QUARTZITE IN CALIFORNIA

BULLETIN 187

California Division of Mines and Geology
Ferry Building, San Francisco, 1966

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By WILLIAM E. VER PLANCK
California Division of Mines and Geology

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ABSTRACT

Quartzite, a compact, granular rock composed of interlocking quartz grains, is common and widespread. Large, uniform deposits of high-purity quartzite containing 95 to 100 percent SiO_2 are relatively scarce in California and are located far from consuming centers. Production in California is several tens of thousands of tons a year.

The Ordovician Eureka Quartzite near Lone Pine, Inyo County, furnishes the only quartzite produced in California that is currently known to be suitable for making super duty silica brick. It occurs in a conformable sequence of predominantly dolomite beds that strike parallel to the mountain front. Of a total thickness of 400 feet, only the upper 150 feet consists of high-purity quartzite. Units of the late Paleozoic Oro Grande Series near Victorville, San Bernardino County, have furnished several million tons of high-purity quartzite, mostly for the portland cement industry. Quartzite, limestone, dolomite, and schist of the Oro Grande Series have been complexly folded and faulted, then overlapped and intruded by rocks of the Triassic (?) Sidewinder Volcanic Series. Both units are intruded by granitic rocks. Near Shoshone, Inyo County, large deposits of the Zabriskie Quartzite Member of the Lower Cambrian Wood Canyon Formation occur in the Dublin Hills, on McLain Peak, and in the Resting Spring Range. The quartzite is of high purity but has not been developed. Quartz rock is associated with carbonate rocks of the Sur Series near Fremont Peak, Monterey County. The nearly complete replacement of carbonate rock by silica has resulted in substantial bodies of material that resembles quartzite. The deposits are not of the highest purity and are undeveloped. Deposits in the Paleozoic (?) Hodge Volcanic Series, 10 to 15 miles southwest of Barstow, San Bernardino County, furnished quartzite for silica brick during the 1920's. Lenticular bodies of high-purity quartzite as much as 200 feet thick and 1000 feet long occur in a sequence of steeply dipping muscovite schist and quartz-biotite schist. Quartzite-bearing formations that probably are not pure enough to be potential sources of high-purity quartzite include the Paleozoic (?) Kernville Series, the Lower Cambrian Prospect Mountain Quartzite, the Paleozoic Saragossa Quartzite, the Lower Cambrian Stirling Quartzite, and the vitreous quartzite series of the Eagle Mountains, Riverside County.

Quartzite is brittle and breaks easily but is abrasive and difficult to drill. Standard quarrying methods are employed.

Silica brick, produced by the careful burning of crushed quartzite mixed with one to three percent of hydrated lime, are used mostly for the roofs of open hearth steel furnaces. Because of technical changes in the steel industry, their use is declining. The purest quartzite obtainable is used. Alumina and alkalies are critically deleterious impurities. In super duty silica brick, the percent of alumina plus twice the percent of alkalies must equal 0.5 or less. Most other oxides are less harmful. The quartzite also must crush to form angular particles that pack tightly and that do not crack or disintegrate in the kiln. In the manufacture of portland cement, some form of silica makes up part of the kiln feed if enough silica is not present in the principal raw materials. Plants use the cheapest available silica material that meets their particular chemical requirements. Relatively few plants use quartzite. Ferrosilican and silicon were not being produced in California in 1961, but have been produced in the past. They are made in the electric furnace from tough quartzite or quartz that contains no minus ⅞-inch material and does not disintegrate in the kiln. A few tenths of a percent of iron and alumina are tolerated; but only traces of arsenic, phosphorus, and sulfur are allowed.

Gladding McBean and Company is now known as "Interpace" (International Pipe and Ceramics Corporation). The firm name has been changed since Mr. Ver Planck prepared this report.

QUARTZITE IN CALIFORNIA

By WILLIAM E. VER PLANCK *

INTRODUCTION

Quartzite In California

Quartzite is a compact, granular rock composed of interlocking quartz grains. Quartzite is a common, widespread rock that is abundant in most metamorphic terranes. Because of its abundance there can never be an absolute shortage. Its unit value is low, and specifications for most uses are exacting. This report is concerned mostly with high-purity quartzite containing 95 to 100 percent SiO_2. Relatively few quartzite formations in the United States consistently reach such high purities. Even such material has no economic value unless it can be cheaply mined and shipped to the consumer.

No detailed statistics are available, but the production of high-purity quartzite in California is on the order of several tens of thousands of tons per year. Of this amount probably 75 percent is consumed by the portland cement industry. The cement industry also consumes a much larger tonnage of silica in forms other than high-purity quartzite. Some of this material, which includes impure quartzite, contains substantially less than 95 percent SiO_2. Most, if not all, of the remainder of the high-purity quartzite produced in California is consumed in the manufacture of super duty silica brick for use as a refractory material. Quartzite for this purpose should contain not more than 0.25 percent combined alumina and alkalies and must also meet certain physical requirements, including the proper particle size distribution of the crushed material. Silicon and ferrosilicon also are made from high-purity quartzite and quartz. Lump material with only a few tenths of a percent of iron and alumina is used. Quartzite from California has never been so used, but, probably some of it would be suitable. Because of its physical properties, quartzite is admirably suited for use as aggregate and railroad ballast; but in California these materials are made from other types of rock, deposits of which are more conveniently located than the quartzite deposits. Relatively minor amounts of decorative building stone are prepared from certain impure colored and stained quartzite in California.

In 1961, two operations in California were producing high-purity quartzite. One, near Lone Pine, Inyo County was supplying the silica brick industry; the other, near Victorville, San Bernardino County, produced quartzite for the portland cement industry. In addition, quartz rock for the silica brick industry was brought into the state from the vicinity of Grants Pass, Oregon.

Previous Work

No comprehensive report on the quartzite resources of California has been published previously. The quarrying of deposits of quartzite associated with the Oro Grande Series and the Hodge Volcanic Series in San Bernardino County has been described in the county reports of the Division of Mines (Tucker and Sampson 1930; 1943; Wright and others, 1953). Quartzite and quartz are summarized together in a four-page article in "Mineral Commodities of California", Division of Mines Bulletin 176. Most quartzite formations are discussed in geologic reports in which areal geology and stratigraphy are given primary consideration, but few of these reports contain the details necessary for the economic evaluation of a particular formation at a particular place. Perhaps the most thorough survey was made by Gladding, McBean and Company during 1953. This survey was summarized by Richard F. Brooks in a paper presented to the Mining Branch, Southern California Section, A.I.M.E., on October 21, 1955.

Scope and Method of Work

This report describes the geologic occurrence, mining, processing, and utilization of quartzite in California. The work began with a survey of the literature. All of the geologic reports available to the writer were examined, and the descriptions of quartzite-bearing formations were noted and tabulated by formation and locality. Most of the quartzite-bearing formations

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* The main body of this paper was prepared by Mr. Ver Planck prior to his untimely death in 1963. It has since been added to by various members of the Division staff, to bring it more nearly up to date.

that have been tabulated are small and impure and of no present economic value. The literature survey indicated that relatively few formations are extensive and uniform enough to warrant further study. A relatively small number of deposits that were thought to be of possible economic value were examined briefly in the field.

Three deposits were examined in detail. A plane table map, scale 1 inch equals 100 feet, was made of a deposit of the Eureka Quartzite near Lone Pine, Inyo County. Oliver E. Bowen, Jr., of the Division of Mines and Geology staff and the author mapped the quartzite-bearing Oro Grande Series near Victorville, San Bernadino County, on a scale of 1:12,000. The report of this work has been published separately, and a summary of it is included here. Two large-scale structure sections were made of the Zabriskie Quartzite near Shoshone, Inyo County.

Acknowledgments

The writer wishes to thank Arthur G. Moore of Gladding, McBean, and Company, Richard F. Brooks, formerly of Gladding, McBean and Company, Oliver E. Bowen Jr., Charles W. Chesterman, and James R. McNitt of the Division of Mines and Geology, and Lauren A. Wright, formerly of the Division of Mines and Geology, for help and advice.

GEOLOGIC OCCURRENCE

Petrography

Quartzite is defined as a rock "consisting largely of quartz fragments so thoroughly cemented or recrystallized that it breaks through the grains as readily as around them." (Grout, 1932, pp 366–368). Some quartzite is a metamorphosed sandstone, the grains of which have been recrystallized as the result of heat and pressure into an interlocking aggregate af anhedral quartz crystals (see photo 3). The term also applies to a sandstone solidly cemented by silica that has grown in optical continuity around each fragment. Grout's definition implies that quartzite must be derived from sand with a high proportion of quartz grains. The tendency, however, is to include other forms of silica, such as chert or quartz silt, that have been recrystallized through metamorphism. Another type of quartz rock results from the replacement of carbonate rock or other rock types by silica (see photo 12). If silicification has been complete, the quartz rock is difficult to distinguish in hand specimen or even thin section from a true quartzite derived from sandstone and also has the same commercial uses.

In practice, the term quartzite is used loosely, and some metamorphic rocks that contain as little as 60 percent quartz have been called quartzite (Heinrich, 1956). Impurities include non-quartz grains, particularly feldspar, that were present in the sand from which the quartzite was derived, micas and other minerals produced from clay during metamorphism, and introduced minerals such as pyrite. With increasing feldspar content, quartzite grades into feldspathic quartzite and then into gneiss. Similarly, with an increasing mica content, quartzite grades into micaceous quartzite (photo 15) and schist. Quartz-rich rocks also exhibit a wide and unbroken range of induration. There is a complete gradation from thoroughly recrystallized or cemented quartzite to sandstone, friable sandstone, and unconsolidated sand.

Geologic Associations

Quartzite is found in metamorphic terranes in association with schist, gneiss, marble, and other metamorphic rocks. Quartzite bodies range in size from discontinuous layers less than an inch thick to formations several hundred feet thick that occur within areas of hundreds of square miles. Some quartzite bodies exhibit heterogeneous mineralogy; others are remarkably uniform. The impurities in a few widespread and uniform quartzite formations are in the order of a few tenths of a percent.

Commercial Sources of High-purity Quartzite

Sources of high-purity quartzite in California are few and poorly located with respect to transportation facilities and markets. Although quartzite occurs in most of the mountainous regions of the state, most of it is feldspathic, micaceous, and in the form of thin layers associated with schist. Formations consisting largely or entirely of quartzite are most numerous in the southeastern deserts and are of Paleozoic or Precambrian age. Very few of them are sufficiently pure and uniform to be potential sources of high-purity quartzite.

The Eureka Quartzite is quarried near Lone Pine, Inyo County, for silica brick. Quartzite of the Oro Grande Series from near Victorville, San Bernardino County is used for portland cement and formerly for silica brick. At one time, quartzite for silica brick was obtained from small deposits associated with the Hodge Volcanic Series near Hodge, San Bernardino County. Deposits of quartz rock near Fremont Peak, Monterey County, and the Zabriskie Quartzite and perhaps parts of the Stirling Quartzite in the Death Valley area may be suitable for some commercial purposes.

SOME QUARZITE DEPOSITS AND OPERATIONS

Eureka Quartzite Near Lone Pine

Outcrops of the Eureka Quartzite near Lone Pine, Inyo County, furnish the only quartzite produced in California that is known to be suitable for making super duty silica brick.

The Eureka Quartzite, of middle Ordovician age, is a remarkably uniform formation that is widespread in central and western Nevada. The type locality is near Eureka, Nevada. In California, it occurs in the Death Valley area and as far west as Owens Valley.

The quartzite deposits under consideration crop out on the steep southwest face of the Inyo Mountains, roughly 6 to 11 air miles southeast of Lone Pine and 100 to 800 feet above the floor of Owens Lake. The outcrops extend discontinuously from the vicinity of Swansea, where quartzite was obtained in 1955, to at least a mile northwest of Alico Siding on the now abandoned narrow gage Owens Valley line of the Southern Pacific Company. Since 1955, quartzite has been obtained intermittently from the Lakeview quarries near Alico Siding.

The Lakeview quarries are connected with State Highway 190 by a privately maintained gravel road about a mile long that is suitable for heavy trucks. The railroad loading point is on the standard gage line of the Southern Pacific Company at its crossing of State Highway 190, roughly 2½ air miles southeast of Lone Pine and 6 miles by road from the Lakeview quarries.

Previous Work

The only published geologic maps covering the Lone Pine quartzite deposits known to the writer are the Death Valley sheet of the State map (Jennings, 1958), and the compiled map of the Owens Valley region (Bateman and Merriam, 1954). The geologic map of the New York Butte quadrangle (Merriam and Smith, 1951, unpublished) was not available to the writer. The Eureka Quartzite has been described in the nearby Ubehebe Peak quadrangle (McAllister, 1955), in the Talc City Hills (Hall and Mackevett, 1958; Gay and Wright, 1954), and in Mazourka Canyon (Langenheim and others, 1956).

As shown on the Death Valley sheet (Jennings, 1958), the southwest face of the Inyo Mountain southeast of Lone Pine is underlain by long, narrow fault blocks of Paleozoic rocks that trend northwest parallel to the mountain front. These fault blocks are composed of successively older rocks ranging from Permian, high on the mountain front, to Ordovician at its base. Ordovician rocks, consisting of the Ely Springs Dolomite, the Eureka Quartzite, and the Pogonip Limestone, crop out in two places, one near Alico Siding and Dolomite, the other near Swansea.

Method of Work

Using the plane table method, a 2,000-foot by 900-foot area, herein called the Lakeview area, that includes the principal Lakeview quarries was mapped (Plate 1) on a scale of 1 inch equals 100 feet. Magnetic azimuths were used, and a datum plane was chosen so that Station A had an elevation of 4,200 feet, approximately that determined by inspection of the New York Butte quadrangle. A structure section, scale 1 inch equals 30 feet, was measured across the central part of the Lakeview area. Outcrops of the Eureka Quartzite between Alico Siding and Swansea were plotted on a map (figure 1), scale 1:31,250, prepared by enlarging a portion of the New York Butte quadrangle. Three and a half weeks were spent in the field between November 1958 and October 1959.

Descriptive Geology

Between Alico Siding and Swansea, the Eureka Quartzite occurs conformably in a sequence of predominantly dolomite beds that strike roughly parallel to the mountain front. It is assumed that the Eureka Quartzite is underlain by the Pogonip Limestone and overlain by the Ely Springs Dolomite as is the case in the nearby Talc City Hills.

As shown on figure 1, there are three outcrops of the Eureka Quartzite. One trends southeast through the Lakeview area and the Lakeview quarries to the quartzite mill, where it disappears beneath the fan at the mouth of a large canyon. The rocks dip southwest at angles of 75° to vertical, and the younger beds lie to the southwest. The second outcrop crosses the canyon mentioned above about ¾-mile northwest of the quartzite mill and runs south at an angle to the mountain front to the edge of the alluvium just north of Dolomite. The beds associated with the second outcrop dip steeply to the northeast, and the younger rocks lie to the northeast. The third outcrop crosses the end of a spur just southeast of Swansea. As in the outcrop near Dolomite, the beds dip steeply northeast.

Most of the discussion that follows pertains to the Lakeview area (Plate 1).

Stratigraphy

All the beds in the Lakeview area that underlie the Eureka Quartzite are assumed to be upper members of the Pogonip Limestone. The lowest unit, which lies northeast of the Lakeview area except for a small area near Station F, consists of 100 to 200 feet of brown-weathering, siliceous beds composed mostly of alternating siliceous and carbonate layers up to about 6 inches thick. The unit forms prominent outcrops and is the most conspicuous unit associated with the Eureka Quartzite in the Lakeview area. Practically all the beds above the brown-weathering, siliceous unit are composed of carbonate rock that is dark gray on the fresh surface and lighter gray on the weathered surface. The gray unit is about 250 feet thick. Most of it is dolomite; but the lower 80 feet, differentiated on A-A Plate 1 but not on the map, is composed of porous-weathering, gray limestone. Northwest of the hairpin turn on the road to the north quarry, where exposures are good, the gray dolomite contains sparsely distributed lenses of brown sandstone about 24 inches in diameter and 8 inches thick. In the same area, a bed of gray quartzite 3 to 5 feet thick occurs about 100 feet below the top of the gray dolomite. The same or a similar quartzite bed occurs on the

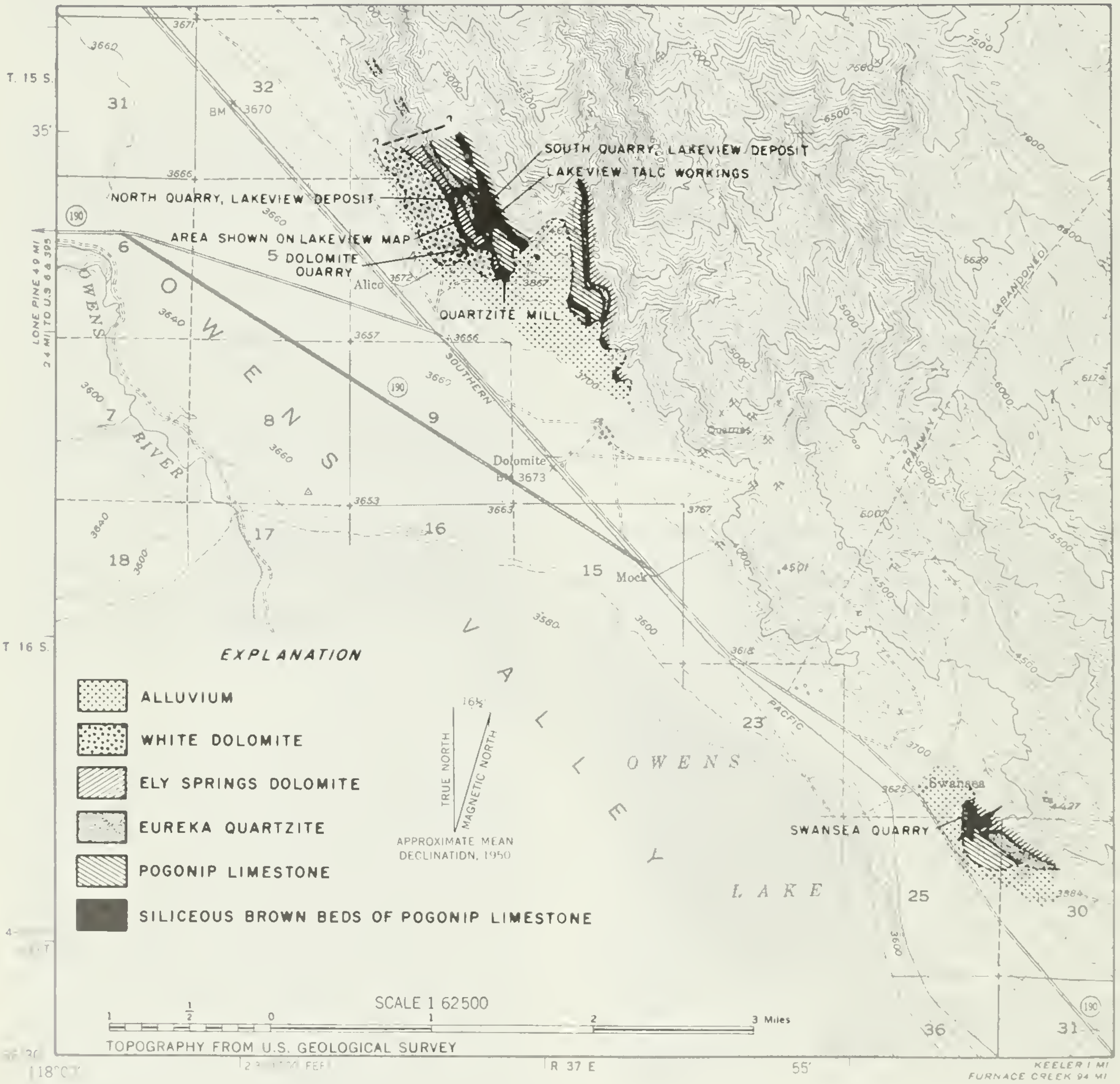

Figure 1. Geologic map of Eureka Quartzite near Owens Lake, New York Butte 15-minute quadrangle, Inyo County. By W. E. Ver Planck, Oct. 7–8, 1959.

Photo 1. Lakeview Quartzite deposit: View northwest along the strike of steeply dipping Ordovician rocks at the base of the Inyo Mountains near Dolomite. The siliceous brown beds of the Pogonip Limestone are at the right edge of the dark outcrop. The Eureka Quartzite, center, is marked by the white cuts and dumps.

hillside east of Station C, but no quartzite was observed in the poorly exposed dolomite between Station B and Station F. Outside of the Lakeview area the contact between the gray dolomite and the overlying Eureka Quartzite seems to be conformable; but in most of the area the two formations are separated by an outcrop of soft, white, granular material that contains abundant calcite. This relationship is further discussed under structure.

The Eureka Quartzite forms two prominent outcrops, one extending northwestward from the vicinity of the north quarry, the other in the vicinity of the south quarry and the talc workings. The two areas are separated by a flat, alluvium-covered saddle in which bedrock does not crop out. The formation, which is about 400 feet thick, is divisible into a lower, impure, relatively thin-bedded part containing much iron-stained quartzite, and an upper part of massive, uniform, and more pure quartzite. Except in artificial openings the Eureka Quartzite is uniformly covered with quartzite debris that conceals its details.

The contact between the Eureka Quartzite and the overlying Ely Springs Dolomite, as exposed in the quarries, is sharp and conformable. The Ely Springs, which consists of about 150 feet of gray dolomite, is made up of a lower unit of nodular dolomite and an upper unit of gray dolomite, which is nodule-free.

The lower unit is characterized by the presence of closely spaced, lenticular nodules up to 6 inches in diameter that are composed of tremolite and calcite. The weathered surface, with its projecting, dark-gray to black nodules, is distinctive. Nodule-free beds of gray dolomite occur, in places, close to the base of the Ely Springs. Higher in the section, beds with nodules become fewer; and there are none in the upper, or gray dolomite, unit. The base of the gray dolomite unit was mapped at the top of the highest nodular bed.

The gray dolomite unit of the Ely Springs is very similar to the gray dolomite of the Pogonip. Both contain disseminated tremolite crystals about 0.05-inch long and also clumps of bladed tremolite crystals.

The gray dolomite of the Ely Springs is overlain by two dolomite units that the writer has not identified. They are shown together as "white dolomite" on Plate 1. The lower unit consists of about 100 feet of pale gray dolomite with abundant disseminated tremolite needles as much as ⅜-inch long. It contains a few white dolomite beds 1 to 5 feet thick. The pale gray tremolitic domolite is overlain by a thick upper unit of massive, coarsely crystalline white dolomite that seems to extend uniformly from the southwest edge of the mapped area to the valley floor. The weathered surfaces of the two units are similar. Both have a sandy texture and are tan in color. The weathered surface of the pale gray tremolitic dolomite is only slightly darker than that of the white dolomite.

The Eureka Quartzite and the dolomite beds above and below it are cut by dikes of deeply weathered porphyritic diorite with phenocrysts of hornblende and feldspar. The dikes are a few inches to 5 feet wide. Probably most are approximately parallel to the

Photo 2. Eureka Quartzite near Lakeview Talc workings: View of the slope southeast of the south quarry (sky line) showing cuts and dumps of Lakeview talc deposit along the contact of the Eureka Quartzite (left) with gray dolomite of the Pogonip Limestone (right).

bedding of the sedimentary rocks, but some cut across the bedding.

Granitic rock intrudes the Eureka Quartzite just north of Dolomite, but was not observed elsewhere in the Alico-Swansea area. Near Dolomite, a sill-like body of granitic rock 50 to 100 feet thick occurs in the quartzite a few feet below its contact with nodular dolomite and has penetrated cracks in the quartzite.

Structure

Throughout the Lakeview area the beds strike northwest and dip steeply southwest except in the north corner, where they are overturned. They lie on the west limb of a faulted anticline, the east limb of which is represented by the east-dipping Eureka Quartzite and associated rocks north of Dolomite. None of the major faults that occur in the Alico-Swansea area was located, but minor faults are numerous. One is a bedding plane fault that, to the northwest of the Lakeview area and for most of its length within it, separates the Eureka Quartzite from the Pogonip Limestone. From a point about 300 feet due east of Station C to the southeast edge of the Lakeview area, where the beds depart from their general northwest trend, it cuts across the Pogonip beds. At the southeast edge of the Lakeview area and to the southeast it is a bedding plane fault in the Pogonip limestone. The fault trace is a strip 30 to 60 feet wide of powdery material that contains calcite. It is exposed in road cuts near the hairpin turn on the north quarry road, in a prospect pit east of the road, and in a tunnel east of the talc workings. East of the South quarry, where exposures are poor, the fault trace probably is represented by a strip of soft soil.

It is to be noted that in the Lakeview area only about 150 feet of the gray Ely Springs Dolomite lies above the Eureka Quartzite compared with 920 feet in the Talc City Hills (Hall and Mackevett, 1958, p. 7). A bedding plane fault may cut off the Ely Springs Dolomite, but the writer found no evidence of it.

In the vicinity of the talc workings, the quartzite outcrop terminates along an irregular boundary as if it had broken by tension acting in a direction parallel to the strike. A quarter of a mile to the southeast and outside of the Lakeview area is the end of another body of quartzite that has the same relationships with the Pogonip and Ely Springs beds as the quartzite in the Lakeview area. This southern body of quartzite disappears beneath alluvium at the quartzite mill, still farther to the southeast. Along the southeast edge of the Lakeview area the Ely Springs beds and the white dolomite that overlies them swing east, and southeast of the Lakeview area, the white dolomite occupies the space where quartzite might be expected. The area between the two quartzite bodies is complexly faulted so that the gray dolomites of the Ely Springs and of the Pogonip, which elsewhere lie above and below the quartzite, are in fault contact.

There may be a similar discontinuity of the quartzite beneath the saddle between the north and south quarries. The writer found no outcrops in the saddle itself or on the slope west of it. Scanty evidence of a cross fault was found to the east, where a gully from the saddle crosses the siliceous brown beds of the Pogonip. Cross faults do offset the Eureka Quartzite and the siliceous brown beds northwest of the Lakeview area.

The Eureka Quartzite in Detail

The Eureka Quartzite in the Alico-Swansea area is not especially uniform. Only a portion of the formation is of high purity, and the sections exposed in the various quarries are not identical.

In the Lakeview quarries, high-purity quartzite seems to be confined to the uppermost 100 to 150 feet of the formation. It consists of massive, grayish quartzite with bedding plane slips or joints 10 to 15 feet apart. These joints are 1 to 6 inches thick and filled with iron-stained, soft, calcite-bearing material. On the hanging wall side, a few feet of dark gray to black quartzite separates the massive quartzite from the overlying nodular dolomite beds. On the footwall side, the massive quartzite is bounded in some places by lower grade quartzite and in other places by a dike. The main part of the Eureka Quartzite, 250 to 300 feet thick, consists of iron-stained quartzite, platy black, impure quartzite with disseminated pyrite, slaty phyllite, thin carbonate beds, and relatively thin beds of unstained quartzite. Dikes are abundant. Joints are filled with powdery calcite, probably caliche derived from the carbonate rocks of the area.

South of the saddle, the Eureka Quartzite has been exposed by benches of the south quarry that almost encircle the knoll surmounted by Station C. As shown on Section A-A and Table 2, the massive hanging wall unit, which consists of high-purity quartzite, is about 110 feet thick in this area. Analyses 1 and 2, Table 1, indicate, however, that only the upper 55 feet (unit 6, Table 2), which consists of medium gray, vitreous quartzite, contains less than 0.25 percent impurities. Analyses 3 to 5, Table 1, indicate that the quartzite from the lower 55 feet (unit 5, Table 2) contains 0.25 to 0.5 percent impurities. Megascopically, the quartzite from the lower section is similar to that of the upper except that it contains streaks of darker gray and is cut by iron-stained cracks.

No significant difference was detected with the microscope. The quartzite consists of a mosaic of anhedral, irregularly interlocking quartz grains, many of which exhibit strain shadows. In size they range from 0.05 millimeters to as much as 3 millimeters and average 0.3 to 0.6 millimeters. Traces of the original rounded sand grains are present but are largely obliterated by the recrystallization that resulted from metamorphism. Non-quartz grains are very sparse and only a little more abundant in the dark, stained quartzite than in the clean gray quartzite. They include clumps of sericite 0.01 to 0.1 millimeter in diameter composed of crystals in the order of 0.005 millimeters in longest dimension, muscovite and biotite flakes up to 0.1 millimeter in longest dimension, and iron oxide grains 0.05 to 0.1 millimeters on a side. Feldspar was not observed.

The main part of the formation, about 260 feet thick, is relatively thin-bedded and impure but contains layers of clean gray quartzite up to 10 feet thick in the central part. (Analysis 6, Table 1). The basal 145 feet (unit 1, Table 2) consists of thin-bedded, shaly, black quartzite with abundant iron stain and caliche-filled cracks.

Some interesting impure rocks occur interbedded with high-purity quartzite in the middle part of the formation. The 25-foot section of quartzite just below the massive hanging wall unit (unit 4, Table 2) contains platy, black, layers with disseminated pyrite, much of which is altered to limonite. In thin section the black quartzite is seen to be composed of quartz with as much as 10 percent of fine-grained claylike material, sericite, limonite, mica, and zircon. The quartz occurs mostly as a mosaic of irregular, interlocking grains 0.07 to 0.2 millimeters in size and also as rounded grains 0.3 to 0.7 millimeters in size, many of which are composed of more than one crystal. Limonite forms cubes 0.07 to 0.3 millimeters on a side. Pyrite was not observed in the thin section examined. The clay and sericite occur as thin films 0.005 millimeters wide between quartz grains, as clumps 0.07 to 0.2 millimeters in diameter, and as veinlets up to 0.1 millimeter

Table 1. Chemical Analyses of Quartzite from Lakeview Deposit[1]
(in percent)

	1	*2*	*3*	*4*	*5*	*6*
SiO_2[2]	99.66	99.59	99.35	99.25	99.23	99.57
Al_2O_3	0.16	0.14	0.31	0.45	0.45	0.37
Fe_2O_3[3]	0.00	0.00	0.07	0.00	0.14	0.05
TiO_2	0.00	0.00	0.00	0.00	0.00	0.00
P_2O_5	0.00	0.10	0.00	0.11	0.00	0.08
CaO	0.00	0.02	0.00	0.02	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00
Na_2O	0.02	0.02	0.01	0.02	0.01	0.01
K_2O	0.02	0.02	0.07	0.07	0.02	0.02
H_2O[4]	0.14	0.11	0.19	0.04	0.15	0.04

[1] Analyses by W. H. Nisson, Division of Mines laboratory, June 1961.
[2] By difference.
[3] Total iron.
[4] Loss on ignition.

1 Sample Al-3, 402 feet from southwest end of section A-A′, Plate 1.
2 Sample Al-4, 441 feet from southwest end of section A-A′, Plate 1.
3 Sample Al-5, 454 feet from southwest end of section A-A′, Plate 1.
4 Sample Al-6, 469 feet from southwest end of section A-A′, Plate 1.
5 Sample Al-7, 500 feet from southwest end of section A-A′, Plate 1.
6 Sample Al-9, 530 feet from southwest end of section A-A′, Plate 1.

Table 2. Section of Eureka Quartzite at South Quarry, Lakeview Deposit.

	Stratigraphic thickness (in feet)
Ely Springs Dolomite	
Eureka Quartzite	
Upper, massive unit of high-purity quartzite	
6. Massive, medium-gray, stain-free quartzite	55
5. Massive quartzite with dark gray streaks and iron-stained cracks	55
Lower (main) unit, relatively thin-bedded and impure	
4. Medium-gray quartzite, quartzite with dark streaks, and platy, black, pyrite-bearing quartzite	25
3. Medium-gray quartzite and soft, gray, clay-like layers	35
2. Medium-gray quartzite and relatively hard, tremolitic, quartz-rich rock	55
1. Thin-bedded, shaly, black quartzite with iron stain and caliche-filled cracks	145
Fault	
Pogonip Limestone	

wide. Clay and sericite have penetrated and embayed the quartz grains, and much of it is iron-stained. One rounded zircon grain 0.2 millimeters in diameter was observed. It is interesting that these iron-bearing beds pass beneath the summit of the knoll, and the high-purity quartzite lies beneath its flank. Locally at least, high-purity quartzite cannot be distinguished by its resistance to weathering.

A 35-foot section near the center of the formation (unit 3, Table 2) consists of beds of medium gray, stain-free quartzite, up to 5 feet thick, separated by layers of soft, yellow-green and gray, clay-like material. Little could be identified with the microscope except abundant tremolite and sparse, rounded quartz grains. Some quartzite has been quarried from this unit.

The 55-foot section below the one just described (unit 2, Table 2) consists of quartzite beds separated by layers of relatively hard, tremolitic, quartz-rich rock. Thin sections of two specimens were examined. One consists of interlocking quartz grains 0.07 to 0.3 millimeters in size with 20 percent tremolite; the other (photo no. 4) consists of rounded quartz grains, some composed of more than one crystal, with 40 percent tremolite. The tremolite occurs as thin films between and penetrating quartz grains, as crescent-shaped clumps 0.07 by 0.3 millimeters between quartz grains, and as clumps as much as several millimeters in diameter that completely surround one or more quartz grains. Limonite cubes pseudomorphous after pyrite 0.07 millimeters on a side are present but not abundant. Much of the tremolite is in the form of interlocking needles in the order of 0.02 by 0.1 millimeters, but in tremolite-rich areas it forms single crystals as much as 1 millimeter across.

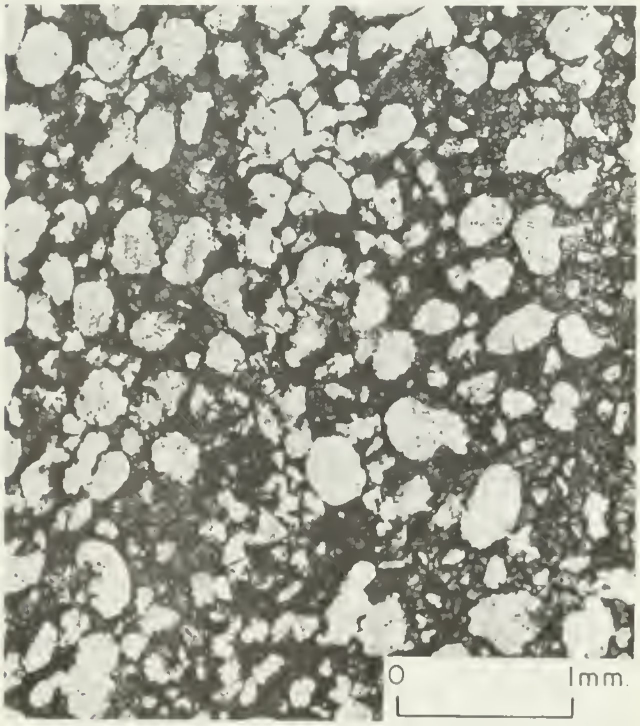

Photo 4. Photomicrograph of quartz-rich rock from the middle part of the Eureka Quartzite, Lakeview deposit. Rounded quartz grains in a matrix of tremolite. Plane polarized light.

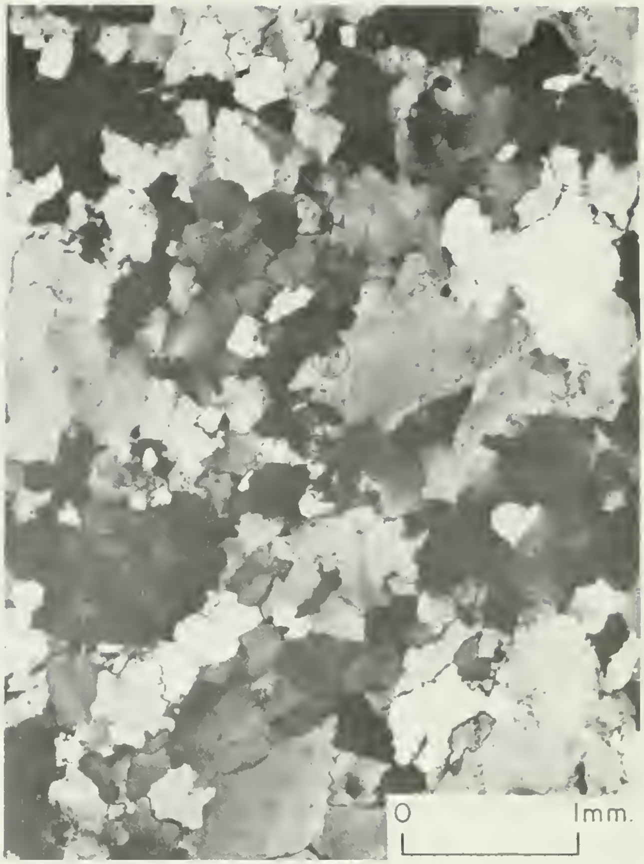

Photo 3. Photomicrograph of Eureka Quartzite from Lakeview deposit. Sample A1-3 from the high-purity upper part of the formation, consisting almost entirely of quartz. Crossed nicols.

The origin of the soft, clay-like layers in unit 3 and the tremolitic, quartz-rich layers in unit 2 has not been determined. Perhaps the central part of the Eureka Quartzite may once have been a sequence of sand beds alternating with sandy dolomite or limestone beds. It is possible that the solutions that produced the talc at the Lakeview talc workings, which are only about 500 feet from the south quarry, may have altered the carbonate layers into clay and tremolite, leaving the disseminated quartz grains unchanged. It is to be noted that elsewhere in the Lakeview area dolomite contains only disseminated tremolite crystals.

North of the saddle, the upper high-purity part of the Eureka Quartzite is exposed in the north quarry, but the main part of the formation is exposed only in cuts along the north quarry road. As shown on section B-B′, Plate 1, and Table 3, the hanging wall unit of massive, high-purity quartzite (unit 4) is about 150 feet thick. The main part, which is about 300 feet thick, contains a second unit of massive quartzite (unit 2, Table 3,) 50 feet thick and 50 feet above the base of the formation. This quartzite is similar to the hanging wall unit, except that it contains sparsely disseminated specks of iron oxide. It has not been developed and is assumed to be non-commercial. Between these massive quartzite units lies a sequence of less resistant beds (unit 3, Table 3) consisting of relatively thin quartzite beds, dikes, and thin carbonate layers. The basal 50 feet of the formation (unit 1, Table 3) consists of platy, black, iron-stained phyllite. The two massive quartzite units persist northwestward beyond the limits of the Lakeview area. South of the saddle, however, nothing was found within the main part of the formation that corresponds to the lower quartzite unit.

Outside of the Lakeview area, the Eureka Quartzite is exposed near the quartzite mill and near Swansea. At the quartzite mill, the formation, which is overturned and dips steeply east, has been benched across, exposing the contacts of the Eureka Quartzite with nodular dolomite of the Ely Springs on the west and with a dike on the east. The Eureka Quartzite is about 300 feet thick and is mostly thin-bedded, impure quartzite with shaly layers and dikes. It seems to lack the upper unit of massive, high-purity quartzite.

A section of the Eureka Quartzite about 200 feet thick is exposed in the quarry near Swansea. Pogonip Limestone lies beneath the quartzite to the west, and the quartzite is overlain by nodular dolomite of the Ely Springs to the east. Faulting complicates the relations south of the quarry. The quartzite is highly brecciated and contains steeply dipping layers of soft material 5 to 10 feet wide. The quartzite itself is a light to medium gray, vitreous material that averages 0.105 percent alumina and 0.085 percent alkalies.*

Table 3. Section of Eureka Quartzite at North Quarry, Lakeview Deposit.

	Stratigraphic thickness (in feet)
Ely Springs Dolomite	
Eureka Quartzite	
Upper, massive unit of high-purity quartzite	
4. Massive, medium-gray, stain-free quartzite	150
Lower (main) unit, relatively thin-bedded and impure	
3. Relatively thin-bedded quartzite and thin carbonate layers	200
2. Massive, medium-gray quartzite with disseminated grains of iron oxide	50
1. Platy, black, iron-stained phyllite	50
Fault	
Pogonip Limestone	

Talc is associated with the Eureka Quartzite near its discontinuity in the southeastern part of the Lakeview area. The largest deposit is at the Lakeview talc workings, where it occurs close to the footwall contact of the quartzite and apparently is a replacement of the quartzite. Some talc also occurs near the northwest end of the quartzite body that lies southeast of the Lakeview area. No talc was observed northwest of the Lakeview talc workings.

Photo 5. South Quarry, Lakeview Quartzite deposit, in 1957: View of the northwest end of the south quarry showing an early stage in the quarrying of the massive, high-purity, hanging wall beds of the Eureka Quartzite. *Photo by L. A. Wright.*

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* Average partial analysis of quartzite shipped in July 1954. Arthur G. Moore, written communication, March 1961.

Photo 6. South Quarry, Lakeview Quartzite deposit, in March 1957: View of the northwest end of the south quarry showing initial operations in the top central part of the Eureka Quartzite. The lower face has been drilled with horizontal holes and loaded ready for blasting. The equipment on the upper bench is being used to clean up loose rock preparatory to drilling.

Operations

In 1953, Gladding, McBean & Co. conducted an intensive search in the Mojave desert region for quartzite suitable for the manufacture of super duty silica brick (Brooks, 1955). A quartzite was desired having less than 0.25 percent alumina and alkalies and meeting certain physical specifications, including a proper size distribution of the crushed material. Late in 1953, samples of the Eureka Quartzite from outcrops near the Cerro Gordo mine, Talc City, Keeler, and Independence were tested, and satisfactory test bricks were prepared. The company then narrowed its search to the east face of the Inyo Mountains northwest of Keeler, where the Eureka Quartzite is closer to rail transportation than anywhere else in California. During 1954, plant run tests were made on 800 tons of quartzite, and possible quarry sites were evaluated. Commercial production began in August 1955. During 1955 and the first part of 1956, quartzite was obtained from the deposit near Swansea. Operations were then transferred to the Lakeview deposit.

Lakeview quarries

Location: NE¼ Sec. 4, T. 16 S., R. 37 E., M.D., 6½ air miles east southeast of Lone Pine. Owner: Gladding, McBean & Co., 2901 Los Feliz Boulevard, Los Angeles 39. General Refractories Company has an interest in the operation which, in effect, allows it to obtain what quartzite it needs. The quarrying, processing, and hauling of the quartzite to the railroad loading point south of Lone Pine is done on contract by the Brownstone Mining Company, William Skinner and Gus Voget, P.O. Box 396, Bishop. Brownstone Mining Company owns the quartzite mill. Several tens of thousands of tons of quartzite have been produced since 1956 for the manufacture of super duty silica brick.

The property consists in part of lode claims located by H. Stewart and H. Taylor of Big Pine, who developed the Lakeview talc deposit, and in part of additional placer claims located by Gladding, McBean & Co. after 1953. Quartzite was obtained at first from the south quarry. In March 1957 a stratigraphic thickness of about 100 feet in the top central part of the formation had been opened, and careful work was required to separate the comparatively thin layers of quartzite from the interbedded waste. This part of the quarry has not been worked since then. Later in 1957, the quartzite was stripped across its full width, exposing mixed low-grade material to the east and massive high-purity quartzite to the west of the original workings. A substantial tonnage was taken from the west side workings, but it seems unlikely that much more could be obtained there without forming a steep, high, and dangerous face or moving a prohibitive amount of waste. The north quarry was opened in 1958. Probably future operations will be conducted there, because the topography is such that comparatively little stripping is necessary, and because the hanging wall unit of high-purity quartzite is thicker than at the south quarry. In the north quarry area, readily obtainable reserves in the massive, hanging wall unit are in the order of half a million tons.

The quarry is operated whenever it is necessary to replenish the stock pile of processed quartzite, from which shipments are made continuously. Benches 10 to 20 feet high are maintained by blasting horizontal holes. Wagon drills with tungsten carbide insert bits are used, and the charges are detonated with electric caps. Dump trucks of about 10 tons capacity take the broken rock to the quartzite mill, which is about half a mile southeast of the quarries and not far above the level of the valley. At the mill the quarry rock is first run through a jaw crusher and then sized with a double trommel that has a coarse screen placed inside a fine screen. The oversize is crushed again with a second jaw crusher and recirculated through the screen; and the undersize, which contains most of the impurities present in the quarried rock, is discarded. The middle size, approximately minus 2 inches and plus ½ inch, is trucked to the stockpile and railroad loading point near Lone Pine. Electric power for the operation of the mill is generated at the site.

Swansea quarry

Location: SE¼ Sec. 24, T. 16 S., R. 37 E., M.D., ½ mile southeast of Swansea and 11 air miles southeast of Lone Pine. Owner: Inyo Marble Company; leased to Gladding, McBean & Co., 2901 Los Feliz Boulevard, Los Angeles 39 (1961). A substantial tonnage of quartzite for the manufacture of super duty silica brick was produced on contract by Mineral Materials Company in the latter part of 1955 and the first part of 1956. All equipment has been removed from the property.

The quarry has been opened on the northwest end of an outcrop of the Eureka Quartzite that crosses a projecting nose of the Inyo Mountains. It has been driven southeast several hundred feet and has three benches 10 to 20 feet high, the lowest of which is about 25 feet above the level of the highway. Reserves are several hundred thousand tons.

Dolomite

Brownstone Mining Company, operator of the Lakeview quartzite quarries, produced dolomite at times in 1958 and 1959 when the quartzite operation was idle. A quarry in white dolomite was developed just south of the mapped area, and test cuts were made elsewhere, including one in the white dolomite west of the north quarry. Several hundred tons of dolomite were processed for white roofing granules and terrazzo chips in the quartzite mill, which was modified for this purpose by the addition of fine screens, bins, and sacking equipment. The dolomite venture was not successful, in part because the presence of dikes made the quarrying of clean dolomite difficult, and in part because of marketing difficulties. Some dolomite was sold locally as garden rock.

Talc

The talc deposit on the Lakeview property, which is called the Lakeview talc deposit, was located and developed by H. Taylor and H. Stewart of Big Pine (Norman and Stewart, 1951, p. 118). The workings explore a steeply dipping body of talc 7 to 10 feet wide along the footwall of the Eureka Quartzite where it seems to be broken off. They consist of a 75-foot adit, which at the portal follows the quartzite-dolomite contact, and a winze sunk close to the portal. A shaft on the hillside above the portal probably connects with the adit near its face. In 1947, some talc was obtained from a stope above the adit level and shipped to a mill at Zurich, Inyo County. The mine has been inactive since December 1947.

Photo 7. Mill, Lakeview Quartzite deposit: Quarry-run rock is crushed and sized with jaw crushers and a trommel screen to approximately minus 2 inches, plus ½ inch. The fines, which contain most of the impurities, are discarded.

On the hillside above the mill, dark nodular dolomite of the Ely Springs (left) is in contact with the Eureka Quartzite (right). The section is overturned here. Camera facing northwest. *Photo by L. A. Wright.*

Quartzites of the Oro Grande Series near Victorville

Units of the Oro Grande Series near Victorville, San Bernardino County, have furnished several million tons of high-purity quartzite since 1928. Most of the output has been consumed by the portland cement industry, but up to 1955 some of it was used in the manufacture of silica brick.

The Oro Grande Series of late Paleozoic, probably Carboniferous, age is limited in occurrence and is nonuniform compared with some of the early Paleozoic formations of the Basin-Range province. At the type

Table 4. Chemical Analyses of Quartzite from the Oro Grande-Victorville District.
(in percent)

	1	*2*	*3*	*4*	*5*
SiO_2	99.04 [1]	99.37 [1]	98.90	99.04	98.57
Al_2O_3	0.44	0.37	0.16	0.27	0.46
Fe_2O_3	0.104	0.068	0.18	0.13	0.34
TiO_2	0.0	0.0	0.04	0.04	0.05
P_2O_5	0.0	0.0	–	–	–
CaO	0.0	0.0	0.23	0.15	0.05
MgO	0.0	0.0	0.08	0.04	0.17
Na_2O	0.014	0.013	0.24 [2]	0.32 [2]	0.15 [2]
K_2O	0.200	0.009	–	–	–
H_2O	0.20	0.08	–	–	–

[1] By difference.
[2] Total alkalies.

1 Upper quartzite from SE¼ SE¼ Sec. 9, T.6.N., R.4.W., S.B. Analysis by W. H. Nisson and Lydia Lofgren, Division of Mines laboratory, August, 1961.

2 Lower quartzite, from SE¼ NE¼ Sec. 16, T.6N., R.4.W., S.B. Analysis by W. H. Nisson and Lydia Lofgren, Division of Mines laboratory, August, 1961.

3 Typical analysis of quartzite from the Atlas quarry. Analysis furnished by Gladding, McBean & Co. (Bowen, 1954, p. 176).

4 Clean quartzite from the Emsco quarry. Analysis furnished by Gladding, McBean & Co. (Bowen, 1954, p. 178).

5 Typical analysis of quartzite from the Riverside quarry. Analysis furnished by Gladding, McBean & Co. (Bowen, 1954, p. 178).

locality on Quartzite Mountain, and within an area of about 5 square miles (Plate 3) the series contains, however, large masses of uniform, high-purity quartzite. Limestone deposits, associated with the quartzite, are of great commercial importance and for many years have supplied portland cement plants at Victorville and Oro Grande. The Quartzite Mountain area lies 5 miles north of Victorville and 1 to 4 miles east of Oro Grande, or 85 miles by railroad or highway from Los Angeles. Both Victorville and Oro Grande are on the combined Santa Fe and Union Pacific main line to Los Angeles and close to U.S. Highway 66–91.

Previous Work and Acknowledgments

The Quartzite Mountain area is included in Bowen's (1954) report on the geology and mineral resources of the Barstow 30-minute quadrangle. As part of a larger study, the U.S. Geological Survey remapped the area, using the newly available 15-minute base maps (Dibblee, 1960). Bowen and Ver Planck (1965) also have remapped the Quartzite Mountain area on a scale of 1:12,000 and have described its nonmetallic mineral resources. The discussion that follows is summarized from that report.

Descriptive Geology

The Oro Grande Series is a sequence of metamorphic rocks that has been complexly folded and faulted. Rocks of the Triassic (?) sidewinder Volcanic Series intrude and overlap the Oro Grande Series. Both series are intruded by granitic rocks of early Cretaceous or late Jurassic age. The type section of the Oro Grande Series on the northeast slope of Quartzite Mountain is as follows, bottom to top, average thickness in feet: (1) white dolomite, 1,200; (2) dark schist-hornfels, 350; (3) blue-gray limestone, 250; (4) schist-quartzite, 60; (5) lower quartzite, 250; (6) black schist with limestone subunits, 500; (7) upper quartzite, 250.

The two quartzite units are indistinguishable from each other. They are composed of vitreous, light to medium gray, massive quartzite with only occasional suggestions of bedding. Weathered surfaces and joint surfaces commonly are ironstained. Chemical analyses are given in Table 4. In thin section, the quartzite is seen to be composed mostly of quartz in the form of irregular, interlocking grains ranging from 0.2 to 1 millimeter in diameter. The rounded outlines of the original sand grains can be detected here and there but mostly have been obliterated. Finely divided sericite is widely distributed but not abundant, both along grain boundaries and included within quartz grains. Calcite was not detected, and feldspar is very scarce. Minute grains of sphene, tourmaline, zircon (?), magnetite, biotite, limonite, and pyrite were identified but are not abundant.

The stratigraphic sections of the various fault blocks cannot be correlated with the type section with confidence because the structure of the Quartzite Mountain area is complex and the units of the type section lack characteristic properties. It is thought, however, that most of the massive quartzite units probably are equivalents of unit 7 of the type section.

Quartzite Quarries

Atlas

Location: NE¼ SE¼ Sec. 17, T. 6 N., R. 4 W., S.B., 1½ miles northeast of Oro Grande. Owner: Mineral Materials Company, 1145 Westminster Avenue, Alhambra. Since it was opened in 1939, the Atlas quarry has produced 150,000 to 200,000 tons of quartzite, mostly for sale to portland cement plants in southern California. Up to 1955, some of the output was used for silica brick.

The deposit consists of a lenticular, partly fault bounded mass of quartzite 100 to 250 feet thick, 900 feet long, and with a maximum width of 500 feet. The quartzite is thoroughly fractured, and in places it contains clay-filled seams up to ½-inch thick. Most joints are iron-stained. The deposit is underlain by schist and, on the west side, a thin lens of limestone. A typical analysis of quartzite from the Atlas quarry is given in Table 4.

Reserves of easily obtainable high-purity quartzite probably are relatively small.

The deposit has been opened from the east side. The quarry is semicircular with benches 20 feet high and is 800 feet long and up to 300 feet wide. Blast holes are made with wagon drills that use steel with tungsten carbide insert bits. In 1960 the practice was to work the quarry intensively about once a year and to maintain a stock pile of quarry-run rock in the Los Angeles

Photo 8. Atlas quarry, Mineral Materials Company: View northwest across lower bench. Since 1939, Mineral Materials Company has quarried 150,000–200,000 tons of quartzite, mostly for portland cement.

area. When the quarry furnished quartzite for silica brick, the company had a crushing and screening plant at the quarry for the removal of fines. The fines contain most of the impurities present in the quarry-run rock.

Emsco (Emsco Quartzite)

Location: NW¼ NE¼ Sec. 11, T. 6 N., R. 4 W., S.B., 4.2 miles east northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 17. The quarry was opened about 1928 by Emsco Refractories Company, now a division of Gladding, McBean & Co., and has produced about 100,000 tons of quartzite for silica brick. It was last operated about 1945.

The quarry has been opened in a ridge of quartzite that borders the valley east of Quartzite Mountain. The quartzite has a maximum exposed width of 400 feet. It dips northwest at 40° to 60° and is overlain by limestone that has been quarried on a large scale for use in the manufacture of portland cement. To the east it is overlain by alluvium and very likely is cut off by intrusive granitic rock only a short distance east of the alluvium contact. The quartzite is shattered and cut by dikes of granitic rock. Reserves are about 3 million tons. The quarry measures 300 feet by 300 feet and has a face up to 75 feet high. No equipment remains on the property. An analysis of clean quartzite from the Emsco quarry is given in Table 4.

Riverside Cement Company

Location: NE¼ NW¼ Sec. 17, T. 6 N., R. 4 W., S.B., 1¼ miles northeast of Oro Grande. Owner: Riverside Division, American Cement Co., 621 South Hope Street, Los Angeles 17. The quarry has been operated intermittently since about 1940 and has furnished several hundred thousand tons of quartzite, mostly for Riverside's portland cement plant at Oro Grande. It also has furnished quartzite for the manufacture of silica brick.

The deposit consists of massive quartzite that occupies most of an isolated hill 700 feet in diameter that rises about 100 feet above local ground level. The quartzite dips north and is underlain by schist. The quartzite is fractured and iron-stained near a north-trending fault zone that crosses the deposit. A typical analysis of quartzite from the Riverside quarry is given in Table 4.

The quartzite on the east half of the deposit has been cut down 50 to 100 feet below the original top of the hill. An estimated 1½ million tons of quartzite remain above the level of Oro Grande Canyon, which is just north of the deposit.

Southwestern

Location: W½ NE¼, SE¼ NW¼ Sec. 11, T. 6 N., R. 4 W., S.B., 4.1 miles east northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 17. At one time the Southwestern Portland Cement Company obtained limestone and other portland cement raw materials on a large scale from a group of ten quarries in section 11. Since the quartzite deposits were opened, about 1928, more than a million tons have been produced for the company's plant at Victorville. Little if any quartzite has been quarried since 1951 when the company began to use limestone with a higher silica content than that which was used before.

The deposit consists of a ridge of massive quartzite bordering the valley east of Quartzite Mountain and in the northern part of which is the Emsco quarry. The quartzite forms a steeply dipping body up to 750 feet wide with an outcrop length of 2,500 feet. It is bordered on the west by limestone and on the east by alluvium, beneath which granitic rock has intruded and cut off the quartzite. As indicated by bore hole analyses, the deposit ranges from 83 to 96 percent silica and averages about 94 percent silica.

Quartzite has been obtained from several places. A quarry at the south end of the quartzite hill, just northeast of the center of section 11, measures 300 feet by 150 feet and has a face 40 feet high. At the north end of the same hill, some quartzite has been obtained from the east side of a quarry that was worked mostly for limestone. A large tonnage of quartzite also has been taken from south end of the same outcrop. Reserves of quartzite within 100 feet of the surface are estimated to be 10 million tons.

Some Undeveloped Deposits

Many millions of tons of quartzite without overburden are exposed on the summits and upper slopes in the central part of the Quartzite Mountain area. No roads have been built into these areas, and, so far as known, the quartzite deposits have not been sampled by the operating companies. The quartzite of the Quartzite Mountain northwest and Quartzite Mountain (upper unit) deposits seems to be less fractured and to contain fewer impurities than that of the other deposits described below.

Klondike

Location: SW¼ NE¼ Sec. 17, T. 6 N., R. 4 W., S.B., 1¼ miles northeast of Oro Grande. Owner: Riverside Division, American Cement Co., 621 South Hope Street, Los Angeles 17. The deposit consists of a large body of quartzite that has not been developed but is readily accessible.

The ridge east of the Shay and Klondike quarries is capped by massive quartzite that lies in the axis of a plunging syncline. The outcrop area is 1700 feet long and 600 feet wide, and the quartzite is several hundred feet thick. A granitic dike bisects the deposit close to its long axis. The quartzite is limited by the Klondike fault to the west and is underlain by schist, which crops out on the east side. Reserves within 100 feet of the surface are 8 million tons. The deposit could be developed easily from the road to the upper benches of the Klondike quarry, which crosses the north end of the ridge.

Quartzite Mountain Northwest

Location: N½ N½ Sec. 16 and part of Sec. 9, T. 6 N., R. 4 W., S.B. (proj.) on the summit and upper north slope of the peak 1 mile west of Oro Grande beacon and 2 miles east northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 621 South Hope Street, Los Angeles 17. An enormous tonnage of quartzite is exposed without overburden, but it is undeveloped and not yet penetrated by roads.

Massive quartzite several hundred feet thick crops out along the ridge crest in the trough of a northwest-plunging syncline. The quartzite is underlain by schist and is exposed without overburden within an area 4,000 feet long and 1,500 feet wide. In the northeastern part of this area the quartzite of the syncline is overlapped by another quartzite unit that forms part of a thrust plate. The quartzite contains minor interbedded lenses of schist and, at least on the surface, iron-stained cracks and joints. Reserves within 100 feet of the surface are estimated to be 36 million tons.

Quartzite Mountain Southwest

Location: S½ NE¼, NW¼ SE¼ Sec. 16, T. 6 N., R. 4 W., S.B. (proj.), ½ mile west of Oro Grande beacon and 2½ miles east northeast of Oro Grande. Owner: not ascertained. The deposit is undeveloped, inaccessible, and relatively small.

The deposit consists of massive quartzite, probably the equivalent of unit 5 of the type section, that crops out near the summit of the western part of Quartzite Mountain. The quartzite is probably about 100 feet thick and is exposed without overburden within an area of roughly 500,000 square feet. It lies on dolomite and is overlain by schist, beneath which it dips at a relatively low angle. Reserves within 50 feet of the surface are estimated to be 2 million tons.

Quartzite Mountain (upper unit)

Location: NW¼ NW¼ Sec. 15, NE¼ NE¼ Sec. 16, T. 6 N., R. 4 W., S.B. (proj.) on the southwest slope of Quartzite Mountain and 2½ miles east northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 17. The deposit contains large, undeveloped reserves in steep terrain of difficult access.

Massive quartzite, unit 7 of the type section, is exposed at the surface in the troughs of two parallel synclines that plunge northwest. The outcrop area is roughly 2,500 feet long by 500 feet wide. The quartzite is underlain by schist which, in limited areas in the western syncline, has been brought to the surface by a combination of folding and faulting. Reserves within 100 feet of the surface are about 10 million tons.

Quartzite Mountain (lower unit)

Location: A strip from the center to the northwest corner of Sec. 15, T. 6 N., R. 4 W., S.B. (proj.) on the summit and northeast face of Quartzite Mountain and 3 miles east northeast of Oro Grande. Owner: not ascertained. The deposit contains a substantial tonnage

Photo 9. Zabriskie Quartzite, Dublin Hills: View northeast of jagged outcrop of Zabriskie Quartzite in NW ¼ Sec. 35, T. 22 N., R 6 E., S.B.

of quartzite in a relatively inaccessible location and has not been developed.

A quartzite body, unit 5 of the type section, that averages 250 feet thick, crops out for about 4,000 feet across the steep northeast face of Quartzite Mountain. It dips steeply southwest into the mountain and is overlain by a thick schist unit. Beneath it and separated by a thin schist unit is limestone, unit 3 of the type section. The quartzite is relatively accessible at the northwest end above Quarry 12 of the Southwestern Portland Cement Company. Perhaps 5 million tons of quartzite could be obtained from the outcrop without excessive stripping. If it were quarried together with the underlying limestone, perhaps a larger tonnage would be available.

Coxcomb Ridge

Location: SE¼ SE¼ Sec. 10, NE¼ NE¼ Sec. 15, T. 6 N., R. 4 W., S.B., 3 miles east northeast of Oro Grande. Owner: not ascertained. The area contains an enormous mass of quartzite that is undeveloped but readily accessible.

Massive quartzite several hundred feet thick crops out for about 1,800 feet along the coxcomb ridge northeast of Quartzite Mountain. It is underlain by schist and is exposed without overburden on the entire northwest slope of the ridge except for a small area, where it dips beneath limestone. The deposit could be reached easily anywhere along its northwest edge. Reserves are estimated to be 16 million tons within 100 feet of the surface.

Zabriskie Quartzite Near Shoshone

Previous Work

The Zabriskie Quartzite Member of the Wood Canyon Formation (Lower Cambrian) is a homogeneous, persistent unit of high-purity quartzite that occurs widely in the Amargosa-Death Valley area of Inyo County and as far west as the east face of the Panamint Range. It is remote from industrial centers and has not been explored or developed commercially.

Several large bodies of the Zabriskie Quartzite occur in the vicinity of Shoshone and not far from State Highway 127. Shoshone is about 80 miles from Dunn Siding, the nearest railroad loading point. Zabriskie Quartzite crops out prominently in the Dublin Hills just west of Shoshone, on McLain Peak 10 miles south of Shoshone, and on the west face of the Resting Spring Range east of Shoshone.

The Zabriskie Quartzite was first described by Hazzard (1937, pp. 309, 310), who measured a detailed stratigraphic section through the Paleozoic rocks exposed in the Nopah and Resting Spring Ranges. The quartzite was named after Zabriskie Station on the

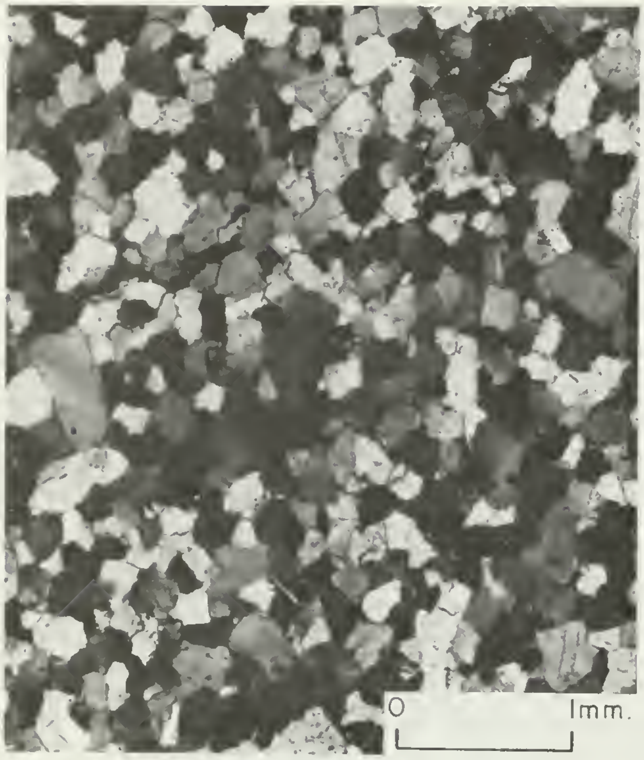


Photo 10. Photomicrograph of Zabriskie Quartzite from Dublin Hills deposit. Sample Z-1 from the central part of the formation, consisting almost entirely of quartz. Crossed nicols.

now abandoned Tonopah and Tidewater Railroad. Using the formations defined by Hazzard, Mason (1948) mapped an area around Tecopa and Shoshone on a base map enlarged from the Avawatz Mountains 60-minute quadrangle. Charles W. Chesterman of the Division of Mines and Geology is remapping the northeast quarter of the Shoshone 15-minute quadrangle.

Descriptive Geology

As shown by Noble and Wright (1954, plate 7), the region around Shoshone contains fault block mountains separated by alluviated valleys. These fault blocks, although complicated by cross faulting and thrust faulting, are essentially tilted homoclines made up of later Precambrian sedimentary rocks, Paleozoic sedimentary rocks, or Tertiary volcanic rocks. The Paleozoic rocks lie disconformably on the later Precambrian rocks and are unconformably overlain by the Tertiary rocks.

A nearly unbroken sequence of Paleozoic rocks, almost 23,000 feet thick from the Lower Cambrian to the Pennsylvanian, occurs in the Nopah and Resting Spring Ranges. These ranges consist of east-dipping homoclines in which the beds strike at a slight angle to the trend of the ranges. Older beds occur to the south, and successively younger ones occur to the north. The Lower Cambrian section, almost 10,000 feet thick, is heterogeneous and characterized by the presence of clastic sediments. The Post-Lower Cambrian rocks, on the other hand, consist almost entirely of limestone and dolomite.

Much more restricted Lower Cambrian sections occur in other fault blocks near Shoshone. In the Dublin Hills, east-dipping, Lower and Middle Cambrian formations are unconformably overlain by Tertiary volcanic rocks. A faulted section of Lower Cambrian rocks is exposed on McLain Peak.

In the section measured by Hazzard in the Resting Spring Range, the top of the Zabriskie Quartzite Member lies 630 feet below the top of the Wood Canyon Formation. The Wood Canyon Formation is a heterogeneous sequence, 3,033 feet thick, of quartzite, sandstone, shale, and limestone with Lower Cambrian fossils in the upper 1,100 feet. Only the Zabriskie Member contains high-purity, vitreous quartzite, and this is confined to the upper 100 feet. The lower 60 feet is composed of sandy shale and shaly quartzite. This in turn is underlain by gray, micaceous, platy shale interbedded with fine-grained, brown-weathering sandstone. The vitreous upper part of the Zabriskie is overlain by brown-weathering, platy quartzite interbedded with dark, greenish shale.

The Zabriskie Quartzite in Detail

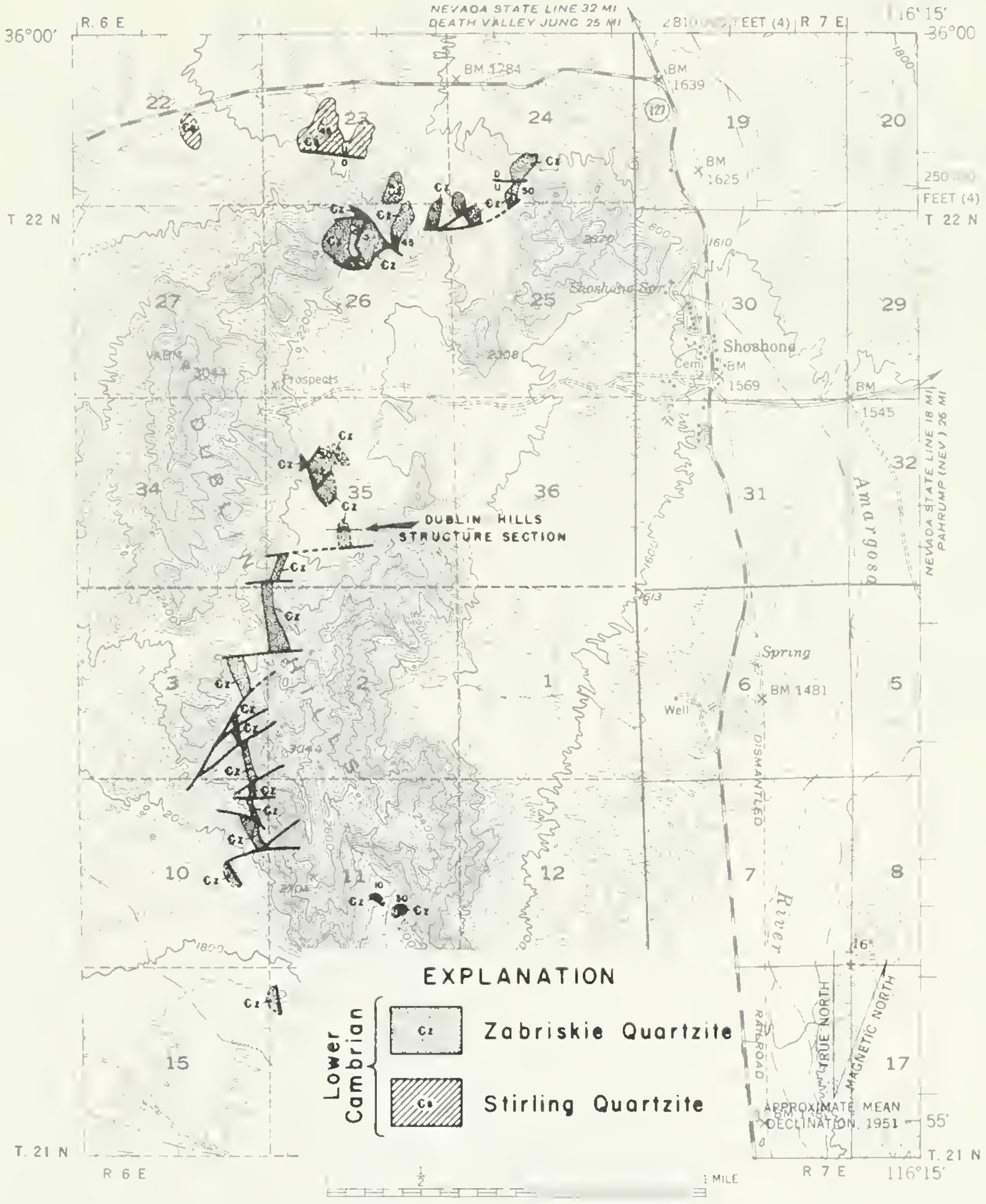
The main, high-purity part of the Zabriskie Quartzite, wherever it is found, consists of massive, vitreous quartzite that is indistinctly cross-bedded. It is tannish- to pinkish-weathering and forms blocky talus. The freshly broken rock is faintly pink to light gray in color. Under the microscope it is seen to be composed of quartz grains 0.1 to 0.7 millimeters in diameter, averaging perhaps 0.2 millimeters. Many of the larger grains are rounded. Most consist of a single crystal, but a few are composed of aggregates of small quartz grains that perhaps represent grains of recrystallized chalcedony or quartzite in the original sand. The rounded grains have overgrowths of quartz with the same optical orientation as the main part. The finer quartz grains are anhedral but not notably interlocking.

Non-quartz grains are not abundant. Sericite occurs in the form of films 0.005 millimeters thick between quartz grains. Small grains of tourmaline, zircon, magnetite, and limonite are sparse.

Dublin Hills

Location: SW¼ Sec. 35, T. 22 N., R. 6 E., S.B., about 2 miles west southwest if Shoshone. Owner: not ascertained. The deposit is undeveloped but readily accessible. It lies about ¾-mile south of the improved road leading to the Shoshone perlite deposit, but a nearly level connecting road across the intervening fan could be made comparatively easily.

The quartzite forms a north-trending ridge 750 feet long and 80 feet high that is surrounded by talus and fan material. Most of the ridge is underlain by quartzite that strikes N. 5° W. and dips 50° NE. As shown on figure 3, the summit of the ridge is underlain by faintly pinkish to grayish, vitreous quartzite of high



TOPOGRAPHY FROM U.S. GEOLOGICAL SURVEY

Figure 2. Map of the Dublin Hills, Inyo County, showing location of Zabriskie Quartzite, and Stirling Quartzite. From unpublished map of northeast quarter of Shoshone 15-minute quadrangle, by C. W. Chestermon.

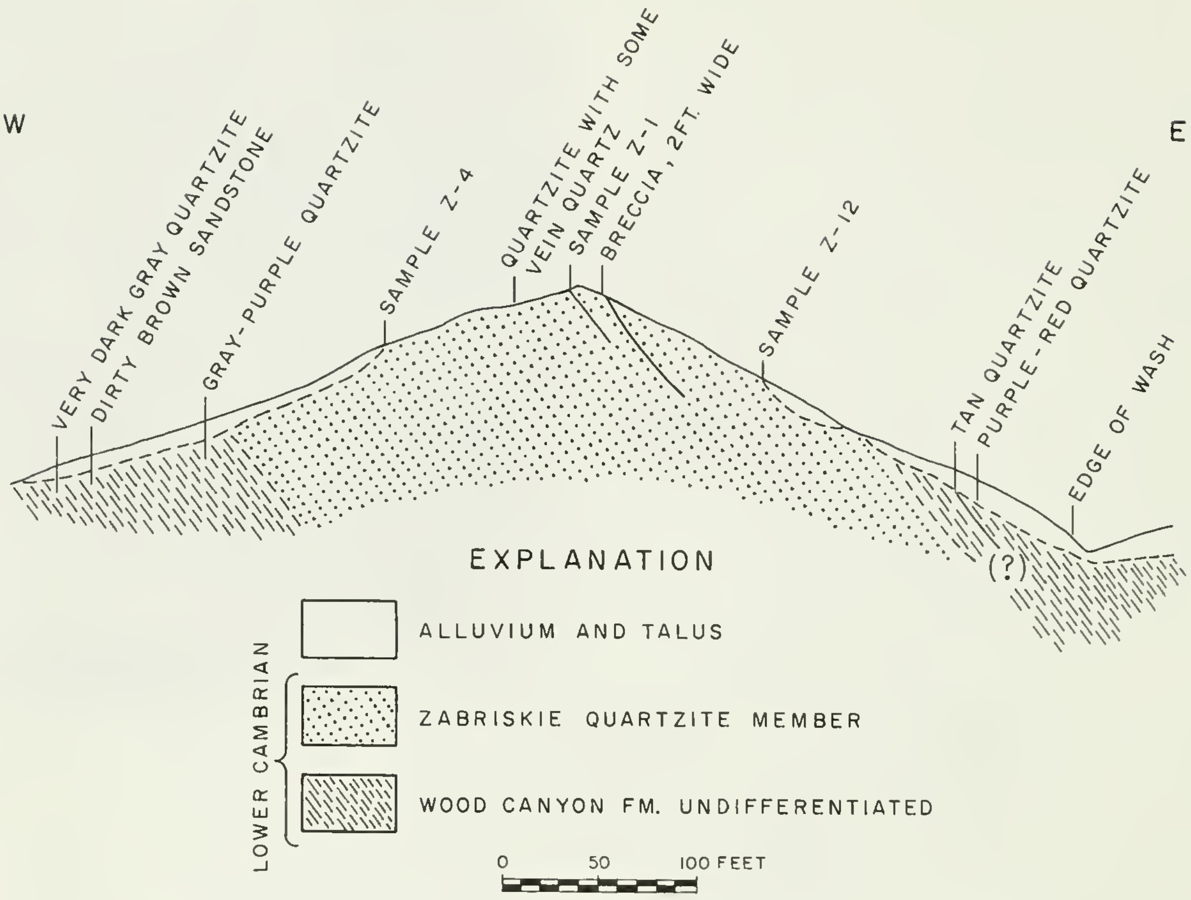


Figure 3. Structure section through Dublin Hills Quartzite deposit, Inyo County. April 16, 1958.

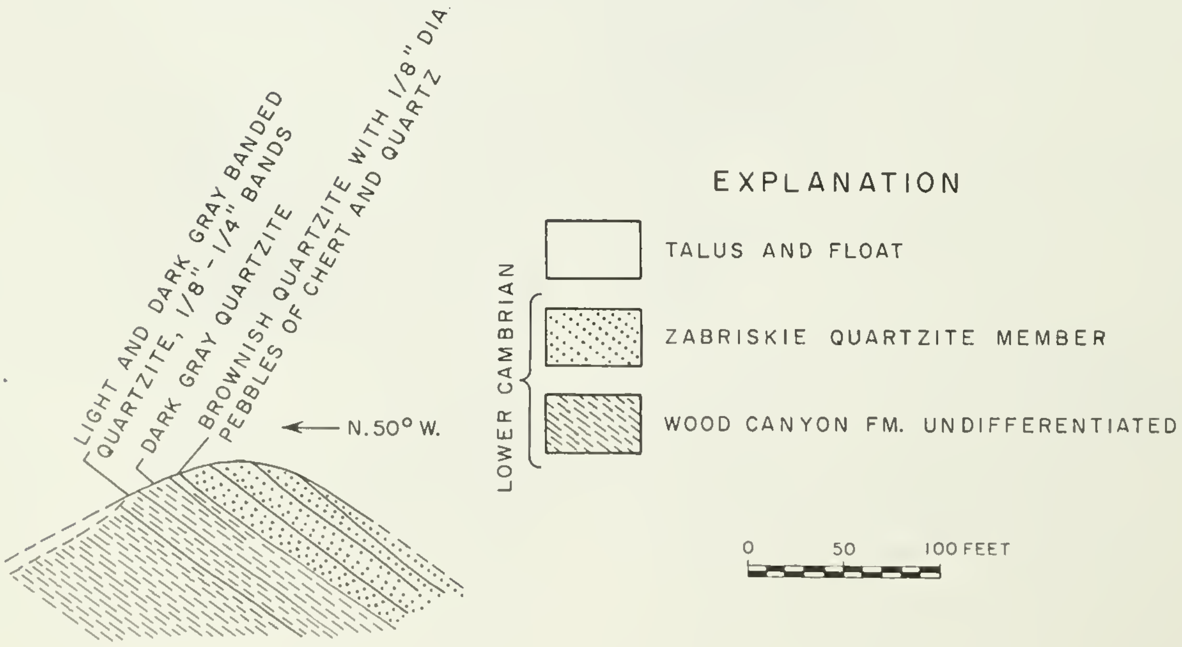


Figure 4. Structure section through McLain Peak Quartzite deposit, Inyo County. April 16, 1958.

Table 5. Chemical Analyses of Quartzite from the Dublin Hills Deposit.[1]

	1	*2*	*3*
SiO_2[2]	98.41%	99.81%	99.39%
Al_2O_3	0.32	0.53	0.36
Fe_2O_3	0.056	0.092	0.04
TiO_2	0.0	0.0	0.0
P_2O_5	Nil	Nil	0.0
CaO	0.0	0.00	0.0
MgO	0.0	0.00	0.0
Na_2O	0.017	0.015	0.016
K_2O	0.086	0.272	0.081
H_2O	0.11	0.28	0.11

[1] Analyses by W. H. Nisson and Lydia Lofgren, Division of Mines laboratory, August 1961.

[2] By difference.

1 Sample Z-4, 180 feet from west end of section, figure 2.
2 Sample Z-1, 280 feet from west end of section, figure 2.
3 Sample Z-12, 375 feet from west end of section, figure 2.

purity. Chemical analyses are given in Table 5. Veinlets of opaque, white quartz with open, crystal-lined cracks 1/16-inch wide cut the quartzite in places. Low on the west side of the ridge, dark gray, banded quartzite and interbedded platy brown sandstone that underlie the high-purity quartzite are exposed. A specimen of the dark, banded quartzite was examined with the microscope and found to be made up of rounded to subrounded quartz grains 0.07 to 0.7 millimeters in diameter. Their average diameter is 0.2 to 0.3 millimeters. An amorphous material with low birefringence forms films around the quartz grains and fills the interstices between them.

The ridge in the southwest quarter of section 35 contains at least a million tons of quartzite, above the wash level, that could be obtained with a minimum of stripping. A very much larger tonnage exists in the ridge in the northwest quarter of section 35, but it probably would be more difficult to quarry. The Zabriskie quartzite also crops out for more than a mile on the relatively inacessible west face of the Dublin Hills in sections 2, 3, and 10, T. 21 N., R. 6 E., S.B., and in Section 26, T. 22 N., R. 6 E., S.B. (see figure 2).

McLain Peak

Location: NW¼ Sec. 18, T. 20 N., R. 7 E., S.B.; about 10 air miles south of Shoshone. Owner: not ascertained. The deposit is undeveloped but contains a large tonnage of quartzite exposed without overburden.

McLain Peak is designated VABM 2688 but not otherwise named on the Shoshone 15-minute quadrangle, 1951 edidition. The Zabriskie Quartzite forms a dip slope, prominent from the north, that trends northeast from the summit. The beds in the dip slope strike N. 40° E. and dip about 35° SE. At the northwest edge of the dip slope, the surface drops precipitously to less resistant beds that underlie the Zabriskie Quartzite. To the southeast, the Zabriskie beds are exposed at the surface and dip nearly parallel to it for 300 to 500 feet. Approximately half a mile northeast of the summit in the direction of the strike, the Paleozoic beds pass beneath high level fan gravel at an elevation of about 1,800 feet. Here gray, banded, pebbly quartzite that underlies the Zabriskie crops out. At an elevation of 2,100 feet, as shown on figure 4, a stratigraphic thickness of about 40 feet of slightly pink to brown, vitreous quartzite of high purity lies on the gray quartzite.

Photo 11. View south from State Highway 127 south of Shoshone. The smooth slope to the left of the summit is underlain by the Zabriskie Quartzite.

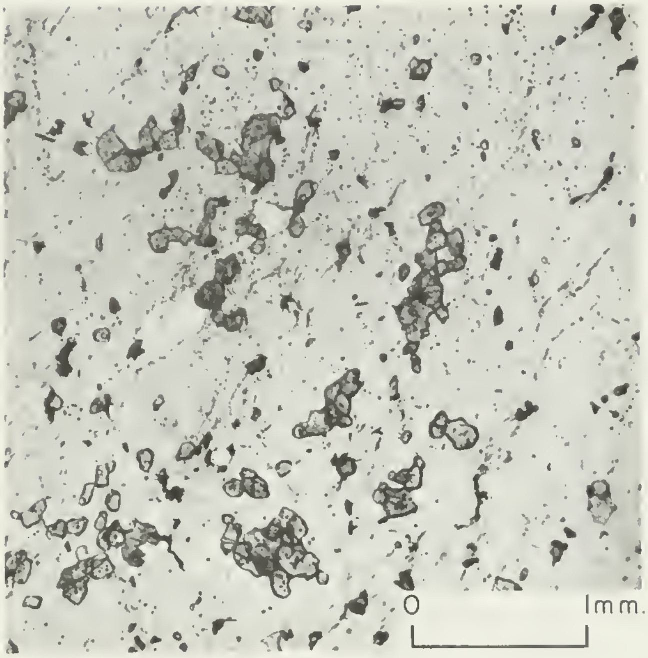


Photo 12. Photomicrograph of quartz rock from Sur Series, Fremont Peak deposit. Quartz (low relief) and dipside (high relief). Plane polarized light.

At least 2 million tons of the Zabriskie Quartzite are exposed on McLain Peak without overburden. Quarrying, however, would be difficult, not only because of the steepness of the slopes, but also because the deposit, although only 1½ miles from the paved road to Tecopa, would be hard to reach with a road.

Resting Spring Range

The Zabriskie Quartzite is exposed for at least 3 miles along the steep west face of the Resting Spring Range east and southeast of Shoshone. There are two outcrops. One is south on the Pahrump Valley road in sections 27 and 34, T. 22 N., R. 7 E.; the other is north of Resting Spring in sections 13 and 24, T. 21 N., R. 7 E. At both localities the quartzite crops out high on the mountain side and dips steeply into it. The nearest paved roads are 2 to 4 miles away.

Quartz Rock Deposits of Gabilan Range

Quartz rock is associated with carbonate rocks of the Sur Series near Fremont Peak in the northern part of the Gabilan Range, about 75 miles south of the San Francisco Bay area. The deposits are undeveloped, and limited data indicate that the quartz rock is not of the highest purity. It may, however, be useful for some commercial purposes, particularly in view of the fact that the deposits are of substantial size and are relatively close to centers of industry.

Descriptive Geology

In the northern part of the Gabilan Range, metasediments of the Sur Series occur as roof pendants suspended in the Late Jurassic or Early Cretaceous Santa Lucia Quartz Diorite. In an east-trending roof pendant at Fremont Peak, the Sur Series is at least 8,000 feet thick and consists of a sequence of quartz-mica schist, limestone, and dolomite that dips steeply north (Bowen and Gray, 1959). In places, bodies of carbonate rock have been replaced to varying degrees by silica. Where the replacement is complete or nearly so, the resulting quartz rock is a vitreous material that resembles quartzite.

Fremont Peak Deposit

Location: Sec. 35, T. 13 S., R. 4 E., M.D. (proj), ½-mile east of Fremont Peak and 6½ miles south of San Juan Bautista. Ownership: the deposit lies on fee land belonging to the Reeves Ranch, and the mineral rights are held by the Ideal Cement Company, 620 Denver National Bank Building, Denver 2, Colorado.

As mapped by Bowen and Gray (1959, plate 1), a body of quartz rock, having an outcrop width of 500 to 1,000 feet and 3,000 feet long, extends east from the vicinity of the Fremont Peak State Park headquarters buildings. Almost all of the deposit lies beyond the limits of the park. The deposit dips steeply, and is exposed by gulleys for a vertical distance of 400 feet. Only the central part of this body consists of clean quartz rock. At the west end, where replacement of the carbonate rock has not been complete, the body consists of a brecciated, porous to cavernous mass of silica with residual limestone in the form of thin lenses and nodules as much as an inch in diameter. At the east end it contains well over 50 percent of limestone and

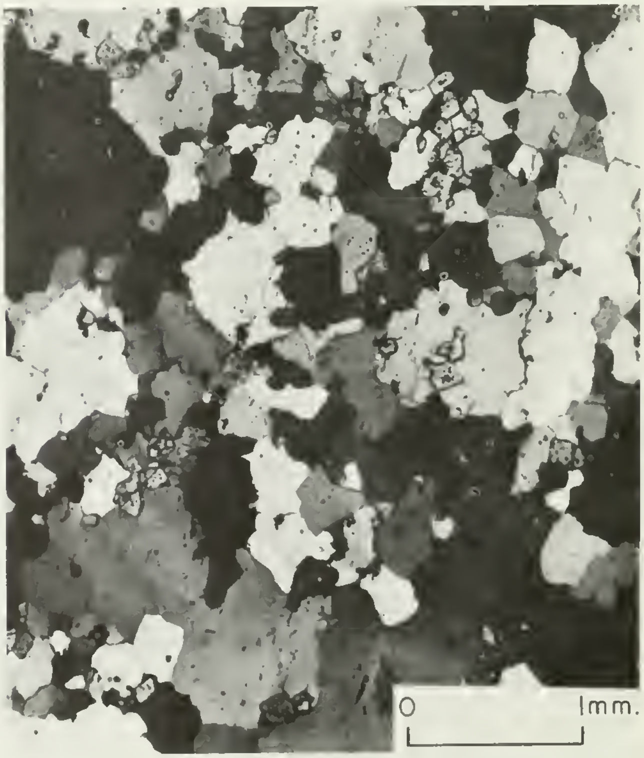


Photo 13. Photomicrograph of quartz rock from Sur Series, Fremont Peak deposit. Crossed nicols.

dolomite. In an area near the center, estimated to be 500 feet long and 200 to 300 feet wide, replacement has been nearly complete. There the quartz rock is a medium to dark gray, vitreous material having a rough surface and cut by vuglike, crystal-lined cracks. In thin section it is seen to be composed mostly of anhedral quartz grains with as much as 10 percent of calcium silicate minerals and unreplaced calcite. The quartz grains are notably non-uniform in size, ranging from 0.1 millimeter to as much as 3 millimeters in diameter. They seem to be larger in areas where residual calcite is sparse. Calcite occurs as grains 0.01 millimeter or less in diameter within the larger quartz grains and also as 0.2 to 0.3 millimeter sized grains dispersed among quartz grains of about the same size.

Reserves of quartz rock containing 90 percent or more silica are estimated to be several hundred thousand tons.

Quartzite in the Hodge Volcanic Series

Quartzite from the Hodge Volcanic Series, which occurs 10 to 15 miles southwest of Barstow, furnished quartzite for the manufacture of silica brick during the 1920's. The deposits, although small, contain high-purity quartzite and are only 3 or 4 miles from a paved highway and the combined Santa Fe and Union Pacific main line to Los Angeles.

Descriptive Geology

The Hodge Volcanic Series, of probable Paleozoic age, is a sequence of metavolcanic rocks that crops out within an area of 5 or 6 square miles on the north side of the Mojave River northwest of Hodge (Bowen, 1954, pp. 34–36). About 10,000 feet of metamorphosed andesite, dacite, and rhyolite flows, tuff, and tuffaceous sediments are exposed in a northwest-dipping homocline. The lower half, which has been weakly sheared, consists of massive, brownish and dark green rocks. The upper half, which has been strongly sheared, consists of alternating units of dark quartz-biotite schist and white muscovite schist. Lenticular quartzite bodies occur in the upper half. Most of them are 10 to 20 feet thick and 200 to 300 feet long, but a few are as much as 200 feet thick and 1,000 feet long.

Typical specimens of the high-purity quartzite consist of a slightly grayish, vitreous material composed of a fine-grained mosaic of irregular, interlocking quartz crystals. The grains range from 0.07 to 0.25 millimeters in size, averaging about 0.2 millimeters. No trace of original sand grains was observed with the microscope. Non-quartz material, consisting of iron oxide grains and fine, intergranular sericite, is very sparse.

Some of the quartzite bodies may have been lenses of sandstone or chert originally. However, the presence of crystal-lined cavities and hematite, originally pyrite, indicate that many of them are metamorphosed quartz veins (Bowen, 1954, p. 35). Unmetamorphosed quartz veins also cut the quartzite bodies.

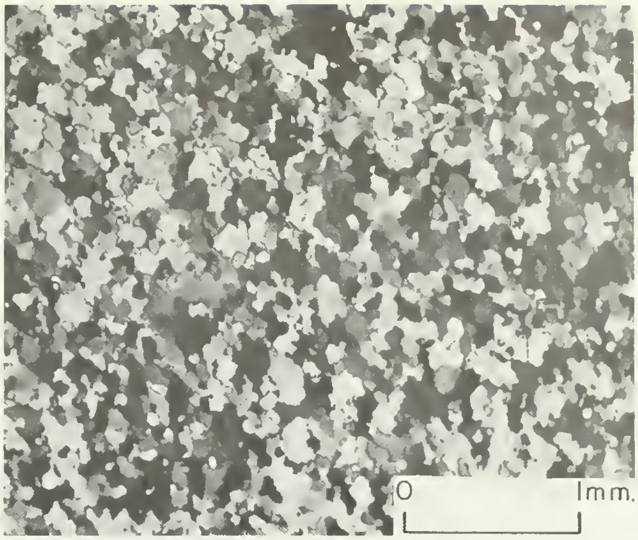


Photo 14. Photomicrograph of quartzite from the Hodge Volcanic Series, Golconda deposit. Consists almost entirely of quartz. Crossed nicols.

Golconda (Emsco Ganister, Leahy Ganister) quarry

Location: SW¼ Sec. 36, T. 9 N., R. 4 W., S.B., 4 miles west of Hodge. Owner: W. E. Leahy, 4238 Edgehill Drive, Los Angeles (1954). The deposit is about 5 miles by road from the old Victorville-Barstow highway by way of Wild Crossing. About 1¼ miles of the road is unimproved. Tucker and Sampson (1930, p. 302) reported that about 1930, Emsco Refractories Company produced a few hundred tons of quartzite for silica brick from one of several quartzite lenses on the Leahy property. There has been no recent activity.

The quartzite body that has been developed underlies the southern of two ridges that trend N. 65° E. in the southwest ¼ of section 36. The ridge is 300 to 400 feet long and perhaps 250 feet wide. Dark quartz-biotite schist crops out low on the north side of the ridge; light muscovite schist is exposed on its south flank. The ridge contains a central layer of high-purity quartz that is in sharp contact with brittle, opaque, off-white vein quartz mixed with quartzite on the south and dark-weathering, vuggy quartz rock containing as much as 25 percent voids on the north. The quartzite is 20 to 25 feet wide at the west end of the ridge but narrows to only 5 feet at the east end. Cross cutting veins and brecciation in the central part of the ridge indicate that the quartzite may have been cross fractured. Reserves of high-purity quartzite probably are not more than 150,000 tons.

The deposit has been developed on the west end by a quarry with a face 60 to 75 feet wide and 40 feet high. A drift adit has been driven east just south of the quarry in light schist beneath the south flank of the ridge.

Kennedy (Atlas Fire Brick Co. Ganister) quarry

Location: Near center Sec. 31, T. 9 N., R. 3 W., S.B., 2 miles northwest of Hodge. Owner: John J. Kennedy, Daggett (1953). The deposit is 3 miles by road

Photo 15. A steeply dipping quartzite body 200 to 300 feet long and 75 to 100 feet wide was quarried for silica brick during the 1920's.

from the old Victorville-Barstow highway by way of the Hinkley cut-off. Dietrich (1928, pp. 97 and 194) reported that in 1927 the Atlas Fire Brick Company was mining quartzite for silica brick at the rate of 3,000 to 4,000 tons a year. There has been no recent activity.

The surface expression of the quartzite body is a knoll that rises a few feet above a smooth surface cut in metavolcanic rocks. The knoll is elliptical in plan with its long axis roughly east and west. The quartzite body is 200 to 300 feet long and 75 to 100 feet wide. Most of the quartzite is light to medium gray. It has been thoroughly shattered, and much of it is iron-stained and has joints containing thin films of mica. Vein quartz is scarce. The rock that immediately encloses the quartzite lens is light colored schist, but dark schist crops out southeast of the knoll. Reserves of high-purity quartzite above the local base level are small.

The principal development, a quarry at the west end of the knoll, has a crudely horseshoe-shaped face 10 to 15 feet high and 60 feet long that has been advanced 100 feet into the outcrop. A waste dump has been built out from the knoll for 50 to 75 feet. A cross-cut trench just west of the dump has exposed light colored schist and gray quartzite on the south side of the quartzite body. A second quarry at the east end of the knoll has a face 25 feet long and 15 to 20 feet high.

The following is the analysis of quartzite from the central part of the west quarry face (analysis by W. H. Nisson and Lydia Lofgren, Division of Mines laboratory, August 1961).

SiO_2[1]	99.44%
Al_2O_3	0.39
Fe_2O_3	0.056
TiO_2	0.0
P_2O_5	0.0
CaO	0.0
MgO	0.0
Na_2O	0.002
K_2O	0.04
H_2O	0.07

[1] By difference.

Deposit in Section 29

Location: Near the common ¼ corner of Secs. 28, 29, T. 9 N., R. 3 W., S.B., 2 miles north northwest of Hodge. Owner: not ascertained. The deposit is undeveloped and comparatively small.

An outcrop of quartzite up to 50 feet thick and about 2000 feet long trends N. 40° E. and projects 50 feet above the general ground level. The massive, vitreous quartzite is flanked by talus-covered slopes, beneath which lies light colored muscovite schist. The quartzite ranges from off-white to dark gray in color. In places it is heavily iron-stained, and it is cut by numerous quartz veins a few inches to 1 foot thick.

Some Impure Quartzites

Quartzites of the Kernville Series

Quartzites of the Kernville Series occur widely in the southern part of the Sierra Nevada. So far as is known, none of them is of high purity, but the Monolith Portland Cement Company quarries a large tonnage of material that averages 85 percent SiO_2 for use in the portland cement plant at Monolith.

The Kernville Series is the name given by Miller (1931, p. 335) to the pre-batholith metasediments around Kernville. As much as 15,000 feet of phyllite and schist with limestone and impure quartzite of probable Paleozoic age are exposed in the Kernville 30-minute quadrangle (Miller and Webb, 1940). The metasediments occur as steeply dipping, elongated roof pendants that trend north to northeast. One roof pendant, along the Kern River, is more than 15 miles long. The Kernville Series also occurs in the Breckenridge Mountain 15-minute quadrangle (Dibblee and Chesterman, 1953), and similar metasediments that probably belong to the Kernville Series occur around Tehachapi.

Monolith Portland Cement Company quarries impure quartzite from deposits near the center of section 14, T. 32 S., R. 33 E., M.D., just northwest of the limestone quarry and 2 miles northwest of the Portland cement plant at Monolith. Micaceous, iron-stained quartzite forms a body several hundred feet wide that crops out for at least half a mile along the crest of a spur just west of the limestone deposit. The quartzite and limestone, together with a minor proportion of schist, form a north-trending roof pendant in granitic rock. The quartzite is shattered, and it contains lenses of schist and stringers of granitic rock and pegmatite.

The quartzite itself is a medium to dark gray, coarsely crystalline material with abundant biotite, plagioclase, and grains of iron oxide; and has a silica content of from 70 to 90 percent. A specimen of the typical material used by the Monolith plant was examined and found to consist largely of interlocking quartz grains with very irregular boundaries. Their size ranges from 0.07 millimeters to 3.25 millimeters and averaged about 2 millimeters. Rectangular flakes of biotite, mostly iron-stained, from 0.07 to 0.3 millimeters square are grouped in clumps up to 0.07 millimeters in diameter. The biotite flakes are oriented but not concentrated in layers. Plagioclase, largely altered to sericite, occurs as rounded grains 0.3 to 1.3 millimeters in diameter. Chlorite and muscovite also are present in minor proportions.

The Monolith plant consumes roughly 100,000 tons a year of quartzite containing 85 percent SiO_2. Because quarrying has to be to some degree selective to obtain material of this grade, several openings with faces 70 to 75 feet high have been made along the nose of the ridge that is underlain by the quartzite. Quarrying is accomplished by blasting a combination of down holes and toe holes made with wagon drills that have tungsten carbide-insert bits. Quarry run rock is reduced in the main crushing plant, which is periodically scheduled for this use.

Prospect Mountain Quartzite

The Prospect Mountain Quartzite occurs widely in southeastern California. As far as the writer knows, it is impure; but the possibility that it may contain usable bodies of high-purity quartzite should not be overlooked. It is a well known Lower Cambrian formation in the Great Basin, with its type locality near Pioche, Nevada. In California it is found in the eastern part of San Bernardino County from the Kingston Range in the north to the Ship Mountains in the south and as far west as the Newberry Mountains. Its relation to the Wood Canyon Formation, the Stirling Quartzite, and other Lower Cambrian formations of the Death Valley country is still in doubt.

In California, a maximum of about 4,000 feet of the Prospect Mountain Quartzite are exposed within areas of as much as 10 square miles. At many localities it occurs at the base of a thick section of Paleozoic rocks and lies with depositional contact on granitic and metamorphic rocks of probable early Precambrian age. It is heterogeneous and in many places contains, in addition to quartzite, shale, slate, carbonate, rock, sandstone, and conglomerate. The quartzite parts are likely to be thin bedded and cross bedded. Conglomerate lenses composed of quartz and chert pebbles are characteristic, especially near the base. Relatively massive sections of vitreous quartzite 50 to 100 feet thick occur in the Marble Mountains, in the Clark Mountains, and near Toughnut Spring in the Providence Mountains, but the quartzite contains feldspar, mica, and iron oxide minerals.

A specimen from near Toughnut Spring, as seen in thin section, is composed of quartz with several percent of limonite and a little sericite. About 75 percent of the quartz is in the form of a mosaic of interlocking grains averaging 0.1 millimeter in size; the rest occurs as well rounded grains that average 0.7 millimeters in diameter. Much of the limonite occurs as veinlets up to 0.7 millimeters thick. In places, discontinuous and branching veinlets form veinlet systems as much as 10 millimeters wide.

Saragossa Quartzite

The Saragossa Quartzite occurs in a relatively small area near Baldwin Lake, San Bernardino County (Guillou, 1953) and also in the Newberry Mountains (Gardner, 1940). From indirect evidence, its age is thought to be Paleozoic, perhaps pre-Carboniferous. It is feldspathic and iron-stained but has been used to a limited extent as decorative building stone.

On Gold Mountain, northwest of Baldwin Lake, gently dipping Saragossa Quartzite occurs in a thrust plate and may be more than 1,000 feet thick if the section has not been repeated by faulting. Within an area of several square miles, the quartzite has no overburden or is covered only by quartzite rubble or a thin layer of old alluvial gravel. Much of it is fractured and readily breaks into rectangular blocks and slabs 3 to 6 inches thick that are stained medium to dark brown by limonite. Some of the quartzite is more

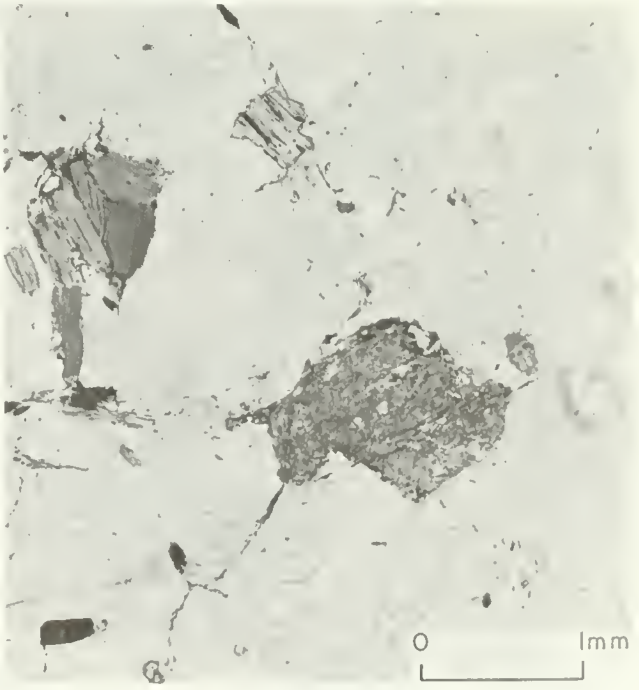


Photo 16. Photomicrograph of micaceous quartzite from the Kernville Series near Monolith. Quartz, light; biotite, dark. Plane polarized light.

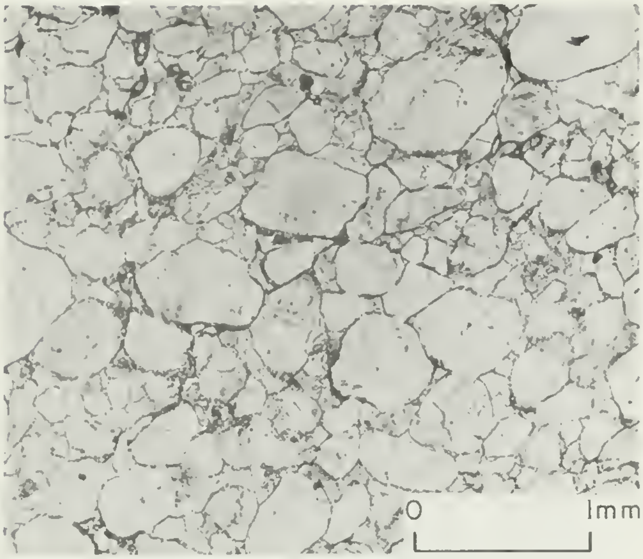


Photo 17. Photomicrograph of Stirling Quartzite from the Dublin Hills. Consists of rounded grains of quartz with thin films of sericite. Plane polarized light.

massive and nearly free from iron stain, but all of it contains several percent of feldspar and mica.

A. Coleman has produced a modest tonnage of decorative building stone from outcrops in sections 6, 7, T. 2 N., R. 2 E.; and sections 1, 12, T. 2 N., R. 1 E., S.B. In a report released by the Board of Building and Safety Commissioners, City of Los Angeles, samples were found to have a compressive strength of 36,770 pounds per square inch and a water absorption of 0.15 percent. The stone was approved for use as solid masonry and as veneer.

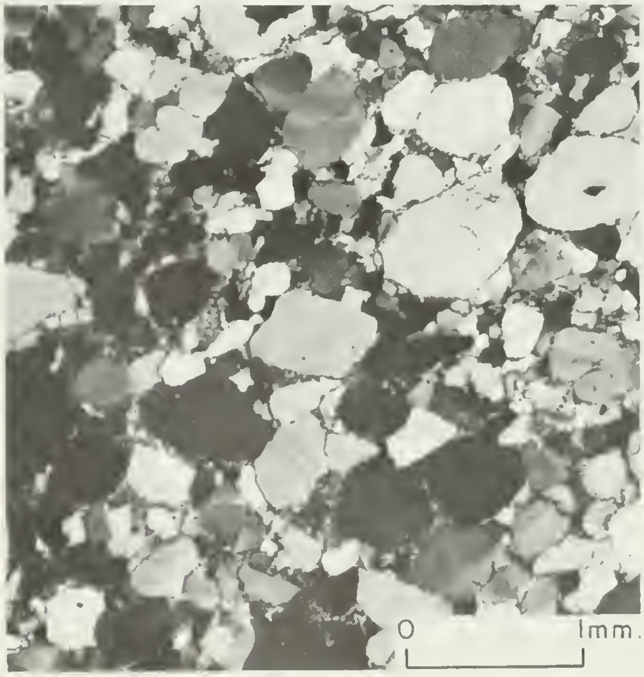


Photo 18. Photomicrograph of Stirling Quartzite. Same field as Photo 17 under crossed nicols.

Stirling Quartzite

The Lower Cambrian Stirling Quartzite, which underlies the Wood Canyon Formation in the Death Valley-Amargosa Valley area, is generally heterogeneous and impure. Its maximum reported thickness, in the Nopah Range, is about 2,600 feet. It consists of three members: a lower member of massive, gray quartzite; a middle member of red, shaly, micaceous quartzite with dolomite lenses; and an upper member of massive, gray quartzite. The massive quartzite is an aggregate of rounded quartz, chert, feldspar, and iron oxide grains 0.01-inch in diameter that have not been completely recrystallized.

A specimen of the Stirling Quartzite from NE¼ SW¼ Section 23, T. 22 N., R. 6 E., S.B., on the north side of the Dublin Hills (figure 2) is a non-vitreous, pinkish to purplish gray material composed of well rounded quartz grains 0.3 to 0.7 millimeters in diameter. Angular quartz grains 0.05 millimeters in size fill the interstices. Most of the large grains are surrounded by thin films of sericite. Rounded grains of recrystallized chert, plagioclase, and microcline are present in proportion of less than 1 percent.

Vitreous Quartzite of Eagle Mountains, Riverside County

A great thickness of vitreous quartzite occurs in the Eagle Mountains at the base of the sequence of metasedimentary rocks that contains the Eagle Mountains iron deposits. The largest outcrops lie 1 to 2 miles west of the Eagle Mountain iron mine of Kaiser Steel Corporation, near the summit of the range. The age of the quartzite has not been determined.

The metasedimentary sequence has been preserved in a west-plunging anticlinal dome that extends east-west for about 6 miles across the northeastern part of the Eagle Mountains (Harder, 1912). Highly metamorphosed rocks that unconformably underlie the metasedimentary sequence are exposed in the core of the structure. Intrusive, sill-like masses of quartz monzonite have invaded the structure, cutting out parts of it and partly to completely altering carbonate units to iron ore. The western part of the structure is nearly intact; but toward the east, only the flanks remain (Harder, 1912, fig. 3). The Eagle Mountain iron mine lies near the eastern end of the north limb.

The vitreous quartzite, which occurs at the base of the metasedimentary sequence, is most widely exposed in the western half of the structure. There its outcrop is more than 5,000 feet wide and its thickness probably more than 1,000 feet (Harder, 1912, pp. 31, 32). The vitreous quartzite is overlain by schistose, feldspathic quartzite, which in turn is overlain by lime silicate-rich quartzite and the carbonate rocks that contain the iron ore deposits. The vitreous quartzite is made up of massive beds of coarse grained, recrystallized quartzite that is pale gray to yellow and brown on weathered surfaces. Limited data indicate that, although feldspar and mica are scarce, the quartzite contains disseminated grains of iron oxide.

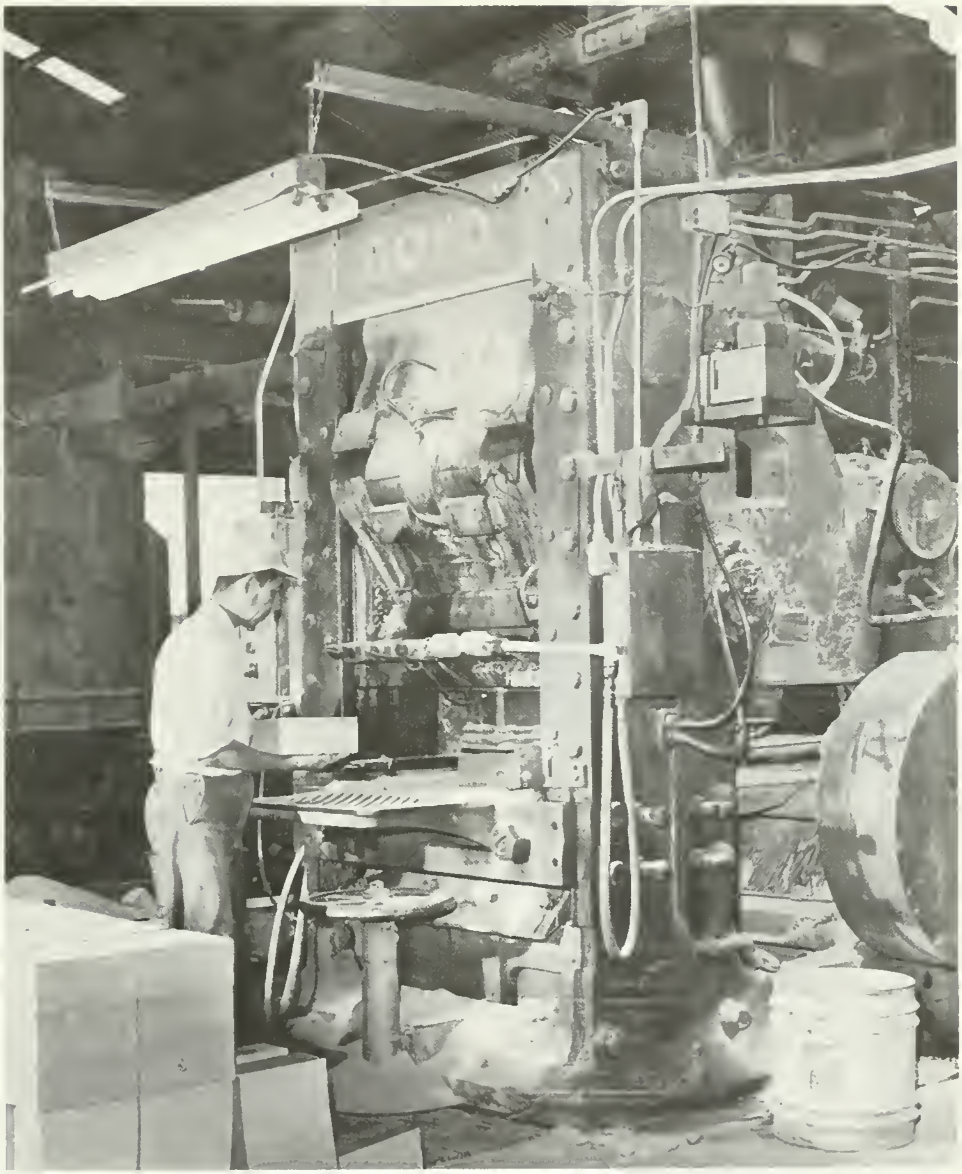


Photo 19. Dry pressing of fire brick. *Photo courtesy of Gladding, McBean & Co.*

Quarrying and Processing

Methods

Quartzite is a relatively low priced commodity. The price of quartzite produced in the Victorville area is around $5.00 per ton but varies, depending on the tonnage purchased. The freight rate is high compared with its value. Early in 1961, the rate by rail from Lone Pine to Los Angeles was 16½ cents per hundred pounds.

The California quartzite operations are relatively small. They are primarily producers of quartzite for specialized purposes; and, because they are far from consuming centers, the operators have but little opportunity to broaden their markets or to dispose of by-products. Processing is simple. Quartzite is either shipped as it comes from the quarry or crushed and screened to specifications.

Because quartzite is very abrasive, it causes severe wear and damage to equipment such as drill bits, shovel teeth, and screens that are subject to abrasion. Because quartzite is brittle, it is relatively easy to blast and crush. Because the impurities in quartzite are likely to be soft, beneficiation can be effected by crushing, screening, and the rejection of fines. Crushing machinery and other sources of highly toxic silica dust are provided with dust collectors. Often personnel wear dust masks to obtain additional protection.

Quartzite is quarried by standard methods. In California, blast holes are made with wagon drills equipped with tungsten carbide-insert bits. Relatively small shovels and trucks are used. Jaw crushers are used if crushing is required.

Performance Data

In 1955, the Swansea quarry was producing Eureka quartzite at an average rate of 800 tons per day (Brooks, 1955). Equipment included two wagon drills, using 2¾-inch tungsten carbide-insert bits, that were supplied by two compressors, each with a capacity of 600 cubic feet per minute. As a bit was worn out after drilling 50 feet of hole, the cost of bits was 35 cents per cubic yard of rock broken. The consumption of explosive was ¾-pound per cubic yard. The teeth of the No. 6 Northwest shovel used to load the broken quartzite wore out and had to be replaced after every 8 to 12 hours of use.

Some figures are available for a much larger operation at Rock Springs, Wisconsin (Meschter, 1958), which, in 1958, had a capacity of 275 tons per hour of quartzite railroad ballast. The quarry had a face 80 feet high. Blast holes 11 inches in diameter and 85 feet deep were made by churn drilling. With a bit weighing 650 pounds and a drill stem weighing 4,200 pounds, drilling was at the rate of 5 to 7 feet per hour. Every 5 to 10 feet, bits had to be reforged and resharpened, at which two men were employed full time. Blasting was accomplished with ammonium nitrate. Seven or eight holes were blasted together to produce 50,000 tons of broken quartzite. Secondary breaking, if required, was done with a drop ball. The broken rock was processed with a 60 by 48-inch jaw crusher, secondary crushers, and vibrating screens to two sizes of railroad ballast (1¾ by ⅜-inch and ⅜-inch by No. 16); the fines were discarded. The manganese steel jaws of the primary crusher had to be rebuilt with hardsurfacing metal after each shift. Screen plates and cloths were replaced every three weeks.

Utilization

In General

At present the uses of high-purity quartzite in California are limited to the manufacture of silica brick and portland cement. If the ferrosilicon and silicon industries were to be established in this state, probably some of the quartzite in California would be suitable to supply them.

For silica brick, silicon, and ferrosilicon, high-purity silica in lump form is required. Both the chemical and physical properties of the raw material are important. A material such as silica sand, no matter how pure, could not be used. For portland cement, however, the suitability of a silica raw material depends mostly on its chemical properties. Its physical form is relatively unimportant, and the material chosen depends largely on economic factors such as availability and cost in terms of its SiO_2 content. The use of quartzite by some of the portland cement plants in California is an exception to standard practice.

Quartzite is an unlikely source of silica that is to be used in sand or powder sizes. Because of the relatively high cost of quarrying, crushing, and grinding quartzite, and because the quartzite deposits are relatively remote from transportation and markets, silica sand ordinarily can be obtained at a lower cost. Most users of pulverized quartz specify a high degree of whiteness in addition to chemical purity. With the possible exception of parts of the Eureka Quartzite, most quartzite in California probably would not meet the color test.

Silica Brick

Silica brick are standard and special refractory shapes that are composed essentially of forms of silica capable of withstanding high temperatures. Silica brick valued at more than $42 million were produced in the United States during 1958 (Clark and McDowell, 1960, p. 700) and accounted for about 15 percent of the production of refractory brick of all kinds. Silica brick are an acid refractory; that is, they react at high temperatures with basic materials such as lime, magnesia, and alkalies. Perhaps their most useful property is the ability to support loads at high temperatures. They are, in addition, resistant to furnace gases, and are relatively cheap. Because of the high thermal expansion of silica, they are sensitive to thermal shock and susceptible to spalling. If kept above 1,200° F., however, they perform well, because in that temperature range, the thermal expansion of silica is small. They are especially suited for use in furnace crowns and wide-span sprung arch roofs. By far the largest use of silica brick is for the roofs of basic open hearth steel furnaces. They are also used for lining parts of coke ovens, reverberatory furnaces, roofs of glass melting tanks, and many other types of furnaces.

Trends in the Steel Industry

Technical changes are taking place in the steel industry that are reducing the consumption of silica brick. Not only is the amount of silica brick used in the construction of open hearths declining, but the open hearth process itself may be displaced.

One of the factors in increasing the efficiency of the open hearth process has always been the need for refractories that would permit higher furnace temperatures. Gradually the performance of silica brick has been improved. Super duty silica brick, the highest quality now available, were developed during World War II. In laboratory tests, super duty silica brick with a load of 50 pounds per square inch have withstood temperatures of 3,080° to 3,090° F. before failure occurred (A. P. Green Fire Brick Co., 1961). Because the melting point of pure silica is about 3,110° F., no great improvement in the performance of silica brick seems possible.

For some time, basic brick made of magnesite and chromite have been available for the construction of open hearth roofs that last longer and allow higher operating temperatures than silica roofs. Until recently, however, the cost of basic roofs in terms of the pounds of refractory consumed per net ton of steel produced has been greater than that of silica roofs.

Basic roofs were first used commercially during World War II in Europe where the difference in cost between basic brick and silica brick was relatively small. Plant tests of all-basic roofs began in Canada and the United States about 1943. Since 1954 the conversion to basic roofs has been accelerated; and by 1959, of approximately 900 open hearths in Canada and the United States, 136 had all-basic roofs (Sommer, 1959).

The use of oxygen in steel making is likely to decrease the demand for silica brick still further. Basic oxygen processes such as the L D (United States Steel, 1957, p. 285) and Kaldo (Johansson, 1957) do not make use of the open hearth at all. The L D process resembles the basic Bessemer process except that the blowing is with oxygen instead of air, and it can treat low-phosphorus raw materials. It was designed to use raw material charges consisting of more than 70 percent of hot metal (crude melted iron from the blast furnace), which cannot be treated efficiently in the basic open hearth. The basic oxygen converter is lined with tar-bonded dolomite-magnesite or high lime-magnesia clinker (Harbison-Walker Refractories Co., 1961).

The L D process was developed in Austria, where scrap steel, one of the raw materials required for the basic open hearth, was in short supply. Plants at Linz and at Donawitz began commercial production in May 1953 (Cuscoleca, 1954). Soon after that, an L D process plant was built in Canada (McMulkin, 1955), and in March 1959 the Kaiser Steel Corporation installed three L D converters at Fontana (California Magazine of the Pacific, 1960; Chemical Week, 1959). Basic oxygen processes have been found to be versatile and, at least under some circumstances, less expensive to install and operate than the basic open hearth process (Philbrook, 1958).

Plant tests have demonstrated that the capacity of the basic open hearth can be significantly increased by using oxygen (Brion and others, 1961; Howkins and others, 1961; Pearson, 1959). The tests were made with furnaces having both basic and silica roofs, but basic roofs are required to obtain the maximum increase possible. The future of the open hearth process is not yet apparent, but it has been suggested that the open hearth may not survive in its present form (Moore, 1961).

Silica Brick Industry in California

Three companies produce silica brick in California; Gladding, McBean & Co. at South Gate, General Refractories Company at Los Angeles, and Harbison-Walker Refractories Company at Warm Springs. Brooks (1955) has summarized the history of the silica brick industry in California. The Atlas Fire Brick Company, in 1918, was the first to produce silica brick in California. The quartzite was obtained from the Kennedy deposit northwest of Hodge, San Bernardino County. This operation was taken over by the Emsco Refractories Company in 1928. At about that time, quartzite deposits in the Quartzite Mountain area near Oro Grande, San Bernardino County, were developed to take the place of the small deposits near Hodge. Gladding, McBean & Co. absorbed the Emsco Refractories Company in 1944.

Photo 20. Setting silica brick in a periodic kiln. *Photo courtesy of Gladding, McBean & Co.*

The Tillotson Clay Products Company began the manufacture of silica brick during the 1930's. This company was purchased by General Refractories Company in 1943.

The Harbison-Walker Refractories Company bought a plant in Warm Springs, Alameda County, that had belonged to Laclede-Christy Company and converted it to the manufacture of basic brick in 1952. The next year, the company began the manufacture of super duty silica brick at Warm Springs, using quartzite from near Grants Pass, Oregon.

By 1953, steel makers in southern California were using super duty silica brick from out-of-state sources in preference to standard brick made locally of quartzite from the Quartzite Mountain area. Gladding, McBean & Co., after a search that began as early as 1947 and was intensified in 1953, developed deposits of the Eureka Quartzite near Owens Lake, from which super duty brick could be made. Since 1955, all of the silica brick produced in southern California have been made from the Eureka Quartzite.

Method of Production

As the first step in the manufacture of silica brick, quartzite is ground in a dry pan and carefully sized to produce a product consisting of angular particles ranging in size from about 6 mesh (3.3 millimeters) to

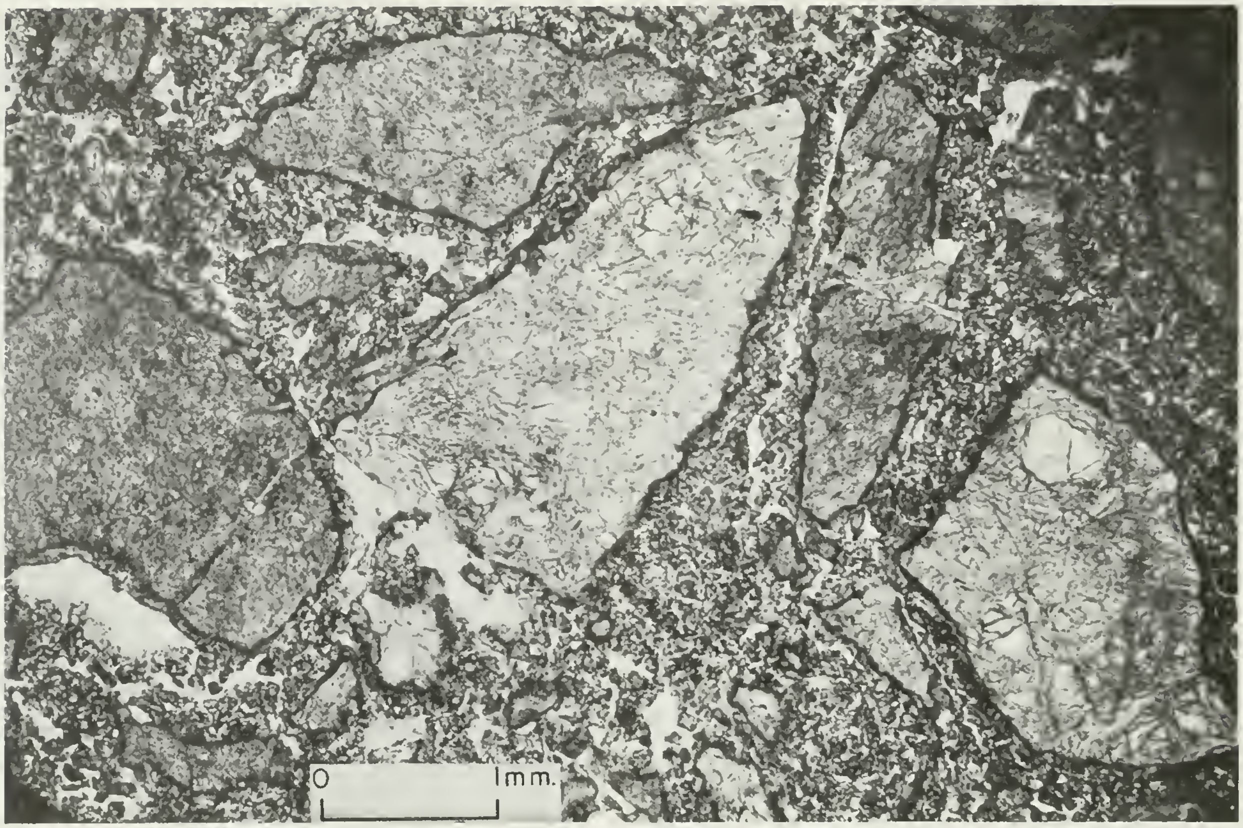
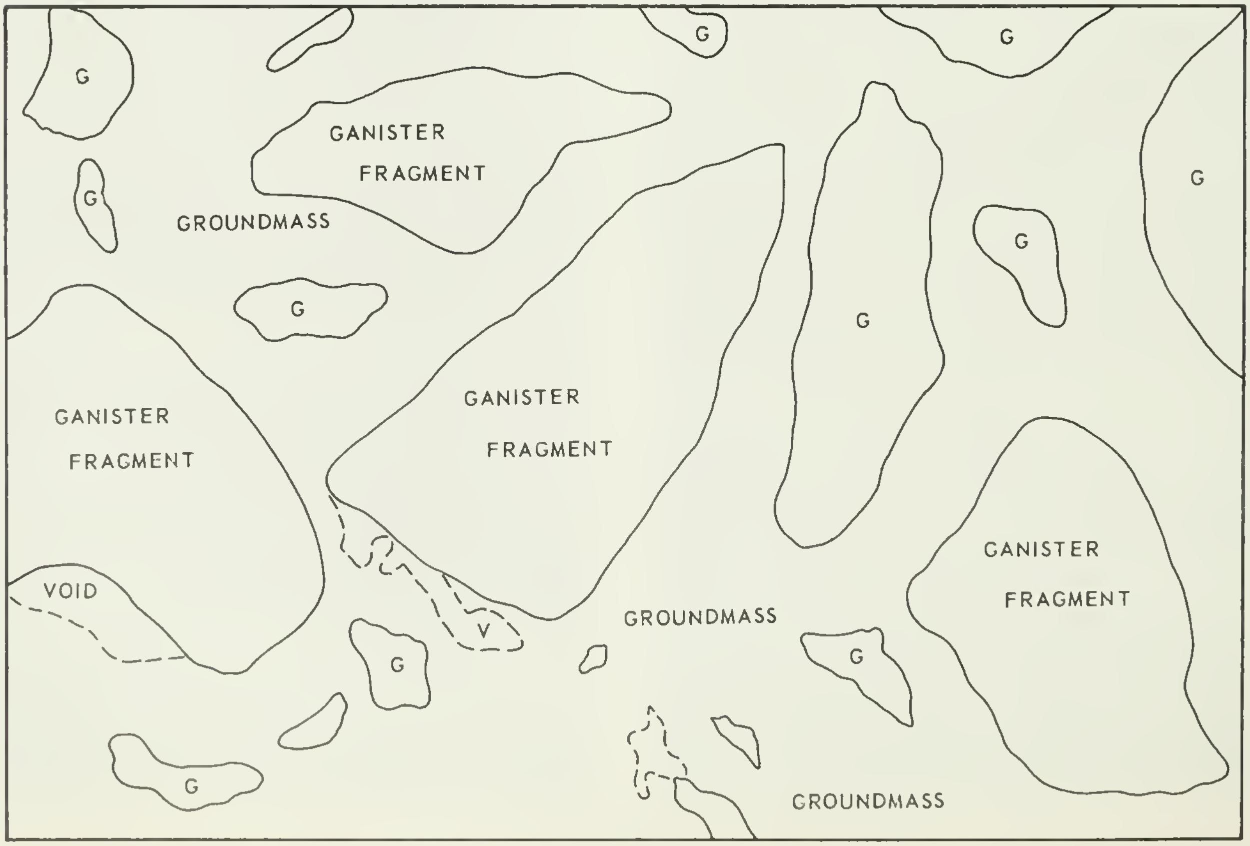


Photo 21. Photomicrograph of silica brick—plain light. Sharply defined, angular fragments of ganister set in moderately crystallized groundmass. Overall textural appearance of the brick is not markedly different from that of an unfired brick.



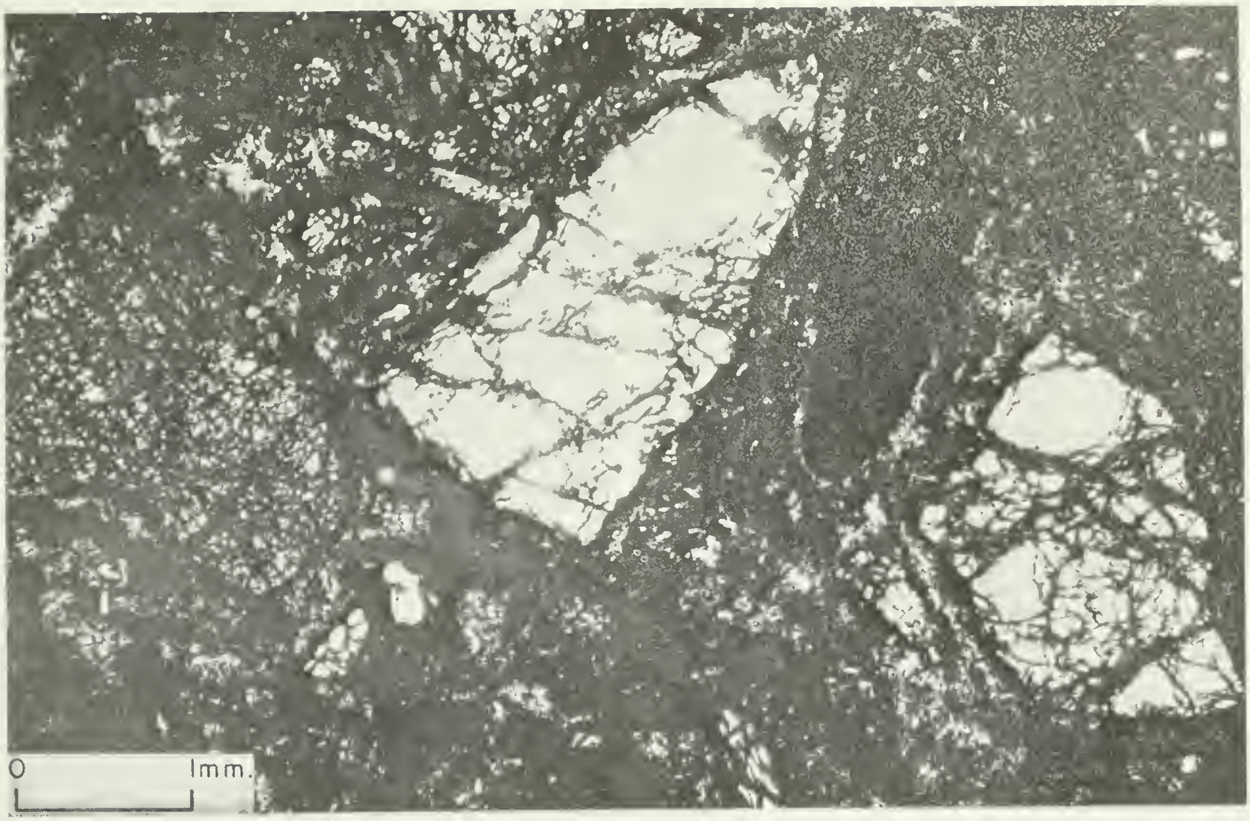
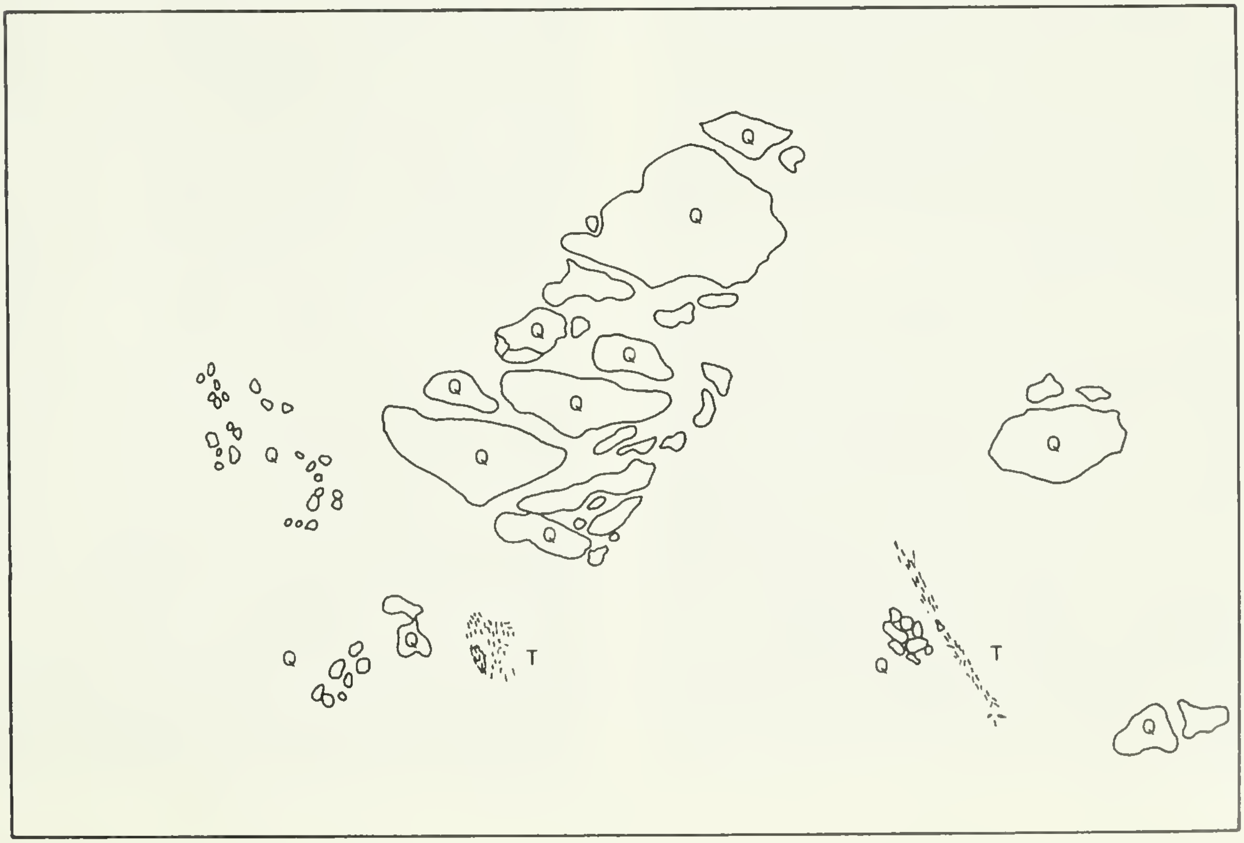


Photo 22. Photomicrograph of silica brick—crossed nicols. Field identical to Photo 21. Bright clear areas in ganister fragments indicate residual quartz. Note degree of fracturing in quartz indicative of shattering that accompanies alpha-beta inversion within quartz as it passes through 575° C. temperature range. Cristobolite has formed along ganister fractures and in some ganister fragments cristobolite predominates. The sharp contrast in the degree of ganister conversion is probably related to different crystal structure of quartz grains within the original ganister. Tridymite is more apparent in the brick than is indicated by the photomicrograph. Two small zones of tridymite (T) are noted in the sketch.



dust. In some plants, ball mills are used to make a fine fraction that is mixed with the product from the dry pan. A particle size distribution is desired that results in a minimum of voids in the tamped material. At one of the plants in California, 15 percent of the ground product is coarser than 10 mesh, and 65 percent is between 100 and 150 mesh.

Next, the ground quartzite is mixed with 1 to 3 percent of hydrated lime to form a ceramic bond, an organic binder to provide green strength before the bricks are burned, and enough water to bring the mixture to the desired consistency. The mixture is then formed into specific brick shapes with a mechanical press. The green brick, which are very fragile, are carefully dried under controlled conditions to avoid cracking.

The brick are burned in a tunnel kiln or round downdraft kiln in which the temperature is slowly and uniformly raised to 2,700° or 2,800° F., then cooled uniformly to room temperature over a period as long as a month. During the burning process, the coarser particles of quartz mostly change to tridymite and cristobalite, high temperature forms of silica that are metastable at room temperature. The fine quartz, combining with lime, iron oxide, and impurities, forms a molten silicate that mostly cools as a glass. The amount of glass in modern brick varies between 10 and 20 percent. At operating temperatures, the glass is molten, while at cooler temperatures, it serves as a groundmass that binds the brick into a solid mass.

The Minerology of Silico Firebrick *

Fired silica brick is composed of two distinct fractions: 1) Large ganister fragments that are mostly converted to cristobalite. 2) Fine grained groundmass consisting of: a) tridymite crystals, b) silicate glass, c) CaFe silicate crystals, d) opaque iron oxides. Converted ganister fragments and groundmass are of approximately equal portions in normal brick; each accounting for 30 to 50 percent of the brick volume. Voids comprise between 15 and 30 percent of an average brick's volume.

As silica brick generally contains more than 95 percent SiO_2, the service performance of the brick depends to a great extent on the behavior of the various forms of silica. Silica exists in seven crystalline modifications: two forms of quartz, two of cristobalite, and three of tridymite. The transformations that occur within the same silica mineral type (e.g. alpha tridymite to beta tridymite) take place with considerable rapidity and are accompanied by a small energy change. The transformations that occur between different silica minerals (e.g. quartz-cristobalite-tridymite) proceed slowly and are accompanied by considerable energy changes that result in volume expansion and a corresponding decrease in specific gravity. The technology of brick manufacture is largely concerned with reducing this volume of expansion to within safe limits in the finished brick product.

Quartz. Control of brick expansion during service is accomplished by preparing and firing the brick in a manner that will convert all or nearly all of the quartz to its polymorphs of cristobalite and tridymite. Methods for accomplishing a near total conversion are multiple. It is certain that strained or flawed quartz is more conducive to conversion than perfect crystalline quartz. G. R. Rigby et al (1946, p. 78) suggests that for a given firing schedule a brick with a low quartz content is obtained by: 1) Choosing a ganister which is finely crystalline and is associated with impurities. 2) Crushing the ganister to a fine size. 3) Using the maximum allowable addition of lime. No information was found in the available literature regarding the role of iron oxide in the conversion of quartz.

The mode of the conversion of quartz to cristobalite varies with the nature of the original rock. The first modification that quartz undergoes during firing is the change from alpha to beta varieties that occurs at 573°C. (964°F.). This inversion is usually accompanied by shattering which is aggravated by large grain size and rapid temperature change (see photos 20 and 21). D. W. Ross (1918) warns that rapid heating through the inversion temperature range is likely to result in friable punky brick and recommends that the firing temperature should not be allowed to exceed 1,350° C. (2,460°F.) until a large fraction of the quartz is converted. There is some question about validity of this theory in modern brick manufacture as shattered quartz is either healed and welded by cristobalite and tridymite or totally converted into the high temperature minerals. It should be noted that in 1918, the year of Ross' investigation, firing methods rarely converted any of the ganister fragments to high temperature silica minerals. The normal brick of that time had a low cristobalite-tridymite content, and contained up to 30 and 40 percent quartz. Alteration of quartz to cristobalite and tridymite occurs within ganister fragments whenever there is impure cementing material.

Cristobalite. Very fine crystals of cristobalite begin to form in brick groundmass above temperatures of 870°C. (1,600°F.). At somewhat higher temperatures conversion occurs around the periphery of ganister fragments and in fragment cracks that formed during the shattering of quartz as it inverted from alpha to beta forms. Cristobalite forms entirely at the expense of the quartz within ganister fragments as the maximum firing temperature is approached. This cristobalite is often characterized by a delicate fish scale structure. In a normal fired brick the maximum cristobalite content is reached at approximately the same time in the firing schedule that quartz is disappearing. Cristobalite is not again formed unless the temperature exceed 1,482°C. (2,700°F.) and the brick is over-fired. If over-firing does take place cristobalite is reformed

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* This section on Mineralogy by J. Morrow Elias, Geological Engineer; Gladding, McBean & Co.

at the expense of tridymite which is unstable above temperatures of 1,482°C.

The author's petrographic examination supplies information that is in accord with the findings of Rigby et al (1946, p. 77); that conversion of quartz to cristobalite can and does occur in a solid state without an intermediate melt or solution period. It is otherwise difficult to explain how large angular shaped areas representative of original ganister fragments can be completely converted to cristobalite. If solution or digestion of ganister fragments had occurred, indefinite gradational zones rather than discernible boundaries would be expected between the original ganister fragments and the bonding matrix.

Tridymite. Tridymite represents the end product of the conversion of quartz in the usual temperature range for silica brick manufacture. Trace amounts of the mineral may form at temperatures below 1,090°C. (2,000°F.), but tridymite does not constitute an important part of the brick until temperatures have reached about 1,315°C. (2,400°F.). The mineral first appears as small crystal grains in the brick groundmass, and as occasional crystals in the impure zones of the ganister fragments. As firing continues, the number and size of the crystals increases and conspicuous wedge shaped twins and laths become visible (see photos 22 and 23).

The mode of tridymite formation is complex. There is petrographic evidence that suggests it forms both from a solution state as precipitation crystals, and also as a direct solid state crystallization product from cristobalite.

By far the largest proportion of tridymite found in silica brick is formed through a melt or solution stage. Tridymite formed in this manner is found in the groundmass and digested portions of the ganister fragments. The digestion zones often occur as a reaction rim completely surrounding ganister fragments. They are a result of progressive corrosion and digestion of the fragment's outer surface by semi-molten groundmass material. Digestion probably occurs during the high temperature soaking period of the firing cycle. The reaction rim consists of a mixture of tridymite and silicates of calcium, iron, aluminum, etc. Glass is present in only minor amounts.

Crystallization of tridymite through a solid stage is characterized by large isolated crystals randomly oriented within ganister fragments that were converted to cristobalite during an earlier period of the firing schedule.

It is probable that the network of elongated tridymite crystals that is formed in brick of certain manufacture bears an important relation to the rigidity of silica brick at high temperature. In the groundmass of sound brick, wedge and lath shaped crystals of tridymite form a continuous network with glass filling the interstices between tridymite crystals. Tridymite that is associated with groundmass glass probably formed by a process in which the smallest ganister fragments passed into solution in the glass melt followed by almost immediate precipitation of tridymite. LeChatelier and Bogitch (1918, p. 15) say that this crystallization will be accomplished the more completely and rapidly if the quartzite used is finely or even very finely ground. They also warn, however, that a certain portion of large fragments is necessary to prevent formation of cracks whose propagation happens easily when material is uniformly fine.

Glass. The iron, aluminum, calcium, etc., oxides that compose the impurities of quartzite, plus the added CaO and FeO mineralizers react and combine with some silica of the groundmass to form a molten silicate that mostly cools as a glass. A small portion of the silicate melt precipitates out as a crystalline material.

The amount of glass in modern brick manufacture varies from 10 to 20 percent. Its color ranges from colorless to yellow to muddy-brown depending upon the relative abundance of CaO, FeO, and the various impurity oxides. The occurrence of glass is restricted to the brick groundmass where it is usually found surrounding and interstitial to rridymite crystals (see photos 22 and 23). Occasional concentrations of semi-pure glass occur in certain brick and are probably attributable to poor mixing.

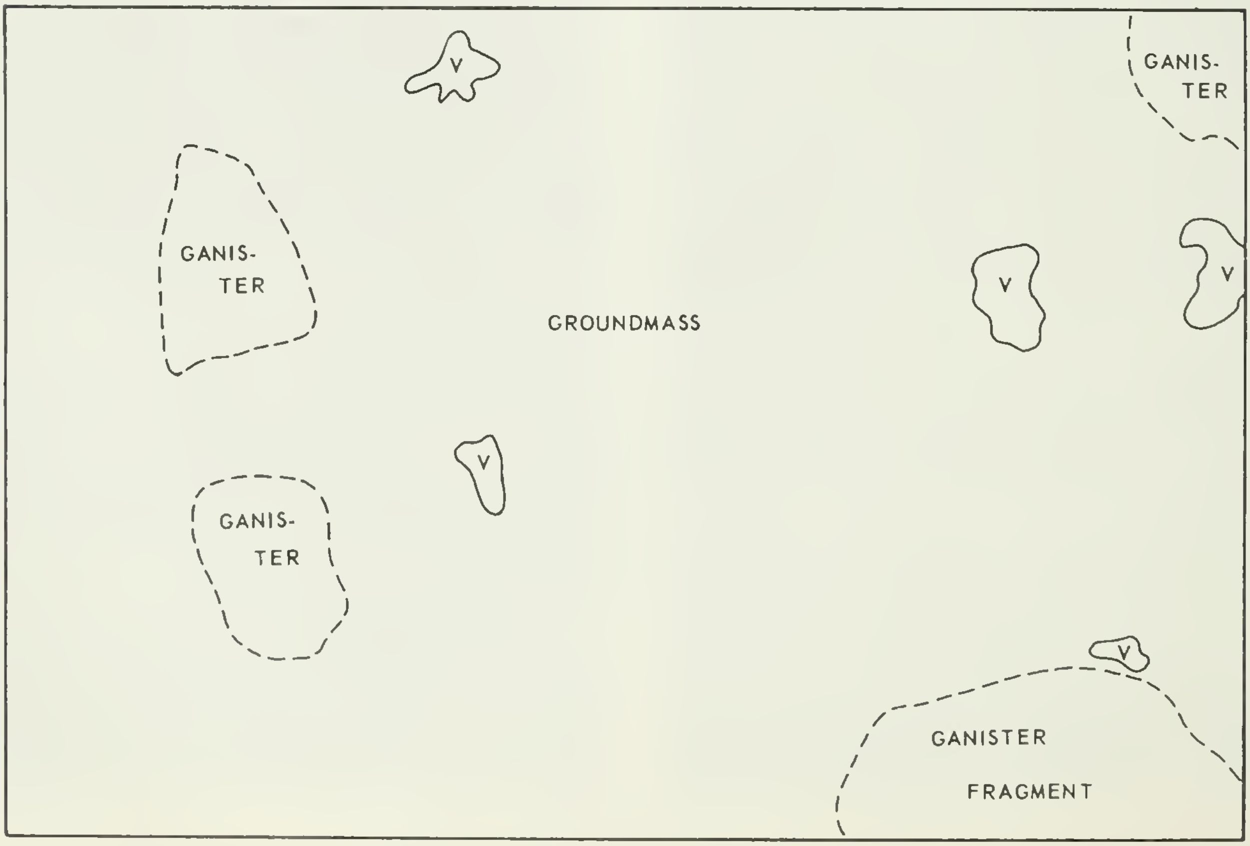
The crystalline material that is precipitated from glass is mostly a "solid solution" of no precise formula, ranging in composition between wollastonite ($CaO \cdot SiO_2$) and fayalite ($2FeO \cdot SiO_2$). These CaFe silicates crystallize as minute grains adjacent to, or disseminated through, the glassy areas of the brick.

It is the opinion of many research workers that the interspersion of small amounts of CaFe silicate crystals through the glass add viscosity to it and are partly responsible for the absence of pronounced plastic flow of brick at high temperatures. Reinforcement of the glass through association with tridymite crystals (and cristobalite) is also important in counteracting plastic flow at elevated temperature. The combination of these associations account for the exceptional strength of silica brick in service regardless of the 10–20 percent molten glass content which should give rise to plastic flow and failure.

A method of estimating the glass and CaFe silicate content of silica brick is proposed by Rigby et al (1946, p. 77): "An approximate idea of the glass content of a silica brick can be obtained by adding together the percentage of all oxides other than silica and assuming that these flux with about twice their own weight of silica, in other words the total percentage of fluxing oxides is trebled."

The approximate nature of this method is emphasized by an interesting statement of H. M. Kraner (1944). He claims that "lime does not increase the amount of liquid at operating temperatures over that provided by the normal impurities of the raw materials of the brick, but in fact reduces it, the reduction

Photo 23. Photomicrograph of silica brick—plain light. Corroded and digested ganister fragments set in a well-crystallized groundmass. Perfect lath- and wedge-shaped crystals of tridymite are easily recognized in the groundmass and stand out in contrast to the interstitial dark-colored glass and CaFe silicates.



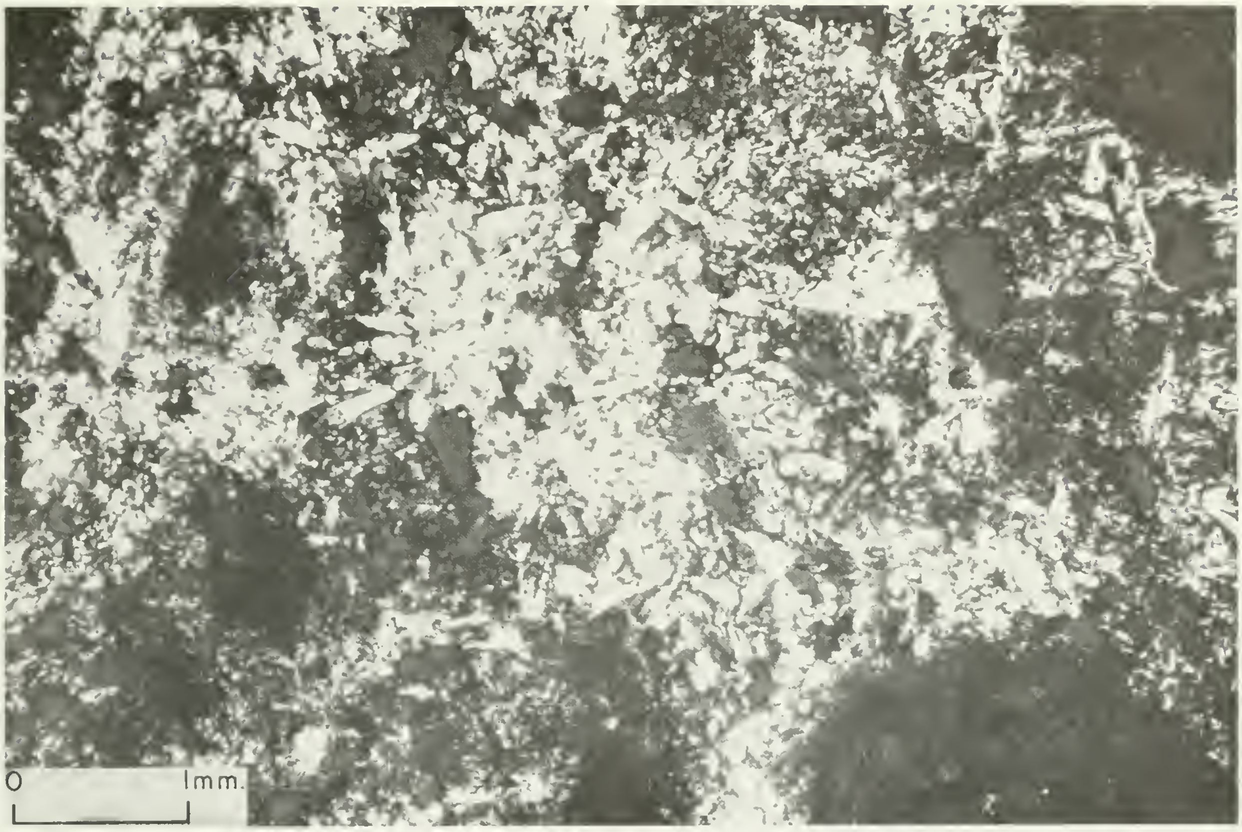
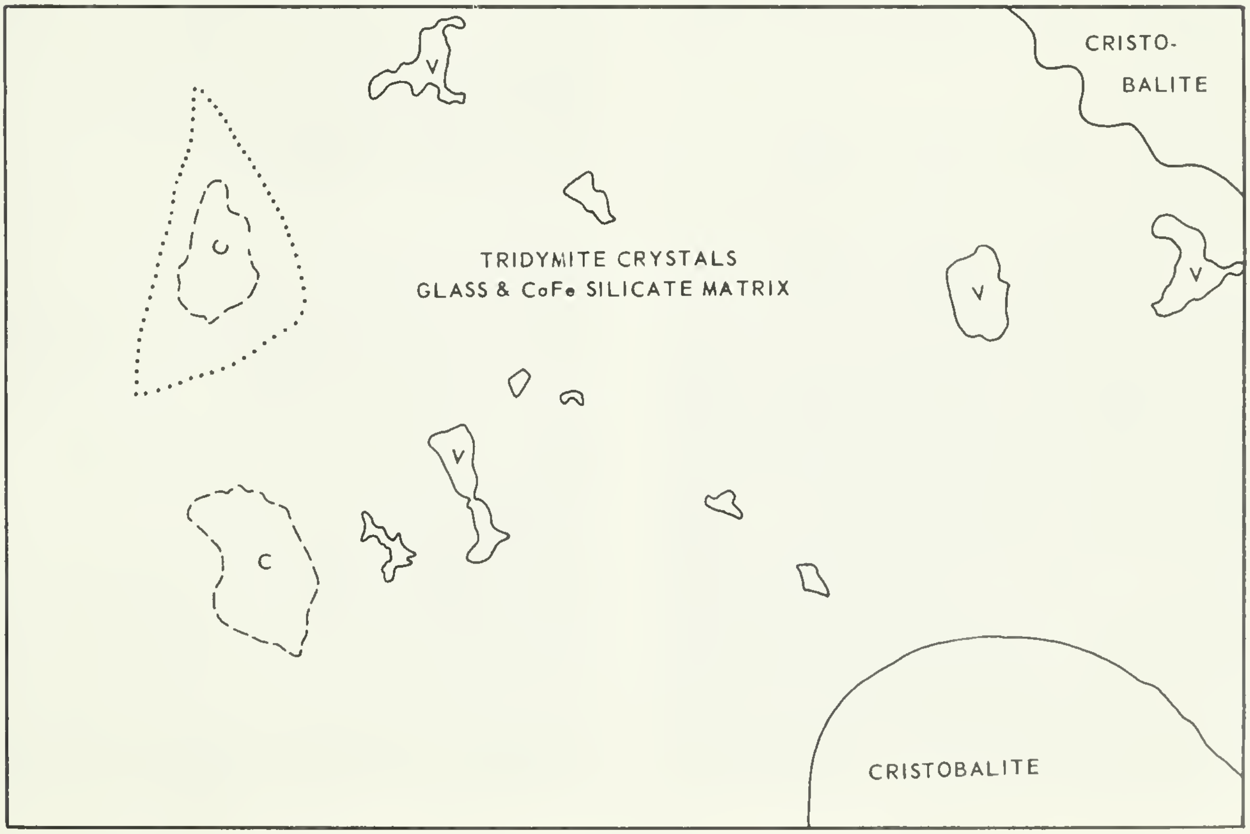


Photo 24. Photomicrograph of silica brick—crossed nicols. Field identical to Photo 23. Well-formed tridymite crystal net with interstitial glass and very fine grained CaFe silicates. Rounded areas of cristobalite represent original angular fragments of ganister. A skeleton outline showing the shape of an original ganister fragment that has undergone strong corrosion and digestion can be traced around one of the cristobalite areas as shown in the sketch.



of CaO from 2–1% resulting in 5% increase in liquid at high temperature."

Opaque Iron Minerals. Iron oxide does not always combine with silica to form iron silicates or CaFe silicates in the brick groundmass. Where uncombined iron does occur it takes the form of blebs, clusters, and dendrites of opaque iron oxide minerals. The iron minerals are generally in the form of hematite (Fe_2O_3), magnetite (Fe_3O_4), or a solid solution of the two.

Uncombined iron oxides can probably be related to either poor mixing or a too large addition of iron oxide for "mineralizing" purposes. The effect of uncombined iron oxide on brick service is unknown.

Specifications

At one time silica brick were made from quartzite that contained enough clay, mica, or feldspar to furnish the ceramic bond. It is now known that alumina and alkalies are critically deleterious impurities that act as fluxes to lower the softening temperature of silica brick, even when present in amounts of less than 1 percent. Lime, iron, and most other impurities are less harmful. Present practice is to use the purest quartzite that can be obtained. The amounts of alumina and alkalies are limited by the specifications for silica brick. *Super duty silica brick has a flux factor of 0.5 or less.*[*]

The following is a typical analysis of a quartzite mix used in the manufacture of super duty silica brick by Gladding, McBean & Co.

SiO_2	96.40%
Al_2O_3	0.15
Fe_2O_3	0.59
TiO_2	0.04
CaO	2.49
MgO	0.08
Na_2O	0.12
K_2O	
Ignition Loss	0.02
	99.89

Average chemical analysis taken April 20, 1955 from production brick at South Gate plant. Arthur G. Moore, written communication, March 1961.

The desirability of quartzite cannot be determined by chemical means alone. Different types of quartzite invert to cristobalite and tridymite at different rates of speed, the rate of conversion being influenced by the size of the quartz crystals, the grading of the quartzite fragments, and the amount and type of the fluxing oxides. Flawed or strained quartz is more conducive to conversion than perfect crystal grains, and a quartzite that breaks readily into angular fragments will yield a better brick than one which disintegrates into rounded fragments. These quartzite requirements usually are associated with a well-metamorphosed quartz sandstone that has not been contaminated by igneous intrusions or hydrothermal solutions.

Quartzite is the form of silica that is usually used in the manufacture of silica brick. Novaculite is suitable and is used where it is available. Some plants use high-purity silica sand as part of the source of the finer sizes in the mixture of ground silica. Vein quartz, however, is unsatisfactory.

Portland Cement

The Manufacture of Portland Cement

The raw materials used in the manufacture of portland cement are limestone and a wide variety of iron-bearing, aluminous, and siliceous materials that may include quartzite. They are blended in the desired proportions, finely ground, and calcined in rotary kilns. The kiln product, called clinker, is then processed further to produce portland cement. Kiln feeds fall within the following analysis range:

CaO	42–44%
SiO_2	13–15
Al_2O_3	4–6
Fe_2O_3	2–3
CO_2	33–35
Others	Up to 3

Magnesia and the alkalies are deleterious. Magnesia, perhaps the most critical, is limited to a maximum of 5 percent in the finished cement. Alkalies tend to volatilize and pass out of the kiln, but for low alkali cements, a maximum of 0.6 percent is tolerated.

Most portland cement plants use limestones that have enough impurities to provide part of the alumina and silica required in the kiln feed. The additional alumina and silica that are required are supplied by adding materials such as clay, schist, alluvium, or even granite. Often the magnesia and alkali content of these materials limits the proportions that can be used. Some form of silica makes up part of the kiln feed if enough silica is not present in the other ingredients.

California Plants That Use Silica

Relatively few portland cement plants have to add silica to their kiln feeds. For some plants that use siliceous limestone, silica may be a critical ingredient that limits the kinds and proportions of the aluminous materials that can be used. The following table lists the portland cement plants in California that use silica.

Plant	*Silica material*
Pacific Cement and Aggregates Co., Davenport	Sandstone
Monolith Portland Cement Co., Monolith	Micaceous quartzite
Permanente Cement Co., Cushenbury	Siliceous mine tailings
California Portland Cement Co., Colton	High-purity quartzite
Riverside Cement Division, Crestmore	High-purity quartzite

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[*] A.S.T.M. tentative classification C416-58T. Flux factor equals the percent of alumina plus twice the percent of alkalies. Standard silica brick has a flux factor of more than 0.5 but does not contain more than 1 to 1.25 percent impurities.

Specifications

Because plant practice is so varied, the specifications of silica for use in the manufacture of portland cement cannot be generalized. A silica material that is suitable for one plant is unlikely to meet the needs of another. Plants use the cheapest material, in terms of its SiO_2 content, that is available and has the desired chemical composition. Quartzite has no intrinsic advantage over vein quartz or silica sand. Other things being equal, quartzite is less desirable than sand because it is abrasive and is relatively difficult to grind.

If the main ingredients are high in magnesia and the alkalies, there would be very little tolerance for these impurities in the silica.

Ferrosilicon and Silicon

Ferrosilicon is an alloy of iron and silicon that is usually produced from metallic iron and lump quartzite or quartz in the electric furnace. The relative proportions of iron and silicon can vary within a wide range. Alloys containing 20 percent or less silicon, called silvery pig iron by the United States Bureau of Mines, also can be made in the blast furnace. Alloys that contain more than 95 percent silicon, called silicon metal, are produced in the electric furnace; but the charge contains no iron.

Ferrosilicon is used principally as a deoxidizing agent in the manufacture of steel and for the addition of silicon to alloy steel and cast iron. It also is the reducing agent in the silicothermic or ferrosilicon process of making magnesium metal from dolomite. Silicon metal is used as an alloying agent in nonferrous metallurgy and as an intermediate in the manufacture of silicones.

Nearly pure silicon, containing only a few parts per billion of impurities, is a very high priced material that is used in small amounts for rectifiers, diodes, transistors, and solar cells. The starting material is metallurgical grade silicon or a silicon compound such as silicon tetrachloride. It is not discussed further in this report.

The Industry in California

Three plants have produced ferrosilicon or silicon in California, but none was in operation in 1961. During World War I, the Noble Electric Steel Company produced ferrosilicon of 75 percent silicon content at Heroult, Shasta County (Bradley and others, 1918, pp. 20-22). The Noble Electric Steel Company enterprise was part of an effort to convert local mineral resources into high priced specialty products, principally high-quality pig iron and ferromanganese, that could be marketed in the east. It did not survive the return to normal demand and prices that followed the war. The ferrosilicon was produced in a small, 600-kilowatt furnace from impure, siliceous material that probably was obtained locally.

The second, and largest, of the California plants was that of Kaiser Aluminum and Chemical Corporation and its predecessor the Permanente Metals Corporation at Permanente, Santa Clara County. It also operated under the special circumstances that prevail during times of war. From August 1942 to May 1944 it produced ferrosilicon of 75 percent silicon content for a silicothermic magnesium plant at Manteca, San Joaquin County, one of a number of plants built by the Federal Government to supply the military demand for magnesium during World War II. Following the war, the Permanente plant produced some ferrosilicon of 50 percent silicon content for the Kaiser Steel Corporation at Fontana. It was operated at capacity again from June 1951 to June 1953 during the Korean crisis, when the Manteca plant was reactivated. Since then the Manteca plant has been dismantled, but the Permanente plant has been maintained and operated from time to time to furnish amorphous silica that is recovered from the furnace fume and used as a bonding agent in the manufacture of basic refractory brick. It has three 8,000 KVA furnaces, each with a capacity of 575 tons per month of ferrosilicon containing 75 percent silicon (Davis, 1954, P. 389). It consumed vein quartz from the White Rock deposit, Mariposa County, and quartz cobbles from the Bear River near Colfax, Placer County.

The third plant is that of Silicon Metals Division, Ward-Lee Chemical Corporation at Dixieland, Imperial County, which produced silicon metal for a few months during 1958 (F. H. Weber, Jr., Dec. 2, 1958, unpublished report). The company planned to market silicon for alloying with aluminum in the Los Angeles area but was unable to produce material of acceptable grade. The plant had a single electric furnace with an estimated capacity of 6½ tons of silicon per day. Quartz was obtained from deposits in San Diego County.

Method of Production

Both ferrosilicon and silicon usually are made in three-phase electric furnaces of the arc-resistance type. Such a furnace consists of an open-topped, cylindrical or rectangular steel shell that is lined with carbon blocks. The charge, consisting of lump silica, charcoal or coke, and, if ferrosilicon is being produced, shredded iron or steel, is introduced through the open top. Electric energy is applied through three vertical electrodes that project into the charge. At the high temperature produced by the arcs between the electrodes and by the passage of the current through the charge, the silica is reduced by the carbon to liquid silicon that collects in the bottom of the furnace. If the charge contain iron, it melts and alloys with the silicon. Periodically, the furnace is tapped, and the ferrosilicon or silicon is cast into pigs. After the pigs have cooled, they are crushed.

Ferrosilicon and silicon furnaces range in size from 9 feet in diameter and 10 feet high to as much as 22 feet in diameter and 14 feet high. Power requirements are from 4,000 kilowatts to 13,000 kilowatts or more. The consumption of electricity, which depends on the silicon content of the product, is 2½ to 3 kilowatt-hours per pound of ferrosilicon of 50 percent silicon content, or 5 to 6 kilowatt-hours per pound of ferrosilicon of 75 percent silicon content (Mantell, 1940, pp. 492, 493, 499). Voltages are in the range of 75 to 150 volts. Electrodes, which are of carbon or graphite, are 2 to 3 feet in diameter. Current densities are 30 to 60 amperes per square inch of electrode surface. Electrode consumption is 50 to 80 pounds per ton of product.

Specifications

Quartzite or quartz containing 98 to 99 percent SiO_2 is required for the production of ferrosilicon or silicon. The ferrosilicon plant at Heroult used siliceous material containing 5 to 10 percent of iron, but in present practice only a few tenths of a percent of iron and alumina are tolerated. Only traces of most other oxides are allowed. Compounds of arsenic, phosphorous, and sulphur are especially objectionable because they form poisonous gases in the furnace.

Physically, the silica should be a tough material that does not crumble in the furnace. It should be crushed to minus 3 or 4 inches, and it should contain no minus ⅞-inch material.

Either quartzite or quartz that meets the above specifications can be used. The California plants have used quartz from veins, pegmatites, and deposits of quartz cobbles because these sources were more convenient than deposits of quartzite. Quartzite, however, is used in other parts of the United States.

ANNOTATED BIBLIOGRAPHY

Allen, John Eliot, 1946, Geology of the San Juan Bautista quadrangle, California: California Div. Mines Bull. 133, pp. 9–75 (quartzite in section through Sur Series near Gabilan School, p. 20).

Averill, Charles Volney, 1931, Preliminary report on economic geology of the Shasta quadrangle: California Div. Mines Rept. 27, pp. 2–65 (quartzite-bearing metasediments including Abrams Formation, pp. 7–9).

Averill, Charles Volney, 1937, Mineral resources of Plumas County: California Div. Mines Rept. 33, pp. 79–143 (Grizzly Formation, Taylorsville Formation, Shoo Fly Formation after Diller 1908, pp. 84, 85).

Barca, Richard Albert, 1966, Geology of the northern portion of Old Dad Mountain quadrangle, San Bernardino County, California: California Div. Mines and Geol. Map Sheet 7, scale 1:62,500 (Prospect Mountain Quartzite near Old Dad Mountain and Seventeenmile Point).

Bateman, Paul C., and Merriam, Charles W., 1954, Geologic map of the Owens Valley region, California: California Div. Mines Bull. 170, map sheet 11 (map, scale 1:250,000, shows undifferentiated Ordovician rocks).

Bowen, Oliver E., Jr., 1954, Geology and mineral deposits of Barstow quadrangle, San Bernardino County, California: California Div. Mines Bull. 165, pp. 7–185 (quartzite-bearing Oro Grande Series, pp. 23–34; quartzite in Hodge Volcanic Series, pp. 34–36; plate 1, scale 1:125,000, shows undifferentiated Oro Grande Series and quartzite bodies in Hodge Volcanic Series).

Bowen, Oliver E., Jr., and Gray, Cliffton H., Jr., 1959, Geology and economic possibilities of the limestone and dolomite deposits of the northern Gabilan Range, California: California Div. Mines Special Rept. 56, 40 pp. (quartzite and quartz rock in Sur Series, pp. 13, 19, shown on Plate 1, scale 1:15,840).

Bowen, Oliver E., Jr., and Ver Planck, W. E., 1965, Stratigraphy, structure, and mineral resources in the Oro Grande Series near Victorville, California: California Div. Mines and Geol. Special Report 84, 41 pp. (quartzite described in detail, shown on map, scale 1:12,000).

Bradley, Walter W., and others, 1918, Manganese and chromium in California: California Min. Bur. Bull. 76, pp. 20–23 (production of ferrosilicon and ferromanganese by Noble Electric Steel Co.).

Brion, D. F., and others, 1961, Operating experience with open-hearth lances: Jour. Metals, vol. 13, pp. 300-302 (use of oxygen in the basic open-hearth process).

Brooks, Baylor, and Roberts, Ellis, 1954 (1955), Geology of the Jacumba area, San Diego and Imperial Counties: California Div. Mines Bull. 170, map sheet 23 (description of quartzite in the Julian Schist).

Brooks, Richard F., 1955, Discovery and development of superduty refractory quartzite in California; unpublished paper, Am. Inst. Min. Met. Engr., Southern California Section, Fall Meeting.

California Magazine of the Pacific, 1960 (March), vol. 50, no. 3, p. 24, Kaiser Steel Corporation (production of steel by L.D. process).

Carlson, Denton W., and Clark, William B., 1956, Lode gold mines of the Alleghany-Downieville area, Sierra County, California: California Jour. Mines and Geology, vol. 52, pp. 237–272 (geology after Ferguson and Gannett, 1932; Relief Quartzite, p. 241, shown on pl. 8, scale 1:24,000).

Chem. Eng. News, 1955 (May 9), vol. 33, no. 19, p. 1948, From the inferno-silicon (production of silicon from quartzite by Dow Corning Co. at Midland, Michigan).

Chem. Week, 1959 (Nov. 14), vol. 85, no. 2, p. 79 (use of LD process by Kaiser Steel Corporation).

Chesterman, Charles W., 1942, Contact metamorphic rocks of the Twin Lakes region, Fresno County, California: California Div. Mines Rept. 38, pp. 243–290 (quartzite, pp. 251, 252).

Chesterman, Charles W., Geologic map of the northeast quarter of the Shoshone quadrangle (unpublished).

Clark, C. Burton, and McDowell, J. Spotts, 1960, Refractories, *in* Industrial Minerals and Rocks, 3d ed., pp. 699–712, New York, Am. Inst. Min. Met. Petroleum Engr. (production statistics of refractories, including silica brick, p. 700).

Clark, C. W., 1921, Lower and Middle Cambrian formations of the Mohave Desert: Univ. Calif. Dept. Geol. Sci. Bull. vol. 13, pp. 1–7 (quartzite, called Prospect Mountain Quartzite in Hazzard 1954, at base of Paleozoic section in Marble Mountains).

Clark, Lorin D., 1954, Geology and mineral deposits of the Calaveritas quadrangle, Calaveras County, California: California Div. Mines Special Rept. 40, 23 pp. (quartzite in the Calaveras Formation, p. 6).

Cox, Dennis Purver, Geology of the Helena quadrangle, Trinity County, California, Stanford University, unpublished Ph.D. thesis, 1956 (Chanchelulla Formation).

Creasey, S. C., 1946, Geology and nickel mineralization of the Julian-Cuyamaca area, San Diego County, California: California Div. Mines Rept. 42, pp. 15–29 (quartzite in Julian Schist, p. 18; quartzite near Inspiration Point shown on plate 3, scale 1:9,600).

Crosby, James W., III, and Hoffman, Samuel R., 1951, Fluorspar in California: California Jour. Mines and Geology, vol. 47, pp. 619–638 (Prospect Mountain Quartzite near Clark Mountain, pp. 628, 629, shown on fig. 2, scale 1:54,000).

Cuscoleca, Otwin, 1954, Development of oxygen steelmaking: Jour. Metals, vol. 6, pp. 817–827 (basic oxygen practice at Linz and Donawitz, Austria).

Davis, Fenelon F., and Jennings, Charles W., 1954, Mines and mineral resources of Santa Clara County, California: California Jour. Mines and Geology, vol. 50, pp. 321–430 (ferrosilicon plant at Permanente, p. 389).

Dibblee, T. W., Jr., 1952, Geology of the Saltdale quadrangle, Kern County, California: California Div. Mines Bull. 160, pp. 7–43 (quartzite in Rand Schist, p. 13; chert and quartzite, member 10 of Garlock Series, p. 16, shown on pl. 1, scale 1:62,500; quartz conglomerate in Paleozoic (?) metasediments east of Redrock Canyon, p. 19).

Dibblee, T. W., Jr., 1954, Geology of the Redrock Canyon-Last Chance Canyon area, Kern County: California Div. Mines Bull. 170, Map sheet 13 (description of quartz conglomerate, shown on map, scale 1:62,500).

Dibblee, T. W., Jr., 1960, Preliminary geologic map of the Victorville quadrangle, California: U.S. Geol. Survey Map Sheets MF-226, MF-229, MF-233 (quartzite-bearing Oro Grande Series).

Dibblee, T. W., Jr., and Chesterman, Charles W., 1953, Geology of the Breckenridge Mountain quadrangle, California, 56 pp. (quartzite in the Kernville Series, p. 15, shown on pl. 1, scale 1:62,500).

Dietrich, Waldemar Fenn, 1928, The clay resources and ceramic industry of California: California Div. Mines and Mining Bull. 99, 383 pp. (silica brick plant of Atlas Fire Brick Co., p. 97; quartzite deposit (Kennedy) near Hicks, p. 194).

Diller, J. S., 1908, Geology of the Taylorsville region, California: U. S. Geol. Survey Bull. 353, 128 pp. (quartzite in Grizzly Formation, pp. 14–16; quartzite in Taylorsville Formation, pp. 17–19; quartzite in Shoo Fly Formation, p. 23).

Donnelly, Maurice, 1934, Geology and mineral deposits of the Julian district, San Diego County, California: California Div. Mines Rept. 30, pp. 331–370 (quartzite in Julian Schist, pp. 337, 338).

Dudley, Paul H., 1935, Geology of a portion of the Perris block, southern California: California Div. Mines Rept. 31, pp. 487–506 (quartzite in Elsinore Metamorphic Series, called Santa Ana Formation in Engel 1959, near Goodhope mine, p. 494).

Durrell, Cordell, 1940, Metamorphism in the southern Sierra Nevada northeast of Visalia, California: Univ. Calif. Dept. Geol. Sci. Bull. v. 25, pp. 1–117 (Homer Quartzite, pp. 13, 32, shown on map 1, scale 1:125,000).

Durrell, Cordell, 1943, Geology of the Sierra Nevada northeast of Visalia, Tulare County, California: California Div. Mines Rept. 39, pp. 153–168 (Homer Quartzite, p. 158, shown on pl. 3, scale 1:125,000).

Engel, Rene, 1959, Geology of the Lake Elsinore quadrangle, California: California Div. Mines Bull. 146, pp. 9–58 (quartzite in Santa Ana Formation, pp. 17–21).

Eric, John H., and others, 1955, Geology and mineral deposits of the Angels Camp and Sonora quadrangles, Calaveras and Tuolumne Counties, California: California Div. Mines Special Report 41, 55 pp. (quartzite in Calaveras Formation, p. 8).

Evans, James R., 1966, Geology and mineral deposits of Mescal Range quadrangle: California Div. Mines and Geology Bull. (in press) (brown weathering, vitreous quartzite in Prospect Mountain Quartzite).

Everhart, Donald L., 1951, Geology of the Cuyamaca Peak quadrangle, San Diego County, California: California Div. Mines Bull. 159, pp. 51–115 (quartzite in Julian Schist, pp. 58–60).

Ferguson, Henry G., and Gannett, Roger W., 1932, Gold quartz veins of the Alleghany district, California: U.S. Geol. Survey Prof. Paper 172, 139 pp. (Relief Quartzite, p. 12, shown on pl. 1, scale 1:12,000).

Fiedler, William Morris, 1944, Geology of the Jamesburg quadrangle, Monterey County, California: California Div. Mines Rept. 40, pp. 177–250 (quartzite in Sur Series, p. 182).

Gardner, Dion L., 1940, Geology of the Newberry and Ord Mountains, San Bernardino County, California: California Div. Mines Rept. 36, pp. 257–292 (quartzite in earlier Precambrian metasediments, Prospect Mountain Quartzite, Saragossa Quartzite, pp. 262–266, shown on pl. 2, scale 1:250,000).

Gay, Thomas E., Jr., Geology of Upper Coffee Creek, Etna quadrangle, California, University of California, Berkeley, unpublished M.A. thesis, 1949.

Gay, Thomas E., Jr., and Wright, Lauren A., 1954 (1955), Geology of the Talc City area, Inyo County: California Div. Mines Bull. 170, map sheet 12 (description of Eureka Quartzite, shown on map, scale 1:24,000).

Goldman, Harold B., 1957, Stone, dimension: California Div. Mines Bull. 176, pp. 591–606 (Red Rose quartzite deposit, p. 602).

Greife, J. L., and others, 1959, Geology of the Mazourka Canyon area, Independence quadrangle, Inyo County, California: Geol. Soc. America Bull. vol. 70, pp. 1722, 1723 (abstract; includes undifferentiated Eureka Group consisting of interbedded quartzite, limestone, dolomite).

A. P. Green Fire Brick Co., 1961 (Jan.), Silica refractories: Brick & Clay Record, vol. 138, no. 1, pp. 71, 106–109 (properties and uses of silica brick).

Grose, L. Trowbridge, 1959, Structure and petrology of the northeast part of the Soda Mountains, San Bernardino County, California: Geol. Soc. America Bull. vol. 70, pp. 1509–1548 (Prospect Mountain Quartzite, pp. 1516, 1517, shown on plate 1, scale 1:31,680).

Grout, Frank F., 1932, Petrography and petrology, New York, McGraw-Hill, 522 pp. (quartzite, pp. 366–368).

Guillou, Robert B., 1953, Geology of the Johnston Grade area, San Bernardino County, California: California Div. Mines Special Rept. 31, 18 pp. (Saragossa Quartzite, quartzite-bearing Chicopee Formation, pp. 7–10, shown on pl. 1, scale 1:24,000).

Hall, Wayne E., and MacKevett, E. M., 1958, Economic geology of the Darwin quadrangle, Inyo County, California: California Div. Mines Special Rept. 51, 73 pp. (Eureka Quartzite in Talc City Hills, p. 7, shown on pl. 2, scale 1:21,000).

Harbison-Walker Refractories Co., 1961 (Jan.), Basic refractories: Brick & Clay Record, vol. 138, no. 1, pp. 70, 71, 96 (uses of basic refractories; refractories for the basic oxygen steel process).

Hadley, Jarvis B., 1948, Iron ore deposits in the eastern part of the Eagle Mountains, Riverside County, California: California Div. Mines Bull. 129, pp. 3–24 (vitreous quartzite, pp. 4, 5, shown on pl. 2, scale 1:2,400).

Hamilton, Warren B., 1956, Geology of the Huntington Lake area, Fresno County, California: California Div. Mines Special Rept. 46, 25 pp. (quartzite, p. 7, shown on pl. 1, scale 1:63,360).

Harder, E. C., 1912, Iron-ore deposits of the Eagle Mountains. California: U. S. Geol. Survey Bull. 503, 81 pp. (vitreous quartzite, pp. 30–35, shown on pl. 1, scale 1:12,000, fig. 3, scale approx. 1:62,500).

Hart, Earl W., 1959, Geology of limestone and dolomite in the southern half of the Standard quadrangle, Tuolumne County, California: California Div. Mines Special Rept. 58, 25 pp. (quartzite and metachert in the Calaveras Group. p. 12, shown on pl. 2, scale 1:9800).

Hazzard, John C., 1933, Notes on the Cambrian rocks of the eastern Mojave Desert, California: Univ. Calif. Dept. Geol. Sci. Bull. vol. 23, pp. 57–80 (quartzite, called Prospect Mountain Quartzite in Hazzard 1954, in Marble Mountains, Providence Mountains, Ship Mountains).

Hazzard, John C., 1937a, Paleozoic section in the Nopah and Resting Springs Mountains: California Div. Mines Rept. 33, pp. 273–339 (Stirling Quartzite, p. 306, Zabriskie Quartzite, p. 309, Eureka Quartzite, pp. 324, 325; columnar section, fig. 3).

Hazzard, John C., 1937b, Paleozoic in the Providence Mountains, San Bernardino County, California: Geol. Soc. America Bull. Proc., pp. 240, 241 (abstract; Lower Cambrian Toughnut Quartzite, renamed Prospect Mountain Quartzite in Hazzard 1954).

Hazzard, John C., 1954 (1955), Rocks and structures of the northern Providence Mountains, San Bernardino County, California: California Div. Mines Bull. 170, chap. 4, contr. 4, pp. 27–35 (Prospect Mountain Quartzite, table 1, pl. 2, scale 1:31,680).

Heinrich, E. William, 1956, Microscopic petrography, New York, McGraw-Hill, 296 pp. (quartzite, pp. 206–209).

Henshaw, Paul C., 1942, Geology and mineral deposits of the Cargo Muchacho Mountains, Imperial County, California: California Div. Mines Rept. 38, pp. 147–196 (Vitrefrax Formation, pp. 153, 154, shown on pl. 2, scale 1:48,000).

Hershey, Oscar H., 1901, Metamorphic formations of northwestern California: Am. Geologist, vol. 27, pp. 225–245 (quartzite in Abrams Formation, p. 226).

Hewett, D. F., 1956, Geology and mineral resources of the Ivanpah quadrangle, California and Nevada: U. S. Geol. Survey Prof. Paper 275, 172 pp. (Prospect Mountain Quartzite in Ivanpah Mountains, Clark Mountains, Kingston Range, Old Dad Mountains, pp. 29–31, shown on pl. 1, scale 1:125,000).

Hinds, Norman E. A., 1932, Paleozoic eruptive rocks of the southern Klamath Mountains, California: Univ. Calif. Dept. Geol. Sci. Bull. vol. 20, pp. 375–410 (Chanchelulla Formation, pp. 392, 393).

Hinds, Norman E. A., 1933, Geologic formations of the Redding-Weaverville districts, northern California: California Div. Mines Rept. 29, pp. 76–122 (quartzite in Abrams Formation, p. 81; Chanchelulla Formation, p. 85, shown on pl. 3, scale 1:250,000).

Hopper, R. H., 1947, Geologic section from the Sierra Nevada to Death Valley, California: Geol. Soc. America Bull. vol. 58, pp. 393–432 (Zabriskie Quartzite, p. 406; Eureka Quartzite, p. 407; both shown on pl. 1, scale 1:220,000).

Hoppin, Richard A., 1954, Geology of the Palen Mountains gypsum deposit, Riverside County, California: California Div. Mines Special Rept. 36, 25 pp. (quartzite in Maria Formation, p. 14, shown on pl. 1, scale 1:9600).

Howkins, J. E., and others, 1961, Analysis of open-hearth oxygen injection: Jour. Metals, vol. 13, pp. 292–297.

Hulin, Carlton D., 1925, Geology and ore deposits of the Randsburg quadrangle, California: California Min. Bur. Bull. 95, 152 pp. (quartzite in the Rand Schist, p. 25).

Irwin, William P., 1960, Geologic reconnaissance of the northern Coast Ranges and Klamath Mountains, California, with a summary of mineral resources: California Div. Mines Bull. 179, 80 pp., (quartzite in Abrams Formation, pp. 18, 19; Chanchelulla Formation, p. 21; quartzite-bearing metasediments, p. 24).

Jahns, Richard H., and Muehlberger, William R., 1954 (1955), Geology of the Soledad basin, Los Angeles County: California Div. Mines Bull. 170, map sheet 6 (description of quartzite in Pelona Schist, shown on map, scale 1:84,000).

Jahns, Richard H., and Wright, Lauren A., 1951, Gem-and-lithium-bearing pegmatites of the Pala district, San Diego County, California: California Div. Mines Special Rept. 7A, 72 pp. (quartzite-bearing metasediments, p. 9).

Jeffrey, J. A., and Woodhouse, C. D., 1931, Note on a deposit of andalusite in California; its occurrence and technical importance: California Div. Mines Rept. 27, pp. 459–464 (quartzite near White Mountains andalusite deposit, p. 460).

Jennings, Charles W., 1958, Death Valley sheet: California Div. Mines Geologic Map of California, scale 1:250,000 (undivided Ordovician rocks, including Eureka Quartzite, in Owens Valley and Nopah Range; undivided Cambrian rocks, including Zabriskie Quartzite, in Nopah and Resting Spring Ranges).

Johansson, Folke, 1957, Swedish oxygen steelmaking: Jour. Metals, vol. 9, pp. 972–975 (Kal-Do process).

Kraner, H. M., 1944, Determining the quality of silica brick: Natl. Open Hearth Conference, A.I.M.E., Proc. vol. 27, pp. 303–309.

Krauskopf, Konrad B., 1953, Tungsten deposits of Madera, Fresno, and Tulare Counties, California: California Div. Mines Special Rept. 35, 83 pp. (quartzite, p. 5, shown on pl. 1, scale 1:125,000).

Kupfer, Donald H., 1954 (1955), Geology of the Silurian Hills, San Bernardino County: California Div. Mines Bull. 170, map sheet 19 (description of quartzite in Pahrump Series, shown on map, scale 1:36,000).

Lamey, Carl A., 1948a, Old Dad Mountain iron-ore deposit, San Bernardino County, California: California Div. Mines Bull. 129, pp. 59–68 (quartzite, called Prospect Mountain Quartzite in Hewett, 1956, pp. 62, 63, shown on fig. 21, scale 1:4000).

Lamey, Carl A., 1948b, Iron Hat (Ironclad) iron-ore deposits, San Bernardino County, California: California Div. Mines Bull. 129, pp. 97–109 (quartzite, called Prospect Mountain Quartzite in Hazzard, 1954, in Marble Mountains, p. 103, shown on pl. 10, scale 1:6000).

Langenheim, R. L., Jr., and others, 1956, Middle and Upper (?) Ordovician rocks of Independence quadrangle, California: Am. Assoc. Petroleum Geologists Bull. vol. 40, pp. 2081–2097 (quartzite in undifferentiated upper part of Eureka Group, pp. 2092, 2093).

Larsen, Esper S., Jr., 1948, Batholith and associated rocks of Corona, Elsinore, and San Luis Rey quadrangles, southern California: Geol. Soc. America Mem. 29, 182 pp. (Paleozoic quartzites, p. 17; quartzite in Bedford Canyon Formation, p. 19).

Larsen, Esper S., Jr., 1951, Crystalline rocks of the Corona, Elsinore, and San Luis Rey quadrangles, southern California: California Div. Mines Bull. 159, pp. 7–50 (Paleozoic schists and quartzites, Bedford Canyon Formation, p. 14—condensed from Larsen 1948).

Le Chatelier H., and Bogitch, B., 1918, Sur les propriétés refractaires de la silica: British Ceram. Soc. Trans. vol. 17, p. 15.

Lindgren, Waldemar, 1900, Colfax folio, California: U. S. Geol. Survey Geol. Atlas of the U.S., folio 66 (Relief Quartzite, p. 2, shown on map, scale 1:62,500).

Lydon, Philip A., and others, 1960, Westwood sheet: California Div. Mines Geologic Map of California, scale 1:250,000 (undivided Paleozoic rocks, including Shoo Fly Formation, Grizzly Formation; undivided Silurian rocks, including Taylorsville Formation).

Macdonald, G. A., 1941, Geology of the western Sierra Nevada between the Kings and San Joaquin Rivers, California: Univ. Calif. Dept. Geol. Sci. Bull. vol. 26, pp. 215–273 (quartzite, p. 220).

MacKevett, Edward M., 1951, Geology of the Jurupa Mountains, San Bernardino and Riverside Counties, California: California Div. Mines Special Report 5, 14 pp. (quartzite in Jurupa Series, p. 6).

Mantell, C. L., 1940, Industrial electrochemistry, 2d ed., New York, McGraw-Hill, 656 pp. (ferrosilicon, p. 492; silicon, p. 493; table showing raw materials, furnace type, operating details for ferroalloys, p. 499).

Mason, J. F., 1948, Geology of the Tecopa area, southeastern California: Geol. Soc. America Bull. vol. 59, pp. 332–352 (Zabriskie Quartzite, Stirling Quartzite, table 1, pp. 336–341; pl. 2, scale 1:62,500, shows undifferentiated Wood Canyon Formation, Stirling Quartzite).

McAllister, James F., 1952, Rocks and structures of the Quartz Spring area, northern Panamint Range, California: California Div. Mines Special Rept. 25, 38 pp. (Eureka Quartzite, pp. 12, 13, shown on pl. 1, scale 1:31,680).

McAllister, James F., 1955, Geology of mineral deposits in the Ubehebe Peak quadrangle, Inyo County, California: California Div. Mines Special Rept. 42, 63 pp. (Eureka Quartzite, p. 11).

McMulkin, F. J., 1955, Oxygen steel produced at Dofasco can compete with open hearth: Jour. Metals, vol. 7, pp. 530–534 (plant of Dominion Foundries and Steel Ltd., Canada).

Melhase, John, 1925, Andalusite in California: Eng. Min. Jour.—Press, vol. 120, pp. 91–94 (quartz, called quartzite in Wright, 1957, near White Mountains andalusite deposit, p. 92).

Merriam, Charles W., and Smith, Ward C., Geologic map of the New York Butte quadrangle, California, scale 1:62,500, U. S. Geol. Survey, unpublished, 1951.

Merriam, Richard, 1946, Igneous and metamorphic rocks of the southwestern part of the Ramona quadrangle, San Diego County, California: Geol. Soc. America Bull. vol. 57, pp. 223–260 (quartzite in Julian Schist, pp. 227, 228).

Merriam, Richard, 1958, Geology of Santa Ysabel quadrangle, San Diego County, California: California Div. Mines Bull. 177, pp. 7–20 (quartzite in Julian Schist, p. 9).

Meschter, Elwood, 1958 (Nov.), Quartzite tough and expensive but hard to beat for railroad ballast: Rock Products, vol. 61, no. 11, pp. 78–81, 135, 136 (quartzite quarry at Rock Springs, Wisconsin).

Miller, William J., 1931, Geologic sections across the Sierra Nevada: Univ. Calif. Dept. Geol. Sci. Bull. vol. 20, pp. 331–360 (Kernville Series, p. 335).

Miller, William J., 1935, A geologic section across the southern Peninsular Range of California: California Div. Mines Rept. 31, pp. 115–142 (quartzite in Julian Schist near Jacumba, p. 120).

Miller, William J., 1944, Geology of the Palm Springs-Blythe strip, Riverside County, California: California Div. Mines Rept. 40, pp. 11–72 (quartzite in Palm Canyon complex, p. 22; quartzite in Maria Formation, p. 26; quartzite in Eagle Mountains, p. 31).

Miller, William J., and Webb, Robert W., 1940, Descriptive geology of the Kernville quadrangle, California: California Div. Mines Rept. 36, pp. 343–378 (quartzite in Kernville Series, pp. 349–353, shown on pl. 2, scale 1:125,000).

Moore, A. K., 1961, Future of the open hearth: Jour. Metals, vol. 13, pp. 303–304.

Noble, Levi F., and Wright, Lauren A., 1954 (1955), Geology of the central and southern Death Valley region, California: California Div. Mines Bull. 170, chap. 2, contr. 10, pp. 143–160.

Norman, L. A., Jr., and Stewart, Richard M., 1951, Mines and mineral resources of Inyo County, California: California Jour.

Mines and Geology vol. 47, pp. 17–223 (Lakeview talc deposit, p. 118).

Oakeshott, Gordon B., 1937, Geology and mineral deposits of the western San Gabriel Mountains, Los Angeles County, California: California Div. Mines Rept. 33, pp. 215–249 (quartzite in Placerita Formation, p. 222).

Oakeshott, Gordon B., 1958, Geology and mineral deposits of San Fernando quadrangle, Los Angeles County, California: California Div. Mines Bull. 172, 147 pp. (quartzite in Pelona Schist, pp. 49, 50; quartzite in Placerita Formation, pp. 50, 51).

Page, Ben M., 1951, Talc deposits of steatite grade, Inyo County, California: California Div. Mines Special Rept. 8, 35 pp. (silica rock, called quartzite in Hall 1958, in Talc City Hills, p. 8, shown on fig. 5, scale 1:14,000 and larger scale maps).

Patchick, Paul F., Economic geology of the Bullion mining district, San Bernardino County, California, University of Southern California, unpublished M.A. thesis, 1959 (Prospect Mountain Quartzite, Ivanpah Mountains).

Pearson, Oscar, 1959 (May 7), New open-hearth practice links oxygen, sprung basic roof: Iron Age, vol. 183, no. 19, pp. 98–100.

Philbrook, W. O., 1958, Thermochemistry of oxygen steel: Jour. Metals, vol. 10, pp. 477–482.

Prout, John W., Jr., 1940, Geology of the Big Blue group of mines, Kernville, California: California Div. Mines Rept. 36, pp. 379–421 (quartzite in Kernville Series, p. 391).

Reiche, Parry, 1936, Geology of the Lucia quadrangle, California: Univ. Calif. Dept. Geol. Sci. Bull. vol. 24, pp. 115–168 (quartzites, pp. 118–121).

Richmond, James Frank, 1960, Geology of the San Bernardino Mountains north of Big Bear Lake, California: California Div. Mines Special Rept. 65, 68 pp. (Chicopee Canyon Formation, pp. 11–15; quartzite in Furnace Formation, p. 16; both shown on pl. 1, scale 1:31,680).

Rigby, G. R., White, R. P., Booth, H., and Green, A. T., 1946, An investigation into the properties of silica bricks: British Ceram. Soc. Trans. vol. 45, pp. 69–105.

Rock Products, 1957 (March), vol. 60, no. 3, pp. 76–79, From rock to silicon (quartzite quarry at Clifton Forge, Virginia; manufacture of silicon and silicones by Union Carbide and Carbon Corp.).

Ross, Donald C., 1958, Igneous and metamorphic rocks of parts of Sequoia and Kings Canyon National Parks, California: California Div. Mines Special Rept. 53, 24 pp. (quartzite near Hospital Rock, p. 5, shown on pl. 1, scale 1:62,500).

Ross, D. W., 1918, Silica refractories: Am. Ceram. Soc. Jour., vol. 1, pp. 447–501.

Silberling, N. J., Schoellhamer, J. E., Gray, Clifton H., Jr., and Imlay, R. W., 1961, Upper Jurrasic fossils from Bedford Canyon Formation, Southern California: Am. Assoc. Petroleum Geologists Bull. vol. 45, pp. 1746–1748.

Simpson, Edward C., 1934, Geology and mineral resources of the Elizabeth Lake quadrangle, California: California Div. Mines Rept. 30, pp. 371–415 (quartzite in Pelona Schist, p. 380).

Sommer, A. H., 1959, Basic construction in the open-hearth: Jour. Metals, vol. 11, pp. 623–627.

Troxel, Bennie W., 1954 (1955), Geology of a part of the Shadow Mountains, western San Bernardino County: California Div. Mines Bull. 170, map sheet 15 (description of quartzite in Oro Grande Series, shown on map, scale 1:20,850).

Tucker, W. Burling, 1926, Imperial County: California Min. Bur. Rept. 22, pp. 248–285 (quartzite in Coyote Mountains shown on map facing p. 276, scale 1:31,680).

Tucker, W. Burling, and Sampson, Reid J., 1930, San Bernardino County: California Div. Mines Rept. 26, pp. 202–325 (quartzite quarries of Emsco Refractories Co., Kennedy quarry, pp. 302, 303).

Tucker, W. Burling, and Sampson, Reid J., 1943, Mineral resources of San Bernardino County: California Div. Mines Rept. 39, pp. 247–249 (Emsco quarry, p. 542).

United States Steel Corp., 1957, The making, shaping, and treating of steel, 7th ed., United States Steel Corp., Pittsburgh, Penna., 1048 pp. (LD process of making steel, p. 285).

Vaughan, F. E., 1922, Geology of the San Bernardino Mountains north of San Gorgonio Pass: Univ. Calif. Dept. Geol. Sci. Bull. vol. 13, pp. 319–411 (Saragossa Quartzite near Baldwin Lake, p. 357).

Ver Planck, William E., 1952, Gypsum in California: California Div. Mines Bull. 163, 151 pp. (quartzite in Maria Formation, Little Maria Mountains, p. 16, shown on pl. 2, scale 1:12,000).

Wallace, Robert E., 1949, Structure of a portion of the San Andreas rift in southern California: Geol. Soc. America Bull. vol. 60, pp. 781–806 (quartzite in Pelona Schist, Portal Ridge, p. 786).

Weber, F. Harold, Jr., 1958 (Dec. 2), California Div. Mines unpublished report (silicon plant of Silicon Metals Div., Ward-Lee Chemical Corp., at Dixieland, Imperial County, California).

Wells, Francis G., and others, 1949, Chromite deposits near Seiad and McGuffy Creeks, Siskiyou County, California: U.S. Geol. Survey Bull. 948-B, pp. 19–62 (quartzite in schist, called Abrams Formation in Irwin 1960, p. 23).

Wiese, John H., 1950, Geology and mineral resources of the Neenach quadrangle, California: California Div. Mines Bull. 153, 53 pp. (quartzite in Pelona Schist, pp. 12–15; quartzite in Paleozoic (?) metasediments, pp. 16–18).

Williams, Howel, 1949, Geology of the Macdoel quadrangle, California: California Div. Mines Bull. 151, pp. 7–60 (quartzite at Yellow Butte, p. 14; quartzite in metasediments near Yreka, pp. 14, 15).

Wright, Lauren A., 1952, Geology of the Superior talc area, Death Valley, California: California Div. Mines Special Rept. 20, 22 pp. (quartzite in Pahrump Series, pp. 9–15, shown on pl. 1, scale 1:4800).

Wright, Lauren A., 1954a, Geology of the Silver Lake talc deposits, San Bernardino County, California: California Div. Mines Special Rept. 38, 30 pp. (quartzite in Earlier Precambrian metasediments, pp. 9, 27, shown on pl. 1, scale 1:1800).

Wright, Lauren A., 1954b, Geology of the Alexander Hills area, Inyo and San Bernardino Counties: California Div. Mines Bull. 170, map sheet 17 (description of quartzite in Pahrump Series, Stirling Quartzite, shown on map, scale 1:31,680).

Wright, Lauren A., 1957, Kyanite, andalusite, and related minerals: California Div. Mines Bull. 176, pp. 275–280 (quartzite in White Mountains andalusite area, p. 276, shown on cross-section, fig. 3; quartzite in Vitrefrax Formation, Cargo Muchacho Mountains, pp. 276, 277).

Wright, Lauren A., and others, 1953, Mines and mineral deposits of San Bernardino County, California: California Jour. Mines and Geology, vol. 49, pp. 49–259 (Atlas quarry, p. 196, tab. list p. 166; quartzite in Earlier Precambrian metasediments near Yucca Grove, pp. 202, 216; Emsco quarry, tab. list p. 166; Golconda quarry, tab. list p. 166; Kennedy quarry, tab. list p. 167).

Wright, Lawrence B., 1946, Geology of Santa Rosa Mountain area, Riverside County, California: California Div. Mines Rept. 42, pp. 9–13 (quartzite in Paleozoic (?) metasediments, p. 11, shown on pl. 1, scale 1:30,000).

LIST OF

QUARTZITE DEPOSITS IN CALIFORNIA

BASIN—RANGES

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
1	Triassic(?) or Paleozoic(?) Quartz conglomerate El Paso Mtns.	Sec. 36, T. 29 S., R. 37 E., Sec. 1, T. 30 S., R. 37 E., MD., approx. 1 mi. E. of Redrock Canyon in El Paso Mtns.	Lenticular masses up to 800 ft. thick in metamorphic rocks cropping out within 1 square mi. area.	Associated with hornfels; rounded, flattened quartz pebbles up to 2 in. long in matrix of dark gray quartzite.	Dibblee 52:19; 54; Ver Planck, unpublished field notes.
2	Pre-Mesozoic Quartzite White Mtns. andalusite area	Sec. 13, T. 3 S., R. 33 E., MD., 18 mi. N. of Bishop on west face of White Mtns.	Elongate bodies of quartzite several hundred to 1,200 ft. wide.	Quartzite associated with schist and metaporphyry; andalusite within or marginal to the quartzite bodies. Lithology: Light-colored. Weathered surface iron-stained from included pyrite. In thin section: holocrystalline with typical hypidiomorphic texture. Principal mineral is quartz. Feldspar occurs sparingly. Zircon is accessory.	Production of andalusite. Jeffrey 31:460; Melhase 25:92; Wright 57:276, fig. 3.
3	Permian Quartzite in Garlock Series El Paso Mtns.	Mostly Sec. 32, T. 28 S., R. 39 E., Sec. 4, T. 29 S., R. 39 E., MD., in NE. part El Paso Mtns.	Steeply dipping quartzite member 700 ft. thick with outcrop 2–3 mi. long	Member 10 of Dibblee (52). Lies on thin-bedded, hard, gray to brown shale of member 9. Overlain by thin-bedded tan to brown shale and chert of member 11. Lithology of the quartzite: Tan, thick-bedded to massive, very fine grained quartzite with interbeds of chert and minor interbeds of shale.	Dibblee 52:16, pl. 1.
4	Middle Ordovician Eureka Quartzite Lakeview	Sec. 4, T. 16 S., R. 37 E., MD., on lower slope of Inyo Mtns., 6 mi. SE. of Lone Pine	Outcrop 370 ft. wide, at least ½ mi. long; dip 75°–85° SW.	Lies on gray dolomite of Pogonip Limestone with possible bedding plane fault at base. Overlain by dark nodular Ely Springs Dolomite. Contains basic dikes. Lower part is platy, iron-stained, and impure. Upper part is massive, vitreous, high-purity quartzite. Lithology of upper part: blocky, brown-weathering, outcrops covered with talus blocks. In hand specimen: light gray, vitreous quartzite with sparse specks of limonite. In thin section: mostly anhedral, interlocking quartz grains with small amount of fine mica and opaque matter. Typical analysis: SiO_2, 99.66%; Al_2O_3, 0.16; Fe_2O_3, 0.00; TiO_2, 0.00; P_2O_5, 0.00; CaO, 0.00; MgO, 0.00; Na_2O, 0.02; K_2O, 0.02; H_2O, 0.14.	Production of quartzite for manufacture of super duty silica brick, 1956 intermittent to present (1961) by Brownstone Mining Co. for Gladding, McBean & Co. Bateman 54; Jennings 58; herein.
5	Mazourka Canyon	West edge T. 12 S., R. 36 E., MD. (proj.), east side of Mazourka Canyon, NE. of Independence.	Quartzite tongues 5–30 ft. thick in Ordovician rocks that crop out for 5 miles and dip 60°–80° W.	Eureka Group of Langenheim lies on Mazourka Fm. of Pogonip Group; overlain by Ely Springs Dolomite. Consists of Barrel Spring Fm. (below), mostly impure quartzite, shale, limestone; and undifferentiated upper part, 160–208 ft. thick, composed of impure carbonate rocks, shale, and quartzite tongues. Lithology of the quartzite: individual beds markedly lenticular; blocky, white- or buff-weathering; massive, vitreous, white, fine- to medium-grained.	Bateman 54; Greife 59; Langenheim 56:2092, 2093.
6	Nopah Range	N. part T. 23 N., R. 8 E., SB. (proj.), on west slope near north end of range.	Outcrop 100–265 ft. thick, 3 to 4 miles long; dip 20°–30° NE.	Lies on sandy buff- to brown-weathering Pogonip(?) Dolomite. Overlain by dark Ely Springs(?) Dolomite with chert nodules near the base. Consists of a main part of massive quartzite with a basal 15 ft. and an uppermost 2 ft. of platy, impure quartzite. Lithology of the massive quartzite: reddish- or yellowish brown-weathering. Has poorly defined bedding planes 2 in. to 1 ft. apart. Cross bedding present but uncommon. White to pale pink	Hazzard 37a. 324, 325, fig. 3; Jennings 58.
7	Quartz Spring area	In and near T. 14 S., R. 41 E., MD. (proj.) in Andy Hills, Last Chance foothills, south flank of Whitetop Mtn.	400 ft. thick, incl. 250 ft. of vitreous quartzite. Total outcrop length, 2 to 3 miles.	Lies on gray, sandy dolomite of Pogonip Limestone Overlain by dark gray Ely Springs Dolomite with abundant chert nodules near base. Lower 150 ft. consists of interbedded hematitic quartzite, vitreous quartzite, and platy quartzite. Upper 250 ft. consists of vitreous quartzite. Lithology of the upper part: forms blocky cliffs or is covered with angular talus blocks. White or pinkish, vitreous quartzite. In thin section: quartz grains 0.25–0.30 mm. dia., well rounded with quartz cement in optical continuity, making an interlocking mosaic.	McAllister 52:12, 13, pl. 1.
8	Swansea	SE. cor. Sec. 24, NE. cor. Sec. 25, T. 16 S., R. 37 E., MD., at end of spur of Inyo Mtns. just south of Swansea.	Outcrop 300 ft. wide, 3,000 ft. long, complexly faulted. Steep dip NE.	Lies on gray dolomite of Pogonip Limestone; overlain by nodular Ely Springs Dolomite. Lithology: white to grayish, vitreous quartzite with numerous steep-dipping zones 5–10 ft. wide of soft material. Representative partial analysis: Al_2O_3, 0.105%; alkalies, 0.085%.	Quartzite for manufacture of super duty silica brick produced 1955 by Mineral Materials Co. for Gladding, McBean & Co. Bateman 54; Brooks 55; Jennings 58; herein.
9	Talc City Hills	T. 18 S., R. 39 E., MD. (proj.) NE. of White Swan mine in NW. part of Talc City Hills.	440 ft. max thickness exposed in NW.-trending fault slices. Total outcrop length several thousand ft.	Lies on medium gray dolomite with dark brown-weathering siliceous beds of Pogonip Group. Overlain by dark gray Ely Springs Dolomite with chert nodules. Mostly vitreous quartzite, but has brown-weathering, in part platy, quartzite near base. Lithology: white to gray, massive, vitreous quartzite with virtually no feldspar or ferromagnesian minerals.	Gay 55; Hall 58:7, pl. 2; Page 51.8, fig. 5.
10	Trail Canyon	T. 18 S., R. 46 E., MD. (proj.), east face Panamint Range near Trail Canyon.	250 ft. thick.	Lies on dolomite beds that contain Lower Ordovician fossils. Overlain by dark gray Ely Springs(?) Dolomite. Lithology: yellowish brown-weathering. Beds a few inches to 1 ft. thick. White, saccharoidal quartzite.	Hopper 47:408, pl. 1.
11	Ubehebe Peak area	T. 14 S., R. 40 E., MD., (proj.), 2½ mi. N. of Ubehebe Peak on W. side Racetrack Valley.	400 ft. thick; outcrop several thousand ft. long.	Lies on Pogonip Limestone, which is sandy or quartzitic in places near the top. Overlain by dark gray Ely Springs Dolomite containing chert nodules near the base. Lower part is platy, iron-bearing quartzite with some shale. Upper part is nearly white, massive, vitreous quartzite.	McAllister 55:11
12	Lower Cambrian Zabriskie Quartzite (member Wood Canyon Fm.) Aguereberry Point	Center of E. edge T. 15 S., R. 45 E., MD. (proj.) at Augereberry Point on E. face of Panamint Range.	70 ft. thick, E. dip. Outcrops for at least 5 mi. along the mtn. front.	Lies on micaceous, somewhat shaly, quartzite with a few beds of dolomite. Overlain by fossiliferous, green shale. Lithology: Light pink, cross laminated, saccharoidal quartzite.	Hopper 47:406, pl. 1

BASIN—RANGES—Continued

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
13	Lower Cambrian Zabriskie Quartzite Dublin Hills (member Wood Canyon Formation)	Sec. 35, T. 22 N., R. 6 E., SB., in Dublin Hills west of Shoshone.	200 ft. thick (may be repeated by faulting). Outcrop length 750 ft. in best exposure, but outcrops in the area total several mi.	Lies on purplish gray quartzite containing sandy, micaceous, and feldspathic(?) layers. Overlain by brown quartzite interbedded with greenish, schistose shale. Lithology: faintly pink to grayish, vitreous quartzite with sparse pin point-sized black and brown specks. Parts are cut by ⅛-inch quartz veins. In thin section: quartz grains, av. 0.2 mm. dia., many well rounded with oriented overgrowths; also anhedral grains not notably interlocking. Sericite, tourmaline, zircon, magnetite, and limonite present but not abundant. Representative analysis: SiO_2, 99.39%; Al_2O_3, 0.36; Fe_2O_3, 0.04; TiO_2, 0.0; P_2O_5, 0.0; CaO, 0.0; MgO, 0.0; Na_2O, 0.016; K_2O, 0.081; H_2O, 0.11.	Chesterman, unpublished; Mason 48; herein.
14	McLain Peak	Sec. 18, T. 20 N., R. 7 E., SB., 10 mi. S. of Shoshone.	40 ft. thick. Exposed without overburden within an area of 50-100 acres.	Lies on gray, banded quartzite and pebbly quartzite. Lithology: Brownish-weathering, massive quartzite that forms blocky talus. In hand specimen: slightly pinkish, vitreous quartzite with sparse black specks. In thin section: quartz, mostly in rounded grains. Interlocking texture not well developed Has minor interstitial sericite.	Herein
15	Nopah and Resting Spring Ranges	Sec. 13, T. 21 N., R. 7 E., SB., 2½ mi. N. of Resting Spring on W. face of Resting Spring Range (section of Hazzard 37a). Also occurs for 1½ miles S. of Shoshone-Pahrump road on W. face of Resting Spring Range, on E. side Emigrant Pass, and near Noonday mine in Nopah Range.	Approx. 100 ft. thick. Total outcrop length is several mi.	Lies on gray, micaceous, platy shale with brown-weathering sandstone beds. Overlain by rusty brown-weathering, platy quartzite interbedded with dark greenish, sandy shale. Upper 100 ft. consists of massive, vitreous quartzite. Lower 60 ft. consists of reddish-brown, sandy shale and shaly quartzite, locally conglomeratic, with 10 ft. of massive quartzite at base. Lithology of massive upper part: Salmon-pink- to rusty brown-weathering, massive, indistinctly cross bedded, pinkish to light gray quartzite in beds 1–6 ft. thick.	Hazzard 37a.306, fig. 3; Mason 48; herein.
16	Stirling Quartzite Alexander Hills	Sec. 34, T. 20 N., R. 8 E., SB., on E. side of Tecopa Pass and extending to S.	Total thickness 2,000 ft. Outcrop length 2–3 mi.	Lies on interbedded shale and quartzite with subordinate dolomite of upper part of Johnnie Fm. Overlain by greenish-gray shale, quartzite, and dolomite of lower part of Wood Canyon Fm. 3 members. Lower (600 ft.): massive, gray quartzite, locally pebbly; middle (600 ft.): red shaly to platy quartzite; upper (800 ft.): light gray, massive quartzite. Lithology of the massive quartzite: feldspathic.	Wright 54b
17	Dublin Hills	Sec. 23, T. 22 N., R. 6 E., SB., on isolated spurs along north edge of Dublin Hills.	East-dipping quartzite exposed in area of 50–100 acres.	Section observed consists mostly of gray quartzite with brown sandy beds and impure quartzite at the base. Lithology of the gray quartzite: faintly pinkish, obvious rounded grains. In thin section: mostly rounded quartz grains 0.3–0.6 mm. dia. with minor recrystallized chert, plagioclase, and interstitial sericite	Mason 48; Ver Planck unpublished field notes.
18	Nopah and Resting Spring Ranges	Sec. 10(?), T. 20 N., R. 8 E., SB., N. of Noonday mine in Nopah Range (section of Hazzard 37a). Also W. front Nopah Range 2–4 mi. N. of Emigrant Pass and for 1½ mi. at S. end of Resting Spring Range.	Average outcrop width 3,000 ft. Total outcrop length is several mi.	Lies on shale, impure dolomite, or quartzite of Johnnie Fm. Overlain by sandstone and shale of Wood Canyon Fm. 3 members. Lower (1,000 ft.): dense to fine grained light gray to pinkish quartzite, indistinctly cross bedded, beds 2 ft. thick. Lenses of quartz pebbles. Partings of siliceous shale; middle (175 ft.): shaly, micaceous sandstone with dolomite lenses; upper (1,200 ft.): gray quartzite similar to lower member but without pebble lenses.	Hazzard 37a 306, fig. 3, Mason 48
19	Tecopa	Sec. 4, T. 20 N., R. 7 E., SB., in isolated hills just south of Tecopa Hot Springs.	Steep-dipping beds exposed in area of 10–20 acres.	Heterogeneous. Light to dark, cross bedded quartzite, brown to black shale. Beds 5–25 ft. thick. Specimen from the lightest quartzite consists of quartz grains with sparse feldspar and limonite.	Mason 48; Ver Planck unpublished field notes.
20	Later Precambrian Quartzite in Pahrump Series Alexander Hills	Secs. 3, 4, 9, T. 19 N., R. 8 E., SB. (proj.) Secs. 32, 33, T. 20 N., R. 8 E., SB., south of Tecopa Pass in Alexander Hills.	Quartzite-bearing members, max. 1,500 ft. thick; outcrop length, 1–2 mi.	Lies on earlier Precambrian rocks, mostly gneiss. Overlain by Lower Cambrian Noonday Dolomite. From base to top: Crystal Spring Fm. (quartzite, shale, 1,500 ft.; cherty dolomite, limestone, massive chert, 900 ft.; quartzite, shale, dolomite, diabase sills, 1,900 ft.), Beck Spring Dolomite (1,200 ft.), Kingston Peak Fm. (quartzite, 700 ft.; impure conglomeratic quartzite with dolomite and quartzite clasts, 1,800 ft.).	Wright 54b
21	Saratoga Hills	Secs. 25, 26, T. 19 N., R. 5 E., SB. (proj.) in Saratoga Hills, S. end Death Valley	Quartzite members. max. 800 ft. thick exposed in E.-dipping, relatively undeformed section with outcrop 2 mi. long	Lies on earlier Precambrian rocks, mostly quartzite, schist, and gneiss. Overlain, at least locally, by brown quartzite of Lower Cambrian Noonday Dolomite. From base to top: Crystal Spring Fm. (conglomerate member, 20 ft., max.; feldspathic quartzite member, 350–1,300 ft.; purple shale member; fine-grained quartzite member, 100–250 ft.; carbonate member; chert member; upper units), Beck Spring Dolomite, Kingston Peak Fm. (green quartzite member, 450 ft.; conglomeratic quartzite member). Lithology of feldspathic quartzite member: medium light grey, coarse-grained pebbly quartzite grading upward to yellowish, fine to medium grained quartzite. In thin section: 10–25% feldspar, mostly microcline, 2-5% clay and sericite. The remainder is quartz in angular, poorly sorted grains, some recrystallized, some retaining original clastic outlines. Lithology of fine-grained quartzite member: fine-grained, yellowish brown, thinly layered to massive, contains lenses of sandy dolomite. Lithology of green quartzite member: olive to greenish gray, fine-grained quartzite and shale.	Wright 52 9-15 pl 1

MOJAVE DESERT

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
22	Pre-Mesozoic Quartzite in Vitrefrax Fm. Cargo Muchacho Mtns.	In and near Sec. 19, T. 15 S., R. 21 E., SB. (proj.), west side Cargo Muchacho Mtns. near Ogilby.	Comparatively small masses of quartzite associated with mica schist and quartz-kyanite rock.	In contact with intrusive quartz diorite. White quartzite at base grading upward into sericite schist or quartz-mica schist and kyanite-bearing schist. Lithology of the white quartzite: fine grained, gray quartzite composed of equidimensional quartz grains, sparse kyanite and iron oxide.	Production of kyanite. Henshaw 42:153, 154, pl. 2; Ver Planck, unpublished field notes; Wright 57·276, 277.
23	Paleozoic (?) Quartzite in Maria Fm. Big Maria Mtns.	T. 4 S., R. 22 E., T. 4 S., R. 23 E., SB., in south-central part of Big Maria Mtns.	Quartzite units several hundred ft. thick associated with metasediments having total thickness of several thousand ft. and outcrop area of 25 square mi.	Thin-bedded quartzites, thick bedded quartzites, associated with crystalline limestone and relatively small amounts of mica schist and gypsum. Some quartzites are almost pure; others are calcareous.	Miller 44 26.
24	Little Maria Mtns.	Secs. 1, 3, 10, 11, T. 4 S., R. 20 E., SB. (proj.), approx. 3 mi. W. of Midland.	Quartzite member 500–600 ft. thick with outcrop approx. 1 mi. long dips 55°–70° NW.	Lies on buff-weathering, white limestone with gypsum-bearing zones. Overlain by dark-weathering, tan limestone with minor quartzite beds. Lithology: brecciated, faintly banded, tan to white. In thin section: 90% quartz in interlocking, equidimensional grains. The remainder is feldspar and biotite.	Ver Planck 52·16, pl. 2
25	Palen Mtns.	NE. cor. T. 2 S., R. 18 E., SB. (proj.), 20 mi. NE. of Desert Center near Palen Pass.	Quartzite 200–300 ft. thick with outcrop several thousand ft. long.	In northeastern gypsum-bearing series of Hoppin (54), quartzite of several types occurs with marble, laminated marble, lime silicate marble, gypsum, and green schist in a complexly deformed section. Lithology of relatively pure quartzite· pink quartzite containing white mica and scattered euhedra of hematite.	Hoppin 54·14, pl. 1.
26	Saragossa Quartzite Newberry Mtns.	Secs. 12, 15, 22, T. 6 N., R. 3 E., SB., on SW. flank Bessemer Mtn. and NE. border Fry Mtns.	Exposed thickness, 360 ft. outcrop area 1–2 square mi.	Roof pendants in granitic rocks. Red, pink, brownish-black weathering, iron-stained, massive quartzite, sugary in appearance. In thin section: rounded to subrounded quartz grains 0.5–1.0 mm. dia., original grains outlined by sericite. Has quartz overgrowths. Pyrite present.	Gardner 40:265, 266, pl. 2.
27	Vitreous quartzite series of Eagle Mtns.	Secs. 31–36, T. 3 S., R. 14 E., SB. (proj.) in NE. part of Eagle Mtns.	At least 150 ft. thick. Outcrop area 5,000 ft. wide.	Lies on gneiss. Overlain by the dolomite-quartzite series containing the lower iron ore bed of Eagle Mtns. Lithology: massive, dense, hard, usually coarse grained quartzite with disseminated grains of iron oxide.	Undeveloped (Harder 12:30–35, pl. 1, fig. 3; Hadley 48 4, 5, pl. 2; herein.)
28	Metasediments in Antelope Valley	Mostly T. 9 N., R. 17 W., SB., N. of Quinn Ranch at head of Antelope Valley.	Minor quartzite associated with marble and hornfels in unit 2,500 ft. thick.	Isolated roof pendants in granitic rock. From base to top: coarse, blue-white marble, 4,000 ft.; gray and reddish, sandy limestone, pinkish-gray quartzite, black biotite hornfels, 2,500 ft.; medium- to coarsely-crystalline, bluish-gray marble 2,500 ft. Lithology of the quartzite: well bedded, layers a few ft. thick, indistinctly cross bedded, highly jointed.	Wiese 50.16–18.
29	Quartzites and marbles Fry Mtns.	Secs. 18, 19, T. 6 N., R. 3 E., SB., along crest of Camp Rock Ridge on N. border of Fry Mtns.	Comparatively small outcrops of interbedded quartzite and marble, max thickness 490 ft.	Intruded by quartz monzonite. May lie on Saragossa Quartzite. Lithology of the quartzite: commonly greenish, but some is buff or white. In thin section: interpenetrating, anhedral quartz grains with an amphibole (pargasite-?) forming wisps, shreds, radiating fibers within or between quartz grains	Gardner 40:266.
30	Permian (?) Quartzite in Hodge Volcanic Series Hodge	Secs. 28, 29, 31, 33, T. 9 N., R. 3 W.; Sec. 36, T. 9 N., R. 4 W., SB., NW. of Hodge	Steeply dipping quartzite lenses up to 200 ft. thick; max. strike length 1,000 ft.	Quartzite enclosed in sericite schist and biotite schist. Lithology of the quartzite: slightly grayish, vitreous, composed of interlocking quartz crystals, 0.2 mm. av. dia. Sparse non-quartz grains. Chemical analysis: SiO_2, 99 44%; Al_2O_3, 0.39; Fe_2O_3, 0.056; TiO_2, 0.0; P_2O_5, 0.0; CaO, 0.0; MgO, 0.0; Na_2O, 0.002; K_2O, 0.04; H_2O, 0.07.	Operations: 1) Golconda quarry, SW. ¼ Sec. 36, T. 9 N., R. 4 W., Emsco Refractories Co. produced several hundred tons quartzite approx. 1930 for silica brick; 2) Kennedy quarry, Sec. 31, T. 9 N., R. 3 W., Atlas Fire Brick Co. produced quartzite at rate of 3,000–4,000 tons per year during 1920's for silica brick. Bowen 54:34–36, 176, 177, pl. 1; herein.
31	Carboniferous Quartzites of Oro Grande Series Quartzite Mtn.	Secs. 9, 10, 11, 14, 15, 16, 17, T. 6 N., R. 4 W., SB., E. of Oro Grande on N. slope of Quartzite Mtn.	At least 2 quartzite units several hundred ft. thick with outcrops several thousand ft. long.	Type section of Oro Grande Series on Quartzite Mtn., base to top: white dolomite, 1,200 ft.; dark schist-hornfels, 350 ft.; blue-gray limestone, 250 ft.; dark schist-hornfels, 60 ft.; massive quartzite, 250 ft.; black schist with limestone subunits, 500 ft.; massive quartzite indistinguishable from lower quartzite, 250 ft. Lithology of the quartzites: brown-weathering, pinkish white to grayish, massive quartzite. In thin section: almost entirely quartz grains, 0.2–1.0 mm. dia., with irregular boundaries; sparse sericite and muscovite. Typical analysis: SiO_2, 98.90%; Al_2O_3, 0.16; Fe_2O_3, 0.18; TiO_2, 0.04; CaO, 0.23; MgO, 0.08; alkalies, 0.24.	Operations. 1) Atlas quarry, NE. ¼ SE. ¼, Sec. 17, Mineral Materials Co., produced 150,000–200,000 tons quartzite, 1939 to present (1961) for portland cement and (up to 1954) silica brick; 2) Emsco quarry, NW. ¼, NE. ¼, Sec. 11, Emsco Refractories Co., produced several tens of thousands of tons quartzite, approx.-1928–1945, for silica brick; 3) Riverside Cement Co., NE. ¼ NW. ¼ Sec. 17, produced several hundred thousand tons quartzite since approx. 1940 for portland cement and silica brick;) 4 Southwestern Portland Cement Co., E. part Sec. 11, produced over 1 million tons quartzite for portland cement and railroad ballast. Bowen 54:23–34, 175–178; Bowen and Ver Planck 65, herein.
32	Section Twenty Hills	SE. ¼ Sec. 12, T. 8 N., R. 2 W., SB., 7 mi. S. of Barstow off Lucerne Valley road	Gently to moderately dipping quartzite beds; outcrop several hundred ft. wide, ½ mi. long.	In (fault-?) contact with granite gneiss. Very coarse grained, gray to dark gray, somehwat platy quartzite. In thin section: 90–95% quartz grains, 0.6–1.0 mm. dia. with interlocking boundaries; crudely banded with muscovite; minor biotite and magnetite.	Bowen 54:178; Ver Planck unpublished field notes.

MOJAVE DESERT—Continued

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
33	Shadow Mtns.	Sec. 31, T. 8 N., R. 6 W., SB., in Shadow Mtns.	Comparatively thin, gently dipping quartzite units, outcrop areas up to 800 ft. wide and ½ mi. long.	Quartzite occurs near base of Oro Grande Series. Overlain by platy lime-silicate hornfels, schist, and marble. Lithology of the quartzite: massive to well bedded, commonly feldspathic.	Troxel 54.
34	Lower Cambrian Prospect Mtn. Quartzite Bessemer Basin	Sec. 5, T. 5 N., R. 5 E., SB., on hill NW. of Galway Lake.	Exposed thickness, 75 ft.; outcrop, 1/5-mi. long.	Lies with depositional contact on c[illegible]tic rocks. Red-brown weathering cross bedded quartzite, beds 3–4 in. thick, with sub-rounded chert and jasper pebbles, especially near base. In thin section: interpenetrating quartz grains, original sand grains outlined by sericite and iron oxide. No feldspar observed.	(Gardner 40:264, pl. 2.)
35	Clark Mtns.	E. part T. 17 N., R. 12 E., to NW. part T. 17 N., R. 13 E., SB., approx. 3 mi. NW. of Clark Mtn.	Exposed thickness at least 1,500 ft., outcrop area several square mi.	Folded section in fault contact with Goodsprings Dolomite. Overlain by Pioche Shale. Mostly quartzite but has shale layers. Lithology: iron-stained, light gray to tan, coarse to medium grained vitreous quartzite with abundant magnetite. No minerals except quartz and magnetite observed.	Crosby 51.628, 629; fig. 2; Hewett 56:29–31, pl. 1; Ver Planck, unpublished field notes.
36	Ivanpah Mtns.	Sec. 2, T. 15 N., R. 13 E., SB., 3 mi. W. of Kokoweef Pk.; Sec. 14, T. 15 N., R. 13 E., SB., 2 mi. NW. of Standard no. 1 mine; W. ½ Sec. 10, T. 15 N., R. 14 E., SB., near New Trail mine; N. ½ Sec. 22, T. 15 N., R. 14 E., SB., near Allured Hillside mine.	Relatively small outcrops exposed in deformed sections.	Fault contact at base. Overlain by Pioche Shale. Section near New Trail mine, base to top: conglomerate with pebbles of quartz, jasper, flint; cross-bedded, medium to coarse red quartzite, beds 5–10 ft. thick, 500 ft.; fine to medium, gray to white quartzite with 12-inch partings of micaceous phyllite, 200 ft.; gray dolomite.	Hewett 56.29–31, pl. 1, Patchick 59.
37	Kingston Range	T. 20 N., R. 10 E., SB., on ridge W. of Resting Spring road, and T. 20 N., R. 11 E., SB., on ridge 3 mi. NE. of Horse Spring.	Exposed thickness 4,700 ft. Outcrop width 3 mi. Strike length approx. 2 mi.	Lies on Noonday Dolomite. Overlain by Pioche Shale. Lithology: mostly sandstone. Lowest 1,000 ft., from base: red shaly sandstone 75 ft.; thin gray dolomite, 100 ft.; fine grained quartzite with beds of vein quartz and chert pebbles, 500 ft.; oolitic dolomite at 700–800 ft. above base, gray dolomite with quartz pebbles up to ½-in. dia. at 1,000 ft. above base.	Hewett 56:29–31, pl. 1.
38	Marble Mtns.	NE. ¼ Sec. 28, T. 6 N., R. 14 E., SB., approx. 2 mi. NE. of Chambless at south end of Marble Mtns.	Quartzite units several hundred ft. thick in total thickness of 390–450 ft. Strike length 2–3 mi.	Lies on Precambrian granite with depositional contact. Overlain by Lower Cambrian shale. From base to top: Quartzite conglomerate with pebbles of quartz, chert, and jasper, 12 ft.; dark brown to gray quartzite, 351 ft., light gray to white quartzite, 55 ft.; quartzite and shale, 27 ft.; green shale, 40 ft.; bluish limestone, 118 ft. Lithology of the quartzite: beds ½–3 ft. thick, has pebble lenses and shaly layers. Cross bedded. Gray, white, or brown. Iron-stained. Quartz, 85–98%; feldspar, 1–14; zircon, apatite, magnetite, 1.	Clark 21; Hazzard 33; Lamey 48b:103, pl. 10; Ver Planck, unpublished field notes.
39	Mesquite Mtns. (southeast)	NE. part T. 18 N., R. 12 E., SB., in Mesquite Mtns. W. of Mesquite Pass.	3,000–4,000 ft. thick. Strike length 2 mi.	Broad W.-pitching syncline. At base is in fault contact with Minte Cristo Limestone. Overlain by alluvium.	Hewett 56 29–31. pl. 1
40	Mesquite Mtns. (northwest)	E. part T. 19 N., R. 11 E., SW. slope of the hills NW. of Winters Pass.	Max. thickness 500 ft., outcrop length several mi.	Lies on Precambrian granite gneiss with depositional contact. Overlain by aluvium. Lithology in SE part: white granular quartzite with dense, blue-gray, vitreous layers, thin layers of feruginous dolomite, conglomerate with ¼-in. dia. pebbles. In NW. part mostly indurated shale.	Hewett 56:29–31, pl. 1
41	Old Dad Mtn.	Secs. 3, 4, T. 12 N., R. 10 E., SB. (proj.), in NW. part Old Dad Mtn.; Secs. 25, 26, 33, 34, T. 13 N., R. 10 E., SB., near Seventeenmile Point.	Quartzite units 50–100 ft. thick in total thickness of at least 2,142 ft. outcrop area, 2–3 square mi.	Lies on Precambrian gneiss with depositional contact. Overlain by Pleistocene gravel. Lithology: massive dolomite, mainly in the lower part; quartzite, throughout the section; black slate, mostly in the middle part; dolomite, quartzite, shale, sandstone, in upper part. The quartzite units: beds up to 20 ft. thick, cross bedded locally, with conglomerete lens containing quartz and jasper pebbles near top. Red-brown, brown, gray or white.	Barca 66; Hewett 56:29–31, pl. 1; Lamey 48a:62, 63, fig. 21.
42	Lower Cambrian Prospect Mtn. Quartzite Providence Mtns.	NE. part T. 10 N., R. 13 E., to SW. part T. 11 N., R. 14 E., SB., on NW. slope of Providence Mtns. between Hayden Wash and Cornfield Spring Canyon.	Quartzite units several hundred ft. thick in total thickness of 1,085 ft. Total outcrop length, several miles.	Exposed in E.-tilted fault blocks. Lies on Precambrian granite, gneiss, schist with depositional contact. Overlain by Latham Shale. From base to top: greenish black, shaly quartzite with pebble lenses near base, 10 ft.; limestone, locally dolomitized, 30–50 ft.; dark, platy, fine grained quartzite, 50 ft., brownish-weathering, white, fine bedded quartzite, cross bedded, local pebble lenses, layers ½–2 ft. thick, 725 ft.; dark, shaly to platy, fine grained quartzite, 130 ft.; brownish-weathering, massive, white quartzite, layers 2–6 ft. thick, 120 ft. Lithology at Toughnut Spring (Sec. 30, T. 11 N., R. 14 E.): heterogeneous, cross bedded, iron-stained. Includes shaly layers; fissile, thin bedded quartzite; layers with quartz and jasper pebbles; white vitreous quartzite. The white quartzite in thin section: poorly sorted quartz grains with abundant iron oxide and a little zircon. Has rounded grains 0.6 mm. dia. in a matrix of angular, interlocking grains 0.06 mm.–0.3 mm. dia.	Hazzard 33; 37b; 55: table 1, pl. 2; Ver Planck, unpublished field notes.
43	Ship Mtns.	Sec. 9, T. 4 N., R. 15 E., SB., SW. cor. Ship Mtns. and Sec. 15, T. 5 N., R. 15 E., SB., NW. end Ship Mtns.	Small outcrops of Lower Cambrian rocks.	Includes Prospect Mtn. Quartzite, Latham Shale, Chambless Limestone.	Hazzard 33.

MOJAVE DESERT—Continued

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
44	Soda Mtns.	Secs. 29, 30, 31, 32, T. 15 N., R. 8 E., SB., in Quartzite Hills of Grose.	Quartzite units several hundred ft. thick in total thickness of 2,250 ft. Total outcrop area 1–2 square mi.	Lies on Lower Cambrian limestone and dolomite. Overlain by alluvium. Lower member, impure dolomite interstratified with dark quartzite, 400 ft. thick; middle member, massive, dense, white, vitreous quartzite, 350 ft. thick; upper member, similar to lower member, 1,500 ft. thick. Lithology of middle member: cross bedded, fine grained to conglomeratic, clasts angular, mostly recrystallized. Feldspathic locally. Dark quartzite of upper member contains 95% quartz, 5% biotite.	Grose 59:1516, 1517, pl. 1.
45	Winters Pass	Sec. 33, T. 19 N., R. 12 E., adjoining part T. 18½ N., R. 12 E., SB., NW. side of Winters Pass.	4,200 ft. thick, outcrop length approx. 2 mi.	Lies on Noonday Dolomite. Overlain by Pioche Shale. Lower 1,000 ft.: mostly dense, cherty quartzite with a few beds of dolomite and red shale up to 10 ft. thick and cross bedded conglomerate beds 5–10 ft. thick with quartz pebbles 1–2 in dia. 2nd 1,000 ft.: mostly quartzite, dolomite less common, brown-weathering oolite beds 1,500 ft. above base. Upper 2,000 ft.: mostly rusty brown-weathering, thin bedded, fine grained quartzite. Lithology of quartzite from upper part: sandy looking, brownish, iron stained quartzite composed of quartz with some feldspar.	Hewett 56:29–31, pl. 1; Ver Planck, unpublished field notes.
46	Later Precambrian Quartzite in Pahrump Series Kingston Range	S. edge T. 20 N., R. 9 E., to E. edge T. 19 N., R. 10 E., SB., on N. and NW. slope of Kingston Range.	Has quartzitic units several hundred ft. thick in max. thickness of 7,000 ft. Total outcrop length approx. 10 mi.	Lies on earlier Precambrian granite gneiss. Overlain by Noonday Dolomite. From base to top: Crystal Spring Fm., 1,616–2,200+ ft. thick (lithology varies. N. of Beck Spring: shale and dolomite with limestone. W. of Beck Spring: 1,000 ft. of dark brown quartzite. NE. of Horse Thief Spring: 500 ft. of conglomeratic quartzite with ½–5-in. clasts at base; arkosic grit; 200 ft. of cross bedded white sandstone; 50 ft. of dense black cherty quartzite; chert and dolomite); Beck Spring Dolomite, 1,137 ft. thick; Kingston Peak Fm., 1,000–2,000 ft. thick (lithology varies. NE. of Beck Spring: sandstone and conglomerate with limestone and quartzite cobbles. NE. of Horse Thief Spring: sandstone and conglomeratic sandstone with quartz cobbles up to 10 in. dia. SE. of Horse Thief Spring: 400 ft. of shale and greenish quartzite; sandstone and dolomite with dolomite and quartzite cobbles; 100 ft. of red, shaly quartzite and dolomite).	Hewett 56:26, 27, pl. 1.
47	Silurian Hills	Mostly T. 17 N., R. 9 E., SB., in Silurian Hills.	Quartzitic units within total thickness of 11,000 ft.	Exposed in a chaos structure beneath Riggs thrust fault. Quartzitic members, base to top: map unit Aa (mixed sediments), member 2, granular white quartzite, 175 ft.; map unit Ab (quartzite and carbonate rocks); member 7, white quartzite, 320 ft., member 9, white quartzite and quartz cobble conglomerate, 600 ft.; map unit Ae (mixed sediments) member 19, impure quartzite with some conglomerate, 475 ft.; member 22, granular quartzite and siltstone, 225 ft.; member 23, red-brown quartzite with iron-rich cement; member 24, vitreous gray, granular quartzite, 185 ft.; map unit Af (quartzite and siltstone); member 26, vitreous quartzite, 80 ft.; member 28, white vitreous quartzite, 50 ft.; member 30, white vitreous quartzite, 220 ft.; member 31, cross bedded quartzite, 950 ft.; member 33, massive vitreous, pinkish quartzite, 380 ft.	Kupfer 54
48	Earlier Precambrian Quartzite in Pelona Schist Portal Ridge	W. part T. 6 N., R. 12 W. to S. part T. 7 N., R. 14 W., SB., on Portal Ridge NW. of Palmdale.	Quartzite beds a few ft. thick.	Quartzite is associated with a great thickness of schist. Lithology of the quartzite: clastic characteristics almost obliterated, banding marked by fine sericite grains, quartz grains have sutured borders.	Simpson 34:378–381; Wallace 49:786.
49	Tehachapi Mtns.	T. 10 N., R. 16 W., T. 10 N., R. 17 W., SB., on S. flank of Tehachapi Mtns. facing Antelope Valley.	Minor quartzite beds associated with 5,000 ft. of schist.	Quartz biotite schist banded with quartzite grades into massive quartzite with dark lines of impurities.	Wiese 50:12–15
50	Earlier Precambrian Quartzites in Rand Schist Rand Mtns.	Center T. 30 S., R. 39 E. to NE. cor. T. 30 S., R. 40 E., MD., in Rand Mtns., mostly SW. of Randsburg.	Quartzite beds, max. 10 ft. thick, max. outcrop length ¼ mi., in a great thickness of schist.	Minor quartzite associated with limestone in upper part of Rand Schist. White, pinkish, brownish, or manganese-stained. Purity varies from essentially pure quartzite to quartzite with thin layers of brown biotite. Has traces of original rounded sand grains.	Dibblee 52:13; Hulin 25:25.
51	Metasediments in Newberry Mtns.	Sec. 33, T. 8 N., R. 3 E., SB., on W. side of Kane Wash.	Minor quartzite and marble in outcrop area of ½ square mi.	Gneiss grading to orthoclase quartzite and biotite quartzite. Lithology of orthoclase quartzite: blasto-clastic texture, pink bands of orthoclase and quartz alternating with dark bands of biotite. Lithology of biotite quartzite: blasto-clastic texture, Quartz, 70%; orthoclase, 20; biotite. Magnetite, titanite, zircon present in both varieties.	Gardner 40:262, 263
52	Metasediments near Silver Lake	Secs. 21, 22, 23, T. 16 N., R. 9 E., SB., (proj.), in hills E. of Silver Lake.	Quartzite unit 25 ft. thick, outcrop length, several thousand feet.	Roof pendant in granitic rocks. From base to top: lower units, 400 ft.; hornfels member, 155 ft.; quartz-biotite schist member, 185 ft.; quartz-muscovite schist member, 125 ft.; marble member, 60 ft.; quartzite member, 25 ft.; upper units, 400 ft. Lithology of the quartzite: light gray, medium grained, massive, compact, vitreous. In thin section: quartz, 90%; feldspar, 10, mica, 2–3. Quartz grains have sutured boundaries, are markedly elongate. Feldspar and mica grains are smaller than quartz grains.	Wright 54a:9, 27, pl. 1.
53	Metasediments near Yucca Grove	Sec. 3, 4, T. 15 N., R. 11 E., SB., N. of Yucca Grove.	Undetermined but small extent.	Quartzite included in roof pendant in granitic rocks	Wright 53:202, 216.

COLORADO DESERT

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
54	Paleozoic (?) Metasediments in Coyote Mtns.	Sec. 12, T. 16 S., R. 9 E., SB., on S. side Coyote Mtns.	Outcrop area of quartzite approx. ¼ sq. mi.	Quartzite and other metasediments intruded by granitic rocks.	Tucker 26:276.

PENINSULAR RANGES

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
55	Pre-Cretaceous Quartzite-bearing metasediments Pala	So-central part T. 9 S., R. 2 W., SB., 2 mi. N. to 3 mi. NW. of Pala.	Quartzite and schist, max. outcrop width 500 ft., strike length 2–3 mi.	Thin screen of metamorphic rocks separating granodiorite to N. from gabbroic rocks to S. Lithology: Similar to parts of Julian Schist.	Jahns 51:9
56	Red Rose quarry	SW¼ Sec. 35, T. 15 S., R. 1 E., SB., ¾ mi. NE of Suncrest.	Undetermined but small extent.	Red, iron-stained, jointed, impure quartzite in roof pendant.	Small tonnage quarried for use as facing stone. Goldman 57:602.
57	Upper Jurassic Quartzite in Bedford Canyon (Santa Ana) Fm. Railroad Canyon	Mostly T. 5 S., R. 4 W., SB., NE. of Elsinore.	Thin quartzite units in body of metamorphic rocks with outcrop area of several square mi.	Roof pendant of slate and phyllite with subordinate quartzite. Lithology of the quartzite: blackish or reddish weathering, feldspathic, contains iron minerals. Sample from near Good Hope mine (NW. ¼ Sec. 15, T. 5 S., R. 4 W.) contains 61% quartz.	Dudley 35:494; Engel 59:17–21; Larsen 48:19.
58	Santa Ana Mtns.	Numerous outcrops.	Thin quartzite units in several bodies of metamorphic rocks with outcrop areas of many square mi.	Roof pendants of argillite and slate with subordinate impure quartzite.	Engel 59:17–21; Larsen 48:19; Silberling 61.
59	San Luis Rey quadrangle	Numerous outcrops	Several bodies of metamorphic rock with outcrop areas of 1 or 2 square mi.	Roof pendants of quartzite and schist. Quartzite is an essential part of the formation. Lithology of the quartzite: nearly white to dark gray, fine grained. Commonly impure. Micaceous, feldspathic, grading into arkose; with sillimanite.	Larsen 48:20
60	Triassic (?) Quartzite in Julian Schist Corral Creek	Cen. part T. 12 S., R. 2 E., SB., 10 mi. NE. of Ramona along Corral Creek.	Impure quartzite 300 ft. thick.	Laminated quartzite, bands from a fraction of an inch to several inches thick with mica partings	Merriam 46:227, 228.
61	Cuyamaca	Belt from NE. Cor. T. 14 S., R. 3 E., to cen. T. 16 S., R. 4 E., SB., SW of Cuyamaca Peak	Minor quartzite in chain of roof pendants totaling about 3 square mi.	Gray to white quartzite locally interbedded with quartz-mica schist in the form of zones or lenses a few tens of ft. thick and several hundred ft. long. Lithology of the quartzite: fine grained, subangular. At least 90% quartz (mostly 98%), feldspar, mica, small crystals of magnetite.	Everhart 51:58–60.
62	Inspiration Point	Cen. Sec. 16, T. 13 S., R. 4 E., SB., ½ mi. SW. of Inspiration Point.	Lenticular masses of quartzite 1–500 ft. thick associated with schist	Usually associated with muscovite-quartz schist. Some of the quartzite has relict cross bedding.	Creasey 46:18, pl. 3
63	Jacumba	SE. part T. 17 S., R. 7 E., SB., 2½ mi. NW. of Jacumba	Quartzite associated with mixed granitic and metamorphic rocks.	Light gray, fine grained, foliated, saccharoidal quartzite. Quartz, 91%, sillimanite, 8, magnetite, 1.	Brooks 55, Miller 35:120.
64	Triassic (?) Quartzite in Julian Schist Julian	SE.-trending strip 1 mi. wide from E. part T. 12 S., R. 3 E., to SW. cor. T. 14 S., R. 4 E., SB., through Julian.	Minor quartzite associated with schist	Mostly laminated impure quartzite consisting of alternating quartzite and schist layers from a fraction of an inch to several inches thick. Forms masses as much as several hundred ft. thick 1) along W. border of main schist mass, 2) near Ready Relief mine (Secs. 3, 10, 11, T. 13 S., R. 4 E.), 3) near Kentwood in the Pines (Sec. 4, T. 13 S., R. 4 E.). Lithology: fine to medium granoblastic. Quartz, 80%, microcline, muscovite, magnetite, garnet.	Creasey 46:18, Donnelly 34:337, 338; Everhart 51:58–60; Merriam 58:9.
65	Quartzite in Jurupa Series Jurupa Mts.	Around common cor. T. 1 S., R. 5 W.; T. 1 S., R. 6 W.; T. 2 S., R. 5 W.; T. 2 S., R. 6 W.	Apparent thickness as much as 2,000 ft.	Quartzite associated with marble, gneiss, schist; intruded by granitic rock. Lithology of the quartzite: yellow-brown-to dark reddish-weathering, crudely banded, light gray, vitreous quartzite. Dark bands contain biotite and chlorite. Some quartzite has disseminated pyrite and sillimanite (?). Quartz, 80–90%, muscovite, biotite, hornblende. Grein size, 0.2–2.0 mm.	MacKevett 51:[illegible]
66	Paleozoic (?) Quartzite in Palm Canyon Complex Cathedral Canyon	T. 5 S., R. 5 E., SB., approx. 5 mi. SE. of Palms Springs in and near Cathedral Canyon	Abundant quartzites and quartz schists.	Metasediments, chiefly marble, but with quartzites and quartz schists, injected with igneous material. Lithology of the quartzites: mostly foliated, light gray, fine to medium grained, biotitic; some are slightly foliated, fine grained, with little biotite.	Miller 44:22
67	Quartzites in Domenigoni Valley	NE. part T. 6 S., R. 2 W., SB., S. of Domenigoni Valley	Apparent thickness, 12,000 ft	Impure quartzite, lies on and overlain by slates and schists. Mostly massive quartzite. Has some thin schist layers and a few schist layers as much as 100 ft. thick. Lithology of the quartzites: much contains little but quartz. Some contains up to 50% feldspar; some is micaceous, grading into quartz schist. Sutured quartz grains.	Larsen 48:17
68	Quartzite near Santa Rosa Mtn	Sec. 31, T. 7 S., R. 5 E., SB., 15 mi. SW. of Indio.	600 ft. thick, strike length, ¼ mi	Quartzite occurs at the base of a section 10,200 ft. thick that is intruded by granitic rocks.	Wright 46:11, pl. 1

TRANSVERSE RANGES

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
69	Pre-Cretaceous Quartzite in Placerita Fm. Little Tujunga	Mostly Sec. 28, T. 3 N., R. 14 W., SB., in Limerock Canyon west of Little Tujunga Canyon.	Small, thin quartzite beds associated with schist and limestone	Typical quartzite. quartz, 73%; feldspar, 25; muscovite, 1; zircon, rutile, magnetite, 1.	Oakeshott 37:222; 58:50, 51.
70	Carboniferous Quartzite in Furnace Fm. Greenlead Camp	Secs. 25, 26, 27, T. 3 N., R. 1 W., SB., E. of Greenlead Camp.	Scattered patches, 200 ft. thick; max. outcrop length, 4,000 ft.	Small tongues of massive quartzite in predominantly carbonate rocks forming roof pendants.	Richmond 60:16, pl. 1.
71	Pre-Carboniferous Quartzite in Chicopee Canyon (Chicopee) Fm. Chicopee Canyon	Secs. 25, 26, 36, T. 3 N., R. 1 E., SB., in Chicopee Canyon near Baldwin Lake	Quartzite units several tens of ft. thick in total thickness of 1,150 ft. outcrop length, several thousand ft.	Lies on Baldwin Gneiss locally with depositional (?) contact. Overlain locally by Furnace Formation (limestone). Four members, base to top: lime-silicate member, ripple-marked member, cross laminated member, upper white quartzite member. Lithology: mostly quartzite with abundant feldspar and biotite except 1) basal 50 ft. of ripple-marked member: white, platy beds 1–8 in. thick composed almost entirely of quartz, and 2) upper member (150 ft. thick): vague bedding, glossy fracture, iron-stained, av. grain size less than 0.5 mm. dia.	Guillou 53:7–10, pl. 1.
72	Holcomb Valley	Secs. 5, 6, T. 2 N., R. 1 E.; Sec. 1, T. 2 N., R. 1 W.; Sec. 36, T. 3 N., R. 1 W., SB., N. of Holcomb Valley.	Quartzite unit 370 ft. thick in total thickness of at least 1,320 ft. Outcrop area of entire formation, 1 sq. mi.	Base intruded by tonalite porphyry Overlain by Furnace Fm. Lower member (1,000 ft. thick): cross-bedded quartzite, thin-bedded quartzite, micaceous quartzite. Upper member: massive white quartzite (370 ft. thick) overlain by andalusite-bearing rock (75 ft. thick). Lithology: quartzite with abundant feldspar and mica except massive white quartzite, which is composed almost entirely of quartz grains 2–5 mm. dia. with sutured, crenulated boundaries. Has sparse, minute crystals of zircon, rutile, sphene, muscovite. Feldspar not observed.	Richmond 60:11–15, pl. 1
73	Saragossa Quartzite Gold Mtn.	Approx Sec. 7, T. 2 N., R. 2 E., to Sec. 34, T. 3 N., R. 1 E., SB., Baldwin Lake to Saragossa Spring.	Gently dipping section more than 1,000 ft. (?) thick	Exposed in thrust plate. Lithology: vague bedding, fractured, heavy iron stain, pinkish or grayish on fresh surface. In thin section: anhedral, interlocking quartz grains with feldspar and sericite.	Production of stained quartzite for building stone. Guillou 53:7, pl. 1; Vaughan 22:357; herein.
74	Earlier Precambrian Quartzite in Pelona Schist Sierra Pelona	N. part T. 5 N., R. 13 W. and S. part T. 6 N., R. 13 W. to N. part T. 5 N., R. 15 W., SB.	Thin quartzite beds max. strike length 1 mi. associated with a great thickness of schist.	Thin bedded, fine grained, schistose quartzite	Jahns 54; Oakeshott 58.49, 50; Simpson 34:378–381.

COAST RANGES

75	Paleozoic Quartz rock of Gabilan Limestone Fremont Peak	Sec. 35, T. 13 S., R. 4 E., MD. (proj.) east of Fremont Peak.	Lenticular body; outcrop 3,000 ft. long, 500–1,000 ft. wide.	Silica replacement of carbonate rock, which is associated with schist of Sur Series and intruded by granitic rock. Lithology of the quartz rock: gray, vuggy, vitreous material, mostly quartz in interlocking grains, but with as much as 10% calcite and calcium silicate minerals.	Bowen 59:13, 19, pl. 1; herein.
76	Quartzite in Sur Series Fremont Peak	Sec. 35, T. 13 S., R. 4 E., MD., (proj.) east of Fremont Peak.	Lenticular beds 2–3 ft. thick.	Minor quartzite associated with schist. Lithology of the quartzite: pale pink to red, medium to fine grained, slightly micaceous.	Bowen 59:13, 19, pl. 1.
77	Gabilan School	Sec. 16, T. 13 S., R. 3 E., MD., 1½ mi. W. of Gabilan School.	Quartzite up to 180 ft. thick.	Roof pendant composed of schist, limestone, quartzite. A section: fine-grained mica schist, 200 ft.; limestone, 250 ft.; light-colored, fine-grained quartzite, 50 ft.; limestone, 300 ft.; pure, well-bedded quartzite, 180 ft.	Allen 46:20.
78	Santa Lucia Range	Santa Lucia Range SW. of Soledad. Approx. T. 18 S., R. 5 E., MD.	Quartzite layers from a fraction of an in. to a few ft. thick in schist and gneiss.	Quartzite is widespread but not abundant. Lithology: grayish or tan, fine-grained, vitreous, thoroughly recrystallized. None contains more than 90% quartz. Locally has biotite partings and grades into quartz-biotite gneiss.	Fiedler 44:182; Reiche 36:118–121.

GREAT VALLEY OF CALIFORNIA

79	Pre-Cretaceous Quartzite NE. of Fresno	A) Secs. 8, 9, 16, 17, T. 11 S., R. 21 E., MD., nr. Friant; B) N. central part T. 12 S., R. 21 E., MD., SW. of Owens Mtn.	Quartzite layers from less than 1 in. to 40 or 50 ft. thick. Beds lens out within short distance.	Numerous lenticular bodies of quartzite associated with a great thickness of mica schist. Lithology of the quartzite: light gray to dark bluish gray, granoblastic texture, av. grain size 0.1 to 1 mm. No pure quartzite reported. Contains feldspar, biotite. Some specimens contain hornblende, diopside, clinozosite, epidote.	Macdonald 41:220.

SIERRA NEVADA

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
80	Pre-Cretaceous Quartzites in E. Fresno County	A) S. part T. 8 S., R. 25 E., N. part T. 9 S., R. 25 E., MD., nr. Tamarck Mtn. B) T. 9 S., R. 26 E., extending into T. 9 S., R. 27 E., MD., nr. Dinkey Creek. C) SW. cor. T. 10 S., R. 28 E., MD., nr. Woodchuck Creek. D) NW. part T. 11 S., R. 27 E., extending into T. 11 S., R. 26 E., MD. nr. Patterson Mtn. E) NW. part T. 12 S., R. 28 E., extending into T. 11 S., R. 28 E., MD., nr. Rogers Ridge. F) NW. cor. T. 13 S., R. 29 E., MD., nr. S. Fork Kings River.	Outcrop areas several square mi.	Unfoliated impure quartzite with but little mica is interbedded with schist and also forms large masses nearly free of schist. Light colored, coarse grained.	Krauskopf 53:5, pl. 1.
81	Quartzite near Hospital Rock	Secs. 19, 29, 30, T. 16 S., R. 30 E., MD., near Hospital Rock ranger station, Sequoia National Park	Lenticular quartzite outcrop 3 mi. long, max. width ½ mi.	Quartzite predominates in SE. part of a roof pendant composed mostly of schist and limestone. Lithology of the quartzite: cloudy white to dark gray, massive, fine-grained. Predominantly quartz, but contains subordinate feldspar, mica, diopside, apatite, magnetite, zircon.	Ross 58:5, pl. 1.
82	Quartzite near Kaiser Peak	Secs. 25, 26, T. 7 S., R. 25 E., MD., approx. 3 mi. N. of Huntington Lake.	Metasediments, mostly quartzite, outcrop area 1 square mi.	Roof pendant in granitic rocks. Lithology of the quartzite (after Hamilton): white, gray, or pink, medium grained, contains minor clinopyroxene and plagioclase, biotite rare; (after Chesterman) 90% quartz with biotite, has zircon, sphene, sericite, chlorite, hornblende, zoisite, granoblastic texture.	Chesterman 42 251; Hamilton 56:7, pl. 1
83	Quartzite near Nellie Lake	Secs. 29, 32, T. 7 S., R. 25 E., MD., 5 mi. NW. of Huntington Lake.	Outcrop area approx. 1 square mi.	Roof pendant, mostly quartzite, in granitic rocks. Lithology of the quartzite: white, gray, pink, medium grained. Has minor feldspar, biotite, zircon.	Hamilton 56:7, pl. 1.
84	Quartzite near Twin Lakes	Secs. 20, 29, T. 7 S., R. 26 E., MD., approx. 3 mi. N. of Huntington Leke	Quartzite body 8 ft. wide, strike length 100 ft.	Associated with limestone in roof pendant. Lithology of the quartzite: granoblastic texture. Quartz, 60%; feldspar, 30%; also sphene, biotite, zircon, epidote, magnetite.	Chesterman 42·252.
85	Quartzite in Western Sierra Nevada	E. part T. 11 S., R. 23 E. to NE. part T. 12 S., R. 24 E., MD., nr. Watts Valley	Quartzite layers from less than 1 in. to 40 or 50 ft. thick. Beds lens out within short distance	Numerous lenticular bodies of quartzite associated with a great thickness of mica schist. Lithology of the quartzite: light gray to dark bluish gray, granoblastic texture, av. grain size 0.1 mm. to 1 mm. No pure quartzite reported. Contains feldspar, biotite. Some specimens contain hornblende, diopside, augite, clinozoisite, epidote.	Macdonald 41.220.
86	Triassic (?) Homer Quartzite of Kaweah Series Dry Creek	Strip from SE. part T. 15 S., R. 26 E., to cen. T. 17 S., R. 28 E., MD., N. and NE. of Lemon Cove along Dry Creek	Quartzite masses as much as several hundred ft. thick, strike length 1–2 mi., in max. thickness of 7,000 ft.	Lies on Lemon Cove Schist. Overlain by Three Rivers Schist. Quartzite occurs as a) lenticular masses consisting of thin, alternating beds of quartzite and quartz schist that are separated by masses of mica schist and phyllite; b) masses composed of quartz-rich bands up to 3 in. thick seperated by sharp partings of graphitic or quartzitic material. The quartzite: quartz, 85% or more; muscovite, biotite, graphite; other minerals infrequent.	Durrell 40.13, 32, map 1; 43 158, pl. 3.
87	Paleozoic Quartzite in Calaveras Fm. Angels Camp to Sonora	T. 1 N., R. 15 E., to T. 3 N., R. 14 E., MD., in Sierra Nevada foothills.	Minor quartzite layers in schist, locally forming units 3–25 ft. thick.	Lithology of quartzite in SE. cor. T. 1 N., R. 15 E., MD.: Fine grained, quartz 90%, micaceous, not much feldspar.	Clark 54 6, Eric 55.8, Hart 59 12
88	Turnback Creek	E. part Sec. 25, E. part Sec. 36, T. 1 N., R. 15 E.; NW. ¼ Sec. 30, T. 1 N., R. 16 E., MD., approx. 10 mi. SE. of Sonora in bed of Turnback Creek.	Quartzite-bearing units up to 150 ft. thick.	Metachert associated with carbonate rocks and schist. Lithology: crenulated beds 1–2 in. thick separated by phyllitic schist and forming thick units. Composed of finely crystalline quartz, 90%; mica, pyrite.	Hart 59:12, pl. 2.
89	Quartzite in Kernville Series Bodfish	T. 27 S., R. 33 E., MD. and to SE., E. and SE. of Bodfish.	Quartzite outcrops several hundred ft. wide, several tens of mi. long.	Roof pendant consisting of Kernville Series in tightly folded anticline with thick axial zone of metavolcanic rocks flanked by small, thin-bedded layers of quartzite that grades outward into marble.	Miller 40:350, pl. 2.
90	Caliente Creek	Secs. 23, 26, 27, T. 30 S., R. 32 E., MD., 12 Mi. E. of Bena in Devil Canyon area of Caliente Creek.	Quartzite beds a few ft. thick, outcrop length up to 1 mi.	Subordinate quartzite beds in schist, total apparent thickness, 6000 ft. Lithology of the quartzite: light-gray to bluish-gray, fine-grained, granoblastic aggregate of quartz, albite, zoisite, hornblende, muscovite, scheelite, graphite.	Dibblee 53 15, pl. 1
91	Dome Land	SW. part T. 22 S., R. 34 E., MD., approx. 30 mi. W. of Little Lake, NW of Dome Land.	Steeply dipping quartzite-bearing metasediments 5000–7000 ft. thick.	Phyllite in E. half of outcrop, quartzite in W. half. Poorly bedded, white, "fisheye" quartzite forming bold outcrops.	Miller 40:351, pl. 2
92	Kernville	Sec. 28, T. 25 S., R. 33 E., MD., 7½ mi. N. of Isabella (new location).	Isolated outcrops up to 500 ft. long, 1 mi. wide of quartzite associated with other metamorphic rocks.	Roof pendant composed of quartzite, schist, phyllite, limestone, that has been intruded by granodiorite, by alaskite, and faulted. Lithology of the quartzite: light yellow, thin bedded, usually interbedded with phyllite. Medium sized, rounded or angular grains cemented by botryoidal, cryptocrystalline chalcedony (?). Has feldspar crystals.	Prout 40:391

SIERRA NEVADA—Continued

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
93	Monolith	Sec. 14, T. 32 S., R. 33 E., MD., approx. 2 mi. NW of Monolith.	Impure quartzite several hundred ft. thick, strike length at least ½ mi.	Roof pendant containing limestone, quartzite and some schist. Lithology of the quartzite: brown and dark gray, shattered, iron-stained quartzite with schist inclusion and cut by stringers of pegmatite and granitic material. Contains 5–10% biotite; also feldspar, chlorite, muscovite. SiO_2, 70–90%.	Material of 85% SiO_2 content quarried by Monolith Portland Cement Co. for use in mfg. of portland cement. Herein.
94	Rockhouse Basin	T. 23 S., R. 36 E., and T. 24 S., R. 36 E., MD., approx. 10 mi. W. of Little Lake, E. and SE. of Rockhouse Basin.	Phyllite, apparent thickness 15,000 ft. with subordinate quartzite.	White to gray, "fine-bedded" quartzite.	Miller 40:351.
95	Sirretta Peak	T. 22 S., R. 33 E., and T. 23 S., R. 33 E., MD., N. and W. of Sirretta Peak.	3 outcrops, total area several square mi.	Septal-like inclusions in granite "composed entirely of quartzite and its variants".	Miller 40:351, pl. 2.
96	Relief Quartzite of Calaveras Group Alleghany	a) Secs. 10, 11, T. 18 N., R. 10 E., MD., SW. of Minnesota Flat. b) Sec. 3, T. 18 N., R. 10 E., MD., W. of Chips Flat. c) Sec. 4, T. 18 N., R. 10 E., Sec. 33, T. 19 N., R. 10 E., MD., nr. French Ravine. d) Secs. 29, 32, T. 19 N., R. 10 E., MD., nr. Oregon Creek. e) Secs. 4, 5, T. 18 N., R. 10 E., MD., nr. Rapps Ravine.	Scattered outcrops of siliceous sediments ¼–½ mi. wide. up to 1 mi. long	Lies on Kanaka Fm. Overlain by Cape Horn Slate. Mica schist and schistose quartzite with muscovite partings. Quartzite is dark and fine grained.	Carlson 56:241, pl. 8; Ferguson 32:12, pl. 1.
97	Dutch Flat to Relief	Strip from Sec. 34, T. 16 N., R. 10 E. to Sec. 4, T. 17 N., R. 10 E., MD.	Quartzite-bearing sediments, outcrop 1 mi. by 10 mi.	Very fine grained quartzite alternating with streaks of siliceous clay slate.	Lindgren 00:2.
98	Quartzite in Shoo Fly Fm. of Calaveras Group Indian Falls	NW.-trending strip through Secs. 10, 15, T. 25 N., R. 9 E., MD.	Quartzite-bearing sediments approx. 6800 ft. thick.	Lies on Taylor Fm. (metavolcanic). Overlain by Peale Fm. Slate, lower part; quartzite, upper part. Thin beds of gray, somewhat slaty, indistinctly schistose quartzite with occasional lentils of limestone.	Diller 08:23; Lydon 60.
99	Quartzite in Grizzly Fm. Grizzly Peak	Sec. 13, T. 25 N., R. 10 E., to Sec. 34, T. 26 N., R. 10 E., MD., SE. of Taylorsville on Grizzly Mtn.	Shale (400 ft. thick, outcrop length 6 mi.) contains quartzite beds 5–20 ft. thick; strike length comparatively short.	Lies on metarhyolite. Overlain by Montgomery Limestone. Gray, thin-bedded quartzite interstratified with shale.	Diller 08:14–16; Lydon 60.
100	Silurian Quartzite in Taylorsville Fm. Taylorsville	NE. part T. 25 N., R. 10 E., and adjoining part T. 26 N., R. 10 E., MD. on Grizzly Peak nr. Taylorsville.	Slate and thin-bedded sandstone 1800 ft. thick, outcrop length 6 mi., with subordinate quartzite.	Lies unconformably on Montgomery Limestone; upper side is in contact with Taylor Fm. (metavolcanic) and granitic rock. Has well defined beds of light colored quartzite near the middle.	Diller 08:17–19; Lydon 60.

CASCADE RANGE

101	Paleozoic Quartzite-bearing metasediments Yellow Butte	Sec. 34, T. 43 N., R. 4 W., MD., at Yellow Butte.	Outcrop area approx. ½ square mi.; mainly quartzite.	Fault block forming bedrock island in Pleistocene and Recent lavas. Lithology of the quartzite: pale bluish white; in places, finely banded gray and black. Dense, almost porcelaneous. Probably metachert in part.	Williams 49:14.

KLAMATH MOUNTAINS

Map No.	Age Formation (group) Locality	Location	Size	Geology	Remarks and references
102	Triassic and Paleozoic Chanchelulla Fm. Chanchelulla Peak	SW. part T. 31 N., R. 10 W., MD., on slopes of Chanchelulla Peak.	Recrystallized chert more than 5,000 ft. thick.	Massive or platy recrystallized chert interbedded with slate, quartzite, and other metasediments.	Hinds 32:392; 33:85; Irwin 60: 21.
103	Helena	T. 34 N., R. 11 W.; T. 34 N., R. 12 W.; T. 35 N., R. 12 W.; T. 36 N., R. 12 W., MD., north of Helena.	Recrystallized chert and slate 2,000–4,000 ft. thick.	Recrystallized chert makes up 80% of section. One small outcrop of quartzite. Lithology of recrystallized chert: microcrystalline quartz and mica. Lithology of quartzite: gray, medium grained, composed of quartz grains with a few % feldspar, a little chert.	Cox 56; Irwin 60:22, 23.
104	Quartzite-bearing metasediments Marble Mtns.	T. 43 N., R. 12 W., MD., in Marble Mtns.	Quartzite included in section more than 10,000 ft. thick.	Quartzite and marble associated with amphibolite and chloritic schists.	Irwin 60:24
105	Klamath River	T. 46 N., R. 7 W., MD., along Klamath River.	Metasediments, including quartzite.	Argillites, phyllites, quartzitic slates, graphitic slaty schists, very fine-grained black schists, quartzites, talcose schists, pyroxene-hornblende schists limestone, marble.	Averill 31.9; Irwin 60:24.
106	Silurian Quartzite-bearing metasediments Yreka	T. 44 N., R. 6 W.; T. 44 N., R. 7 W.; T. 45 N., R. 7 W., MD., Yreka to Grenada.	Alternating bands several ft. wide of quartzite and schist or slate.	Lithology of the quartzite: white, massive, apparently pure, recrystallized, fine grained	Averill 31:9; Irwin 60:16; Williams 49 14, 15.
107	Pre-Silurian Quartzite in Abrams Fm. Coffee Creek	T. 37 N., R. 9 W., T. 38 N., R. 9 W., MD., in upper Coffee Creek	Minor quartzite in section 1,000 ft. thick.	Schist with a minor proportion of micaceous quartzite, pure quartzite, meta-conglomerate, marble. In places quartzite predominates and forms vein-like outcrops of very glassy white or dark quartzite.	Gay 49; Irwin 60:19; Hershey 01:226.
108	Scott Valley	A) T. 41 N., R. 9 W.; B) T. 43 N., R. 8 W.; C) T. 43 N., R. 9 W.; D) T. 44 N., R. 8 W., MD., in Scott Valley.	Quartzite layers up to 1 in. thick in a great thickness of metasediments.	Schist with subordinate layers of white quartzite.	Averill 31:9; Irwin 60:18.
109	Seiad Creek	NW. part T. 46 N., R. 11 W.; SW. part T. 47 N., R. 11 W., MD., near Seiad Creek.	Schist with subordinate quartzite.	Thin bands of nearly pure quartzite.	Irwin 60:18; Wells 49:23.
110	Stewart Fork	T. 35 N., R. 9 W.; T. 36 N., R. 9 W., MD., near Stewart Fork of Trinity River.	Schist and subordinate quartzite 2,500 ft. thick.	Alternating layers of schist and quartzite.	Hinds 33:81; Irwin 60:19.

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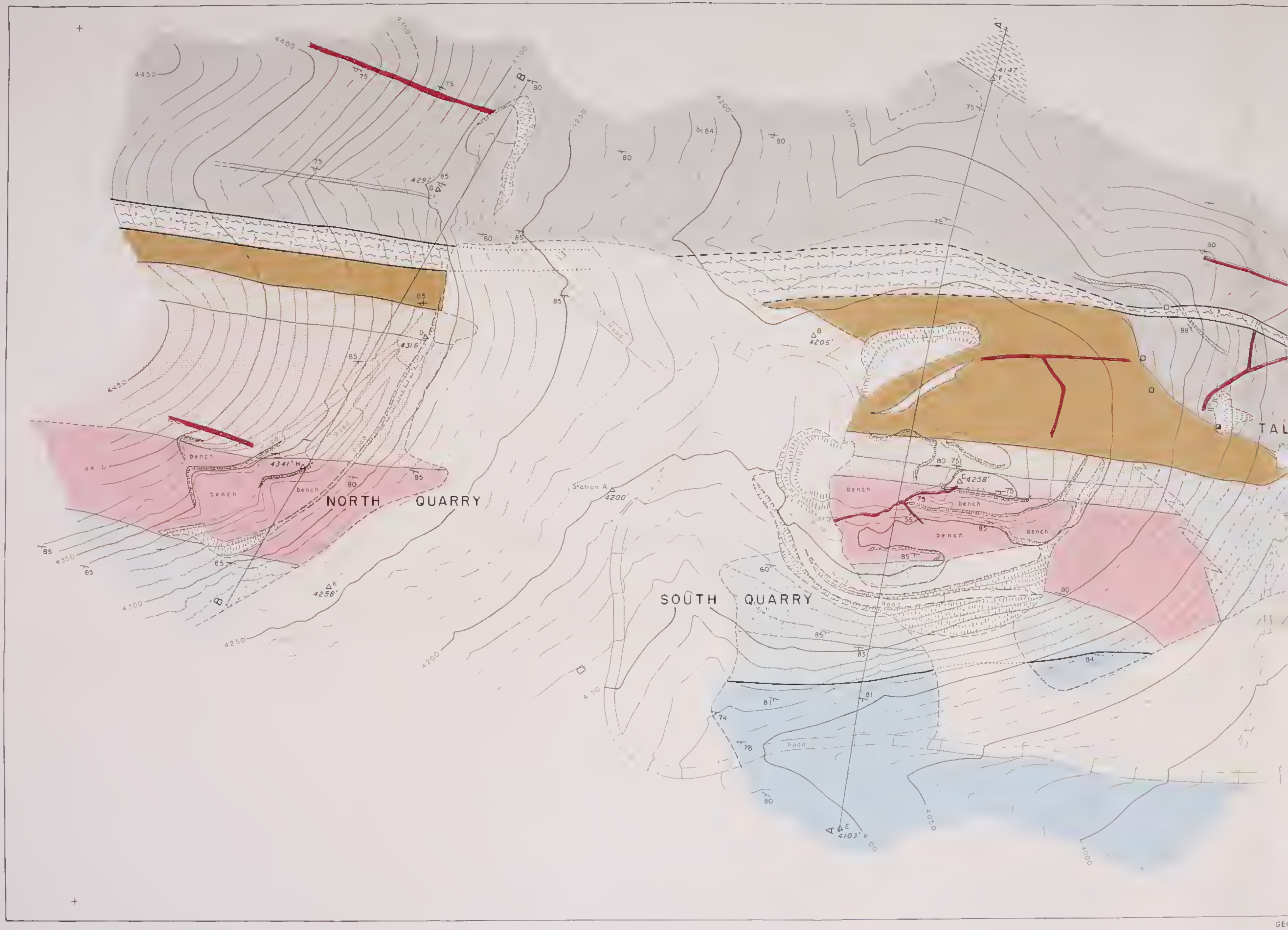
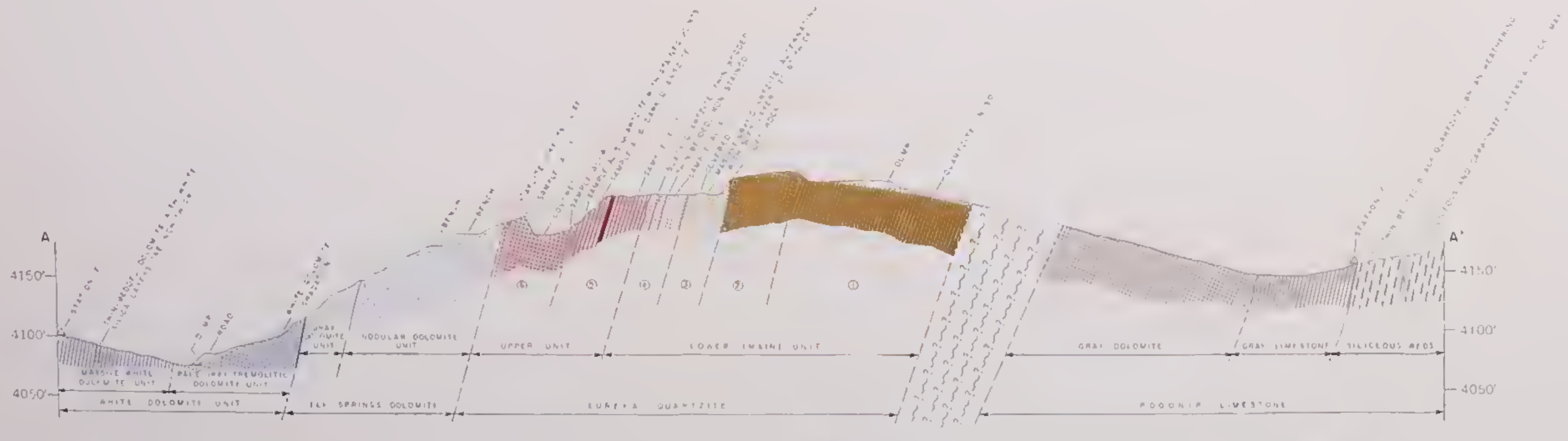
△ 66134—650 3-66 3,500

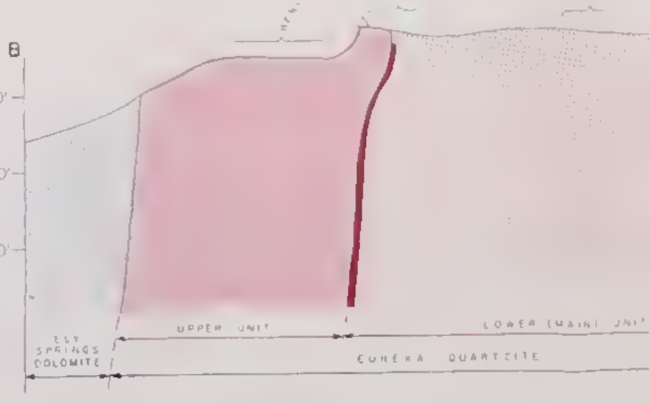
BULLETIN 187
PLATE 1

DIVISION OF MINES AND GEOLOGY
IAN CAMPBELL, STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION







GEOLOGY AND TOPOGRAPHY COMPILED BY WILLIAM E. VER PLANCK 1958-1959

GEOLOGIC MAP AND SECTIONS OF THE LAKEVIEW QUARTZITE DEPOSIT, INYO COUNTY, CALIFORNIA

by

William E. Ver Planck

0 100 200 300 400 500 FEET

CONTOUR INTERVAL 10 FEET
ELEVATION OF STATION A ASSUMED TO BE 4200 FEET

1966

CORRELATIVE EXPLANATION

Geologic Map and Section B-B'

- ▨ Dumps and fill
- ☐ Alluvium and talus
- ☐ Probable fault zone
- 🟥 Dikes
- White dolomite unit
  - ☐ White dolomite unit, including pale gray tremolitic dolomite at base. Age not determined
- Middle Ordovician
  - Ely Springs Dolomite
    - ☐ Gray dolomite unit
    - ☐ Nodular dolomite unit, including some gray dolomite
  - Eureka Quartzite
    - 🟥 Upper massive unit of high-purity quartzite
    - Lower (main) unit
      - ☐ Medium-gray quartzite, quartzite with dark streaks, and platy, black, pyrite-bearing quartzite
      - ☐ Massive quartzite with disseminated iron oxide grains, quartzite with interbedded, soft, clay-like layers
      - 🟫 Quartzite interbedded with pyrite-bearing layers, with thin carbonate layers, with hard tremolitic layers, shaly black quartzite, platy phyllite
  - Pogonip Limestone
    - ☐ Gray dolomite unit, including some gray limestone
    - ▨ Thin quartzite bed
    - ▨ Brown-weathering, siliceous beds

Section A-A'

- ▨ Dumps and fill
- ☐ Alluvium and talus
- ☐ Probable fault zone
- 🟥 Dikes
- ▨ Massive white dolomite
- ▨ Pale gray tremolitic dolomite
- ☐ Gray dolomite
- ☐ Nodular dolomite
- 6 Medium gray quartzite with no visible impurities
- 5 Medium gray quartzite with dark streaks and slight iron stains
- 4 Medium and dark gray massive, iron-stained quartzite
- 3 Soft, clay like layers
- 2 Medium gray quartzite with interbedded, tremolitic quartz-rich rock
- 1 Thin-bedded, platy, black quartzite with pyrite
- ☐ Gray dolomite
- ▨ Gray limestone
- ▨ Brown-weathering, siliceous beds

SYMBOLS

Contact
Dashed where approximately located

Fault
Dashed where approximately located

Concealed Fault

20
Strike and dip of beds

90
Strike of vertical beds

90
Strike and dip of overturned beds

Vertical foliation and vertical lineation

Adit

Shaft

A
Station point

Pit

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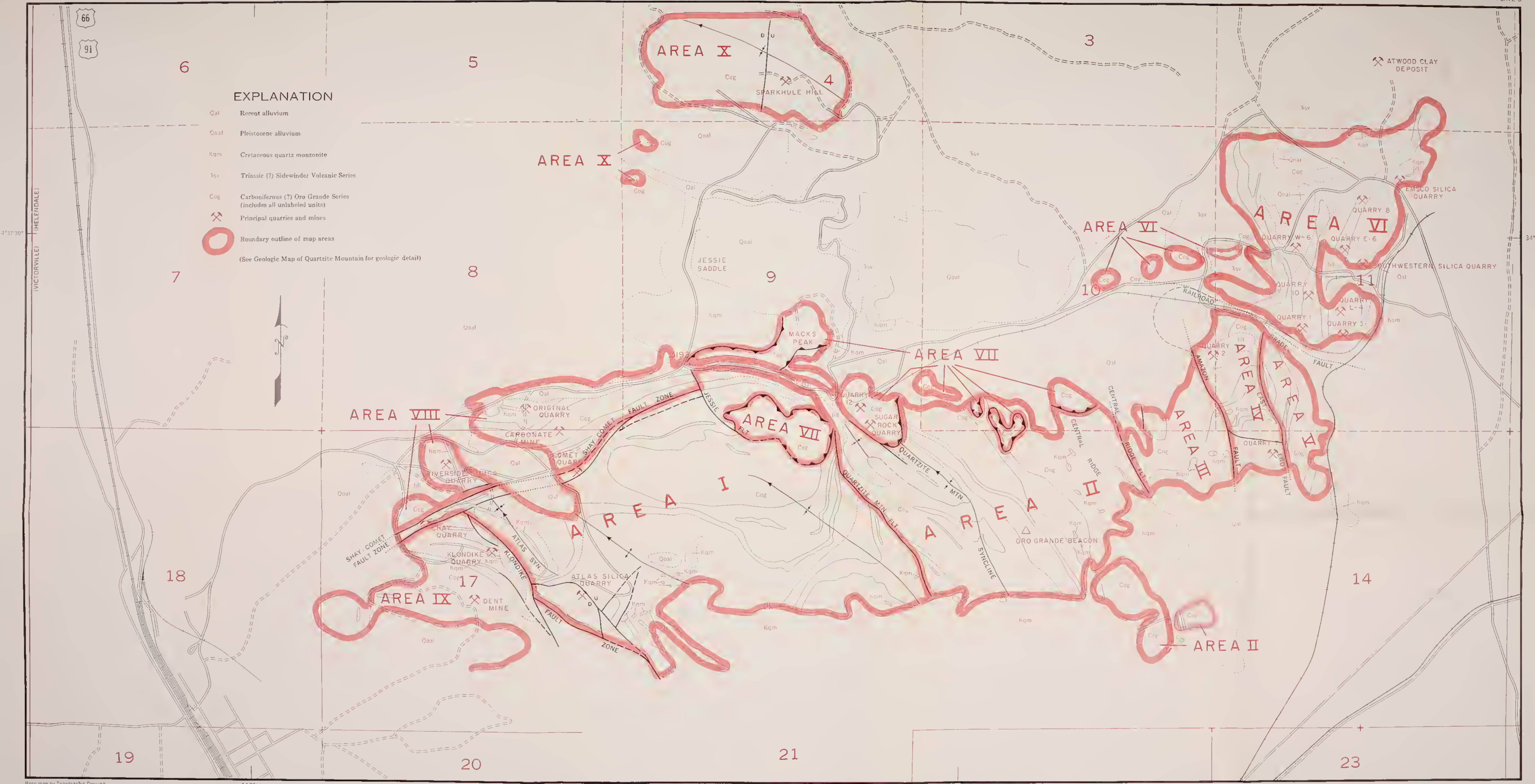
BULLETIN 187
PLATE 3



Base map by Topographic Division,
U.S. Geological Survey
Portions of Victorville and Helendale quadrangles

117°20'

117°17'30"

Williams & Heintz Map Corporation, Washington, D. C. 20027

QUARTZITE MOUNTAIN AND VICINITY SHOWING ORIENTATION OF THE AREAS AND MAJOR STRUCTURAL ELEMENTS DISCUSSED IN THE TEXT

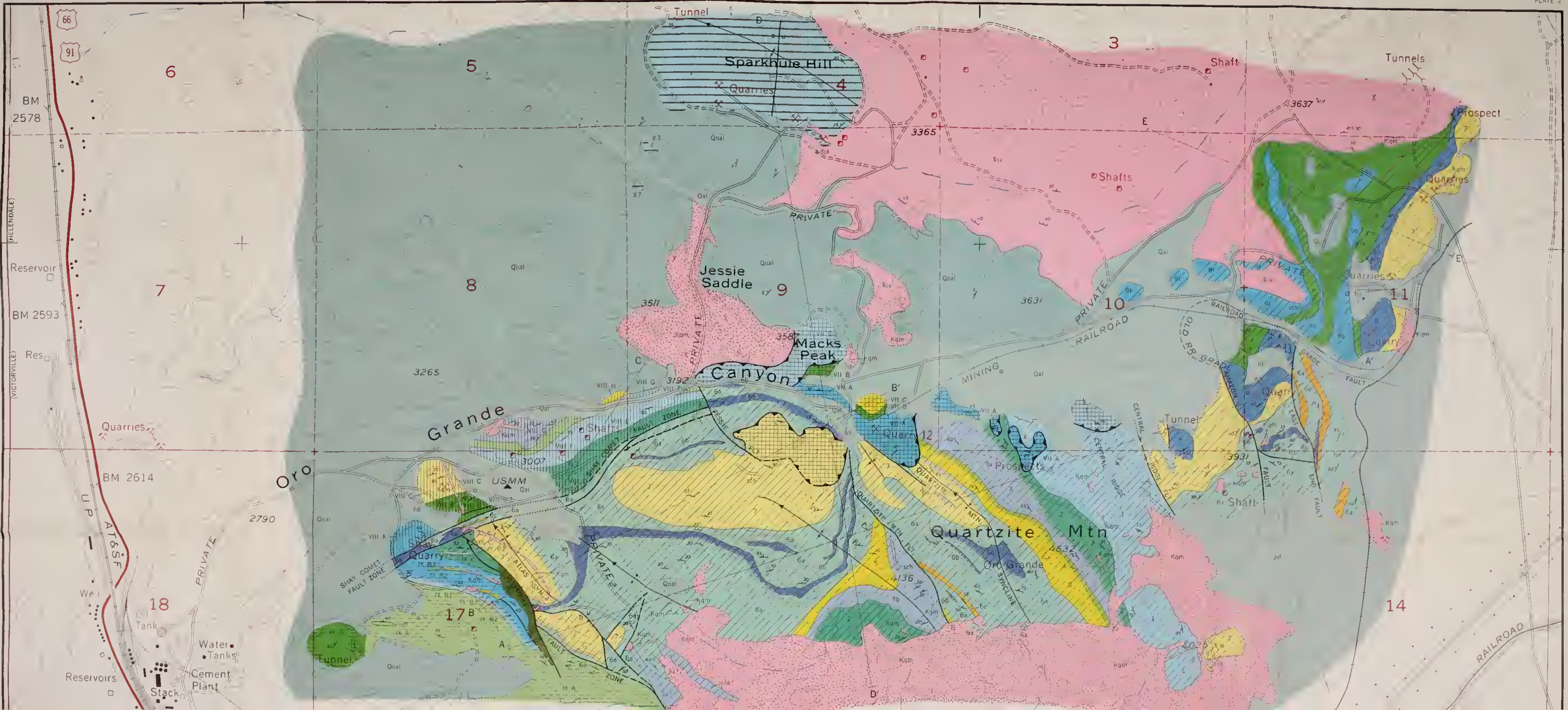
0 1000 2000 3000 4000 5000 6000
SCALE IN FEET

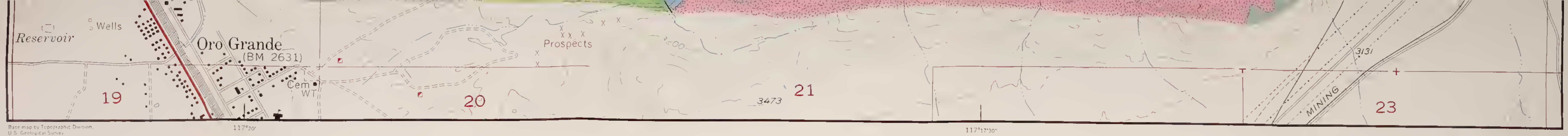
Geology by Oliver E. Bowen and William E. Ver Planck
1960

DIVISION OF MINES AND GEOLOGY
IAN CAMPBELL, STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

BULLETIN 187
PLATE 2





Base map by Topographic Division,
U.S. Geological Survey
Portions of Victorville and Helendale quadrangles

Williams & Heintz Map Corporation, Washington 27, D.C.

SYMBOLS

Contact
(Dashed where approximately located, gradational or inferred)

Fault
Dashed where approximately located
U, upthrown side; D, downthrown side

Concealed fault

Fault, showing relative movement

Thrust fault
(Barbs on upper plate, dashed where approximately located)

Strike and dip of cleavage

Strike of vertical cleavage

Strike and dip of bedding and cleavage

Strike and dip of beds

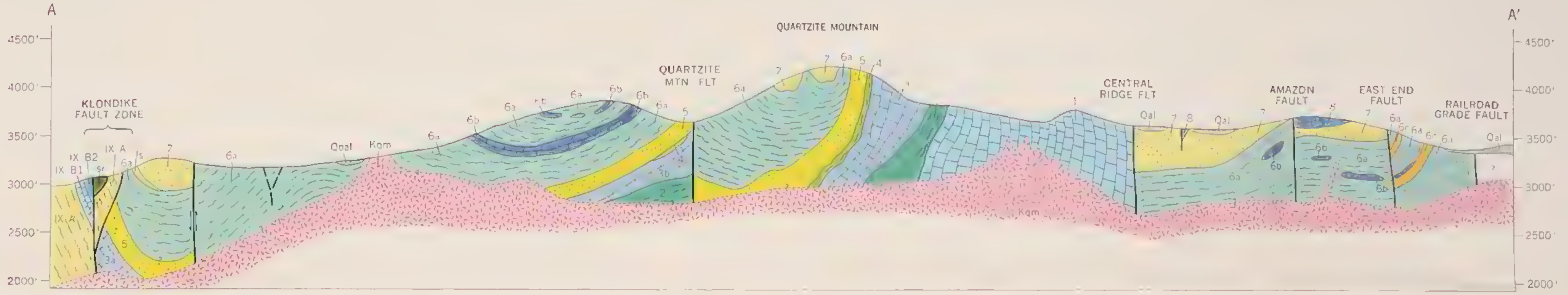
Strike and dip of overturned beds

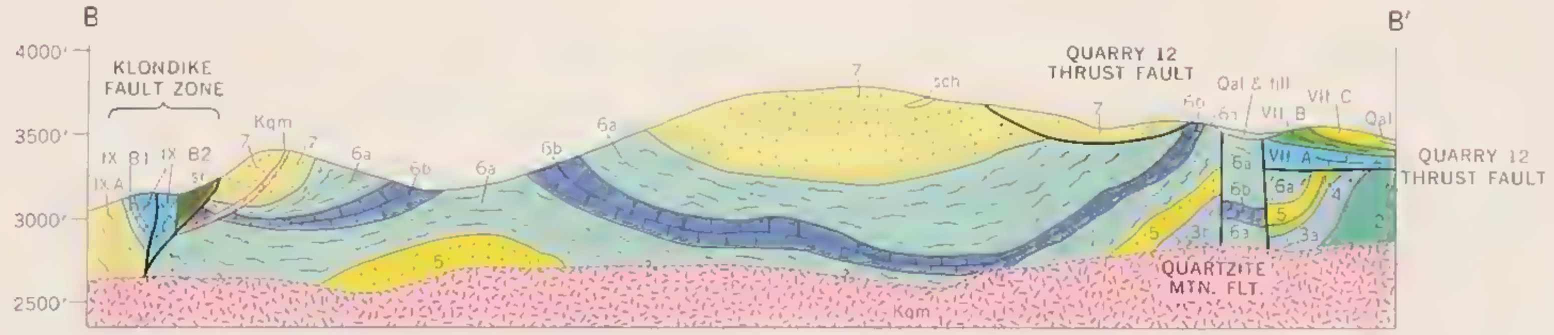
Strike of vertical beds

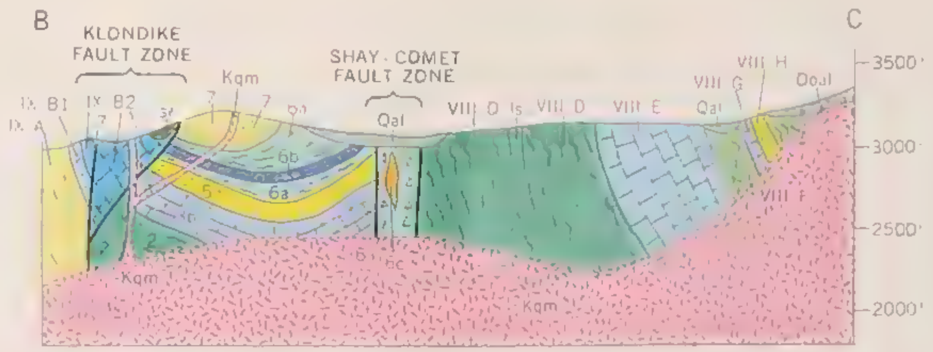
Axis of anticline

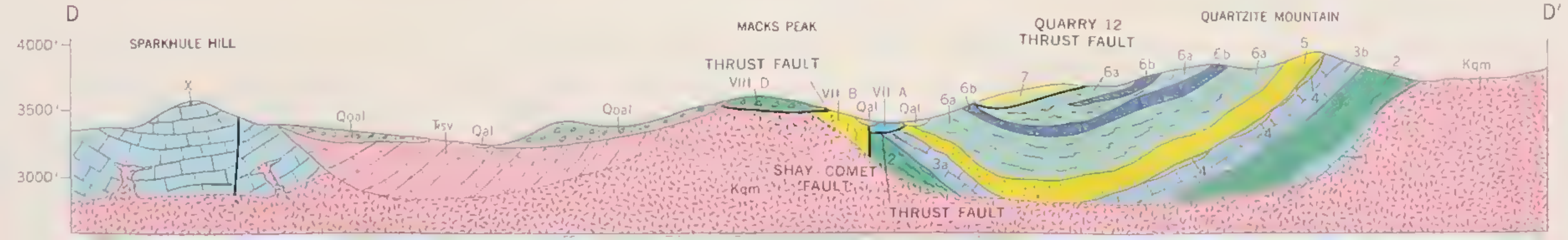
Axis of syncline

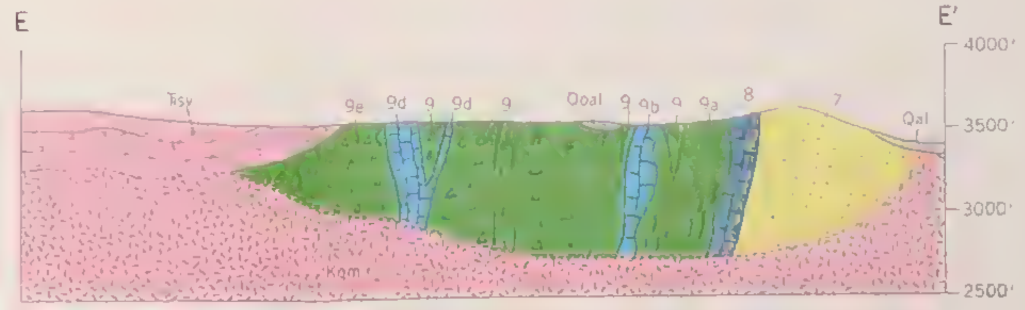
STRUCTURE SECTIONS











EXPLANATION

RECENT

🟩 *Slide-rock in Klondike quarry composed chiefly of limestone debris resulting from quarrying.*

PLEISTOCENE

Qal *Alluvium. Locally includes artificial fill.*

Qoal *Older alluvium, fanglomerate, locally cemented to hard breccia by caliche. Locally includes artificial fill.*

CRETACEOUS

Kqm *Granitic rocks, chiefly medium- and coarse-grained biotite quartz monzonite; includes aplite and pegmatite.*

SIDEWINDER VOLCANIC SERIES

TRIASSIC (?)

Tsv *Black to dark-gray latite, light-gray rhyolite and dacite.*

CRETACEOUS

Kqm	*Granitic rocks, chiefly medium- and coarse-grained biotite quartz monzonite; includes aplite and pegmatite*

SIDEWINDER VOLCANIC SERIES

TRIASSIC (?)

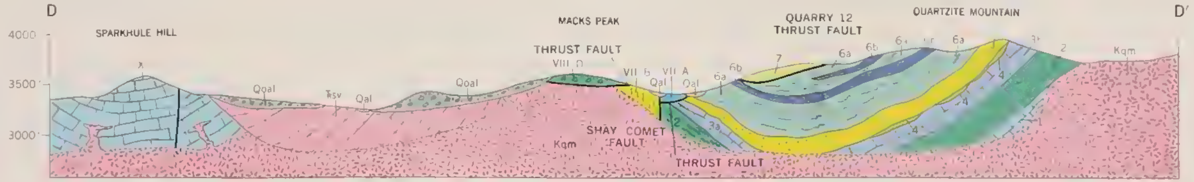
T̄sv	*Black to dark-gray latite, light-gray rhyolite and dacite*

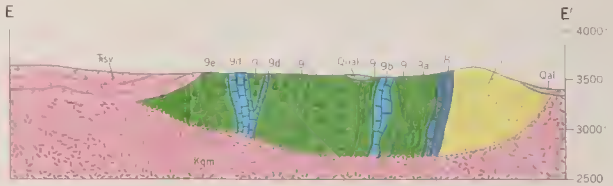
ORO GRANDE SERIES

MAP AREAS I THROUGH VI

CARBONIFEROUS (?)

9f 9d 9b	*Dark-brown to black-weathering quartzite breccia, dark quartz-mica schist and thin-bedded greenish calc-silicate hornfels (9); lower dark quartz-mica schist and hornfels (9a); blue-gray, medium crystalline limestone (9b); middle dark quartz-mica schist and hornfels (9c), lower blue-gray to off-white, medium crystalline dolomite (9d), upper dark quartz-mica schist and hornfels (9e), upper blue-gray to off-white medium-crystalline dolomite with minor schist (sch) (9f)*
8	*Massive blue-gray and white, medium-crystalline limestone; lenses of dark schist (sch).*
7 sch	*Upper commercial quartzite—massive, even-grained, medium-crystalline, off-white quartzite Lithologically indistinguishable from the lower quartzite; contains a few lenses of schist (sch) and limestone (ls).*
6c 6b 6a	*Principal schist—black, severely crumpled quartz-mica schist (6a), blue-gray to light-brown-weathering limestone and dolomitic limestone, thin and commonly lenticular (6b); off-white quartzite (6c)*
5	*Lower commercial quartzite—massive, even-grained, medium-crystalline, off-white quartzite*
4	*Quartzite-schist transition unit—black, greenish-black and dark-brown schist and micaceous quartzite; minor calc-silicate hornfels*
3a 3b sch	*Principal carbonate—blue-gray, medium-crystalline limestone (3a), brown-weathering, off-white, medium-crystalline dolomite (3b); schist (sch).*
2	*Lower schist-hornfels—green, brown, and black, thin-bedded schist, calc-silicate hornfels and micaceous quartzite.*
1	*Lowermost dolomite—white, massive, medium- to coarse-crystalline dolomite, locally serpentinic.*





GEOLOGIC MAP OF QUARTZITE MOUNTAIN AND VICINITY NEAR ORO GRANDE, SAN BERNARDINO COUNTY, CALIFORNIA

Geology by Oliver E. Bowen and William E. Ver Planck

1960

SCALE IN FEET

CONTOUR INTERVAL 20 FEET

DATUM IS MEAN SEA LEVEL

MAP AREA VII - MACKS PEAK VICINITY

QUARRY 12 PLATE

VII C	*Massive, even-grained, off-white quartzite lithologically similar to units 5, 7.*
VII B	*Dark-brown to black schist, thinly laminated.*
VII A	*Massive, blue-gray, medium-crystalline limestone.*

PLATE WEST OF QUARRY 12

7	*Upper commercial quartzite—massive, even-grained, medium-crystalline, off-white quartzite Lithologically indistinguishable from the lower quartzite.*

PLATE SOUTH OF MACKS PEAK

VII C	*Massive, even-grained, off-white quartzite lithologically similar to units 5, 7.*
VII B	*Dark-brown to black schist, thinly laminated.*

MACKS PEAK PLATE

VII D	*Massive to brecciated blue-gray, medium-crystalline limestone, magnesian in part*

PLATE AT NORTH END OF CENTRAL RIDGE

1	*Lowermost dolomite—white, massive, medium- to coarse-crystalline dolomite, locally serpentinic.*

NOTE LINE PATTERNS IDENTIFY MAP AREAS

MAP AREA VIII

LOWER ORO GRANDE CANYON

VIII H	*Massive, off-white, quartzite.*
VIII G	*Blue-gray to white, crystalline limestone, dolomitic in part*
VIII F	*Black to dark-brown quartz-mica schist with minor limestone, hornfels, quartzite.*
VIII E	*Blue-gray, medium-crystalline limestone.*
VIII D	*Black to dark-brown quartz-mica schist; few thin lenses of limestone (ls), quartzite, hornfels*
VIII C	*Massive, off-white quartzite, joints stained by iron oxide; weathers rust-colored.*
VIII B	*Dark-brown to black quartz-mica schist; few thin lenses of limestone, quartzite, hornfels.*
VIII A	*Massive, blue-gray to off-white, medium- to coarse-crystalline limestone; some dolomite.*

MAP AREA IX

SHAY - KLONDIKE BLOCK

IX D	*Green calc-silicate hornfel and black quartz-mica schist with one thin lens of blue-gray crystalline limestone (ls)*
IX C	*Dark-brown to black quartz-mica schist with thin lens of green hornfels and gray or light-brown dolomite (dol)*
IX B3 IX B2 IX B1	*Blue-gray to white crystalline dolomite (IX B 1); light-gray crystalline limestone (IX B 2), lenses of schist and quartzite (IX B 3).*
IX A	*Light-gray to brownish-gray, medium-grained quartz-feldspar-mica gneiss and schist probably derived by granitization of shale*

MAP AREA X - SPARKHULE HILL

X	*Massive, medium-crystalline limestone, light blue-gray grading to black; off-white, brown-weathering dolomite (dol).*

DIVISION OF MINES AND GEOLOGY
IAN CAMPBELL, STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

BULLETIN 187
PLATE 4

MAP OF CALIFORNIA
SHOWING LOCATION OF QUARTZITE OCCURRENCES

Compilation By William E. Ver Planck 1959

QUARTZITE OCCURRENCES.

0 40 80 120 160 MILES

BASE BY U.S. GEOLOGICAL SURVEY
1966

BULLETIN 187
PLATE 1