MINERAL INFORMATION SERVICE

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The Portland Cement Industry in California--1962

PART I

BY OLIVER E. BOWEN AND CLIFFTON H. GRAY, JR.

California leads the nation in production of portland cement. Its 13 mills produced 41,207,000 barrels of cement during 1961 (preliminary U. S. Bureau of Mines figures) valued at more than $130,000,000 at the mill. Among California mineral products portland cement ranks in value per annum just behind products of the petroleum industry—petroleum, natural gas liquids and natural gas. The industry provides direct employment for over 4,000 people and many others indirectly.

After nearly 4 years of fluctuating and at times markedly depressed demand, the industry once more is experiencing a steady increase in cement consumption. Nearly all firms are expressing optimism for the

California Portland Cement Company's plant and quarries at Creal siding, 9 miles west of Mojave in Kern County. This is a dry process plant having an annual rated capacity of 6,000,000 barrels. Initially constructed during 1954-55 it has been enlarged until it ranks among the 5 largest and most modern plants in California.

MINERAL INFORMATION SERVICE

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MINERAL INFORMATION SERVICE is designed to inform the public on the geology and mineral resources of California and on the usefulness of minerals and rocks, and to serve as a news release on mineral discoveries, mining operations, markets, and statistics, and activities and publications of the Division. It is issued monthly by the California Division of Mines and Geology. Subscription price, January through December, is $1.00.

Other publications of the Division include the Annual Report of the State Geologist; the Bulletin, Special Report, Map Sheet, and County Report series; the Geologic Map of California; and other maps and publications. A list of the Division's available publications will be sent upon request. Communications to the Division of Mines and Geology, including orders for publications, should be addressed to the San Francisco office.

MARY H. RICE, *Editor*

future. Permanente Cement Company recently announced that the capacity of its Cushenbury Canyon plant (east of Victorville, San Bernardino County) would be more than doubled to 5,200,000 barrels per year, and Calaveras Cement Division of the Flintkote Company has just completed the first phase of its new construction at Redding, Shasta County—an initial capacity of 1,500,000 barrels. As of April 1, 1962 the total capacity of the California plants exceeds 53,000,000 barrels. When all of the announced rebuilding and expansion plans are completed (by 1965), the total annual rated capacity of the California mills will exceed 56,500,000 barrels. Rebuilding projects are underway at the Colton plant of California Portland Cement Company, the Crestmore plant of the Riverside Division of American Cement Corporation and the Monolith Cement Company plant. There is still great interest in the California market by firms that have not yet operated here. Other new plants and further expansions are likely in the not too distant future.

Meanwhile some firms have been experimenting to increase kiln efficiencies through introduction of pure oxygen into one side of the cone of burning gases. Capacity increases up to 30 percent have been reported. Kiln capacities have also been increased through pre-heater installations.

During 1961 the Calaveras Company put a new buff-colored cement on the market designed for use in art concrete and other applications where a light-colored but not necessarily white cement is desirable. Completion of Riverside Cement's new white plant at Crestmore once more makes California self sufficient in most varieties of Portland cement. Except for a short period in the mid-1950's when white cement was made at the Calaveras plant at San Andreas, California has been dependent upon Texas and other states for its white cement.

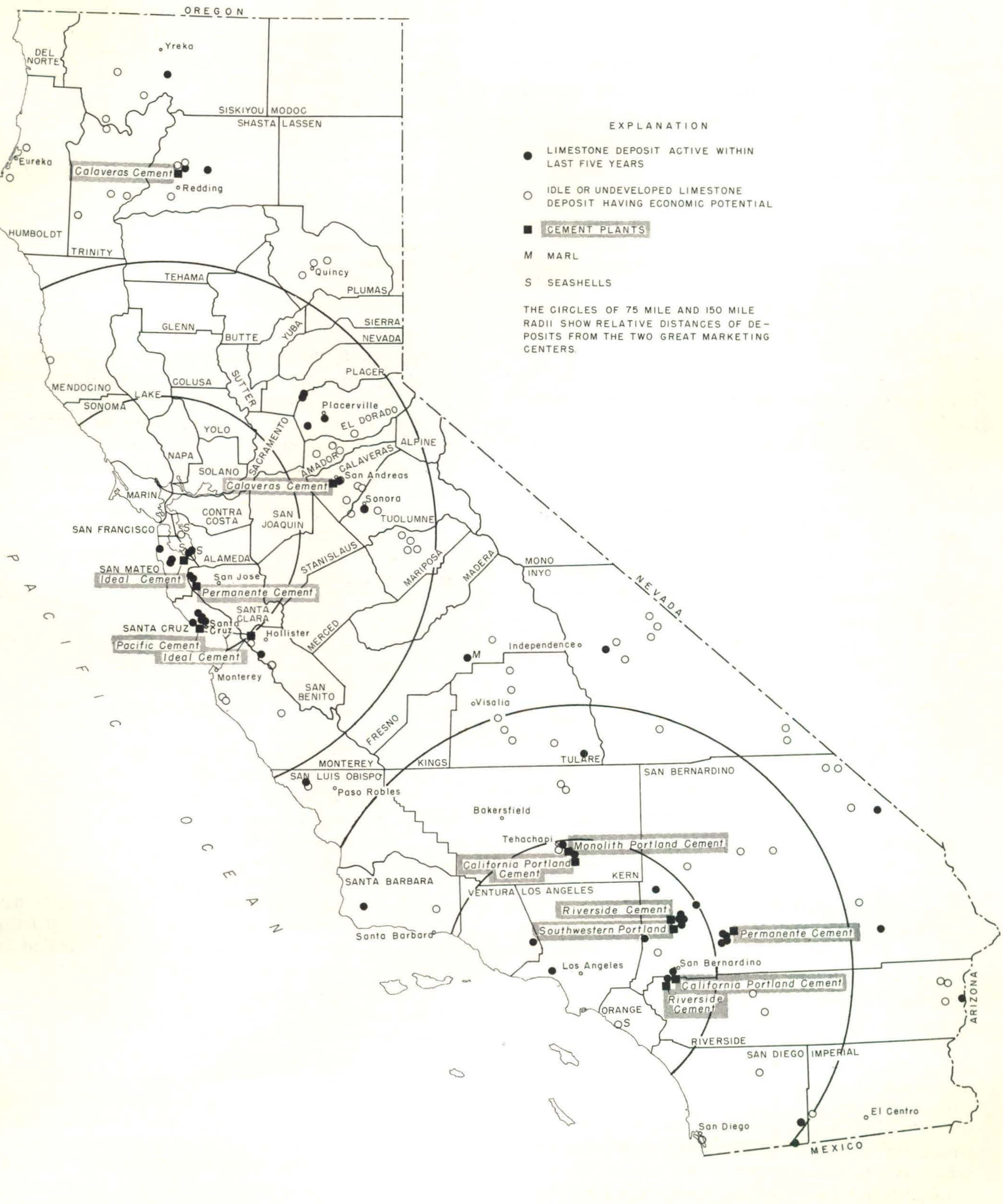
All but one of the 13 cement plants lie within a radius of 125 miles of one of the two principal marketing centers—Los Angeles and San Francisco. Most of the mineral materials consumed by these plants are obtained close to them with the exception of gypsum, pyrite cinder, iron ore, fluorite, and a few other special additives. About the only imported ingredient used in substantial amounts in manufacture of California cement is gypsum, part of which comes in by water from Baja California. The current marketing situation is such that virtually all of the cement manufactured in California is consumed here. More than 80 percent of production is delivered by truck, a little more than 15 percent goes by rail and less than 5 percent by water. A little more than 86 percent is delivered in bulk and less than 14 percent is packaged in paper bags.

Cement Economics—Markets and Prices

As cement is a relatively low cost product with a small margin of profit, it must be produced as close to marketing centers as availability of raw materials, public utilities and heavy transportation will allow. Urbanization, with its increasing competition for land from widely divergent interests, may well drive cement plants farther from the markets than availability of raw materials normally would dictate. Opposition to industrial plants has been particularly strong in parts of Riverside and Monterey Counties. At least one plant has turned to beneficiation of its raw material to keep from going farther from market for these materials.

Five cement plants are situated within a radius of 125 miles of San Francisco and seven within a like distance of Los Angeles. A thirteenth plant recently was completed north of Redding in Shasta County where construction of the Trinity River Dam and near-future other large public works projects have created a market not governed by population concentrations. The accompanying figure illustrates the disposition of the various cement plants with respect to markets and to distribution of limestone deposits. Typical price ranges among the various types of portland cement in California may be seen in the following table of U. S. Bureau of Mines figures for 1961. Average prices obtained for cement packaged in 94-pound paper bags were:

Types I and II—General use and moderate heat	$3.13
Type III—High early strength	3.77
Type IV—Low heat of hydration	*
Type V—Sulfate resistant	3.82
Oil well	3.28
White	*



Map of California showing the location of the various cement plants with respect to the principal markets and to the limestone deposits of current and potential economic importance.

Portland-pozzolan	*
Air entrained	*
Waterproof	3.82
Miscellaneous	3.69

* Figures confidential because of small number of producers.

The average mill price per barrel of cement during 1961 was $3.16, somewhat higher than the national average.

Characteristics of Portland Cement

Portland cement is the principal binding agent used in modern concrete. It is also an important constituent of various mortars, plasters and stucco mixes used in the construction industry. Its most important characteristic is its ability to "set" or harden the concrete mixture in the presence of water. Portland cement readily combines with water to form new, stable crystals. Concrete is simply a mass of rock particles of various sizes bound together by criss-crossed, often interlocking, crystals that form as the wet mixture hardens.

Portland cement is made by heating to incipient fusion, under carefully controlled conditions, suitable mixtures of finely ground raw materials that include, as essential ingredients, calcium carbonate ($CaCO_3$), silica (SiO_2) and alumina (Al_2O_3). Iron oxide is also an important ingredient used in all types of cement except white portland. Cements that must resist sulfate-high-mineral waters are made with a relatively large proportion of iron oxide. Blended portland cement mixtures ready to be fed into the kilns generally lie within the following chemical limits, (dry basis):

	Percent
Lime	42–44
Silica (SiO_2)	13–15
Alumina (Al_2O_3)	4–6
Iron oxide (Fe_2O_3)	2–3
Carbon dioxide (CO_2)	33–35
Remainder (includes magnesia, alkalies, water, etc.)	1–3

Magnesia (MgO) is a deleterious ingredient often found in materials otherwise suitable for portland cement. Cements too high in magnesia tend to set erratically and alteration of periclase (MgO) may cause cracking in concrete. For these reasons the MgO content of cement is held below 5 percent in types I to IV and below 4 percent in type V.

During calcination the pulverized raw materials are converted into walnut-sized cindery particles called clinker—with loss of a large volume of carbon dioxide gas (about 35 percent of the raw mix (dry basis). The clinker is composed of newly formed lime-bearing compounds the most important of which are tricalcium silicate ($3CaO.SiO_2$), dicalicum silicate ($2CaO.SiO_2$), tricalcium aluminate ($3CaO.Al_2O_3$) and (except in white cement), tetracalcium aluminoferrite ($4CaO.Al_2O_3.Fe_2O_3$). Each of these compounds has a distinctive behavior during hydration or setting that is important in certain kinds of construction. By controlling the raw material mix and the time and temperature of calcination, various proportions of these compounds can be obtained in the clinker and several types of cement result. A typical general purpose (Type I) portland cement yields the following analysis (dry basis):

	Percent
Silica (SiO_2)	22.0
Alumina (Al_2O_3)	6.0
Iron oxide (Fe_2O_3)	2.7
Lime (CaO)	64.0
Magnesia (MgO)	2.0
Sulfur trioxide (SO_3)	1.8
Ignition loss	1.3
Insolubles	0.2
Total	100.0

Since 1940, the American Society for Testing Materials has recognized 5 types of portland cement for the following general uses:

Type I—For general use in concrete construction where special properties are not required.

Type II—For use in concrete construction where contact with weak sulfate water is expected or where a moderate heat of hydration (during setting of the concrete) is desired.

Type III—For use in structures where high early strength is required.

Type IV—For use where low heat of hydration is required.

Type V—For use where contact with highly concentrated sulfate solutions is expected.

Under normal conditions, more than 95 percent of the California production of concrete is in types I and II.

White portland cement is a variety of Type I cement in which the iron oxide content is held to less than 0.5 percent and presence of manganese and titanium is held to trace amounts. Iron tends to darken the color of portland cement, manganese tends to color it green, and titanium, yellow.

In recent years much attention has been paid to harmful reactions between unsuitable aggregate materials and portland cement in concrete structures. These reactions are not the result of any fundamental weakness in the quality of portland cements, which are made under carefully controlled conditions, but rather are caused by the poor quality aggregates that have been used in some areas. The reactions, which may take place years after the initial hardening of the concrete, result in slow formation of new chemical compounds which require greater space than is present in voids between the aggregate particles. Cracks, spalls (popouts) and other damage to the concrete result. To combat such failures cement companies have developed special cements for use with poor quality aggregate. Portland pozzolan is the commonest of these.

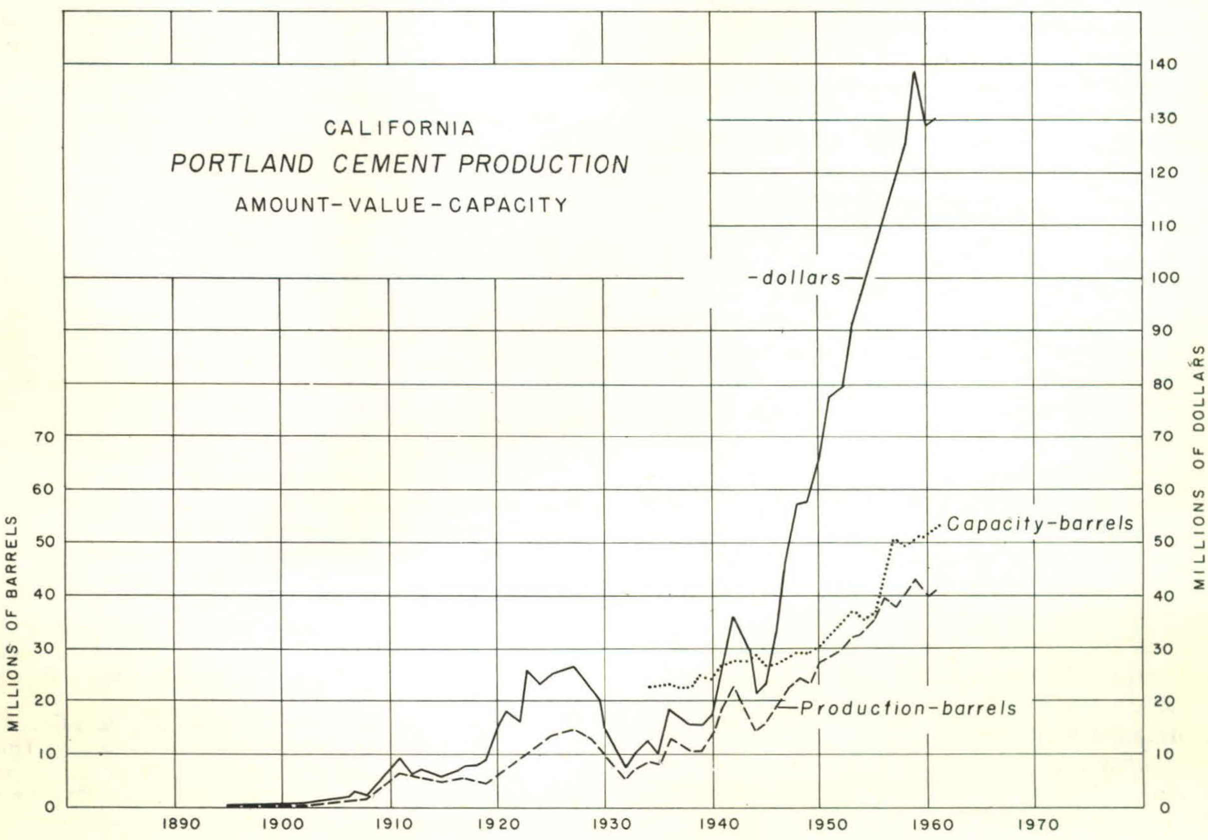
Extensive research has revealed that numerous concrete failures were caused by reactions between small amounts of free lime and free alkalies (present in most portland cements) and certain minerals present in the aggregates, such as opal, nontronite and zeolites. Consequently, the free lime and alkali contents of cement are carefully controlled and low alkali cements having less than 0.60 percent alkalies are specified for use where potential alkali-aggregate reactivity is suspected. Pozzolanic additions for use with portland cement have been developed to further avoid the harmful effects of alkali-aggregate activity. Opaline silica seems to be the chief active ingredient in these. Opaline chert and shale, felsic volcanic tuffs and calcined diatomaceous earths have all been utilized for pozzolans in California. In addition to preventing the alkali-aggregate reactions from taking place, pozzolans also are satisfactory low-cost substitutes for portland cement, if high early strength is not desired in the concrete, and they latently increase the strength and textural quality of concrete over a period as long as 2 or 3 years.

Although considerable air is normally entrapped in concrete during the mixing process, more can be introduced and uniformly distributed by use of synthetic additions such as resins and hydrous silicates of calcium. Air-entrained concrete has superior frost and weathering resistance, increased workability and cohesiveness, reduced tendencies toward segregation and bleeding (separation of water from the aggregate particles), and increased resistance to deterioration by sulfate water. The increased porosity and decreased permeability of air-entrained concretes are results of the presence of innumerable unconnected, nearly spherical voids induced by presence of the air-entrainment additives. Increased frost resistance, decreased weight and decreased thermal conductivity are the chief advantages of air entrained over common concrete. These advantages are sometimes achieved at only a slight loss in strength.

Cements having other special characteristics have been developed for use in oil wells, in water proof structures and for applications where high plasticity is desirable. Oil well cements, which must set under a wide variety of conditions of temperature, pressure and water quality, commonly are manufactured under rigid specifications with special additives, and special mixing procedures have been devised.

Raw Materials Used in Cement

Low-magnesium limestones and clay shales, or their metamorphosed equivalents, are the raw materials most abundantly used in manufacture of portland cement. However, a wide variety of satisfactory substitute materials can be used when more readily available at lower cost. In some parts of the United States natural



cement rocks are available—i.e., rocks which already contain the approximate desired proportions of lime, alumina, silica, and iron oxides. Most commonly these are clayey marine limestones. Thus far, large natural cement-rock deposits have not been found in California near enough to marketing centers to be utilized. During the past two years, the approximate annual consumption of raw materials by California cement plants has been as follows (short tons):

Crystalline limestone	8,500,000
Oyster shells and amorphous or fine-crystalline limestone	3,500,000
Mixed rocks—interbedded schist and crystalline limestone with some intrusive granitic rocks	1,000,000
Clay shale, clay and topsoil	800,000
Quartz-mica schist	500,000
Quartzite and crushed quartz mill tailings	120,000
Sandstone and loose sand	6,000
Pyrite cinder, mill scale, and iron ores	125,000
Gypsum	325,000
Miscellaneous additives, fluxes and acids (includes fluorspar, hydrochloric acid, calcium chloride, asbestos, air-entraining compounds and pozzolanic additives)	25,000

HISTORY OF THE CEMENT INDUSTRY IN CALIFORNIA

The California cement industry had its beginnings in the period 1859 to 1891. The Benicia Cement Company began production of a natural hydraulic cement at Benicia (now in Solano County) in 1859 using local travertine and shale. During 1859 and 1860 this company produced between 50 and 100 barrels of hydraulic cement per day at a mill price of $4.00 per barrel. At that time it was estimated that San Francisco alone was using 12,000 barrels per year (Mercantile Trust Company Review, 1925). By 1865 the San Francisco rate of consumption had increased to 100,000 barrels annually and the price of hydraulic cement had fallen to $2.50 per barrel. Most of the cement consumed in California was imported from England.

The first company to make portland cement in California was probably the California Portland Cement Company organized January 18, 1877 at Santa Cruz (R. A. Kinzie, personal communication, 1956). This firm, not the same as the present day California Portland Cement Corporation, apparently remained in business only a short time, but the name was retained on corporation lists as late as the mid-1920's. Cement was manufactured in stationary brick kilns. Limestone to supply this plant came from the vicinity of Wagner Park and clay was taken from pits at the head of Walnut Ave., both within the present Santa Cruz city limits. This operation predates by 14 years cement plant erected on the Jamul Ranch in San Diego County long considered to be the first portland cement plant in California (Storms, 1892).

In 1891 a bank of stationary brick kilns was erected on the Jamul Ranch known as the Jamul Portland Cement Works. This plant had a daily capacity of 150 barrels. Because of high freight costs to get the cement to coastal markets and trans-shipping points and because of competition from low-cost cements shipped in by water from England, this enterprise lasted less than a year. It utilized a clayey, calcareous caliche as its principal raw material.

The first contemporary concern to build a cement plant in California was California Portland Cement Corporation. Their Colton plant was opened late in 1894 and has been in continuous operation since that time.

Production of portland cement progressed very slowly through the 1890's, an increase from 5000 to 52,000 barrels per year being recorded during this period. Between 1902 and the pre-World War I slump of 1912-16 production increased from 171,000 barrels to 6,371,369 barrels. A second slump occurred during the depression of the 1930s and again, to a lesser extent, during World War II. With these exceptions, however, the cement industry has enjoyed much the same meteoric rise as California's population.

Salient events in the cement industry in California are as follows:

1860—First California production of natural cement at Benicia, Solano County. Cement was produced intermittently at Benicia until 1890. The plant utilized travertine and clay shale.

1877—Erection of the first California plant for manufacture of portland cement at Santa Cruz, Santa Cruz County by a firm known as California Portland Cement Company (not the same as the firm currently operating in southern California). Crystalline limestone and surface clay were utilized.

1891—Erection of a 150-barrel-per-day plant on the Jamul Ranch, San Diego County. Production there ceased in 1892 owing to high transportation costs and competition with foreign cement. Raw material used was chiefly a clayey calcareous caliche.

1894—Opening of the first California plant to survive to the present day, that of California Portland Cement Corporation at Colton, San Bernardino County. Much of the oval hill of crystalline limestone that was Slover Mountain has been quarried away during the 68 years of major operation but the limestone mass is known to extend 1200 feet below local base level. The plant is currently being rebuilt.

1902-3—Establishment of two plants, one near Napa, Napa County, by Standard Portland Cement Company and one at Cement, near Fairfield, Solano County, by Pacific Portland Cement Company. The Napa plant closed in 1919 and the Fairfield plant in 1927, both because raw materials were exhausted. The Fairfield plant ran for some time on limestone hauled in from the Mountain Quarries near Auburn in Eldorado County. It originally utilized Recent travertine and various clayey materials. The Napa plant used some travertine, some shell limestone and clay shale of Cretaceous age.

1906—Opening of the plant at Davenport, Santa Cruz County, by Santa Cruz Portland Cement Company. This plant is now operated by Pacific Cement and Aggregates Company, the merger taking place in 1956. Crystalline limestone and diatomaceous clay shale are the chief raw materials used. The plant was temporarily shut down during 1962 by a rock slide and operations have been curtailed from time to time by flooding on San Vicente Creek, but the plant has remained in almost continuous operation since 1906.

1908—First cement shipments made from Henry Cowell Lime and Cement Company at Cowell, Contra Costa County. Depletion of the calcareous tufa and travertine deposits and loss of rail facilities resulted in closing of the plant in 1942.

1909—Plant of Riverside Portland Cement Company erected at Crestmore, Riverside County. This plant, altered and enlarged several times, is now being rebuilt. Also completed during 1909 was a plant at Monolith near Tehachapi, Kern County. Originally built and operated by the City of Los Angeles to supply cement for the Los Angeles aqueduct, this plant was ultimately taken over and is still operated by Monolith Portland Cement Company. It is in process of modernization.

1910—The Golden State Portland Cement Company commenced production at Oro Grande, San Bernardino County. This plant was later taken over by Riverside Cement Company and was rebuilt during the period 1950-55.

1914—Old Mission Portland Cement Company began to build a plant at San Juan Bautista, San Benito County. First shipments made in 1918. This plant was later acquired by Pacific Portland Cement Company which in turn was sold to Ideal Cement Company in 1952.

1916—Establishment of Southwestern Portland Cement Company at Victorville, San Bernardino County. This plant has been enlarged and modernized several times.

1924—Opening of Pacific Portland Cement Company's plant at bayside in Redwood City, San Mateo County. This is the only California plant that utilizes seashells and bay mud. It is now operated by Ideal Cement Company.

1925—Yosemite Portland Cement Company built a plant at Merced, Merced County. A slaty limestone from a tributary to the Merced River Canyon was utilized. This plant closed down on June 30, 1944 when traffic over the Yosemite Valley Railroad was discontinued.

1926—Calaveras Cement Company opened a plant at San Andreas, Calaveras County. Productive capacity has been tripled since World War II. Calaveras became a division of the Flintkote Company in 1960.

1930—Blue Diamond Corporation, Ltd. completed a grinding and finishing plant at Los Angeles utilizing clinker purchased from other companies. The company became a division of the Flintkote Company in 1961.

1931—National Cement Company of Dallas, Texas built a small plant (annual capacity 5,320 barrels) for making white cement at Chubbuck, San Bernardino County. It never operated at full capacity and was shut down in 1932.

1940—Establishment of the Permanente Cement Company plant at Permanente near Los Altos, Santa Clara County —currently the largest producer in California.

1952—Ideal Cement Company acquired the holdings of Pacific Portland Cement Company.

1954—California Portland Cement Corporation began construction of a new plant at Creal near Mojave, Kern County. The raw materials deposits were purchased from Ideal Cement Company. The plant capacity recently was enlarged to 6,000,000 barrels per year.

1955—Permanente Cement Company began construction of its second plant near Lucerne Valley, San Bernardino County. The capacity of this plant is now being more than doubled to 5,200,000 barrels per year.

1956—Pacific Coast Aggregates Company and Santa Cruz Portland Cement Company merged, the new corporation being re-named Pacific Cement and Aggregate Company.

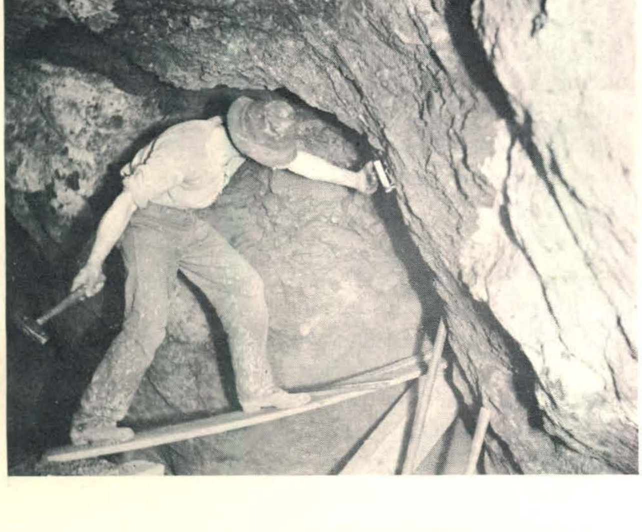
1958—Riverside Cement Company, Peerless Cement Corporation of Detroit and Hercules Cement Corporation of Philadelphia merged, the new corporation being named the American Cement Corporation. Later that year the Phoenix Cement Company also became a division of American Cement Corporation.

1959—Calaveras Cement Company and the Blue Diamond Corporation, Ltd. became divisions of the Flintkote Corporation.

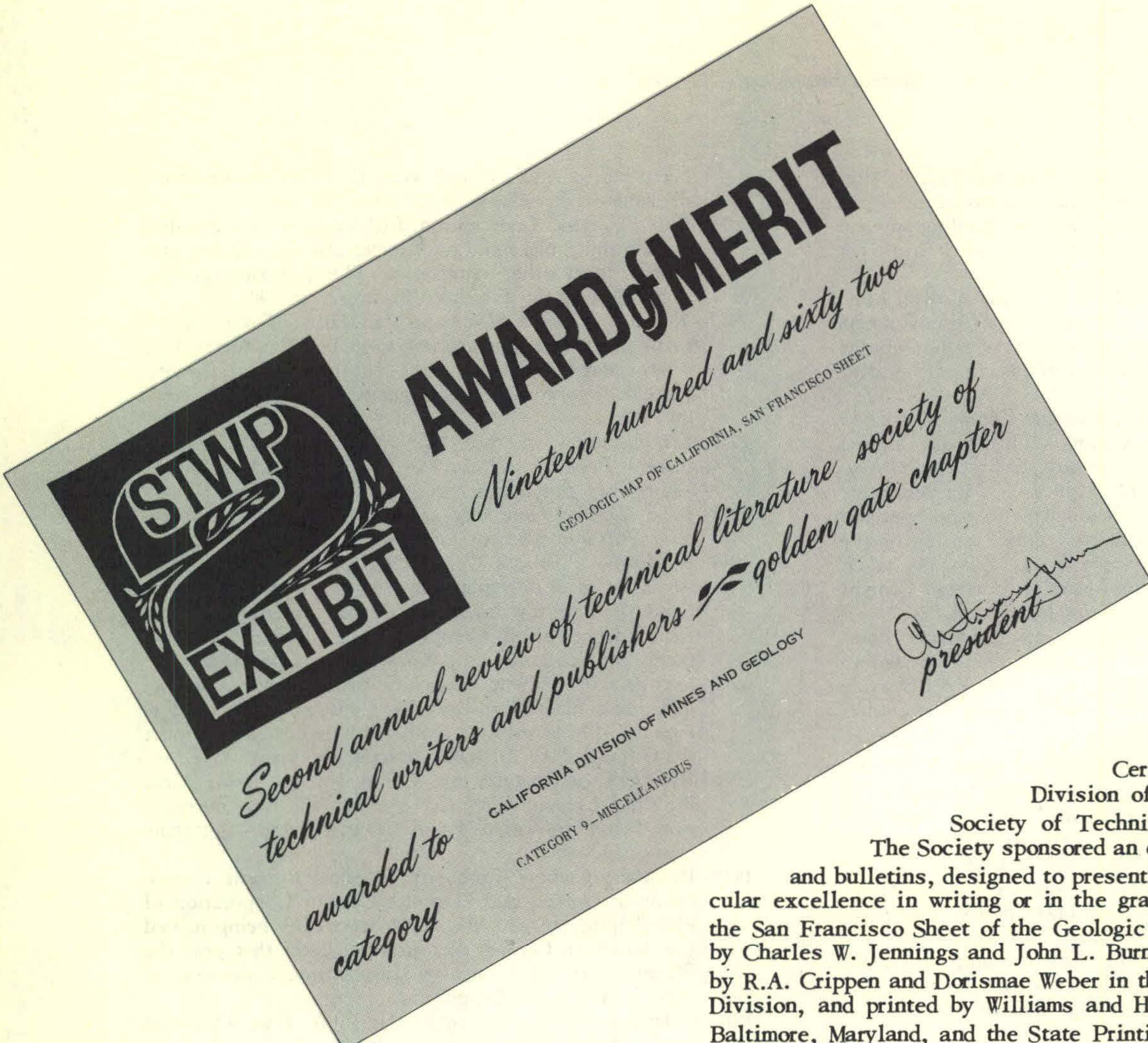
1961—The old Blue Diamond mill on Alameda Street in Los Angeles closed down January first and has been dismantled.

1962—The first shipments of cement from the new Redding plant of Calaveras Cement Division of the Flintkote Corporation were made, bringing the total number of California cement plants to 13.

The first of two parts. This article will be concluded in the next issue of Mineral Information Service.



Left. Miner engaged in the lost art of single-jacking. In single-jacking, a miner worked alone, using a short-handled, light-weight hammer to strike the drill, which he held in his other hand. Miner's candle is stuck into wall beside drill. Photo taken in the Keystone mine, Good Springs, Nevada, in 1902. *Courtesy J.H. Morris.*



Certificate awarded to the Division of Mines and Geology by the Society of Technical Writers and Publishers. The Society sponsored an exhibit of reports, brochures, and bulletins, designed to present technical materials of particular excellence in writing or in the graphic arts. A Division entry, the San Francisco Sheet of the Geologic Map of California, compiled by Charles W. Jennings and John L. Burnett, prepared for publication by R.A. Crippen and Dorismae Weber in the drafting department of the Division, and printed by Williams and Heintz, Inc., lithographers of Baltimore, Maryland, and the State Printing Office, won this "Award of Merit"

PETROLEUM GEOLOGISTS STUDY FAULTING IN CALIFORNIA

A committee for the study of Lateral Faulting in California was formed in 1961 under the auspices of the Pacific Section of the American Association of Petroleum Geologists. The objectives of the committee were: 1) to compile all available data relative to lateral faulting in California; 2) to publicize widely the results of such compilations; 3) to stimulate and support additional basic research of critical problems and areas; and 4) to sponsor field trips to provide a first hand view of important areas.

The project has been divided into several specific areas of study, each under the supervision of a committee member. Among the more immediate aims of the committee are: the compilation of an annotated bibliography covering faulting in California, the collection and cataloguing of samples from outcrops and wells near the San Andreas fault, the preparation of a matched pair of cross sections on either side of the San Andreas fault, and the integration of available geophysical data. A field trip along the San Andreas fault in the Cuyama Valley area is planned for October of this year.

The greatest challenge facing the committee at the present time is that of enlisting as many workers as possible for the many phases of the project. The enthusiastic response to the exhibit on lateral faulting at the A.A.P.G. Convention in San Francisco in March 1962 showed that many geologists are in-showed that many geologists are interested in these studies, and a gratifying number have already volunteered to help out with abstracting and other phases of the work. The committee is interested in securing additional workers and additional information. If any professional geologist has a desire to help in a small or a large way with the aims outlined above, it is suggested that he write, wire, or phone Richard Walters, Humble Oil Company, Box 997, Chico, California.

CARVING STONE PRODUCED NEAR COALINGA

By John L. Burnett

An unusual new mining activity has recently been started near Coalinga in Fresno County. Permi-Arts Industries of Coalinga is quarrying diatomaceous shale for use as carving stone and marketing the material under the trade name of "Maple-Rok". The stone is presently being sold by art and craft supply houses in California and parts of the midwest but nationwide distribution is being planned, according to C.E. Hardin, president of Permi-Arts.

The quarry is located 7 miles north of Coalinga on land leased from the Shell Oil Company. The diatomaceous shale is quarried from a thick sequence of beds 100 or more feet in thickness. Hand sorting is used to select stone with the best carving qualities.

The carving stone is composed primarily of the siliceous tests of fossil diatoms—minute marine organisms, clay and small quantities of quartz. The stone is soft, porous and can readily be worked with ordinary knives and abrasives. Bedding planes in the stone are marked by buff to light brown color banding which creates the effect of a wood-like grain. The stone is very light in weight (specific gravity below 1.0) and breaks with a smooth, concoidal fracture. Permi-Arts has developed a plastic fixative compound and glazes in several colors which can be used to harden and finish the stone after carving.

KERN RIVER SAND AND GRAVEL STUDY RELEASED

A comprehensive study of the sand and gravel resources of the Kern River near Bakersfield, California, has been released by the Division of Mines and Geology as Special Report 70.

The publication is the result of a cooperative study by Harold B. Goldman of the staff of the Division, and Ira E. Klein, of the staff of the U.S. Bureau of Reclamation.

The Kern River drains a portion of the southern Sierra Nevada in Kern and Tulare Counties and in the Bakersfield area has deposited a great volume of gravelly alluvium which forms the basis of a thriving aggregate industry.

The report presents a general picture of the sand gravel resources along the lower reaches of the Kern River near Bakersfield, their present state of development, and calls attention to those areas that might be of economic significance for future development. These sand and gravel deposits have been a source of concrete aggregate and road base materials for many years. Here is a remarkable case of large scale commercial production of sand and gravel from a small area in which these geologic formations were mined. The formations, of different ages (Recent floodplain, Quaternary terrace, and Pliocene alluvial fan) represent three different stages in the geologic history of Kern River. Operational problems vary with each formation depending upon the topography, status of industrial development, and the extent to which weathering has affected the older deposits.

Data presented include the results of field examination of undeveloped terrace and floodplain deposits; standard laboratory acceptance tests; petrographic appraisal; and plant descriptions. Detailed information on the mineralogy of the fine sand from the stream bed by Kern River has also been included.

A generalized geologic map of the Kern River basin and a detailed geologic map of the aggregate resources accompanies the report.

Special Report 70, *Sand and gravel resources of the Kern River near Bakersfield, California,* consists of 33 pages, 20 photos, 3 figures, 7 tables, and 2 folded maps in a pocket and is priced at $1.00 plus tax. The form on the last page may be used for ordering.

Left. Bas relief carving from Coalinga shale. *Courtesy Permi–Arts.*

NEW BOOKS FROM

The exploration of the Colorado River and its canyons. By J.W. Powell. New York, Dover Publications, Inc. 400 pp. Price (in paper) $2.00.

This issue of Major Powell's account of his exploration of the Colorado River is taken from his own journal, made on brown paper—that soon became water-soaked—during the course of the eventful journey. Although the scientific results of his expedition were separately printed, Major Powell did not issue what might be termed a "popular" account until long after the expedition, and then at the insistence of a member of the Congress.

Powell's account of the expedition is one of great classics of exploration literature, as thrilling as the deed itself must have been. Starting from the Green River Portage on May 24, 1869, with a motley group of geologists, geographers, scouts, and adventurers, and four rowboats designed by the Major himself, the expedition emerged 95 days later with six men, and a record of the first scientific chartering of the hitherto unmapped Colorado River.

The country through which the expedition traveled was an enigma even to the Indians who lived on its fringes, some 1,000 miles of impassable badlands, wild waters, roaring rapids and the steep walls of the Grand Canyon. Powell's achievement ranks with that of Lewis and Clark, Pike, Fremont, and the others who ventured into the unexplored areas of the continental United States.

It is always a joy to read Dover books; not only because they are time-tested classics, but also because they are nicely printed and firmly bound. This reviewer has yet to have a paper-back Dover book fall apart during reading.

The rock-hunter's range guide: How and where to find minerals and gem stones in the United States. 1962. By Jay Ellis Ransom. Harper & Brothers, New York. Price $4.95. Available at bookstores.

Designed to guide the amateur "rock hound", the book is divided into two major sections. The first part deals with how to go about rock collecting (including a section on "The geologic map" adapted from this magazine), the second part with where to go and how to recognize the various minerals. On the whole, the first part is the more valuable; the "where to look" section is marred by too great brevity with no further bibliographic leads and by several errors that may lead to confusion (for example, the Eel River is listed as being in Marin County).

Life in the universe—a scientific discussion. By Michael W. Ovenden. Science Study Series S 23. Doubleday and Company, Anchor Books, Garden City, New York. 1962. Price 95¢. An engaging book about the likelihood of life on other planets, based on recent discoveries in biology, chemistry, and physics. Not a book of "idle speculation", which, as Dr. Ovenden points out, has no place in science, but a book of "speculation", which is the lifeblood of science. He has some very pertinent words for those who charge that science, by its investigations, is destroying our sense of wonder in the world about us:

"Respect", he wrote, "is not the prerogative of ignorance. An African bushman presented with his first sight of a television screen might 'wonder' at pictures in a box. But this sentiment is ephemeral, and it soon dissipates with familiarity. On the other hand, to know how a television picture is produced is to induce (in me, at least) a profound respect for the ingenuity of the many scientists and technologists who have made the finished product possible. This is a respect refined and tempered by knowledge, and is the more enduring...."

Gravity. By George Gamow. Science Study Series S 22. Doubleday and Company, Anchor Books, Garden City, New York. 1962. Price 95¢. Professor Gamow has developed, in this little book, a very clear presentation of our knowledge of the force of gravity. This portion of his introduction not only sets the stage for the book, but is also a good sampling of its flavor:

"Gravity rules the Universe. It holds together the one hundred billion stars of our Milky Way; it makes the Earth revolve around the sun and the Moon around the sun and the Moon around the Earth; it makes ripened apples and disabled airplanes fall to the ground. There are three great names in the history of man's understanding of gravity: Galileo Galilei, who was the first to study in detail the process of free and restricted fall; Isaac Newton, who first had the idea of gravity as a universal force; and Albert Einstein, who said that gravity is nothing but the curvature of the four-dimensional space-time continuum."

Professor Gamow, who begs his readers not to be deterred by his brief chapter on the Calculus ("if you want to learn physics, *please do try* to understand Chapter 3!"), urges them forward by charming cartoons that he himself has drawn.

OTHER PUBLISHERS

Foraminifera from the type section of the San Lorenzo Formation, Santa Cruz, California. By Frank R. Sullivan. Published in volume 37, no. 4, pp. 233-352 of the University of California Publications in Geological Sciences. University of California Press, Berkeley and Los Angeles. 1962. Price $3.00. Available from the University of California.

> *Two hundred thirteen species and varieties of fossil Foraminifera of late Eocene, Oligocene, and "Oligo-Miocene" age are recorded from the upper Butano, San Lorenzo, and lower Vaqueros formations of the Santa Cruz Mountains, California. This stratigraphic sequence is exposed along the San Lorenzo River, in the type area of the San Lorenzo formation, two to four miles north of Boulder Creek, in Santa Cruz County.* Haplophragmoides deflata, Lagena becki, Plectofrondicularia minuta, *and* Valvulineria tumeyensis *var.* conica *are described as new. The foraminifers indicate that this sequence was deposited during Narizian, Refugian, and early Zemorrian time, in marine waters mostly at bathyal depths, with tropical to subtropical surface temperatures throughout. The indications are that normal open-sea conditions prevailed, except toward the middle of the sequence, until late within this interval of time.*

Evolution of the echinoid genus Astrodapsis. By Clarence A. Hall, jr. Published in volume 40, no. 2, pp. 47-180, of the University of California Publications in Geological Sciences. University of California Press, Berkeley and Los Angeles. 1962. Price $3.00. Available from the University of California.

> Astrodapsis *specimens from several areas of California seem on casual observation to be morphologically distinct from others in the same bed or at the same horizon, but upon closer scrutiny and comparison can clearly be shown to represent members of one variable popultaion. Many of the previously described species are morphologically intergrading taxa that come from the same horizon, and thus represent one population, i.e., a group of freely interbreeding individuals at a locality.*
>
> *Because of these relationships the echinoid genus* Astrodapsis *is revised.*
>
> Astrodapsis *is a late Middle Miocene to Early Pliocene genus that is apparently restricted to California.*

Anza-Borrego Desert guidebook: southern California's last frontier. By Horace Parker. 1957. Paisano Press, Balboa Island, California. Price $2.50.

One of the handiest guidebooks this reviewer has seen, the *Anza-Borrega guide* should be invaluable to anyone who visits—personally or vicariously—this large desert park. Utilizing a spiral binding (which nevertheless has an identification on the backstrip so that it may be easily spotted in the bookcase), and heavy cardboard covers attractively printed, the book will lie flat at any page without falling apart.

There are two foldout maps, completely indexed; one of Borrego Valley and one of the Vallecito area. Several trip logs with mileage accompany each map.

The bulk of the guidebook consists of an interesting text about some of the more important areas, notes on the history, geology, animals, plants, all illustrated by historical photographs and sketches and fine modern photographs.

High- and low-temperature feldspars in granitic xenoliths in diabase. By J.F. White. Published in volume 38, no. 3, pp. 151-176, of the University of California Publications in Geological Sciences. University of California Press, Berkeley and Los Angeles. 1962. Price 75¢. Available from the University of California.

A study of some large granite and granite gneiss xenoliths that were found in diabase within the Tortilla Mountains of central Arizona. High-temperature plagioclase, typical of volcanic rocks, and low-temperature feldspars similar to feldspars of plutonic rocks are distinctive features of the xenoliths. Petrographic evidence prompted the author to conclude that the feldspars were produced through local fusion of the xenoliths, resulting in a granitic magma. The higher temperature forms he attributes to crystallization from the newly formed melt; the lower temperature forms to crystallization of some of the newly crystallized material.

Bibliography of geochronology. Compiled by Geochron Laboratories, Inc. n.d. A 24- page list of published articles and books on the subject of geological age measurements (excluding Carbon 14). Total entries number more than 450, including numerous Russian contributions. Free on application to Geochron Laboratories, Inc., 24 Blackstone St., Cambridge 39, Massachusetts.

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LIST OF MAJOR CIVIL WAR BATTLEFIELD AREA MAPS AVAILABLE

The U.S. Geological Survey has recently prepared a bibliography of topographic maps covering major battlefield areas of the War between the States that are available from various Government agencies.

The list includes not only Survey maps but pertinent maps and charts issued by the U.S. Coast and Geodetic Survey and the Army Map Service. Included is information on map scale, contour interval, year of issue, map size, price, and detailed instructions on how to order maps desired.

In completing the list, only major battles have been considered. No attempt has been made to list maps of areas in which countless skirmishes and small engagements took place. In many cases, the battlefields as such are not outlined on the maps, but it is believed Civil War students will have no difficulty in identifying areas of interest.

The "Bibliography of Maps of Civil War Battlefield Areas" by Irwin Gottschall, has been published as Geological Survey Circular 462. Copies are available free upon request to the Director, Geological Survey, Washington 25, D.C. The Division of Mines and Geology does not stock them.

MUSEUM TO BE OPEN SOME SATURDAYS

The California Division of Mines and Geology has recently made a change in the exhibition hours to provide a greater opportunity for the public to view the extensive collection of minerals, rocks and ores contained in the Division's museum. Saturday, June 2nd, marked the inauguration of the new schedule: the museum will now be open between 10 AM and 12 noon on the first Saturday of each month.

Other exhibition hours are from 8 AM to 5 PM, Monday through Friday, and are now coincident with business hours of the Division's information section.

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