine is located near the summit of a pinnacle peak, $1\frac{1}{2}$ miles east of Calistoga. Formerly the paint was shipped to San Francisco to be milled. Two small pits have been opened in the light yellow oehre, which, when exposed to the atmosphere, slakes and covers the sides of the pits with loose talus. Closed since 1902.

NEVADA COUNTY.

Spence Mineral Company; Karl Howard, president, 330 Pine street, San Francisco. The mine and plant are situated at Spenceville, in Sec. 25, T. 15 N., R. 6 E. The plant has recently been idle, but resumption is contemplated. The paint material is a brownish red oxide of iron produced from the residue of iron pyrite ores mined for their copper values. In the mine dump are several thousand tons of this residue, from which the copper values have been extracted. While the mine was worked by shaft and incline, the bulk of the ore now awaiting treatment for paint values was extracted from a pit 150 feet long, 60 feet wide, and 150 feet deep. The paint produced was disposed of to the San Francisco trade, and commanded a ready market. The first price obtained was \$18 per ton, but the price of the last shipment was raised to \$20. (See Bulletin No. 23, California State Mining Bureau.)

RIVERSIDE COUNTY.

George W. Lord, Corona. In Sec. 14, T. 4 S., R. 7 W., about 500 yards southeast of the Paint Mine, is a ledge of yellow oehre, stated to be 8 feet wide, in a deposit of fire clay. The oehre is light-colored, fine-grained, but contains minute inclusions.

Paint Mine; Corona Pressed Brick and Terra Cotta Company, owner; formerly owned by George W. Lord. In Secs. 10, 11, 14, and 15, T. 4 S., R. 7 W., S. B. M.

National Paint and Color Company; William Dyer, manager, Ramona and Olive streets, Corona. Manufactures about twenty various colors—oehre, red oxide, vermilion red, grays, etc. The works are equipped with all required machinery, a 15-horsepower engine and 35-horsepower boiler, using oil as fuel. The company owns extensive clay deposits near Corona, among which is a tract of about 20 acres containing about 5 feet of oehre, stated to be of a very choice quality.

SISKIYOU COUNTY.

In Secs. 19 and 20, T. 46 N., R. 10 W., on the north side of the Klamath River, runs a bed of breccia, dipping toward the river at about 45 degrees. The cementing material is a red ochre clay, which was used formerly by the Indians as paint.

SONOMA COUNTY.

Brown's Ochre Mine; M. C. Meeker, Camp Meeker, owner. Located at Ochre, a station on the North Shore Railroad. This mine was opened in 1898 and has been operated intermittently since. The ochre was shipped to W. P. Fuller & Co., of San Francisco. It occurs as a bedded deposit; a face about 50 feet wide has been exposed.

Healdsburg Paint Company's Mine; T. S. Merchant, Healdsburg, manager. It lies about 10 miles (by road) south of Healdsburg, on Porter Creek, in T. 8 N., R. 10 W. The ore is a low-grade hematite, high in silica. It outcrops over the hill, with a course slightly north of east, and averages 60 feet in width. The ore body is extensively fractured and is soft in spots, while quartz stringers in places make it necessary to sort the ore and to throw a portion out as waste. It was originally opened by a tunnel, which was driven in about 100 feet in a general easterly direction. An upraise was then driven to the surface, and the ore has since been mined in an open cut, stoped down this chute and loaded into a mine car, which takes it out of the tunnel to the bins. The present open cut ranges from 10 to 20 feet in depth, and has been directed more in the nature of development work than for mere mining purposes. The sorted ore is hauled by wagon to the company's mill on the Santa Rosa road, one half mile south of Healdsburg. Here the ore is first crushed in a small jaw crusher, and then thoroughly dried in a cylindrical drier of their own patent. It is next fed to a 5-stamp mill, crushing dry with 1000-pound stamps dropping $8\frac{1}{2}$ inches, after which it is passed through sets of burr stones and is then bolted through No. 200 silk to insure a uniform grade of fineness. At present, two shades of paint are marketed—"Indian red metallic" and a lighter shade "Venetian red." The darker shade is made by mixing a black carbonaceous shale under the stamps. Power is derived from a 75-horsepower engine and boiler. The capacity of the mill is from 24 to 30 barrels per day.

Occidental.—M. C. Meeker states that there is a 40-acre deposit of ochre west of the hotel at Occidental, which was prospected by an Oakland company several years ago.

STANISLAUS COUNTY.

Gallup Ranch; Mrs. M. A. Gallup, Stockton, owner. In Sec. 1, T. 2 S., R. 13 E. Ochre was shipped from this deposit, first in 1887, again in 1891, and in 1899, but stopped because of expensive wagon haul. The Sierra Railway now passes within $3\frac{1}{2}$ miles of the deposit. The ochre bed covers several acres.



ILL. No. 144. LEWIS VOYLE'S OCHRE MINE, KNIGHT'S FERRY, STANISLAUS COUNTY.

Pentland Ochre Mine; Henry B. Pentland estate, owner. In Sec. 28 T. 1 S., R. 12 E., about one quarter of a mile southwest of Knight's Ferry. The beds of ochre are similar to that in the Voyle mine, except the ochre is of a fainter color. No shipments have been made for about ten years.

Voyle Mine; Lewis Voyle, owner. Located in a small gulch one quarter mile north of Knight's Ferry. It is operated under bond each

summer by George Kaehler of Fresno, the work commencing about the middle of April. The ochre occurs in a nearly flat bed, averaging about 4 feet in thickness, and overlies a compact blue clay. It is overlaid by a 6-inch bed of iron ore, which in turn is covered by a great thickness of gravel. Both a yellow and a reddish ochre are available, but only the former is shipped in quantities. The ochre is mined by means of short tunnels on either side of the gulch, and sacked at mouths of tunnels ready for shipment.

TRINITY COUNTY.

T. Bowerman, Minersville. In Sec. 15, T. 35 N., R. 8 W., M. D. M., on the east side of the east fork of Stewart's Fork, is a body of red ochre, used as mineral paint. The ochre shows the blocky structure of the country rock, a highly weathered deposit of igneous origin. This material has been used locally.

Southern Pacific Railroad Company owns a deposit of similar material in Sec. 9, T. 35 N., R. 8 W., M. D. M.

YUBA COUNTY.

Dempsey Ranch, in Sec. 3, T. 15 N., R. 6 E.; the development work was done several years ago. The weathered and rain-beaten red ochre still on the dump gives some indications of a fair quality.

Yellow Ochre is exposed in small croppings in Sec. 29, T. 20 N., R. 8 E., one mile west of Strawberry Valley.

PAVING BLOCKS.

NAPA COUNTY.

Zollner Paving Block Quarry, formerly the Olsen Quarry. It lies about 2 $\frac{3}{4}$ miles southeast of Napa, and has been idle for the past three years.

RIVERSIDE COUNTY.

See Granite, pages 40 to 47.

SAN BERNARDINO COUNTY.

See Granite, pages 48 to 53.

SOLANO COUNTY.

Cordelia Quarry. See Macadam, pages 325 and 326.

SONOMA COUNTY.

The quarrying of paving blocks has been a very important industry in Sonoma County, but owing to the introduction of bituminous rock pavement the demand has decreased each year. There is a slight increase of demand at present. The principal quarries are near Santa Rosa, Sonoma, and Petaluma. The rock quarried for paving blocks is erroneously called basalt. It is a dark gray trachyte. The lower portion is often a heavy deposit of tuff of varying shades, and somewhat vesicular. Some of the stone is used for building purposes.

Bacigalupi Quarry; N. Bacigalupi, 315 Fourth street, Santa Rosa, owner. In the northern part of Sonoma. At present three men are employed getting out paving blocks.

Boca Quarry; Boca Brothers, Glen Ellen, owners. Located one half mile east of Glen Ellen. No paving blocks have been produced for about four years.

City Improvement Company's Quarry (formerly the Violetti Quarry). It is one half mile southwest of Melitta, and the blocks are shipped from there. This quarry is worked in conjunction with the McDonald Quarry, and is in charge of B. W. Lester, of Santa Rosa.

Cooney Quarry; James Cooney, owner. Five miles northeast of Petaluma. Worked intermittently.

Craig Quarry; D. N. Craig, owner. Two miles north of Penngrove, on east side of road to Santa Rosa. The quarry is operated on royalty. About 50,000 paving blocks are produced a year, as well as stone for curbing, gutter rocks, and bridges.

Davis Quarry; Warren Davis, owner. About 3 miles northeast of Penngrove. Idle for past five years.

Dickinson Quarry; D. S. Dickinson, owner. On the Dickinson ranch, 7 miles northeast of Petaluma. Idle for past seven years.

Elliott Quarry; Part of the McDonald ranch, Baku Siding. Idle.

Flinn & Treacy Basalt Block Quarry; Flinn & Treacy, 302 Montgomery street, San Francisco, owners. At Olsen Siding, near Melitta, on the Southern Pacific Railroad. The quarry has been operated constantly for three years, producing about 40,000 blocks per month.

Frugley Quarry; N. Bacigalupi, of Santa Rosa, lessee. On the Rincon Valley road, 6 miles northeast of Santa Rosa. It produced about 50,000 blocks last year. The blocks are hauled $2\frac{1}{2}$ miles to Baku Siding. Two men are at work.

Hardin Quarry: L. B. Hardin, owner. It is 5 miles northeast of Petaluma, and has been idle about two years.

John Hugert Quarry, 3 miles east of Melitta, on Joe Bowers' property. From two to eight men are employed, and the blocks are shipped from Melitta.

Hutchison Quarries.—The Borg Quarry is one half mile south of Borg Siding, and the Annadel Quarry is one mile south of Annadel Station. Thomas Hutchison of Santa Rosa operates both quarries and worked them a little during the summer of 1904, but they are idle at present.

Lichau Quarry (formerly the Beason Quarry); A. C. Lichau, owner. It is 4 miles northeast of Penngrove, and has been idle for about seven years.

John Lynch Quarry, 6 miles east of Petaluma; has been idle for several years.

McDonald Quarry; Capt. J. McDonald, San Francisco, owner. It is 3 miles east of Santa Rosa. A portion of this quarry is leased to N. Bacigalupi, of Santa Rosa. He has four men at work, and produces about 50,000 blocks a year.

A portion is also leased to the City Street Improvement Company of San Francisco; B. W. Lester, 410 Santa Rosa avenue, Santa Rosa, superintendent. They produce about 400,000 blocks a year, as well as flagstones, curbing, and building stone. The Carnegie Library of Santa Rosa and the California Northwestern Railway depot in Santa Rosa were built of rock from this quarry. The stone is shipped from Baku Siding, on the Southern Pacific Railroad.

Metone Quarry; Mr. Metone, owner. It is $3\frac{1}{4}$ miles west of Healdsburg. The rock is dark blue trachyte. P. Maroni has worked the quarry intermittently for building stone and paving blocks. He furnished considerable stone to the army department at the Presidio and Fort Baker.

F. Milani Quarry, 2 miles north of Sonoma, just beyond the Schocken quarry faces. Two men are employed to get out paving blocks, and occasionally some building stone is quarried.

Norris Quarry; C. Norris, owner. It is 5 miles north of Santa Rosa, in Rincon Valley. Twenty men are at work getting out paving blocks and curbing rock. They make about 250,000 blocks a year.

Petroncelli Quarry; Frank Petroncelli, owner. It is half a mile southwest of Kenwood, and is worked intermittently. Five men are employed. They produce about 30,000 paving blocks a year, and also some building stone and gutter rocks.

Roberts Quarry; Frank Roberts, owner. It is about 3 miles north of Penngrove. Idle for the past seven years.

Roy Bert Quarry; N. Bacigalupi, Santa Rosa, lessee. It is 4 miles northeast of Santa Rosa, in Rincon Valley. Four men are employed. They produce about 75,000 blocks a year.

Santa Rosa Basalt Rock Quarry; Captain McDonald, of Santa Rosa, owner. Leased out and operated on a royalty basis.

Schocken Quarry; S. Schocken, Sonoma, owner. This is the largest quarry being operated in the vicinity of Sonoma, and is located $1\frac{1}{2}$ miles north of the town. The rock occurs in boulders of various sizes and shapes, ranging from 1 to 20 feet in cross-section. About ten men are at work getting out gutter rock and paving blocks, and they average about 10,000 blocks a month.

This and nearby quarries have been worked for many years, and great dumps of chips cover the steep hillsides. This apparent waste rock would, with very little crushing, make a very good material for macadam or concrete purposes.

Stacey Quarry; S. Stacey, Kenwood, owner. This quarry is one half mile south of Lawndale, a station on the Southern Pacific railroad, northwest of Kenwood. Twelve men are at work in quarry, and they produce about 200,000 blocks a year.

Swank Quarry (formerly the Clute Quarry); J. W. Swank, Santa Rosa, owner. In Sec. 13, T. 7 N., R. 8 W. Formerly paving blocks were quarried, but stone is now used for foundations and bulkheads.

Union Construction Company, 207 Montgomery street, San Francisco. The quarry is in Sec. 3, T. 4 N., R. 7 W. The rock is a basalt, and is used for macadam, concrete, and paving blocks. The crusher is located at foot of hill by roadside, and the rock is brought from the quarry at the summit by a tram. The crushed rock is shipped by both rail and schooner. Twenty men are at work.

H. Weyl Quarry, operated by H. Stagnassa. About 2 miles north of Sonoma. Only paving blocks are produced, and these are shipped from the town. The rock in the hills north of the town of Sonoma is mostly a dark bluish, close-grained basalt, but it weathers rapidly to a dark reddish color.

Wilkinson Quarry, on the McNiell ranch, 4 miles north of Penngrove. It has been idle for a number of years.

Wymore Quarry, one mile south of Melitta, on Mr. Wymore's property, but it is operated by Louis Laurent, of Melitta. Sixteen men are employed in the quarry. They produce 500,000 blocks a year.

PLATINUM.

Pure platinum is a silvery white metal, with a specific gravity of 21.5. It is the heaviest metal occurring in nature, with the exception of iridosmium. It is almost as hard as iron, and very malleable. Platinum does not amalgamate with quicksilver; is not dissolved by potassium cyanide when cold; is not attacked by acids, except the mixture of nitric and hydrochloric acids known as aqua regia; and is more difficult to melt than gold. Platinum is most readily distinguished as follows: (1) By its great weight—in panning it remains even behind the gold in the pan; (2) by its white color—it is whiter than lead and is distinguished from amalgam by its smooth surface, whereas the surface of amalgam, as seen under a good glass, is rough; (3) by its resistance to nitric acid as compared with native silver or lead.

Native platinum has been found most frequently in gold-bearing sands. On account of its weight it remains in the sluices with gold and other heavy material. The native platinum is usually very impure. Occasionally it contains so much iron, chromite, and other impurities as to be dark in color and not easily distinguished from grains of chromite with which it is very frequently associated. It often contains iridosmine, which occurs as flat angular scales, while platinum grains are usually rounded like gold dust. Generally, platinum grains are smaller than gold grains. Large nuggets are very rare.

More platinum is obtained from California than from any other State in the Union; and it occurs in this State in more localities than elsewhere in either North or South America. The product of this State for 1904 was as follows:

	Value.
Butte County	\$1,000 00
Del Norte County	18 00
Humboldt County	140 00
Placer County	375 00
Siskiyou County	21 00
Stanislaus County	20 00
Trinity County	275 00
Total	\$1,849 00

It will be noted that whereas formerly Trinity County made the largest annual output of this metal, Butte County now makes the largest output, which is principally owing to the fact that in the dredging operations account is kept of the amount of platinum saved, and some attempt is made to save it.

Platinum has been reported in California from the following places, and doubtless occurs in other localities where little or no attention has been paid to saving it. This shows a distribution of thirty-eight localities in fifteen different counties of the State:

Locality.	County.	Value of Platinum per Ton of Concentrated Sands.	Value of Platinum contained for Each Dollar in Gold.	Remarks.	
Chico	Butte	\$5 46	\$0 08	Found frequently in dredging operations.	
Magalia	Butte	30	01		
Oroville	Butte				
Mokelumne Hill	Calaveras	02	002	Has yielded platinum in commercially appreciable quantity.	
Crescent City	Del Norte	04	17		
Smith River	Del Norte	54	07		
South Fork, Smith River	Del Norte	618 31	02		
Wilson Creek	Humboldt	02	08		
Stone Lagoon (beach)	Humboldt				
China Flat	Humboldt	177 08	1 38		
Orleans	Humboldt	6 87	50	Platinum is very fine grained.	
Gold Bluff beach north of Arcata	Humboldt				
Little River beach	Mendocino			Has yielded platinum.	
Michigan Bluff	Placer	34	01	Promising locality.	
Genesee	Plumas	06	Trace.		
Beach	San Luis Obispo			Do.	
Santa Barbara beach	Santa Barbara			Do.	
Lompoc beach	Santa Barbara			Very fine grains.	
Santa Cruz beach	Santa Cruz				
Beegum district	Shasta			Promising district.	
Sawyer's Bar	Siskiyou	2 30	31	Plentiful.	
Oak Bar	Siskiyou	54	12		
Fort Jones	Siskiyou	07	001		
Klamath River	Siskiyou	2 40	51		
Rock Ranch	Siskiyou	51	26		
Callahan	Siskiyou	7 02	1 34		
Hornbrook	Siskiyou	18	06		
Happy Camp	Siskiyou	50 97	1 48		
Cecilville	Siskiyou	2 01	14		
Beegum	Tehama				Promising district.
Trinity Center	Trinity	28	79		
Burnt Ranch	Trinity	13 09	1 04		
Big Bar	Trinity	3 75	11		
Junction City	Trinity	1,934 18			
North Fork	Trinity				
Hawkins Bar	Trinity	4 05	34		
Hayfork district	Trinity			Platinum contains much iridosmium.	
Camptonville	Yuba	32	04		

During the last session of Congress an appropriation was made to enable the United States Geological Survey to investigate the black sands of placer mines in this country, especially with a view of finding the amount of platinum contained. This investigation was placed in the hands of Dr. David T. Day, Chief of the Division of Mineral Resources of the Survey. In connection with the mining exhibit at the

Lewis and Clark Exposition at Portland, Or., concentration experiments were carried on all summer under the direction of Dr. Day. Of the many samples of black sand received several hundred specimens were tested to ascertain their contents of gold and platinum. In a preliminary report Dr. Day gives the following results obtained from the assays of the black sands from various localities in California:

Amount of Gold and Platinum contained in Black Sand Concentrates from various Placer Mining Districts in California.

[Ounces per ton.]

Locality.	County.	Gold.	Platinum.
Oroville	Butte	19.94	27.45
Alvarado placer mine, Butte Creek	Butte	5.22	.17
Buchanan Hill	Butte	1.09	.08
Peavine Creek	Butte	7.03	.83
Empire	Butte .....	.08	Trace
Wild Goose mine	Calaveras	39.08	.35
Orleans	Humboldt	19.00	4.00
Sec. 7, T. 16 N., R. 12 W.	Mendocino	Trace	Trace
Rough and Ready township	Nevada	5.60	.52
Taylor mine, North Fork American River, Colfax	Placer	29.26	1.27
Southwest of Auburn	Placer	24.14	1.48
Gold Run	Placer	37.61	8.78
Gold Blossom mine, Butcher Ranch mining district	Placer	191.60	3.36
American River	Placer	126.90	9.67
Nelson Creek	Plumas	1.45	.12
Boulder Nest mine on Grizzly Creek, Genesee district	Plumas	1.44	.66
Rock Island Hill mine	Plumas	10.80	.16
Little Grizzly mine	Plumas	Trace	Trace
La Porte	Plumas	2.98	.21
Van Duzen Cañon, Holcomb	San Bernardino .....	.12	.06
Gem mine, Sacramento River, north of Redding	Shasta .....	.64	.28
Gypsy mine, Shasta district	Shasta	8.29	.25
Fox Creek	Siskiyou .....	.72	Trace
Grouse Creek	Siskiyou	10.31	.18
Happy Camp district	Siskiyou	None	.82
Junction City mining district	Trinity	28.43	25.80
South Fork and Trinity River	Trinity	9.02	1.28
T. 5 N., R. 7 E.	Trinity	4.90	4.61

As before stated, previous to 1904 most of the platinum obtained in this State was derived from Trinity County.

TRINITY COUNTY.

Platinum is found in a great number of placer mines in Trinity County, but more especially in a belt from 10 to 12 miles wide, from Junction City westward down Trinity River; from there the platinum belt runs in about a southerly direction, covering the east side of Hayfork Valley up to the east fork of the Hayfork. The gold of the placer mines of this vicinity carries invariably some platinum. The belt then turns a little to the southwest, including Salt, Post and Rattlesnake creeks. All the placer mines in the south fork below Rattlesnake Creek carry more or less platinum.

In the south fork near Hyampo, and in the Marsh & Ham claim,

near Junction City, the largest nuggets, up to one ounce, have been found. One clean-up in the latter claim gave about 7 ounces of platinum to 240 ounces of gold. The platinum is always found in well-rounded grains; in the vicinity of Hayfork, it occurs as shot.

(See also Bulletin No. 36, California State Mining Bureau.)

PYRITES.

ALAMEDA COUNTY.

Alma Mine; Stauffer Chemical Company, 318 Front street, San Francisco, owners. Located 4 miles east of Broadway, Oakland, on the Redwood Cañon road, on the old Fritz Boehmer ranch. The mine was opened about 1892. There are seven tunnels (the longest being about 500 feet), and about 2000 feet of drifts. The solid body of pyritic ore is about 360 feet long, 300 feet wide, and averages about 30 feet in thickness, following in a general way the topography of the hill. The character of the ore varies, but it averages about 55 per cent of sulphur, from 3 to 4 per cent of copper, and carries \$2 in gold. The ore is hauled by wagon to Leona Heights station and shipped to the company's chemical works at Stege, or to the Peyton Chemical Company or the Flemming Chemical Company, both of San Francisco, where the sulphur content is used principally in the manufacture of sulphuric acid. (See Bulletin No. 23, California State Mining Bureau, "The Copper Resources of California," page 144.)

Leona Heights Mine, owned and operated by the California Improvement Company, under control of the Realty Syndicate of Oakland, F. M. Smith, president. Located to the south of the Alma Mine, and on the strike of its ore-bearing zone. The ore body is similarly situated and is similar in character to that of the above mine. It is developed by a 200-foot tunnel. The ore averages about 12 feet in thickness.

QUARTZ CRYSTALS.

(See Bulletin No. 37, California State Mining Bureau.)

CALAVERAS COUNTY.

Green Mountain Mine; J. J. McSorley, superintendent. In Sec. 24, T. 5 N., R. 11 E., about 2 miles south of Mokelumne Hill. Some fine specimens of quartz crystals have been shipped for several years to New York for art purposes.

EL DORADO COUNTY.

(See page 65, Bulletin No. 37, California State Mining Bureau.)

PLUMAS COUNTY.

Quartz crystals are reported in the limestone formation at Nelson Point, east of north from La Porte, a distance of 22 miles. No attention, however, has been given to their commercial value.

SOAPSTONE—TALC.

Talc is a hydrous silicate of magnesia ($4 \text{ MgO}, 5 \text{ SiO}_2, \text{ H}_2\text{O}$) that occurs in different varieties, of which soapstone is one of the most important.

Soapstone is a harder, more compact variety, and is used in the manufacture of many articles such as bath and laundry tubs, firebacks for stoves, hearthstones, mantels, sinks, griddles, slate pencils, gas tips, switchboards for electric plants, and other articles.

Talc is used as powder, or flour talc, and as pieces sawed into various sizes and shapes. The flour talc is used in fireproof paints, lubricants, many of the cheaper soaps, electric insulators, boiler and steam-pipe coverings, foundry facings, for the dressing of skins, and in the manufacture of dynamite, toilet powder, and paper. (See Bureau of Census, Mines and Quarries, 1903, p. 1065.)

ALAMEDA COUNTY.

Gray Eagle Talc Claim; A. J. Merchant, Livermore, owner. In Sec. 32, T. 4 S., R. 4 E., 20 miles southeast of Livermore. The talc is light green in color, and outcrops in several places in small seams in serpentine. The claim has been opened by a small pit.

BUTTE COUNTY.

SOAPSTONE.

In Butte County soapstone has been employed only for local structural purposes, chiefly for firebacks in the neighborhood of Flea Valley and Clear Creek. The belt of soapstone occurrences extends from Pike City, in the southwest corner of Sierra County, through Yuba and the southwest corner of Plumas to Magalia, in Butte County. The chief occurrences are in Sec. 21, T. 21 N., R. 3 E., E. Taylor, Clear Creek P. O.;

Sec. 35, T. 23 N., R. 4 E.; Sec. 4, T. 21 N., R. 5 E., J. Bohannon, Yankee Hill P. O. Within this area of soapstone occurrences there are also asbestos and talc. There has been no practical development of any of these materials.

Edward Martin, Brush Creek P. O., reports a deposit of soapstone in Secs. 7 and 8, T. 21 N., R. 6 E.

TALC.

Talc occurs chiefly within the area described above.

Chico Ochre and Metallic Company; Park Henshaw, Chico, secretary. In Sec. 6, T. 22 N., R. 4 E., talc was observed lying near the ochre, and talc float and croppings were encountered. It has not been developed nor prospected.

J. A. Clark, owner. In Sec. 3, T. 21 N., R. 5 E., in the Big Bend of the North Fork of Feather River, occurs a deposit of talc of the tailor's chalk variety. The talc occurs in narrow layers, in serpentine trending northwest and southeast, dipping to the northeast.

CALAVERAS COUNTY.

Ed. Black's Claim, $2\frac{1}{2}$ miles west of Murphys, on the French Gulch road. Some talc has been taken out for local use in building chimneys and fireplaces.

Vallecito—One and a half miles southwest of Vallecito a 50-foot cropping of drab-colored talc is crossed by the wagon road. No regular quarry has ever been opened, but it is dug out as needed for firebacks and boiler linings.

GLENN COUNTY.

Talc occurs in the eastern edge of Glenn County, underlying the serpentine formation that extends from T. 22 N., R. 7 W., southerly into Colusa County.

Alexander Brown, Oakland, owner. In T. 18 N., R. 6 W., various croppings indicate the presence of a good quality of talc of the tailor's chalk variety. The exposures, which are made by the flow of Salt Creek, are associated with the blue and light-colored clays.

LOS ANGELES COUNTY.

Banning Company, 593 Pacific Electric Building, Los Angeles. At Empire Landing, Santa Catalina Island, soapstone is found in conjunction with the serpentine. It has a grayish color and can be easily worked. (See also Serpentine.) Steatite (French chalk) of a good grade is also found in the same vicinity.

PLACER COUNTY.

D. Russell, Colfax. In Sec. 35, T. 15 N., R. 9 E., under Cape Horn, is a deposit of tale that has never been thoroughly prospected nor any effort made toward development. The material is exposed in small outcroppings that indicate a good quality.

RIVERSIDE COUNTY.

F. A. Stephens, Winchester. Some superficial work has been done on deposits of white, scaly tale, about 3 miles southwest of Winchester. (See XIIIth Report of the California State Mining Bureau, p. 639.)

SIERRA COUNTY.

Soapstone of a structural character has been quarried for local use at the Alaska Quartz Mine (George St. John, Pike City, superintendent), near Pike City, in Sec. 8, T. 18 N., R. 9 E. This dike of soapstone is 300 feet wide, strikes nearly north and south, and is part of the belt mentioned above (see Butte County, page 350). The furnaces and the foundation bed for the hoist were constructed twenty years ago of this soapstone. These structures are still standing, and have been recently used. The soapstone is of whitish tint, weathers brown, resists the elements, is hardened by the action of fire, but is wasted by friction with other material. It is easily cut with a common saw. Other structures have also been satisfactorily constructed of this material.

SISKIYOU COUNTY.

SOAPSTONE.

Soapstone is found in several places in Siskiyou County.

E. Hunt, Fort Jones, owner. In Sec. 12, T. 42 N., R. 9 W. The soapstone is found in schist, interstratified with beds of limestone from 1 to 3 inches wide.

A. Robertson, Fort Jones, owner. In Sec. 1, T. 42 N., R. 9 W. Soapstone is shown by shallow diggings on the top of a serpentine hill. The workings are insufficient to show either the extent or the character of the soapstone.

A large belt of soapstone is reported from south of Marble Mountain, near the head of Wolley Creek, in the northeast part of T. 13 N., R. 8 E., H. M.

A large exposure of soapstone is found in the northeast sections of T. 45 N., R. 11 W., southeast of Hamburg Bar, having a course N. 50° E. It can be traced toward the ridge west of Scott River. On the

divide it is from 40 to 50 feet wide. The soapstone is of very good quality, and resists the effect of fire for years in fireplaces without any deterioration, resembling pressed firebrick. It is also used in sheets one half to three quarters of an inch thick for stovebacks.

TALC.

J. Conners, Etna, owner. In Sec. 32, T. 42 N., R. 9 W., a short cut above the ditch of the Etna Development Company shows a narrow belt of serpentine, in which a deposit of talc is found, very pure and without any grit.

G. K. Crowley and **E. Caldwell**, Eugene, Or., and others, owners, in Sec. 3, T. 48 N., R. 8 W. In the Cottonwood Mountains is a body of ochreous-colored talc 30 feet wide. It has been to some extent excavated on the top of the divide between Beaver Creek and Bumblebee Creek, and can be traced southeast to the latter. It has no grit. Its light ochreous color is due to iron, which, however, does not interfere with its refractory character.

TRINITY COUNTY.

On Brown's Mountain, in Sec. 21, T. 33 N., R. 9 W., M. D. M., is a cropping of soapstone. The color is light gray, with numerous specks of ochre. Part of the material is steatite. It is obtained by sawing the uncovered blocks, and is used as fireproof material in fireplaces, etc. Apparently, it does not weather on exposure to the air, nor harden. When put in the fire, it does not disintegrate.

TUOLUMNE COUNTY.

Dr. F. T. Davis, Box 413, Sonora, owner. In Sec. 32, T. 34 N., R. 15 E., M. D. M., 9 miles north of Sonora, is an outcrop of a greenish-white talc, nearly 200 feet in width.

YUBA COUNTY.

Soapstone is of frequent occurrence in Yuba County, and occasional local uses have been made of it for copings and firebacks. The principal occurrences are:

W. S. Godfrey, Camptonville. Sec. 35, T. 19 N., R. 8 E., M. D. M.

J. D. Jaynes, Camptonville. Sec. 10, T. 18 N., R. 8 E., M. D. M. A strong cropping of soapstone.

In the vicinity of Challenge, T. 19 N., R. 7 E., M. D. M.; and near Oak Valley, T. 19 N., R. 8 E., M. D. M., croppings of soapstone are found.

SULPHUR.

COLUSA COUNTY.

Elgin Mine, Sulphur Creek District. Elgin Quicksilver Mines, owner; C. F. Humphrey, president, 137 Montgomery street, San Francisco. Attempts have been made to distill sulphur from the rocks in this mine. (See "Quicksilver Resources of California," Bulletin No. 27, California State Mining Bureau, p. 43.)

TEHAMA COUNTY.

In the northeastern part of the county, on the south slope of Lawson Butte, at Bompus Hell, and Supan's sulphur works, are very strong hot springs, the waters of which contain a great amount of sulphur, which is deposited in cones, covering an area about one mile long east and west, and about half a mile wide. This sulphur occurs partly in large crystals.

VENTURA COUNTY.

Dr. W. L. Watts reports sulphur in the Sulphur Mountains, 3 miles east of Fillmore. (See Bulletin No. 19, California State Mining Bureau, p. 86.)

TUNGSTEN.

Tungsten is used principally in the manufacture of tool steel. It is added to the steel in the form of ferro-tungsten. Generally tungsten steel contains from 2 to 5 per cent of tungsten, but Mushet's steel contains 7.8 per cent of tungsten. Also, for hardening a copper-aluminum alloy. It is used for small-caliber projectiles. Tungsten bronze is used for coating metals. Sodium tungstates are used for dyeing and as a fire-protecting ingredient in wearing apparel.

Metallic tungsten varies much in price. Quotations July, 1905, were: ferro-tungsten (37 per cent), 45 cents per pound; tungsten, \$1.25 per pound.

Tungsten ores are sold per unit of tungstic trioxide; to be marketable it must contain at least 45 per cent WO_3 ; the price per unit increases with the percentage.

Tungsten ores are mined in the United States in Arizona, California, Colorado, and Idaho.

KERN COUNTY.

Scheelite is reported to have been found at a depth of 250 feet in the ledge of a gold mine 2 miles west of the Buckboard mine.

Churchill, Johannesburg, Kern County.

R. E. Graham, Randsburg. Four claims.

Papoose Claim, Randsburg District; Thomas McCarthy and C. S. Taylor, owners; C. S. Taylor, Johannesburg, manager. The claim was located April 13, 1900, and since that time the owners have opened a surface cut for about 400 feet along the ledge and sunk two shafts, one 50 feet and the other 20 feet, both on the ledge, which is nearly perpendicular. The ore is scheelite and is claimed to assay between 60 and 70 per cent of tungstic acid. The vein varies in width from 6 to 20 inches. A carload of this ore was recently shipped to Germany.

J. N. Thompson, Tehachapi. A deposit of scheelite near St. Elmo.

SAN BERNARDINO COUNTY.

South of Johannesburg, running west to the Kern County line, over an area about one mile long and half a mile wide, occurrences of tungsten are found. In the gulches chunks of scheelite are found in the granitic wash, and separated by dry washing. The scheelite is distributed apparently through the country rock, a white decomposed granite, in numerous narrow seams, without any regular orientation. Boulders or fragments, some weighing 150 pounds, are found on the surface. Where sunk on the ledges, inclusions of scheelite are found in both walls.

Guadalupe Tungsten Mine, about 4 miles from the town of Manvel. The owners claim that the ore shows 60 per cent of tungstic oxide and that \$4000 has been expended upon development work.

ZINC.

SHASTA COUNTY.

Kentuck Mine, Herbert Bass and D. Brandstetter, Montgomery Creek P. O., owners. In Sec. 21, T. 34 N., R. 1 W.; elevation, 1925 feet. A body of ore carrying zinc blende and galena has been developed to a slight extent. A tunnel 70 feet long has been run in an easterly direction on a ledge about 4 feet wide, dipping north. The hanging wall is too decomposed to give its precise character. The foot wall is appar-

ently a shale. About 20 feet from the entrance of the tunnel a shaft 40 feet deep has been sunk. The shaft and the tunnel past the shaft were inaccessible. The ore on the dump from the shaft shows galena and zinc blende. About 30 feet west of the tunnel entrance, on the opposite side of a shallow ravine, an open cut about 20 feet long has been run westward, from which ore similar to that found in the entrance to the tunnel has been taken. It is reported that this ore has been traced for a considerable distance east of this deposit, and kidneys of similar ore have been found on ground belonging to the Afterthought mine, 5 to 6 miles west.

G. H. Lambson, L. Bass et al., Baird P. O., owners. In Sec. 21, T. 34 N., R. 4 W. A shallow cut about 15 feet long, course N. 30° E., shows a well-defined vein of quartz, strike N. 45° W., dipping northeast, carrying some zinc blende and galena.

Specimens of zinc ore are found in the Museum of the California State Mining Bureau labeled as coming from the following places:

INYO COUNTY—Smithsonite and Cerrussite from the *Modoc mine*. Willemite from the *Ygnacio mine*, Cerro Gordo.

MARIPOSA COUNTY—Zinc blende.

SAN BERNARDINO COUNTY—Calamite from the *Cuticura mine*, near Daggett.

SUPPLEMENT.

LIST OF SPECIMENS
IN THE
MUSEUM OF THE STATE MINING BUREAU
OF
MINERAL SUBSTANCES ENUMERATED IN THIS BULLETIN.

ANTIMONY.

Location.	Donor.
Calaveras County—	
Mokelumne Hill . . .	Frank Cummings.
Inyo County—	
Cerro Gordo.	
Death Valley, north end	Dr. Chase.
Lottie Mine	Jos. Davidson et al.
Panamint Mine	George K. Phillips.
Kern County—	
Buffalo Mine	Charles E. Sherman.
Caliente	Smith & Brown.
Havilah	A. Blanc.
Havilah	William Menzel.
Kernville	Dr. D. G. George.
Little Caliente Spgs.	A. Blanc.
Mojave	H. E. Cunningham.
Ruby Mine	Hickey, Cunningham & McViear.
San Emidio Mine	S. Boushey.
Los Angeles County—	
Lancaster	James P. Ward.
Los Angeles (7 miles from)	Thomas G. Hunter.
Mono County—	
Comanche Mine	Joseph Wasson.
Comet Mine.	
Diana Mine.	
Keniek Mine	H. M. Levy.
Napa County—	
Manhattan Mine	R. B. Knox.
Riverside County—	
South Riverside	John N. Anderson.
San Benito County—	
Alta Mine (Sec. 30, T. 11 S., R. 7 E., M. D. M.)	Daniel Ambrose.
Ambrose Mine	W. L. Watts.
Hollister	Chas. Bronson.
Hollister	L. Lanzweert.
Hollister	Mr. Collins.
Hollister	C. C. Jones.
McLeod.	
Sam Mine.	
Shriver Mine.	

ANTIMONY—Continued.

Location.	Donor.
San Luis Obispo County—	
Angel and Baker Mine	Myron Angel.
Cambria.	
San Simeon (Sec. 38, T. 27 S., R. 9 E., M. D. M.).	
Santa Clara County—	
Gilroy.	
Sierra County—	
Downieville	Richard Sparling.
Tulare County—	
Mammoth Mine	S. H. George.
Mineral King Dis- trict	G. W. Brown.

ARTIFICIAL STONE.

Contra Costa County—	
Antioch (pressed brick)	Golden Gate Co.
Los Angeles County—	
Chatsworth Park	H. Clement & Co.
Los Angeles	L. A. Pres'd Brick Co.
Los Angeles	Western Art Tile Wks.
Tropico	Pacific Art Tile Co.
Placer County—	
Lincoln (firebrick)	John Landis.
San Francisco—	
San Francisco	Ransome Artificial Stone Co.
Santa Clara County—	
San José (pressed brick)	Peterson & Karts- choke.
Santa Cruz County—	
Santa Cruz (brick)	W. T. Hatch.

ASBESTOS.

Location.	Donor.
Amador County—	
Sutter Creek	E. C. Voorhies.
Butte County—	
Forbestown	Norton & Eekmann.
Oroville	R. J. Perrin.
Red Hill.	
El Dorado County—	
Kelsey District	S. E. Holcomb.
Fresno County—	
Coalinga	Geo. H. Battenfeld.
Inyo County—	
.....	F. B. S. Keeler.
Madera County—	
Fine Gold Gulch	Mrs. A. M. Ulyard.
Fresno Flat.	
Mariposa County—	
Bear Valley	Edward M. Price.
Mount Bullion	Mark Brumagin.
Placer County—	
Iowa Hill	Mr. Thelfal.
Morning Star Mine	J. H. Neff.
Pritchard Mine	H. G. Staab.
San Benito County—	
Hollister	George Vaughn.
San Bernardino County—	
Barstow.	
San Diego County—	
Elsinore	J. D. Hoff.
San Jacinto Mts.	Chalmers Scott.
Shasta County—	
.....	L. Wellendorf.
Hazel Creek	B. F. Miller.
Sierra County—	
Consolidated Mine	Robert Stuart.
Siskiyou County—	
Sisson	W. H. Shebley.
Trinity County—	
Minersville.	
Tulare County—	
White River	S. G. George.
Yolo County—	
California Mine	R. G. Hart.

BARYTES.

Calaveras County—	
Satellite Copper Mine	H. D. Ranlett.
Contra Costa County—	
Mt. Diablo	J. W. Nellis.

BARYTES—Continued.

Location.	Donor.
El Dorado County—	
Georgetown (10 mi. above)	A. L. Burbridge.
Inyo County—	
Bishop Creek	W. B. McSwiney.
Defiance Mine.	
Lake County—	
Glenbrook	H. B. Aldrich.
Los Angeles County—	
Azusa	W. H. Adams.
Mono County—	
Mammoth Mine (Mineral Hill).	
Orange County—	
San Joaquin Ranch	J. Irvine.
San Bernardino County—	
Calico	R. Gribben.
Daggett.	
Needles	P. J. McIntyre.
Santa Barbara County—	
Santa Maria	F. Fugler.
Shasta County—	
Copper City.	
Copper City	F. McMillan.
Lost Horse Mine.	
Siskiyou County—	
Callahan's Ranch	J. F. O'Gorman.
Trinity County—	
Hay Fork P. O. (15 miles below).	

BASALT.

Fresno County—	
King's Creek	R. Reynolds.
Mono County—	
Green Creek.	
San Bernardino County—	
Calico	J. R. Scupham.
Santa Barbara County—	
San Miguel Island.	
Santa Cruz Island.	
Siskiyou County—	
Dunsmuir.	
Sonoma County—	
Mt. Pisgah Quarry (Petaluma).	
Yolo County—	
Putah Cañon	James T. Ish.

BAUXITE.

Location.	Donor.
Riverside County—	
Riverside	J. H. McKnight.
Yuba County—	
Smartsville	J. H. Dempsey.

CEMENT.

Alameda County—	
Niles	H. T. Holmes & Co.
Sunol Valley	Pedro de Saisset.
Washington Corn's	C. R. Merrill.
Contra Costa County—	
Byron Springs.	
Stewartsville (½ mi. east of).	
Humboldt County—	
Yager	Thomas Dickinson.
Kern County—	
.....	J. A. Lytle.
Lake County—	
Glenbrook	H. A. Aldrich.
Los Angeles County—	
Los Angeles	George W. Hazzard.
Riverside County—	
South Riverside (6 miles S. W. of)	Frazer Bros.
San Bernardino County—	
Colton	California Portland Cement Co.
Santa Barbara County—	
Moore's Ranch.	
Santa Clara County—	
Madrone (7 miles east of)	William Clark.
Santa Cruz County—	
Santa Cruz	California Portland Cement Co.
Solano County—	
Benicia	H. T. Holmes & Co.

CLAYS.

Alameda County—	
Livermore	R. Wegner.
Oakland	Alameda Pottery.
Amador County—	
Carbondale (potter's clay)	A. E. Smith.
Carbondale (stone-ware and sewer-pipe clay)	Mrs. W. Irelan.
Carbondale (kaolin and fire clay)	N. Clark & Sons.
Ione.	[feldt.
Ione Valley	Judge S. Heyden-
Jackson	Isaac Bluxome.
Plymouth	E. F. Montgomery.

CLAYS—Continued.

Location.	Donor.
Butte County—	
Chico	B. A. Harrison.
Oroville (pipe clay)	Norton & Eckmann.
Calaveras County—	
Big Trees	A. Jaquith.
Mokelumne Hill	George Muthe.
Contra Costa County—	
Byron Springs.	
Mt. Diablo	H. T. Holmes & Co.
El Dorado County—	
Georgetown	W. F. Flick.
Newton.	
Placerville	W. F. Flick.
Fresno County—	
Oil Creek Cañon.	
Humboldt County—	
Eureka	James B. Brown.
Inyo County—	
Independence	J. D. Hudigin.
Kern County—	
Rosamond	Tod Robinson.
Lake County—	
Glenbrook	H. A. Aldrich.
Kelseyville	C. C. Reynolds.
Soda Bay	Charles Goodwin.
Sulphur Banks.	
Los Angeles County—	
Los Angeles	E. W. Doss.
Marin County—	
Duncan's Mills	R. H. Sinton.
Mendocino County—	
Point Arena	C. I. Ross.
Modoc County—	
Adin.	
Mono County—	
Bodie	A. Saderling.
Bodie	J. P. Morrow.
Bodie	W. H. C. Matthews.
Bodie	S. D. Connell.
Monterey County—	
Indian Creek.	
Jolon.	
Napa County—	
Calistoga	G. F. Boynton.
Calistoga	H. Steven.
Nevada County—	
Grass Valley	J. W. DeGolia.
.....	Mellin Ford.

CLAYS—Continued.

Location.	Donor.
Placer County—	
Lincoln	John Landis.
Lincoln	Cook & Spinks.
Weimar	R. J. Dunn.
Yankee Jims.....	C. Trafton.
Sacramento County—	
Michigan Bar	Gladding, MeBean & Co.
San Bernardino County —	
Daggett	Hon. John Daggett.
Fish Ponds.	
Halleck	H. L. Morrow.
San Bernardino.....	S. S. Simon.
San Diego County—	
El Cajon Mts.	
Elsinore	Dolbeer & Hoff.
San Diego (brick clay).	
Terra Cotta.	
San Luis Obispo County—	
Arroyo Grande.	
Las Tablas Creek.	
San Miguel	T. P. Clark.
Santa Barbara County—	
————	T. L. Perry.
Shasta County —	
Castella	L. M. Girard.
Sierra County—	
————	F. E. Birge.
Siskiyou County—	
Yreka	John Wheeler.
Sonoma County—	
Agua Caliente	L. W. Mayer.
Guerneville.	
Healdsburg	P. H. Shelford.
Mark West Springs.	
Santa Rosa	A. W. Dana.
Sonoma	D. W. Curtis.
Stanislaus County—	
Crow's Landing	D. Fairchilds.
Sutter County—	
Sutter City	W. C. Smith.
Trinity County—	
Carrville	J. A. Little.
Tuolumne County—	
Alpha Mine.....	John Collins.
Sonora.....	Louis Blanding.
Ventura County—	
Spregel Cañon	S. P. Guiberson.

CHROMITE.

Alameda County—	
Irvington	E. J. Hicks.
Mendenhall Mine.	

CHROMITE—Continued.

Location.	Donor.
Amador County—	
Jackson	Isaac Bluxome.
Mountain Spring	
House	J. P. Lambing.
Butte County—	
Pentz	Norton & Eckmann.
Calaveras County—	
French Gulch.....	John Soltuari.
Murphys.....	E. H. Shaeffe.
Colusa County—	
Newville	J. R. Whitlock.
T. 17 N., R. 6 W.....	J. P. Rathburn.
Del Norte County—	
French Hill Mine.....	Tyson Mining Co.
El Dorado County—	
Coloma	I. N. Thorn.
Latrobe	Michael Grogan.
Shingle Springs.....	W. Bryant.
Stigman's Hill.	
Fresno County—	
T. 11 S., R. 23 E.	
Lake County—	
Middletown.	
Marin County—	
Maillard Ranch.	
Mendocino County—	
Willits	E. R. Shimmin.
Ukiah.	
Napa County—	
Chiles Valley	D. K. Doble.
Placer County—	
Burnt Flat.....	J. C. Rhodes.
Sec. 21, T. 14 N., R.	
9 E.	R. L. Dunn.
Plumas County—	
Meadow Valley	J. A. Edman.
San Benito County—	
Hollister.....	Wm. Johnson.
————	Louis Oldham.
San Luis Obispo County—	
Capajoro Creek.	
San Luis Obispo.....	Luther Wagoner.
Santa Clara County—	
Greystone.	
Lexington.	
Los Gatos.....	A. Barstow.
San José	W. H. Simpson.
Shasta County—	
Chromite	Kruse & Euler.
Hazel Creek	Mt. Shasta Chrome Mfg. Co.
Simms Station.	

CHROMITE—Continued.

Location.	Donor.
Siskiyou County—	
Yreka (1½ mi. from).	
Solano County—	
Fairfield	Wm. Neeley Johnson.
Sonoma County—	
Cloverdale	C. Bowman.
Geysers	W. Flick.
Tehama County—	
.....	J. A. Heslewood.
Trinity County—	
.....	Arch. B. McCaw.

INFUSORIAL EARTH.

Calaveras County—	
Near Comanche.....	C. G. Yale.
Contra Costa County—	
Pinole Station.	
Inyo County—	
Lone Pine.....	J. M. Cook.
Kern County—	
.....	W. H. Whorff.
Lake County—	
Lost Spring Ranch.....	H. B. Callahan.
Los Angeles County—	
Santa Monica	A. M. Chase.
S'ta Catalina Isl'd.....	C. W. Jarboe.
Monterey County—	
.....	A. Gonzales.
Napa County—	
St. Helena.....	R. E. Wood.
San Benito County—	
Bitterwater Ranch.....	J. H. Matthews.
San Diego County—	
.....	H. Hanks.
San Joaquin County—	
Staples Ranch.	
San Luis Obispo County—	
Port Harford	Geo. McNear.
San Mateo County—	
San Gregorio.....	J. Ralston.
Santa Barbara County—	
.....	W. W. Finch.
Santa Clara County—	
Cayetano Ranch.....	J. E. Bowman.
Siskiyou County—	
Yreka.....	H. A. Morse.
Sonoma County—	
Doolan Mine.....	H. T. Holmes.
Petaluma.	

FULLER'S EARTH.

Location.	Donor.
San Bernardino County—	
.....	S. S. Simon.

GLASS SAND.

Alameda County—	
Livermore.	
Los Angeles County—	
.....	L. A. Glass Co.
Riverside County—	
Corona.	
San Bernardino County—	
.....	C. L. Metzger.
Trinity County—	
Poison Camp.	

GRANODIORITE.

Amador County—	
Amador City.	
Calaveras County—	
Indian Creek.	
El Dorado County—	
Greenwood.	
Rattlesnake Bar.....	Frank Rodrick.
Lake County—	
Lower Lake	P. Christiansen.
Mono County—	
Mineral Hill	A. J. Jaquith.
Placer County—	
Sec. 15, T. 18 N.,	
R. 13 E.	California Iron Co.
Sec. 24, T. 18 N.,	
R. 13 E.	
Sacramento County—	
Folsom.	
Santa Clara County—	
San José	Gay Quarry.
Tuolumne County—	
Carters.	
Soulsbyville.	

GRAPHITE.

Fresno County—	
.....	C. D. Coats.
Humboldt County—	
Eureka.....	W. Hutchins.
Los Angeles County—	
Newhall.	
Verdugo Cañon.	

GRAPHITE—Continued.

Location.	Donor.
Mendocino County—	
Point Arena	G. B. Dolman.
Riverside County—	
Perris	J. Chipman.
San Bernardino County—	
————	W. H. Anderson.
Sonoma County—	
Cazadero.	
Guerneville.	
Santa Rosa	J. S. Titus.
Pine Flat	Wm. Raynor.
Tehama County--	
Manton	L. V. Loomis.
Tulare County--	
————	J. H. Redmond.
Drumm Valley	M. Braverman.

GRANITE.

Calaveras County--	
West Point.	
Humboldt County—	
Eureka.	
Mad River.	
Inyo County--	
Argus Range.	
Los Angeles County--	
Little Tejunga Cañon.	
Madera County—	
Raymond	Knowles & Hosmer.
Raymond	Pacific Stone Co.
Mariposa County—	
Yosemite Valley.	
Marin County—	
Porter's Point.	
Nevada County—	
Crystal Lake.	
Placer County—	
Cisco.	
Lincoln Quarry.	
Penryn	J. H. Neff.
Rocklin	F. Williams.
Yuba Pass.	
Sacramento County—	
Near Sacramento.	
San Bernardino County—	
Victor	St. John's Quarry.
Victor	Shearer's Quarry.
San Diego County—	
Foster	Waterman Quarry.
Temecula Cañon.	
Mesa Grande.	

GRANITE—Continued.

Location.	Donor.
San Mateo County—	
Halfmoon Bay	Joseph Presho.
Tulare County—	
Exeter	Griffiths, Owens & Hughes.
Tuolumne County—	
Hyde Ranch.	[ite Co.
Phoenix Lake	Phoenix Lake Gran-

GYP SUM.

Contra Costa County—	
Antioch.	
Inyo County—	
Clark's Fork.	
Lassen County—	
Susanville	J. H. Merrill.
Los Angeles County—	
San Pedro	A. E. Buck.
Riverside County—	
Adams Blakely De-	
posit	L. E. Aubury.
San Bernardino County—	
————	F. E. Monteverde.
San Diego County—	
Winton.	
Santa Barbara County—	
Santa Rosa Island.	
Tulare County—	
White River.	
Ventura County--	
Ventura	A. G. Maus.

IRON ORE.

Amador County—	
Irishtown	Chapman Mine.
Ione Valley	Judge S. Heydenfeldt
Jackson	I. Bluxome.
Sutter Creek.	
Butte County—	
Bangor	S. A. Sawtelle.
Oroville	S. W. Collins.
Pentz	Norton & Eckmann
Calaveras County—	
Campo Seco	B. Orengo.
Campo Seco (Iron	
Monarch)	C. Berger.
Campo Seco	Detert's Mine.
Murphys	E. H. Shaeffle.
Murphys	E. Cutting.
Sec. 3, T. 4 N.,	
R. 10 E.	A. M. Thrift.
Colusa County—	
Smithville	H. W. Wilton.

IRON ORE—Continued.

Location.	Donor.
Del Norte County—	
—————	Chas. F. Goodrich.
El Dorado County—	
Coloma	F. C. Leavitt.
Coloma	Geo. W. Kimble.
Diamond Springs ..	N. D. Buckingham.
Iron King M. & S. Co.	
Latrobe.	
Shingle Springs....	W. Bryant.
Fresno County—	
N. E. corner.....	R. Reynolds.
Humboldt County--	
Centerville.	
Little River	C. E. Beach.
Rainbow Ridge	Dr. R. D. Chase.
Inyo County—	
Alvord Station.....	J. S. Graham.
Big Pine.	
Darwin.	
Old Coso District.	
Shepherd's Cañon.	
Kern County—	
San Emidio (Sec. 17, T. 19 N., R. 21 W.)	C. R. Merriam.
Two-to-One Mine.	
Lake County—	
Glenbrook	H. A. Aldrich.
Lassen County—	
Susanville.....	L. L. Frost.
Los Angeles County—	
Newhall.	
Ravenna Station.	
Rancho San Fran- cisco	H. G. Newhall.
Madera County—	
Mt. Raymond.	
King's Creek.....	C. J. Beck.
King's Creek.....	R. Reynolds.
Mariposa County—	
Hornitos.....	John Muller.
Mt. Hoffman.....	J. S. Shilling.
Napa County—	
St. Helena	Dr. J. W. Hood.
St. Helena	E. W. Woodward.
Nevada County—	
Grass Valley.	
Holden Ledge (T. 15 N., R. 7 E., M. D. M.)	G. A. Holden.
Placer County—	
Clipper Gap Mine (Sec. 24, T. 13 N., R. 8 E., M. D. M.)	California Iron Co.
Red Hill Mine (Sec. 15, T. 13 N., R. 8 E., M. D. M.)	California Iron Co.

IRON ORE—Continued.

Location.	Donor.
Plumas County—	
Moonlight Valley.	
Riverside County—	
Riverside	R. P. Chandler.
San Benito County—	
San Benito Iron Mine (Secs. 31 and 6, T. 16 S., R. 6 E.)	Chas. Sellers.
Tres Pinos	Thomas Wallace.
San Bernardino County—	
Banning	C. O. Barker.
Daggett (30 miles S. E. of).....	H. W. Lake.
Halleek	P. W. Campbell.
Needles	John Denair.
Oro Grande (Stoddart's Mills).	
Ivawatt Mts.	
San Luis Obispo County—	
Arroyo de Choro...	F. Adams.
San Luis Obispo (Harrington Iron Co.)	Ezra Carpenter.
Shasta County—	
Iron Mountain.....	F. McMillan.
Junction McCloud and Pit Rivers...	Wm. P. Miller.
Potter's Iron Mine	E. P. Figg.
Redding	D. G. Reid.
Sierra County--	
Mohawk Valley....	Sierra Iron Co.
Sonoma County—	
Cazadero.....	F. W. Reynegom.
Mark West Coal Mine.....	J. L. Gordon.
N. W. corner.....	L. L. Bullock.
Tehama County—	
Corning	Aitken Maggard.
T. 28 and 31 N., R. 8 to 10 W.	J. A. Heslewood.
Tulare County—	
Visalia.....	Wm. Lavelle.
Yolo County—	
Capay.....	B. Orenge.
Yuba County--	
—————	C. Baird.
Wheatland.....	John Landis.

JASPER.

Calaveras County—	
Murphys	E. Cutting.
Fresno County—	
Jacilitos Creek.	
Inyo County—	
Coso District.	

JASPER—Continued.

Location.	Donor.
Lassen County— -----	L. L. Frost.
Marin County— Lagunitas Creek.	
Mariposa County— Bear Valley.	
Monterey County— San Miguel Cañon.	
Nevada County— Nevada City	C. N. Canfield.
Placer County— Bald Prairie	C. Purdy.
Plumas County— Diadem Mine	J. A. Edman.
San Benito County— -----	J. B. Smith.
San Francisco County— Potrero.	
San Luis Obispo County— Oceanic Quicksilver Mine.	
Shasta County— Mt. Shasta	H. E. Josselyn.
Siskiyou County— Montague.	

LIMESTONE.

Alpine County— Woodfords	E. Barnes.
Butte County— Pentz.	
Calaveras County— San Andreas.	
Humboldt County— Jacoby Creek.	
Kern County— Grizzly Cañon, Te- hachapi	Hendrickson's Qu'ry.
Grizzly Cañon, Te- hachapi	Poirer Quarry.
Summit Lime Co.	Mrs. D. B. Rogers.
San Emidio	C. B. Barstow.
Poso Creek	E. Donnelly, M.D.
Madera County— Mt. Raymond.	
Mono County— Hot Creek. Mono Lake.	
Monterey County— Mill Creek	Rockland Lime Q'ry.
Soledad (10 mi. south of).	

LIMESTONE—Continued.

Location.	Donor.
Placer County— Auburn	G. W. Kimble.
San Benito County— Bitterwater Ranch	Hon. J. H. Matthews.
Cienega, 16 mi. S. E. of Tres Pinos	Mrs. A. E. Bush.
San Bernardino County— -----	H. T. Holmes & Co.
Ivanpah	M. D. Katz.
Oro Grande	Lynman's Quarry.
Swartout Cañon	Marble Limekiln Co.
San Diego County— Julian	H. O. Siskler.
San Jacinto (7 mi. west of)	J. W. Brian.
San Luis Obispo County— Carpenter Ranch. Nipomo.	
Santa Barbara County— Moore's Ranch.	
Santa Clara County— Ellis Ranch. Guadalupe Quarry.	
Santa Cruz County— Blue Crystalline Quarry	Davis & Cowell.
Santa Cruz.	
Shasta County— Kennet	Kennet Quarry.
Siskiyou County— Yreka	James T. Skinner.
Sonoma County— Geyserville	Sonoma Lime Works.
Tulare County— Limekiln	M. Braverman.
Porterville (6 mi. west of)	J. D. Field.

LITHIA.

San Diego County— Banner	L. N. Bailey.
Mesa Grande. Pala, Caterina Mine	Fred M. Sickler.
Pala, Vanderburg Mine. Temecula Cañon.	

MARBLE.

Amador County— Ione (9 mi. north of)	J. W. Loomis.
Jackson	A. L. Seager.
Volcano, Carrara Quarry	A. L. Seager.
Butte County— Pentz	Norton & Eckmann.

MARBLE—Continued.

Location.	Donor.
Calaveras County—	
Deer Park	E. J. Caldwell.
Cave City.	
San Andreas (Treat Quarry).....	J. F. Treat.
Bear Mountain.	
Colusa County—	
Smithville	H. W. Wilton.
El Dorado County—	
Indian Diggings ...	H. Rees.
Humboldt County—	
Bear River.....	H. Niebur.
Inyo County—	
.....	D. A. Bender.
Keeler (Inyo Mar- ble Co.).....	A. L. Seager.
Kern County—	
San Emidio Cañon.	
Tehachapi	Bright's Valley.
Tehachapi	Tehachapi Building Stone Co.
Los Angeles County—	
Antelope Valley ...	A. L. Seager.
Los Angeles	Dobinson & Fairchild
Santa Catalina I'd	Smith & Young.
Mariposa County—	
Mered River	W. F. Rector.
Mono County—	
Bridgeport (traver- tine).....	S. G. Limer.
Topaz (Mono Mar- ble Quarry)	W. E. Lindley.
Walker River(Lind- sey's Quarry) ...	E. W. Lindsey.
Nevada County—	
Bear Creek (3 mi. from Colfax)	J. & F. Kessler.
Bloomfield, Freeman's Crossing.	
Placer County—	
Auburn, Cave Val'y	Davis & Cowell.
Auburn	G. H. Hawes.
Clipper Gap.	
Colfax	J. C. Rhoads.
Sec. 15, T. 13 N., R. 8 E., M. D. M.	
Riverside County—	
Riverside (Sky Blue Quarry).....	Kretik & Vertiska.
San Bernardino County—	
Barstow.	{Brick Stone Co.
Colton	California Marble and
Colton	A. L. Seager.
Fairchild's Cañon	A. Higbie.
Oro Grande	Hill & Brady.
Victor	Victor Marble Co.
Santa Clara County—	
Llagar Creek.....	Taylor Rogers.
Wright's Ranch.	

MARBLE—Continued.

Location.	Donor
Siskiyou County—	
Etna.	
Tulare County—	
Porterville	A. L. Seager.
Tule River	Dr. George.
Tuolumne County—	
Abby's Ferry	J. & F. Kessler.
Columbia	Columbia Marble Co.
Columbia (Grant's Quarry).....	A. L. Seager.
.....	J. H. Redmond.

MICA.

El Dorado County—	
.....	M. Boynton.
Inyo County—	
Saratoga District.	
Los Angeles County—	
.....	J. R. Wolverton.
Riverside County—	
Walters.	
San Diego County—	
Temeecula Cañon.	
Siskiyou County—	
Oro Fino.....	J. M. Conner.
Ventura County—	
.....	Mt. Alamo Min. Co.

MAGNESITE.

Lake County—	
.....	F. McMillan.
Napa County—	
.....	J. Z. Davis.
San Diego County—	
.....	A. Blane.
San Luis Obispo County—	
Port Harford.	
Santa Barbara County—	
.....	J. G. Moraga.
Santa Clara County—	
.....	C. C. Derby.

MANGANESE.

Alameda County—	
Corral Hollow.	
Livermore (Arroyo Mocho Mine).....	Ad. Sommers.
Livermore (Sec. 30, T. 4 S., R. 4 E., M. D. M.).....	J. W. Hearst.
Livermore (Railroad Mine).	

MANGANESE—Continued.

Location.	Donor.
Calaveras County—	
Angels Camp	L. M. Cogswell.
Milton.	
Railroad Flat	M. H. Peck.
Milton (Toughnut Mine).	
San Andreas	W. D. Allen.
Del Norte County—	
Crescent City	L. F. Cooper.
El Dorado County—	
Greenwood.....	Alex. Keller.
Glenn County—	
Elk Creek.....	Winchester Riffe.
Lake County—	
Climax (John Reed Mine)	W. C. Hart.
Glenbrook	H. A. Aldrich.
Los Angeles County—	
Banning	J. M. Gilman.
Madera County—	
Fresno Flat.	
Marin County—	
San Geronimo	Maillard Ranch.
Tomales	Peter Morrissey.
Sausalito.....	R. H. Sinton.
Mariposa County—	
Hunter Valley	J. W. Wilcox.
Mendocino County—	
Elk	A. L. Field.
Westport.....	R. H. Sinton.
Monterey County—	
Soledad (Chalona District).....	H. F. Melville.
Soledad.	
Napa County—	
Mount St. Helena	F. H. Hausmann.
Moore Creek	R. A. Coleman.
St. Helena	John Graham.
St. Helena	F. W. Keeney.
Nevada County—	
Sweetland Creek Mine.	
Placer County—	
Auburn	Alexander Keller.
Yankee Jim's	Charles Trafton.
Plumas County—	
Mumford's Hill.....	J. A. Edman.
Riverside County—	
Elsinore (6 miles N. E.).	
San Benito County—	
Cleveland Mine (20 mi. E. of Tres Pinos).	
Hendricks Mine	S. Hendricks.

MANGANESE—Continued.

Location.	Donor.
San Bernardino County—	
Barstow.....	J. M. Redfern.
Colton	McIntosh & Co.
.....	E. C. Seymour.
San Diego County—	
Julian (30 miles south of).....	Joseph Marks.
Winchester	H. H. Raggencamp.
San Francisco County—	
Hunter's Point.....	H. Burnell.
Potrero	George Smith.
St. Mary's College.....	P. J. Healy.
San Joaquin County—	
Caire Mine.	
Tracy (9 miles west of)	Jenkin Richards.
San Mateo County—	
Baden.....	W. E. Iber.
San Luis Obispo County—	
Ranch of P. B. Prefumo.	
Santa Barbara County—	
San Rafael Mountains.	
Santa Clara County—	
Faville Mine.	
Hohn's Ranch	E. C. Hohn.
Penetencia Creek.	
.....	James Enright.
Siskiyou County—	
Sawyer's Bar.....	E. V. Burke.
Sonoma County—	
Cloverdale	S. A. Raymond.
Freestone	W. J. Wooley.
Guerneville	G. Watson.
Mark West Springs.....	J. L. Jordan.
Santa Rosa	C. W. Frost.
Santa Rosa	Alfred W. Dana.
Stanislaus County—	
Radovich Mine	L. Radovich.
Tuolumne County—	
Columbia	Knapp's Ranch.
Sonora	H. S. Macomber.
Summerville (Sec. 14, T. 1 N., R. 16 E., M. D. M.)	W. A. Lewis.
Tulare County—	
Lemon Grove	J. S. Eastwood.
Traver	W. R. Corrington.
MINERAL PAINT.	
Alameda County—	
Laundry Farm	A. Bardet.
Mission San José	W. B. Hughes.
Alpine County—	
Monitor.....	Lewis Chalmers.

MINERAL PAINT—Continued.

Location.	Donor.
Calaveras County—	
Valley Springs	Vulcanized Fiber Co.
El Dorado County—	
Shingle Springs.....	William Troop.
Humboldt County—	
Ferndale.	
Placer County—	
Rio Hill.	
Santa Barbara County—	
.....	Samuel Staddon.
San Bernardino County—	
.....	W. Stockton.
Santa Clara County—	
Gilroy	O. N. Nelson.
Siskiyou County—	
Bailey Ranch.	
Sonoma County—	
Healdsburg.	
Santa Rosa	A. W. Dana.
Stanislaus County—	
Knight's Ferry.	
Ventura County—	
.....	D. S. Bowers.

ONYX.

Colusa County—	
Sulphur Creek	Frank Green.
Kern County—	
Mineral Springs	S. G. George, M.D.
Mojave	F. Braasch.
Lake County—	
Eel River	E. Wilson.
Los Angeles County—	
Santa Catalina Island.	
Little Castaca Cañon.	
Mendocino County—	
Fort Bragg.	
Mono County—	
Bridgeport.	
Napa County—	
Zem Zem	A. G. Gilbert.
Orange County—	
Santa Ana Range..	George F. Hoyt.
Sugar Loaf Mt.	George F. Hoyt.
Placer County—	
Gold Run	Mrs. E. Miller.
Riverside County—	
Riverside	Sky Blue Marble and Onyx Co.

ONYX—Continued.

Location.	Donor.
San Bernardino County—	
Colton	California Marble and Building Stone Co.
Oro Grande	Hill & Brady.
San Diego County—	
Los Penasquitos Creek	W. H. Martin.
San Luis Obispo County—	
Sec. 9, T. 32 S., R. 15 E., M. D. M.	Ezra Carpenter.
San Luis Obispo ...	Kessler & Co.
.....	J. Z. Davis.
Santa Clara County—	
San José	A. J. Col.
Siskiyou County—	
Berryville	M. E. Hammond
Dunsmuir.	
Yreka	F. G. Hearn.
Solano County—	
Suisun	Dickie Ranch.
Suisun	Henry G. Hanks.
Suisun	J. & F. Kessler.
Suisun	F. M. Swan.
Vacaville.....	D. P. Belknap.
Sonoma County—	
Healdsburg	George Madeira.
Geyserville	A. H. Ingham.
Tehama County—	
Tuscan Mineral Springs.	
Tulare County—	
Three Rivers.....	M. Braverman.
.....	J. A. Lytle.

PLATINUM.

Butte County—	
Cherokee (Spring Valley Mine).....	Louis Glass.
Del Norte County—	
Happy Camp	H. A. Bowen.
Klamath River.....	R. W. Miller.
Humboldt County—	
Upper Gold Bluff ..	Dr. J. W. Wood.
Siskiyou County—	
Happy Camp	O. C. Pope.
Trinity County—	
Chapman & Fisher Mine	George Chapman.
Junction City (French Mine)....	E. Saladin.
Taylor Flat (Highland Bar Mine).	
Ventura County—	
.....	James A. Noyer.

PYRITES.

Location.	Donor.
Amador County—	
Amador City (Mayflower Mine)	A. B. Swan.
Calaveras County--	
Angels	Angels Mine.
Knox & Osborn Mine	Knox & Osborn.
Kreling Mine	Edwin Davidson.
Napa County—	
Pope Valley	Etna Mine.
Nevada County—	
Grass Valley	Betsy Mine.
Placer County—	
Auburn	Miss F. Von Lindner.
San Luis Obispo County—	
Sunderland Quick-silver Mine	Luther Wagoner.
Shasta County—	
Delta, Tom Neal Mt.	[per Mine.
.....	Black Diamond Cop-
Siskiyou County—	
Dunsmuir	John Gorman.
Sonoma County--	
Healdsburg	George Madeira.
Tuolumne County--	
Tuttletown	Patterson Mine (Alfred Wright).
Trinity County—	
Oregon Gulch	William M. Lowe.

QUARTZ CRYSTALS.

Amador County—	
Oleta	Tyler's Ranch.
Volcano	W. Q. Mason.
Butte County—	
Gold Bank Mine	H. P. Stow.
.....	J. Z. Davis.
Calaveras County—	
Chili Gulch	F. McSorley.
Mokelumne Hill	Sam Sonnelfeld.
El Dorado County--	
.....	E. W. Hulford.
Placerville (20 mi. north of)	J. Z. Davis.
Inyo County—	
Modoc Mine.	
Union District	S. D. Woodland.
Mariposa County—	
Mount Bullion	J. W. Brumagim.
Mount Bullion	Mrs. M. K. Potthast.
Mono County—	
Bodie.	
Bodie	Noonday Mine.

QUARTZ CRYSTALS—Continued.

Location.	Donor.
Napa County—	
Calistoga	B. Tucker.
Plumas County—	
.....	H. Engels.
Sacramento County—	
Folsom	I. N. Choyinski.
Sierra County—	
Bald Mountain Mine.	
Tuolumne County—	
Jamestown	G. A. Leland.
Sonora	Golden Gate Mine.
Tulare County—	
Bull Run Meadows	H. Hughes.
Visalia	M. Braverman.
Yokohl Valley	Thomas Osborn.

RHYOLITE.

Calaveras County—	
Valley Spring Peak.	
San Bernardino County—	
Calico.	
Vanderbilt.	

SANDSTONE.

Alameda County—	
Altamont.	
Niles	J. D. Farwell.
San Leandro	F. Bacheller.
Amador County—	
Ione	A. Abbott.
Ione	H. O'Neil.
Colusa County—	
Sites.	
Contra Costa County—	
Martinez.	
Port Costa	G. W. McNear, Jr.
Fresno County—	
Sec. 21, T. 21 S., R. 14 E.	
Humboldt County—	
Eureka	George C. Sarvis.
Kern County--	
San Emidio Cañon	George H. Schmidt.
Tehachapi	Tehachapi Building Stone Co.
Los Angeles County--	
Chatsworth Park	Cal. Construction Co.
East Los Angeles	Southern Ledge Stone
San Fernando.	[Co.
Marin County—	
San Rafael	J. W. C. Maxwell.

SANDSTONE—Continued.

Location.	Donor.
Napa County—	
Napa	J. J. Newsome.
San Francisco County—	
San Francisco	Gray Brothers.
San Mateo County—	
Pescadero Creek	Judge Hastie.
Redwood City	W. G. Britton.
San Miguel	O. E. Brady.
San Luis Obispo County—	
Arroyo Grande.	
Santa Barbara County—	
Santa Barbara.	
Santa Clara County—	
Goodrich Quarry.	
Stanford Quarry.	
Santa Cruz County—	
Santa Cruz	J. L. Thurber.
Shasta County—	
Clear Creek	California Sandstone and Construct'n Co.
Redding.	
Siskiyou County—	
Henley.	
Yreka.	
Solano County—	
Suisun	C. P. Reeves.
Ventura County—	
Fillmore	George J. Henley.
Sespe	Los Angeles Granite and Construct'n Co.
Yolo County—	
Putah Cañon.	

SOAPSTONE.

Amador County—	
—	L. H. Brown.
Calaveras County—	
Murphys	E. H. Schaeffle.
Sheep Ranch.	
El Dorado County—	
Kelsey District.	
Inyo County—	
Death Valley.	
Los Angeles County—	
Santa Catalina I'd	T. P. Lukens.
Mariposa County—	
Coulterville	W. J. McCarthy.
Lewis	R. M. Collins.
Napa County—	
Chiles	John Johnson.

SOAPSTONE—Continued.

Location.	Donor.
Placer County—	
Colfax	Stockbridge Soaps'ne Works.
—	H. T. Holmes & Co.
San Diego County—	
Escondido	A. W. Pray.
Santa Clara County—	
Mt. Hamilton.	
Shasta County—	
Delta.	
Siskiyou County—	
Hamburgh	Daniel Caldwell.
Tehama County—	
Manton	L. V. Loomis.
Trinity County—	
Weaverville.	
Tuolumne County—	
Robinson's Ferry	F. F. McArdle.
Sonora	J. F. Faxon.
—	J. H. Redmond.
Tulare County—	
Tule River	S. G. George, M.D.
Ventura County—	
Talc Mine	S. S. Simon.
—	Ventura Rock Soap Co.
Yuba County—	
—	C. Baird.

SLATE.

El Dorado County—	
Chili Bar	California Slate Co.
Eureka Slate Quarry.	
Fair Play	Jas. A. Scott.
Kelsey	Strable Slate Co.
Mariposa County—	
Pacific Slate Co.	S. S. Burge.

SERPENTINE.

Amador County—	
Cora Belle Mine	Richard A. Weiss.
Calaveras County—	
Valley Springs	J. D. Cook.
Lake County—	
Kelseyville.	
Mendocino County—	
Eel River.	
Monterey County—	
Black Diamond Mine.	

SERPENTINE—Continued.

Location.	Donor.
Placer County—	
Forest Hill Divide	G. F. Stone.
-----	E. W. Haslow.
San Francisco County—	
Lone Mountain.	
Fort Point.	
San Luis Obispo County—	
San Simeon (14 mi. N. W. of).	
Santa Barbara County—	
Goleta.	
Sierra County—	
Downieville	Telegraph Drift Mining Co.
Sonoma County—	
Healdsburg.	
Tulare County—	
Frazer Valley.	

SULPHUR.

Calaveras County—	
Copperopolis.	
Colusa County—	
Sulphur Creek	(Bromley's Mine) W. L. Bromley.
Sulphur Creek (Manzanita Mine).	
Inyo County—	
Defiance Mine.	
Little Lake.	
Kern County—	
-----	W. H. Green.
Bakersfield (40 mi.	west of) -----
Sec. 28, T. 11 N., R.	Sunset Co., lessee.
23 W. -----	John Hambleton.
Lake County—	
Sulphur Bank	Henry S. Durden.
Lassen County—	
Lassen Butte	J. A. Heslewood.
Sonoma County—	
Geysers.	
Ventura County—	
Santa Paula (Sulphur Mt.).	
Sespe	W. W. Young.

SYENITE.

Kern County—	
Kernville	A. Blanc.
Mariposa County—	
Ward's Ranch	A. H. Ward.
San Mateo County—	
Point San Pedro	D. L. Stone.

TRACHYTE.

Location.	Donor.
Calaveras County—	
West Point.	
Marin County—	
San Rafael	T. J. Elliott.
Napa County—	
St. Helena	Mrs. W. H. Grattan.
San Bernardino County—	
Daggett.	
Vanderbilt.	
San Luis Obispo County—	
Arroyo Grande.	
Lee's Ranch	Charles Lee.
Morro.	
Sonoma County—	
Sonoma	J. H. Cutter.

TUFF.

Calaveras County—	
Angels.	
Campo Seco.	
Mokelumne Hill.	
El Dorado County—	
Diamond Springs	Dr. W. C. Morgan.
Mono County—	
-----	D. A. Bender.
Napa County—	
Napa	John R. Roe.
-----	J. H. Francis.
Santa Barbara County—	
Moore's Ranch.	
Tehama County—	
Red Bluff.	

TUNGSTEN.

Humboldt County—	
Eureka	F. McGowan.
Kern County—	
Randsburg, Baltic	
Mining Co.	C. H. Wynn.
Los Angeles County—	
Sierra Madre	Mr. Quitzow.
Madera County—	
Raymond (9 miles from).	
Mariposa County—	
Buchanan	R. B. Thomas.
San Bernardino County—	
Manvel	J. Le Cyr.
San Diego County—	
Julian	A. J. Burnett.
Siskiyou County—	
Scott Bar	Martin Andrews.

ZINC.

Location.	Donor.
Fresno County—	
Comstock Mine.	
Inyo County—	
Cerro Gordo	Ygnacio Mine.
Los Angeles County—	
Santa Catalina I'd .	Silver Cañon.
Santa Catalina I'd .	Small Hill Mine.
Madera County—	
Advance Mine	Thomas Agnew.
Homestake Mine ..	H. Clere de Landress.

ZINC—Continued.

Location.	Donor.
Mono County—	
Bunker Hill Mine .	A. McNabb.
Orange County—	
Santiago Cañon	Blue Light Mine.
San Bernardino County—	
Daggett	Cuticura Mine.
San Mateo County—	
Martin's Ranch	G. Rich.
Shasta County—	
Furnaceville	Afterthought Mine.
North Cow Creek ..	S. S. Sweet.

QUARRIES AND MINES

IN ADDITION TO THOSE MENTIONED IN THE BODY OF
THIS BULLETIN.

ANTIMONY.

Name of Quarry, Mine, Etc.	Town.	Official Owner.
Inyo County—		
A. W. Eibenschutz	Ballarat	A. W. Eibenschutz, Independence.
Kern County—		
Mojave Antimony Co.		A. Blane, care of B. Pasquale, 123 Geary street, San Francisco.
San Emidio	Bakersfield	Kern County Land Co., Bakersfield; H. A. Jastro, superintendent.

ASBESTOS.

Calaveras County—		
Magnesia Asbestos Supply Co.		119 Spear street, San Francisco.
El Dorado County—		
French Hill	Greenwood	A. J. Johnston and E. S. Hadley, 500 Montgomery street, San Francisco.
F. B. Norton	Georgetown	Mr. Norton, Auburn, Cal.

BRICK.

Alameda County—		
N. Clark & Sons	Alameda	17 Spear street, San Francisco.
Butte County—		
J. A. Walker	Nimshew.	
Contra Costa County—		
Demur & Coleman	Point Richmond.	
Humboldt County—		
Arcata Brickyard	Arcata	P. M. Tracy, owner.
Crowe Bros.	Eureka.	
Eureka Brickyard	Eureka	John Porter, superintendent.
Lentill	Eureka	Leased by J. Porter.
Fortuna Brickyard	Eureka	James Thompson & Sons.
Kern County—		
John Koar & Son	Kern City.	
Kern County Brick and Con- tract Co.	Bakersfield	M. C. Farnum.
Kings County—		
Hanford Brick Co.	Hanford	J. H. Johnson, manager.
Los Angeles County—		
G. Alexander	San Pedro	342 San Pedro avenue, Santa Cruz.
California Ornamental Brick Co.	San Pedro	H. C. Ward, Los Angeles.
Los Angeles Stoneware and Sewer Pipe Co.	Los Angeles	320 N. Avenue 26, Los Angeles.
St. Louis Firebrick and Clay Co.	Los Angeles	Thos. Mitchell, Third st., Los Angeles.
Southern California Pottery and Fire Clay Works	Los Angeles	J. F. Tomaseck & Son, 48 McKinley avenue, Los Angeles.
Whittier Brick Co.	Whittier	John Cala, owner.

BRICK—Continued.

Name of Quarry, Mine, Etc.	Town.	Official Owner.
Mendocino County—		
I. & F. H. Betz	Fort Bragg	Postoffice Box 55.
John Standacher	Mendocino.	
John Brower	Pomo.	
W. N. Briggs	Ukiah.	
Riverside County—		
Corona Pressed Brick and Terra Cotta Co.	Corona	434 Stimson Block, Los Angeles.
California Clay M'fg Co.		
San Diego County—		
Union Brick Co.	San Diego	J. R. Wade, superintendent.
Santa Clara County—		
H. Dreischmeyer, Jr.	San José.	
Garden City Brick Co.	San José	H. M. Stammer, Box 768.
Wheeland Brick Co.	Mountain View	309 Merchants' Exc'ge, San Francisco.
D. J. Bryon	San José.	
Remillard Brick Co.	San José	J. P. Gelinis, secretary, Oakland.
San José Brick Co.	San José	J. M. O'Keefe, sec'y, 8 N. First st., San José. San Francisco office: 802 Mutual Bank Building.
Solano County—		
Port Costa Brick Co.	Port Costa.	
Yuba County—		
Swain & Hudson	Marysville.	

CHROME.

Tehama County—		
Frank Henderson	Paskenta.	
Byron W. Hatch	Paskenta.	
Jesse Walcott	Paskenta.	
Trinity County—		
J. T. Hailstone et al.	Hayfork.	

CLAY.

Riverside County—		
Standard Pottery Works	South Riverside	411 N. Ave. 20, Los Angeles: W. H. Brown, manager and secretary.
Southern California Pottery and Fire Clay Works	South Riverside	{ J. F. Tomaseck & Son, 878 E. Forty- eighth street, Los Angeles.
Santa Cruz County—		
C. B. Hodge	Santa Cruz	L. C. Hodge, supt., 24 Otis street.
Tulare County—		
Murphy & Bailey	Milo	Hy. Murphy, superintendent.

FULLER'S EARTH.

Kings County—		
C. A. Boyd	Coalinga (Fresno County).	

GLASS SAND.

Amador County—		
N. Clark & Sons	Carbondale	Office, 17 Spear street, San Francisco.
Riverside County—		
Corona Pressed Brick Co.	Corona.	

GRANITE.

Name of Quarry, Mine, Etc.	Town.	Official Owner.
Madera County—		
Day Granite Quarry	Raymond	J. G. & I. N. Day.
Placer County—		
D. A. Roberts Quarry and Stone Co.	Penryn	D. A. Roberts, Colma, San Mateo Co.
S. Casperi	Lincoln	Box 91.
R. H. Copp.	Rocklin.	
Byrne Bros.	Lincoln	M. Byrne.
San Diego County—		
American Marble and Gran- ite Works	San Diego	{ Office, San Pedro and Seventh sts. { Covas & Escalli, proprietors.
Santa Clara County—		
T. O'Neil & Co.	San José	370 First street.
Sonoma County—		
Mary T. Hayes	Agua Caliente.	

GYPSUM.

Orange County—		
The Irvine Co.	Tustin City	J. Irvine, Standard Fertilizer Co. of Corona, lessee.

INFUSORIAL EARTH.

Tulare County—		
Thomas Mine	Exeter.	

LIME.

Butte County—		
West Branch	Pentz	A. Parrish.
Kern County—		
Hy. Seeger	Tehachapi.	
Snider & Co.	Tehachapi.	
Central Lime Co.		303 Henne Building, Los Angeles.
Los Angeles County—		
L. C. Tilghman	Llano.	
Mono County—		
Mono Lime Co.	Bodie	H. C. Blanchard.
San Bernardino County—		
R. H. Atwood	Halleck.	
Jos. L. Sherer & Co.	Victorville	Office, Stevenson, off Fourteenth street, San Francisco.
Santa Cruz County--		
De Dero Quarry	Santa Cruz	R. De Dero.

LITHIA MICA AND LEPIDOLITE.

San Diego County--		
N. G. Douglas and R. O. But- terfield		1523 James Building, New York.
F. F. Griffith and C. Stuben- rauch		934 N. Alameda street, Los Angeles.
Gay & Blakely	Pala	Gay & Blakely, Redlands.
Gem	Pala	C. M. Stevens & Co., 203 Tajo Build- ing, Los Angeles.

MACADAM.

Name of Quarry, Mine, Etc.	Town.	Official Owner.
Alameda County—		
Red Rock.....	Oakland	W. H. Maxwell.
Los Angeles County--		
Fairechild-Gilmore-Wilton Co.	Los Angeles	204 Bryson Block, Los Angeles.
F. D. Lauterman.		
Madera County—		
Raymond Granite Co.		Tenth and Division streets; Avel Hosmer, secretary, San Francisco.
Placer County—		
Adolph Penru.....	Rocklin.	
Riverside County—		
Barber Asphalt Co.....		Carl F. Adams, 321 Henne Building, Los Angeles.
San Francisco County--		
City Street Improvement Co.	San Francisco....	J.W. McDonald, secretary, Mills Building, San Francisco.
Santa Cruz County—		
Holmes Lime Co.....	Felton	24 Sacramento street, San Francisco.
W. E. Miller.....	Santa Cruz	28 Church street, Santa Cruz.
Solano County—		
Pacific Portland Cement Co.	Suisun	M. Kidd, Rialto Bldg., San Francisco.
Union Construction Co.	Petaluma	702 F street, Petaluma.

MANGANESE.

San Joaquin County—		
Lorraine M. Co.	Tesla	515 Safe Deposit Bldg., San Francisco.
Plumas County—		
Penrose	Meadow Valley..	J. A. Edman.

MARBLE.

San Bernardino County—		
Jos. Sherer & Co.		

MINERAL PAINT.

Butte County—		
Monitor and El Dorado	Chico.....	H. Epperson.
Calaveras County—		
Happy Jack and Ochre.....	Valley Springs ..	S. E. Unger, 825 Battery street, San Francisco.
Penn Chemical Works	Campo Seco	A. C. Harmon, supt. of works.
Napa County—		
C. R. Look	Napa.	

PAVING BLOCKS.

Riverside County—		
Sierra Granite Co.	Corona	J. J. Clark, Oro Grande P. O.
Barber Asphalt Paving Co....	Corona	515 Pacific Electric Building.
Fairchild-Gilmore-Wilton Co.	Riverside (also San Bernardino).	E. W. Gilmore, superintendent.
Victor Quarry	Victorville	J. H. Hargraves.
Joseph Sherer & Co.	Victorville	Tenth and Bryant sts., San Francisco.
Sonoma County—		
A. Pinelli.....	Sonoma.	

PYRITES.

Name of Quarry, Mine, Etc.	Town.	Official Owner.
Alameda County—		
George D. McKinnon	1160 Broadway,	Oakland.
Nevada County—		
Spence Mineral Co.	Spenceville	C. Howard, 330 Pine st., San Francisco.
Shasta County—		
Mountain Copper Co.	Keswick	Lewis T. Wright, 604 Montgomery street, San Francisco.

QUARTZ CRYSTALS.

Placer County—		
Shady Run Mining Co.	Shady Run	John Jackson, 42 E. Main st., Stockton.

SANDSTONE.

Los Angeles County—		
Chatsworth Park	324 E. Market street,	Los Angeles; H. Clement & Co., 214 Bay st., L. A.
Santa Barbara County—		
John Gaggis	Santa Barbara.	
Fred Henderson	Santa Barbara.	
T. M. Hogan	Santa Barbara.	
San Luis Obispo County—		
Los Berros Stone Quarry	San Luis Obispo	Los Berros Stone Co., 221 Collins st., Los Angeles; Dave O'Neil, supt.
P. Moore	Arroyo Grande	Leased to the Los Berros Stone Co.

SOAPSTONE AND TALC.

Butte County—		
E. Taylor	Clear Creek.	
Shasta County—		
W. R. Conant	Castella.	

TUNGSTEN.

Kern County—		
Baltic Mining Co.	Randsburg	C. H. Wynn.

APPENDIX.



ILL. No. 113. FERRY BUILDING, SAN FRANCISCO, ONE HALF THE UPPER FLOOR OF WHICH IS OCCUPIED BY THE STATE MINING BUREAU.
(Constructed of Colusa Sandstone.)

CALIFORNIA STATE MINING BUREAU.

This institution aims to be the chief source of reliable information about the mineral resources and mining industries of California.

It is encouraged in its work by the fact that its publications have been in such demand that large editions are soon exhausted. In fact, copies of them now command high prices in the market.

The publications, as soon as issued, find their way to the scientific, public, and private libraries of all countries.

STATE MINERALOGIST.

The California State Mining Bureau is under the supervision of Hon. Lewis E. Aubury, State Mineralogist.

It is supported by legislative appropriations, and in some degree performs work similar to that of the geological surveys of other States; but its purposes and functions are mainly practical, the scientific work being clearly subordinate to the economic phases of the mineral field, as shown by the organic law governing the Bureau, which is as follows:

SEC. 4. It shall be the duty of said State Mineralogist to make, facilitate, and encourage special studies of the mineral resources and mineral industries of the State. It shall be his duty: To collect statistics concerning the occurrence of the economically important minerals and the methods pursued in making their valuable constituents available for commercial use; to make a collection of typical geological and mineralogical specimens, especially those of economic or commercial importance, such collection constituting the Museum of the State Mining Bureau; to provide a library of books, reports, drawings, bearing upon the mineral industries, the sciences of mineralogy and geology and the arts of mining and metallurgy, such library constituting the Library of the State Mining Bureau; to make a collection of models, drawings, and descriptions of the mechanical appliances used in mining and metallurgical processes; to preserve and so maintain such collections and library as to make them available for reference and examination, and open to public inspection at reasonable hours; to maintain, in effect, a bureau of information concerning the mineral industries of this State, to consist of such collections and library, and to arrange, classify, catalogue, and index the data therein contained, in a manner to make the information available to those desiring it, and to provide a custodian specially qualified to promote this purpose; to make a biennial report to the Board of Trustees of the Mining Bureau, setting forth the important results of his work, and to issue from time to time such bulletins as he may deem advisable concerning the statistics and technology of the mineral industries of this State.

THE BULLETINS.

The field covered by the books issued under this title is shown in the list of publications. Each bulletin deals with only one phase of mining. Many of them are elaborately illustrated with engravings and maps. Only a nominal price is asked, in order that those who need them most may obtain a copy.

THE REGISTERS OF MINES.

The Registers of Mines form practically both a State and a County directory of the mines of California, each county being represented in a separate pamphlet. Those who wish to learn the essential facts about any particular mine are referred to them. The facts and figures are given in tabular form, and are accompanied by a topographical map of the county on a large scale, showing location of each mineral deposit, towns, railroads, roads, power lines, ditches, etc.

HOME OF THE BUREAU.

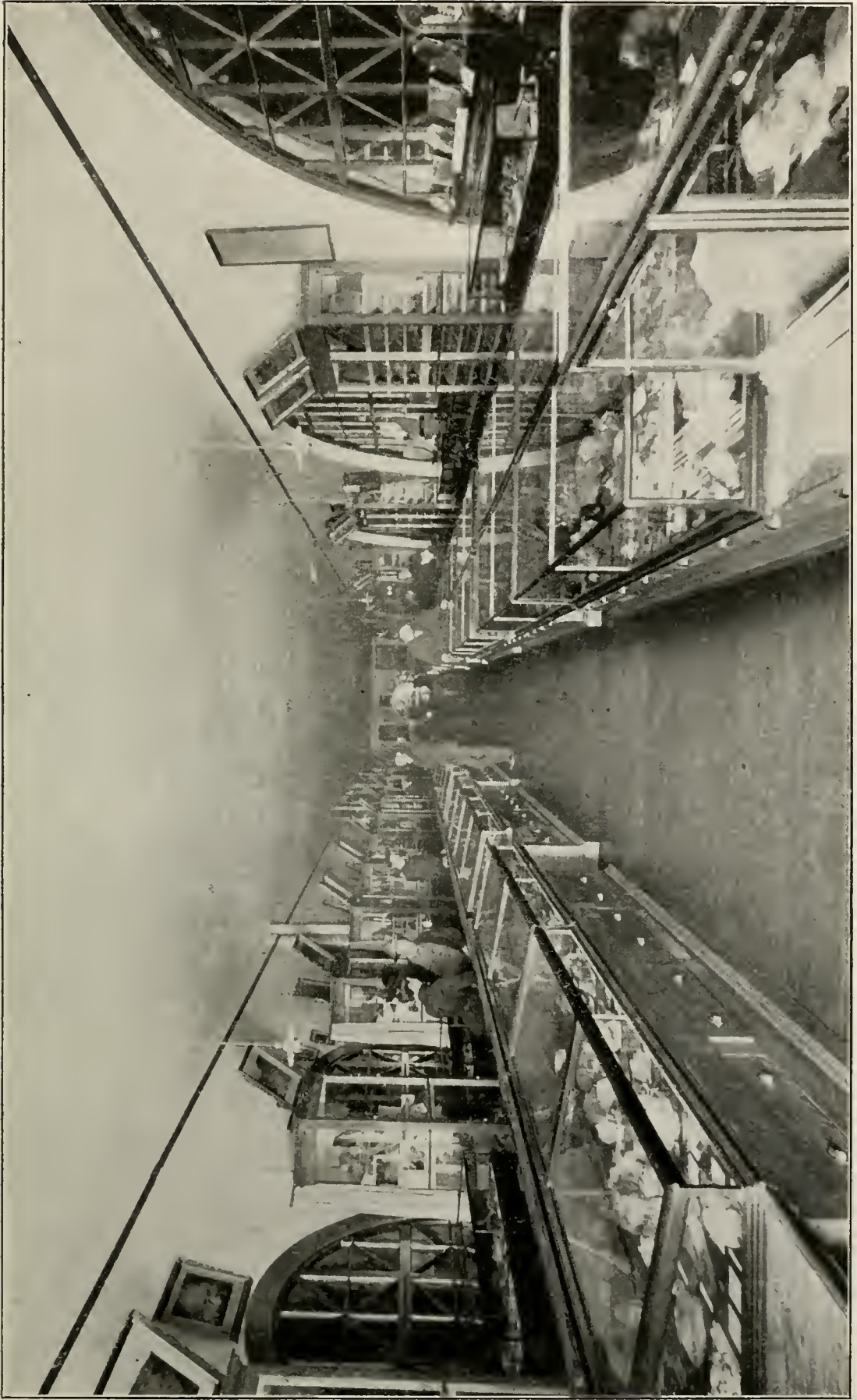
The Mining Bureau occupies the north half of the third floor of the Ferry Building, in San Francisco. All visitors and residents are invited to inspect the Museum, Library, and other rooms of the Bureau and gain a personal knowledge of its operations.

THE MUSEUM.

The Museum now contains over 16,000 specimens, carefully labeled and attractively arranged in showcases in a great, well-lighted hall, where they can be easily studied. The collection of ores from California mines is of course very extensive, and is supplemented by many cases of characteristic ores from the principal mining districts of the world. The educational value of the exhibit is constantly increased by substituting the best specimens obtainable for those of less value.

These mineral collections are not only interesting, beautiful, and in every way attractive to the sightseers of all classes, but are also educational. They show to manufacturers, miners, capitalists, and others the character and quality of the economic minerals of the State, and where they are found. Plans have been formulated to extend the usefulness of the exhibit by special collections, such as one showing the chemical composition of minerals; another showing the mineralogical composition of the sedimentary, metamorphic, and igneous rocks of the State; the petroleum-bearing formations, ore bodies, and their country rocks, etc.

Besides the mineral specimens, there are many models, maps, photographs, and diagrams illustrating the modern practice of mining, milling, and concentrating, and the technology of the mineral industries. An educational series of specimens for high schools has been inaugurated, and new plans are being formulated that will make the Museum even more useful in the future than in the past. Its popularity is shown by the fact that over 100,000 visitors registered last year, while many failed to leave any record of their visit.



ILL. No. 146. MINERAL MUSEUM, CALIFORNIA STATE MINING BUREAU.

THE LIBRARY.

This is the mining reference library of the State, constantly consulted by mining men, and contains between 4000 and 5000 volumes of selected works, in addition to the numerous publications of the Bureau itself. On its shelves will be found reports on geology, mineralogy, mining, etc., published by states, governments, and individuals; the reports of scientific societies at home and abroad; encyclopædias, scientific papers, and magazines; mining publications; and the current literature of mining ever needed in a reference library.

Manufacturers' catalogues of mining and milling machinery by California firms are kept on file. The Registers of Mines form an up-to-date directory for investor and manufacturer.

The librarian's desk is the general bureau of information, where visitors from all parts of the world are ever seeking information about all parts of California.

READING-ROOM.

This is a part of the Library Department and is supplied with over one hundred current publications. Visitors will find here various California papers and leading mining journals from all over the world.

The library and Reading-Room are open to the public from 9 A. M. to 5 P. M. daily, except Sundays and holidays, and from 9 A. M. to 12 M. on Saturdays.

THE LABORATORY.

This department identifies for the prospector the minerals he finds, and tells him the nature of the wall rocks or dikes he may encounter in his workings; but this department *does not* do assaying nor compete with private assayers. The presence of minerals is determined, but not the percentage present. No charges for this service are made to any resident of the State. Many of the inquiries made of this department have brought capital to the development of new districts. Many technical questions have been asked and answered as to the best chemical and mechanical processes of handling ores and raw material. The laboratory is well equipped.

THE DRAUGHTING-ROOM.

In this room are prepared scores of maps, from the small ones filling only a part of a page, to the largest County and State maps; and the numerous illustrations, other than photographs, that are constantly being required for the Bulletins and Registers of Mines. In this room, also, will be found a very complete collection of maps of all kinds relating to the industries of the State, and one of the important duties of the department is to make such additions and corrections as will keep the maps up to date. The seeker after information inquires here if he wishes to know about the geology or topography of any district; about the locations of the new camps, or positions of old or abandoned



ILL. No. 147. LIBRARY AND FREE READING ROOM, CALIFORNIA STATE MINING BUREAU.

ones; about railroads, stage roads, and trails; or about the working drawings of anything connected with mining.

MINERAL STATISTICS.

One of the features of this institution is its mineral statistics. Their annual compilation by the State Mining Bureau began in 1893. No other State in the Union attempts so elaborate a record, expends so much labor and money on its compilation, or secures so accurate a one.

The State Mining Bureau keeps a careful, up-to-date, and reliable but confidential register of every producing mine, mine-owner, and mineral industry in the State. From them are secured, under pledge of secrecy, reports of output, etc., and all other available sources of information are used in checking, verifying, and supplementing the information so gained. This information is published in an annual tabulated, statistical, single-sheet bulletin, showing the mineral production by both substances and counties.

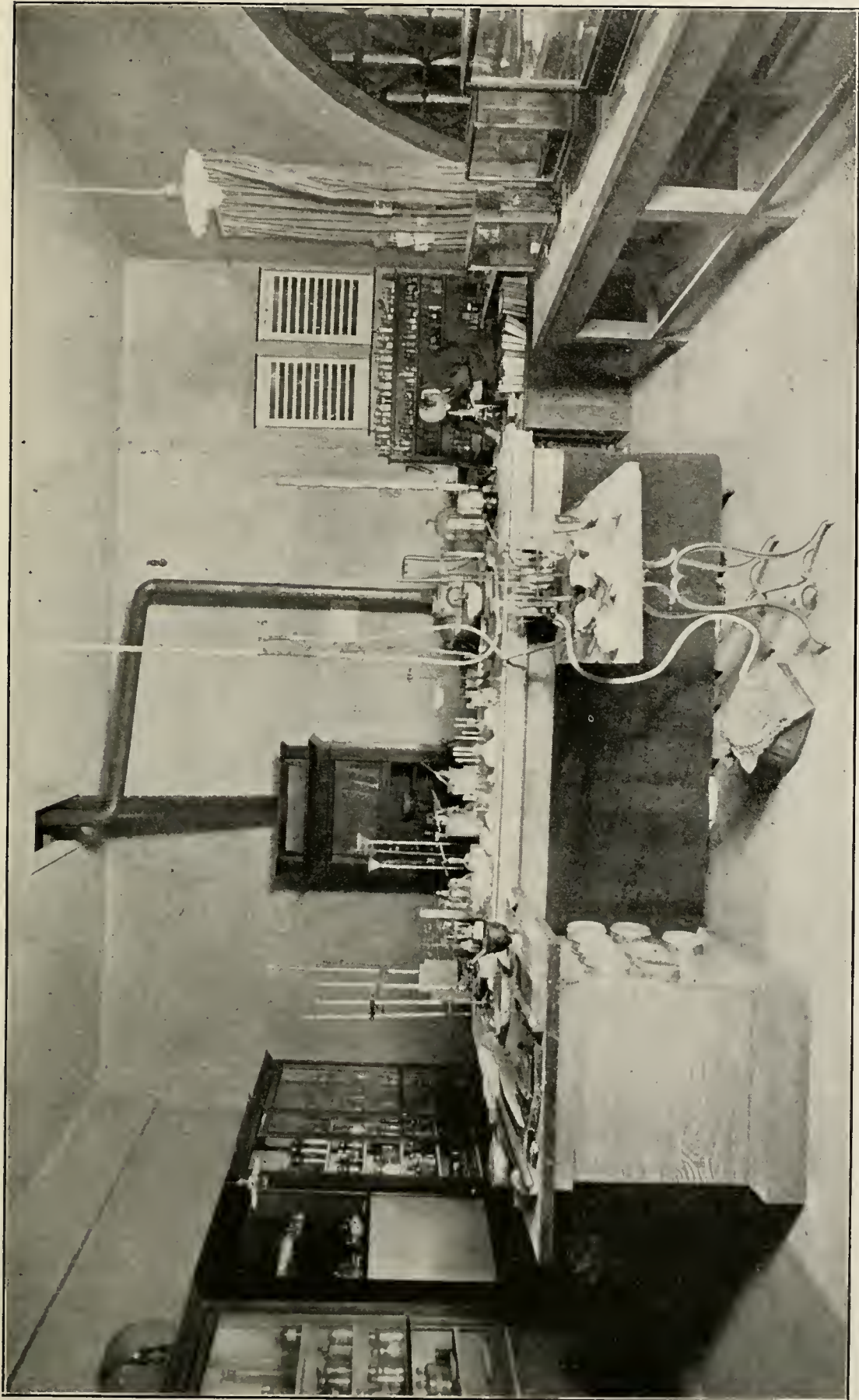
TOTAL GOLD PRODUCT OF CALIFORNIA—1848-1904.

1848.....	\$245,301	1863.....	\$23,501,736	1878.....	\$18,839,141	1893.....	\$12,422,811
1849.....	10,151,360	1864.....	24,071,423	1879.....	19,626,654	1894.....	13,923,281
1850.....	41,273,106	1865.....	17,930,858	1880.....	20,030,761	1895.....	15,334,317
1851.....	75,938,232	1866.....	17,123,867	1881.....	19,223,155	1896.....	17,181,562
1852.....	81,294,700	1867.....	18,265,452	1882.....	17,146,416	1897.....	15,871,401
1853.....	67,613,487	1868.....	17,555,867	1883.....	24,316,873	1898.....	15,906,478
1854.....	69,433,931	1869.....	18,229,044	1884.....	13,600,000	1899.....	15,336,031
1855.....	55,485,395	1870.....	17,458,133	1885.....	12,661,044	1900.....	15,863,355
1856.....	57,509,411	1871.....	17,477,885	1886.....	14,716,506	1901.....	16,989,044
1857.....	43,628,172	1872.....	15,482,194	1887.....	13,588,614	1902.....	16,910,320
1858.....	46,591,140	1873.....	15,019,210	1888.....	12,750,000	1903.....	16,471,264
1859.....	45,846,599	1874.....	17,264,836	1889.....	11,212,913	1904.....	19,109,600
1860.....	44,095,163	1875.....	16,876,009	1890.....	12,309,793	Total ..	\$1,414,856,268
1861.....	41,884,995	1876.....	15,610,723	1891.....	12,728,869		
1862.....	38,854,668	1877.....	16,501,268	1892.....	12,571,900		

COUNTY RANK IN GOLD PRODUCT IN 1904.

While gold is still the leading mining product, its yield no longer puts the greatest gold-producing county in the first place. The petroleum of Kern County and the copper of Shasta give them precedence. Gold is more widely distributed than any other substance thus far mined in California; 34 counties out of the 57 in the State showing a gold yield in 1904, and it is known to exist in several others. The order in rank of the counties of the State, in the production of gold alone, is at present as follows:

1. Nevada.....	\$3,130,304	14. Sacramento ..	\$419,287	27. Riverside.....	\$7,488
2. Amador.....	2,060,573	15. Sierra.....	374,763	28. Del Norte.....	7,399
3. Butte.....	1,932,552	16. San Diego.....	331,697	29. Monterey.....	6,941
4. Calaveras.....	1,789,184	17. Plumas.....	270,439	30. Alpine.....	4,827
5. Tuolumne.....	1,563,907	18. Mono.....	268,930	31. Ventura.....	2,700
6. Kern.....	1,426,523	19. Inyo.....	150,474	32. Tulare.....	1,100
7. Shasta.....	1,031,429	20. Yuba.....	139,528	33. San Luis Obispo	630
8. Siskiyou.....	892,685	21. Lassen.....	116,993	34. Mendocino.....	75
9. Placer.....	778,355	22. Madera.....	75,303	Unapportioned	114,835
10. S. Bernardino	595,828	23. Humboldt.....	62,061	Total.....	\$19,109,600
11. Trinity.....	574,814	24. Stanislaus.....	50,000		
12. El Dorado.....	474,994	25. Los Angeles ..	12,402		
13. Mariposa.....	429,771	26. Fresno.....	7,809		

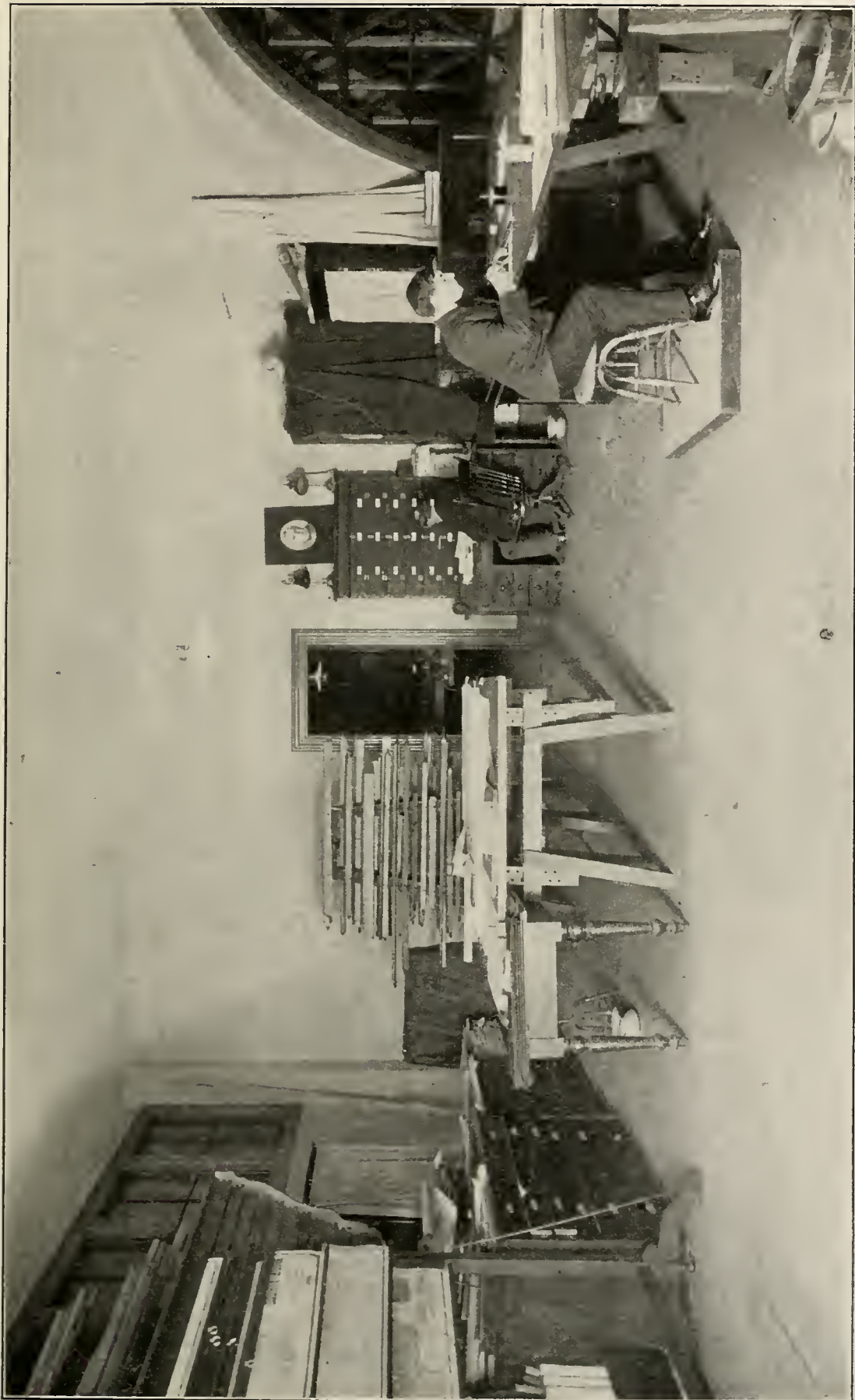


ILL. No. 148. LABORATORY, CALIFORNIA STATE MINING BUREAU.

TOTAL MINERAL PRODUCT OF CALIFORNIA FOR 1904.

The following table shows the yield and value of mineral substances of California for 1904, as per returns received at the State Mining Bureau, San Francisco, in answer to inquiries sent to producers:

	Quantity.	Value.
Asbestos	10 tons	\$162
Asphalt	56,187 "	672,910
Bismuth	20 "	2,400
Bituminous Rock	45,280 "	175,680
Borax (Crude)	45,647 "	698,810
Cement	969,538 bbls.	1,539,807
Chrome	123 tons	1,845
Clays (Brick)	281,750 M	1,994,740
Clays (Pottery)	84,149 tons	81,952
Coal	79,062 "	376,494
Copper	29,974,154 lbs.	3,969,995
Fuller's Earth	500 tons	9,500
Glass Sand	10,004 "	12,276
Gold	-----	19,109,600
Granite	520,687 cu. ft.	467,472
Infusorial Earth	6,950 tons	112,282
Gypsum	8,350 "	56,592
Lead	124,000 lbs.	5,270
Lithia Mica	641 tons	25,000
Lime	579,451 bbls.	571,749
Limestone	40,207 tons	87,207
Macadam	532,690 "	414,668
Manganese	60 "	900
Magnesite (Crude)	2,850 "	9,298
Marble	55,401 cu. ft.	94,208
Mica	50 tons	3,000
Mineral Paint	270 "	1,985
Mineral Water	2,430,320 gals.	496,946
Natural Gas	144,437 M cu. ft.	91,035
Paving Blocks	3,977 M	161,752
Petroleum	29,736,003 bbls.	8,317,809
Platinum	-----	1,849
Pyrites	15,043 tons	62,992
Quicksilver	28,876 flasks	1,086,323
Rubble	1,764,208 tons	1,227,209
Salt	95,968 "	187,300
Sandstone	363,487 cu. ft.	567,181
Serpentine	200 tons	2,310
Soda	12,000 "	18,000
Silver	----- (Com. value)	873,525
Slate	6,000 squares	50,000
Soapstone	228 tons	2,315
Tourmaline	-----	65,000
Other Gems	-----	71,000
Total value	-----	\$43,778,348



ILL. No. 149. DRAUGHTING AND MAP DEPARTMENT, CALIFORNIA STATE MINING BUREAU.

MINING BUREAU PUBLICATIONS.

Publications of this Bureau will be sent on receipt of the requisite amount and postage. Only stamps, coin or money orders will be accepted in payment. (*All publications not mentioned are exhausted.*)

Attention is respectfully called to that portion of Section 8, amendment to the Mining Bureau Act, approved March 10, 1903, which states:

“The Board (Board of Trustees) is hereby empowered to fix a price upon, and to dispose of to the public, at such price, any and all publications of the Bureau, including reports, bulletins, maps, registers, etc. The sum derived from such disposition must be accounted for and used as a revolving printing and publishing fund for other reports, bulletins, maps, registers, etc. The prices fixed must approximate the actual cost of printing and issuing the respective reports, bulletins, maps, registers, etc., without reference to the cost of obtaining and preparing the information embraced therein.”

	Price.	Postage.
Report XI—1892, First Biennial	\$1 00	\$0 15
Report XIII—1896, Third Biennial	1 00	20
Bulletin No. 6—“Gold Mill Practices in California” (3d edition)	50	04
Bulletin No. 9—“Mine Drainage, Pumps, etc.,” bound	60	08
Bulletin No. 15—“Map of Oil City Oil Fields, Fresno County, Cal.”	05	02
Bulletin No. 16—“Genesis of Petroleum and Asphaltum in California,” (3d edition)	30	03
Bulletin No. 23—“Copper Resources of California”	50	12
Bulletin No. 24—“Saline Deposits of California”	50	10
Bulletin No. 27—“Quicksilver Resources of California”	75	08
Bulletin No. 30—“Bibliography Relating to the Geology, Palaeontology and Mineral Resources of California, including List of Maps”	50	10
Bulletin No. 31—“Chemical Analyses of California Petroleum”	---	02
Bulletin No. 32—“Production and Use of California Petroleum”	75	08
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In Preparation:

Map and Register of Santa Barbara County.

Samples (limited to three at one time) of any mineral found in the State may be sent to the Bureau for identification, and the same will be classified free of charge. It must be understood, however, that *no assays, or quantitative determinations will be made*. Samples should be in lump form if possible, and marked plainly on outside of package with name of sender, postoffice address, etc. A *letter* should accompany sample, and a *stamp* should be inclosed for reply.

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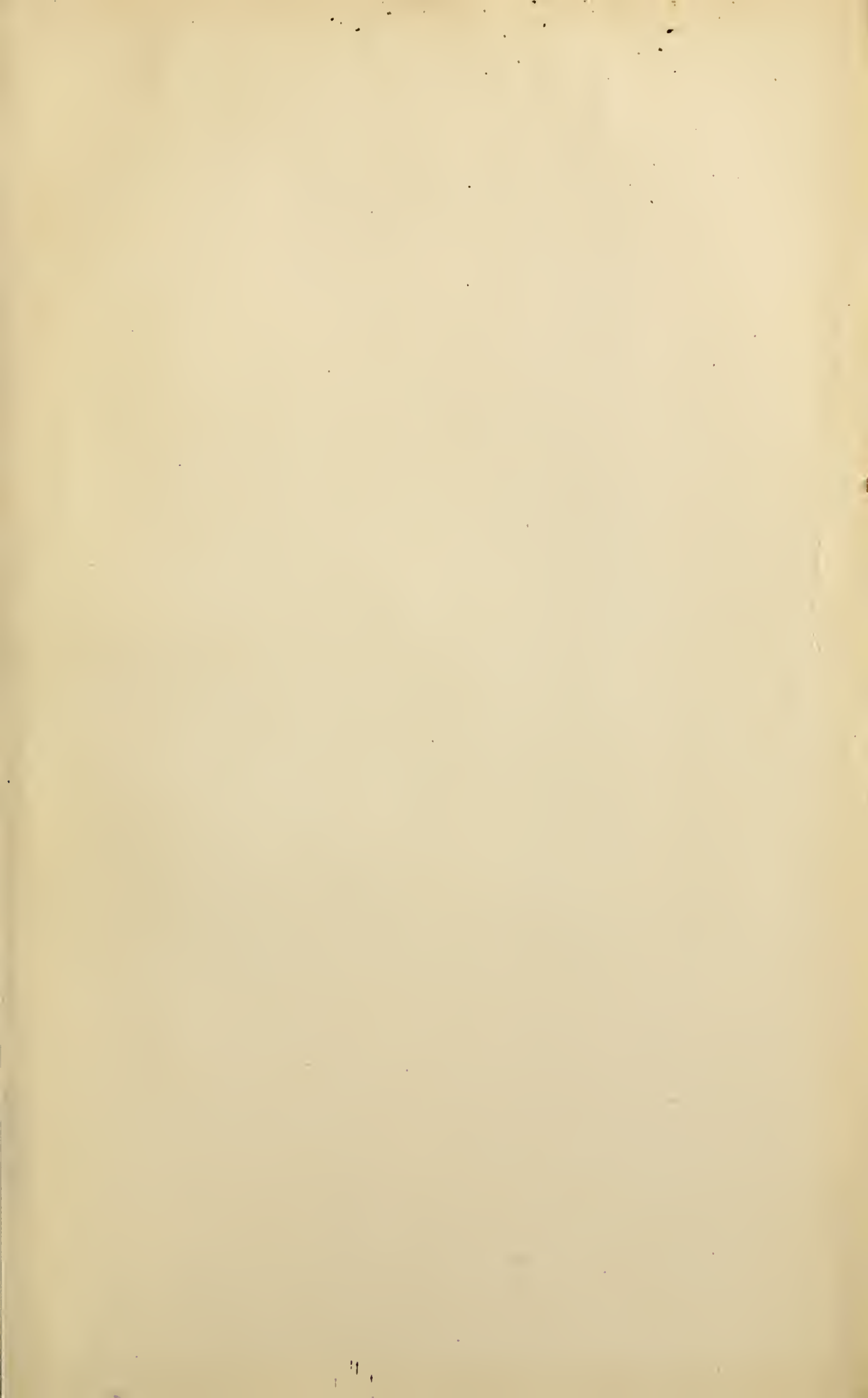
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