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BULLETIN No. 129—PART F

[JUNE 1945

**Iron Resources of California**  
**Bulletin No. 129**

**PART F**

**Vulcan Iron-Ore Deposit**  
**San Bernardino County, California**

By **CARL A. LAMEY**

GEOLOGICAL SURVEY, U. S. DEPARTMENT OF THE INTERIOR



*Issued by the*  
**STATE DIVISION OF MINES**

# VULCAN IRON-ORE DEPOSIT, SAN BERNARDINO COUNTY, CALIFORNIA \*

BY CARL A. LAMEY \*\*

UNITED STATES DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY

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## ABSTRACT

The Vulcan iron-ore deposit is in the Mojave Desert, San Bernardino County, California, in secs. 25 and 36, T. 10 N., R. 13 E., S.B., about 9 miles southeast of Kelso, a station on the Union Pacific Railroad.

Limestone of early Paleozoic age and monzonite which appears to intrude the limestone are the chief rocks exposed. Diorite and aplite dikes intrude the monzonite. Fanglomerate and younger alluvium cover the other rocks at places.

The orebodies are contact-metamorphic replacements in the limestone near the contact with the monzonite. The age relations between the limestone and the monzonite are obscure; at some places the contact is faulted, at others the monzonite appears to be intrusive. The ore is thought to have been brought in by the monzonite.

The ore minerals are chiefly magnetite and hematite, but limonite is present also. The chief gangue minerals are calcite, serpentine, and pyrite.

The reserves in the principal orebody are estimated to be 5,680,000 long tons of ore containing about 50 percent iron. They are subdivided into 1,160,000 long tons of measured ore; 1,130,000 long tons of indicated ore; and 3,390,000 long tons of inferred ore. A smaller orebody is estimated to contain at least 315,000 long tons of inferred ore and could well contain several times this amount.

The deposit is owned and mined by Kaiser Company, Inc., Fontana, California. Production started December 1, 1942, with mine installations capable of handling a daily output of 2,500 tons of ore. About 43 percent of the total amount of ore present is expected to be recovered by open-pit mining. The ore is extracted in 50-foot benches, crushed at the mine, and transported by truck over a paved road to Kelso for shipment by rail.

Water is obtained from springs about 1½ miles southeast of the deposit, and from the Union Pacific Railroad reservoir about 1 mile south of Kelso.

## INTRODUCTION

The Vulcan iron-ore deposit is in the Mojave Desert, San Bernardino County, California, in secs. 25 and 36, T. 10 N., R. 13 E., about 9 miles

\* Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Manuscript submitted for publication September 28, 1944.

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southeast of Kelso, a station on the Union Pacific Railroad (fig. 30). The deposit is reached by a paved road from Kelso.

The orebodies are along the western slope of the Providence Mountains at altitudes ranging from 3,900 to 4,100 feet. West of the Providence Mountains is an alluvium-filled valley, in part of which there are large sand dunes.

The property is owned and operated by the Kaiser Company, Inc., Fontana, California. Production started December 1, 1942; since then about 2,500 tons of ore averaging 52 percent iron has been produced daily.

References to brief articles describing the deposit follow:

Hewett, D. F., Callaghan, Eugene, Moore, B. N., Nolan, T. B., Rubey, W. W., and Schaller, W. T., Mineral resources of the region around Boulder Dam: U. S. Geol. Survey Bull. 871, p. 79, 1936.

Vulcan iron deposit: California Div. Mines, Min. Abstracts, Iron, pp. 30-31, 1941.

Hodge, E. T., Available raw material for a Pacific Coast iron industry: War Dept., North Pacific Division, vol. 3, appendix E-5, California iron ore deposits, pp. 12-13, 1935.

Jones, Charles Colcock, An iron deposit in the California desert region: Eng. and Min. Jour., vol. 87, pp. 785-788, 1909.

Jones, Charles Colcock, The iron ores of California and possibilities of smelting: Am. Inst. Min. Eng. Trans., vol. 53, pp. 306-317; Discussion, pp. 318-323, 1915.

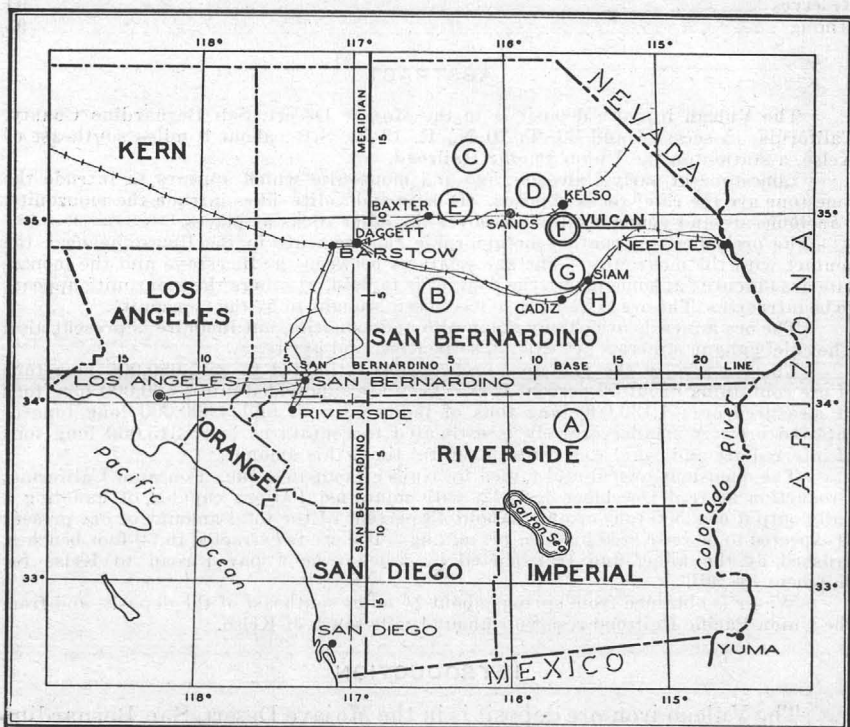


FIG. 30. Index map of southern California iron-ore deposits showing: (A) Eagle Mountains; (B) Iron Mountain (Lava Bed); (C) Iron Mountain (Silver Lake); (D) Old Dad Mountain; (E) Cave Canyon; (F) VULCAN, described in this report; (G) Iron Hat; (H) Ship Mountains.

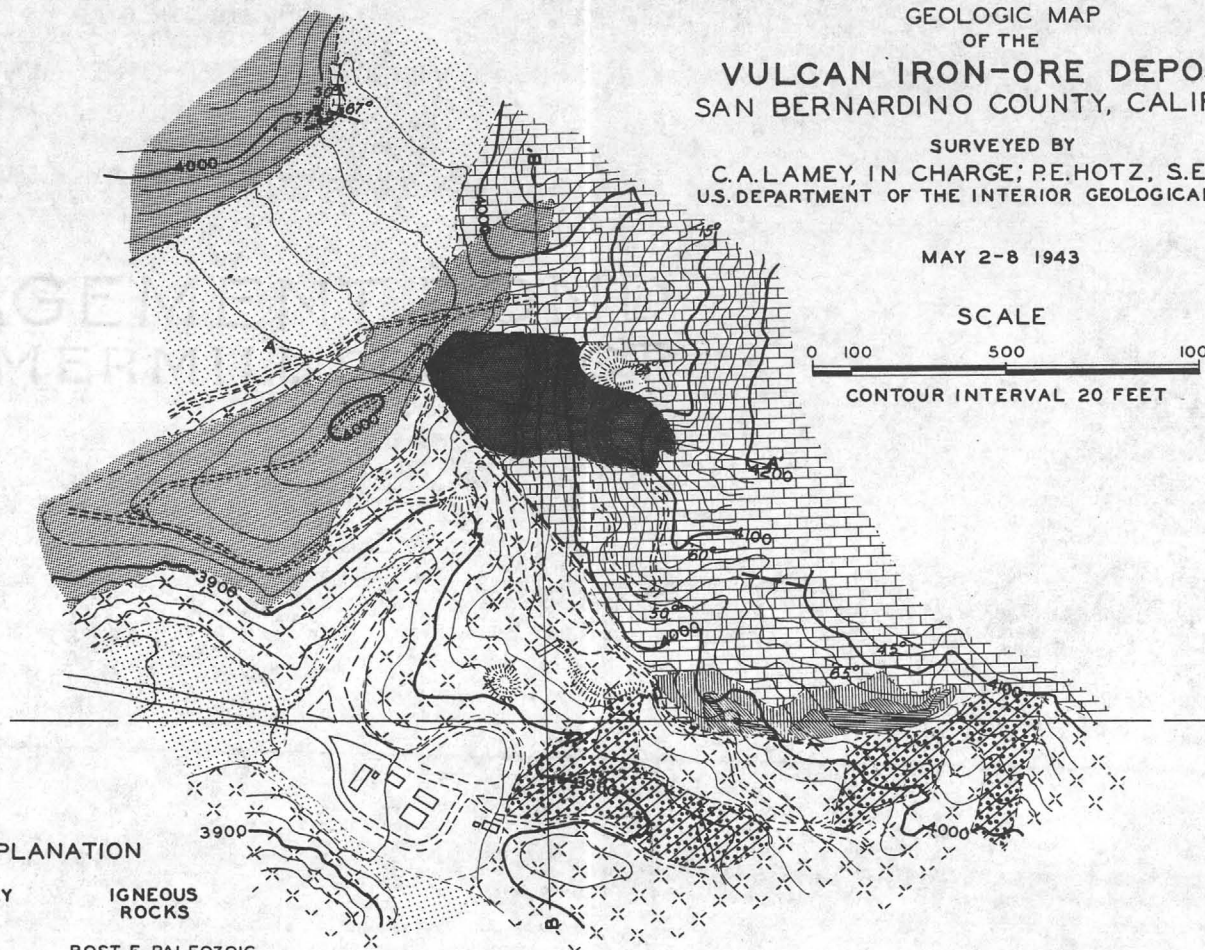


GEOLOGIC MAP  
 OF THE  
**VULCAN IRON-ORE DEPOSITS**  
 SAN BERNARDINO COUNTY, CALIFORNIA

SURVEYED BY  
 C.A. LAMEY, IN CHARGE; P.E. HOTZ, S.E. GOOD  
 U.S. DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY

MAY 2-8 1943

SCALE



EXPLANATION

SEDIMENTARY  
ROCKS

QUATERNARY  
 ALLUVIUM

TALUS

FANGLOMERATE  
 chiefly rhyolite  
 fragments and  
 boulders

E. PALEOZOIC  
 CRYSTALLINE  
 LIMESTONE  
 (moderately well-bedded  
 buff to gray limestone)

IGNEOUS  
ROCKS

POST E. PALEOZOIC  
 MONZONITE  
 including acidic  
 and basic dikes

IRON ORE

LEAN IRON  
 ORE

CONTOURS

FAULTS

CONTACTS

DIP AND STRIKE  
 of bedding

DUMP

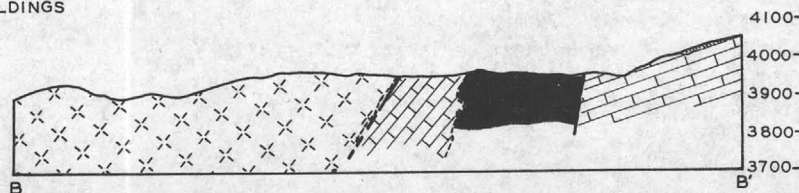
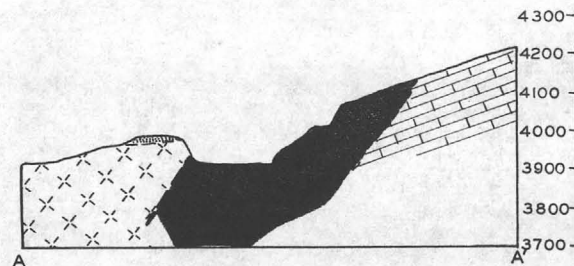
ROADS solid where paved,  
 dotted where dirt.

MINE BUILDINGS

Areas possibly containing  
 iron ore as indicated by  
 dip needle observations.

high  
 magnetic attraction

moderate  
 magnetic attraction



The deposit was examined and mapped during May 1943, by Carl A. Lamey, Preston E. Hotz, and Stanley E. Good. Mapping was done by means of telescopic alidade and plane table. True north was determined by use of the Baldwin solar chart.

#### ACKNOWLEDGMENTS

Acknowledgment is due to employees of Kaiser Company for courtesies extended in the field, and for the use of material contained in a private report on the geology of the Vulcan iron-ore deposit.

#### GEOLOGY

##### General Relations

The rocks<sup>1</sup> exposed include limestone, fanglomerate, alluvium, monzonite, diorite, and aplite (Pl. IX). Rhyolite is exposed about half a mile northeast of the area. The limestone and the monzonite are the most important rocks, as the ore deposits occur in the limestone near its contact with the monzonite. The diorite and the aplite occur only as dikes in the monzonite.

The geologic ages of all rocks are not known, but the relative ages are probably (from youngest to oldest): alluvium, fanglomerate, diorite and aplite dikes, monzonite, limestone. The limestone is early Paleozoic, possibly Cambrian.<sup>2</sup> The age relations between the limestone and the monzonite are obscure. At one place the contact is faulted; at another the monzonite appears to intrude the limestone, and there are minor amounts of pyroxene and amphibole or anthophyllite. The monzonite is probably younger than the limestone. The diorite and aplite dikes intrude the monzonite. The fanglomerate and alluvium are tentatively classed as Quarternary. The relative age of the rhyolite in the area adjoining the deposits was not determined.

##### Description of Rock Units

*Limestone.* The limestone is chiefly buff and gray, but it includes white and brown varieties. Much of it is crystalline, but some of it is very fine grained and approaches lithographic limestone. It ranges from massive to thin bedded. The thicker beds are 3 to 6 feet, the thinner ones, half an inch to 2 inches. Chert lenses 3 feet or more long and 2 to 3 inches wide are interbedded with some of the limestone.

*Fanglomerate.* The fanglomerate is composed chiefly of rhyolite fragments, many of which are several feet long and show flow structure. Other rock fragments are limestone, igneous rock breccia or agglomerate, and metamorphic rocks.

*Alluvium.* The alluvium is of the usual type, composed of sand and a variety of rock fragments.

*Monzonite.* The monzonite is coarsely granitoid to slightly porphyritic. Much of it has a mottled appearance, due to pink and lilac orthoclase, white plagioclase, and black biotite. Hornblende, quartz, and light-

<sup>1</sup> Rocks and minerals were identified megascopically only.

<sup>2</sup> Hazzard, John C. Notes on the Cambrian rocks of the eastern Mohave Desert, California (with a paleontological report by Colin H. Crickmay): Univ. California, Dept. Geol. Sci., Bull. 23, pp. 58-60, 75-76, 1933.

green epidote are present also. The epidote occurs disseminated throughout the monzonite, and as veins as much as half an inch wide. The monzonite is banded at some places, due to segregation of the hornblende and biotite. Serpentinization of parts of the monzonite was noted near faults.

*Dikes.* The dike rocks are diorite, aplite, and rhyolite. The diorite is dark gray to brownish gray and is finely granitoid. It is partly epidotized, and apparently it caused some epidotization of the monzonite that it cuts. The aplite is conspicuously white, due to the presence of white feldspar. The rhyolite is buff to light brown, and contains visible quartz and orthoclase.

#### Structure

The structure of the rocks is relatively simple. As a rule the limestone dips to the southwest. Dips range from  $15^{\circ}$  to  $65^{\circ}$  and decrease northward. The principal fault trends about N.  $45^{\circ}$  W., dips about  $70^{\circ}$  SW., and probably is a normal fault with the downthrown side to the southwest. The other faults trend nearly west.

### ORE DEPOSITS

#### Mineralogy

The ore minerals are chiefly magnetite and hematite, but limonite is present locally. The chief gangue minerals are calcite, serpentine, and pyrite; subordinate amounts of gypsum and copper-bearing minerals are sometimes present. Most of the ore contains only small amounts of gangue, but pyrite is abundant at a few places.

#### Distribution and Occurrence

The principal exposure of iron ore forms a northwest-trending oval area 700 feet long and 325 feet wide in the SW $\frac{1}{4}$  sec. 25 (Pl. IX). Smaller exposures trending nearly west are present near the quarter corner between secs. 25 and 36.

The principal orebody has a replacement contact with limestone to the east and south, but a fault contact with limestone to the north, and a fault contact with monzonite to the southwest (Pl. IX). The northwest edge of the orebody is covered by fanglomerate, but it appears likely that the faults along the north and the southwest sides of the body intersect and terminate the ore to the northwest.

The large orebody has been explored by 16 diamond-drill holes and 3 adits. Drill holes range in depth from 116.5 to 897 feet, and all but 4 of them went through iron ore into limestone. One vertical hole passed through 873 feet of iron ore. Two of the adits, about 2,500 feet and 1,400 feet long, passed along the central part of the body and were in ore for most of the distance. The third adit was in monzonite.

The smaller orebody is in contact with limestone except on the south, where it is in fault contact with monzonite. The extent of this orebody is unknown. It has been explored only by a few pits along the south side. Outcrops ranging in width from 5 to 40 feet are present in an area about 650 feet long (Pl. IX). Dip-needle observations show that there is a zone of magnetic attraction 75 to 125 feet wide and 800 feet long surrounding the iron-ore outcrops, although surface exposures in part of the magnetic zone are limestone. The magnetic attraction is highest near



the iron-ore outcrops (Pl. IX); it diminishes abruptly to the south and gradually to the north. It may reasonably be expected, from the distribution and intensity of magnetic attraction, that a body of iron ore about 700 feet long and 50 to 75 feet wide, probably dipping north, occurs in this area.

#### Chemical Composition

The average composition of the large orebody, based on surface, adit, and drill samples, follows:

| Fe    | P     | Mn   | SiO <sub>2</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO  | MgO  | S    | TiO <sub>2</sub> | Ign. loss |
|-------|-------|------|------------------|--------------------------------|------|------|------|------------------|-----------|
| 50.69 | 0.063 | 0.11 | 3.89             | 1.45                           | 6.30 | 5.18 | 1.19 | 0.20             | 8.60      |

The sulphur content varies considerably; the range shown by drill samples is from 0.011 to 3.77 percent. The sulphur content may be higher in the lower part of the orebody than in the upper part, but this relation is not definite or consistent, as is shown by the following table:

*Range of sulphur content shown by drill holes, Vulcan iron-ore deposit, sec. 25, T. 10 N., R. 13 E.*

| Depth from surface | Number of holes | Lowest S content | Highest S content | Average S content |
|--------------------|-----------------|------------------|-------------------|-------------------|
| 0-50               | 2               | 0.201            | 1.13              | 0.665             |
| 50-100             | 5               | 0.050            | 2.93              | 1.024             |
| 100-150            | 7               | 0.011            | 3.17              | 0.910             |
| 150-200            | 7               | 0.027            | 3.50              | 0.856             |
| 200-250            | 7               | 0.764            | 2.20              | 1.495             |
| 250-300            | 9               | 0.152            | 3.77              | 1.505             |

#### Origin

The orebodies were formed by replacement of limestone. Gradation of limestone into ore showing preservation of bedding and texture of the limestone occurs both at the large orebody and at the smaller one. The contact between the limestone and the monzonite, where it is not faulted, is obscure; but at several places the monzonite appears to intrude the limestone, and at one such contact a light-gray to white pyroxene and a greenish-black, fibrous mineral, possibly amphibole or anthophyllite, were noted, indicating that there had been some contact metamorphism. Serpentine is a characteristic constituent of the Vulcan orebodies, and could well have been formed by hydrothermal metamorphism during intrusion. Serpentine is associated with many of the contact-metamorphic iron-ore deposits of California where the intrusive rock is monzonite or granite. It is thought that the monzonite brought in the Vulcan ore, although the evidence is not clear.



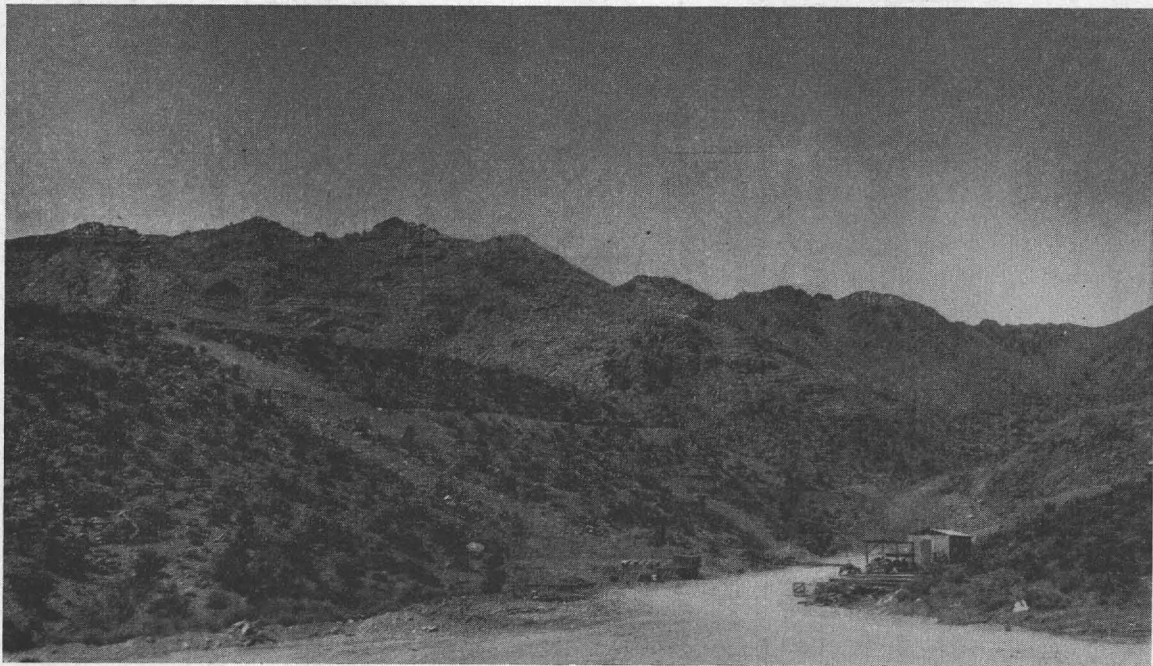


FIG. 31. Part of panorama of Vulcan iron-ore mine near Kelso, California. *Photo by E. F. Burchard, 1943.*

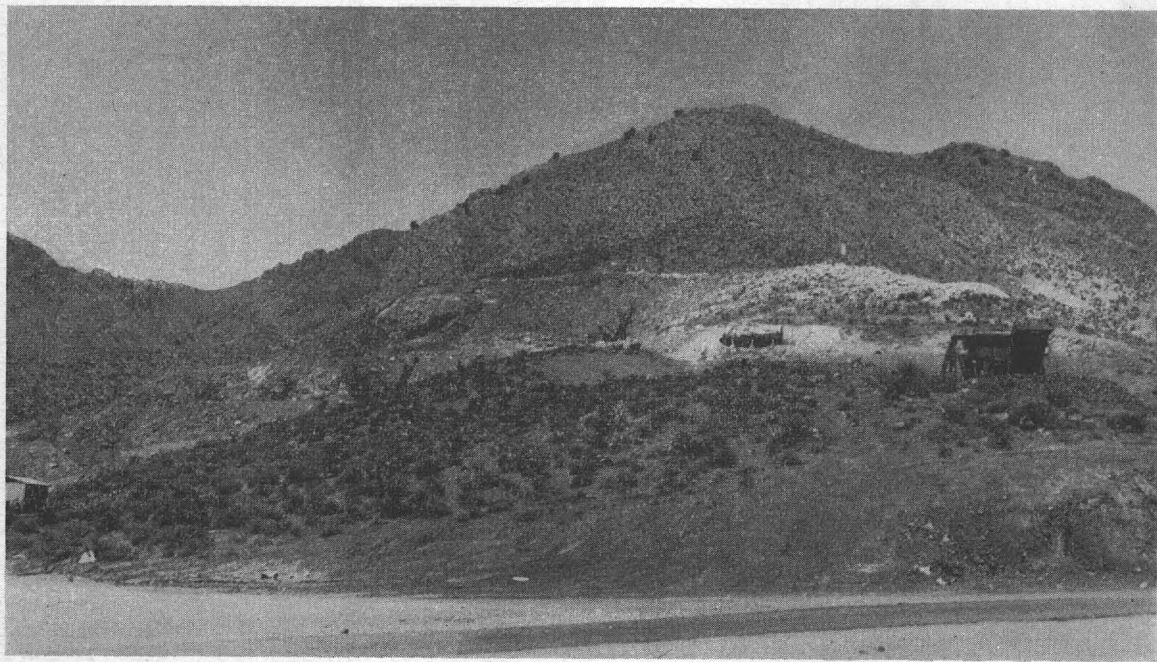


FIG. 32. Part of panorama of Vulcan iron-ore mine near Kelso, California. *Photo by E. F. Burchard, 1943.*

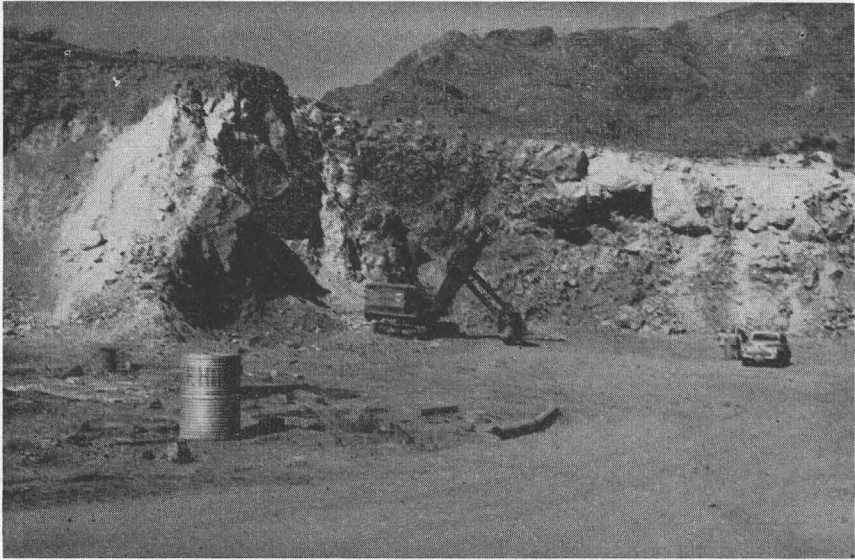


FIG. 33. A bench in open pit of Vulcan iron mine of Kaiser Company, Inc., near Kelso. Photo by Walter W. Bradley; reprinted from *California Journal of Mines and Geology*, vol. XXXIX, p. 472.

### RESERVES

The reserves contained in the large orebody are estimated to be 5,680,000 long tons of ore, using a tonnage factor of 10 cubic feet per long ton and deducting 10 percent for waste material. The reserves are subdivided into measured, indicated, and inferred ore, as follows:

|  |                     |
|--|---------------------|
| Measured ore .....   | 1,160,000 long tons |
| Indicated ore, in addition to measured ore.....              | 1,130,000 long tons |
| Inferred ore, in addition to measured and indicated ore..... | 3,390,000 long tons |

The measured ore is contained in three benches, from the top of the pit to the present floor. Exposure is continuous and there is no overburden.

Drill holes and adits indicate that almost continuous ore may reasonably be expected for 100 feet below the present pit floor, the distance to which it is planned to conduct open-pit mining. If so, there should be 1,130,000 long tons of ore in that part of the orebody.

It is inferred that there should be as much as 3,390,000 long tons of ore remaining below the depth to which it is planned to do open-pit mining. This estimate is based on the assumption that ore extends to a depth of 400 feet below the present pit floor, or nearly 600 feet below the uppermost bench. A vertical drill hole near the central part of the orebody shows 873 feet of ore.

In addition to the ore in the large body, it is inferred that there may be at least 315,000 long tons of ore in the smaller body, and there could well be several times this amount. An orebody 700 feet long, 50 feet wide, and 100 feet deep would yield 315,000 long tons of ore. The depth to which ore extends in the large body may well indicate a depth considerably greater than 100 feet in the smaller body.

## MINING

The ore is being mined by open-pit methods in 50-foot benches. The limit of open-pit mining will be reached after the extraction of ore from 5 benches. It is estimated that about 43 percent of the total amount of ore will be recovered in this manner. The remaining ore is considered not to be minable except at emergency prices, as it could be extracted only by underground methods.

The capacity of mine installations is 2,500 tons of ore daily. The ore is crushed to 10-inch size by a Traylor 42- by 48-inch Bulldog jaw crusher, and transported by conveyor belts to a storage bin and to trucks. It is shipped from Kelso, where a loading dock has been constructed.

Water is obtained from two springs about  $1\frac{1}{4}$  and  $1\frac{3}{8}$  miles southeast of the deposit and approximately 500 feet higher than the top of the chief orebody. It is conveyed by gravity through a 1-inch pipe. Water is also obtained from the Cornfield or Union Pacific Spring on the north slope of the Providence Mountains, about 3 miles by airline from the mine. It is piped from the Union Pacific Railroad reservoir 1 mile south of Kelso to a storage tank along the ore haulage road, and thence transported about 4 miles by truck.