GEOLOGY, STRUCTURE, AND

MINERAL DEPOSITS

IN THE

Oro Grande Series

NEAR VICTORVILLE
CALIFORNIA

San Bernardino, Co

SPECIAL REPORT 84

CALIFORNIA DIVISION OF MINES AND GEOLOGY

1965

STRATIGRAPHY, STRUCTURE, AND MINERAL DEPOSITS IN THE ORO GRANDE SERIES NEAR VICTORVILLE, CALIFORNIA

By O. E. BOWEN, JR., *Geologist*
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California Division of Mines and Geology

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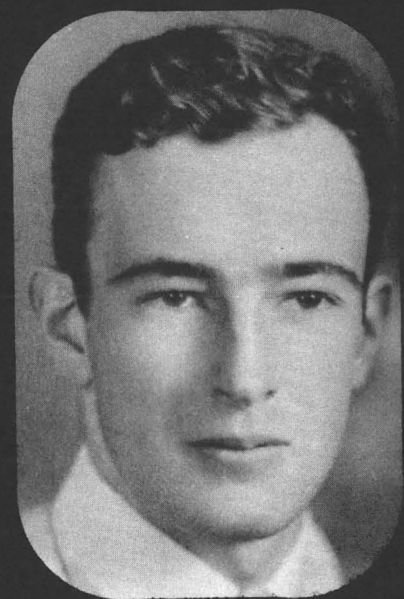
Tabulation of miscellaneous deposits.

Name of claim, mine, or group	Location	Owner	Geology	Remarks and references
Althea				See Embody (Crawford 94:228; 96:319)
Amazon (Copper Mountain, Copper King, Lucky Rose)	NE¼ sec. 15, T. 6 N., R. 4 W., S.B. (proj.) on south face of Coxcomb Ridge, 3½ mi. ENE of Oro Grande	Blane A. Frazier and R. R. Percival (1948)	Two centers of mineralization consisting of chalcopyrite with secondary malachite and chrysocolla occupying fractures and replacement patches in magnetite. 1) On Copper King claim in fractured intrusive and schistose black hornblende lamprophyre intrusive along N. 10°-20° W-trending fault that offsets quartzite-limestone beds of Oro Grande Series. 2) 1500 ft. S. 26° W. in vein system striking N. 63° E., dipping 60° NW, in and along blue-black meta-andesite of Sidewinder Volcanic Series that intrudes quartzite and mica schist of Oro Grande Series.	First worked by Mormons, approximately 1880. Active 1890-95; no record of production. Copper Mountain Mining Co. produced and shipped 300 tons of oxidized copper ore, 1912-16. Eastern ore bodies developed by vertical shafts 265 and 175 ft. deep; western ore bodies developed by shaft inclined 60° NW, several short tunnels, open cuts. Workings caved and inaccessible, 1951. (Aubury 08:333; Bailey 02:11; Bowen 54:119; Cloudman 19:784; Crawford 94:69; 96:60; Storms 93:363)
Atwood (Excello) clay	SE¼ sec. 2, T. 6 N., R. 4 W., S.B., S. slope of Silver Mountain and 4½ mi. NE of Oro Grande	Two most westerly claims held by F. R. Mason and F. E. Burton; ownership of other claims not ascertained (1948)	White kaolinitic clay, alunite, and alunitic clay in irregularly distributed masses derived from felsic lava and tuff of Triassic(?) Sidewinder Volcanic Series by hydrothermal alteration. Clay-bearing mass is overlain by hard, silicified felsite. Reserves probably several hundred thousand tons, but quantity and distribution of various grades not ascertained.	Unknown tonnage of clay produced pre-1904 by selective mining, probably by H. L. Atwood of Victor (Victorville). Workings consist of tunnels, crosscuts, shallow winzes, and room-and-pillar stopes. Deepest horizontal penetration, 100 ft.; maximum thickness of clay penetrated, 30 ft. (Aubury 06:226; Bowen 54:141,142)
Carbonate	N½NE¼ sec. 17, T. 6 N., R. 4 W., S.B., ½ mi. NE of Shay quarry and 1½ mi. NE of Oro Grande	Riverside Division, American Cement Co., 621 S. Hope St., Los Angeles 17 (1960)	Cerussite, free gold, silver in north-dipping vein system in pre-vein fault system several hundred feet wide, trending N. 75°-80° E. in schist and limestone of Oro Grande series. Two parallel veins up to 2 ft. thick in limestone, separated by 1-4 ft. of mica schist. Richest ore reported at or near contact of veins with altered rhyolite felsite dike.	Silver-bearing gossan outcrop discovered 1890. Main shaft inclined 20°-40° N. with inclined depth of 225 ft. and vertical depth of 100 ft.; 40 ft. of drifting on 60-ft. level; 90 ft. on 200-ft. level. A group of 8 shafts 1000 ft. N. 67° E. of main shaft; one with 600 ft. of drifting on 180-ft. level. Worked intermittently 1890-1942. (Bowen 54:129; Cloudman 19:811; Crossman 90:233; Eng. Min. Jour. v 51:450, 1891; Storms 93:361)
Copper Mountain				See Amazon (Aubury 08:333)
Dents Grandview Lode	NE¼SW¼ and NW¼SE¼ sec. 17, T. 6 N., R. 4 W., S.B., ¼ mi. W. of Klondike quarry and 1 mi. NE of Oro Grande	Dent estate (1954)	Quartz and brecciated schist impregnated here and there with auriferous pyrite. Wall rock in the upper part of the shaft is chiefly mica schist of the Oro Grande Series.	Developed by shaft roughly 100 ft. deep. Property contains extensive foundations for uncompleted mill buildings. Active 1947, 1931, and prior to 1931. Production not ascertained. (Bowen 54:124)
Embody (Althea)	NW¼NW¼ sec. 20, T. 6 N., R. 4 W., S.B., ½ mi. E. of Oro Grande	Riverside Division, American Cement Co., 621 S. Hope St., Los Angeles 17 (1960)	Gold-bearing pyrite in fractured schist and gneiss derived from granite porphyry of Upper Paleozoic(?) age.	An old mine well known in 1880s, but largely inactive since 1890. Developed by two vertical shafts 100 and 30 ft. deep. Ore reported to average $8 to $10 per ton. Total production not ascertained. (Bowen 54:124; Cloudman 19:812; Crawford 94:228; 96:319; Storms 93:261)
Gold Bullion	NW cor. sec. 10, T. 6 N., R. 4 W., S.B., 3 mi. NE of Oro Grande	J. F. Tedford, Oro Grande (1931)	Auriferous pyrite and chalcopyrite in shear zone 1-3 ft. wide, striking N. 10°-15° E. Vein nearly vertical at surface, but reported to dip 60° W. at depth. Wall rock is black andesite tuff of Sidewinder Volcanic Series.	Developed by 80-ft. vertical shaft. Active 1931. (Bowen 54:125; Tucker 30:237; 31:297)
Hoganson	Sec. 14, T. 6 N., R. 4 W., S.B., on SE slope of Quartzite Mountain	Hoganson Mining Co., Culver City (1943)	Steeply dipping 4-ft. quartz vein cutting quartz monzonite. Samples reported to contain $10 to $16 worth of gold per ton.	Developed by 125-ft. vertical shaft with drifts at 50 ft. and 100 ft. (Bowen 54:126; Tucker 43:454)
Oro Grande (Oro Grande II, Oro Grande Gold Mines Co.)	NW¼ sec. 20, T. 6 N., R. 4 W., S.B., just S of Oro Grande and just E of Santa Fe Railroad	Oro Grande Gold Mines Co., Geo. Anderson, pres., Oro Grande (1930)	Vein of gold-bearing quartz and silicified brecciated wall rock, few inches to 12 ft. wide, strike N. 15° W., dip 70° W. in mica schist of Oro Grande Series and dikes of dark gray, nonporphyritic andesite, probably associated with Sidewinder Volcanic Series.	Developed by open cut 200 ft. by 10-25 ft. by up to 20 ft. deeo, 120-ft. shaft in the open cut, and 40-ft. shaft 200 ft. SE of the open cut. Ore reported to run $4.50 per ton was milled in a 10-stamp mill on the property. Active 1930; earlier history not ascertained. (Bowen 54:131; Tucker 30:247; 31:308)
Oro Grande II				See Oro Grande (Bowen 54:131)
Oro Grande Gold Mines Co.				See Oro Grande (Tucker 30:47; 31:308)
Ozark (Big Ten, Garrison, Midas)	SW¼ sec. 3, T. 6 N., R. 4 W., S.B., 1½ mi. N of Quartzite Mountain and 3½ mi. NE of Oro Grande	R. R. Garrison, Oro Grande, leased to G. A. Childers (1940)	Quartz stringers and pyrite-impregnated, brecciated meta-andesite in vertical shear zone striking N. 35° E. Mineralized material thoroughly oxidized to depth of 50-60 ft. Wall rocks are meta-andesite and metadacite of Sidewinder Volcanic Series.	Developed by 100-ft. vertical shaft reported to have levels at 50 and 90 ft. Also other shafts, cuts, and shallow pits. Water in main shaft at 70 ft., 1951. Located about 1888. Developed about 1916 by Ozark Mining & Milling Co., J. S. Garrison, gen. mgr. A small production of gold and silver. Last active 1926-40. (Bowen 54:128; Cloudman 19:813; Tucker 30:248; 31:309)

ILLUSTRATIONS



WILLIAM E. VER PLANCK

1916–1963

Co-author Bill Ver Planck passed away June 14, 1963, while this report was in early stages of publication. This work is an outgrowth of a larger study on the quartzite resources of California, completed by Bill and now being prepared for publication. It was prompted by him because of the need to map in detail the complex structures which govern the distribution of the quartzites and carbonate rocks near Victorville, both of which have considerable commercial potential. Bill was a specialist of long standing in the Division of Mines and Geology on mineral utilization and on a wide variety of nonmetallic minerals, although his original interest was the mining of metallic minerals. His works on gypsum, salt, and saline minerals in California remain the best references we have on these subjects.

Bill graduated from the Massachusetts Institute of Technology in 1939 and completed more than 100 units of graduate work in geology at Stanford University in 1946–48. He had several years of experience in the gold mines of Quebec before the war intervened and he was inducted into the U. S. Army in January 1948. After his release from active duty and completion of his graduate work at Stanford, he joined the Division of Mines and Geology staff. His first statewide commodity study on the gypsum resources of California was published in 1952. He wrote 14 chapters of Bulletin 176, *Mineral Commodities of California*, published in 1957, and during the same period completed *Salt in California*, also published in 1957. Much of his time between 1957 and 1963 was devoted to a study of the silica resources of California—particularly to quartzites, vein quartz, and the quartz-bearing Tertiary channel gravels of the Sierra Nevada. For the last 2 years prior to his death he was chairman of the Division's Committee on Publications. It has been my great pleasure to be associated with this staunch friend and able scientist during the preparation of this report, as well as throughout his career at the Division of Mines and Geology.

OLIVER E. BOWEN
San Francisco, California
February 17, 1964

feet wide. The rock consists almost entirely of sheared and brecciated schist. The quarry has been driven from the west. It is 400 feet long and 350 feet wide, and the east face is up to 150 feet high. Only limited reserves remain without quarrying unbroken schist or creating a dangerously high face.

Oro Grande Canyon Quartz-Mica Schist Deposits

Location: South side of Oro Grande Canyon between the southeast corner of section 8 and Road Junction 3192. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. Deposits along Oro Grande Canyon have furnished several tens of thousands of tons of schist as sources of alumina and silica for the Oro Grande plant. They have not been worked recently.

The deposit consists of steeply-dipping bodies, map units VIII B and VIII F, several hundred feet wide, of quartz-mica schist with minor lenses of limestone, calc-silicate hornfels, and quartzite. The following is an analysis of typical material intercepted in a bore hole at the Original quarry (analysis courtesy of Riverside Division, American Cement Company):

	Percent
SiO_2	— 46.62
Al_2O_3	— 17.42
Fe_2O_3	— 4.22
CaO	— 11.99
MgO	— 4.03
Na_2O	— 1.80
K_2O	— 4.80
Loss	— 7.32

Small quarries have been opened near the Original quarry and south of Road Junction 3192. Reserves are large.

Quarry 7 (Iron Shale Quarry)

Location: NW¼NW¼ sec. 14, T. 6 N., R. 4 W., SB., on the southeast slope of Quartzite Mountain, south of Quarry 2 and 3¾ miles east-northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. A small tonnage of iron-rich schist has been obtained from map unit 6a at Quarry 7 to supply part of the iron required at the Victorville plant. The quarry has not been worked recently. The following is a typical partial analysis (courtesy of Southwestern Portland Cement Company):

	Percent
SiO_2	— 62.82
Al_2O_3	— 14.18
Fe_2O_3	— 9.22
CaO	— 2.60

Quarries West 6 and 11

Location: SE¼ NW¼ sec. 11, T. 6 N., R. 4 W., SB., at the east end of Quartzite Mountain and 4 miles east–northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. Quarries West 6 and 11 probably have yielded several hundred thousand tons of schist with some limestone to furnish part of the feed for the Victorville plant. They have not been operated since about 1951.

The quarries have been opened in map unit 9c, which consists of steeply dipping quartz-mica schist with thin-bedded calc-silicate hornfels and some limestone, that lies west of the limestone unit worked in Quarries 3, L-4, East 6, and 8. The following are typical analyses of the material that was quarried:

	Quarry West 6 Percent	Quarry 11 Percent
SiO_2	43.80	27.14
Al_2O_3	11.24	9.00
Fe_2O_3	7.60	4.04
CaO	21.00	33.00
MgO	1.02	2.58
Loss	12.79	24.19

Quarry West 6 measures 500 feet by 150 feet and has a face 60 feet high. Quarry 11, which lies between West 6 and East 6 is notably smaller.

Shay and Klondike Quarries

The Shay and Klondike quarries have furnished several million tons of material other than limestone—mostly containing alumina and silica for the Oro Grande plant. The hanging wall beds, map unit IX C, consist of green calc-silicate hornfels and black quartz-mica schist with thin limestone lenses. In the Shay quarry area, this unit has an outcrop area of 1000 feet by 400 feet. The following is a typical analysis (courtesy of Riverside Division, American Cement Company):

	Percent
SiO_2	— 52.28
Al_2O_3	— 17.62
Fe_2O_3	— 5.24
CaO	— 10.27
MgO	— 3.48
Na_2O	— 0.15
K_2O	— 4.48

Other sources are the brecciated schist and limestone of the Shay-Comet and Klondike fault zones, and the granitic dikes and schist lenses that are enclosed in limestone. An iron-bearing shear zone on the east wall of the Klondike quarry at one time was used to supply iron for the plant feed (Tucker and Sampson, 1943, p. 524). Most of the alumina-silica material has been obtained while quarrying limestone or in preparing the quarries for removing limestone. Much of the lowest level of the Shay quarry is in schist.

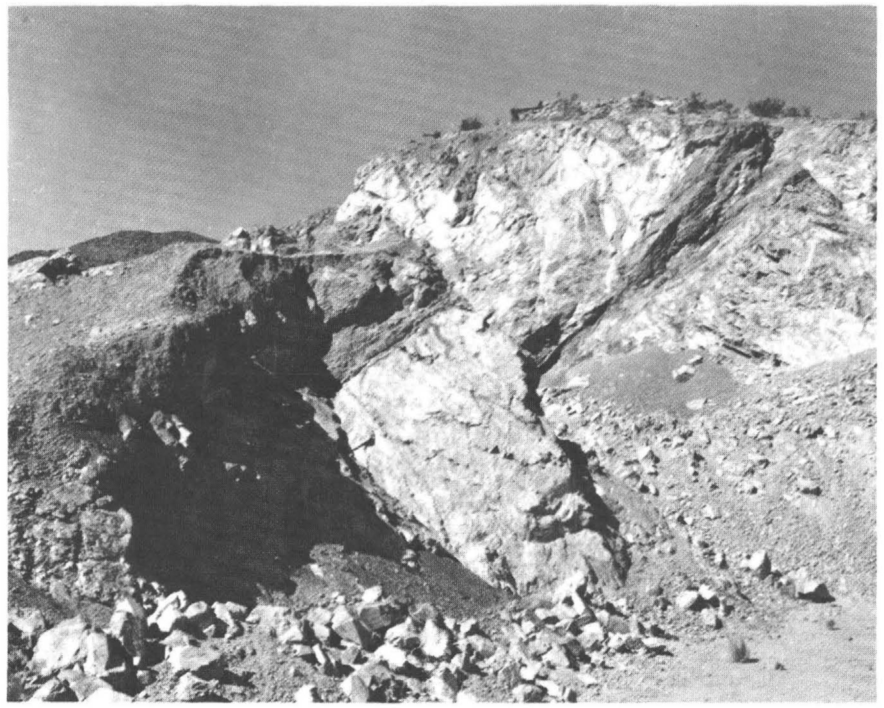


Photo 17. The Emsco silica quarry operated by Gladding McBean and predecessors from 1928 to about 1945. The light-colored quartzite of map unit 7 is cut by a darker sill of granitic rock. The quartzite was used in manufacture of silica brick. Photo taken in March 1960, observer facing northeast.

rock only a short distance east of the alluvium contact. The quartzite is shattered and contains intrusions of granitic rock. Reserves are about 3 million tons. The quarry is 300 feet by 300 feet with a face up to 75 feet high. A screening plant for beneficiating the quartzite formerly was on the property but has been removed. The following analysis of quartzite was furnished by Gladding McBean and Company (Bowen, 1954, p. 178):

	Percent
SiO_2	99.04
Al_2O_3	0.27
Fe_2O_3	0.13
TiO_2	0.04
CaO	0.15
MgO	0.04
Alkalies	0.32

Southwestern Quarries

Location: W½NE¼, and SE¼NW¼, sec. 11, T. 6 N., R. 4 W., SB., just east of Quarries E-6 and 8, and 4.1 miles east northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. A group of quarries near the Southwestern Portland Cement Company's limestone quarries in section 11 has furnished more than a million tons of quartzite for the Victorville plant since they were opened about 1928. They have been idle since 1951, when the company began to use limestone with a relatively high silica content from the Black Mountain quarry east of the mapped area.

The deposit consists of a ridge of massive quartzite, map unit 7, bordering the valley east of Quartzite Mountain and in the northern part of which is the Emsco quarry. It is a steeply dipping body with outcrop length of 2500 feet and width of up to 750 feet. It is bordered on the west by limestone and on the east by alluvium, beneath which granitic rock probably 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.

The deposit has been opened in several places. The Southwestern Silica quarry is 300 feet by 150 feet and has a face 40 feet high. It was opened in the south end of the quartzite hill just northeast of the center of section 11. At the north end of the same hill some quartzite has been quarried from the east side of Quarry 8. To the south, a large tonnage of quartzite has been taken from the quartzite ridge just east of Quarry 3. We estimate the reserves within 100 feet of the surface at 10 million tons.

Miscellaneous Cement Plant Materials

Comet Quarry (Quartz-Mica Schist)

Location: NE¼NE¼ sec. 17, T. 6 N., R. 4 W., SB., ½ mile east of the Shay quarry and just east of the road to the Atlas quarry. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. The Comet quarry has produced several hundred thousand tons of fault zone material, mostly schist, to supply alumina and silica for the Oro Grande cement plant. It has not been worked recently.

The Comet quarry has been driven on the Shay-Comet fault zone, which in places is several hundred

ABSTRACT

Re-mapping of the Carboniferous(?) Oro Grande Series in the Victorville-Oro Grande district on a scale of 1: 12,000 has provided detailed information that allows revision of the sequence at the type locality as follows, bottom to top, average thicknesses in feet: (1) lowermost white dolomite, 1200; lower dark-brown to dark-green schist-hornfels, 350; (3) lower blue-gray crystalline limestone (principal carbonate), 250; (4) dark brown schist-quartzite (transitional), 60; (5) lower quartzite, off-white to pale-pink, 250; principal schist, dark-brown to black with thin limestone lenses, 500; upper quartzite, off-white to pale-pink, 250. On to this sequence we can now project two additional units present in adjoining fault blocks. These are: an upper blue-gray crystalline limestone, 300; and a mixed unit of interlensed, interfingering quartzite breccia, carbonate rocks, schists and hornfelses, 2000. The total thickness of the series is therefore roughly 5160 ft., but individual units thicken and thin throughout the various structures partly from depositional and partly from tectonic causes. Neither the upper nor the lower stratigraphic limits are known to be present in the Victorville-Oro Grande district.

The Oro Grande Series is in part overlain unconformably and in part intruded by rocks of the Triassic(?) Sidewinder Volcanic Series. Both these sequences of rock are intruded by granitic rocks of Early Cretaceous or Late Jurassic age. All of the older rocks are overlapped and in places wholly masked by Pleistocene and Recent alluvium.

The Oro Grande Series was complexly deformed and eroded prior to emplacement of the Sidewinder Volcanic Series and the granitic rocks. West of the Central Ridge fault a series of northwest-trending folds developed, one anticline of which was disrupted by the Klondike fault system and another by the Quartzite Mountain fault. In sharp contrast, units of the Oro Grande Series east of the Central Ridge fault lie in a northeast-trending, northwest dipping homocline, indicating a large displacement on the Central Ridge fault. Prior to placement of the Sidewinder Volcanic Series and the granitic rocks these earlier structures were cut obliquely by the Shay-Comet and Railroad Grade faults.

Following emplacement of the granitic rocks but prior to deposition of the older alluvium, elements of at least 3 and probably 4 units of the Oro Grande Series were thrust over the northwest-trending structures previously alluded to, but this plate (or plates) has been so widely dissected by erosion that only a few isolated remnants are still present. The bases of these plate-remnants dip as low as 20° north. The configuration of several of the plate-remnants indicates that they were deformed and faulted at some time later than the original thrusting although the pattern produced in this episode has been destroyed by erosion.

Well over 50 million tons of limestone, several million tons of quartzite and many millions of tons of miscellaneous cement rocks have been produced from units of the Oro Grande Series, mostly for the plants of the Riverside Division of the American Cement Company at Oro Grande and the Southwestern Portland Cement Company at Victorville. Quartzite was produced for silica brick by several companies up to 1955. The Oro Grande Series has also acted as host for deposition of small, although at times important, deposits of gold, silver, copper and lead.

Reserves of limestone, dolomite and quartzite amount to many hundreds of millions of tons each. The Sparkhule Hill quarry is at present the principal source of limestone for Riverside's Oro Grande plant although the Klondike quarry, formerly Riverside's principal limestone source still contains substantial reserves and is still active. Prior to 1951 quarries in the eastern part of the district yielded limestone and other cement rocks for Southwestern Portland Cement Companies' Victorville plant. Substantial reserves still remain there although current operations are at Black Mountain east of the area described here. The Summit Claims contain an enormous tonnage of undeveloped limestone. Large undeveloped reserves of dolomite occur in Central Ridge and in the Klondike quarry. Mineral Materials Company produces quartzite from the Atlas quarry, mostly for portland cement plants in Riverside County. Immense undeveloped reserves of quartzite occur on Quartzite Mountain, on the mountain west of Quartzite Mountain and on Coxcomb Ridge.

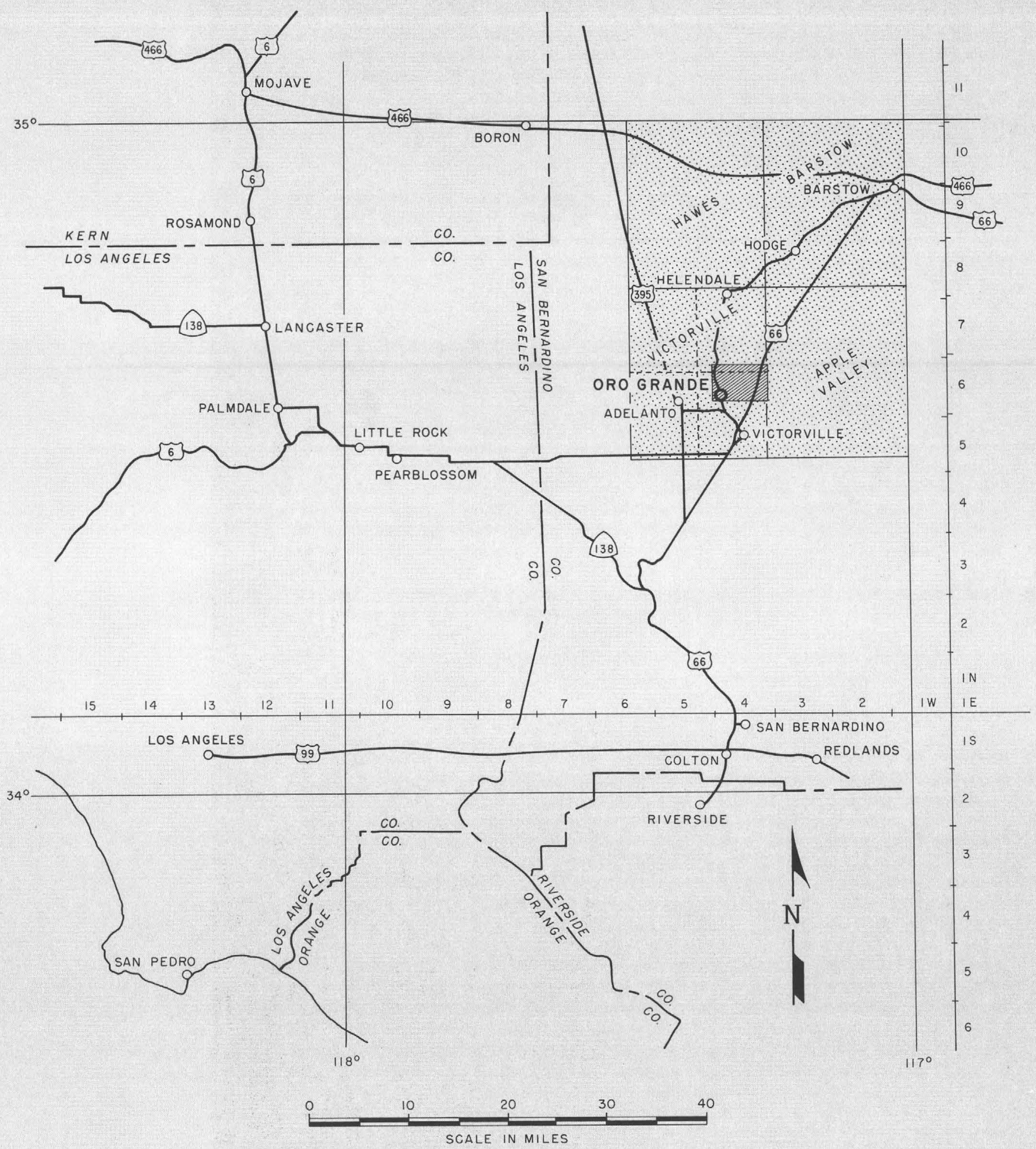


Figure 1. Index map showing location of Barstow quadrangle and the area mapped.

carbide-tipped steel. At present, the quarry is worked intensively about once a year, and a stockpile of quartzite is maintained in the Los Angeles area. For cement plants, quarry-run rock is used. 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.

Quartzite Mountain Northwest Deposit

Location: N½N½ sec. 16, part of sec. 9, T. 6 N., R. 4 W., SB. (proj.), on the summit and upper north slope of the peak 1 mile west of the Oro Grande beacon and 2 miles east northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. An enormous tonnage of quartzite is exposed without overburden, but it is undeveloped and relatively inaccessible.

Massive quartzite of map unit 7 is exposed along the ridge crest in the trough of a northwest-plunging syncline. The quartzite, which is underlain by schist, is several hundred feet thick and is exposed within an area 4000 feet long and 1500 feet wide. In the northwestern part of this area the quartzite of the syncline is overlapped by another quartzite mass that forms part of a thrust plate. Both quartzite masses contain minor interbedded lenses of schist. On the surface at least, cracks and joints in the quartzite are iron-stained. We estimate the reserves within 100 feet of the surface at 36 million tons.

Quartzite Mountain (Upper Unit)

Location: NW¼NW¼ sec. 15, NE¼NE¼ sec. 16, T. 6 N., R. 4 W., SB. (proj.), on the crest of the ridge between Oro Grande beacon and Quarry 12, 2½ miles east-northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. The deposit contains large undeveloped reserves of quartzite in steep terrain of difficult access.

An upper massive quartzite, map unit 7, is exposed at the surface in the troughs of two parallel synclines that plunge northwest. The outcrop area is roughly 2500 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 combined folding and faulting. Reserves to 100 feet below 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., SB. (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 of quartzite in a relatively inaccessible location and has not been developed.

A steeply dipping lower quartzite, map unit 5, that averages 250 feet thick crops out for about 4000 feet across the steep northeast face of Quartzite Mountain. Underneath and separated from it by a thin schist unit is the limestone of the Summit claims. The quartzite is overlain by schist. The quartzite is relatively accessible at the northwest end above Quarry 12. Perhaps 5 million tons of quartzite could be obtained from the outcrop without excessive stripping. If it were quarried together with the Summit limestone, perhaps a larger tonnage would be available.

Quartzite Mountain Southwest Deposit

Location: S½NE¼, NW¼SE¼, sec. 16, T. 6 N., R. 4 W., SB. (projected), on and near Summit 4136, half a 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, map unit 5, that crops out near the summit of the western part of Quartzite Mountain. It is probably 100 feet or more thick and lies on dolomite. It is overlain by schist and dips under it at a relatively low angle. It is exposed without overburden within an area of roughly 500,000 square feet. We estimate the reserves within 50 feet of the surface at 2 million tons.

Coxcomb Ridge Deposit

Location: SE¼SE¼ sec. 10, NE¼NE¼ sec. 15, T. 6 N., R. 4 W., SB., southwest of Quarry between 2 and 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, map unit 7, crops out for about 1800 feet along the Coxcomb Ridge northeast of Quartzite Mountain. It dips northwest at about 45 degrees and is exposed on the entire northwest slope of the ridge except for a small area, where it dips beneath limestone. It is several hundred feet thick and is underlain by schist. The deposit could be reached easily anywhere along its northwest edge. Recoverable reserves are estimated to be roughly 16 million tons.

Emsco Quarry

Location: NW¼NE¼ sec. 11, T. 6 N., R. 4 W., SB., just northwest of Quarry 8, and 4.2 miles east northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. The quarry was opened about 1928 by Emsco Refractories Company, later a division of Gladding McBean and Company, 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, map unit 7, 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. To the east it is overlain by alluvium and very likely is intruded by granitic ated intermittently since about 1940 and has furnished several hundred thousand tons of iron oxide-stained quartzite, mostly for the company's portland cement plant at Oro Grande.

The deposit consists of massive quartzite, map unit VIII C, that occupies most of an isolated hill 700 feet in diameter that rises about 100 feet above local ground level. The quartzite dips gently north and is underlain by schist. A north-trending fault zone crosses the deposit, and near it the quartzite is fractured and iron stained. The following analysis of typical material was furnished by Gladding McBean and Company (Bowen, 1954, p. 178):

	Percent
SiO_2	— 98.57
Al_2O_3	— 0.46
Fe_2O_3	— 0.34
TiO_2	— 0.05
CaO	— 0.05
MgO	— 0.17
Alkalies	— 0.15

The quartzite on the east half of the deposit has been cut down 50 to 100 feet below the original top of the hill. We estimate that 2 million tons of quartzite remain above the level of Oro Grande Canyon, which is just north of the deposit.

Klondike Deposit

Location: SW¼NE¼ sec. 17, T. 6 N., R. 4 W., SB., just east of the Klondike quarry and 1¼ miles northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. 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, map unit 7, 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. To the west, the quartzite is limited by the Klondike fault and underlain by schist, which crops out on the east side. Reserves within 100 feet of the surface are 8 million tons. A granitic dike bisects the deposit close to its long axis. The deposit could be developed easily from the road to the upper benches of the Klondike quarry, which cuts across the north end of the ridge.

Atlas Quarry

Location: NE¼SE¼ sec. 17, T. 6 N., R. 4 W., SB., adjoining the Klondike quarry on the southeast and 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. Before 1955 some of the output was used for silica brick.

The deposit consists of a mass of quartzite, map unit 7, 100 to 250 feet thick, that forms a wedge-shaped fault block 900 feet long and 500 feet wide. It is underlain by schist and, on the west side, a thin lens of limestone. The following analysis of typical quartzite from the Atlas quarry was furnished by Gladding McBean and Company (Bowen, 1954, p. 176):

	Percent
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

The deposit has been opened from the east side. The quarry is semicircular with benches about 30 feet high and is 800 feet long and up to 300 feet wide. Blast holes are made with wagon drills that use tungsten

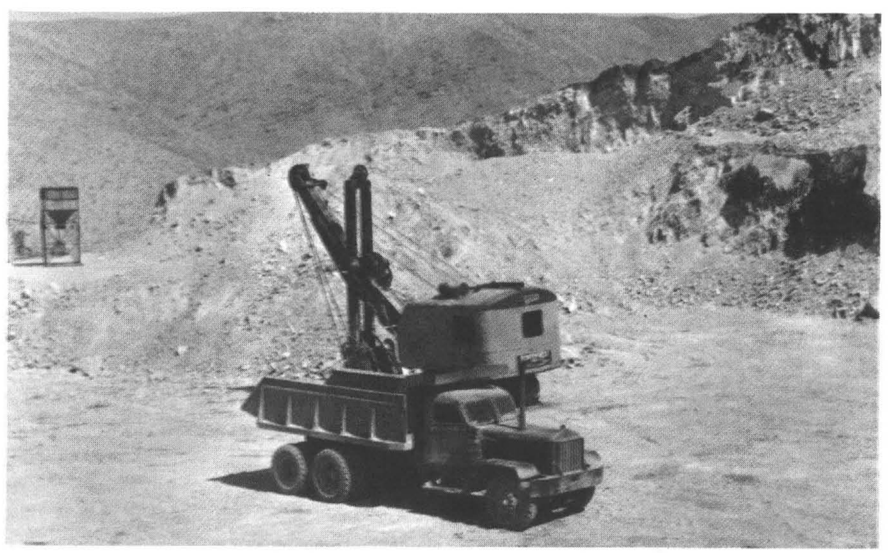


Photo 16. The Atlas quartzite quarry of Mineral Materials Company as seen in 1956, observer facing southeast. The company has produced 150,000–200,000 tons of quartzite since 1959, mostly for use by portland cement plants.

STRATIGRAPHY, STRUCTURE, AND MINERAL DEPOSITS IN THE ORO GRANDE SERIES NEAR VICTORVILLE, CALIFORNIA

By O. E. BOWEN, JR., and W. E. VER PLANCK

Introduction

Metasedimentary rocks of the late Paleozoic (?) Oro Grande Series near Victorville, California have yielded industrial minerals for more than 80 years. Between 1860 and 1910 marble dimension stone and lime were the chief products obtained, whereas after 1910 the principal output has been in raw materials for manufacture of portland cement. Silica in the form of quartzite (ganister) has been quarried intermittently for refractory purposes since 1925 and substantial tonnages of quartzite are used annually in cement manufacturing. Masses of white crystalline limestone in and adjacent to the mapped area have yielded high-grade ground limestone products for more than 25 years, as well as roofing granules, crushed limestone for glass, and other specialty products. Well over 50 million tons of limestone, several million tons of quartzite and many millions of tons of quartz-mica schist have been utilized thus far, and demand for such raw materials has sky-rocketed since World War II. Reserves of limestone and quartzite still amount to many hundreds of millions of tons.

The Victorville-Oro Grande district lies 85 miles, by either rail or truck, northeast of Los Angeles or 40 miles northeast of San Bernardino. The industrial mineral deposits are clustered around Quartzite Mountain at elevations ranging from 2800 to 4500 feet. The relief is great enough to provide good quarry sites but the terrain is not excessively rugged. Both Victorville and Oro Grande are served by the Santa Fe Railroad and all of the deposits are within a few miles of Highway U.S. 66. In the Mojave Desert annual rainfall seldom exceeds 5 inches but the Victorville-Oro Grande district is adjacent to the Mojave River from which water supplies have thus far proved adequate for industrial development.

The present study was undertaken to provide detailed information on the very complex structure and stratigraphy which controls the shape and distribution of the non-metallic mineral deposits. Adequate base-maps were not available for such a study at the time the Barstow quadrangle bulletin (Bowen, 1954) was written in 1953. In 1956 the 7½-minute Victorville quadrangle was released by the U.S. Geological Survey and a 1:12,000 enlargement (1 inch = 1,000 feet) of this map has been adopted for this work. The field survey was made during 1959 and the first quarter of 1960.

Early works of a reconnaissance nature covering the Victorville-Oro Grande district include those of Hershey (1902), Baker (1911), Darton (1915) and Miller (1944). The first intensive study of the 30-minute Barstow quadrangle was made by Bowen (1954) during the period 1940-1952. In the process of a still larger study made in the 1950's, covering much of the Mojave Desert, the 30-minute Barstow quadrangle was re-mapped on the new 15-minute base maps by T. W. Dibblee, Jr. of the U.S. Geological Survey. Preliminary releases of this mapping appeared in 1960 as U.S. Geol. Survey Map Sheets MF- 226, 229, 232, and 233.

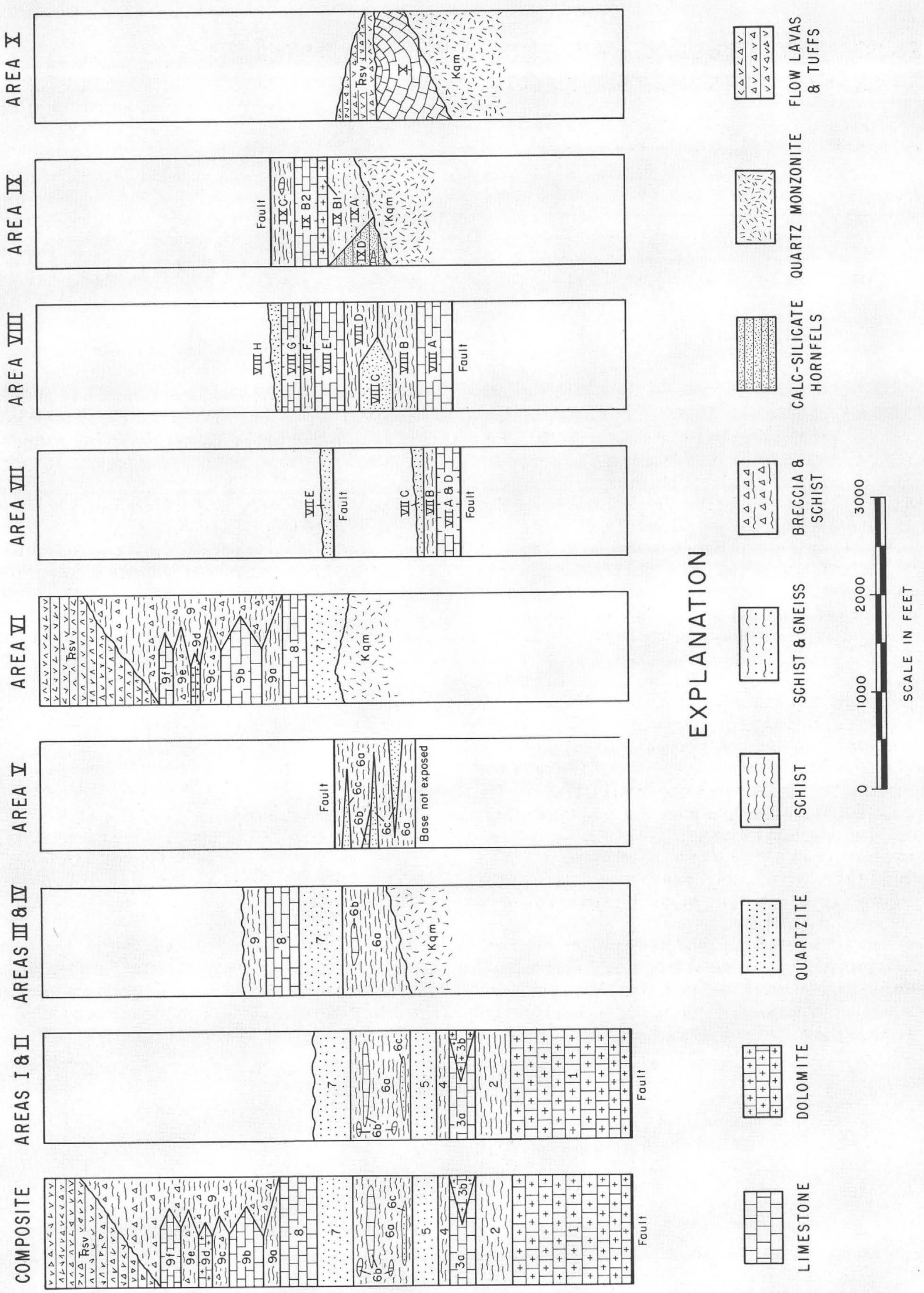


Figure 2. Columnar sections showing probable correlation of stratigraphic units, map areas 1–10.

The Oro Grande Canyon deposits are small but readily accessible. The Original quarry furnished a modest tonnage of limestone for lime in the late 19th and early 20th Centuries and probably for the Golden State Portland Cement Company's plant at Oro Grande. Elsewhere, the deposits have been opened by test cuts or small quarries that perhaps were made by the lime burners and sugar rock producers of the late 19th Century. The deposits are relatively thin and steeply dipping, and the readily recoverable reserves are small compared with other deposits on the Riverside property.

Macks Peak consists of massive to brecciated, blue-gray, medium crystalline limestone and dolomite, map unit VII D, that have been thrust over other Oro Grande Series units. The upper 50 feet is fair quality limestone low in silica, alumina, and iron but with 3 to 4 percent of magnesia. The material at greater depth is even more dolomitic. The following are the analyses of samples from two test cuts at the south edge of Macks Peak just north of the Oro Grande Canyon road (Analyses by the Twining Laboratories, Fresno):

	Percent	Percent
SiO_2	1.10	3.84
Al_2O_3	0.25	0.77
Fe_2O_3	0.19	0.19
CaO	51.18	50.42
MgO	2.98	2.46
P_2O_5	0.08	0.12

Unit VIII E is a steeply south-dipping limestone bed on the south side of Oro Grande Canyon just southwest of Road Junction 3192. The limestone is low in silica, alumina, and iron, but contains 2½ to 4 percent magnesia. A narrow outcrop north of Oro Grande Canyon road and west of Road Junction 3192, map unit VIII G, also is low in silica, alumina, and iron but contains 3½ to 4½ percent magnesia. In the Original quarry, the limestone of map unit VIII G contains 2 to 3 percent magnesia and a considerable proportion of interbedded schist and granitic intrusives.

Dolomite Deposits

Central Ridge Deposit

Location: SW¼SE¼ sec. 10, W½NE¼ sec. 15, T. 6 N., R. 4 W., SB., on the ridge and in the intervening canyon northeast of Oro Grande beacon and 3 miles east-northeast of Oro Grande. Owner: not ascertained. Central Ridge is underlain by an enormous mass of dolomite that is undeveloped and unexplored. The northern part of it is readily accessible to the road through Oro Grande Canyon.

White, massive, medium-to-coarse-crystalline dolomite map unit 1, occupies a northwest-trending belt 2500 feet long and 1500 feet wide across the east-central part of Quartzite Mountain. The beds dip steeply. Locally, the dolomite contains dikes of granitic rock, zones of contact metamorphic minerals, and thin lenses of schist. The analyses of two representative samples of dolomite follow (analyses by the Twining Laboratories, Fresno):

	BD-1	BD-2
SiO_2	2.10%	5.16%
Al_2O_3	4.89	1.80
Fe_2O_3	2.07	1.10
CaO	31.95	30.68
MgO	16.15	19.70
P_2O_5	0.12	0.14

BD-1: Top of unit between prospect pits east of pole line.
BD-2: Pit at north end of Central Ridge, near base of unit.

The reserves within 50 feet of the surface exceed 15 million tons.

Dolomite Southwest of Quartzite Mountain

Location: SE¼NE¼ sec. 16, T. 6 N., R. 4 W., SB., at the head of the canyon west of Oro Grande beacon and 2¼ miles east-northeast of Oro Grande. Owner: not ascertained. The deposit is undeveloped, relatively small, and difficult to get to.

The deposit consists of medium crystalline, off-white dolomite, map unit 3b, about 200 feet thick that dips gently into the mountain. Dolomite is exposed without overburden within an area 1500 feet long and 800 feet wide. The analyses of two samples follow (analyses by the Twining Laboratories, Fresno):

	MD-1	MD-2
SiO_2	4.66%	3.44%
Al_2O_3	2.90	2.83
Fe_2O_3	1.18	1.21
CaO	30.08	30.46
MgO	19.02	20.58
P_2O_5	0.06	0.08

MD-1: Near top of unit in canyon west of Oro Grande beacon.
MD-2: Lowest exposure in canyon west of Oro Grande beacon.

Klondike Deposit

Location: SE¼NW¼, SW¼NE¼, NW¼SE¼ sec. 17, T. 6 N., R. 4 W., SB., 1¼ miles northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. Dolomite is associated with limestone in the Shay-Klondike quarries. Although none has been produced, a substantial tonnage of dolomite could be obtained easily. Blue-gray to white crystalline dolomite, map unit IX B 1, 50 to 60 feet thick underlies the limestone. It is exposed for a strike length of 1000 feet and forms an unquarried remnant on the west wall of the Klondike quarry. We estimate that about 200,000 tons of dolomite are exposed above the local ground level. At the borders the deposit grades into dolomitic limestone.

Quartzite Quarries

Riverside Cement Company Deposit

Location: NE¼NW¼ sec. 17, T. 6 N., R. 4 W., SB., just north of the Shay quarry and 1 mile northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. The quarry has been oper-

	Sm-1	Sm-2	Sm-3	Sm-4	Sm-5	Sm-6	Sm-7
SiO_2	0.52%	0.97%	1.57%	0.63%	0.99%	1.45%	5.33%
Al_2O_3	0.15	0.11	0.15	0.59	0.20	0.28	1.50
Fe_2O_3	0.45	0.75	0.43	0.32	0.38	0.24	0.22
CaO	50.85	50.24	53.27	51.00	51.29	50.65	50.80
MgO	3.94	4.98	1.98	4.14	3.49	4.58	1.47
P_2O_5	0.05	0.11	0.04	0.05	0.04	0.03	0.08

Sm-1: Banded limestone collected near the base of map unit 3 near the most southeasterly prospect adit.

Sm-2: Typical, medium-crystalline, blue-gray limestone from the middle of map unit 3—collected in upper middle test pit.

Sm-3: Limestone from upper beds of map unit 3 about 500 feet upslope from the Oro Grande beacon service roadway and nearly due west of the most southeasterly prospect adit.

Sm-4: Typical blue-gray, faintly-banded limestone collected near the top of map unit 3 directly above the cluster of open cuts located S. 25° W. of the Oro Grande beacon generator house.

Sm-5: Typical medium-grained, blue-gray limestone from the uppermost cut lying S. 25° W. of the Oro Grande beacon generator house. Collected in the middle of map unit 3.

Sm-6: Typical, medium-grained, blue-gray limestone from near the base of map unit 3 due south of the generator house.

Sm-7: Typical sample collected near the base of map unit 3 directly downslope from the uppermost cut in which sample Sm-5 was collected.

The deposit is undeveloped and unexplored except for several test cuts at the northwest end of the outcrop just above the line along which the limestone disappears beneath the alluvium of Oro Grande Canyon. Even though the limestone dips steeply into the mountain, we estimate that 10 to 15 million tons could be recovered within a strike distance of 2000 feet from these test cuts where the mountain slope is relatively gentle.

Quarry 2

Location: SE¼SE¼ sec. 10 and SW¼SW¼ sec. 11, T. 6 N., R. 4 W., SB., at the east end of Quartzite Mountain and 3¾ miles east-northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. Quarry 2 is the most southerly of the group of quarries in and around section 11 that supplied the Victorville plant until about 1951.

The quarry has exposed a mass of gently dipping blue-gray, medium-crystalline limestone, map unit 8, up to 500 feet thick that is underlain by quartzite and overlain by schist. It crops out in an area 1000 feet long and 750 feet wide. The limestone contains about 2 percent of magnesia and 5 percent of silica. We estimate the reserves to a depth of 100 feet to be 2 million tons.

Quarry 2 has been developed by an upper bench 1000 feet long and up to 100 feet high that was worked southward into the hillside. There is also a bench about 100 feet lower that has been started from a long cut through the overlying schist.

Quarries 3, L-4, E-6, and 8

Locations: Sec. 11, T. 6 N., R. 4 W., S.B., at the east end of Quartzite Mountain and 4 miles east-northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. These quarries furnished many millions of tons of limestone for the Victorville plant from the time it was opened in 1916 to about 1951.

These quarries have developed a north-trending, nearly vertical mass of blue-gray and white, medium-crystalline limestone, map unit 8, lying between quartzite to the east and schist to the west. It ranges in thickness from 600 feet in the south to 200 feet in the north. Granitic rock is exposed at the surface within a few hundred feet to the east of the limestone and undoubtedly underlies it at a relatively shallow depth. The limestone has been extensively altered and locally contains patches of garnet-epidote tactite and magnesian limestone. The unaltered limestone contains 1 to 2 percent of magnesia and 2 to 6 percent of silica.

The deposit has been developed by advancing several faces from east-west trending gullys. Quarry 3 and Quarry L-4 in NE¼SW¼ section 11, originally were opened on opposite sides of a good sized hill, have merged and ultimately resulted in a hole approximately 100 feet below the surrounding land surface. Quarry E-6 in SE¼NW¼ section 11 was driven north toward Quarry 8 in NE¼NW¼ section 11 and NW¼NE¼ section 11. Reserves in the Quarry 3 area are probably too small for the property to be of further use for cement, but probably one to two million tons could be recovered from Quarry E-6 northward.

Quarries 1 and 10

Location: NE¼SW¼ sec. 11, T. 6 N., R. 8 W., SB. west of Quarries 3 and L-4 and 4 miles east northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. These quarries furnished siliceous limestone as part of the feed for the Victorville plant from 1916 to about 1951.

Quarries 1 and 10 have developed blue-gray, medium crystalline limestone, map unit 9b, of map area VI. The limestone forms a steeply dipping, lenticular body 100-200 feet thick enveloped in schist. It contains 1 to 2 percent MgO, 1 to 5 percent Fe_2O_3, 5 to 10 percent Al_2O_3, and up to 20 percent SiO_2. Quarries 1 and 10 were driven toward each other from opposite sides of the hill west of Quarries 3 and L-4. Ultimately they joined, forming a cut 150 feet wide and 50 feet deep. No reserves remain above local ground level. Immediately east of this cut, there is a notable mass of limestone that has not been quarried and the properties of which we have not ascertained.

Oro Grande Canyon Deposits

Location: southeast corner sec. 8 and southwest part of sec. 9, T. 6 N., R. 4 W., SB., along Oro Grande Canyon and 2 miles northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057.

Lithology and stratigraphic succession

The Oro Grande Series

The name Oro Grande Series was first applied by O. H. Hershey in 1902 (p. 287-288) to the exposures just east of Oro Grande. Baker (1911) in his fine contribution to the Cenozoic history of the Mojave Desert also used the name. The series was further mentioned, un-named, and briefly described by Darton (1917, p. 163). Miller (1944) used the name Oro Grande metasediments and designated the type locality. Bowen (1954, p. 23-24) wrote a detailed description of the Oro Grande Series, reaffirmed Miller's designation of the type locality, measured the type section on Quartzite Mountain and compared various isolated sections of the series found within the Barstow 30-minute sheet. Because of space limitations, Dibblee (1960), could not include a detailed discussion of the stratigraphy of the Oro Grande Series on his map sheet.

The term "series" is not used here in the time-stratigraphic sense. Early workers such as Hershey and Baker simply meant sequence or succession. The name Oro Grande Series is well entrenched in the literature and the authors do not believe that any good purpose will be served by giving the assemblage formation or group status.

The Oro Grande Series is a heterogeneous, metamorphosed marine sedimentary sequence exposed in the Victorville-Oro Grande district, the Shadow Mountains northwest of Adelanto, the Sidewinder Mountain district and the Hinkley Valley district. It is probably correlative to the combined Furnace Limestone, Chicopee and Saragossa Quartzite formations of the San Bernardino Mountains and to isolated patches of marble and quartzite in the Newberry and Ord Mountains. The sequence generally consists of carbonate rocks, schists derived from silty and sandy shales and claystones, and quartzite (probably metasandstone) in that order of abundance. Gradational facies exist between the carbonate rocks and aluminous rocks—commonly calcareous mudstones that have been metamorphosed to calc-silicate hornfelses. Much less commonly carbonate and aluminous rocks are intimately interbedded as in the Shadow Mountains where part of the series consists of alternating layers of crystalline limestone, quartz-mica schist or metasandstone. In contrast, the quartzite units are much more sharply defined, particularly in the Victorville-Oro Grande district, and consist almost entirely of nearly pure quartz sands in which feldspar is almost nil and sericite is the chief minor accessory mineral. Bedding in the quartzites, where visible at all, is poorly defined. This characteristic is true of the thicker carbonate units as well.

Because of the lithologic variation and structural complexity of the Oro Grande Series in the Victorville-Oro Grande district, in which the rocks have been tightly folded and then cut into fault blocks, it is necessary to: (1) divide the map into well defined areas and (2) describe and compare the successions in the various areas. These areas are designated by Roman numerals (I etc.) and are arranged counterclockwise starting with those areas containing the best exposed, most complete, best defined stratigraphic units. It so happens that the degree of certainty in correlation among the various map units of the several areas for the most part decreases counterclockwise around the map. The rock-stratigraphic map units are designated by cardinal numbers plus lower case letters (where applicable i.e. 6a) where the succession is believed to be quite reliable and by capital letters plus area numerals where correlation is less reliable (i.e. VIIIA). A revision of the type section described by Bowen (1954, p. 24-25), which is located in map area II, and a suggested correlation among rock-stratigraphic units in the several map areas may be found in figure 2. An index map showing the orientation of the several "map areas" may be seen as an inset adjacent to the geologic map on plate 1.

Map Areas I Through VI

Map area I is bounded on the west by the Klondike fault system, on the north by the Shay-Comet fault, on the east by the Quartzite Mountain fault and on the south by quartz monzonite intrusions. *Map area II* is bounded on the west by the Quartzite Mountain fault, on the north partly by Quaternary alluvium and partly by plate remnants of the Quarry 12 thrust, on the east by the Central Ridge fault and on the south by quartz monzonite intrusions. *Map area III* is bounded on the west by the Central Ridge fault, on the north by Quaternary alluvium, on the east by the Amazon fault and on the south by Quaternary alluvium. *Map area IV* is bounded on the west by the Amazon fault, on the north by alluvium and artificial fill, on the east by the East End fault and on the south by alluvium. *Map area V* is bounded on the west by the East End fault and elsewhere by overlapping alluvium and artificial fill. *Map area VI* is bounded on the west and north by overlapping Triassic (?) volcanic rocks and on the east and south by overlapping Quaternary alluvium.

The stratigraphic units in map area I through VI are distinct enough and correlation is reliable enough

Photo 1.

Photo 1. An end-on view, observer facing south, of north-trending Central Ridge, together with part of the northeast slope of Quartzite Mountain, showing part of the type section of the Oro Grande Series. The units are numbered along the skyline. The Central Ridge interval occupied by map unit 1, the lowermost dolomite, is approximately 1200 feet.

Photo 2. Northeast face of Quartzite Mountain, showing the disposition of the units in the type section. The light-colored ridge in the left middle ground is Central Ridge. Observer faces southwest. The map units are numbered along the skyline.

Photo 3. Old quarries and pits worked for sugar rock on the Summit claims of Southwestern Portland Cement Company on the northeast slope of Quartzite Mountain. The blue-gray, medium-crystalline limestone is part of map unit 3 in the type section.

Klondike Quarry

Location: SW¼NE¼ and NW¼SE¼ sec. 17, T. 6 N., R. 4 W., SB., adjoining the Shay quarry on the southeast and 1¼ miles northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. The Klondike quarry was opened in 1942 and until about 1961 was the principal source of limestone for the Oro Grande plant. Total production amounts to many millions of tons.

Medium to coarse crystalline blue-gray limestone, map unit IX B 2, 200 to 450 feet thick, crops out for 1500 feet along the west face of the low ridge that adjoins the Quartzite Mountain group of hills on the west. The beds continue to the northwest into the Shay quarry but are cut off by a fault to the southeast. The limestone is underlain by 50 to 60 feet of dolomite, and the dolomite is underlain by gneiss. To the east the limestone is in fault contact along the Shay-Klondike fault with schist and quartzite of map area I. The rocks in the quarry are, in addition, disrupted by minor faults and folds and have been intruded by granitic bodies. Much of the quarry is filled with slide rock, mostly limestone debris, that slid off the east face of the main quarry along the Klondike fault surface. The great bulk of the limestone is low in silica and magnesia. Reserves are undoubtedly substantial but difficult to quarry without removing an enormous amount of material of little usefulness.

The Klondike quarry is 1500 feet long, 300 to 500 feet wide, and was developed with 25-foot transverse benches. It was driven from the northwest. On the west side the face is 50 to 75 feet high, and the slide on the east side is as much as 250 feet high.

Quarry 12

Location: SE¼SE¼ sec. 9, T. 6 N., R. 4 W., SB., in Oro Grande Canyon northwest of Oro Grande beacon and 2¼ miles northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90057. Quarry 12 was developed after 1938, and until about 1951 was one of the principal sources of limestone for the Victorville plant. It was idle in 1960. Total production has been several million tons.

At Quarry 12, massive blue-gray, medium crystalline limestone, map unit VII A, occurs in a northwest-dipping thrust plate that overlies Oro Grande Series units of map area II. The limestone is several hundred feet thick and crops out over an area 1000 feet long and 700 feet wide. North of the quarry the limestone is overlain by relatively thin schist and quartzite units, but south of it the limestone has no overburden. The limestone averages 2½ to 3 percent magnesia and 3 to 4½ percent silica.

Quarry 12 is an opening 500 feet long, 300 feet wide, with faces up to 60 feet high, that was driven from the east. Quarrying has been carried westward to the west boundary of the property. We estimate, however, that 4 million tons of limestone remain to the south of the quarry and beneath the quarry floor.

Sugar Rock Quarry

Location: SE¼SE¼ sec. 9, T. 6 N., R. 4 W., SB., just west of Quarry 12 and 2¼ miles northeast of Oro Grande. Owner: Ideal Cement Company, 620 Denver National Bank Building, Denver 2, Colorado. The Sugar Rock quarry was one of several in Oro Grande Canyon that furnished high quality limestone for beet sugar factories and for lime from the 1880's to about 1914. It has been idle for many years.

The Sugar Rock quarry embraces the western edge of the deposit that has been opened at Quarry 12. On the southwest the deposit is limited by the northwest-trending Sugar Rock quarry fault. The following is the analysis of a typical specimen (analysis by the Twining Laboratories, Fresno):

	Percent
SiO_2	— 1.55
Al_2O_3	— 0.96
Fe_2O_3	— 0.14
CaO	— 51.14
MgO	— 3.00
P_2O_5	— 0.19

Reserves are fairly small as the entire property consists of less than 2 acres and the limestone does not persist at depth; in addition, access to the quarry could not be obtained without arranging a right-of-way across the adjoining properties. In addition to the limestone in place, the property contains a dump of 50,000 to 75,000 tons of broken limestone rejected by the Sugar Rock quarry men but probably suitable for portland cement.

Summit Claims

Location: a strip from the center to the northwest corner of sec. 15, T. 6 N., R. 4 W., SB., on the northeast face of Quartzite Mountain and 3 miles east northeast of Oro Grande. Owner: Southwestern Portland Cement Company, 1034 Wilshire Boulevard, Los Angeles 90017. The deposit contains an enormous tonnage of limestone but is practically undeveloped.

The Summit claims cover much of the strike length of map unit 3—a massive blue-gray, medium crystalline limestone that averages 250 feet thick. It crops out from near the summit of Quartzite Mountain, down its steep northeast face to the base, a distance of about 4,000 feet. It dips steeply southwest into the mountain and is overlain by massive quartzite. As far as we know, the deposit has not been sampled by any of the operating companies. The following analyses are of clean spot samples that we collected. They suggest that the limestone is fairly high in magnesia and that some blending might be necessary for use in portland cement (analyses by the Twining Laboratories, Fresno):

Photo 14 (top). West face of Quarry 12 of Southwestern Portland Cement Company, showing gently dipping, platy character of the limestone of map unit VIIA. Quarry 12 was one of the principal sources of limestone for the Victorville plant from 1938 to about 1951. Photo, March 1960.

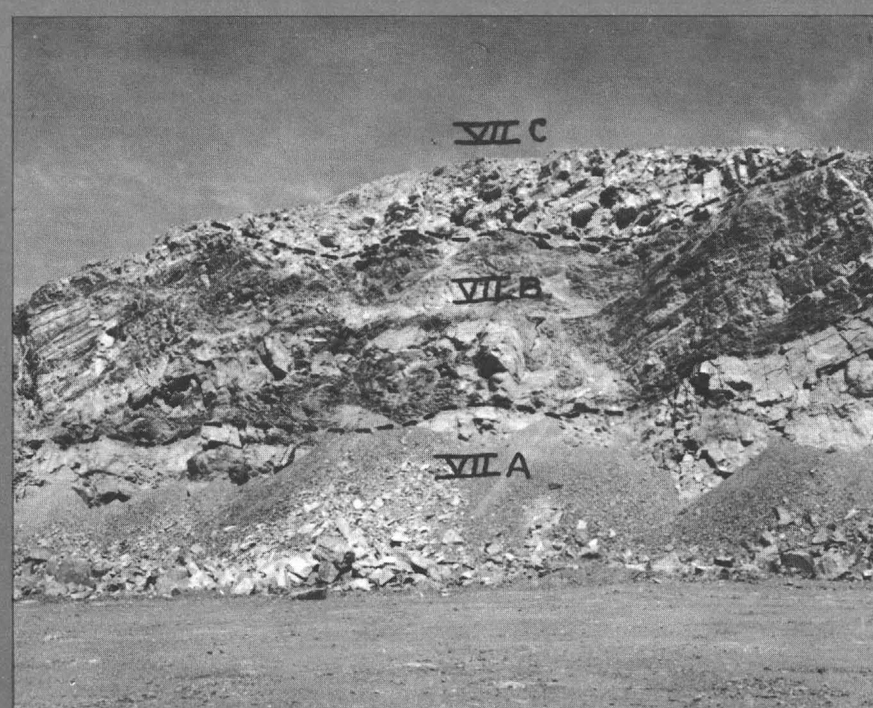
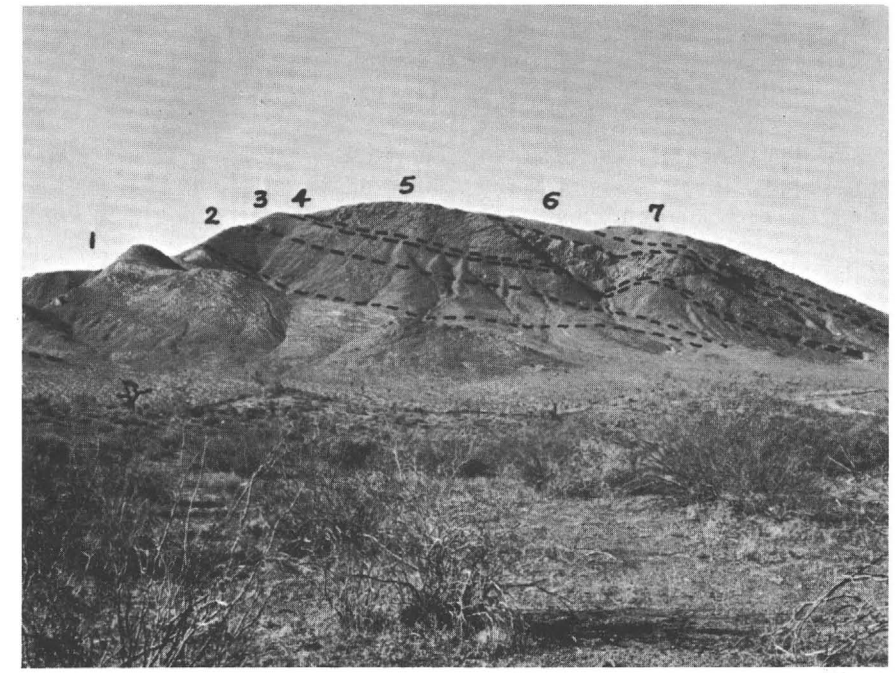


Photo 15 (bottom). North face of Quarry 12 of Southwestern Portland Cement Company as seen in March 1960. Massive quartzite (VIIC) and platy schist (VIIB) conformably overlie limestone of map unit VIIA. These are all parts of one of the thrust plate remnants which override the northwest end of Quartzite Mountain.

Photo 2.



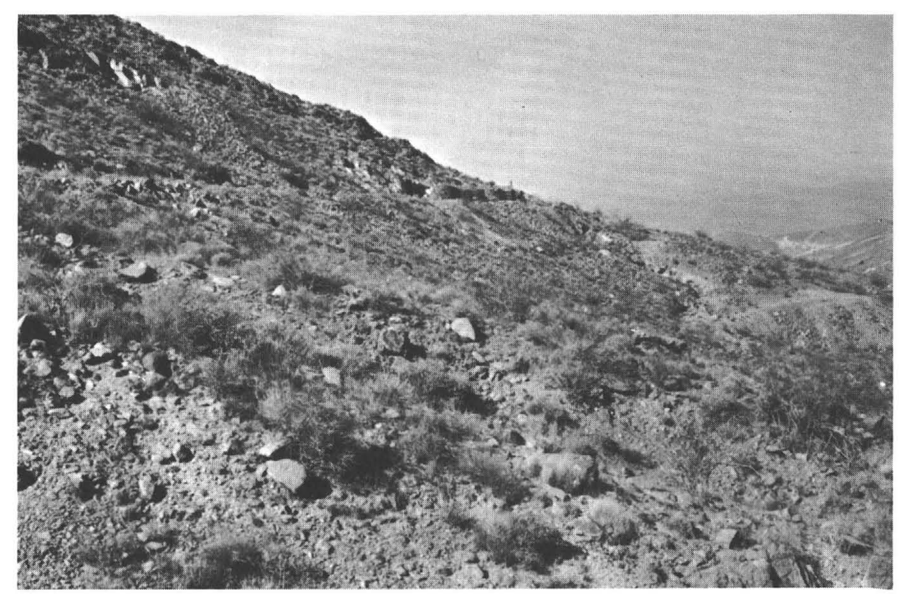


Photo 3.

to consider these areas together. Although the type section, which is the most complete succession available, lies in map area II, we began our area numbering system in map area I adjacent to it on the west because the structure there is simpler and the succession more obviously in order. The base of the type section commences at the Central Ridge fault and continues southwesterly to the crest of Quartzite Mountain. Dolomite of the lowermost unit stands out prominently from drab surroundings as a light-colored, north-trending ridge, here called the Central Ridge. Central Ridge lies close to the northeast base of Quartzite Mountain and merges with Quartzite Mountain on the south. Because of excellent, continuous exposures and lack of structural complications the type section was measured southwesterly along the drainage divide between Oro Grande Canyon and Sidewinder Valley from the Central Ridge fault to the crest of Quartzite Mountain. At this point the crest is underlain by map unit 5, with precipitous topography and poor exposures to the west. Consequently, map unit 5 was followed along the strike half a mile northwest to a point where the other 2 existing stratigraphic units could better be measured.

Map unit 1, the lowermost dolomite, consists of about 1200 feet of medium- to coarse-grained, white, crystalline dolomite. Irregular patches of crystalline limestone a few feet thick and an occasional lens of black quartz-mica schist reflect the only variations in sedimentation for this interval. Locally, the rock is contact-altered to sulfur-yellow serpentine and white calcite (ophicalcite) or, less commonly, to dark-weathering diopside-tremolite-garnet-idocrase-calcite rock. A few dikes of hornblende diorite, biotite quartz monzonite, granite pegmatite and granite aplite penetrate the dolomite unit. Muscovite, phlogopite and green chlorite clots and disseminations commonly occur close to the dikes, as well as occasional concentrations of sphalerite, galena and pyrite.

The bulk of the rock in Central Ridge, even on weathered surfaces, is white or very light-colored but to the south, where the ridge merges with the southeast slope of Quartzite Mountain, the iron content of the rock increases slightly and it weathers to a uniform light brown.

The steep-dipping dolomite of map unit 1 is in fault contact with quartzite and schist on the east and grades rather sharply into schist and hornfels of map unit 2 on the west. Fossils have not been found in it. At the northern end of Central Ridge elements of the lowermost dolomite unit have been overturned and truncated by an overthrust developed along the axis of a reclining fold.

Selected sites in the lowermost dolomite unit would yield dolomite of fairly good commercial grade but thus far there has been little demand for it in this vicinity.

Photo 4 (below). Typical outcrops of the lower commercial quartzite (map unit 5) on the northeast face of Quartzite Mountain.

The gross-silica content as quarried, however, is high, averaging 10 percent or more. Reserves are in the order of several hundred million tons.

The quarry has been developed with 50-foot benches of large areal extent. Up to 1961 rock had been removed chiefly from the top and the south face of Sparkhule Hill.

Shay Quarry

Location: SE¼NW¼ sec. 17, T. 6 N., R. 4 W., SB., 1 mile northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. The Shay quarry furnishes schist and part of the limestone required for the Oro Grande plant. It was developed following World War II at the time the Oro Grande plant was modernized.

The Shay quarry exposes blue-gray, medium to coarsely crystalline limestone and overlying schist units at the intersection of the Shay-Comet and Klondike fault zones. Two limestone units are present, map unit VIII A north of the Shay-Comet fault zone, and map unit IX B 2 south of it. The rocks are intricately folded, faulted, and intruded by granitic rocks. Both limestone units also contain relatively thin interbeds of schist and quartzite. Part of the limestone is dolomitic. In general the beds strike northwestward and dip north at 40° to 60°. The limestone is underlain by up to 200 feet of dolomite. Bore holes show that, although good quality limestone is present, much of the limestone in the Shay quarry contains 3 to 5 percent of magnesia. Reserves of limestone are probably several million tons, but become available relatively slowly as the high silica and high magnesia material that must be concurrently removed can be absorbed by the plant.

The quarry is crudely elliptical in plan, and measures about 1000 feet by 800 feet. By means of 50-foot benches it has been sunk to 50 feet below ground level on the west side. The face on the east side is as much as 150 feet high.

Photo 13 (below). Panorama across the south face of the Sparkhule Hill limestone deposit of the Riverside Division of American Cement Corporation, observer facing northeast. Limestone several hundred feet thick crops out without overburden over more than 200 acres. Reserves exceed 100 million tons.

kilns have been placed in operation, making a total of seven, having a combined annual capacity of 6,250,000 barrels.

Silica Brick

The Atlas Fire Brick Company began the manufacture of silica brick in California in 1918. Emsco Refractories Company purchased Atlas Fire Brick Company in 1928 and became a Division of Gladding McBean and Company in 1944. Tillotson Clay Products Company, now part of General Refractories Company, and Harbison-Walker Refractories Company also manufacture silica brick in California but as far as we know have never quarried quartzite in this state.

Gladding McBean and its predecessors initially obtained quartzite from deposits north and east of Hodge. About 1929 Emsco Refractories Company transferred its operations to a deposit leased from Southwestern Portland Cement Company at the east end of Quartzite Mountain. The Atlas quarry at the west end of Quartzite Mountain was opened by Mineral Materials Company about 1939 to furnish quartzite for the manufacture of silica brick as well as for portland cement. Riverside Cement Company's quartzite quarry has also yielded quartzite for the silica brick industry.

Limestone Deposits

Sparkhule Hill

Location: E½SW¼ and W½SE¼ sec. 4, T. 6 N, R. 4 W., SB. on Sparkhule Hill approximately 3 miles northeast of Oro Grande. Owner: Riverside Division, American Cement Company, 2404 Wilshire Boulevard, Los Angeles 90057. The Sparkhule Hill quarry has been developed since 1952 and in 1960 was the principal source of limestone for the Oro Grande plant.

The deposit consists of a hill over which massive, blue-gray to black limestone, map unit X, crops out virtually without overburden for more than 200 acres. The limestone is gently folded into a northwest-trending syncline. To the east it is overlapped and locally intruded by rocks of the Sidewinder Volcanic Series; to the north, west, and south it is bordered by older alluvium. Test borings reveal that granitic rock as well as volcanic rocks of the Sidewinder Volcanic Series underlie the limestone at depths of several hundred feet. The limestone mass contains numerous siliceous veins and veinlets.

Most of the limestone is a blue-gray material with sugary texture. Some of it is fine-grained and black, and some is coarse-grained and white. Analyses of bore holes show that virtually none of the limestone contains more than a few tenths of a percent of magnesia.

Map unit 2, the lower schist-hornfels, consists predominantly of dark-brown to black quartz-mica schist with lesser dark green calc-silicate hornfels and dark brown quartz-biotite hornfels. It ranges from 150 to 500 feet thick and averages about 350 feet thick. Thin dikes and sills of black hornblende quartz diorite have penetrated the unit and have been rendered schistose along with the metasediments. Minor proportions of light-gray micaceous quartzite also occur in thin scattered beds within the unit.

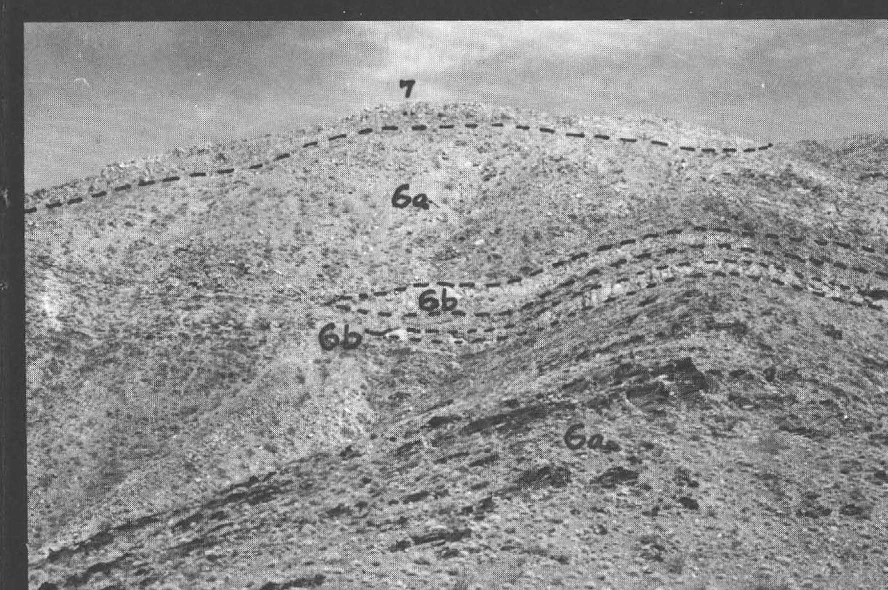
Map unit 3, the principal carbonate unit, consists chiefly of blue-gray, massive, medium-grained crystalline limestone, in the type section on Quartzite Mountain (map area II). It contains the principal undeveloped reserve of commercial limestone in the Victorville-Oro Grande district. In map area I, however, this stratigraphic interval is occupied chiefly by light-gray to off-white, light-brown-weathering dolomite—apparently a replacement of the normally calcitic beds of this interval. The principal carbonate unit is in sharp but slightly gradational contact with the lower schist-hornfels unit. It ranges in thickness from 150 to 550 feet and averages about 250 feet.

Map unit 4, the schist-quartzite transition unit, lies conformably above the principal carbonate unit in the type section on Quartzite Mountain where it consists of 60 to 80 feet of dark-brown to black quartz-mica schist. Thin beds of light-colored micaceous quartzite and dark calc-silicate hornfels are also present. The unit is persistent along the east side of Quartzite Mountain for about a mile but west of Quartzite Mountain the corresponding interval is represented only by thin lenses of schist interspersed with the uppermost carbonate beds of map unit 3.

Map unit 5, the lower commercial quartzite, consists almost solely of glassy to off-white, light-gray to pale-pink-weathering, medium-grained quartzite. Bedding is faintly discernible here and there but sedimentary structures generally are lacking. The unit ranges from 150 to 400 feet in thickness and averages about 250 feet in thickness.

Under the microscope the quartzite is a dense mosaic of quartz grains ranging in diameter from 0.2 to 1 mm. The original outlines of the sand grains are discernible in some thin sections whereas in others the original sedimentary texture has been obliterated during metamorphism. Calcite is absent and feldspar is rare—well under half of one percent. Finely divided muscovite

Photo 5 (below). Southwest slope of Quartzite Mountain, showing typical exposures of schist (6a) and limestone (6b) of map unit 6. This predominantly schist unit is about 1100 feet thick on this slope, but on the opposite side of the Quartzite Mountain syncline (on the northeast slope of Quartzite Mountain), it has been reduced to only 100 feet in thickness through extreme compression between two competent quartzite units.



is widely distributed in interstitial and included wisps but does not exceed 1.0 percent in any of the thin sections examined. Minute grains of tourmaline, sphene, zircon(?), magnetite, biotite, limonite and pyrite were identified in various specimens collected from map unit 5. Joint surfaces commonly are coated with a film of iron oxide minerals.

Map unit 6, the principal schist unit, lies conformably between the two commercial quartzite units. It consists mainly of black to dark-brown quartz-mica schist, biotite causing the dark hues. Amphiboles are uncommon to rare in this unit. Green calc-silicate hornfels is locally developed and an occasional bed of clean quartzite (map unit 6c) is to be seen in the lower part of the unit. Long, thin lenses of light-brown-weathering limestone and magnesian limestone (map unit 6b) are characteristic of the upper middle third of the principal schist unit. In map area I, one of these limestone subunits can be followed continuously for over a mile and acts as a structural marker bed. Lesser lenses of carbonate rock occur both above and below this horizon in map area I and on the west flank of Quartzite Mountain in map area II.

As the principal schist unit lies between the two commercial quartzites, which are massive and competent, it has been intensely deformed by being compressed between the two. As the compressive forces probably were not symmetrically directed and as the quartzite "anvils" probably were lenticular to start with, the principal schist unit has suffered marked thinning at some points and equally intense thickening at others—both by plastic flow and by shearing. The average thickness of the principal schist unit probably is 500 feet but on the east side of the Quartzite Mountain syncline the thickness of the unit has been reduced to as little as 100 feet in contrast to the west side where it has been thickened to something like 1100 feet.

Map unit 7, the upper commercial quartzite, is lithologically and chemically identical to the lower commercial quartzite and need not be described further. It occupies much of the crest of Quartzite Mountain but passes beneath a flatiron-shaped salient of the Oro Grande Canyon thrust plate at the north end of the mountain. The unit reaches a maximum thickness of 450 feet but probably does not average more than 250 feet in thickness. An occasional interbed of dark quartz mica schist a few inches to a few feet thick is the only feature indicative of structure or of variation in the sedimentation within either of the two massive quartzite units.

Although the Quartzite Mountain fault separates the sequences in map areas I and II the successions correspond so closely that the authors feel no further comment is necessary. East of the Central Ridge fault, however, strikes of the units change abruptly from the uniform northwest course seen in map area II to the northeast course seen in map areas III and IV; the dips change dramatically too so that a large (possibly lateral) displacement must have taken place along the Central Ridge fault. However, the conformable succession of thick schist, quartzite and limestone units in map areas III and IV can hardly be other than map units 6 and 7 as delineated in map areas I and II plus an overlying limestone unit (map unit 8) and schist (map unit 9) not present in I and II. No alternative is reasonable.

Map unit 8, the Quarry 3 Limestone, is massive, blue-gray limestone similar in most physical respects to the principal carbonate (map unit 3) of the type section. The rock is higher in silica, iron oxide and alumina than the average of samples from the principal carbonate collected along the northeast flank of Quartzite Mountain and materially lower in magnesia (2.0 versus 3.5). The unit reaches a thickness of 550 feet but is not exposed, within map areas III and IV, for any great strike length (less than 1200 feet). The average thickness is 300 feet. As this limestone is conformably overlain by a relatively thick schist unit and conformably underlain successively by thick quartzite and schist units, it can hardly belong anywhere, stratigraphically, but directly above the upper commercial quartzite of the type section. Notable reserves of commercial limestone remain in this unit.

Map unit 9, the uppermost mixed unit is represented, in map areas III and IV, by uniform dark-brown-to-black quartz-mica schist, the transition between it and the adjacent members being conformable and abrupt. This uppermost schist is about 250 feet thick. Toward the top it is overlapped by alluvium and presumably is cut off by the Railroad Grade fault. Lithologically it is similar to other schist map units, but because of its stratigraphic position it is, in all probability, a schist subunit of the upper mixed unit delineated in area VI.

In map area VI a complex unit consisting of quartzite breccia, quartz-mica schist, crystalline limestone, crystalline dolomite, quartzite and calc-silicate hornfels occupies the uppermost part of the stratigraphic succession. There it is unformably overlain by latite and dacite flows of the Triassic (?) Sidewinder Volcanic Series (Bowen 1954, p. 42-53).

In the southwest half of map area VI this mixed unit consists of 3 schist-quartzite-hornfels subunits alternating with 3 carbonate subunits. To the northeast, however, the carbonate subunits lens out, and the entire 2400 feet of exposed thickness consists of sedimentary quartzite breccia, including lenses of quartz-mica schist, quartzite, hornfels and carbonate rocks. We have somewhat arbitrarily taken 2000 feet as the average thickness of map unit 9, but it ranges from 1200 to 2400 feet in thickness. This appearance of quartzite breccia is unique among rocks of the Oro Grande Series in Barstow quadrangle although sedi-

State Portland Cement Company, it is possible that the Original quarry was worked by the Union Lime Company. There may have been small workings in the Klondike area also. The "upper quarries" (Aubury 1906, p. 78) could be the small openings along Oro Grande Canyon. What is now called the Sugar Rock quarry could be the Superior quarry or the Summit quarry or both. None of the properties listed by Bailey (1902) was patented.

Portland Cement Industry

The Portland cement industry did not assume significant proportions in California until about 1900. The limestone deposits in the Victorville-Oro Grande area, were known considerably earlier; and their potential value was recognized by men who were interested in dimension-stone and lime. Despite the fact that there was a steady production of precious metals before 1900, metal miners in this area seem to have played no part in the development of the nonmetallic mineral resources. The first cement plant in the district was opened at Oro Grande in 1910 by Golden State Portland Cement Company—a predecessor to Riverside Cement Division of the American Cement Corporation. The Victorville plant of Southwestern Portland Cement Company began production in 1916.

Golden State Portland Cement Company. Some time after 1902, the limestone deposits closest to Oro Grande were acquired by the Wyman Limestone Company. The Golden State Portland Cement Company, F. O. Wyman, President, was organized with British capital (Utley, 1948), and in 1910 the new company completed a dry-process cement plant of 225,000 barrels per year capacity. It had a single kiln 8 feet in diameter and 125 feet long. Limestone was obtained from the Original quarry and brought to the plant by rail. Perhaps there was a quarry in the Klondike area too.

The operation was not very successful, apparently. Tucker (1921, p. 336) reported that in 1920 the plant was reopened after a long shutdown. In June 1923, it was sold to Riverside Cement Company. Under the new management it was enlarged somewhat, but in 1928 it was shut down again and remained shut until reopened by Riverside Cement Division of American Cement Corporation in 1942.

Southwestern Portland Cement Company. The limestone deposits at the east end of Quartzite Mountain, and also deposits near Barstow and northeast of Victorville, were located by Joseph Scheerer about 1900. At that time the Scheerer family had one of the granite quarries at the Lower Narrows of the Mojave River, 3 miles north of Victorville. About 1914, Scheerer sold the property northeast of Victorville to the Riverside Cement Company, which even then had long range plans for a cement plant in the Victorville-Oro Grande area. Southwestern Portland Cement Company bought the deposits at the east end of Quartzite Mountain and on September 1, 1916 completed a wet-process plant of 300,000 barrels per year capacity near Victorville.

At first, quarrying was carried out with a churn drill and steam shovel that loaded broken rock directly into railroad cars for the 5½ mile haul to the plant. Production began with a single kiln 9 feet by 200 feet. A second kiln was added almost at once, and by 1930 four kilns were in operation; five quarries had been opened to supply them. Some time after that, steam shovels were replaced with electric shovels that loaded broken rock into 10-ton trucks that discharged into railroad cars at nearby loading docks. Each car was fitted with 3 containers, each holding 10 tons of rock, or one truck load. Eventually, 10 quarries were developed in and near section 11, and there was an additional quarry (no. 12) a mile to the west.

By 1942, the plant had 5 kilns and a capacity of 7000 barrels of cement a day, and it was becoming difficult to obtain limestone from the variable deposits at Quartzite Mountain at the rate required by the enlarged plant. The Reserve quarry was brought into production 9 miles to the east. At first, special trucks were used to bring the broken limestone over a paved road to the nearest point on the quarry railroad. The vastly increased demand for portland cement after World War II led to the expansion of the entire operation. In 1951, a large new limestone deposit half a mile northeast of the Reserve Quarry at Black Mountain was brought into production, and the older quarries in section 11 were shut down. A primary crushing plant was built at the new quarry, and the railroad was extended to it. By April 1959 two new kilns had been added, making a total of nine with a capacity of 6 million barrels a year.

Riverside Cement Company. Riverside's Oro Grande plant was rehabilitated early in World War II at the request of the War Production Board. The finishing end of the old plant being obsolete, only clinker was produced at first and shipped to the company plant at Riverside for grinding. A shortage of railroad cars made it necessary to rebuild the finishing end of the Oro Grande plant, which was completed in 1946. The Klondike quarry was opened in this period and was operated by a contractor. Quarrying in the Klondike area must have been started at an earlier period, because the Barstow 30-minute quadrangle (surveyed in 1932) shows a railroad extending to the west face of the hills east of Oro Grande.

After the war, the plant was modernized and enlarged. The new plant had 3 new 10-foot x 350-foot kilns and a capacity of 2½ million barrels a year. Two more kilns were added by 1953. In 1959 the operation was rebuilt a second time. The Sparkhule quarry has been opened and new automatic crushing, sampling, and storage facilities installed (Utley 1959). Two new

Many consumers require a product that does not exceed 1 percent of material retained on a 325-mesh screen. For ceramic whiting, consumers commonly specify:

$CaCO_3$ not less than 96 percent
$MgCO_3$ not more than 1 percent
Fe_2O_3 not more than 0.25 percent
SiO_2 not more than 2.0 percent
SO_3 not more than 0.1 percent

A content of 98 percent calcium carbonate is commonly required by paint consumers and as high as 99 percent by varnish manufacturers. Ground limestone for putty should contain more than 95 percent $CaCO_3$, a maximum of 3.5 percent of insolubles, not more than 0.8 percent Al_2O_3 and a particle size range between 15 and 50 microns.

Dolomite

Thus far there has been only intermittent, small-volume demand for the various grades of dolomite found in the Victorville-Oro Grande district. Dolomite was first used as a building stone. At various times small amounts have been sold as a basic flux in steel manufacturing. In recent years it has been used mainly for roofing granules in which color, reasonably high tenacity and opacity are the chief characteristics that govern utility. Since 1942 the largest consumers of dolomite in California have been the magnesia refractories industries, but as none of these plants have been established in the vicinity no demand yet exists at Oro Grande or Victorville.

For steel manufacturing dolomite is seldom accepted that contains more than 5 percent silica (SiO_2) or more than 2 percent alumina (Al_2O_3). The magnesia content (MgO) must not be less than 15 percent and phosphorous pentoxide (P_2O_5) not more than .005 percent to .006 percent. Dolomite for refractories should exceed 18 percent in magnesia and silica, alumina and ferric oxide should not be more than 1 percent each. At some plants the ferric oxide content is held to less than 0.5 percent; at others much less rigid specifications are in effect.

Quarrying Methods

Limestone Quarries. Limestone for the portland cement plants is quarried on a large scale at low cost. Benches are developed by blasting rows of vertical holes, and power shovels load the broken rock into trucks. The shovel operator can sort out and discard large pieces of waste fairly efficiently.

In recent years the scale of operations has increased enormously. Rotary drills have replaced wagon and churn drills. Explosives have been improved, and larger shovels and trucks are used than formerly. Present practice is to make 50-foot benches by blasting 6-inch vertical holes made with rotary drills. Large electric shovels and 35- to 40-ton quarry trucks are used. Riverside Cement Division of the American Cement Corporation hauls the quarry-run rock about two miles over a paved road to the primary crusher near the plant. Southwestern Portland Cement Company's primary crusher is at the quarry, which is 16 miles from the plant and connected with it by rail.

Quartzite Quarries. The quarries have been operated intermittently on a fairly large scale using men and equipment usually employed elsewhere. Quartzite, which is abrasive, is difficult to drill and is damaging to equipment. Blast holes are made with wagon drills equipped with tungsten carbide-tipped steel.

History of Operations

Lime Industry

It is likely that the lime industry at Oro Grande was established soon after the Santa Fe Railroad was completed between Los Angeles and Needles, about 1884. It was further stimulated by a building boom in southern California at about that time. Crossman (1890) reports that there were 8 stone kilns with a combined capacity of 950 barrels a day at Oro Grande in 1889 and that the principal quarry measured 250 feet by 100 feet by 60 feet. Probably the industry consisted of a number of very small operations plus one or two larger ones, and the plants seem to have been run intermittently. De Groot (1890, p. 528) mentions two operations, that of Oro Grande Lime Company, and that of Union Lime Company, which also had operations at Tehachapi, Kern County. These companies obtained stone from different and apparently widely separated quarries.

With the opening of the American Beet Sugar Company's factory at Chino, San Bernardino County, in 1891, sugar rock became a significant product of the Oro Grande quarries. In 1902, however, lime was still being burned by the Union Lime Company, of which F. O. Wyman was agent, and by the Red Star Line Company. The ruins of one or other of these operations still remain near Riverside Division's newest stack. What became of the Oro Grande Lime Company is not clear. Red Star operated the Summit quarry which, according to an unpublished report written by H. C. Cloudman in 1913, consisted of 60 acres in section 9 T.6N., R.4W., S.B. By 1913 lime burning had ceased. Red Star, which became Oro Grande Lime and Stone Company, was producing limestone for the sugar industry; and the American Beet Sugar Company also was operating the Superior quarry in a nearby 110-acre property. Both operations were discontinued about 1914.

We have not been able to identify in the field the individual quarries that supplied the various early operations. It seems likely that "the large quarry nearest the railroad" (Aubury, 1906, p. 78) is the Original quarry. Because of the association of F. O. Wyman with both the Union Lime Company and the Golden

mentary breccias made up of carbonate rocks are present in Sidewinder Mountain 15 miles to the east.

As the carbonate rocks found in the uppermost mixed unit are magnesian or else of highly variable chemistry, and as the chemistry of the siliceous rocks is also heterogeneous, production of cement-rock from them has been discontinued. Small tonnages of limestone and dolomite of fair grade could be produced from this unit if the demand arose, but presence of large blocks of uniform material in this unit within the map area is unlikely.

Map area V is underlain chiefly by alternating stratigraphic subunits of dark quartz-mica schist and clean quartzite. A single thin sheet of blue-gray dolomitic limestone nowhere over 20 feet thick (subunit 6c) lies between a quartzite and a schist subunit in the southwest half of the area. The quartzite subunits are substantially thinner than either map unit 5 or 7 of the type section but are lithologically indistinguishable among themselves or from map units 5 and 7. The schist subunits likewise have no distinctive features. The entire succession in area V is roughly 1200 feet thick. It most closely resembles map unit 6 as seen on the southwest slopes of Quartzite Mountain, but it may possibly be correlative with the uppermost mixed unit in area VI. Still less possibly it could be higher stratigraphically than anything present in areas I, II, III, IV or VI.

Map Area VII

In the vicinity of Macks Peak, on the north slopes of Quartzite Mountain, and on the intervening floor of Oro Grande Canyon the Oro Grande Series is found in several thrust-plate remnants (klippen) and in two small patches not involved in the thrusting. The dark schists and intercalated blue-gray limestones lying between Macks Peak and Quartzite Mountain and which are not involved in the thrusting most probably are elements of map unit 6. The brecciated-to-massive, blue-gray, magnesian limestone blanketing Macks Peak (map unit VII D) may correlate with map unit 3 of the type section. If so it has been partially dolomitised. In the small hill just north of Southwestern Portland Cement Company's Quarry 12, three units are present; unit VII A, blue-gray limestone; unit VII B, dark quartz-mica schist, and unit VII C, massive, off-white quartzite. Unit VII A most probably correlates with unit 3 of the type section; unit VII B with unit 4; and unit VII C with unit 5.

East of Quarry 12 and west of Central Ridge (if it were projected north), the blue-gray limestone plate-remnants probably correspond to map unit 3 of the type section. At the north extremity of Central Ridge, beds of the lowermost dolomite (map unit 1) have been thrust over other beds of the same unit.

The large plate-remnant west of Quarry 12 can hardly be made up of any unit other than the upper commercial quartzite (map unit 7) of the type section.

Map Area VIII—Lower Oro Grande Canyon

Map area VIII lies north of the Shay-Comet fault and west of the Jessie fault. Its northern and western limits are provided by overlapping Pleistocene alluvium. South of the Original quarry the probable continuity of a north-dipping homocline is partly masked by alluvium and artificial fill, but beginning at the north half of the Shay quarry and continuing northeast toward Jessie Saddle the following sequence of 7 units is believed to be unbroken and conformable. Map unit VIII A, the lowermost limestone unit, crops out only in the Shay quarry. Its thickness is indeterminate, as part is cut out by the Shay-Comet fault and bedding is poorly defined, but it probably reaches 400 feet. Massive, coarsely crystalline, blue-gray limestone makes up the entire unit.

Conformably overlying the limestone unit is 350-450 feet of dark-brown quartz-mica schist and calc-silicate hornfels designated map unit VIII B. This in turn is overlain by massive, off-white quartzite (map unit VIII C) rather universally stained reddish brown, along joints, by iron oxide. It may exceed 500 feet in stratigraphic thickness but the bedding is poorly defined. The three foregoing units most probably correspond to units 3, 4 and 5 of the type section; less probably they could all be elements of map unit 6. All three have yielded rock used in manufacture of portland cement although the schist is fairly high in alkalies and some of the limestone is magnesian.

The next unit in the homoclinal sequence, where it should be in contact with quartzite of unit VIII C, is concealed by alluvium and artificial fill but a probable thickness of 500 feet is thus hidden. The authors believe this interval to be occupied by dark quartz-mica schist like map unit VIII B and that the quartzite unit VIII C lenses out beneath fill leaving units VIII B and VIII D in contact with one another.

Continuing northeast across the homocline the next unit exposed is massive, blue-gray crystalline limestone (map unit VIII E) 250 to 300 feet thick. Although this limestone is notably thicker than any of the lenses present in map unit 6 in areas I and II, it most probably is the thickened equivalent of the most persistent limestone subunit present in map unit 6 of map areas I and II. Map unit VIII E has yielded limestone suitable for lime and for sugar refining and much of it is usable for portland cement. Thus far it has not been used extensively for cement because more suitable deposits were available.

Map unit VIII F is a dark-brown to black quartz-mica schist similar in all respects to map units VIII B, VIII D and 6a. Nowhere does it exceed 100 feet in thickness and thus far has not been used for cement rock except to a very minor extent when the Original quarry was in operation.

Map unit VIII G is best exposed in the vicinity of the Original quarry. Although its continuity has been disrupted by granitic intrusions it can hardly have exceeded 200 feet in thickness. The rock is medium-grained, blue-gray limestone similar to limestones found in map unit 6(b). During the initial years of operation of the Oro Grande cement plant this unit was the principal source of supply, but the magnesium content proved variable and granitic intrusions are troublesome. The economic potential of unit VIII G is believed to be small.

A strip of massive, off-white quartzite (map unit VIII H) only a few feet wide is exposed on the north wall of Oro Grande Canyon. This seems to overlie conformably map unit VIII G but as it is almost completely overlapped by Pleistocene alluvium relationships are uncertain.

Map units VIII D, E, F, and G are all believed to correlate with map unit 6 of the type section, the carbonate subunits having thickened by vagaries in the original sedimentation. Map unit VIII H is believed to be equivalent to map unit 7 of the type section.

Map Area IX—The Shay-Klondike Block

Map area IX lies south of the Shay-Comet fault and west of the Klondike fault system. Overlapping Pleistocene alluvium provides the remaining boundaries. Three well defined, apparently conformable units can be recognized in the Klondike quarry complex and a fourth is present in an isolated hill west of the Klondike quarries. The lowermost unit, map unit IX A is a light-gray quartz-mica-feldspar gneiss—partly a granitised aluminous sediment and partly a sheared intrusive granitic rock. An occasional thin lens of limestone remains in it and there are small patches of well-developed lit-par-lit (injection) gneiss in it as well. Parts of the mass are strongly foliated whereas others are crudely lineated or gneissoid and consequently much less foliated. The quartz content ranges from 35 to 50 percent. Orthoclase, albite-oligoclase and microcline, in that order of abundance, make up the bulk of the remainder of the rock. Locally, micas make up 8 or 10 percent of the rock and minor accessory minerals include tourmaline, apatite, magnetite and pyrite. The metasedimentary parts of the gneiss most probably are the severely metamorphosed equivalents of map unit 6 of the type section; less probably they could be equivalent to map unit 2.

Overlying the gneiss unit is a carbonate-rock unit (map unit IX B) consisting of 50 to 60 feet of white dolomite at the base overlain by 350 to 450 feet of massive, medium- to coarse-grained crystalline limestone. This carbonate-rock unit contains minor lenses and horses of dark schist and light quartzite. The unit has been extensively fractured and many parts dislocated by minor faults of the Klondike system.

Map unit IX C, conformably overlying IX B, consists mainly of black or dark-brown quartz-mica schist and greenish calc-silicate hornfels, with minor interbeds of blue-gray limestone and brown dolomite. It probably had a stratigraphic thickness of 400 to 500 feet but has been badly disrupted by faulting.

Map unit IX D, found only in the isolated hill west of the Dent mine, consists principally of rusty weathering, green calc-silicate hornfels. A lens of blue-gray limestone less than 10 feet thick occurs in the unit near the east base of the hill. The lower or east contact, apparently a conformable one, is against the gneiss of map unit IX A; elsewhere the unit is overlapped by Pleistocene alluvium. The hornfels of map unit IX D is believed to be a lenticular mass enclosed in gneiss of unit IX A.

Identity of the gneiss, carbonate and schist units of map area IX must remain uncertain. The carbonate rocks may well correspond to subunits of map unit 6 (i.e. 6b) which were thickening by deposition in a westernly direction and thickening could have been greatly enhanced during folding by plastic flow. Less probably the carbonate-rock unit could be equivalent to map unit 3. The uppermost schist unit (IX C) most probably corresponds to map unit 6a although it might be equivalent to map unit 4 of the type section.

The limestone part of map unit IX B was once the principal source of limestone for the Oro Grande cement plant and still supplies part of its requirements. Rock from the gneiss and schist units has only been used to a minor extent because of high alkali contents.

Map Area X—Sparkhule Hill

Sparkhule Hill is an isolated, roughly oval mass elongated northwest which occupies about 190 acres. It is a gently folded syncline having an axial trend of N. 65° W. and a plunge of 10°-15° NW. To the north, west and south the Oro Grande Series in Sparkhule Hill is overlapped by the Triassic (?) Sidewinder Volcanic Series of Bowen (1954, p. 42-53). A sill-like mass of metalatite of the Sidewinder Volcanic Series intrudes the southwestern part of the hill face. Much of the hill is underlain by metalatite and quartz monzonite intrusions (these have been penetrated by diamond drill holes). Quartz veins, given off by the granitic intrusives, penetrate the limestone and have proven to be a material detriment to quarry operations in the south half of the limestone mass.

Except for one small wedge of buff-weathering dolomite cropping out low on the southwest flank of Sparkhule Hill, the Oro Grande Series here consists entirely of massive crystalline limestone (map unit X). At the northwest end of the hill the limestone is fine-grained, black, and graphitic, but the rock grades irregularly to the southeast from black through blue-gray to nearly white. Correspondingly, the grain size increases from fine to medium-coarse. These clearly

that contains more than 3 percent MgO cannot be used for portland cement. Alkalies (K_2O, Na_2O) are also objectionable in cement raw-material as they may react with poor quality aggregate in concrete and cause disruptive reactions in the concrete. A maximum of only 0.6 percent total alkalies in the finished cement is tolerated at most cement plants.

A wide variety of materials are used in the Victorville-Oro Grande district to provide the alumina and silica required in the cement mix but not ordinarily present in the limestone. These include schist, quartzite, alluvium and even granitic rocks. Commonly the alkali content of these materials greatly limits the proportions that can be used. The relatively pure quartzites of the district have been extensively used as supplemental sources of silica at the local plants. Intermittently, quartzite is exported from the district to other cement plants in southern California.

Iron oxide, commonly not present in cement raw materials in the desired proportion, is obtained from a variety of materials such as mill scale, iron ore or pyrite cinder. These are obtained largely from sources outside the district. Pyrite cinder is most widely used.

The raw materials are finely ground, blended in the desired proportions and calcined in rotary kilns. The kiln product, a nodular clinker, is finely ground and intermingled with 2 or 3 percent of rock gypsum to form finished cement. Gypsum comes from sources outside of the Victorville-Oro Grande district.

Kiln feeds in general fall within the following analysis range dry basis:

	Percent
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

Most of the cement materials quarried in the Victorville-Oro Grande district are consumed locally by the Southwestern Portland Cement Company mill at Victorville and the Riverside Cement Division of the American Cement Corporation at Oro Grande. Intermittently, quartzite is shipped to cement plants in Riverside County.

Lime

Lime was an important product in the Victorville-Oro Grande district up to about 1910, when portland cement replaced lime for many construction purposes. Lime is not now being produced in the district. Limestone for high-calcium lime should contain 97 to 98 percent $CaCO_3$. Magnesian limestone for special plaster limes commonly contains 11 percent Mgo and a correspondingly lower lime content. For use in vertical (Belgian type) kilns, limestone must retain its lump form throughout calcination. Limestone suitable for nearly all classes of lime manufacturing are present in the district.

Sugar Beet Processing

Limestone for the sugar beet processing industry was quarried near Oro Grande intermittently until about 1914. Substantial reserves of limestone suitable for this purpose remain in the district but are not now being quarried. Most plants require limestone that retains its lump form throughout calcination. Silica must must not exceed 1 percent nor magnesia more than 4 percent. Graphitic impurities are objectionable and some plants limit the iron content to 0.5 percent.

Silica Refractories

Silica brick is an acid refractory having considerable strength at high temperatures. It is used for the roofs of open hearth steel furnaces, glass melting tanks and similar furnaces. The bricks are prepared from crushed and graded quartzite mixed with a few percent of lime. They are calcined carefully for many hours during which the quartz changes to tridymite and cristobalite and lime combines with some silica to form a glassy bond. In most industries the trend has been toward use of mineral raw materials that can satisfy ever more exacting specifications. Silica brick producers have been induced by the steel industry to raise the softening temperature of silica brick. Alkalies have been found to be critically deleterious impurities that substantially lower the softening temperature of silica brick. At one time, quartzite that contained enough fluxing materials to form the glassy bond was used, but present practice is to use the purest quartzite available. Quartzite for standard silica brick should contain a maximum of 0.5 percent of alkalies and alumina together. Much of the standard silica brick produced in California has been made from quartzite quarried in the Victorville-Oro Grande district.

Since 1955, however, super duty silica brick has been produced in California and has displaced standard silica brick in the steel industry. Quartzite for super duty silica brick is limited to a maximum of 0.25 percent of combined alumina and alkalies. Most of the quartzite from the Oro Grande district does not meet these specifications and consequently is no longer being produced for this purpose.

White Carbonate Fillers

The white crystalline limestones of the Victorville-Oro Grande district have been used in a wide variety of ground filler-products among which are paint, varnish, paper, ceramics, floor coverings and putty. Desirable characteristics of high-grade white fillers are: a high degree of whiteness, fine particle size (commonly minus 325-mesh), freedom from minerals harder than calcite, and as high a chemical purity as is commensurate with the prevailing prices and competition. Although dolomitic limestones and dolomites are used to make white fillers in some parts of the country, the limestones converted to filler in California nearly always contain 96 percent or more of calcium carbonate.

just described is also a plate remnant. A careful survey of the lower contact of the larger quartzite mass, however, did not reveal sufficient attitudes in the quartzite and adjacent schist to prove this suggestion.

Jessie and Sugar Rock Quarry Faults

A fault of small displacement, here designated the Jessie fault, cuts the Shay-Comet fault 2000 feet south of Jessie Saddle. Whether or not the fault extends as far north as Jessie Saddle could not be determined because granitic bedrock there is deeply weathered and partly masked by mantle and alluvium. Movement along it must have been predominantly right lateral because an east-striking, south dipping limestone bed now shows a normal horizontal separation of 200 feet. Neither normal nor rotational movement alone could account for this separation although both could have contributed to the displacement. The fault apparently dies out to the south as it does not appear to have offset the southern edge of one of the quartzite plate remnants whereas the northern edge of the same plate remnant has been dropped at least 50 feet long the fault.

Another indication of the kind of movement that has taken place along the Jessie fault should have been provided by the amount of offset on the Shay-Comet fault zone. This fault zone is well exposed in a cement-rock quarry just west of the Jessie fault but to the east of the Jessie fault, exposures are poor and the projection of the zone could not be located. The alternative possibilities of movement are discussed under the Shay-Comet fault.

A fault of normal type, which we have named the Sugar Rock Quarry fault drops the west boundary of the Quarry 12 flatiron down against the quartzite of map unit 7. This fault cuts the west wall of Quarry 12 and the east side of the smaller sugar rock quarry that adjoins Quarry 12 on the west.

Shay-Comet Fault Zone

The Shay-Comet fault zone is strikingly exposed in quarry walls east of the Shay quarry, in the Comet quarry east of the Atlas mine road, and in several small shale pits south of the junction of the Oro Grande Canyon and Sparkhule Hill roads. It is a vertical zone 50 to 250 feet wide in which lenticular horses of schist, quartzite and carbonate rocks are aligned in a general direction of N. 65° E. It truncates the northwest-trending fold and fault structures of map area I and northwest-trending units in the Klondike quarries are dragged toward the west adjacent to the fault. This suggests left-lateral movement on the Shay-Comet fault. The width of the fault zone, the variety of rock types in it, and the areal distribution of the probable parent units suggest that the vertical and horizontal displacement components are large.

As mentioned in discussion of the Jessie fault, one of the problems in connection with the Shay-Comet fault is that its projection east of the Jessie fault cannot be even approximately located. Being a strike fault it could easily have died out along minor slips parallel to the strike of the beds and hence be hard to recognize. Also, major movement may well have been taken up along an en echelon fracture zone concealed beneath the alluvium of the bottom of Oro Grande Canyon. Unfortunately, the critical areas are either poorly exposed or entirely masked by debris.

Nonmetallic mineral deposits

Rock units of the Oro Grande Series near Victorville have yielded many millions of tons of limestone, quartzite and quartz-mica schist for industrial purposes, mostly in the manufacture of portland cement. Limestone from the mapped area also is or has been used for specialty products such as white carbonate fillers, rock for processing of sugar beets, and rock for lime manufacturing. Up to 1955 quarries in the district furnished most of the quartzite required in manufacture of the silica brick produced in southern California. The following discussion deals principally with the district's resources of industrial minerals—limestone, dolomite, quartzite and miscellaneous materials required by the cement plants. Deposits in the Oro Grande Series have also yielded small, although at times important amounts of gold, silver, copper and lead. These, as well as certain deposits of white clay, are of hydrothermal origin and the host rocks are units of the Oro Grande Series, the Sidewinder Volcanic Series or the granitic rocks. These deposits are briefly summarized in the tabulated list to complete the economic picture of the district, although they are, in 1964, largely idle properties.

Industrial Raw Material Requirements in the Victorville-Oro Grande District

Portland Cement

The principal raw material consumed by portland cement manufacturing plants is limestone. It can contain a very considerable amount of silica and alumina as these ingredients are necessary in the cement mix. Magnesia, however, is objectionable as it causes the finished cement to set erratically. Ordinarily, limestone

are contact metamorphic effects derived from the granitic rocks below. The limestone ranges in thickness from 240 feet to more than 700 feet in various parts of the syncline because of the presence of latitic and granitic intrusions. The maximum thickness has not yet been revealed by drilling.

Although the stratigraphic relationships between the Sparkhule Hill limestone unit and other units of the Oro Grande Series has not yet been revealed by drilling, the unit most closely resembles map unit 3 of the type section—appearance, thickness, and chemistry considered. Less probably it could correlate with map unit 8 of map areas III, IV and VI and there is a remote possibility that it correlates with some part of unit 6 of the type section.

The small septum of dolomite cropping out on the southwest slope of Sparkhule Hill is enveloped by intruding metalatite so that its stratigraphic relationship with other units cannot be determined. Most probably it is a locally dolomitised septum of the main limestone mass. Less probably it could be a horse of dolomite broken off from map unit 1 and moved into its present position by faulting done prior to intrusion of the latite.

The limestone in Sparkhule Hill at present is the main source of supply for the Oro Grande Cement plant of Riverside Cement Division of the American Cement Corporation.

Recapitulation of the Stratigraphy of the Oro Grande Series

From the foregoing discussion of the stratigraphy of the various blocks it is apparent that no single line-of-section measurement will yield the probable original thickness relationships in the Oro Grande Series. The probable original thickness of each unit must be reconstructed after due consideration of the present average thicknesses of the units and the vagaries of compression and probable plastic flow undergone by the units during folding.

It should also be apparent that no single fault block or map area contains all of the units of the Oro Grande Series that were originally present in the Victorville-Oro Grande district. A complete section can, however, be reconstructed if it is assumed that the upper commercial quartzite (map unit 7) of the type section in map area II is the same as the lowermost unit of map area VI. The first 6 units of map area II (unit 7 in map area II has been eroded) plus the 3 units of map area VI, therefore, comprise a composite section of 9 units having an estimated average thickness of 5160 feet. Our conception of the adjusted stratigraphic makeup of the Oro Grande Series in and adjacent to the type locality appears in the first column of fig. 2.

Age of the Oro Grande Series

The age of the Oro Grande Series has been discussed at length by Bowen (1954, p. 34). Further fossil material was not obtained during this investigation. Crinoid and brachiopod debris of probable Carboniferous age was found by Bowen in the upper part of the limestone unit in Sparkhule Hill in 1954. All of the meager material thus far found in the Oro Grande Series indicates a probable Carboniferous age. Seven miles east of the type locality, the Oro Grande Series is unconformably overlain by the Permian Fairview Valley Formation so it is doubtful if the series contains rocks younger than Pennsylvanian. The lower age limit of the formation is still unknown.

The Sidewinder Volcanic Series

The Triassic(?) Sidewinder Volcanic Series has been described at length by Bowen (1954, p. 42-53). In the northeast part of the map area south and east of Sparkhule Hill the Sidewinder Volcanic Series consists mainly of dark-gray to almost black latite. Locally a little quartz appears and the rock is gradational into quartz latite or dacite. Tuff, intrusive and flow-rock facies are all present. In the vicinity of the Atwood clay deposits, in the northeast corner of the map area, there is an arcuate zone of strong hydrothermal alteration consisting of a lower belt of white, kaolinized latite and dacite 50 to 100 feet thick and an overlying belt of pinkish gray, silicified volcanic rock 100 to 200 feet thick. This resembles fine-grained quartzite. Relict, uncompletely silicified parts of this quartz rock indicate that it was originally dacite or rhyolite containing quartz and feldspar phenocrysts. The replacing silica in the upper zone came from breakdown of the feldspars in the kaolinized part of the zone.

Rocks of the Sidewinder Volcanic Series intrude and overlap both the Oro Grande Series and the unconformably overlying Permian Fairview Valley Formation (Bowen, 1954, p. 36-53). All of these units are intruded by granitic rocks of Early Cretaceous or Late Jurassic age. Consequently, the Sidewinder Volcanic Series is younger than Permian and older than mid-Cretaceous. These and similar pre-granitic rocks are generally regarded as Triassic (Gardner, 1940; Hazzard, et al, 1937; Bowen, 1954).

Granitic Rocks

The granitic rocks of the Victorville-Oro Grande district have been described at length by Bowen (1954, p. 53-76) and will only be touched upon here. Biotite quartz monzonite is the principal intrusive rock and the only variety found in large intrusions within the map area. It is a light-colored, coarse-grained rock that was intruded in a relatively dry state. Many hundreds of feet of contact between quartz monzonite and carbonate rocks show no development whatever of contact silicates in the carbonate rock. The quartz monzonite is best exposed on the south and southwest slopes of Quartzite Mountain and on the adjacent pediment. There it cuts off both folds and faults in the Oro Grande Series.

Black or dark gray-green hornblende-quartz diorite dikes and sills cut the Oro Grande and Sidewinder rocks in numerous places. These are only a few feet or a few tens of feet thick. Many must have been intruded with accompanying evolution of hydrous gases, as fairly extensive silicated zones have developed in carbonate rocks near the larger intrusions. In some instances magnesium has been introduced or at least mobilized by the emanations causing local late dolomitization of limestones.

Aplite and pegmatite dikes and irregular intrusions satellitic to the quartz monzonite also penetrate the Oro Grande and Sidewinder Volcanic Series. Some consist predominantly of quartz and potash feldspar whereas others approach the mineral proportions of the parent quartz monzonite. Biotite and muscovite are common accessories; tourmaline, ilmenite and other minor accessories are rare or absent. Quartz veins commonly are associated with granitic intrusions particularly under the south half of Sparkhule Hill.

The quartz monzonite intrusions of the Victorville-Oro Grande district almost certainly correlate with other quartz monzonite masses in the Granite Mountains southeast of Victorville. A specimen of quartz monzonite from the Granite Mountains has been dated by the lead-alpha method at 116 million years (Jaffee, H. W., et al., 1959). By the Holmes "B" time scale this would be of Early Cretaceous age. As the quartz monzonites and their aplitic and pegmatitic satellites are the youngest granitic rocks in the district, the pre-quartz monzonite granitic rocks may well be of Jurassic age. Determinations have not yet been made on any of these.

Quaternary Deposits

The Oro Grande Series is overlapped and masked at numerous places by alluvium and fanglomerate. An older uplifted and partly dissected alluvial formation containing scattered vertebrate remains (Bowen, 1954, p. 91) is of upper Pleistocene age. Contemporary aggrading surfaces are easily separated from the Pleistocene alluvial fans although lithologically there is little difference between the two. Fragments of virtually all of the older rock units in this part of the Mojave Desert are found in both the Pleistocene and Recent alluvial deposits.

Structure

The Oro Grande Series was folded, severely deformed, complexly-faulted, and eroded prior to emplacement of the Sidewinder Volcanic Series and intrusion of the granitic rocks. These events could have been part of a local disturbance related to the end-Paleozoic or Appalachian Revolution or they could be early episodes in the mid-Mesozoic Nevadan Revolution. The age of the Sidewinder Volcanic Series is not sufficiently well determined to establish the age of this orogeny.

West of the present location (and projection) of the Central Ridge fault, a series of tightly-compressed, northwest-trending folds developed consisting of at least three synclines and three anticlines. Two of the anticlines were ruptured and displaced—one by the Klondike fault, and one by the Quartzite Mountain fault.

The vertical Central Ridge fault is the line of demarcation between the series of northwest-trending folds and an area in which the fold limbs strike northeast. In order to bring into contact units oriented 90° from one another, a large lateral displacement as well as considerable rotation must have taken place along the Central Ridge fault. Furthermore, disposition of the faulted units in the various blocks is such that considerable lateral and some rotational movement must have taken place along nearly all of the northwest-trending faults. These movements can best be accounted for by assuming a shift of opposing compressional force-vectors, from an original southwest-northeast direction, roughly perpendicular to the fold axes, counter-clockwise to a more northerly direction oblique to the original fold axes. Major shear parallel or slightly oblique to the original fold axes would almost inevitably result from such a shift of forces. The Klondike, Quartzite Mountain, Central Ridge, Amazon and East End faults almost certainly are related to the same deformation.

Some time later, but still prior to emplacement of the Sidewinder Volcanic Series and granitic rocks, the northwest and north-trending structures were truncated by the well exposed Shay-Comet fault zone and the concealed and therefore hypothetical Railroad Grade fault.

Still later than the Railroad Grade and Shay-Comet faulting, later than emplacement of the Sidewinder Volcanic Series and granitic rocks, but prior to deposition of the late Pleistocene alluvium, overthrusting took place—probably from the north. Along the northeast foot of Quartzite Mountain, plate-remnants having base-surface (or sole) dips as low as 20° north over-ride the steep-dipping, northwest trending map units of the type section described previously. At least three and probably four map units of the Oro Grande

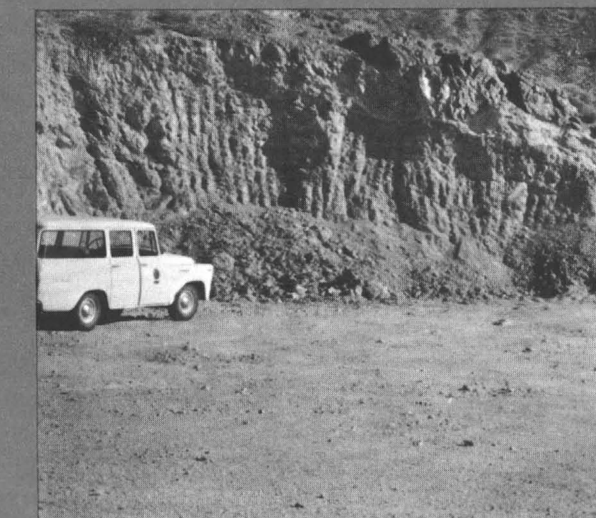


Photo 12. The bleached, crushed, basal part of the Macks Peak plate of the Quarry 12 thrust as exposed in a borrow pit close to the northeast junction of the Sparkhule Hill and Oro Grande Canyon roads. The caliche-stained greenish gouge lies along the contact of limestone (above) and quartz monzonite (below). Photo taken in March 1960.

Photo 11. Part of one of the gently dipping limestone plate-remnants of the Quarry 12 thrust lying on the steep upturned edges of map unit 2 low on the northeast slope of Quartzite Mountain. The contact and the designation of the units are shown in black-line.

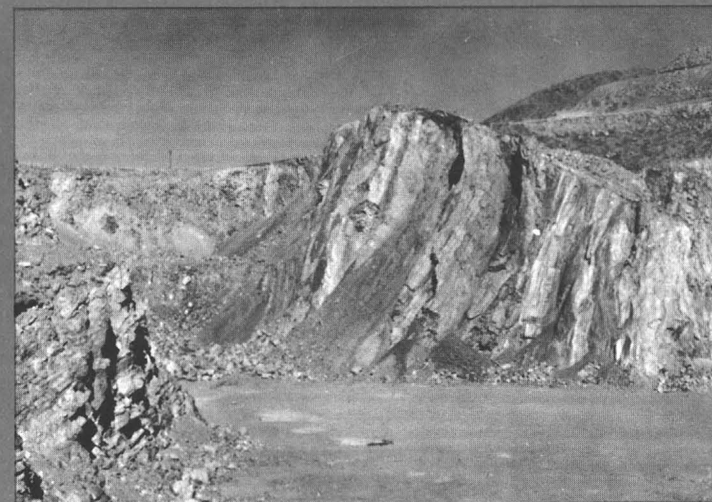


Photo 8. The Shay-Comet fault zone as seen facing east from the top of the northface of the Shay quarry. Horses of schist, quartzite, and limestone, separated by slickensided fault surfaces, form the steep-dipping bands in the east face.

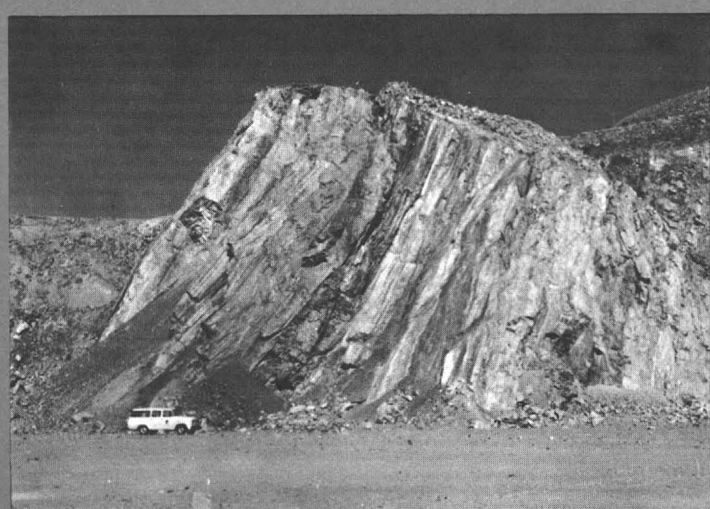


Photo 9. A closer view of the Shay-Comet fault zone in the same face shown in photo 8.

Photo 10. The northwest end of Quartzite Mountain, observer facing northwest, showing map units 3, 4, 5, 6, and 7 passing beneath the thrust plate of map unit VIIA.

Series were involved in the thrusting and several imbricated plates probably were produced. The configuration of the Macks Peak plate indicates that it was probably folded prior to being eroded. Erosion has removed most of the plates except for seven or eight remnants. Whether elements of the Sidewinder Volcanic Series or the granitic rocks were involved in the thrusting cannot be ascertained because of masking alluvium.

Several minor faults came into being later than the time of thrusting, as two of the plate-remnants have been cut by such faults—the Jessie fault and the fault cutting the west border of Southwestern Portland Cement Company's Quarry 12.

Folds

Quartzite Mountain Synclinorium

The Quartzite Mountain synclinorium, containing the type section of the Oro Grande Series, is bordered on the west by the Quartzite Mountain fault and on the east by the Central Ridge fault. On the southeast it is engulfed by quartz monzonite and on the northwest is over-ridden by the Quarry 12 thrust. At ridge crest its axis bends from a course of N. 23° W. to one N. 52° W. and it pitches 10-15° NW. Dips are notably steeper on the east limb than on the west and the units there are more tightly compressed. An asymmetry is thus produced that is not exhibited by the other northwest-trending folds. The principal schist unit (6) has been severely reduced in thickness on the east limb, apparently because of compression between the thick, competent quartzite members, and correspondingly thickened on the west limb (see structure section AA′).

In the axial region of the syncline west of the summit of Quartzite Mountain, the s-surfaces of the schist are strongly grooved and lineated. These striations pitch moderately northwest parallel to the fold axis. Boudinage structures, and mullion structures of both cleavage and boudinage types (see DeSitter, 1956, p. 89) are conspicuous in this vicinity.

A minor, partly fault-displaced crenulation occurs along the synclinal axis close to the over-riding thrust plate south of Quarry 12.

Syncline and Anticline West of the Quartzite Mountain Fault (Map area 1)

The syncline is a fairly broad, open, uncomplicated fold striking N. 60° W. and pitching about 20° NW. Like the Quartzite Mountain syncline it is over-ridden from the north by the Quarry 12 thrust and is engulfed on the southeast by quartz monzonite.

The adjoining anticline, occupying the valley between the Quartzite Mountain group of hills and the ridge containing the Atlas and Klondike quarries, is also a broad, open, uncomplicated fold striking N. 60° W. and pitching moderately northwest. Part of its course is masked by alluvium and much of the structure is intruded by quartz monzonite.

Atlas Syncline

The Atlas syncline occupies the ridge north of the Atlas silica quarry at the west side of map area I. It is a slightly asymmetrical fold striking N. 38° W. and pitching very gently northwest. Dips on the east limb are steeper than those on the west and the axial plane appears to dip slightly to the northeast. Little further can be said about this fold as the stratigraphic units are not well exposed on the east limb and the west limb is broken up and parts are displaced by faults of the Klondike system. A better picture of the west limb of the syncline will be had after the Riverside Cement Company completes removal of the slide which masks the east wall of the main Klondike quarries.

Homocline Northeast of Central Ridge Fault

All of the fault blocks to the northeast of the Central Ridge fault appear to be displaced elements of a single northeast-striking, northwest-dipping homocline. Whether this homocline was one limb of a large, northeast-trending anticline, the crest of which has been obliterated by quartz monzonite intrusions, or whether it was simply a single, tilted block prior to the cross-faulting cannot definitely be ascertained. The probability of it being the limb of a former fold is considerably greater than the probability of a single tilt-block.

Faults

Klondike Fault System

The several breaks that displace the rocks in and southeast of the Klondike quarries are here designated the Klondike fault system. It has a general northwest trend but several of the branches or segments thereof have sinuous or arcuate traces. The most persistent break, which passes along the east side of the Klondike quarries, dips 60°-70° to the southwest. Other associated shear planes are nearly vertical. The senses of the various displacements are obscure. Quarry operations have undercut the hanging wall side of the east-boundary fault so that by June 1960 the mass had broken up and was sliding down the dip of the fault surface toward the floor of the main pit. Ultimately this slide rock will be removed for use in the cement plant at Oro Grande and the synclinal footwall side will be exposed. The branch of the fault system which roughly borders the west wall of the main Klondike quarry becomes a bedding fault and either dies out to the northwest or else cannot be traced because of debris on the quarry floor. The branch that borders the Atlas silica quarry on the northeast likewise appears to pass into a bedding fault and dies out. The whole fault zone is so complexly displaced that only the larger features can be shown. Granitic rocks have been intruded along some of the fault planes. The system is truncated on the northwest by the Shay-Comet fault zone and dies out to the southeast in gneiss and quartz monzonite.

Quartzite Mountain Fault

The Quartzite Mountain fault is represented by a single, sinuous, nearly-vertical fault plane cut off on the south by quartz monzonite and concealed on the north by quarry waste and alluvium. Its trace lies somewhere near the crest of a former anticline but there apparently has been right-lateral movement on it of at least 2,000 feet (judging by displacement on the lower quartzite unit). The vertical component can hardly have been more than a few hundred feet judging from the disposition of carbonate subunits in map unit 6. Little or no breccia is to be seen along the trace.

Central Ridge Fault

As the exposed strike length of the Central Ridge fault is less than 2,000 feet, information on it is limited. Both the horizontal and vertical displacement components must be several thousand feet in order to create an angular strike difference of 90° between stratigraphic units of map areas II and III. The fault plane is essentially vertical and is a single break where well exposed. Both northwest and southeast extremities are masked by alluvium but its southern end is almost certainly cut off beneath the alluvium by quartz monzonite.

Amazon Fault

The Amazon fault is conspicuously exposed on the north slope of the Coxcomb Ridge east of the Central Ridge fault and is well exposed along the west wall of Southwestern Portland Cement Company's quarry no. 2. It is a vertical fault of small normal displacement—probably on the order of 200 feet. The lateral displacement, if any, is small. Both ends are concealed by alluvium.

East End Fault

The East End fault cuts the east extremities of Coxcomb Ridge. It brings into contact and truncates subunits of sequences which differ considerably on opposite sides of the fault. Both horizontal and vertical components of movement may well be several thousands of feet. Although both ends of the fault trace are covered by alluvium, the East End fault is almost surely cut off by the Railroad Grade fault on the north and by quartz monzonite on the south.

Photo 6 (left). Klondike limestone quarry of the Riverside Cement Division of the American Cement Corporation near Oro Grande, in March 1960 (observer facing southeast). The mass of broken slide rock, which is chiefly limestone, is being removed to supply part of the cement plant requirements. It is gradually sliding down one of the surfaces of the Klondike fault. Quartzite of map unit 7 occupies the left skyline.

Railroad Grade Fault

The Railroad Grade fault is a hypothetical fault that is presumed to be concealed beneath alluvium and railroad-grade fill. Its position is inferred from the disposition of rock units northeast and southwest of the railroad spur track. South-trending units north of the railroad swing around toward the west and do not continue south of the alluvium and fill. A fault of large displacement, possibly right lateral in sense, is believed to be present as shown on the map in dotted contact.

Quarry 12 Thrust

Seven and possibly eight thrust-plate remnants have been mapped along the north slopes of Quartzite Mountain from the vicinity of Macks Peak east to Central Ridge. With the exception of the Macks Peak remnant which has been considerably warped since emplacement, the rocks in these remnants strike east and dip north at angles ranging from 15 to 30 degrees. They over-ride the steeply-dipping edges of the northwest-trending series of strata. In some places the contact is marked by breccia; in others breccia is negligible or absent. Macks Peak and the limestone foreland (closely adjacent to the Oro Grande Canyon road on the north) consists partly of limestone breccia and massive limestone thrust over granite and schist. An arcuate line of prospect holes sunk along the northern edge of the plate and extending onto the peak reveal 5 to 15 feet of brecciated quartz monzonite lying beneath the plate. A quarry located just northeast of the junction of the Oro Grande Canyon and Sparkhule Hill roads shows relatively undisturbed quartz monzonite overlain by one or two feet of green fault gouge. This, in turn, is overlain by limestone breccia. South of quarry 12 a flatiron of limestone over-rides the upturned edges of northwest-striking, southwest-dipping quartzite and schist. Like relationships exist at the plate remnants lying east of the flatiron. At the north end of Central Ridge part of an overturned fold in the basal dolomite member of the type section has been overthrust along the fold axis.

West and across the canyon from the Quarry 12 flatiron a nearly flat-based mass of quartzite of the upper commercial quartzite (map unit 7) has been thrust over an east-striking, 45° south-dipping homocline of schist and limestone. Along the south contact this mass also over-rides part of its own unit as well. From the disposition of the persistent limestone subunit in the principal schist of map area I (see the geologic map) there is a strong suggestion that the still larger quartzite mass lying southwest of the one

Photo 7 (right). A view of the south wall of the Shay cement-rock quarry, as seen March 1960, observer facing southeast. A slickensided surface of one of the faults of the Klondike system may be seen in the right middleground, in shadow.

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GEOLOGIC MAP OF CALIFORNIA

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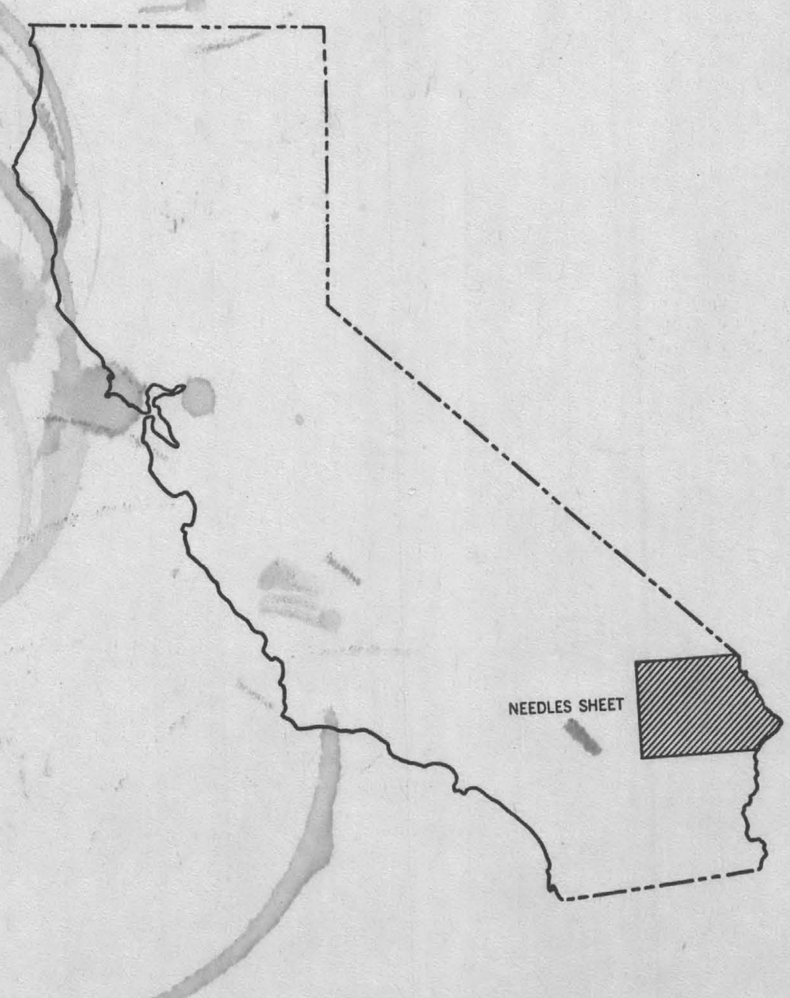

DIVISION OF MINES AND GEOLOGY
IAN CAMPBELL, *State Geologist*
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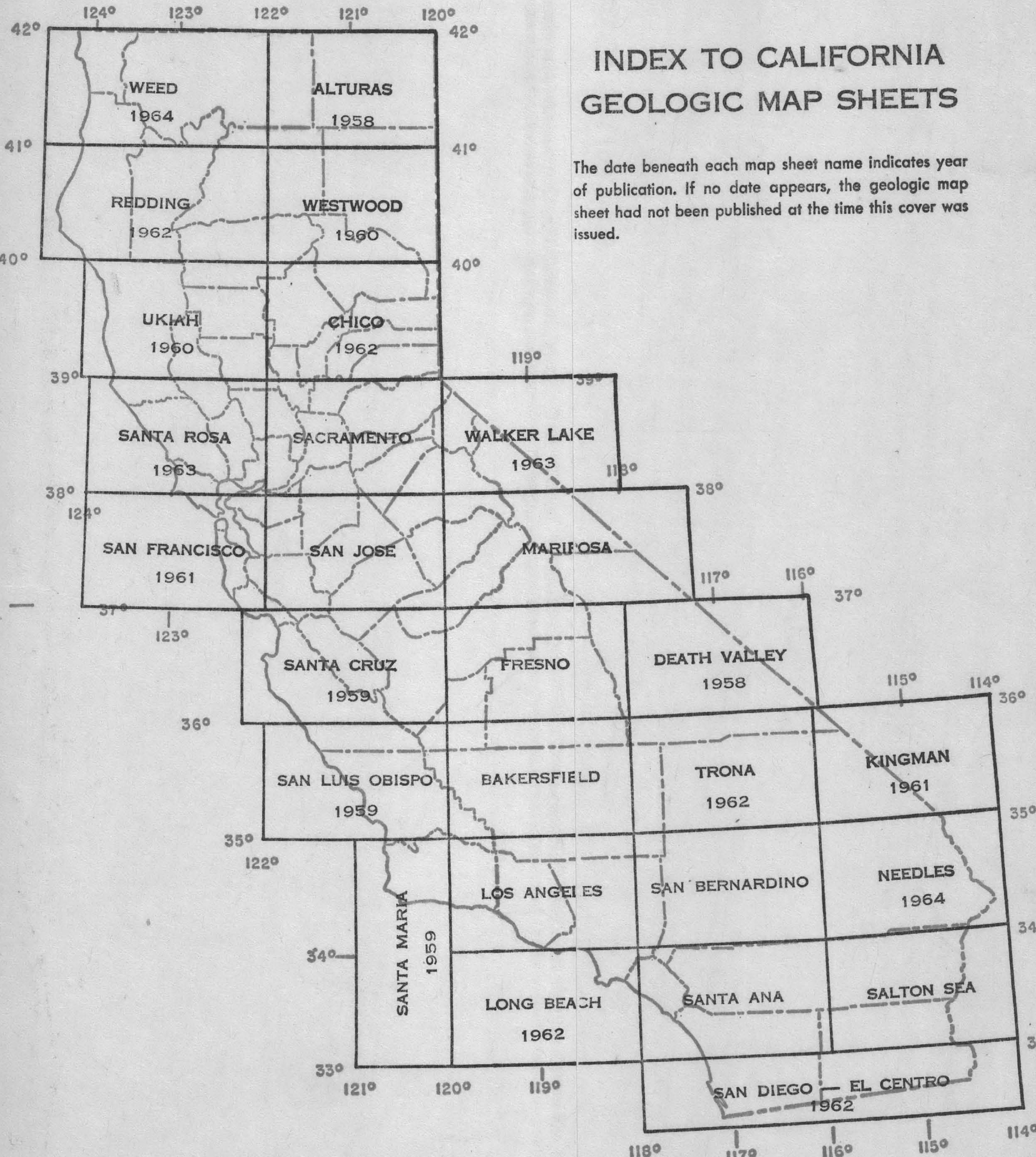
The date beneath each map sheet name indicates year of publication. If no date appears, the geologic map sheet had not been published at the time this cover was issued.



TECTONIC HISTORY OF EASTERN SAN BERNADINO CO.

J.C.Olson et alii(1954): Rare-earth mineral deposits of the Mountain Pass district, San Bernardino Co.,Calif.USGS PP 261.

Andesite and rhy.dikes probably Tertiary.

Clark Mt.fault cuts Mescal thrust,which shoves Paleo seds.over K?flow breccias. Post*K age for both. Clark Mt.thrust 15 mi.N of Mt.Pass is overriden by Mesquite thrust,hence Clark Mt.formed between the 2 thrust periods; thrusts thought to be Laramide,or at least post mid-K.

D.F.Hewett(1954):General geology of the Mojave Desert region,Calif.,,in Geology of Southern Calif.,Div.Mines Bull.170.

Mesozoic intrusives,QM to granite. Largest body of QM invades a minor Laramide thrust. post-Mid K. (Mescal thrust;age dated from overthrust K flow-breccias).

Block subjected to vigorous erosion,late Mesozoic into Mid-Tertiary. Rose 15-20,000',rocks removed as block rose.

While Clark Mt.thrusts are Laramide,those in Shadow Mts.the many klippen represent a great Pliocene thrust. Part of Death Valley N-S chaos belt.

Although map shows Mi9cene volcanics,Hewett shows only Pleostocene and recent flows.

D.F.Hewett(1954): A fault map of the Mojave Desert region,in same. Intrusion late K in E region. Thrusts associated with tear faults and late pre-mineral normal faults (Clark Mt).

Ivanpah fault is mid-pleistocene.

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MINERAL INFORMATION SERVICE

STATE OF CALIFORNIA DIVISION OF MINES

VOLUME 14 NUMBER 9
SEPTEMBER 1961

HISTORY OF MINING IN NORTHEASTERN SAN BERNARDINO COUNTY

By William E. Ver Planck

To the highway traveler, northeastern San Bernardino County is a particularly bleak, barren, and desolate section of U.S. Highway 91 between Baker and the California line on the way from Los Angeles to Las Vegas, Nevada. The region discussed in this article is the triangular area, amounting to a little more than 2900 square miles, that is covered by the Kingman sheet of the State Geologic Map, comprising the northeast corner of San Bernardino County and an adjoining strip of Inyo County. Although but little evidence of mining activity is visible from the highway, ore valued at several million dollars has been taken from mines in this area during the past century.

The principal metals that have been obtained are silver, copper, gold, lead, zinc, and rare earth elements. The nonmetallics are represented by talc and clay. Commodities that have been recovered in relatively small amounts include antimony, dimension stone, fluorspar, magnesite, molybdenum, perlite, silica, tin, tungsten, and vanadium. At one time or another, more than 80 mines have been in production. An occasional ore truck in the stream of highway traffic indicates that mining is still going on.

The character of the mining industry in northeastern San Bernardino County has almost completely changed since the first prospectors arrived, about 100 years ago. At least three phases can be identified. In the first, beginning about 1860, prospectors sought only those deposits that could be worked profitably by one man alone or with a few partners. Only the richest deposits, mostly of silver, were of interest. With the exhaustion of the high-value deposits of precious metals, the first phase died out.

The second phase was characterized by the mining of deposits of base and precious metals that were larger but of lower grade than those worked earlier. Mining ventures required substantial investments for mining and milling equipment, and they depended on low-cost transportation. The second phase began about 1900 with the construction of railroads into the area and reached its peak during the first World War.

During the third and present phase, metal mining has declined virtually to the vanishing point. After World War I, however, the growing west and its developing industries began to create markets for commodities that had been of no interest before. Today clay and talc are mined for use in the manufacture of ceramic products that were virtually unknown in 1860. Using techniques perfected after World War II, prospectors found rare earth mineral deposits large enough to supply the needs of the entire United States. Rare earth elements are currently employed as alloys for parts of jet engines and gas turbines.

A fourth and future phase may be the mining of low-value industrial materials that are too far from industrial centers to be of interest now. Perhaps the time is not far off when limestone from northeastern San Bernardino County will be quarried for the portland cement industry.

Geologic Occurrence and Localities

According to D.F. Hewett, most of the precious and base metal deposits of northeastern San Bernardino County are associated with thrust faulting and the intrusion of the Teutonia quartz monzonite and related dikes and sills that occurred in late Cretaceous time. The talc deposits and the deposits of rare earth elements formed in Precambrian time. The clay deposits and some of the gold deposits are associated with late Tertiary volcanic rocks.

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

Other publications of the Division of Mines include the Annual Report of the State Mineralogist, the Bulletin and Special Report series, county reports, and maps. A list of the Division's available publications will be sent upon request. Communications to the Division of Mines, including orders for publications, should be addressed to the headquarters office.

With a few exceptions, the Upper Cretaceous deposits contain several metals in recoverable amounts. Because oxidation has penetrated to depths of 100 to 150 feet below the present surface, most of the ores produced have consisted of the carbonates of copper, lead, and zinc with gold and silver. Pyrite is abundant in the zone of oxidation. Chalcopyrite and silver-bearing galena are common in the deeper deposits, but sphalerite is not—at least at the depths reached so far in mining. The production of tungsten, although small, is interesting because some of the deposits are quartz veins that contain wolframite with copper sulfide and lead sulfide minerals.

Clark Mountains and Ivanpah Mountains

Deposits in the Clark Mountains and Ivanpah Mountains have been the most prolific with an estimated output of four million dollars, mostly from copper and silver, but including gold, lead, and zinc. The deposits on the north slope of Clark Mountain are associated with the Clark Mountain fault, which separates lower Precambrian granite and metamorphic rocks on the east from the Paleozoic Goodsprings dolomite on the west. The silver mines of old Ivanpah worked oxidized veins, rich in silver, that occupy fractures in the Goodsprings dolomite. The ore contains stromeyerite (a silver-copper sulfide) and also cerargyrite (silver chloride) and oxidized copper and lead minerals. At the Pacific fluorspar mine a shear zone in dolomite contains a mixture of fluorite and sericite. At the Colosseum mine deposits of gold-bearing pyrite and chalcopyrite are associated with rhyolite dikes that intrude granitic and metamorphic rocks.

The Copper World and the Mohawk mines lie on the south side of the Clark Mountains where the Goodsprings dolomite has been intruded by quartz monzonite. At the Copper World, oxidized copper minerals with some lead and silver form veinlets in a contact zone of silicate minerals as much as 200 feet wide. The Mohawk deposits consist of bodies of lead and zinc carbonate minerals with some copper that occur in the dolomite near its contact with the quartz monzonite.

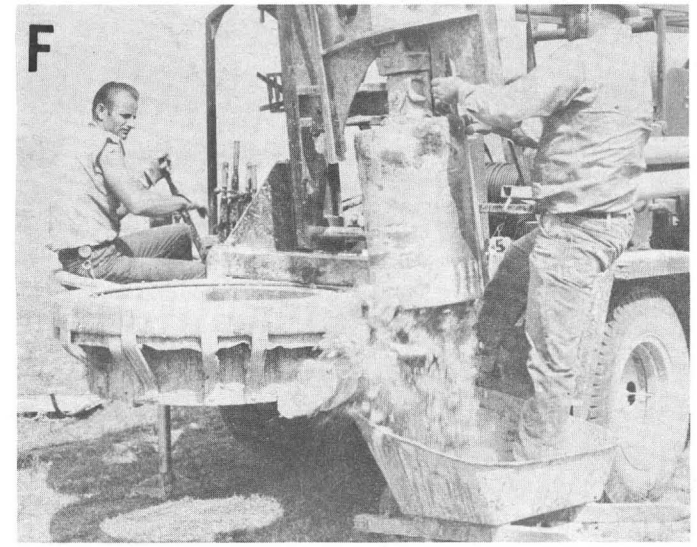
In the Ivanpah Mountains a group of deposits occurs within a few thousand feet of a wedge of Teutonia quartz monzonite that is separated from the Goodsprings dolomite by thrust faults. The Mollusk mine explored a quartz vein that contains gold- and silver-bearing sulfides. The Carbonate King Zinc mine produced oxidized zinc ore from a deposit consisting mainly of hemimorphite and smithsonite that occurs in the Yellowpine member of the Monte Cristo limestone. At the Standard No. 1 mine, oxidized copper minerals with gold and silver occur along a high angle fault that separates the Goodsprings dolomite from the Teutonia quartz monzonite. At the Evening Star mine, scheelite and cassiterite occur in contact metamorphic deposits in the Goodsprings dolomite near an intrusive body of the Teutonia quartz monzonite.

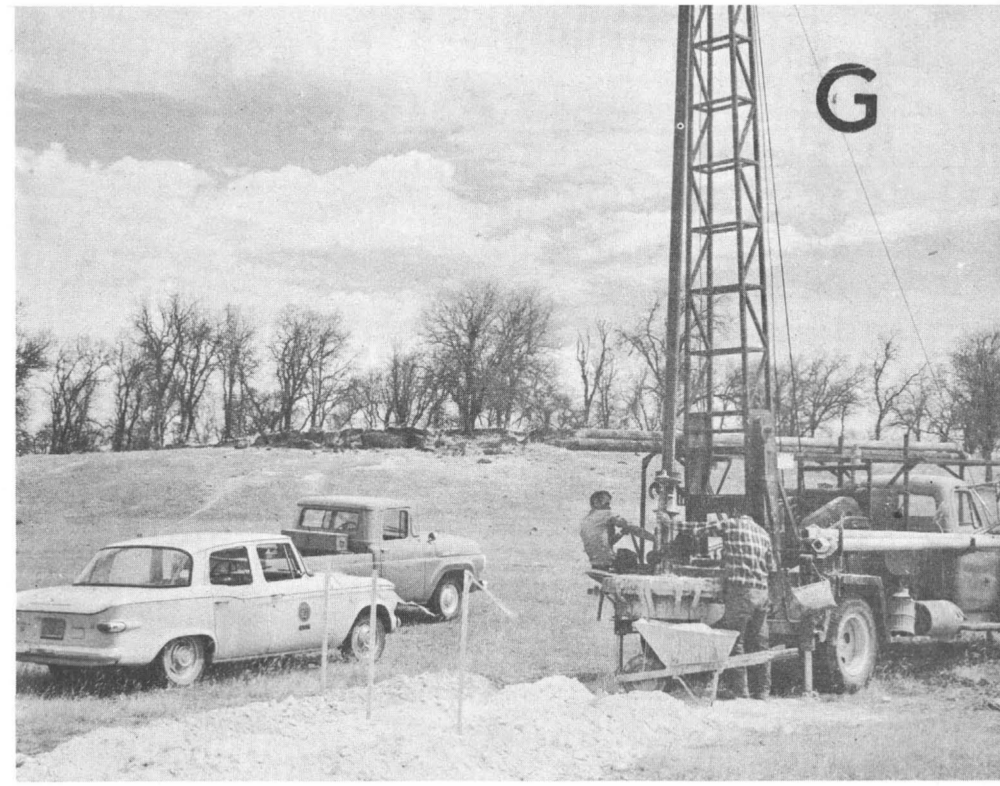
Mountain Pass Rare Earth Deposits

The unique deposits of the rare earth mineral bastnaesite occur in a northwest-trending zone 7 miles long and 3 miles wide athwart U.S. Highway 91 at Mountain Pass. Veins and masses of bastnaesite with barite and calcite are associated with shonkinite and other potash-rich rocks that have intruded the lower Precambrian complex east of the Clark Mountain fault.

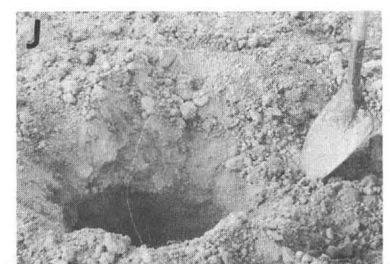
Castle Mountains area

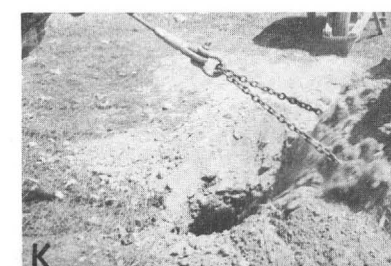
Deposits that are associated with Tertiary volcanic rocks in the Castle Mountains have furnished clay valued at nearly two million dollars, and also smaller amounts of gold, perlite, and silica. The clay was formed by hydrothermal alteration of rhyolite along steeply dipping fractures. The same fractures contain small but very rich gold veins.





(I) Bureau of Mines engineer (John Paden) taking samples for laboratory test. (J) Completed hole. (K) Hole being filled to prevent accidents. *Photos F, J, and K by John Paden.*





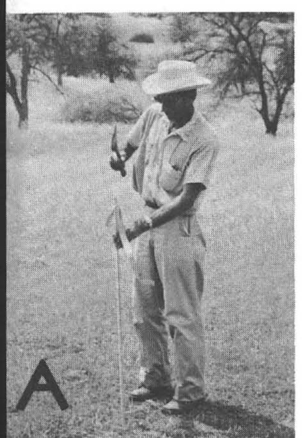
CALIFORNIA DIVISION OF MINES–U.S. BUREAU OF MINES COOPERATIVE DRILLING PROGRAM

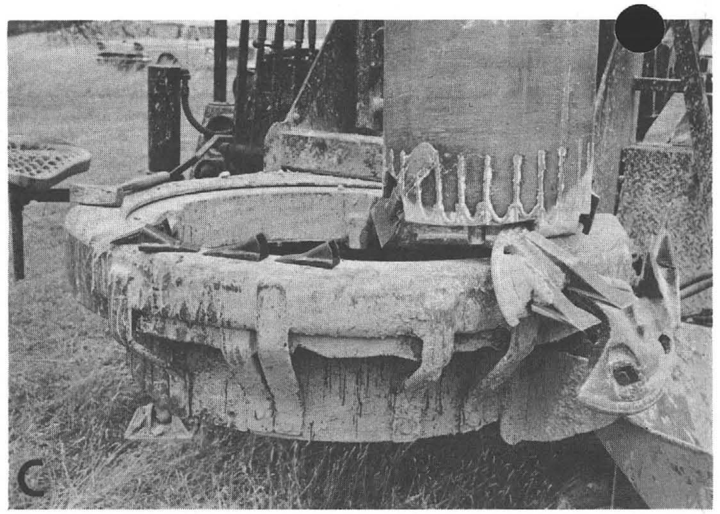
The California Division of Mines combines with the U.S. Bureau of Mines in several cooperative programs to investigate the mineral resources of California. In one of these joint efforts, a drilling program was conducted in June and July to obtain samples and subsurface information on the clay– and sand-bearing Ione formation southeast of Oakdale, California.

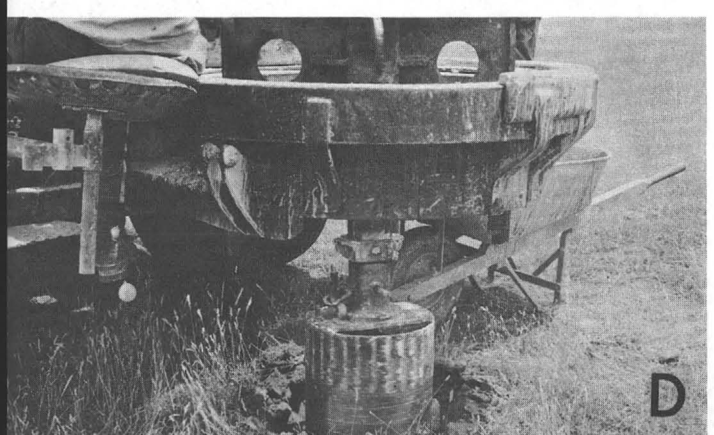
The Division of Mines mapped the surface geology to determine where the Ione formation was exposed in the area in order to suggest proper sites for drilling. The drilling operations were carried out under supervision of the U.S. Bureau of Mines to augment the surface information. After testing of the samples by state and federal laboratories (University of California and United States Bureau of Mines) a report on the results of the project will be published.

The drilling program itself consisted of the sinking of 45 holes with a bucket-auger type of drilling rig. This method is well-adapted to drilling in relatively soft formations to depths of about 200 feet, and the 16-inch diameter of bucket used provides a large amount of sample material for testing purposes. Total footage drilled in the cooperative program was over 3400 feet, with hole depths ranging from about 20 feet to 160 feet. Samples were obtained from several horizons including the Tertiary Valley Springs and Ione formations and the weathered zone of the Mesozoic bedrock of the region. The area investigated lies in the Sierran foothill belt in the vicinity of La Grange and Cooperstown.

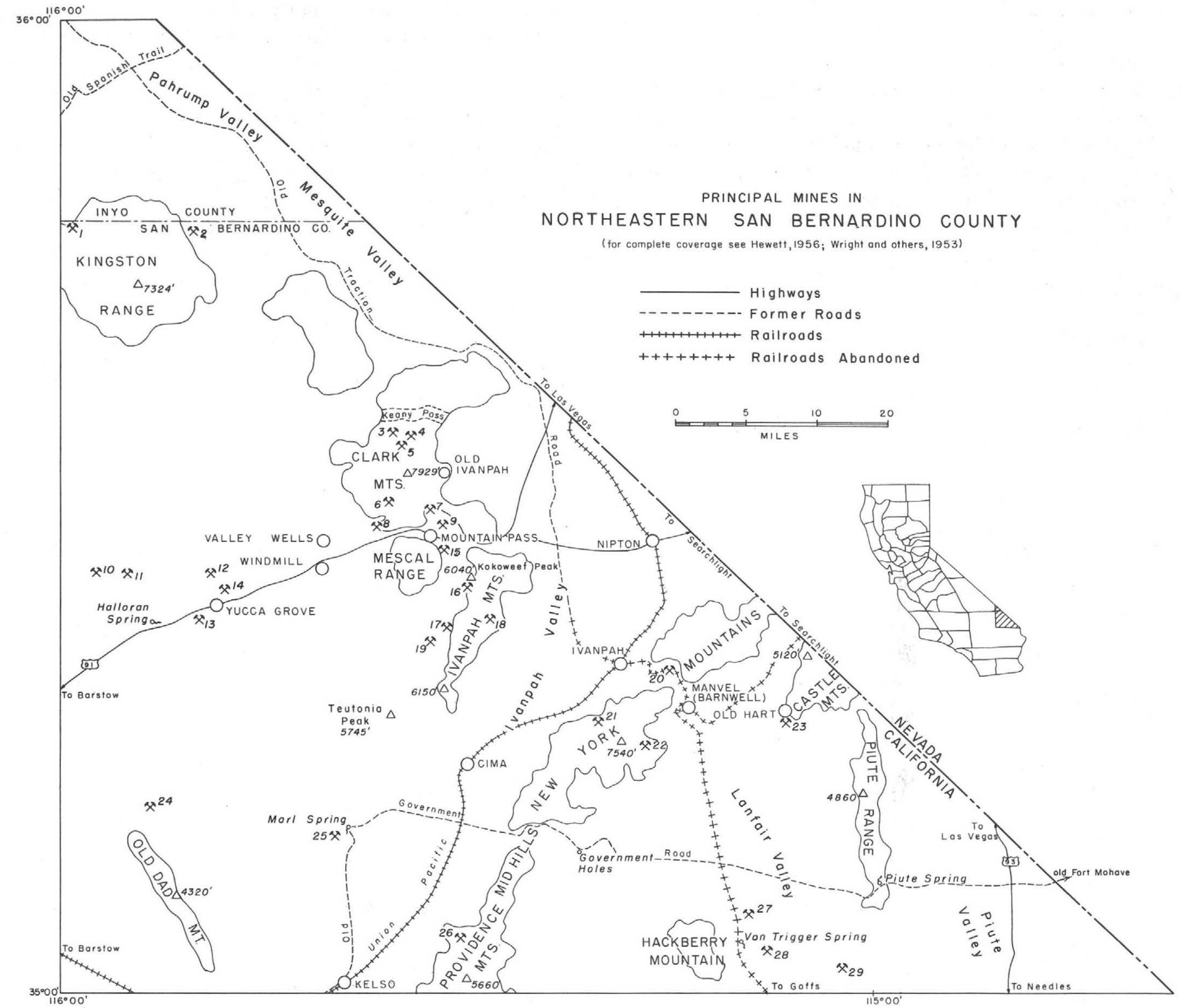
The accompanying pictures give details of the bucket-auger type of drilling machine, which can be fitted with various sizes of buckets (to 30") for test-drilling, foundation work and various other purposes.







(A) Division of Mines geologist (F.R. Kelley) marking selected drilling site by stake. (B) Rig is moved into position. (C) Close up of drill bucket showing bits used for drilling. Extra bits are lying on top of the collar. (D) Spudding in. (E) Drilling contractor (L.W. Ecker) operating drill. (F) Sample emptied from drill bucket by driller's helper (Richard Robles). (G) Hole nearing completion. Samples are laid in rows, each representing 20 ft. of hole. (H) Division of Mines geologist examining sample.



PRINCIPAL MINES IN NORTHEASTERN SAN BERNARDINO COUNTY

		Map no.			Map no.
Bullion	Silver; also copper, lead, zinc	18	Mountain Pass (Birthday)	Rare earth elements	7
Carbonate King Zinc	Zinc; also copper, lead, zinc	16	Mtn. Pass(Sulphide Queen)	Rare earth elements; also gold, copper, lead, zinc	9
Castle Mtns. deposits	Clay and gold	20	Pacific	Fluorspar	5
Colosseum	Gold; also copper, lead, and zinc	4	Paymaster	Gold; also copper	24
Confidence	Tungsten; also copper	26	Sagamore	Lead and zinc; also silver, copper, tungsten	22
Copper World	Copper; also lead, zinc	6	Silver mines of Old Ivanpah	Silver; also gold, copper, lead, zinc	3
Evening Star	Tin and tungsten	19	Standard No. 1	Copper; also gold, silver, lead, zinc, tungsten	17
Excelsior	Talc	2	Tecopa	Talc	1
Garvanza	Tungsten; also copper	21	Telegraph	Gold; also silver	13
Gold mines of Vanderbilt	Gold; also silver, copper, lead, zinc	20	True Blue	Gold	27
Leiser Ray	Gold; also silver, copper, lead, zinc, vanadium	29	Turquoise mines of		10, 11
Marl Spring prospects	Gold	25	prehistoric Indians	Turquoise	12
Mohawk	Lead and zinc; also silver, copper	8	Von Trigger	Copper and gold; also silver	28
Mollusk	Silver and gold	15	Yucca Grove	Talc	14

Talc Deposits

Mines in two areas have produced talc valued at more than 2½ million dollars. On the west and northwest slope of the Kingston Range, talc is associated with a diabase sill that intruded the Crystal Spring formation in Precambrian time. At Yucca Grove, talc is associated with metasediments of probable early Precambrian age.

New York Mountains

Mines in the New York Mountains near Manvel and Vanderbilt have an output of several hundred thousand dollars worth of silver and gold with smaller amounts of copper, lead, and tungsten. They occur near the contact of the Teutonia quartz monzonite with older sedimentary or metamorphic rocks. At the Sagamore mine, quartz veins containing copper, lead, and zinc sulfide minerals with wolframite occur in the Cambrian Tapeats sandstone. At Vanderbilt, quartz veins with sulfide minerals and gold cut lower Precambrian metamorphic rocks.

Other Deposits

Additional deposits are widely distributed throughout the area. Although small, they are numerous; and their total production, mostly precious and base metals, is of the same order of magnitude as that of the more concentrated group in the New York Mountains. Many of them lie near the contact of the Teutonia quartz monzonite with older rocks. At the Von Trigger and True Blue mines, shear zones in lower Precambrian rocks contain copper minerals and gold. At the Leiser Ray and the Telegraph mines, quartz veins with gold and a minor proportion of sulfide minerals occur in the Teutonia quartz monzonite. The Paymaster deposits are far from the Teutonia quartz monzonite and probably are not related to it. Gold-bearing quartz veins without sulfides other than pyrite occur there in lower Precambrian granitic and metamorphic rocks.

Mining in the Early Days

Travelers did not cross northeastern San Bernardino County regularly until the 1860's. The Spanish, and later the Mormons, used the Spanish Trail over Cajon Pass and across the north corner of the area to the Virgin River.

The region was virtually unknown until shortly before the Civil War, when the War Department sent out an expedition to explore for a route for a proposed railroad to the Pacific Coast. In 1854, a party in charge of Lieutenant A.W. Whipple went from the Colorado River near Needles to Cajon Pass by way of Piute Spring, Rock Springs, Marl Spring, Kelso Wash, and the Mojave River. Fort Mohave was established on the Colorado River in 1858 as a base for Federal troops. The principal route to it from the west, which in general followed the route of Lieutenant Whipple, came to be known as the Government Road. With the construction of a toll road across Cajon Pass in 1861 and the establishment of a ferry at Needles the next year, the Government Road became an important route of travel.

How Mining Began

No one knows when mining began in northeastern San Bernardino County. At the turquoise deposits north of Halloran Spring, traces of old workings and primitive tools have been found. Archaeologists tell us that these were not the workings of local Indians but of Pueblo peoples who came from New Mexico and Arizona for the sole purpose of mining turquoise. Of all the riches of the area, apparently only turquoise appealed to them. By means of stone hammers and scoops made of tortoise shells, they made pits, short tunnels, and cuts, one of which measures 30 feet by 12 feet by 12 feet deep. These workings, as well as those made by white miners from 1897 to 1903, encountered turquoise in the form of veinlets and disseminations in altered granitic rocks.

Discoveries by White Men

If we except the Indian turquoise miners, mining began about the time the Government Road was opened. Some discoveries were made by Mormon and off-duty soldiers from Fort Mohave who were in the area primarily on other business; most were made by prospectors who, like the Indian miners, came from other areas for the purpose of finding mineral deposits. Following the discovery of the Comstock lode at Virginia City, Nevada, mining ranked high in popular opinion, and grubstakes were easy to obtain. Swarms of men converged on Virginia City with the hope of finding mineral wealth, but only a few found what they sought there. The rest formed a

An annotated bibliography of California Cretaceous microfossils, by Joseph J. Graham. Special Report 66. 43 pp., frontispiece, 1 fig. Illustrated cover. Price $1.00.

"California Cretaceous strata totaling some 50,000 feet in thickness have been investigated for over a century. Because of industrial requirements, some of these rocks have been studied and restudied. This research, however, has not always been systematic, co-ordinated or integrated. Workers have not yet set up a usable time-stratigraphic classification. Some stratigraphers believe such a classification should be founded on microfossils and synchronized with the ammonite scale, with careful attention to stratigraphic control. That a time-stratigraphic classification of this nature is urgently needed becomes more and more apparent. It is the thought of the writer that for the bio-stratigrapher to work toward such a goal in California some sort of a synopsis is needed—perhaps one in the form of an annotated bibliography—of what has been published on the composition, stratigraphic occurrence, and ecology of the various micro-faunal and floral assemblages of the Cretaceous System.

"It is hoped that this bibliography—covering 180 references—adequately summarizes the vast amount of research that has already been published on the micropaleontology of the Cretaceous System in California and will be of some aid in suggesting problems that will add to our understanding of this portion of the geologic column."

Special Report 66 is bound in a particularly attractive cover that reproduces illustrations of Campanian Foraminifera drawn by Perfecto M. Mary.

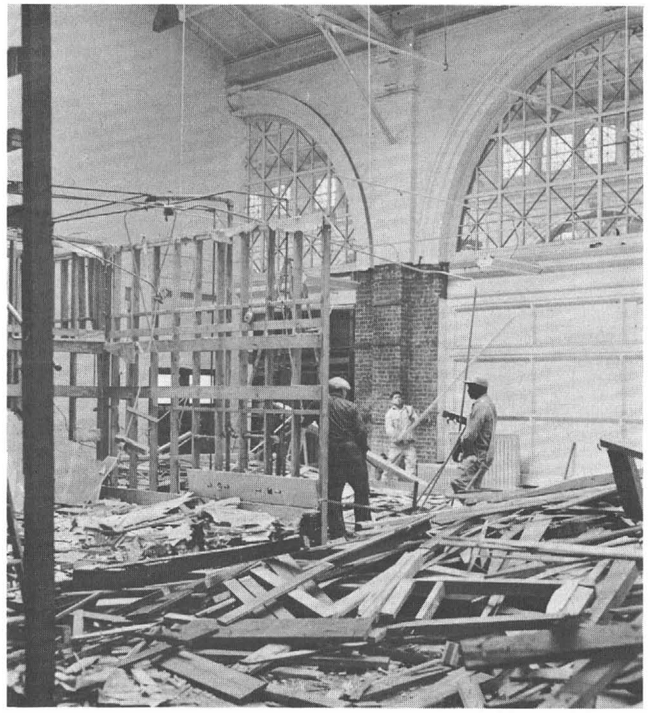
NEWS OF THE DIVISION

Lauren A. Wright, who has been in charge of the Los Angeles office for the past eleven years, resigned from the Division of Mines on August 1st. Dr. Wright, an authority on talc deposits and on the Death Valley area of California, has accepted the chairmanship of the Department of Geology at Pennsylvania State University at University Park, Pennsylvania.

While with the Division of Mines, Dr. Wright became the author of numerous technical papers and books. Among his best known and most appreciated contributions to knowledge of the state's mineral resources was the Division's Bulletin 176, *Mineral Commodities of California*, for which he served as editor.

James R. McNitt, a Division staff geologist, is presently in Rome attending the United Nations Conference on New Sources of Energy. He is presenting a paper at the conference concerning the leashing of geothermal power in California, a subject he discussed in the March, 1960 issue of *Mineral Information Service*.

Charles C. Bishop has been added to the staff in the Division's laboratory in San Francisco.



Division of Mines offices in the Ferry Building will be moved after renovation of the south wing. Work has begun, and is expected to be completed by next year. The Division's Mineral Exhibit may have to be closed during part of the renovation period. Groups intending to visit the exhibit are advised to check by telephone, GArfield 1-8800.

NEW PUBLICATIONS OF THE DIVISION OF MINES

Geology of the San Bernardino Mountains north of Big Bear Lake, California, by James Frank Richmond, with a *Tabulated list of mines and mineral deposits*, by Cliffton H. Gray, Jr. Special Report 65. 68 pp., 1 plate in pocket (a geologic map and sections, scale 2″=1 mile, in process color, covering the southwest portion of the Lucerne Valley 15-minute quadrangle), 72 figures, 1 table, and tabulated list. Price $1.50. The geologic map is available separately for 25¢.

The author's abstract follows:

The San Bernardino Mountains are a highland region in southern California about 100 miles east of Los Angeles. The area mapped for this report consists of about 60 square miles north of Big Bear Lake; it covers the north-central part of the mountains and the slope that falls steeply north to the Mojave Desert. Formations and structure are shown on a topographic map and in structure sections on the scale 1:24000. The topographic base is enlarged from the southwestern part of the U. S. Geological Survey Lucerne Valley quadrangle.

The rocks are grouped in three main units: (1) Carboniferous and older sedimentary rocks, which cover about one-fourth of the area; (2) volcanic and plutonic rocks of Mesozoic age, exposed over more than half the area; and (3) late Cenozoic clastic sedimentary rocks which cover the remainder.

Metamorphosed sedimentary rocks, older than the igneous rocks, occur in two formations. The Chicopee Canyon formation of pre-Carboniferous age is predominantly quartzite and has a minimum thickness of 1320 feet. It is overlain in apparent conformity by the Furnace formation, which consists chiefly of calcitic and dolomitic marbles and which may be 5000 feet thick. Probably at least 1000 feet of the Furnace formation is of Mississippian age; the remainder may be in part of Pennsylvanian age. The Furnace formation was dolomitized, locally silicified, and folded prior to the intrusion of the igneous rocks. The Chicopee Canyon formation shared this deformation. Static metamorphism resulted from the granitic intrusions; foliated rocks were not developed and the northwesterly trend of the pre-intrusive folds was preserved. Contact metamorphism produced low- and medium-grade hornfelses in both of the older sedimentary formations. In the Furnace formation contact-metamorphic effects included marmarization and dedolomitization, and contact metasomatism at granitic contacts produced thin zones of tactite and skarn.

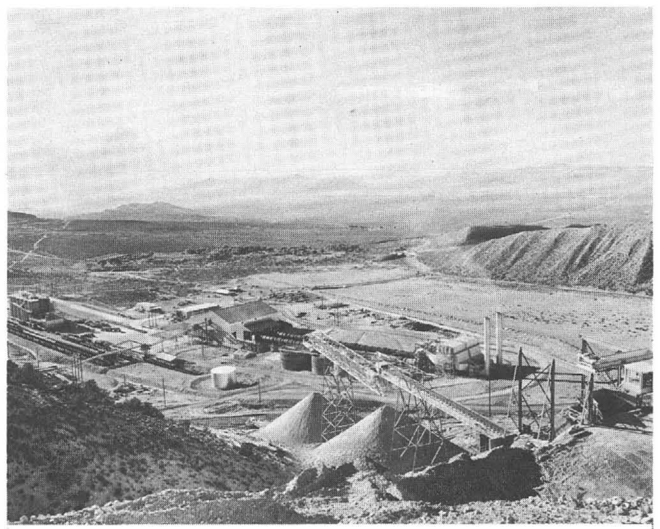
Volcanic eruptions of Triassic(?) age preceded intrusions of the Jura-Cretaceous plutonic series. Quartz latite porphyry, quartz latite tuff, and trachy-andesite are preserved partly in dikes in Furnace marble and more extensively as migmatites formed by reaction with biotite quartz monzonite magma or its emanations.

The plutonic sequence and allied intrusions are part of a composite batholith widely exposed in the San Bernardino Mountains and southeastern Mojave Desert. The rocks comprised in the batholith have an exposed thickness of 4000 feet in the area studied, where they consist of small bodies of gabbro, diorite, and tonalite porphyry, and larger mases of hornblende quartz monzonite, biotite quartz monzonite, and granite porphyry. Hornblende quartz monzonite was in part forcibly injected in older sedimentary rocks, whereas biotite quartz monzonite, the predominant rock of the batholith, was emplaced probably in the main by stoping. Most of the granitic rocks consolidated and differentiated from a magma, but biotite quartz monzonite was formed locally by replacement of Triassic(?) volcanic rocks.

The post-batholithic sedimentary rocks, of continental origin, include the Old Woman sandstone, a conglomeratic sandstone of Miocene-Pliocene age; terrace deposits and talus breccias of Pleistocene(?) age; and alluvium of two ages.

Late Cenozoic thrust-faulting along the range front produced cataclasis in the igneous rocks and minor sharp folds in the Furnace formation, and initiated higher relief which led to the accumulation of the terrace deposits and talus breccias. The terrace deposits have been uplifted along later high-angle faults.

The predominant trend and dip of faults and overturned folds reflect a long history of compressive stress from the west and southwest. Similar relations east and west of the mapped area suggest that the San Bernardino Mountains were uplifted mainly by thrust-faulting rather than by block-faulting.



View northwest from quarry toward Cushenbury plant of Permanente Cement Company, 1957. In foreground are portions of crushing and stockpiling facilities which handle limestone obtained from adjacent quarry. The limestone is moved via belt conveyor to manufacturing plant in middleground. Lucerne Valley in background. ***Photo courtesy Permanente Cement Company, Oakland California.***

great out-moving wave of prospectors who worked their way southward across the desert. Eventually some of them reached northeastern San Bernardino County. Some shafts and tunnels near Marl Spring that explore a pyrite-bearing quartz vein are thought to be the work of soldiers and to date from as early as 1860. In 1861 prospectors found gold-bearing veins near Vanderbilt, but significant production did not begin there until the 1890's. In 1865 other prospectors found rich deposits of silver on the north slope of Clark Mountain. Probably most of the obvious deposits in northeastern San Bernardino County had been found and evaluated by 1880.

Old Ivanpah

For a long time the silver mines of Old Ivanpah on the north slope of Clark Mountain were the most important, not only of the area under consideration, but of all San Bernardino County. The Clark mining district, which roughly coincided with Clark Mountain, was organized in July 1865; and in 1875, about 500 people lived in Old Ivanpah on the east slope of Clark Mountain. The principal mines—the Allie, the Beatrice, the Lizzie Bullock, and the Jackson or Stonewall—worked oxidized veins that were rich in silver. Some of the operations were very profitable. The Allie mine, for example, is reported to have paid $100,000 in dividends before 1880 from ore containing as much as 4,400 ounces of silver per ton. The Copper World mine, on the south slope of Clark Mountain, also was known at an early date. A small quantity of very rich copper ore was shipped from it in 1869, but its main period of activity came much later.

Other Early Mines

During the 1860's and 1870's high-grade silver-lead carbonate ore was obtained from the Bullion mine in the Ivanpah Mountains. In 1870 some Mormons obtained silver from rich, narrow veins near the Sagamore mine in the New York Mountains. The Mollusk mine, in the Mescal Range, was originally located as the Cambria mine in 1881 and also has been known as Mescal mine. Gold and silver were produced there from 1882 to 1888, and in 1886 a 10-stamp mill was installed at Mescal Spring.

The Supply Problem

All the early mines were isolated far out at the extremities of a long communications system. Supplies for northeastern San Bernardino County came from San Francisco by way of San Bernardino and a long haul by freight wagon over the Government Road. Burros were used for the last stage of the journey where wagons could not go. The outgoing ore had an even longer journey, because most of it was shipped to Wales for smelting. Freight rates were hundreds of dollars per ton.

Under the conditions outlined above, all but the most necessary supplies were prohibitively expensive. Workings were necessarily small and shallow, mostly above the water table; and only the simplest beneficiation techniques could be employed. Only the richest deposits could be considered.

Relatively low-grade deposits of base metals and precious metals were discovered but were of little interest in a region supplied only by freight wagon. Their development could not begin until some form of transportation appeared that would lower freight rates and make supplies more readily available.

Railroads and Mining

The Santa Fe Line

In 1884 the main line of the Santa Fe railroad was completed through Needles; but it had no immediate, pronounced effect on the mining industry. For one thing, the line runs south of the area, some 40 miles from Old Ivanpah. In addition, the rich deposits were approaching exhaustion; and of the Ivanpah mines, only the Jackson was still operating in 1880. A decline in the price of silver offset in large measure the reduction in freight rates that the railroad made possible.

The presence of the railroad, however, did help to revive interest in mining and stimulated prospecting. Deposits of copper, lead, silver, and gold in the New York Mountains were evaluated again and found promising; but to mine them profitably, the railroad would have to be brought closer.

The Manvel Line

In 1893 a branch line was completed from Goffs through Lanfair Valley to Manvel, now Barnwell. Its immediate purpose was to serve the Sagamore mine in the New York Mountains, which was worked for copper, lead, and zinc during the 1890's.

The Manvel line stimulated mining throughout the territory that it served. A little to the north of Manvel the highly productive gold-bearing veins at Vanderbilt were brought into production. Farther north, on Clark Mountain, the Copper World mine began to produce copper ore on a significant scale. To the south, near Von Trigger Spring, the True Blue mine produced gold, and the copper-gold veins of the Von Trigger mine were explored.

For some time Manvel was the point of departure for a wide area of surrounding country. It was from Manvel that, in 1904, the Pacific Coast Borax Company built a traction road to the Lila C. colemanite mine in the Death Valley country. In 1907, a branch of the railroad was completed from Manvel to Searchlight, Nevada. Eventually the Manvel line was extended through the New York Mountains into Ivanpah Valley.

Completion of the Transportation Network

With the construction of the Union Pacific line through Kelso, Cima, and Ivanpah in 1905, railroad transportation was available to the central part of the area and the west slope of the New York Mountains-Providence Mountains chain. The Arrowhead Trail, predecessor of the present U.S. Highway 91, was opened in 1925. About that time the railroad to Manvel, having outlived its usefulness, was dismantled. Today, graded gravel roads traverse most of the valley areas.

The Great Years (1900-1919)

Metal mining in northeastern San Bernardino County reached its peak between 1900 and the end of the first World War. More mines were active and production was higher than at any other time. Some mines were first worked in that period; afterwards many were closed and never reopened.

The discoveries at Tonopah, Nevada, in 1900 ended a long drought of mineral discoveries and rejuvenated mining on a large scale. For the second time hordes of prospectors backed by adequate capital began to comb the desert hills. This time they looked, not only for gold and silver, but also for copper, lead, and zinc to supply the expanding industries of the United States. The need arose for metals such as chromium, manganese, tungsten, and vanadium that had had only limited uses before. Especially during the war years, the demand, and consequently the prices, for base metals increased enormously. Every part of northeastern San Bernardino County was served by railroads or graded roads, so that freight rates were greatly reduced. Now it was feasible to mine deposits that had been of no economic value earlier.

The Copper World Mine

The Copper World, which ranks among the larger copper mines in California, yielded small amounts of extremely rich ore in 1869. In 1898 the Ivanpah Smelting Company operated it on a larger scale and smelted the ore at Valley Wells. There the Company produced black copper, 98 percent pure, but the enterprise failed because of a high loss of copper in the slag. The Cocopah Mining Company reopened the mine in 1907 and produced ore that averaged 6 to 10 percent copper. This time it was shipped to Needles, where the company operated a custom copper and lead smelter. Production lasted through 1908.

The principal period of activity came during 1916 to 1919 when the price of copper was high. The Ivanpah Copper Company mined ore containing 2 percent copper at the rate of 100 tons a day and reduced it to copper matte in a new blast furnace at the site of the old smelter at Valley Wells.

Mohawk Mine

A significant production of lead, zinc, and copper has come from the Mohawk mine and nearby workings on Mohawk Hill just north of U.S. Highway 91 near Mountain Pass. The deposits on Mohawk Hill were known by 1908 and had been explored for their copper content by the owners of the Copper World. The first production came in 1917 when they were explored again and ore containing 16 to 30 percent lead was shipped.

Other Mines

At the Von Trigger mine near Von Trigger Spring, production began in 1907 with a few tons of ore containing nearly 9 percent copper. In 1909, 30,000 tons of ore averaging 4 percent copper was mined. At first copper was recovered from it by a leaching process, but in 1913 a more elaborate plant was installed that

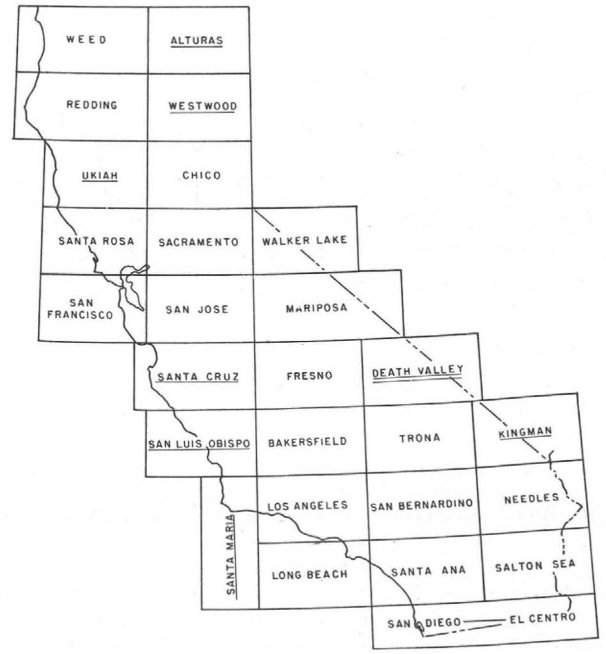
KINGMAN SHEET

The Kingman sheet of the Geologic Map of California, Olaf P. Jenkins edition, has been distributed to subscribers to the automatic purchase plan and is now being released for public sale.

The new sheet, comprising approximately the area of northeastern San Bernardino County discussed in the major article of this issue of *Mineral Information Service*, is the eighth sheet of the geologic map to be published. As shown on the accompanying cut, this completes the mapping of slightly less than one-third of the state in this present project. Previously published sheets in the Olaf P. Jenkins edition, on the scale 1:250,000, include Death Valley (currently being reprinted), Alturas, Westwood, Ukiah, Santa Cruz, San Luis Obispo, and Santa Maria. All sheets are printed on topographic map bases issued by the Army Map Service. Included with each one is a data sheet that gives an index to the geologic mapping, a table of stratigraphic nomenclature, a key to the topographic quadrangles, and photographs illustrating the geologic terrain of the area.

The Kingman sheet, prepared by Charles W. Jennings, embraces an interesting area of the Mojave Desert that exhibits rocks ranging in age from early Precambrian to Recent dune sand.

This geologic map sheet is priced at $1.50, including the map and the data sheet, encased in a manila envelope. The map is also available separately, uncolored, without the envelope or data sheet, for 50¢.



Map showing planned sheets in the Geologic Map of California. Sheet names underlined have been issued. All except Death Valley (out-of-print; reprint in progress) are available for $1.50 each.

Ukiah, Westwood, and Kingman are also available in an uncolored edition—without data sheet or envelope—for 50¢ each.

MORE CALIFORNIA LANDS

Many who were disappointed at being too late to purchase a copy of *California Lands*, by Samuel Trask Dana and Myron L. Krueger, will be glad to know that a second shipment (comprising the last of the copies printed) has been received by the Division of Mines.

Those who did wish copies and were not able to procure them (our entire stock was disposed of in less than a week) will no doubt recall that the purchase price of the cloth-bound, 308-page book was announced at 96¢, plus 4¢ tax for California residents. This is a considerable saving over the initial cost of the book, which was $4.50 per copy.

Mail orders should be addressed to the headquarters office of the Division in the Ferry Building.

WATER-RESOURCES REPORTS

The U.S. Geological Survey has announced that the following reports on water resources in California are released in open file. Copies of all these reports are available for consultation in Room 1242-G, General Services Building, Washington 25, D.C., as well as the other places listed.

Data on water wells on Marine Corps base, Twentynine Palms, California, by F.S. Riley and J.S. Bader. 18 p., 1 fig. Available at the U.S. Geological Survey, 221 Redondo Avenue, Long Beach, California.

Water levels in observation wells in Santa Barbara County, California, in 1960, by P.M. Merritt. 51 p., 9 figs. Available at the U.S. Geological Survey offices, 121 West De La Guerra Street, Santa Barbara, California, 2929 Fulton Avenue, Sacramento, California.

LEGAL GUIDE ADDENDA AND ERRATA

All holders of the 1960 revised edition of the *Legal Guide for California Prospectors and Miners* are advised to file the following paragraphs between pages 30 and 31 in the *Guide*.

Geological, geophysical and geochemical surveys may be considered as "labor" with respect to the annual expenditure requirement for unpatented mining claims. Public Law 85-876 (72 Stat. 1701) approved September 2, 1958 adds sections 28-1 and 28-2 to the Revised Statutes, Volume 30 of the United States Code as follows:

§ 28–1. Inclusion of certain surveys in labor requirements of mining claims; conditions and restrictions.

The term "labor", as used in the third sentence of section 28 of this title, shall include, without being limited to, geological, geochemical and geophysical surveys conducted by qualified experts and verified by a detailed report filed in the county office in which the claim is located which sets forth fully (a) the location of the work performed in relation to the point of discovery and boundaries of the claim, (b) the nature, extent, and cost thereof, (c) the basic findings therefrom, and (d) the name, address, and professional background of the person or persons conducting the work. Such surveys, however, may not be applied as labor for more than two consecutive years or for more than a total of five years on any one mining claim, and each such survey shall be nonrepetitive of any previous survey on the same claim. (Pub. L. 85–876, § 1, Sept. 2, 1958, 72 Stat. 1701.)

§ 28–2. Same; definitions.

As used in this section 28–1 of this title,

(a) The term "geological surveys" means surveys on the ground for mineral deposits by the proper application of the principles and techniques of the science of geology as they relate to the search for and discovery of mineral deposits;

(b) The term "geochemical surveys" means surveys on the ground for mineral deposits by the proper application of the principles and techniques of the science of chemistry as they relate to the search for and discovery of mineral deposits;

(c) The term "geophysical surveys" means surveys on the ground for mineral deposits through the employment of generally recognized equipment and methods for measuring physical differences between rock types or discontinuities in geological formations;

(d) The term "qualified expert" means an individual qualified by education or experience to conduct geological, geochemical or geophysical surveys, as the case may be. (Pub. L. 85–876, § 2, Sept. 2, 1958, 72 Stat. 1701.)

Errata to Legal Guide

p. 13, line 11, change "page 50" to "page 46"

p. 26, under Relocation, line 7, change "July 1" to read "September 1"

p. 34, at end of Sec. 2312, add "A mill site may be located in connection with a placer claim. See Appendix 1, page 109"

NEW BOOKS FROM OTHER PUBLISHERS

History of the Earth, by Bernhard Kummel. Published by W.H. Freeman and Company, San Francisco. Available at bookstores, $8.75.

Intended particularly as a college text, this 610-page, cloth-bound book bears the stamp of the outstanding typography and makeup of the W.H. Freeman press. The author presents a summary of the geologic history of the earth, and has taken the trouble to assemble an outstanding group of illustrations, a majority of which are drawings by Evan L. Gillespie.

The interested layman or fossil hunter who wishes a comprehensive introduction to the natural history of the earth—including its fossils—would do well to have this book as a reference on his shelf.

Field geology, by Frederic H. Lahee. Sixth edition. Published by McGraw-Hill Book Company, Inc. Available at bookstores, $10.75.

Professional geologists as well as students will be interested to read—and to own—the latest (6th) edition of "the classic" handbook, Lahee's *Field geology*. For here the progress of the science in terms of the refinement of its tools shows clearly. Dr. Lahee has brought the forty-five-year-old handbook up-do-date, and, in doing so, has included topics from nearly every phase of the earth sciences.

The 6th edition, like the 5th and earlier ones, is bound in soft leather and contains some 926 pages.

employed cyanidation for the recovery of gold and an electrolytic process for the recovery of copper. The plant was not successful.

Copper was obtained from the Standard No. 1 and other mines in the Ivanpah Mountains. Production was small, but some of the ore contained as much as 22 percent copper.

The Paymaster mine at the north end of Old Dad Mountain was discovered in 1900. Between 1910 and 1914 it produced gold valued at $50,000 to $100,000. It was recovered by amalgamation in a 10-stamp mill.

The small but rich gold mines in the Castle Mountains were discovered in 1907. The town of Hart, now disappeared, grew up during 1908 and 1909 when the deposits were explored intensively. Two mines, the Oro Belle and the Valley View, were brought into production. The ore from them was treated in a cyanide mill at the Valley View.

During or shortly before World War I, small amounts of tungsten were produced from the Sagamore mine, the Garvanza mine in the New York Mountains, and the Confidence mine in the Providence Mountains. All of these mines had been worked earlier for precious and base metals.

Another interesting, but unsuccessful, venture was the attempt to recover vanadium from the Leiser Ray mine, which is east of Von Trigger Spring. Fractures in the gold-bearing quartz veins there are coated with yellow cuprodescloizite, a vanadium mineral. The deposit was discovered in 1902 and worked intermittently for gold. Interest in vanadium began in 1911 when W.T. Schaller identified the yellow coating.

Mining since World War I

After World War I the general trend of metal mining activity was downward, even though some mines, such as Von Trigger, achieved their greatest productions in the 1920's. The depression of the 1930's, which brought a revival of gold mining, and World War II, when many base metal mines were reopened, reversed this trend only temporarily. The output of metals, however, has been replaced by that of nonmetallic commodities such as clay and talc, the demand for which became significant after World War I.

Depression and Gold Mining

With the price of gold raised, costs low, and men not having much else to do, gold deposits everywhere were reexamined. Now deposits were valuable that could not have been profitably mined before. New mines were found, and new ore bodies were discovered in old mines.

One old mine was the Colosseum on the north side of Clark Mountain, which had been known since 1880. It was explored in 1900 to 1906 and again beginning in 1923, but its main period of production began about 1929.

The Telegraph was a new mine discovered near Halloran Spring in 1930. From 1932 to 1938 it produced gold valued at $100,000.

World War II and the Base Metals

The base metal mines responded to the high demand resulting from World War II, but production did not reach the peak it attained 25 years before. The Mohawk mine was reopened in 1942 and produced several hundred thousand dollars worth of lead and zinc. The Carbonate King Zinc mine on Kokoweef Peak, which had been discovered in 1900, was developed in 1940. It produced several thousand tons of oxidized zinc ore.

The production of copper was small. Some mines, including the Sagamore and the Von Trigger, were reopened and worked on a small scale, but no attempt was made to reopen the Copper World.

During 1942 to 1944 some tin ore was taken from the Evening Star mine on the west slope of the Ivanpah Mountains and concentrated in a mill at Windmill Station on U.S. Highway 91. Scheelite was produced at about the same time from a tactite zone on the same property.

The Nonmetallics

In 1921, the mining of clay began in the Castle Mountains. Large scale production began in 1932, and the deposits have been a significant source of high-quality clay for special purposes to the present day.

The mining of talc was well established just west of the area covered by this discussion when, in 1935, the Tecopa mine on the northwest slope of the Kingston Range was brought into production. The Yucca Grove, the first of the talc mines at Yucca Grove, was opened in 1938.

At present the only producer of fluorspar in California is the Pacific mine on the north slope of Clark Mountain. Flotation is used to make a fluorspar concentrate from a mixture of fluorite and sericite. Production began in 1959.

Mountain Pass

A most significant event in recent mining history was the discovery of the Mountain Pass rare earth deposits. The story begins in March 1949, when H.S. Woodward, an engineer from Goodsprings, Nevada, organized a group to prospect the Goodsprings area for uranium. The only radioactive material they found were some specimens in a collection belonging to Fred B. Piehl. These Piehl had collected from all over the desert, but he was able to identify the radioactive ones as coming from his Sulphide Queen property. The Sulphide Queen was an old property within sight of U.S. Highway 91 at Mountain Pass that Piehl had prospected in 1924. It had been developed further in 1941 and 1942 by H.C. Howard, who had obtained an option on it and had mined some gold from a quartz vein.

Piehl showed no interest in tracking down the source of the radioactivity on the Sulphide Queen, so Woodward and his associates were forced to prospect elsewhere. On April 23, 1949, they found what is now called the Birthday deposit, two miles to the north. Then it turned out that the deposit did not contain uranium at all. Specimens of the heavy, light brown mineral that Woodward sent to the United States Bureau of Mines were identified by E.T. Schenk as bastnaesite, an uncommon mineral containing rare earth elements. The radioactivity that led to the discovery of the deposits is attributable to a small proportion of thorium-bearing monozite that accompanies the bastnaesite.

That June, D.F. Hewett of the United States Geological Survey confirmed Schenk's identification. Preliminary mapping by the Survey revealed that the Birthday property contains veins of bastnaesite in shonkinite and that a significant deposit exists there. The public announcement of the discovery, in November 1949, brought a swarm of prospectors to Clark Mountain for the third time. With the aid of Geiger counters they soon found a score of previously unsuspected bastnaesite veins in the same region that the silver miners of the 1870's and the copper miners of World War I had already examined.

The discoveries interested the Molybdenum Corporation of America, which used rare earth elements in the manufacture of lighter flints, and had experienced difficulty in obtaining raw materials during World War II. In February 1950 the Company bought the Birthday property and that summer explored it with a shaft and drifts. The results of this work were disappointing.

Meanwhile the Survey was mapping in detail the entire Mountain Pass radioactive area. During the course of this work, an enormous mass of bastnaesite and barite was found on the Sulphide Queen property. This discovery the Survey announced in January 1951. Two days after the announcement the Molybdenum Corporation of America bought the Sulphide Queen property, including its equipment, mill, and buildings, and also the nearby claims of the prospectors Otto Krone and J.B. Kasey. During 1951, the company developed an ore body with a rare earth content of 10 percent or more and estimated to contain more than 200,000 tons of rare earth elements. This tonnage is many times the total world consumption up to that date.

The development of a process to treat the barite-bastnaesite ore was exceedingly difficult. Gravity methods could not be used. A chemical process was devised, but it did not work well. The company tried a flotation process in which barite was floated and discarded, but the recovery of rare earth minerals was low. To this writer, at least, it seems fitting that it was H.S. Woodward, discoverer of the Birthday deposit, who devised and perfected the method of floating the rare minerals that is now used. With the treatment problem solved, the capacity of the plant is far in excess of demand. New uses for rare earth metals and compounds must be found before the full potential of the deposit can be realized.

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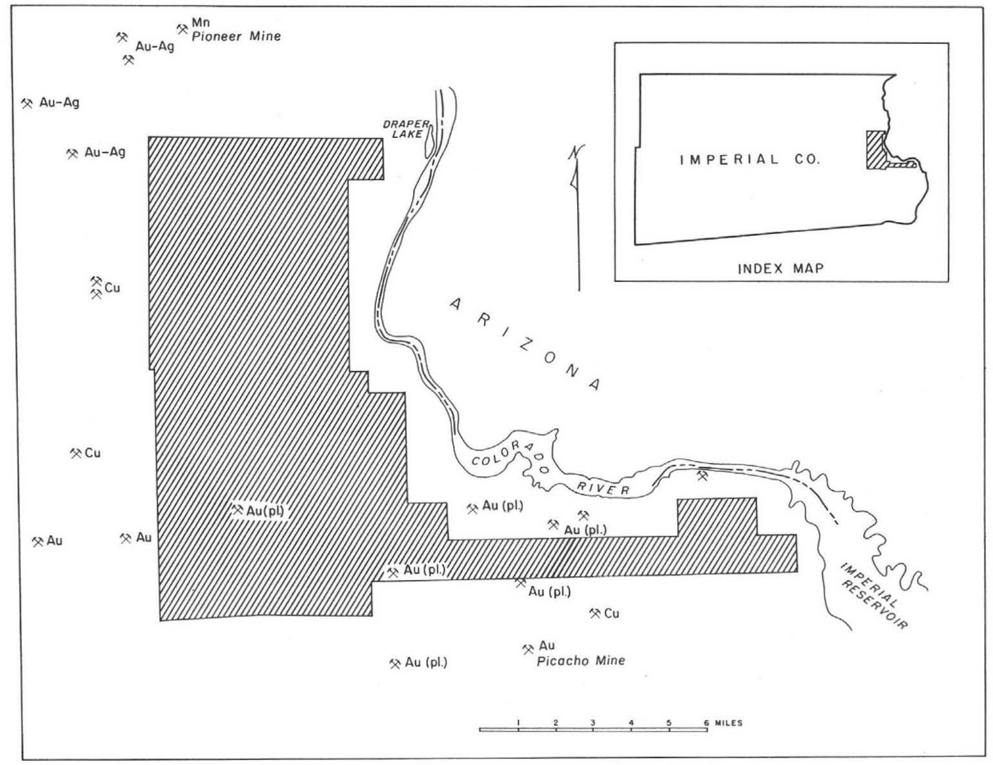


Map showing land in Imperial County opened to mineral location as of October 16, 1961. Text below was inadvertently omitted from the July issue of *Mineral Information Service*.

LAND IN IMPERIAL COUNTY OPENED TO LOCATION

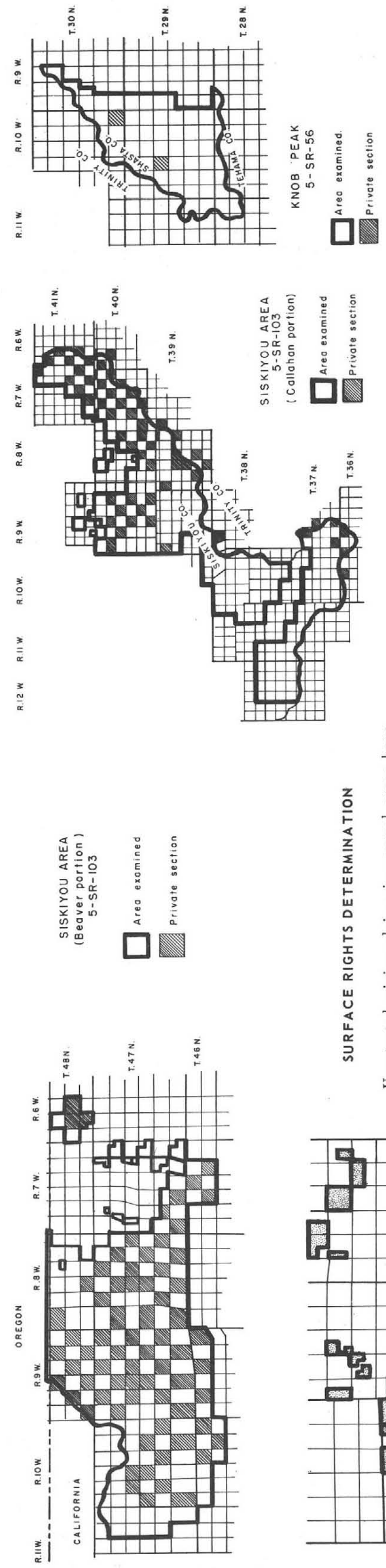
By order of the U.S. Bureau of Land Management (Public Land Order 2324) certain reclamation withdrawals in Arizona and California have been partly revoked, and the lands involved will be opened to mineral location on October 16, 1961. The lands were open to mineral leasing. Legal descriptions of the land in California are listed in the text of the order published in the Federal Register, April 13, 1961, page 3151. The area, which is L-shaped, comprises about 55,780 acres centered about 22 miles north of Yuma, Arizona. The area is near the part of the Colorado River that lies between Draper Lake on the north and Imperial Reservoir on the southeast.

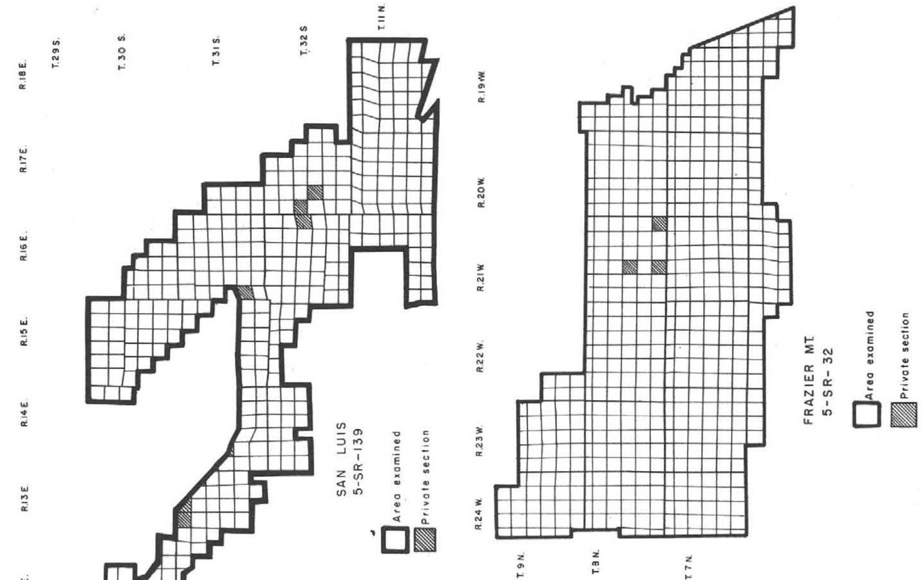
Relatively few mineral deposits are known to occur in the area, but placer gold is reported to have been mined from many of the dry washes, especially in the southern parts of the area. A large manganese deposit, the Pioneer mine, lies 3 miles north of the northeastern corner of the area, and several copper and gold-silver prospects lie within a few miles of its western boundary. The Picacho gold mine, a large producer, is about 2 miles south of the east-trending leg of the area.

THE "$500" FALLACY

The Division of Mines receives frequent inquiries about the expenditures required before patenting mineral claims. A common misconception is that a $500-expenditure for assessment work over a 5-year period is necessary in order to obtain a mineral patent from the U.S. Government, and that the patent is automatically obtained upon completion of the work. Actually, work involving the $500 expenditure can be completed immediately following location of a mineral claim or during a 1-year, 2-year, or longer period. The expenditure of $500, however, does not guarantee that a mineral patent will be granted, nor does it relieve the claim locator or owner from the necessity of continuing the annual assessment work in an amount involving the expenditure of $100 per claim per year.

An outline of the procedure for obtaining patent to a mining claim is included in the 1960 revision of *Legal Guide for California Prospectors and Miners*, which is sold for $1.00 by the Division of Mines. Additional information is available from offices of the U.S. Bureau of Land Management, the governmental agency that processes applications for mineral patents.

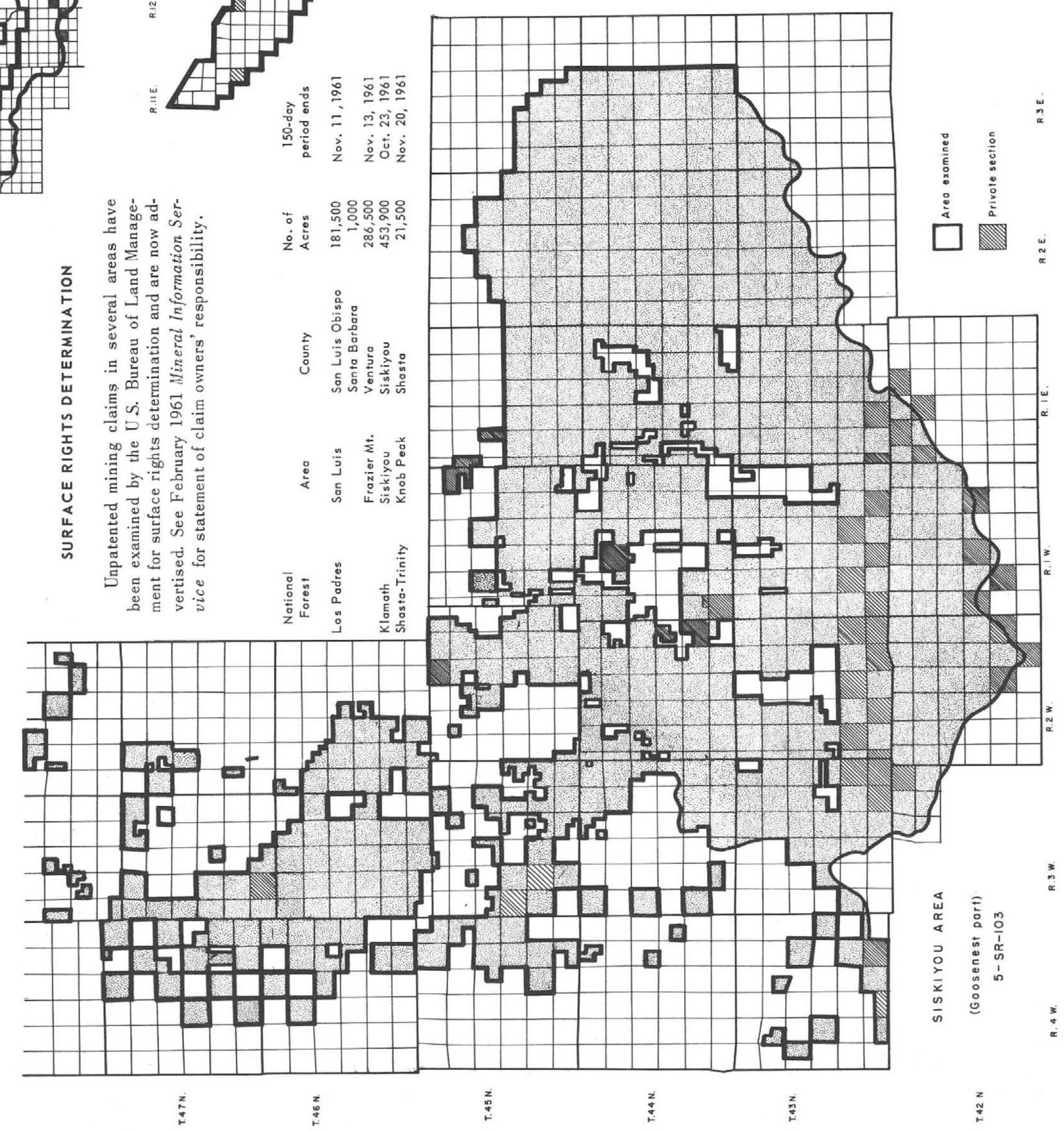




SURFACE RIGHTS DETERMINATION

Unpatented mining claims in several areas have been examined by the U.S. Bureau of Land Management for surface rights determination and are now advertised. See February 1961 *Mineral Information Service* for statement of claim owners' responsibility.

National Forest	Area	County	No. of Acres	150-day period ends
Los Padres	San Luis	San Luis Obispo Santa Barbara	181,500 1,000	Nov. 11, 1961
	Frazier Mt.	Ventura	286,500	Nov. 13, 1961
Klamath	Siskiyou	Siskiyou	453,900	Oct. 23, 1961
Shasta-Trinity	Knob Peak	Shasta	21,500	Nov. 20, 1961



WESTWOOD SHEET

The recently published Westwood Sheet of the new State Geologic Map of California, prepared by Philip A. Lydon, Thomas E. Gay Jr., and Charles W. Jennings, of the Division of Mines, shows the geology of Lassen, Plumas, Shasta, and Tehama counties, and a small portion of Butte County. Within the confines of the area of this sheet is the famous Lassen Volcanic National Park. The Westwood Sheet covers a region south of and adjacent to the Alturas Sheet, and immediately northeast of the Ukiah Sheet, both of which are available in published form from the Division of Mines.

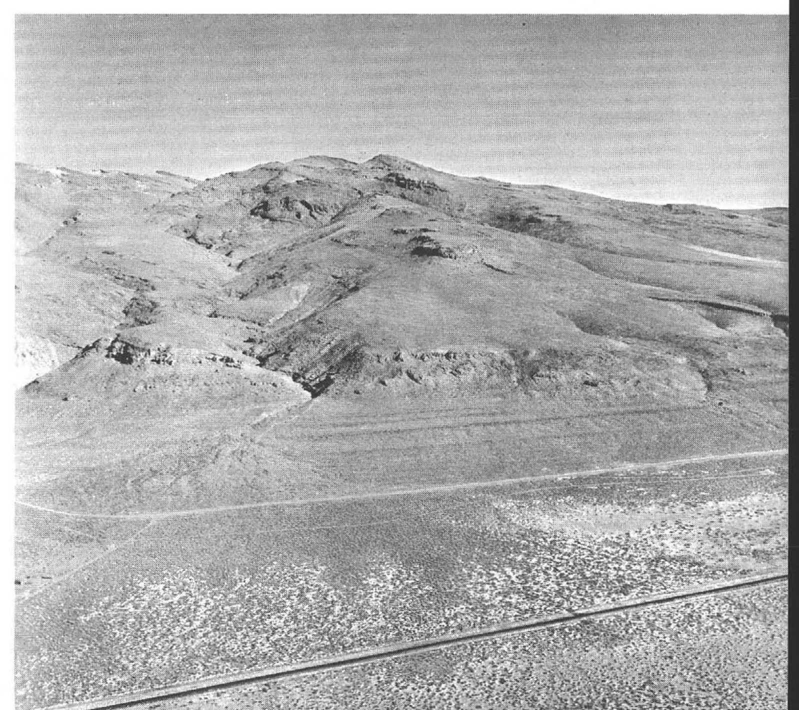
Previously published geological information was available for only relatively small portions of the sheet. Division of Mines geologists therefore were assigned the task of mapping about 5,000 square miles during 1959 field season. Unpublished geological information for an additional 1,500 square miles was obtained from five university geologists and one soil scientist.

The map sheet shows a number of interesting and significant geological features, some of which have not heretofore been described. For example, much was learned about the distribution of the upper Pliocene Tuscan formation. New mapping of this widespread unit, which consists of volcanic mudflow deposits and interbedded lava, tuff, sand, and gravel, revealed several source areas for the mudflows. Exposures of metamorphic and granitic rock were discovered underlying the Tuscan formation in an area farther northwest than had previously been recognized. The other discoveries of interest were granitic and metamorphic rocks which crop out from beneath Tertiary and Quaternary volcanic flows at Eagle Lake, and are probably the northernmost exposure of basement rocks now recognized in eastern California.

Of especial interest in the structural geology of this area is the complex pattern of faults. Normal faults that have disrupted Tertiary and Quaternary volcanic rocks are quite prominent, and the northwest-trending alignment of cinder cones north and east of Lassen Peak is probably fault controlled. There are also prominent faults in the Sierran portion of the map and complex thrust faults in the classic Mount Jura area within Jura-Triassic and Paleozoic rocks. The geology of the Indian Valley—Mt. Jura area as shown on this map represents a reinterpretation and remapping of an area of considerable geologic complexity. The mapping was done by Vernon McMath, one of the contributing authors.

Some localities of specific interest that are shown include calcareous tufa mounds east of Honey Lake, and intrusive dacite cones in the Mineral-Lassen Peak area. Quaternary glacial deposits are more widely distributed than hitherto suspected.

Copies of the Westwood Sheet may be purchased from the Division of Mines for $1.50 each (plus 6¢ tax for California residents). It is accompanied by an explanatory data sheet that describes the sources from which the map was compiled, and explains the geological units shown on the map. An uncolored, unfolded copy of the map may be obtained without the explanatory data sheet at a cost of 50¢ (plus 2¢ tax for California residents).



View northeast toward the Amedee Mountains and the edge of Honey Lake Valley. The Amedee Mountains consist of gently dipping Pliocene andesite flows. Note the alluvial fan at the mouth of Amedee Canyon which partially obscures Quaternary shore-line markings (terraces) of ancient Lake Lahontan. The Southern Pacific R.R. and the Wendel-Flanagan road cross Quaternary lake deposits in foreground. *Photo courtesy of Robert S. Ford, California Department of Water Resources.*

VOLCANIC CINDERS NEAR BAKER

By James R. Evans

A source of volcanic cinders has been developed about 20 miles east of Baker in the Mojave Desert and about 8 miles south of Valley Wells Station, San Bernardino County. The cinders are mined from volcanic cones principally for use as lightweight concrete aggregate. These cones are part of an extensive volcanic field composed of olivine basalt flows which rests on the northwest slope of Cima Dome. The flows and associated basaltic cinder cones are of Quaternary age, but were extruded and ejected at two different times. They are typical of other Quaternary volcanic material in the east-central Mojave Desert. The older cones are weathered and eroded, and as a result the cinders are not suitable for commercial use. Younger cinder cones are as much as one-half mile in diameter, and range in height from about 200 to 400 feet. Cinders are well bedded, coarse to medium cellular, rusty-red and black in color, and range in size from less than 1/8 of an inch to angular pieces 5 to 6 inches in diameter. Locally, cinders are agglutinated and form masses as much as 2 to 3 feet in size. Volcanic bombs, as much as 1 foot in length, are abundant, especially along lines of bedding. Oxidation of iron contained in the constituent minerals has produced the red color. The cinders are composed essentially of fine- to medium-grained phenocrysts of labradorite and olivine set in a dense intergrowth of plagioclase, olivine, augite, magnetite, and minor amounts of glass.

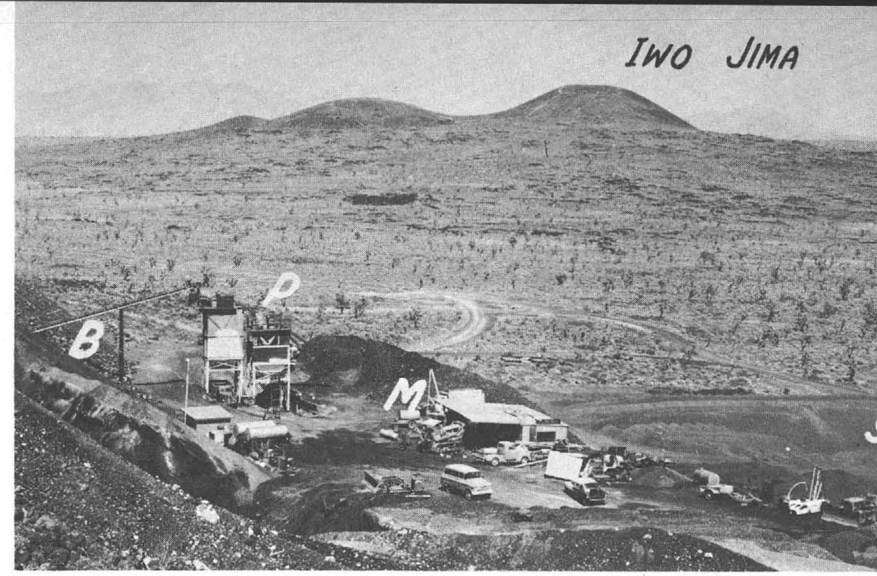
The Cima Cinder Company is operated by B.B. Walpole, 1392 Orange Drive, Los Angeles 19, California, who leases the cinder deposits from Emerson Ray of Glendale.

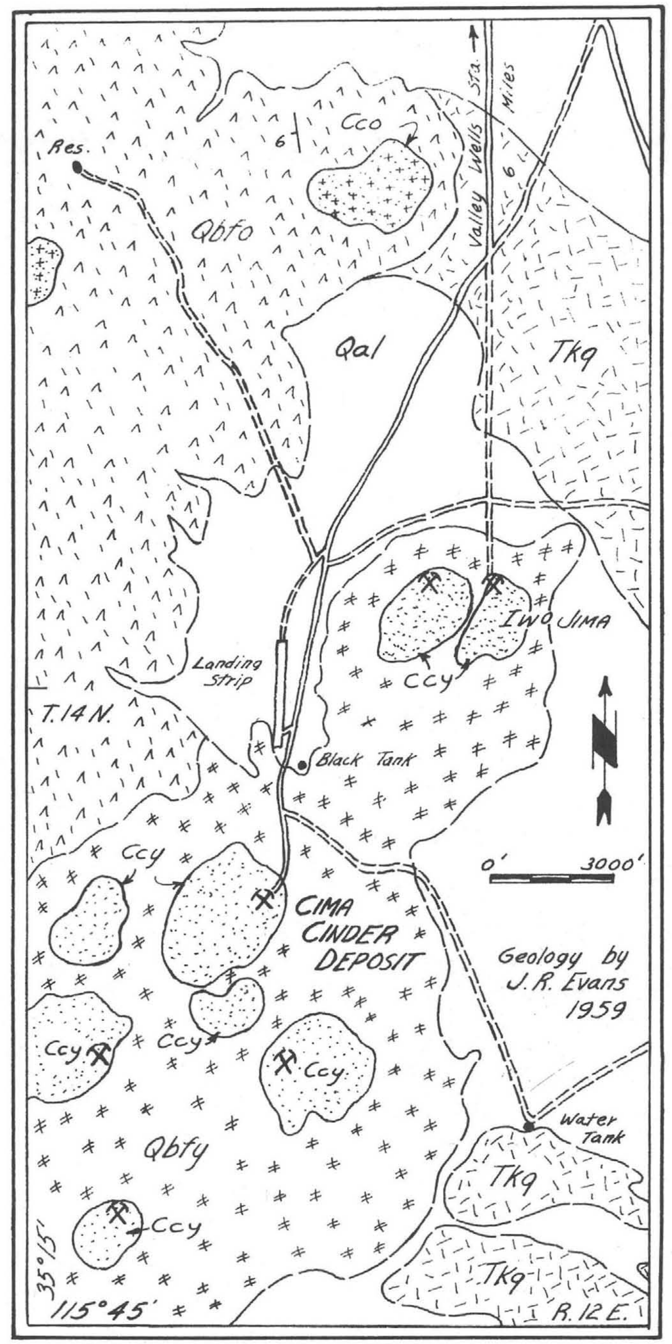
Cinders are mined from the cones, after some preliminary blasting, by bulldozers which push the material onto a conveyor belt. The conveyor belt feeds the material into a crushing and screening system. Red and black cinders are sized separately and stockpiled.

Mining cinders at Cima Cinder deposit. Cinders are well bedded and contain volcanic bombs. The processingplant is in the right center (P), and the stockpiles (S) are below. View is west.

Right

Cima Cinder Company processing plant. The belt conveyor system (B) feeds cinders into the crushing and screening plant (P) from which the material is trucked to the stockpiles below (S). The machine shop (M) is adjacent to the plant. View is northwest toward Iwo Jima and adjacent cinder cone.





Left

Geologic map of the area of the Cima Cinder deposit. Tkq indicates Upper Cretaceous Teutonia quartz monzonite; Qbfo, an older cinder cone; Qal, Recent alluvium. Symbol ⚒ represents a cinder pit. In large part the flows were extruded on a surface of Teutonia quartz monzonite and are at an elevation of about 4000 feet. Cinder cones are associated with each of two distinct flows, but only the cinders in the younger cones are commercial.

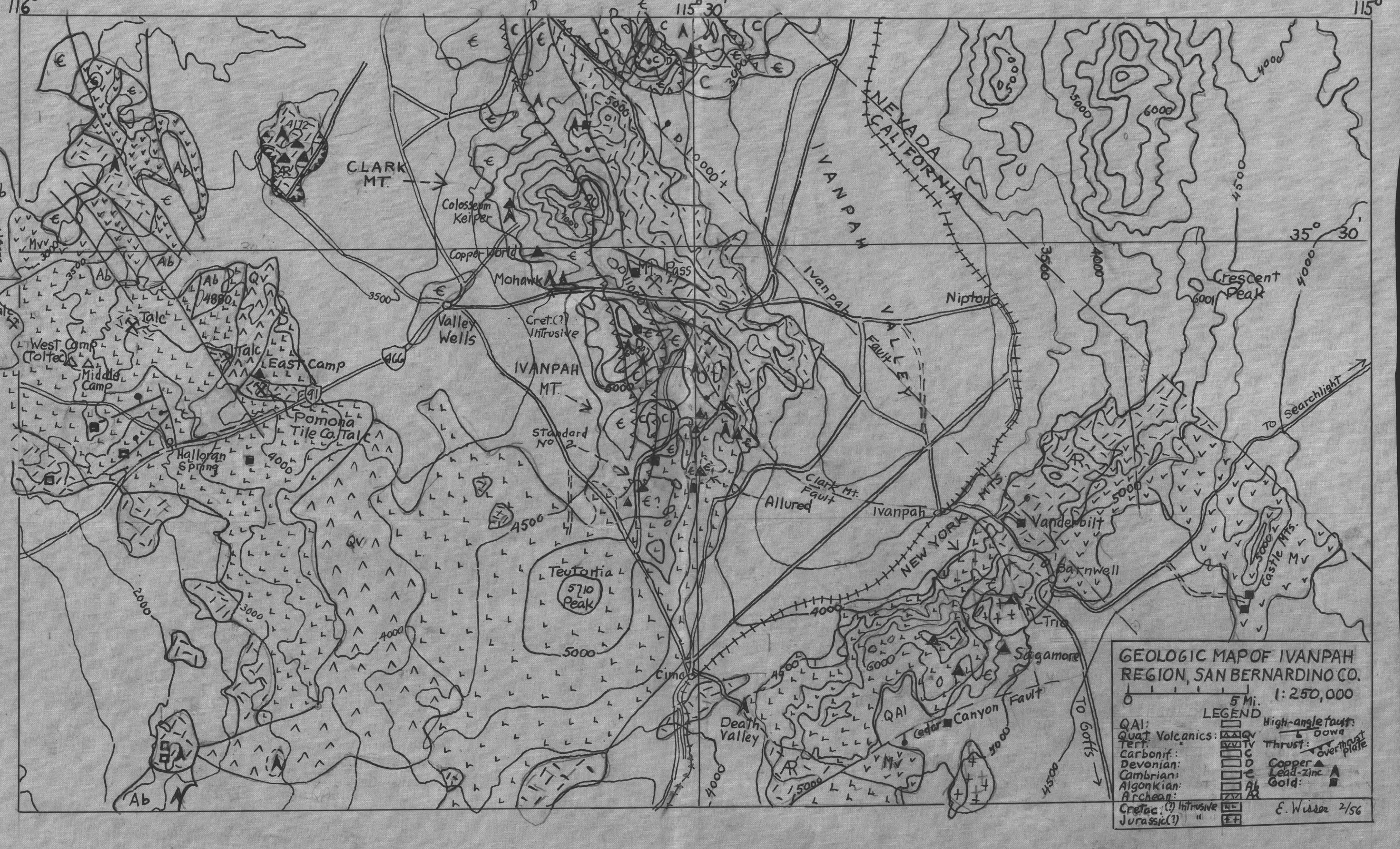
Sizes stockpiled.

INCHES

1)	3	-	1
2)	1	-	3/4
3)	3/4	-	5/8
4)	5/8	-	15/32
5)	15/32	-	5/16
6)	5/16	-	1/8
7)		-	1/8

Material sells from $2.00 to $6.50 per ton (f.o.b. deposit) in truckload lots.

Nearly all the black cinders are marketed in Las Vegas for use as lightweight concrete aggregate. Some red cinders are used by the Hal Manufacturing Company, Van Nuys, for insulation in barbecue pits. Their product is called Volcanic Ash Reflecto Heat and ranges from 3/4 - 5/8 inch in size.



GEOLOGIC MAP OF IVANPAH REGION, SAN BERNARDINO CO.
0
5 Mi.
1:250,000
LEGEND
QAl:
Quat. Volcanics: Qv
Tert. " Tv
Carbonif.: C
Devonian: D
Cambrian: Є
Algonkian: Ab
Archean: AR
Cretac.(?) Intrusive
Jurassic(?) "
High-angle fault: Down
Thrust: overthrust plate
Copper
Lead-Zinc
Gold:
E. Wisser 2/56
116°
115° 30'
115°
35° 30'
NEVADA
CALIFORNIA
IVANPAH VALLEY
Ivanpah Fault
Clark Mt. Fault
Cedar Canyon Fault
CLARK MT.
IVANPAH MT.
NEW YORK MTS.
Castle Mts.
Crescent Peak
Teutonia Peak
5710
Colosseum
Keiper
Copper World
Mohawk
Mt. Pass
Valley Wells
Cret.(?) Intrusive
Standard No 2
Nipton
Ivanpah
Allured
Vanderbilt
Barnwell
Trio
Sagamore
Cima
Death Valley
Halloran Spring
Pomona Tile Co. Talc
West Camp (Toltec)
Middle Camp
East Camp
Talc
To Searchlight
To Goffs
10,000'+