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Bureau of Mines Information Circular/1971

Economic Evaluation of California-Nevada Iron Resources and Iron Ore Markets

UNITED STATES DEPARTMENT OF THE INTERIOR

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Information Circular 8511

Economic Evaluation of California-Nevada Iron Resources and Iron Ore Markets

By Lyman Moore

UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

BUREAU OF MINES
Elburt F. Osborn, Director

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ECONOMIC EVALUATION OF CALIFORNIA-NEVADA IRON RESOURCES AND IRON ORE MARKETS

by

Lyman Moore[1]

ABSTRACT

This Bureau of Mines report describes and evaluates iron ore resources in California and Nevada and analyzes the California and Japanese iron ore markets in which these resources will be used. The competitive position of California-Nevada ores, in these markets, was estimated by comparing regional iron ore prices, production costs, and transportation costs with those of foreign suppliers.

Resources were determined to be sufficient to produce the equivalent of 585 million tons of 64-percent iron pellets at a price of less than $15 per ton delivered at California ports. Much higher tonnage could be produced at higher prices.

Iron ore requirement of the California iron and steel industry will increase to an estimated 15.9 million tons by the year 2000. A study of the iron ore production potential of California-Nevada deposits and of out-of-State sources indicated that this ore requirement can be supplied most economically by California-Nevada ores.

Iron ore import requirements of the Japanese iron and steel industry will increase to an estimated 150.0 million tons by the year 2000. A study of price trends in this market indicated that very little California-Nevada iron ore will be sold in Japan after 1973 when existing sales contracts expire. Iron ore exports might be economically possible if ore could be transported from California to Japan at ballast rates as backhaul on existing petroleum shipping.

INTRODUCTION

This report, one of a series of Bureau of Mines publications on the Nation's mineral resources, presents information on the iron ore resources of California and Nevada and on present and potential markets for regional iron ores.

[1]Mining engineer, Intermountain Field Operation Center, Bureau of Mines, Denver, Colo.

All reported iron occurrences in California and Nevada were studied and inventoried. Information was compiled on the location, physical features, ownership, history, development, geology, resources, and mining environment of the principal deposits. Production costs of ore from each deposit were estimated and resources were grouped in cost-of-production classifications that provide an estimate of overall production potential of California-Nevada resources at various price levels. Cost data needed for evaluation were obtained by studying mining, milling, and pelletizing costs at existing mines. Factors were developed for estimating the relative effect of operating conditions such as plant size, stripping ratio, milling difficulty, and similar factors on overall costs. Mine-to-seaport transportation costs were added to production costs from each deposit to give the delivered price which was used for classification purposes.

Known resources were estimated to be sufficient to manufacture, at 1968 production costs, cumulative totals of the equivalent of 585 million tons of 64-percent iron pellets at a cost of less than \$15.00 per ton; 1,300 million tons at a cost of less than \$20.00 per ton; and 1,580 million tons at a cost of less than \$25.00 per ton.

In addition to chapters on iron ore occurrences in California and Nevada, the report contains chapters on the history and structure of the California steel industry, the California iron ore market, the Japanese iron ore market, and economic classification of California-Nevada iron ore resources.

Almost all of the iron ore produced in California and Nevada has been used in the California and Japanese iron and steel industries. Relatively small quantities are consumed locally in cement manufacture, are shipped to iron and steel plants in other States, or are used for miscellaneous purposes. No new markets for California-Nevada ore are expected to develop in the foreseeable future.

Of the two major markets for California and Nevada iron ore--California and Japan--the California market is the more important because producers are protected in it from foreign competition by a significant transportation differential. Iron ore consumption in California is not reported, but based on published steel shipments, scrap purchases, and iron ore grades, the 1967 ore consumption is estimated at about 3.1 million tons. The local iron ore market in 2000 was estimated to be the equivalent of 15.9 million tons of 64-percent iron pellets.

At present California blast furnaces are being supplied almost entirely by local mines but future furnaces will probably be built at seacoast sites which will reduce the transportation advantage that California-Nevada iron ore producers have over foreign suppliers and therefore make the latter sources more competitive. An analysis was made to estimate the extent of possible foreign market penetration by comparing the f.o.b. prices received by iron ore suppliers to Japanese steelmakers (including most potential California suppliers), plus their respective ocean shipping costs to California, with California seacoast prices. It was estimated that the 1968 California price of \$12.30 per ton of 64-percent iron pellets was \$1.90 per ton less than the indicated delivered price of the lowest cost foreign supplier.

The principal foreign iron deposits that supply the Japanese market also were studied to determine the ability of foreign shippers to make the price reductions necessary to allow them to enter the California market. The data indicated that substantial price cuts by some foreign suppliers were possible but that California producers should be able to lower production and shipping costs sufficiently to retain a competitive advantage.

Japanese crude steel production grew at a steady rate from about 9 million tons in 1954 to 52 million tons in 1966. Since Japan has relatively small iron resources, this has created a large overseas market for iron ore. Japanese imports were 45.1 million tons in 1966, and it is estimated that in 2000 imports will be at an annual rate of 150 million tons. Total imports from 1966 to 2000 are estimated at 4.2 billion tons.

Exports of iron ore to Japan by California-Nevada shippers in 1967 were about 3.6 million tons. After existing contracts expire between 1971 and 1973, iron ore export prices are expected to drop $3.10 to $4.50 per ton below 1967 prices, and iron ore pellet prices will be $1.90 per ton less. Consequently, by 1973 local producers will be unable to continue shipments to Japan unless counterbalancing economies can be made in production and transportation. It is not believed that large economies can be made in production but cost reductions of about the same magnitude as the indicated price reductions could probably be made in shipping charges if the ore could be transported in large combination ore-oil carriers as backhaul on ships bringing petroleum to California from Persian Gulf oil ports.

California-Nevada iron ore resources, producible at seacoast prices of less than the equivalent of $15.00 per ton for 64-percent iron ore pellets, are adequate to supply the local iron and steel industry and to continue exports to Japan at the present rate; however, they are too small to allow California-Nevada producers to increase exports to Japan significantly even if transportation costs are reduced.

ACKNOWLEDGMENTS

The author would like to thank all agencies, companies, and individuals who aided in this study and without whose help this report could not have been prepared.

The author is particularly indebted to geologists of the California Division of Mines and Geology and the Nevada Bureau of Mines and to the officers and staffs of Jackson Mountain Mining Co., J. R. Simplot Co., Kaiser Steel Corp., Minerals Materials Co., Nevada-Barth Co., Overseas Central Enterprises, Southern Pacific Co., Standard Slag Co., and to several consulting engineers including E. L. Stephenson, Donald Gene Fisher, Keith Meador, and others who are mentioned in the text and in the bibliographies.

CHAPTER 1.--CALIFORNIA STEEL INDUSTRY

The California steel industry is the main consumer of California and Nevada iron ore. This chapter describes the history, present position, and growth potential of this industry.

History

The first foundry in California was established in 1849 and the first steam forge and rolling mill in 1868. By 1930 the annual productive capacity of the California steel industry, using mostly scrap plus some out-of-State pig iron, had grown to more than 700,000 tons per year and by 1945 it was 1,940,820 tons,[2] distributed as shown in table 1.

TABLE 1. - California steelmaking capacity in 1930, 1938, and 1945

(Tons of crude steel per year)

Company or plant	1930	1938	1945
Kaiser Steel Corp.: Fontana plant.........	-	-	750,000
Columbia Steel Co.:			
Pittsburg plant..........................	192,000	290,000	416,600
Torrance plant..........................	171,000	204,000	211,000
Pacific Coast Steel Corp.:			
South San Francisco plant..............	155,000	174,000	235,000
Los Angeles plant......................	85,000	95,000	117,000
Pacific States Steel Co..................	-	-	88,820
Judson Steel Co..........................	60,000	86,000	76,500
National Supply Co.......................	15,000	([1])	45,900
Warman Steel Casting Co..................	10,000	-	-
Southern Pacific Railroad Co.............	12,500	-	-
Enterprise Foundry.......................	11,200	-	-
Total..................................	711,700	849,000	1,940,820

[1]Not reported.

Source: American Iron and Steel Institute. Directories of Iron and Steel Works of the United States and Canada. 1930, 1938, 1945.

Following the outbreak of war in Europe in 1939, a strong demand for steel developed on the west coast of the United States, mainly for use in

[2]Weight of steel, iron, and pig iron are reported in the United States as short or net tons (2,000 pounds). In foreign countries metric and long tons are used. For ease of comparison all steel, iron, and pig iron tonnages in this report are in short tons.

shipbuilding and heavy construction. This demand was met by (1) construction of a primary steel plant at Fontana, Calif., by the newly organized Kaiser steel Corp., aided by a loan from the Reconstruction Finance Corp. (RFC) and (2) by construction of the Geneva Steel Co. plant in Utah by the RFC.

At the end of World War II steel plants in California and neighboring States had an ingot capacity much higher than prewar levels, but the wartime-installed finishing mills were capable of producing only heavy plate, structural shapes, and bars, whereas much of the peacetime consumer demand was for sheet, tin plate, light structural shapes, and bars. The postwar market was much larger than the prewar market because of the rapid population growth in California and surrounding States. To supply this market, area steelmakers adapted the war-created plants to peacetime uses.

Kaiser Steel Corp. installed new mills at Fontana to produce sheet, structural shapes, pipe, tin plate, and other consumer items, and in November 1948 initiated iron ore production from its Eagle Mountain, Calif., property. This property, with several enlargements, has provided all the company's iron ore needs, as well as substantial tonnages for export sales. After the war, United States Steel Corp. purchased the Government-owned Geneva Steel Co. plant in Utah, combined it with its Columbia Steel subsidiary, and built new finishing mills to produce sheet, structural shapes, and pipe. Coils of sheet and billets from the Utah plant were shipped to California for final processing into thinner sheet, tin plate, galvanized sheet, and other consumer shapes. California steel plant capacity increased to 2,071,800 net tons in 1948 and to 3,280,000 tons by 1956. Open-hearth furnaces in operation in California in 1956 included: Kaiser Steel Corp., nine at Fontana; Columbia Geneva Steel Co., five at Pittsburg and four at Torrance; Bethlehem Pacific Coast Steel Corp., five at South San Francisco; Pacific States Steel Corp., three at Niles; and Judson Steel Co., three at Emeryville. Electric furnaces in operation included: Bethlehem Pacific Coast Steel Corp., three at Los Angeles; National Supply Co., three at Torrance; Southwest Rolling Mills, Inc., one at Los Angeles.

By 1959, Kaiser Steel Corp. had four blast furnaces, three oxygen steelmaking furnaces, a 126-inch plate mill, an 86-inch hot-strip mill, and other facilities, at Fontana. The company's blast-furnace capacity had risen to 1,997,000 tons and its ingot capacity to 2,933,000 tons per year.

The ingot capacity of California steel plants in 1960 had increased to 4,856,500 tons. The distribution of this steelmaking capacity is shown in table 2. An additional annual capacity of about 900,000 tons of steel in the form of hot-rolled billets and coils was available from the Geneva steel plant in Utah. The semifinished products were shipped as required to California rolling mills. Plant capacity figures have not been published since 1960.

The 1967 inventory of production equipment at steelmaking plants in California is summarized in table 3. The locations of area plants are shown in figure 1.

TABLE 2. - California steelmaking capacity in 1960

(Short tons)

Company	Open hearth	Basic oxygen	Electric	Total
Kaiser Steel Corp......................	1,493,000	1,440,000	-	2,933,000
United States Steel Corp:				
Pittsburg plant......................	380,000	-	-	380,000
Torrance plant......................	237,000	-	-	237,000
Bethlehem Pacific Coast Steel Corp.:				
South San Francisco plant...........	276,000	-	-	276,000
Los Angeles plant....................	-	-	478,000	478,000
Pacific States Steel Corp............	265,000	-	-	265,000
Judson Steel Co......................	76,500	-	-	76,500
National Supply Co...................	-	-	50,000	50,000
Southwest Steel Rolling Mills, Inc.....	-	-	100,000	100,000
Soule Steel Co.......................	-	-	36,000	36,000
Etiwanda Steel Producers Inc..........	-	-	25,000	25,000
Total............................	2,727,500	1,440,000	689,000	4,856,500

Source: American Iron and Steel Institute, Directory of Iron and Steel Works of the United States and Canada. 1960.

TABLE 3. - Inventory of production equipment at steelmaking plants in California in 1967

Plant	Number of installations											
	Blast furnaces	Open-hearth furnaces	Basic-oxygen furnaces	Electric furnaces	Coke ovens	Plate mill	Structural mill	Pipe mill	Cold-roll mill	Tin-plate mill	Bar mill	Nail, bolt, mill
Kaiser Steel Corp: Fontana plant......	4	9	3	-	315	Yes	Yes	Yes	Yes	Yes	Yes	No
U.S. Steel Corp:												
Pittsburgh plant...................	-	-	-	-	-	No	No	Yes	Yes	Yes	Yes	Yes
Torrance plant.....................	-	4	-	-	-	No	Yes	No	No	No	Yes	No
Bethlehem Pacific Coast Steel Corp:												
South San Francisco plant...........	-	-	-	-	-	No	Yes	No	No	No	Yes	Yes
Los Angeles plant..................	-	-	-	2	-	No	No	No	No	No	Yes	Yes
Pacific States Steel Corp: Niles plant	-	4	-	-	-	No	No	No	No	No	Yes	No
Judson Steel Co: Emeryville plant.....	-	3	-	-	-	No	No	No	No	No	Yes	No
National Supply Co: Los Angeles plant.	-	-	-	2	-	No	No	No	No	No	No	No
Southwest Steel Rolling Mills Inc: Los Angeles plant.....................	-	-	-	2	-	No	No	No	No	No	Yes	No
Soule Steel Co: Los Angeles plant.....	-	-	-	1	-	No	No	No	No	No	No	No
Etiwanda Steel Products Inc: Etiwanda plant..........................	-	-	-	1	-	No	No	No	No	No	No	No
Total............................	4	20	3	8	315							

Source: American Iron and Steel Institute, Directory of Iron and Steel Works of the United States and Canada. 1967.

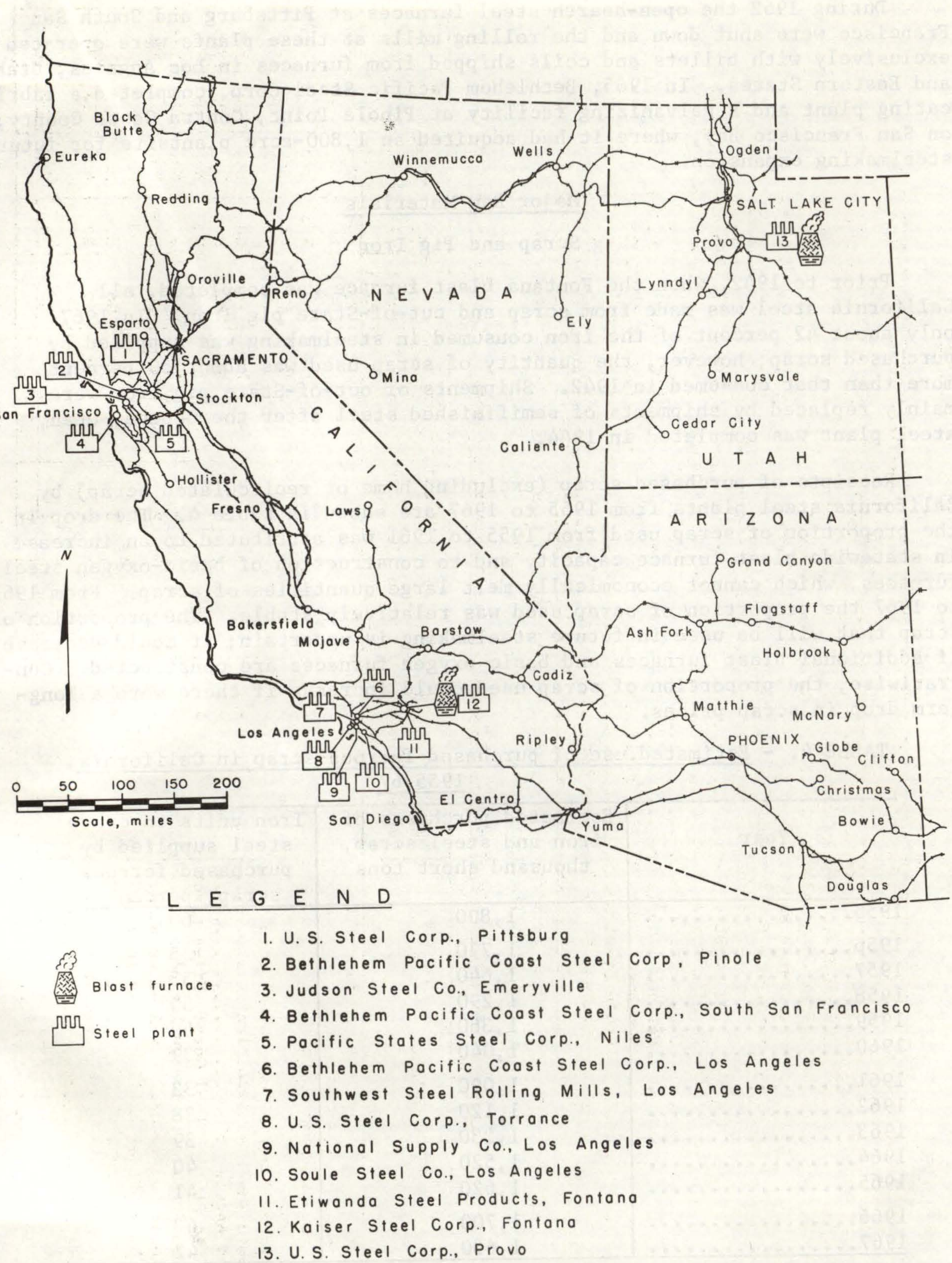

FIGURE 1. - Location of Blast Furnaces and Steel Plants in Southwestern United States.

During 1962 the open-hearth steel furnaces at Pittsburg and South San Francisco were shut down and the rolling mills at these plants were operated exclusively with billets and coils shipped from furnaces in Los Angeles, Utah, and Eastern States. In 1965, Bethlehem Pacific Steel Corp. completed a fabricating plant and a galvanizing facility at Pinole Point, Contra Costa County, on San Francisco Bay, where it had acquired an 1,800-acre plantsite for future steelmaking expansion.

Major Raw Materials

Scrap and Pig Iron

Prior to 1942, when the Fontana blast furnace was completed, all California steel was made from scrap and out-of-State pig iron. In 1967 only about 42 percent of the iron consumed in steelmaking was supplied by purchased scrap; however, the quantity of scrap used was about 50 percent more than that consumed in 1942. Shipments of out-of-State pig iron were mainly replaced by shipments of semifinished steel after the Geneva, Utah, steel plant was completed in 1944.

Receipts of purchased scrap (excluding home or recirculated scrap) by California steel plants from 1955 to 1967 are shown in table 4. The drop in the proportion of scrap used from 1955 to 1961 was attributed to an increase in statewide blast furnace capacity and to construction of basic-oxygen steel furnaces, which cannot economically melt large quantities of scrap. From 1961 to 1967 the proportion of scrap used was relatively stable. The proportion of scrap that will be used in future steelmaking is uncertain; it could decrease if additional blast furnaces and basic-oxygen furnaces are constructed. Contrariwise, the proportion of scrap used could increase if there were a long-term drop in scrap prices.

TABLE 4. - Estimated use of purchased ferrous scrap in California, 1955-67

Year	Estimated purchases of iron and steel scrap, thousand short tons	Iron units in crude steel supplied by purchased ferrous scrap, percent
1955.................	1,800	60
1956.................	1,770	55
1957.................	1,640	53
1958.................	1,290	50
1959.................	1,360	50
1960.................	1,040	39
1961.................	1,090	33
1962.................	1,120	38
1963.................	1,230	39
1964.................	1,520	40
1965.................	1,620	41
1966.................	1,700	43
1967.................	1,630	42

Source: Bureau of Mines. Minerals Yearbooks.

Factors that might cause lower prices include:

1. Decline in export demand due to completion of scheduled foreign blast furnace construction;

2. More complete salvage of scrap resulting from greater emphasis on the environment and on conservation of natural resources.

Iron Ore

About 58 percent of the steel produced in California in 1967 was made from iron ore, nearly all of which was mined in Southern California. Iron deposits in California and Nevada are described in some detail in chapters 5 and 6 of this report.

Coal

Coking coal does not occur in California or Nevada. Coal is the only major steelmaking ingredient that must be obtained from out-of-State sources. Fair to excellent grade coking coal is available from fields in central Utah, northeastern New Mexico, west-central Colorado, the Appalachian States, and southeastern British Columbia. Because of high transportation charges, coal costs are greater in California than in most steel-producing areas.

Steel Consumption

An estimate of future California steel marketing area[3] steel mill-product consumption is essential for estimating future iron ore consumption because about 89 percent of pig iron produced is used in steel mill products.

Yearly estimates of consumption of steel mill products in California and in the California steel marketing area have been published since 1952 by Kaiser Steel Corp. which conducts an annual areawide poll of consumers of steel mill products. During 1952-67 receipts in California increased from 4,279,000 to 6,514,000 tons (table 5), a compound growth rate of 2.9 percent. Receipts in the California steel marketing area increased from 5,347,000 to 8,455,000 tons (table 6), a compound growth rate of 3.1 percent. In 1967 per capita receipts of steel mill products in California were 680 pounds and in the California steel marketing area 600 pounds compared with the national average of 950 pounds.

The relatively low per capita rate of consumption of steel mill products in California and neighboring States is a result of their late period of settlement and extremely high recent population growths. Eventually, a much larger proportion of the steel-containing products consumed in the California area will be made in area plants to save transportation costs on finished products. This will substantially enlarge the California market for steel mill products.

[3] The California steel marketing area includes the States of Arizona, California, Idaho, Nevada, Oregon, Utah, and Washington. California steel shipments outside these States are limited by transportation cost differentials.

TABLE 5. - Receipts of steel mill products in California, 1952-67

(Thousand short tons)

Year	Plate	Structural shapes	Concrete reinforcing	Sheet and strip	Pipe	Tin plate	All other products	Total receipts
1952.........	769	295	306	787	396	703	1,023	4,279
1953.........	901	366	260	966	404	733	1,062	4,692
1954.........	588	294	243	780	295	732	1,028	3,960
1955.........	579	321	292	1,008	412	860	1,174	4,646
1956.........	639	409	390	1,062	365	922	1,123	4,910
1957.........	880	460	403	950	342	890	1,125	5,050
1958.........	653	247	400	891	256	950	809	4,206
1959.........	659	286	429	1,032	332	940	1,022	4,700
1960.........	658	312	370	1,097	320	905	944	4,606
1961.........	457	287	450	1,053	485	943	937	4,612
1962.........	432	327	453	1,085	440	949	1,114	4,800
1963.........	519	321	500	1,279	484	1,016	1,186	5,305
1964.........	578	382	575	1,299	514	1,067	1,340	5,755
1965.........	639	478	589	1,427	573	1,163	1,492	6,361
1966.........	707	480	676	1,626	628	1,039	1,473	6,629
1967.........	656	490	634	1,666	506	1,168	1,394	6,514

Source: Western Steel Market. Kaiser Steel Corp. Annual issues.

TABLE 6. - Receipts of steel mill products in California steel-marketing area, 1951-67

(Thousand short tons)

Year	Plate	Structural shapes	Concrete reinforcing	Sheet and strip	Pipe	Tin plate	All other products	Total receipts
1936-40[1]......	150	185	120	285	212	399	779	2,130
1951.........	1,155	468	461	925	453	876	1,702	6,040
1952.........	939	414	457	869	475	867	1,326	5,347
1953.........	1,108	544	396	1,126	530	895	1,480	6,079
1954.........	748	440	396	943	392	894	1,337	5,150
1955.........	921	477	469	1,224	572	1,061	1,576	6,300
1956.........	1,043	594	560	1,295	557	1,150	1,520	6,719
1957.........	1,333	702	560	1,144	503	1,100	1,455	6,797
1958.........	925	400	550	1,065	360	1,150	1,090	5,540
1959.........	936	460	600	1,257	470	1,120	1,373	6,216
1960.........	1,095	495	580	1,360	440	1,040	1,260	6,270
1961.........	700	455	670	1,302	830	1,053	1,238	6,248
1962.........	675	485	663	1,330	637	1,040	1,480	6,310
1963.........	785	510	720	1,560	670	1,130	1,600	6,975
1964.........	945	581	815	1,548	715	1,169	1,727	7,500
1965.........	1,045	740	908	1,733	793	1,280	2,001	8,500
1966.........	1,082	757	1,035	1,905	879	1,153	2,048	8,859
1967.........	976	739	913	1,992	696	1,290	1,849	8,455

[1] Average.

Source: Western Steel Market. Kaiser Steel Corp. Annual issues.

An estimate of this potential market for steel mill products is required before an estimate of the potential iron ore market can be made. The size of the potential market for steel mill products depends on the quantity of steel contained in products consumed in the California marketing area and on the proportion of steel-containing products consumed in the California area that are manufactured in the California area. Final steel consumption in the California steel-marketing area is not definitely known because no record is kept of the tonnage of steel shipped in and out of the area in manufactured goods. However, an estimate can be made based on reported nationwide steel consumption and on the reported personal income of the entire United States and of the California steel-marketing area.

The estimate assumes that consumption of steel-containing products is proportional to personal income. This assumption was judged by the author to be approximately correct for consumer goods such as automobiles, residences, appliances, containers, and for steel consumed by mercantile and service industries. Steel uses, such as industrial, construction, and agricultural machinery, industrial buildings, transportation equipment, and long-distance transportation networks are not directly related to personal income. However, a comparison of nationwide and areawide receipts of steel mill products that are used mainly in industrial equipment, agriculture, and heavy construction showed that their consumption, nationwide and areawide, has been approximately proportional to respective personal incomes. The California marketing area consumes steel at a rate higher than that for the national average for agricultural and construction machinery and for long-distance transportation networks, but this is balanced by lower consumption of steel in industrial machinery.

Estimates of future final steel consumption, needed to predict potential future iron ore consumption, were made similarly to those of past final steel consumption. Predictions, by U.S. Government agencies, of future national steel consumption and of future national and California steel-marketing area personal incomes were used.

The proportion of steel-containing products consumed in the California marketing area that will be manufactured in the California area in the future is difficult to estimate because available historical data do not establish a trend upon which a prediction can be based. Thus, only an approximate estimate of future growth is possible. To develop a working estimate three alternative assumptions were analyzed: (1) Assume a development in the California marketing area by the year 2000 of industrial capacity which will supply 100 percent of the California marketing area demand for steel-containing items; (2) assume a development of areawide industrial capacity by the year 2000 that will supply 50 percent of the steel-containing items that would otherwide be shipped into the area; and (3) assume no development in the California marketing area of facilities to manufacture steel-containing items that are now being shipped into the area. Estimates for each of the alternatives are shown on figures 2 and 3.

The second alternative (50-percent development of new industry) is considered by the author to be the best estimate possible and is used to make

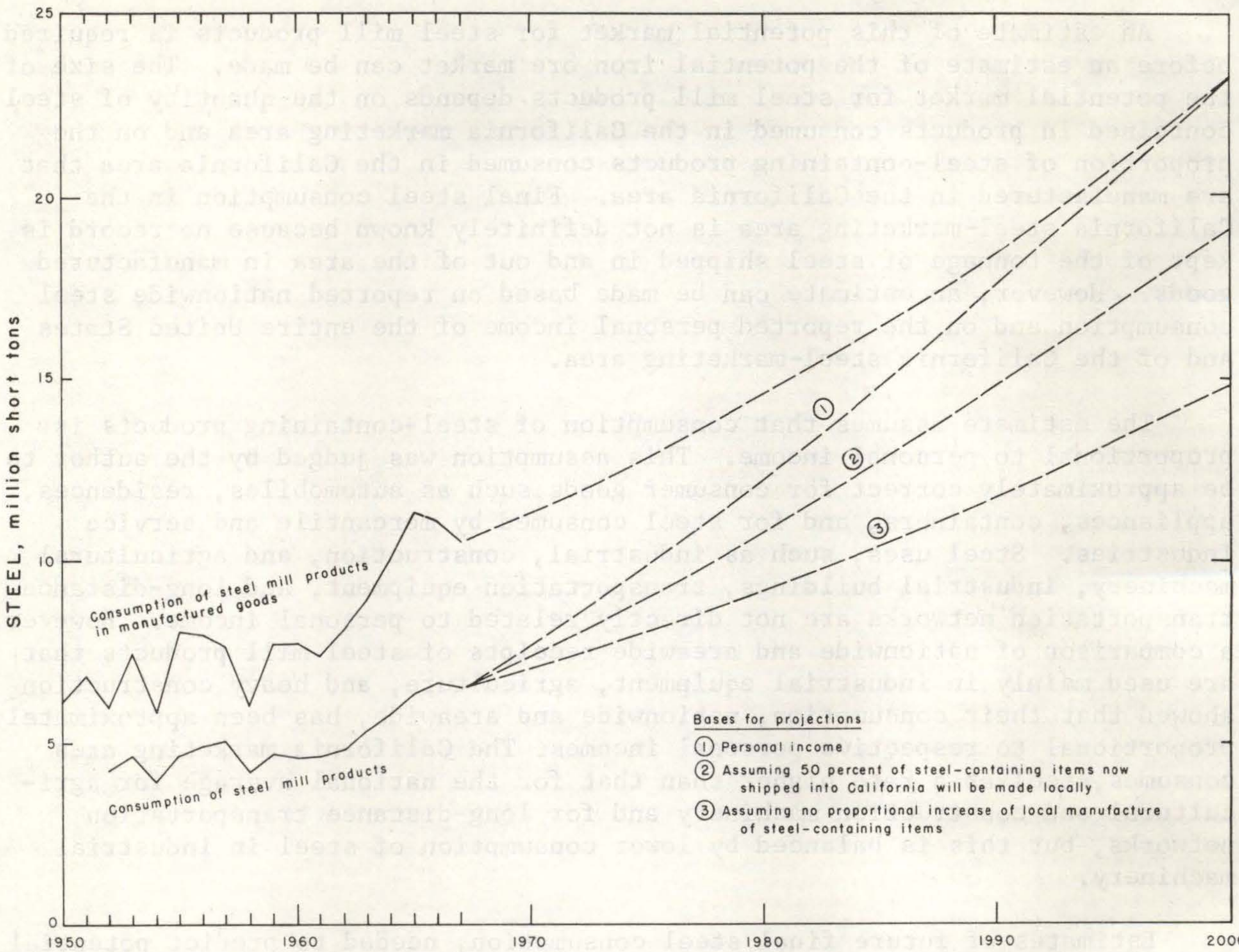

FIGURE 2. - Estimated Consumption of Steel Mill Products in California 1950-67 and Projected Consumption to Year 2000.

the working estimate of consumption of steel mill products needed to evaluate the future market for iron ore in California. The estimated consumption of steel mill products in California for 1970 is 7.4 million tons; 1980, 10.7 million tons; 1990, 14.8 million tons; and 2000, 19.0 million tons. The equivalent figures for the California steel marketing area are for 1970, 9.7 million tons; 1980, 14.5 million tons; 1990, 20.1 million tons; and 2000, 26.3 million tons.

Steel Supplies

The market for steel mill products in California is now being supplied by imports from foreign countries, by shipments from plants in eastern and neighboring States, by shipments of semifinished steel from other States, and by production of California mills. In 1967, about 60 percent of the finished steel consumed in the California marketing area was either shipped from States other than California or imported from foreign countries.

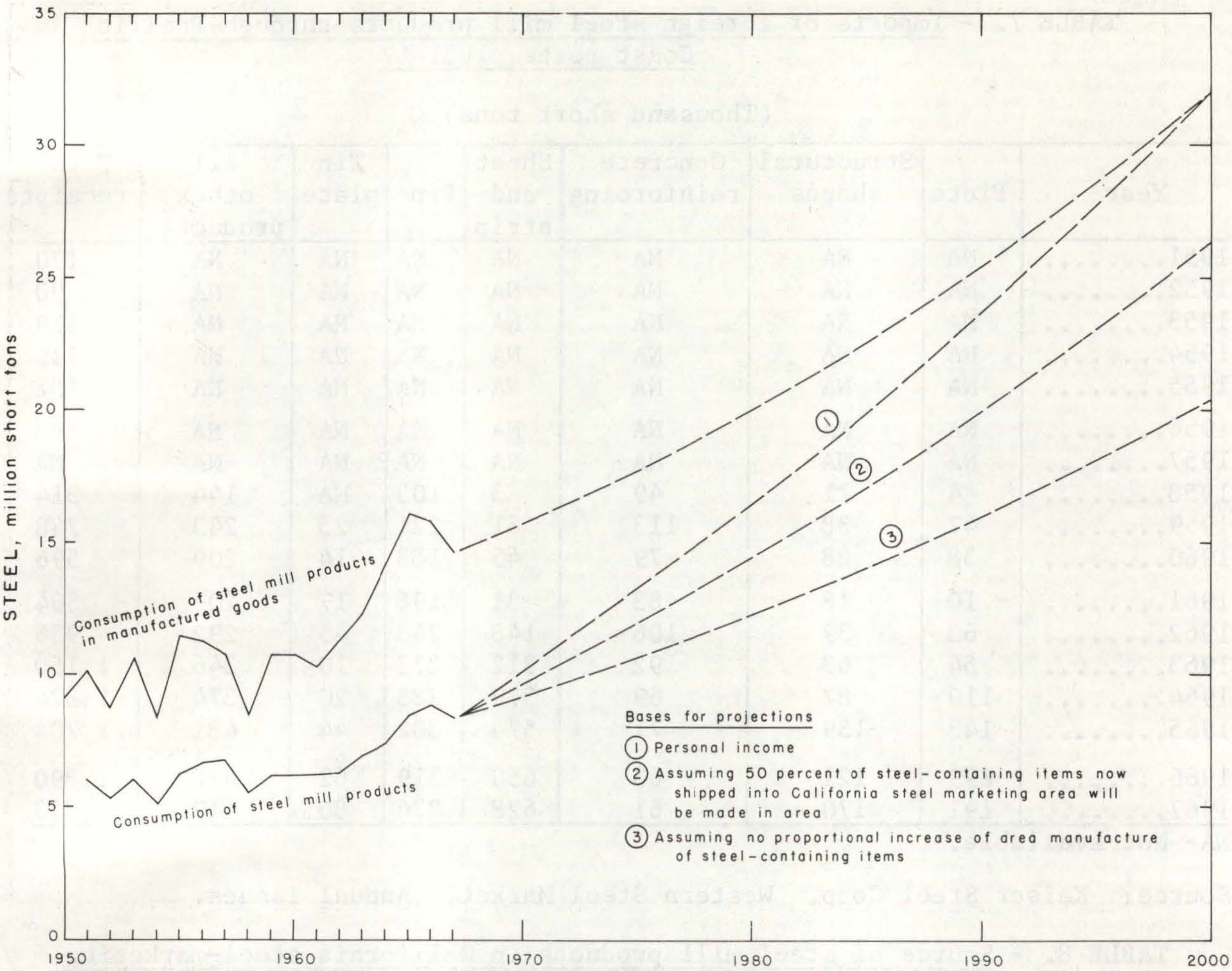

FIGURE 3. - Estimated Consumption of Steel Mill Products in California Steel-Marketing Area 1950-67 and Projected Consumption to Year 2000.

Imports

Prior to 1958, steel imports supplied about 2 percent of the western steel market. Development of a modern steel industry in postwar Japan resulted in additional competition for California steelmakers. Imports, mainly from Japan, were 314,000 net tons in 1958 and increased to 1,823,000 tons in 1967 (tables 7 and 8), a quantity equal to about 22 percent of the total California market. Imports now include most steel mill products.

The future level of steel imports depends upon political as well as economic factors and a prediction of future imports based on their present rate of increase is not justified. In this report it is assumed that foreign imports will continue to provide their present 22 percent of the California market.

TABLE 7. - Imports of foreign steel mill products through Pacific Coast ports, 1951-67

(Thousand short tons)

Year	Plate	Structural shapes	Concrete reinforcing	Sheet and strip	Pipe	Tin plate	All other products	Total receipts
1951........	NA	NA	NA	NA	NA	NA	NA	170
1952........	NA	NA	NA	NA	NA	NA	NA	90
1953........	NA	NA	NA	NA	NA	NA	NA	119
1954........	NA	NA	NA	NA	NA	NA	NA	119
1955........	NA	NA	NA	NA	NA	NA	NA	152
1956........	NA	NA	NA	NA	NA	NA	NA	168
1957........	NA	NA	NA	NA	NA	NA	NA	NA
1958........	4	11	49	3	103	NA	144	314
1959........	47	38	113	61	221	25	243	748
1960........	38	28	79	45	183	14	209	596
1961........	10	18	83	31	198	17	207	564
1962........	63	39	106	148	243	45	292	936
1963........	54	63	92	312	273	10	346	1,150
1964........	110	87	69	379	285	20	374	1,324
1965........	143	139	71	574	302	44	431	1,704
1966........	199	121	63	650	319	62	476	1,890
1967........	191	170	61	628	274	80	419	1,823

NA--Not available.

Source: Kaiser Steel Corp. Western Steel Market. Annual issues.

TABLE 8. - Source of steel mill products in California steel-marketing area by location of suppliers, 1958-67

(Thousand short tons)

Year	Estimated Western U.S. steel mill shipments[1]	Estimated shipments from Eastern U.S. steel mills[1]	Imports from foreign steel mills	Seven-State steel receipts
1958........	3,134	2,092	314	5,540
1959........	3,624	1,844	748	6,216
1960........	3,651	2,023	596	6,270
1961........	3,691	1,993	564	6,248
1962........	3,628	1,746	936	6,310
1963........	4,011	1,814	1,150	6,975
1964........	4,313	1,863	1,324	7,500
1965........	4,888	1,908	1,704	8,500
1966........	5,094	1,875	1,890	8,859
1967........	4,942	1,690	1,823	8,455

[1] Estimates based on information supplied by Kaiser Steel Corp.

Source: Kaiser Steel Corp. Western Steel Market. Annual issues.

Shipments From Mills in Eastern States

Shipments of finished steel from producers in other areas, principally the Eastern United States, have dropped from 2,090,000 tons in 1958 to 1,690,000 tons in 1967, an average annual decrease of over 2.0 percent; the market share of shipments from these areas dropped from 38 percent in 1958 to 20 percent in 1967. Shipments from outside the California marketing area are expected to continue their present slow decline (tables 8 and 9).

TABLE 9. - Estimated source of steel mill products in California steel-marketing area by location of suppliers, 1967-2000

(Thousand short tons)

Year	Shipments from California mills	Shipments from Oregon, Utah, and Washington mills	Shipments from Eastern States	Imports from foreign countries	Total receipts of steel mill products
1967..........	[1]3,400	1,542	1,690	1,823	8,455
1970..........	[1]4,300	1,700	1,600	2,100	9,700
1980..........	[1]7,100	2,800	1,400	3,200	14,500
1990..........	10,400	4,200	1,200	4,300	20,100
2000..........	14,100	5,400	1,000	5,800	26,300

[1] Includes products made from out-of-State semifinished steel.

West coast steel prices exceeded east coast prices by about $10.00 per ton until 1962 because of added shipping costs. Since then, eastern producers have absorbed this expense, thus terminating the price differential. Direct production costs are about the same in California as in the Eastern States. Raw materials cost less in California but other production costs are higher than in the East because of the smaller size of California plants. The extra freight and inventory costs now charged to out-of-State shipments presently are balanced by low capital costs due to excess capacity in eastern mills. When this, now surplus, capacity is needed to supply nearby markets, shipments to the west coast will be phased out and new capacity will be constructed in California.

Shipments From Mills in Oregon, Utah, and Washington

Much of the demand for steel mill products in the seven-State California marketing area is supplied by mills in Oregon, Utah, and Washington. Steel mill products from these plants are marketed in the same area as are products from California mills, but these plants purchase only small quantities of California and Nevada iron ores.

In 1968 none of the Oregon and Washington plants have blast furnaces although a plant to produce prereduced pellets for electric furnace use is under construction. The steel plants now use scrap, much of which comes from California, and use billets that are formed in California. Blast furnaces in Utah are mainly supplied from mines near Iron Springs, Utah, and Atlantic City, Wyo. It is unlikely that important production will be shifted from these sources to mines in California or Nevada.

The quantity of steel mill products shipped by plants in Oregon, Utah, and Washington is not reported, but an estimate can be made on the basis of reported consumption of pig iron and scrap and on published plant capacities. On this basis it is estimated that about 62 percent of the crude steel made in the seven-State area during 1958-67 was made in California furnaces. The proportion of steel mill products made was about 70 percent, because of a net importation of semifinished steel by California steel plants.

Some variation has existed in recent years in the market division between California and other marketing-area plants. However, this was not the result of long-term trends but rather the result of variations in the demand for specific products such as heavy structural shapes and large-diameter pipes, for which some plants have large manufacturing capacities.

In the short run, the market division between plants in various districts in the area is expected to remain in its present proportion. Over the long run, California plants will increase their share of the market. New area capacity most logically would be located close to the main markets, which are in California. Small direct iron ore reduction furnaces and electric steel furnaces may also be installed to satisfy local demand for iron and steel products.

By the year 2000 it is expected that the steel production from the plants in the seven Western States will be divided approximately in proportion to the personal income of the population in individual marketing areas. California plants would then make 72 percent of the area's production of crude steel and of steel mill products (tables 8 and 9).

Shipments of Semifinished Steel From Out-of-State Mills

In 1967 an estimated one-twelfth (280,000 tons) of California's production of steel mill products was rolled from billets and coils imported from other States. This volume was partly balanced by shipments of billets from California plants to mills in other west coast States for finishing. The procedure is strictly an intracompany operation resulting from the obsolescence of some furnaces at the same time that an excess capacity is available in other company plants. Economics frequently dictate that it is less costly to operate existing plants at higher rates and absorb $10 to $15 per ton in freight and handling charges on the increased production than to build new plants that would have to be operated below capacity with consequent lower efficiency. A significant difference exists in unit costs between a plant operated at a low rate (60 percent of capacity or less) and at full capacity. This applies to most industries, but large steel companies with several plants making the same product with the same sequence of production operations are particularly favorably situated to increase efficiency by concentrating specific operations at certain plants, thus allowing less efficient sections of other plants to be completely closed.

This operational factor is currently reducing California's production of crude steel, but it is a temporary condition. When countrywide steelmaking capacity is more fully utilized, west coast furnaces probably will be built

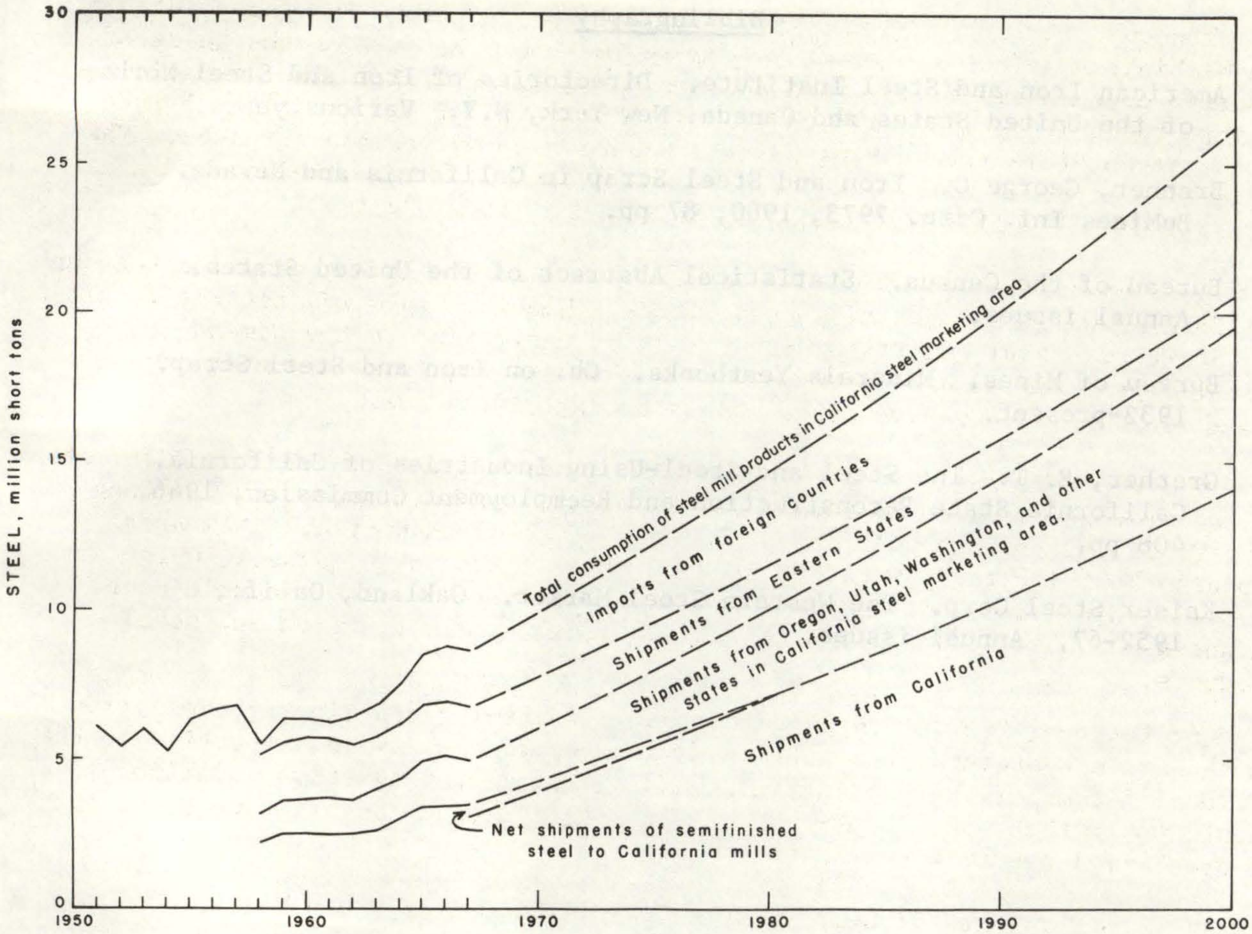

FIGURE 4. - Sources of Steel Mill Products in the California Steel-Marketing Area by Location of Suppliers 1958-67 and Estimated Source to Year 2000.

to reduce transportation and handling charges. Receipts of semifinished steel are assumed to be phased out during the next 15 years, for this study.

Shipments From California Mills

Historical shipments are shown in table 8 and figure 4; the estimated future shipments are shown in table 9 and figure 4. The tonnage of steel mill products that will be made in California, exclusive of that made from out-of-State semifinished steel, is estimated as follows: 1970, 4.1 million tons; 1980, 7.1 million tons; 1990, 10.4 million tons; and 2000, 14.1 million tons.

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CHAPTER 2.--CALIFORNIA IRON ORE MARKET

Iron ore consumption in California was of minor importance before 1942, when the Kaiser Steel Corp. Fontana steel plant was built. Several plant enlargements in subsequent years have raised iron ore consumption to a high level, and the rapid growth of population and personal income in the California marketing area promises a much larger future demand. Information on iron ore consumption has not been published since 1956, but based on published steel shipments, scrap purchases, and iron ore grades, the 1967 ore consumption is estimated at about 3.1 million long tons.[4] Existing furnace capacity requires the equivalent of about 3,200,000 long tons of 64-percent iron ore for full-scale operations. About 91 percent of the pig iron produced by blast furnaces is used in steelmaking; almost all of the remainder is used in castings. Open-hearth furnacing, cement manufacture, and miscellaneous uses require an additional 200,000 tons of iron ore annually.

Requirements of California Steel Industry

The estimated production of 14.1 million tons of steel mill products in California in the year 2000 will require an equivalent quantity of iron-supplying material. Figure 5 shows the present and estimated future sources of iron.

Assuming that scrap and iron ores maintain their 1967 shares of the area steelmaking market (table 4), it is estimated that in 1970 the demand for iron ore in the California steel industry, expressed as 64-percent iron-ore pellets, will be 4.0 million long tons; in 1980, it will be 6.9 million tons; in 1990, 10.2 million tons; and in 2000, 14.2 million tons. The total quantity required from 1969 to 2000 will be 269 million tons. These figures are based on nationwide steelmaking statistics which show that the equivalent of about 1.7 long tons of 64-percent iron pellets is needed to produce a short ton of steel mill products. Statistics are not reported separately for California plants but probably their consumption rates are similar.

About 9 percent of the pig iron is used for castings (table 10), and about 2 percent of steel is used for castings and forgings. Incomplete data on shipments and receipts indicate that these products have a growth pattern similar to that of steel mill products. Based on this, the consumption of iron ore for cast and forged products in 1970 is estimated as 0.5 million tons of 64-percent iron pellets; in 1980, 0.9 million tons; in 1990, 1.3 million tons; and in 2000, 1.7 million tons. The total quantity required from 1969 to 2000 is estimated at 33 million tons.

Total iron ore required for all iron and steel industry products in the California area, expressed as 64-percent iron pellets, is estimated as follows: in 1970, 4.5 million tons; in 1980, 7.8 million tons; in 1990, 11.5 million tons; and in 2000, 15.9 million tons. The total quantity required from 1969 to 2000 will be 302 million tons.

Sources of Iron Ore

Abundant iron ore resources, described later in this report, occur in California and Nevada. Resources also occur in neighboring States and in many foreign countries within possible economic shipping distance.

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[4] The long ton is used to express iron ore quantities in the United States. Both long tons and metric tons are used in foreign countries. For ease of comparison all iron ore tonnages in this report are expressed in long tons.

TABLE 10. - Consumption of pig iron in California for castings

(Thousand short tons)

Year	Pig iron	Year	Pig iron	Year	Pig iron	Year	Pig iron
1951	182	1956	188	1961	452	1966	208
1952	189	1957	169	1962	218	1967	197
1953	161	1958	161	1963	181		
1954	155	1959	208	1964	201		
1955	197	1960	310	1965	208		

Source: Bureau of Mines. Minerals Yearbooks. Ch. on California. 1951-67.

California's only primary steel plant is 70 miles from tidewater and the transportation costs of iron ore and coal from overseas shippers to the plant are relatively high. New plants will be built on harbors, and transportation costs to these plants from foreign or coastal ports will be much lower.

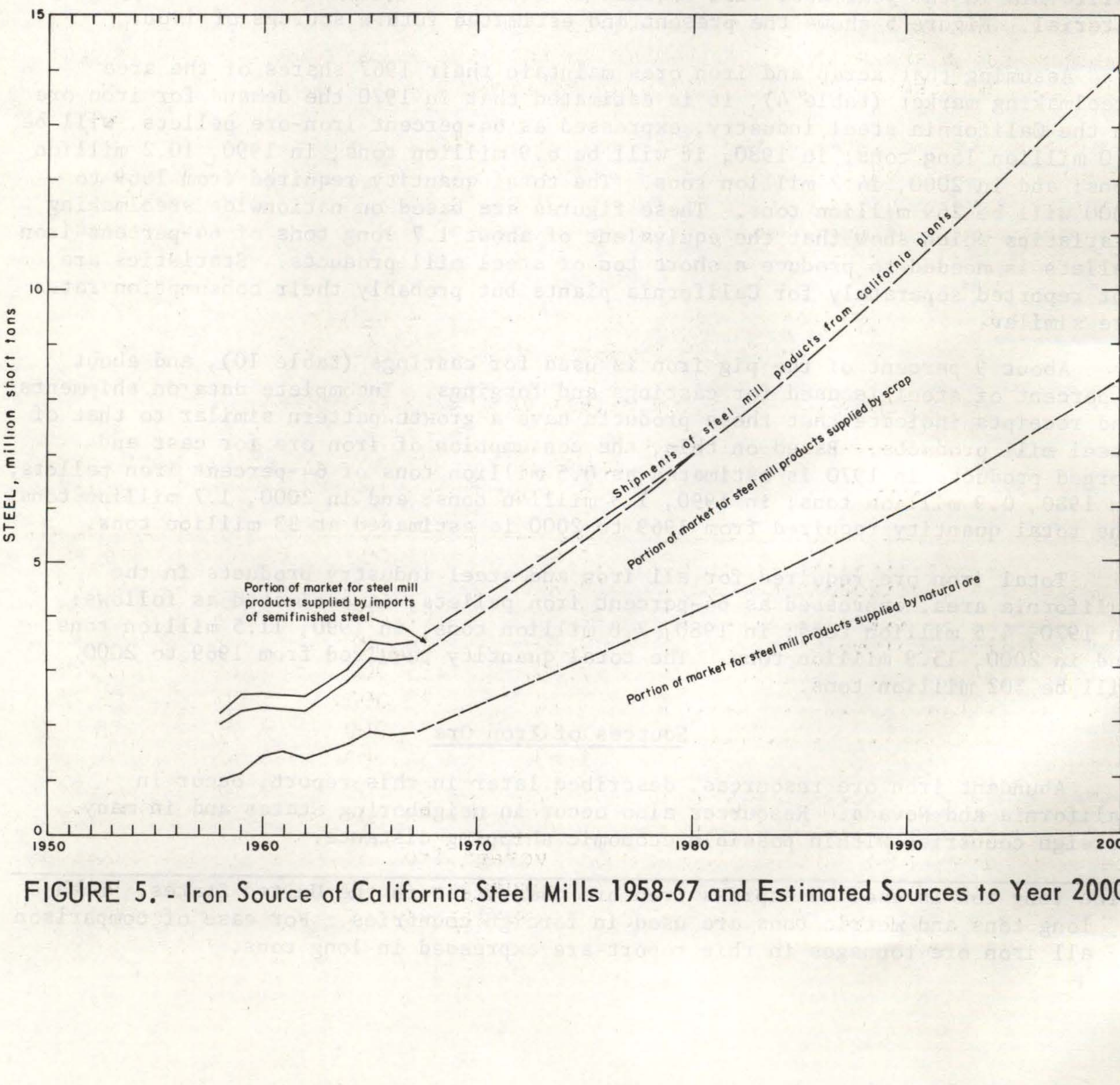

FIGURE 5. - Iron Source of California Steel Mills 1958-67 and Estimated Sources to Year 2000.

In 1968 only a little iron ore from foreign countries or other States is being used in California. However, when seacoast blast furnaces are built competition may develop between California-Nevada mines and merchant and steel-company-owned mines in South America, Africa, Asia, and Australia that are now shipping large tonnages of iron ore to plants in Europe, Japan, and the eastern and southern sections of the United States. Short-term factors such as excess capacity in foreign mines may temporarily favor foreign ore sources but long-term production and shipping cost relationships favoring local shippers probably will determine the final division of the market (see section on Imports).

Imports

Most of the large, developed iron ore deposits within shipping distance of California are now supplying the Japanese steel industry. The prices f.o.b. ships of these ores plus estimated shipping charges to California are the prices at which suppliers could deliver ore to California and earn the same profit that is being made on shipments to Japan. A comparison of the estimated delivered price of a foreign ore and the price of California ore at the consuming point shows the price reduction that the respective foreign shipper would have to make to compete with California-Nevada producers.

Tables 11 and 12 show the 1968 cost of California natural iron ore and iron-ore pellets and the estimated delivered costs in California from all countries supplying iron ore and pellets to Japan; and table 13 shows the comparative cost of iron ore pellets as contracted for in 1975 by Japanese steelmakers.

TABLE 11. - Equivalent costs in California of natural iron ores supplied to Japan under 1968 contracts[1]

(Dollars per long ton unless otherwise specified)

Country	Average f.o.b. cost	Ship capacity, long tons	Freight cost	Delivered cost
Peru	$7.40	65,000	$3.50	$10.90
United States (California-Nevada)	11.10	-	-	11.10
Chile	7.90	65,000	4.00	11.90
Canada (British Columbia)	9.30	26,000	2.60	11.90
Brazil	7.70	125,000	4.50	12.20
India	7.70	93,000	5.00	12.70
Liberia	7.10	50,000	6.00	13.10
Venezuela	8.90	50,000	4.50	13.40
Australia	9.40	65,000	4.40	13.80
Angola	7.80	50,000	6.50	14.30

[1]Estimated from 1968 purchase schedules; average iron ore composition taken as 62.0 percent Fe, 0.10 percent P, 0.10 percent S, 0.10 percent TiO_2, particle size 80 percent plus (10 mm (agglomerating cost for fines estimated at $1.00 per ton).

TABLE 12. - Equivalent costs in California of iron ore pellets supplied to Japan under 1968 contracts[1]

(Dollars per long ton unless otherwise specified)

Country	Average f.o.b. cost	Ship capacity, long tons	Freight cost	Delivered cost
United States (California-Nevada)	$12.30	-	-	$12.30
Peru..........................	10.70	65,000	$3.50	14.20
India.........................	11.30	93,000	5.00	16.30
Australia.....................	12.40	65,000	4.40	16.80
Philippines...................	11.90	50,000	5.00	16.90

[1]Estimated from 1968 purchase schedules; average composition taken as 64 percent Fe and insignificant contaminants.

TABLE 13. - Equivalent costs in California of iron ore pellets contracted to Japan under 1975 contracts[1]

(Dollars per long ton unless otherwise specified)

Country	Average f.o.b. cost	Ship capacity, long tons	Freight cost	Delivered cost
Peru..........................	$9.30	65,000	$3.50	$12.80
Australia.....................	11.80	65,000	4.40	16.20
India.........................	11.30	93,000	5.00	16.30
Philippines...................	11.90	50,000	5.00	16.90

[1]Estimated from published 1975 purchase contracts; average composition taken as 64 percent iron and insignificant contaminants.

Pellet contract prices are more indicative of competitive relationships than are the prices in natural ore contracts because most California-Nevada iron-ore contracts were negotiated before 1962 and natural ore prices have decreased considerably since this period. California pellet contracts were negotiated in about 1965 and the prices established are closer to 1968 levels. The California 64-percent iron pellet price (1968) is $12.30 per ton at tidewater, $1.90 less than that for Peruvian pellets, the lowest cost foreign source (table 12), and is $4.00 per ton below the next lowest cost supplier. Foreign pellet prices specified for delivery in 1975 are lower but are still at least $0.50 per ton above the California 1968 price (table 13). The average California-Nevada natural-ore price in present contracts is $11.10 per ton, $0.20 above the equivalent price for Peruvian ore, the lowest cost foreign source. However, very little natural ore would be purchased at this price if pellets were available at a cost of only $1.30 per ton more. The usual difference in spot price between 64-percent iron pellets and 62-percent iron lump ore is about $2.50 per ton and natural ore prices would seldom be above $9.80 per ton if pellets were available. Most California-Nevada iron ore is of a grade and composition that is more suitable for pelletizing than for use as lump.

The competitive position of local iron ore suppliers appears to be reasonably secure for the long term, but competition could force prices down during periods of excess foreign capacity.

Shipping costs of foreign suppliers could be significantly reduced by harbor improvements to allow the use of larger ships. Presumably California-Nevada suppliers could also reduce transportation costs by the use of unit trains or other improved transportation methods. Foreign suppliers would have to accept a very substantial reduction in profit margins to ship natural iron ore and iron ore pellets to California.

Shipments From Other States

Only small tonnages of iron ore have been shipped in recent years to California from States other than Nevada or to Japan from States other than California and Nevada, which indicates that more profitable markets exist for production from other States. During World War II, mines in the Iron Springs district, southwestern Utah, shipped large quantities of ore to the Fontana plant. These shipments terminated with the opening of the Eagle Mountain mine. Iron Springs mines have been large producers, supplying most of the ore for the Geneva and Ironton, Utah, steel plants and much of the ore for the Pueblo, Colo., plant. The mined ore has contained 50 to 55 percent iron, principally as magnetite.

The major producers in the Iron Springs district are United States Steel Corp., CF&I Steel Corp., and Utah Construction and Mining Co. Production from these mines has apparently been committed to the Geneva, Utah, and Pueblo, Colo., plants through direct ownership or long-term contract. It is not anticipated that any part of this production will be sold in California or Japan because higher freight charges make these markets less profitable than those in Utah and Colorado.

No other large domestic iron ore resources have been developed in other States within economic shipping distance of the California steel centers.

Requirements for Other Iron Ore Uses

The cement industry is the second largest consumer of iron ore although the quantity used is small (about 1.5 percent of total production) compared with that used in steelmaking.

Table 14 gives California cement shipments, iron ore consumed in its manufacture, and iron ore consumption per barrel of cement for 1944-65. Consumption of iron ore has generally paralleled shipments of cement. The irregularities in iron ore consumption are mainly due to fluctuations in the proportion of massive concrete construction, which requires more high-iron cement than other uses, and to inventory adjustments.

The average growth rate of cement consumption in California was 2.5 percent annually for the period 1950-67. Iron ore consumption in the cement industry has grown at a similar rate. If this rate continues, consumption of iron ore by California cement plants in 1970 will be 62,000 tons; in 1980, it will be 79,000 tons; in 1990, it will be 101,000 tons; and in 2000, it will be 130,000 tons. Figure 6 shows the past consumption and the projected trend of iron ore consumption.

TABLE 14. - Consumption of iron ore in California cement plants, 1944-67

Year	Cement shipments, thousand 376-pound barrels	Iron ore consumed, long tons	Iron ore per barrel, long ton
1944	14,977	16,298	0.00109
1945	15,922	20,583	.00129
1946	20,173	48,172	.00239
1947	22,846	35,112	.00154
1948	24,163	38,062	.00158
1949	23,202	29,945	.00129
1950	26,685	33,881	.00127
1951	28,956	39,242	.00136
1952	29,786	44,579	.00150
1953	32,002	43,484	.00136
1954	32,762	43,963	.00134
1955	35,084	46,776	.00130
1956	39,290	NA	NA
1957	37,731	NA	NA
1958	39,583	NA	NA
1959	43,635	NA	NA
1960	39,712	NA	NA
1961	41,092	NA	NA
1962	43,667	NA	NA
1963	46,278	NA	NA
1964	48,981	NA	NA
1965	45,352	NA	NA
1966	45,387	NA	NA
1967	42,034	NA	NA

NA--Not available.

Source: Bureau of Mines. Minerals Yearbooks. Ch. on Cement and Ch. on Iron Ore. 1944-67.

Other uses of iron ore are of general interest although their economic importance is slight.

During World War II concrete made from iron ore was used for ship ballast because it was cheaper than pig iron and iron scrap that had previously been used but which were in short supply during the early years of the war. About 360,000 long tons of 60-percent iron ore was used by the wartime shipbuilding industry (2); its use has been continued in the few ships built during the postwar period. Small quantities of heavy aggregate have also been used for counterweights, and similar uses, where a cheap heavy material is required.

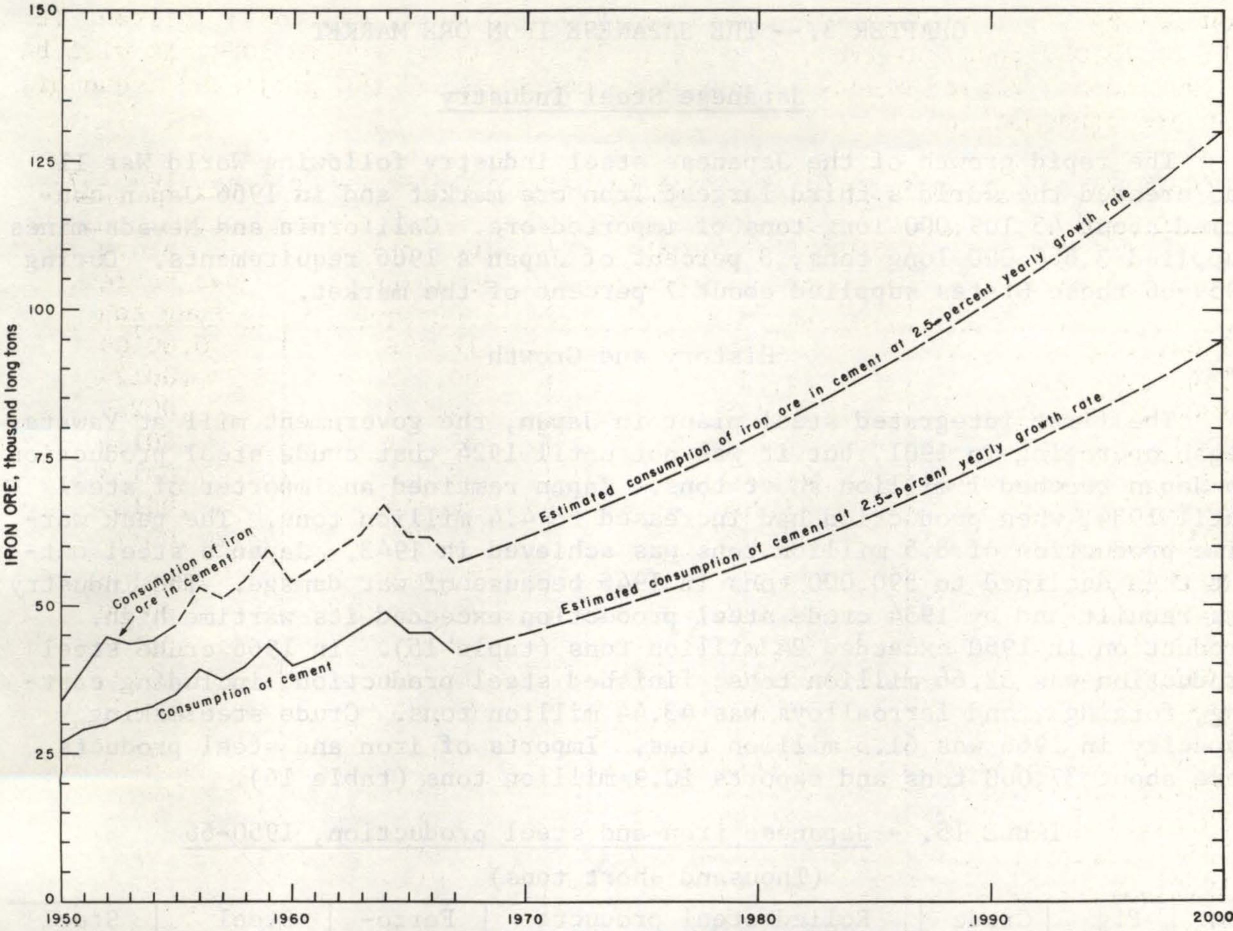

FIGURE 6. - Iron Ore Consumption in California Cement Industry 1950-55 and Estimated Consumption to Year 2000.

Concrete containing iron ore is used for shielding against X-ray and atomic radiation in hospitals, nuclear powerplants, and experimental nuclear reactors. It is unlikely that the future California-Nevada market for this use will exceed a few thousand tons per year.

Minor quantities of iron ore were shipped by California producers to pigment manufacturers from 1890 to 1955. The largest annual shipment was 3,418 tons in 1950. No shipments have been reported since 1955.

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CHAPTER 3.--THE JAPANESE IRON ORE MARKET

Japanese Steel Industry

The rapid growth of the Japanese steel industry following World War II has created the world's third largest iron ore market and in 1966 Japan consumed about 45,109,000 long tons of imported ore. California and Nevada mines supplied 3,664,000 long tons, 8 percent of Japan's 1966 requirements. During 1959-66 these States supplied about 7 percent of the market.

History and Growth

The first integrated steel plant in Japan, the government mill at Yawata, began operating in 1901, but it was not until 1924 that crude steel production in Japan reached 1 million short tons. Japan remained an importer of steel until 1934, when production had increased to 4.4 million tons. The peak wartime production of 8.5 million tons was achieved in 1943. Japan's steel output then declined to 590,000 tons in 1946 because of war damage. The industry was rebuilt and by 1954 crude steel production exceeded its wartime high. Production in 1960 exceeded 24 million tons (table 15). In 1966 crude steel production was 52.66 million tons; finished steel production, including casting, forgings, and ferroalloys was 43.44 million tons. Crude steelmaking capacity in 1966 was 61.5 million tons. Imports of iron and steel products were about 37,000 tons and exports 10.9 million tons (table 16).

TABLE 15. - Japanese iron and steel production, 1950-66

(Thousand short tons)

Year	Pig iron	Crude steel	Rolled steel products			Ferro-alloys	Steel forgings	Steel castings
			Ordinary	Special	Total			
1950	2,461	5,333	3,842	88	3,930	NA	NA	NA
1951	3,446	7,165	5,222	175	5,397	NA	NA	NA
1952	3,828	7,701	5,317	249	5,566	NA	NA	NA
1953	4,979	8,444	5,882	337	6,219	NA	NA	NA
1954	5,078	8,541	6,030	323	6,353	NA	NA	NA
1955	5,749	10,368	7,505	352	7,857	NA	NA	NA
1956	6,598	12,239	8,949	545	9,494	NA	NA	NA
1957	7,510	13,852	10,210	690	10,900	351	224	304
1958	8,148	13,354	9,887	559	10,446	328	145	230
1959	10,409	18,325	13,082	913	13,995	439	193	309
1960	13,110	24,397	17,274	1,288	18,562	490	300	399
1961	17,435	31,152	21,978	1,618	23,596	620	377	490
1962	19,805	30,356	22,298	1,687	23,985	514	298	418
1963	21,969	34,715	24,960	2,545	27,505	549	297	433
1964	26,204	43,859	31,524	2,790	34,314	740	354	498
1965	30,308	45,360	33,097	2,658	35,755	725	338	467
1966	35,284	52,658	38,164	3,522	41,686	799	429	529

NA--Not available.

Source: Japan Iron and Steel Federation. Statistics of the Iron and Steel Industry of Japan. 1963, 1966.

TABLE 16. - Japanese exports of iron and steel products by country of destination, 1959-66

(Thousand short tons)

Destination	1959	1960	1961	1962	1963	1964	1965	1966
Asia:								
Burma	41	75	47	67	84	81	90	26
China (mainland)	([1])	1	45	62	52	182	243	712
Formosa	102	123	97	147	153	207	302	385
Hong Kong	26	44	36	185	280	289	279	144
India	116	324	287	158	212	369	242	99
Indonesia	68	55	99	114	77	69	107	37
Iran	11	15	17	16	34	43	73	66
Korea, South	21	35	34	161	204	83	179	373
Malaysia	27	62	41	103	114	125	150	141
Pakistan	28	60	105	25	50	69	97	105
Philippines	134	166	219	191	316	401	493	442
Ryukyu (Okinawa)	28	31	36	57	52	43	77	87
Singapore	51	82	75	132	147	147	190	162
Thailand	133	150	179	228	267	303	324	483
Europe:								
Belgium	([1])	1	2	87	108	66	72	70
France	-	-	-	([1])	([1])	1	7	9
Germany, West	2	4	8	27	3	9	14	13
Italy	([1])	4	2	154	389	238	68	191
Spain	4	2	1	120	125	160	180	114
U.S.S.R.	1	([1])	4	249	361	113	223	172
North America:								
Canada	76	73	60	82	96	169	271	255
United States	723	643	678	1,281	1,979	2,851	4,792	5,175
South America:								
Argentina	39	88	117	153	30	81	324	73
Brazil	140	17	20	84	166	94	55	106
Chile	([1])	26	37	37	42	2	44	20
Columbia	26	24	41	38	58	114	54	105
Peru	4	9	17	29	48	48	82	79
Venezuela	12	17	7	28	52	134	119	159
Africa:								
Kenya	-	-	17	42	42	42	33	7
Nigeria	-	-	25	32	38	57	39	36
South Africa, Republic of	([1])	([1])	1	7	20	69	263	31
United Arab Republic	7	13	50	35	18	34	34	48
Oceania:								
Australia	5	305	71	44	118	298	464	164
New Zealand	([1])	9	7	66	121	128	187	90
Undistributed	163	305	288	312	357	508	748	725
Total	1,988	2,763	2,770	4,553	6,213	7,627	10,919	10,904

[1]Less than 500 short tons.

Source: Japan Iron and Steel Federation. Statistics of the Iron and Steel Industry of Japan. 1965, 1966.

Steel and steel products have become Japan's most important class of exports and a vital factor in its economy, which relies heavily on foreign exchange earnings for much of the country's standard of living and industrial raw materials. About 60 percent of Japanese steel was consumed domestically in 1966; the remainder was exported as steel mill products and in ships, automobiles, machinery, and other manufactured goods.

Future Growth

The average growth of Japanese steel production from 1953 to 1966 was 15 percent. From 1966 into 1969 the growth rate increased to over 20 percent. Based on this rate and on estimates in trade papers, Japanese steel shipments and consumption in 1970 are estimated at 85.0 and 64.0 million tons, respectively.

Steel production from 1970 to 2000 was estimated, by the author, using the following assumptions:

1. Japan's population will continue to grow at its present 0.9 percent annual rate.

2. By the year 2000 Japanese per capita consumption of iron and steel will be equal to U.S. consumption. This assumption is based on the following reasoning: Japan's steel production increased at an annual rate of 14.6 percent from 1957 to 1966; consumption increased at a rate of 12.3 percent, with the difference being exported. The per capita consumption increase was 11.4 percent. After allowance for steel exported in manufactured goods, per capita final consumption of iron and steel in 1966 was about 640 pounds.

For the United States, steel shipments increased at an average annual rate of 1.0 percent from 1956 to 1966: apparent consumption (shipments plus imports less exports) increased at a 2.2 percent rate. Imports supplied the difference. Population increased at a rate of 1.5 percent, making the average per capita consumption increase 0.7 percent. Per capita final iron and steel consumption in 1966 was about 1,170 pounds.

If these growth rates were to continue, Japanese per capita steel consumption in time would surpass that of the United States. However, much of Japan's growth appears to be a catching up with the U.S. standard of living and eventually Japanese per capita consumption growth is expected to decrease to the mature growth rate of United States steel consumption. At this future time total steel consumption growth in the two countries will be, more or less, proportional to population growth.

3. Japanese steel exports will continue to grow at the same rate as production, thus earning the foreign exchange needed for raw-material purchases. Justification for this assumption is as follows:

Japan's exports of steel mill products and of steel in manufactured goods must be approximately 30 percent of the value of total steel production if the steel industry is to earn exchange to pay for foreign raw materials consumed in steelmaking. During the period 1960 to 1966 Japan exported 19.5 percent of its production of iron and steel mill products. During the same period an estimated (Japanese Iron and Steel Federation) 10 percent of iron and steel mill products were exported in manufactured goods. Total exports of iron and steel products reached an estimated 40 percent of production in 1966.

Japanese and U.S. iron and steel shipments and consumption from 1957 to 1966 are shown in tables 17 and 18 and in figure 7. Figure 7 shows estimated shipments and consumption in the United States and Japan from 1966 to 2000.

TABLE 17. - Japanese iron and steel consumption, 1957-66

(Thousand short tons)

Year	Shipments of steel mill products	Shipments of castings and forgings	Imports of iron and steel products	Exports of iron and steel products	Apparent domestic consumption
1957	10,900	2,715	([1])	1,167	12,622
1958	10.446	2,194	174	2,025	10,789
1959	13,994	2,898	353	1,988	15,257
1960	18,563	3,782	264	2,763	19,846
1961	23,596	4,544	397	2,770	25,767
1962	23,984	4,045	241	4,553	23,717
1963	27,505	4,128	60	6,213	25,480
1964	34,314	4,899	69	7,627	31,655
1965	35,754	4,618	37	10,919	29,490
1966	41,686	4,946	37	10,904	35,768

[1]Not reported.

Source: Japan Iron and Steel Federation. Statistics of the Iron and Steel Industry of Japan. 1965, 1966.

TABLE 18. - United States iron and steel consumption, 1956-66

(Thousand short tons)

Year	Shipments of steel mill products	Shipments of castings and forgings	Imports of iron and steel products	Exports of iron and steel products	Apparent domestic consumption
1956	82,251	16,744	1,479	4,749	95,725
1957	79,895	15,294	1,295	5,917	90,567
1958	59,914	12,123	1,820	3,225	70,632
1959	69,377	14,645	4,615	1,973	86,664
1960	71,149	13,806	3,570	3,247	85,278
1961	66,126	12,764	3,309	2,235	79,964
1962	70,552	13,844	4,297	2,266	86,427
1963	75,555	15,200	5,637	2,670	93,722
1964	84,945	17,152	6,630	4,065	104,662
1965	92,666	18,810	10,640	2,888	119,228
1966	89,995	19,005	11,043	2,145	117,898

Source: Bureau of Mines. Minerals Yearbooks. Ch. on Iron and Steel. 1956-66. Bureau of the Census. Report of Iron and Steel Foundries and Steel Ingot Producers. Annual issues.

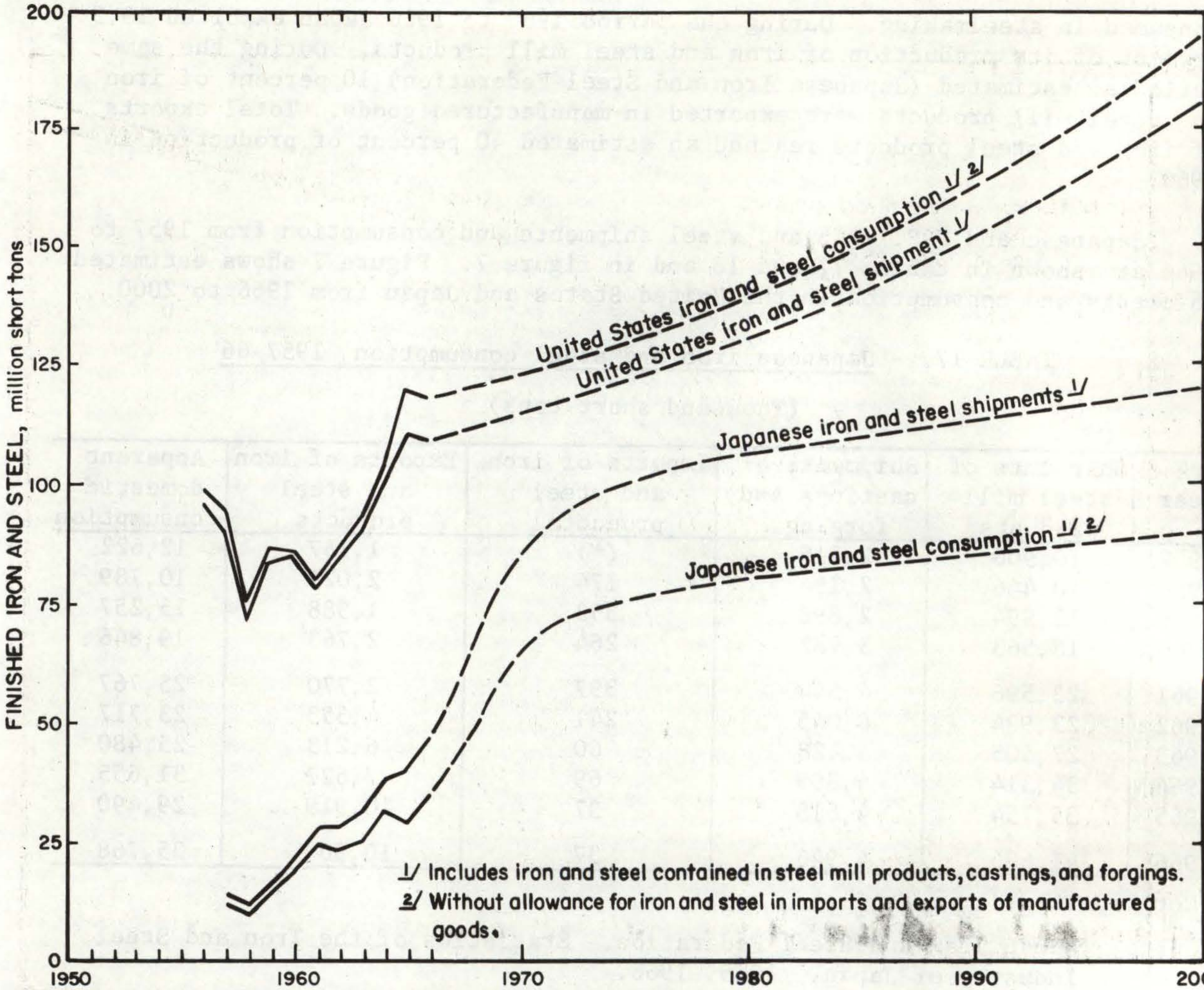


FIGURE 7. - United States and Japanese Iron and Steel Shipments and Consumption in 1957-66 and Estimated Shipments and Consumption to Year 2000.

Japanese iron and steel shipments are estimated to be 85.0 million tons in 1970; 105.0 million tons in 1980; 112.0 million tons in 1990; and 119.0 million tons in 2000.

Iron Ore Import Requirements

Past sources of iron for the Japanese steel industry are shown in table 19. Figure 8 shows the equivalent quantities of imported iron ore, domestic iron ore, domestic scrap, imported scrap, and imported pig iron used by the Japanese steel industry from 1957 to 1966 and the estimated equivalent quantities of each that will be used from 1966 to 2000.

The forecast of future iron ore requirements was made using the following assumptions:

1. Use of domestic iron ore, iron sand, and pyrite sinter will continue at its 1966 rate.

2. Use of domestic scrap will increase at the same rate as steel production.

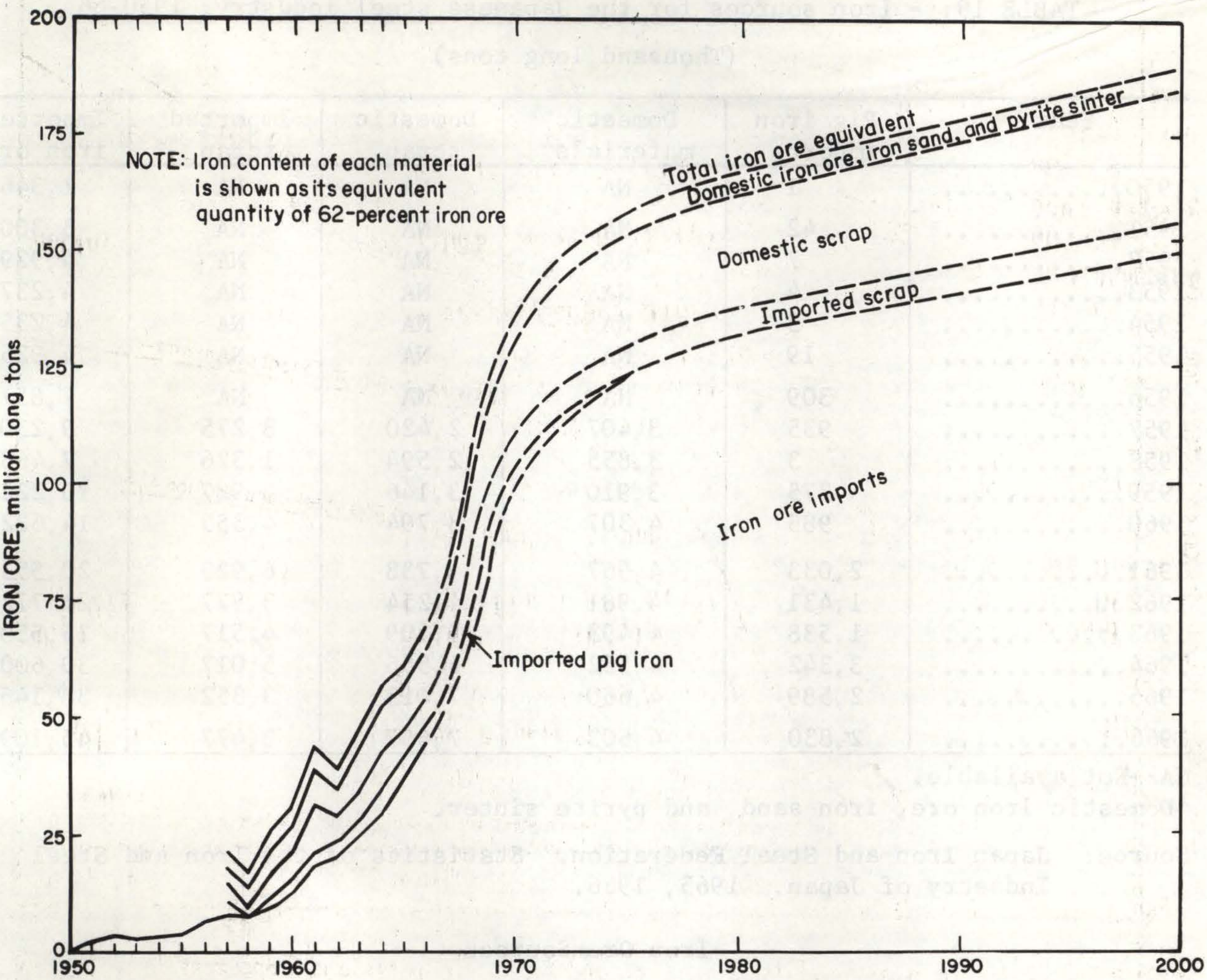


FIGURE 8. - Source of Ferrous Material for Japanese Steel Industry 1957-66 and Estimated Source to Year 2000.

3. The quantity of imported scrap will remain constant at its 1966 figure.

4. Imports of pig iron will be reduced to an insignificant tonnage by 1975 when scheduled blast furnace construction is completed and deliveries of Australian iron ore and coking coal have reached a high level.

5. The remaining iron-making requirements will be met by iron ore imports.

The projection shows estimated iron ore imports for 1970 of 100 million tons having the same average grade as present imports (62 percent iron). The estimate for 1980 is 133 million tons; 1990, 142 million tons; and 2000, 150 million tons.

TABLE 19. - Iron sources for the Japanese steel industry, 1950-66

(Thousand long tons)

Year	Pig iron imports	Domestic materials[1]	Domestic scrap	Imported scrap	Imported iron ore
1950............	1	NA	NA	NA	1,346
1951............	42	NA	NA	NA	3,300
1952............	7	NA	NA	NA	4,929
1953............	4	NA	NA	NA	4,237
1954............	3	NA	NA	NA	4,235
1955............	19	NA	NA	NA	4,925
1956............	309	NA	NA	NA	7,851
1957............	935	3,407	2,420	3,275	9,230
1958............	3	3,855	2,594	1,326	7,463
1959............	275	3,910	3,146	3,987	10,222
1960............	985	4,307	3,794	4,355	14,622
1961............	2,033	4,967	4,738	6,923	20,553
1962............	1,431	4,981	4,254	3,577	21,772
1963............	1,538	4,493	5,409	4,517	25,558
1964............	3,342	4,552	6,555	5,017	30,600
1965............	2,589	4,660	7,013	3,352	38,146
1966............	2,830	4,603	7,667	3,477	45,109

NA--Not available.

[1]Domestic iron ore, iron sand, and pyrite sinter.

Source: Japan Iron and Steel Federation. Statistics of the Iron and Steel Industry of Japan. 1965, 1966.

Iron Ore Sources

Before World War II Japan imported iron ore mainly from China, Korea, and Malaysia. Political instability has greatly reduced imports from China and North Korea, while Japan's demand for iron ore has increased enormously. Table 20 and figure 9 show the trend of iron ore imports from 1950 to 1966.

Malaysia and the Philippines in 1950 were the main sources of Japan's small iron ore imports, with minor quantities supplied by Hong Kong, India, and Goa. Tripling of the market during the early 1950's resulted in increased production from these areas and purchases from the Western United States and Canada. A further tripling of the moderate-sized market during the late 1950's was met by expansions in Malaya, Goa, and India; however, during this period ore also was contracted for in Brazil, Chile, Peru, Korea, and South Africa as the need for expanding the supply base was recognized. The rapid rate of growth continued and by the end of 1966 imports were three times the 1960 level. This sizable increase, about 30 million long tons, was met by additional shipments from nearly all suppliers but notably from Chile and Peru. The source of Japan's 1966 iron ore imports and the location of the principal iron ore deposits within shipping distance of Japan are shown in figure 10.

TABLE 20. - Japan: Domestic production and imports of iron ore, by countries, 1937-66

(Thousand long tons)

Year	Production	South Korea	North Korea	China, mainland	Hong Kong	Thailand	Malaysia	Philippines	India	Goa	United States	Canada	Peru	Chile	Brazil	Australia	South Africa	Other[1]	Total imports	Total supply
1937	592	-	297	589	-	-	1,607	316	7	-	-	-	-	-	-	-	-	445	3,261	3,853
1938	759	-	361	148	-	-	1,575	553	130	-	-	-	-	-	-	-	-	394	3,161	3,920
1939	823	-	395	687	-	-	1,906	1,307	337	9	-	-	-	-	-	-	-	230	4,871	5,694
1940	1,105	-	432	1,203	-	-	2,009	1,190	21	-	-	-	-	-	-	-	-	194	5,048	6,154
1941	1,233	-	754	2,636	-	-	1,174	896	2	-	-	-	-	-	-	-	-	125	5,587	6,820
1942	1,768	-	595	3,569	-	-	75	-	-	-	-	-	-	-	-	-	-	55	4,294	6,062
1943	2,470	-	-	3,573	-	-	37	84	-	-	-	-	-	-	-	-	-	13	3,707	6,177
1944	2,956	-	-	1,426	-	-	-	47	-	-	-	-	-	-	-	-	-	-	1,473	4,429
1945	1,609	-	-	77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77	1,686
1946	547	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	547
1947	488	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	488
1948	549	-	-	373	-	-	69	9	8	-	34	-	-	-	-	-	-	-	493	1,042
1949	749	-	-	309	47	-	477	340	45	5	287	-	-	-	-	-	-	19	1,529	2,278
1950	812	4	-	71	147	-	513	557	35	59	-	-	-	-	-	-	-	17	1,403	2,214
1951	896	6	-	-	147	-	705	886	151	192	804	86	-	-	-	-	30	35	3,040	3,936
1952	1,055	11	-	-	129	-	808	1,163	412	247	1,403	488	-	-	-	-	9	22	4,692	5,747
1953	1,119	11	-	-	117	-	850	1,186	448	247	457	895	-	-	-	-	-	11	4,222	5,341
1954	1,117	30	-	-	93	-	1,103	1,457	746	489	415	548	-	28	10	-	-	8	4,926	6,043
1955	969	-34	-	-	116	-	1,606	1,590	944	376	217	489	-	-	-	-	-	-	5,373	6,342
1956	1,070	54	-	-	123	-	2,285	1,549	1,273	850	989	276	187	12	42	-	12	64	7,716	8,786
1957	1,132	126	-	-	100	-	2,826	1,428	1,510	1,271	1,068	326	386	13	130	-	14	35	9,230	10,362
1958	1,157	204	-	-	111	-	2,349	1,134	1,573	779	538	543	165	16	46	-	2	3	7,463	8,620
1959	1,172	217	-	-	122	-	3,690	1,275	1,847	1,382	530	666	101	69	154	-	150	21	10,222	11,394
1960	1,270	238	-	-	127	-	5,268	1,183	1,867	2,502	2,502	1,067	623	245	349	-	281	63	14,622	15,895
1961	1,140	446	-	-	117	-	6,533	1,210	1,681	3,113	931	1,097	2,348	2,143	419	12	445	61	20,553	21,694
1962	1,126	396	-	-	120	48	6,360	1,449	4,432	(2)	850	1,549	2,456	2,963	636	-	585	-	21,772	22,898
1963	1,114	582	-	23	125	-	6,592	1,395	5,708	(2)	1,792	1,856	2,869	3,265	490	-	582	281	25,558	26,669
1964	1,121	999	-	50	130	109	6,516	1,477	6,599	(2)	1,973	1,737	3,438	5,330	432	64	1,007	741	30,600	31,721
1965	1,125	1,089	-	208	143	711	6,844	1,458	7,605	(2)	2,617	1,918	4,459	6,818	900	207	1,131	2,038	38,146	39,271
1966	1,098	1,118	-	320	149	708	5,700	1,574	9,904	(2)	3,664	1,789	4,982	7,506	1,677	2,010	1,273	2,735	45,109	46,207

[1] Venezuela, Rhodesia, Turkey, Fiji, Angola, Spain, Cuba.
[2] Included with India.

Source: Japan Iron and Steel Federation. Statistics of the Iron and Steel Industry of Japan. 1963 (1937-55 data) and 1967 (1956-66 data).

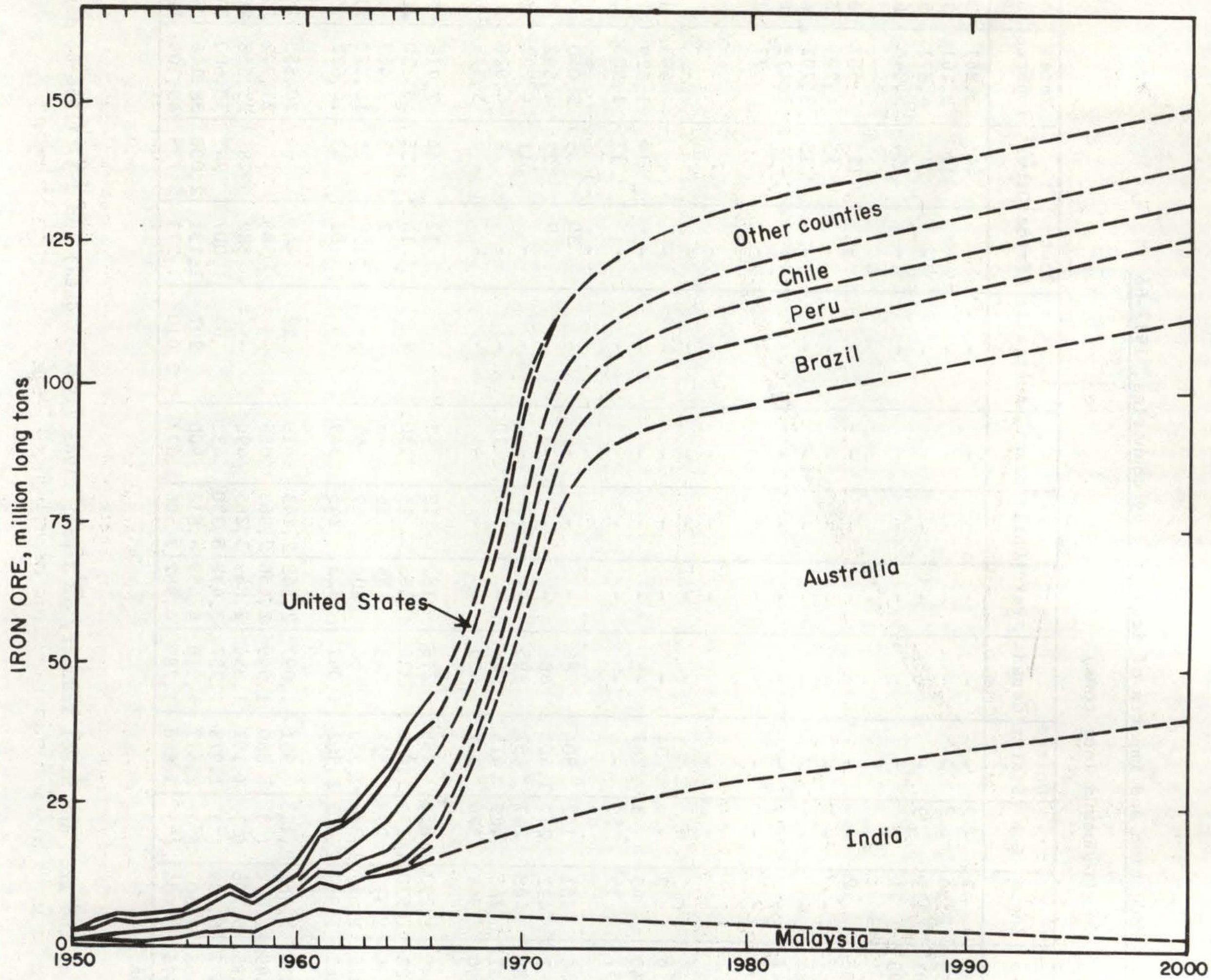


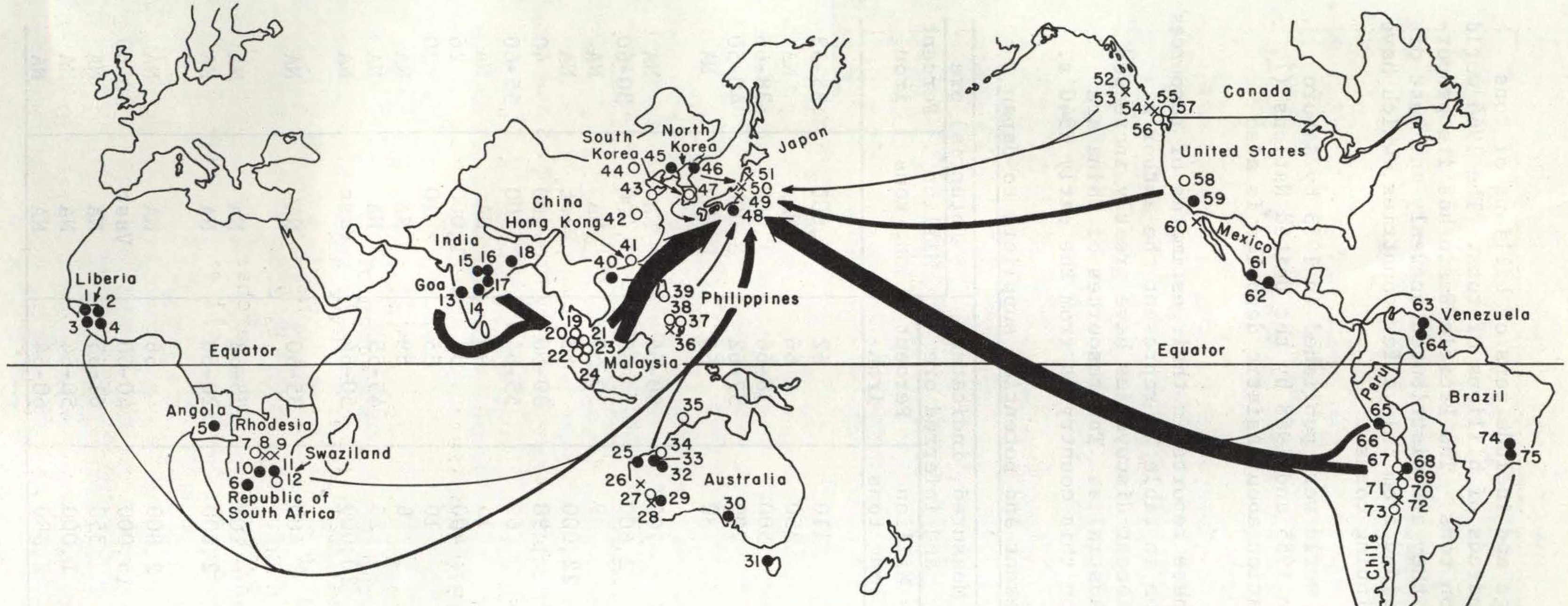
FIGURE 9. - Source of Imported Iron Ore for Japanese Steel Industry From 1950-66 and Estimated Source to Year 2000.

Sources of 1970 Supplies

Imports of iron ore in 1970 will be an estimated 100 million tons, an increase of about 55 million tons over the 1966 consumption of 45.1 million tons. To meet this demand Japanese steel manufacturers have already contracted for increased purchases by 1970 of 28.0 million tons from Australia, 7.1 million tons from India, 4.2 million tons from Brazil, 2.3 million tons from Peru, and 2.2 million tons from Swaziland. These purchase contracts plus long-term and short-term contracts in force in 1966 (if all are extended) will provide a total of 88.9 million tons.

Estimated Sources of 1970-2000 Supplies

Japanese iron ore imports are expected to increase from 45.1 million tons in 1966 to 150 million tons in 2000. Total iron ore imports required from 1966 to 2000 are estimated at 4,200 million tons.



L E G E N D

● Resources of over 100 million long tons 64-percent iron ore equivalent
○ Resources of 10 million to 100 million long tons 64-percent iron ore equivalent
× Resources of under 10 million long tons 64-percent iron ore equivalent

1. Mano River
2. Mount Nimba
3. Bong Range
4. Bomi Hills
5. Angola
6. Postmasburg
7. Beacon Tor
8. Bukwa
9. Norie
10. Pretoria
11. Palabora
12. Bomvu Ridge
13. Goa
14. Bellary
15. Drug
16. Rowgat
17. Bailadila
18. Singhbhum
19. Temangan
20. Kinta
21. Dungun
22. Srimedan
23. Rompin
24. Langkap
25. Robe River
26. Tallering Peak
27. Koolyanobbing
28. Mount Gibson
29. Yilgarn
30. Iron Knob
31. Savage River
32. Mount Newman
33. Mount Tom Price
34. Mount Goldsworthy
35. Yampi Sound
36. Sibuguey
37. Surigao
38. Manicani
39. Larap
40. Hainan Province
41. Ma-Ah-Shan
42. Hupeh Province
43. Shantung Povince
44. Chahar Province
45. Liaoning Province
46. Musan
47. Yang Yang
48. Iron Sands
49. Gumma
50. Akatani
51. Kamaishi
52. Tasu
53. Jedway
54. Zeballos
55. Quatsino
56. Kennedy Lake
57. Texada
58. Minnesota
59. Eagle Mountain
60. El Manzano
61. El Mamay
62. La Esperanza
63. El Pao
64. Cerro Bolivar
65. Marcona
66. Acari
67. El Tofo
68. Boqueron-Chanan
69. Cerro Inman
70. El Romeral
71. El Algarrobo
72. Los Colarados
73. El Dorado
74. Itabira Area
75. Rio Paraopeda

FIGURE 10. - Source of Japanese Iron Ore Imports in 1966 and Location of **Principal Deposits Within Shipping** Distance of Japan.

World iron ore reserves are very large and include tens of billions of tons on each continent; total resources are hundreds of billions of tons. The 1966 world consumption was only about one-half billion tons. The Pacific Basin has its proportionate share of the world's reserves but they are distributed unevenly and most of Japan's requirements are likely to be obtained from only a few countries, which have vast iron resources and relatively low shipping costs.

Surveys of the iron resources of the world were published in 1963 by Saburo Tabe (6), in 1962 by R. W. Hyde (3) and in 1955 and 1968 by the United Nations (7, 10). Additional valuable resource information about Asiatic deposits is also available (2, 8-9).

Considerable variance exists among these reports in their estimates of resources of specific countries. The estimates given in table 21 represent the author's evaluation of the quantities available. Recent discoveries have greatly increased reserves in some countries, particularly Australia. The resources of China are uncertain as the most recent information on this country is from the early 1940's.

TABLE 21. - Iron ore resources of present and potential suppliers to Japan

Continent and country	Measured, indicated, and inferred ore		Potential ore	
	Million long tons	Percent iron	Million long tons	Percent iron
Africa:				
Angola	110	62	5,000	35-53
Liberia	350	66	NA	NA
Do	500	38-66	1,000	38-66
South Africa, Republic of	700	57-62	3,000	40-50
Swaziland	30	63	NA	NA
Asia:				
China, mainland	700	50-64	NA	NA
Do	2,600	36	7,000	30-60
Hong Kong	9	30-50	NA	NA
India (including Goa)	22,000	63	Vast	NA
Japan	90	30-50	100	40
Malaysia	60	55-64	100	55-60
Korea, North	15	48	NA	NA
Do	400	36	1,000	26
Korea, South	10	55	10	30
Philippines	8	59	NA	NA
Do	26	45-55	NA	NA
Oceania: Australia	20,000	50-64	Vast	NA
North America:				
Canada (British Columbia)	400	35-60	NA	NA
Mexico (Baja California, Jalisco, Oaxaca)	105	58-68	NA	NA
United States (California-Nevada)	2,800	20-60	NA	NA
South America:				
Brazil	2,800	66	NA	NA
Do	15,000	40-60	Vast	30-60
Chile	350	61-65	NA	NA
Peru	1,000	50-64	NA	NA
Venezuela	2,300	60-64	NA	NA

NA--Not available.

India and Australia each could supply all of Japan's ore requirements between 1966 and the year 2000 without any serious drain on their own reserves. Brazil's reserves also allow large exports to Japan and contracts have been negotiated which provide for exports of 9.5 million tons per year by 1973. Peru and Chile have adequate resources to double their present exports. South Africa has large reserves but transportation costs from the deposits to the coast are high. Venezuela has reserves sufficient to support a Japanese trade of several million tons annually but transportation costs are high because large ore carriers cannot use the Panama Canal. Accessible reserves in Malaysia, the Philippines, Hong Kong, the Republic of Korea, Swaziland, Liberia, Angola, and western Canada are adequate to support their present production. China and North Korea have substantial reserves and probably could export as much as 10 million tons per year.

Reserves of direct shipping ore in the Western United States are limited and no increase in sales of this type ore is likely. Reserves of milling ore are large and could support an export industry if low freight rates could be obtained. High-capacity automated plants requiring large investments are the only type that can produce at a competitive price. Many of the major domestic iron deposits are controlled by operating steel companies which may prefer to keep their deposits for later domestic use.

Iron Ore Prices in 1968

Iron ore prices received in the Japanese market during 1968 are compared in this report by evaluating purchase contracts. The average price received by each shipper was converted to the price that would have been received under the terms of his individual contract if his ore had had the grade and composition of a hypothetical standard ore, with the following analysis: 62 percent Fe, 0.10 percent P, 0.10 percent S, 0.10 percent TiO_2, and no moisture. The specified particle size of the hypothetical crude ore or sintered concentrate is considered to be 80 percent plus 10 mm and 100 percent minus 250 mm. This is approximately the average composition and size of all ore imported by Japanese steelmakers during 1966.

Bonuses and penalties provided in individual contracts were applied to the differences in composition and size between the specified analyses of the individual ore contracts and the composition and size of the hypothetical standard to determine price adjustments. These adjustments then were applied to the base prices of the individual ores to obtain comparability. The calculated prices of hypothetical standard ores from shippers from each exporting country were combined into countrywide f.o.b. price averages which are listed in table 22.

The ocean freight costs paid by shippers in each country were also averaged and listed in table 22. The calculated f.o.b. prices and ocean freight charges were combined to give average delivered prices.

Mines in California and Nevada receive the highest f.o.b. and delivered prices of any of Japan's suppliers of iron ore. Prices of iron ore pellets delivered to Japan from all sources during 1968 also were compared. All pellets being shipped were fairly uniform in composition, although they differed somewhat in iron content and in the gangue minerals present. None contained serious contaminants. For comparison, the unit price for each pellet contract was reduced to that payable for pellets containing 64 percent iron and average impurities using the contract schedules. Average f.o.b. price, ocean freight rate, and delivered price, by country, are shown in table 23. The delivered price of U.S. shippers was the highest of any of Japan's suppliers.

TABLE 22. - Estimated price per long ton of average composition iron ore under 1968 purchase contracts to Japanese steelmakers[1]

(Dollars)

Country	Average price f.o.b. port of origin	Average freight rate	Average delivered price at Japanese ports
Korea, North	$9.75	$1.70	$11.45
Australia	9.40	2.40	11.60
India	7.70	4.00	11.70
Liberia	7.10	4.60	11.70
Peru	7.40	4.50	11.90
Angola	7.80	4.10	11.90
Canada (British Columbia)	9.30	2.90	12.20
U.S.S.R.	6.30	6.00	12.30
Brazil	7.70	4.60	12.30
Hong Kong	9.70	2.80	12.50
Philippines	9.90	2.70	12.60
All countries, average	8.40	4.20	12.60
Korea, South	11.10	1.70	12.80
Malaysia	9.00	4.00	13.00
Thailand	9.20	4.00	13.20
Swaziland	8.30	5.80	14.10
Chile	7.90	6.50	14.40
South Africa (Republic of)	9.00	5.80	14.80
United States (California-Nevada)	11.10	4.30	15.40

[1]Estimated from 1968 purchase schedules; average iron ore composition taken as 62.0 percent Fe, 0.10 percent P, 0.10 percent S, 0.10 percent TiO_2, particle size 80 percent plus 10 mm (agglomerating cost for fines estimated at $1.00 per ton).

TABLE 23. - Estimated price per long ton of average composition iron ore pellets under 1968 purchase contracts to Japanese steelmakers[1]

(Dollars)

Country	Average price f.o.b. port of origin	Average freight rate	Average delivered price at Japanese ports
Philippines	$11.90	$2.70	$14.60
Australia	12.40	2.30	14.70
Peru	10.70	4.50	15.20
India	11.30	4.40	15.70
United States (California-Nevada)	12.30	3.90	16.20

[1]Estimated from 1968 purchase schedules; average composition taken as 64 percent Fe and insignificant contaminants.

Future Price Trends

Japanese steelmakers have contracted for large tonnages of iron ore and pellets under long-term agreements which extend to as late as 1991. Summaries by years of long-term contracts in force as of 1968 for deliveries of ore (1969 through 1984) and pellets (1969 through 1991) are shown in tables 24 and 25, respectively. The contract prices are indicative of present opinion concerning future prices; however, future spot quotations, which are influenced by short-term factors, may at times differ considerably from long-term contract prices. Iron ore contracts contain escalator clauses, and general production-cost increases will result in higher ore prices.

TABLE 24. - Long-term iron ore contracts between overseas suppliers and Japanese steelmakers, 1969-84, inclusive[1]

(Dollars unless otherwise noted)

Year	Weight, thousand long tons	Average price f.o.b. port of origin	Average charge ocean freight	Average delivered price at Japanese ports
1969..........	67,910	$8.20	$3.90	$12.10
1970..........	69,484	8.20	3.90	12.10
1971..........	68,069	8.20	3.70	11.90
1972..........	68,197	8.20	3.70	11.90
1973..........	59,190	8.20	3.60	11.80
1974..........	57,890	8.20	3.60	11.80
1975..........	53,650	8.20	3.50	11.70
1976..........	48,640	8.30	3.40	11.70
1977..........	44,444	8.50	3.30	11.80
1978..........	41,590	8.50	3.20	11.70
1979..........	30,900	8.90	2.90	11.80
1980..........	25,800	8.90	3.00	11.90
1981..........	9,300	9.10	2.40	11.50
1982..........	8,300	9.10	2.40	11.50
1983..........	3,100	9.20	2.40	11.60
1984..........	3,100	9.20	2.40	11.60

[1]Estimated for ore or concentrates containing 62 percent Fe, 0.10 percent P, 0.10 percent S, 0.10 percent TiO_2, particle size 80 percent plus 10 mm.

The average delivered long-term contract price for 62-percent iron ore is $12.10 per ton in 1969 and decreases to $11.60 in 1984. The contract price of 64-percent iron pellets is $15.20 in 1969 and $13.80 in 1991. The lowest iron pellet contract prices negotiated to date have been with Australian producers and are $13.80 per ton delivered in Japan for 64-percent iron pellets with low impurities. The deliveries were scheduled to begin in 1971 and extend as late as 1991.

The lowest cost source of additional iron ore is from production increases at large active mines in Australia, Brazil, and India. The increases can be made without enlargement of transportation and harbor facilities except for the purchase of additional rolling stock. The cost of the harbors and railroads averaged about $20 per long ton of annual production for iron ore shipments contracted for before 1968. The amortization and interest cost of this investment is about $1.75 per ton based on a 20-year repayment period and 6-percent interest. This cost would be saved on ore produced in excess of the original contract.

TABLE 25. - Long-term iron ore pellet contracts between overseas suppliers and Japanese steelmakers, 1969-91[1]

(Dollars unless otherwise noted)

Year	Weight, thousand long tons	Average price f.o.b. port of origin	Average charge ocean freight	Average delivered price at Japanese ports
1969..........	10,455	$12.00	$3.20	$15.20
1970..........	10,405	12.00	3.20	15.20
1971..........	9,910	11.90	3.10	15.00
1972..........	11,425	11.80	2.70	14.50
1973..........	11,925	11.70	2.70	14.40
1974..........	11,825	11.60	2.70	14.30
1975..........	10,675	11.60	2.70	14.30
1976-77........	10,025	11.60	2.60	14.20
1978..........	6,925	11.50	2.30	13.80
1979-87........	6,325	11.40	2.30	13.70
1988-91........	4,200	11.50	2.30	13.80

[1]Average iron ore pellet composition taken as 64 percent Fe and insignificant contaminants.

Economies resulting from larger scale mining operations would further reduce mining, processing, and transportation costs. The estimated total saving would be $2.00 to $2.25 per ton of new capacity. Under competitive conditions, prices for additional ore could be reduced this amount without lowering profit margins of the shippers.

Similarly, costs will be reduced when the transportation installations have been amortized. However, part of this saving will be needed to meet increased production costs resulting from lower ore grades and increased stripping ratios.

Political factors could significantly affect prices, but they are difficult to evaluate.

Past government policy on iron ore exports in the principal countries has varied from embargos to government aid in developing overseas markets.

High tariffs on steel or other Japanese exports could cause a foreign-exchange shortage and force Japanese steelmakers to obtain ore only from countries to which Japan exports manufactured goods. The possibility of a resumption of large-scale Japanese trade with mainland China and the Soviet Union also must be recognized.

A consideration of all factors indicates that it will be difficult for shippers from other countries to underbid the 1978-91 price of $13.80 per ton for Australian iron ore pellets because the Australian deposits are large and high grade and the ocean freight rate from the Australian deposits to Japan is much less than that from large deposits in other countries. However, if a price war should develop for new contracts, prices could be reduced $2.25 per ton or more. A price war is unlikely because most iron resources are in countries from which exports are closely regulated by government agencies.

Freight Rates in 1968

Freight is usually the largest cost item in low-unit-value commodities such as iron ore; consequently, transportation efficiency is of major importance. Only ocean shipping is considered in this discussion although it may comprise less than one-half the total haulage cost. Mines in industrialized countries usually employ common-carrier facilities for most of their overland shipping. Transportation of ore in undeveloped areas usually requires the private construction and operation of railroads, highways, barge lines, or pipelines and is considered part of production with the f.o.b. point being the ocean shipping terminal.

Average published ocean shipping rates between Japan and iron-ore-supplying countries are listed in tables 22 and 23. Rates between Japan and some iron ore ports in various-sized ships are shown in table 26. Rates are based on the distance of the trip, the size of ships that can be used, and the docking and loading facilities available. Shipping charges can be lowered by port improvements, which permit the use of larger carriers, and by improvements in loading facilities, which reduce the time in port.

Harbor facilities in use vary from ports that can berth 125,000-ton ships and load at a 9,000-ton hourly rate to shoaling coasts where small lighters transfer the ore and loading is done offshore with the ship's own equipment. Ocean freight contracts are awarded on a bid basis and are competitive as far as the shipper is concerned; however, shipping lines are often helped by government subsidies. Rates reflect the supply and demand relationship between the volume of freight and the quantity of unused shipping capacity when the contract was advertised. Long-term contracts are usual for iron ore transportation and therefore tariffs often vary considerably between carriers on the same run depending on the time the contract was negotiated.

Competition for freight may cause rates to vary greatly between the two directions of movement. If more freight enters a port than leaves it, the entering ships can only obtain partial backhaul loads. Competition for the backhaul generally results in low bids. Undeveloped countries seldom have a surplus of import tonnage, as manufactured goods have a much higher unit value than raw materials. However, such income as can be realized by a partial backhaul load is considered by the carriers when making their bids.

TABLE 26. - Typical ocean shipping rates from iron ore ports to Japan (Yawata Base), in 1968

Country	Port	Ship capacity, long tons	Shipping rate,[1] dollars per long ton
Africa:			
Angola	Mossamedes	30,000	$7.20
Do	do	93,000	4.10
Liberia	Buchanan	55,000	5.80
Do	do	93,000	4.10
Mozambique	Lourenço Marques	88,000	4.34
South Africa, Republic of	Port Elizabeth	50,000	4.60
Asia:			
India	Visakhapatnam	30,000	3.90
Do	Marmagao	44,000	4.40
Do	do	93,000	4.10
Europe: U.S.S.R.	Iljicheusk	70,000	5.10
North America:			
Canada (British Columbia)	Port Texado	45,000	2.85
United States (California-Nevada)	Pittsburg	17,000	5.20
Do	Long Beach	50,000	3.90
South America:			
Brazil	Tubarao	125,000	4.05
Chile	Bandurias	70,000	6.15
Do	Caldera	65,000	6.56
Oceania:			
Australia	Port Darwin	38,000	2.40
Do	Port Hedland	65,000	2.40
Do	Whyhalla	96,000	2.30

[1] Some rates are for haulage in combination ore-oil carriers which transport petroleum on part of return trip.

Japan buys most iron ore at an f.o.b. price and the recent large contracts with Australian producers were negotiated on this basis. This enables the importing country to employ its own merchant marine and shipbuilding industry and to conserve foreign exchange. The Peruvian suppliers are the only large shippers who transport their own ore, although some small shippers also sell on a delivered basis.

Future Freight Rate Trends

During the 1960's, freight rates have been reduced by the use of larger and faster carriers, faster loading and unloading equipment, and the reduction of manpower by the use of improved machinery on shipboard. Before 1960, nearly all of the bulk carriers and ore carriers launched in Japan were of 15,000 deadweight tons or less in capacity, but in subsequent years a trend to larger ships developed and the average capacity of five ore carriers launched in 1963 was 51,600 tons. Ore carriers of 67,500 tons are used between Japan and Saint Nicolas, Peru; 88,000-ton carriers are in service between Japan and Lourenço Marques, Mozambique; and 125,000-ton carriers are in service between Japan and Tubarao, Brazil. Future plans specify carriers of more than 125,000-ton capacity. Loading and unloading facilities have been improved, with loading rates as high as 9,000 tons per hour.

An analysis of shipping rates shows that when port improvements have allowed the use of carriers with a 50-percent increase in capacity, freight rates decreased about 14 percent. A private analysis shows a similar relation between operating cost and ship size, indicating that most of the savings resulting from the use of larger ships is being passed on to the shippers.

Many iron ore ports are being enlarged and nearly all important ports will be during the next few years. Recently completed facilities in Tubarao, Brazil, accommodate 125,000-ton vessels. Similar-sized installations are expected to be built at western Australian ports. In Lourenço Marques, Mozambique, 78,000 tons is now being loaded directly into 88,000-ton ships in port and an additional 10,000 tons is being loaded offshore from lighters. Present dredging will allow the large ships to load entirely at dockside. The San Nicolas, Peru, facilities are being enlarged to handle 91,000-ton carriers.

Combination iron ore carriers and oil tankers provide by far the cheapest means of ore transport if conditions are such that the ore can be transported as a backhaul of petroleum shipping.

Most tankers now in service are not designed to handle iron ore, coal, or similar dry cargos. Combination-type ships to handle these commodities can be constructed at an estimated cost 15 percent above that of a straight tanker. Open-sea operating cost is approximately the same as for a conventional tanker. Extra operating cost results mainly from extra distances traveled to reach iron ore ports.

Japan, 600 miles off the Persian Gulf-California petroleum route, California, with iron ore shipping points immediately adjacent to petroleum unloading facilities, and western Canada, with ports about 1,000 miles from a petroleum route, are favorably located to make use of combination freighters. South American and African iron ports are a considerable distance from petroleum routes but are still able to use combination ships to advantage. Asian and Australian ports are less favorably located to use this type carrier. New oil discoveries could change petroleum trade routes and indirectly affect shipping costs.

Ore from the Marcona deposit in Peru has been transported by combination carriers for several years. The Marcona vessels carry iron ore from Peru to Japan, then, if crude oil is available, run empty to Sumatra where they load petroleum for transportation to California. Such back-haul freight as is available is loaded in California and transported to Peru. The triangular route increases the round trip distance by about 70 percent; however, the ship carries a payload about 80 percent of the time compared with 50 percent on a straight ore haul.

Brazilian ore is being carried in a recently built 125,000-ton combination vessel. The ship transports iron ore from Tubarao, Brazil, to Japan, runs empty to the Persian Gulf, carries petroleum from there to the United States, and runs empty to Brazil. On this circuit the ship is loaded about 70 percent of the time. The iron ore freight rate in combination oil-ore carriers is $4.05 per long ton compared with $5.60 in single-cargo ore-carriers of 70,000-ton capacity.

A factor which may reduce future shipping costs is a probable increase in back-haul freight. Most ore hauling is from undeveloped regions and constitutes nearly one-way traffic with little chance of securing a return cargo; however, as the purchasing power of these areas increases, more imports will be desired and the volume of back-haul freight will increase.

Economic Comparison of Foreign Iron Ore Sources

Iron ore and pellet prices by countries in 1968 are shown in tables 22 and 23. Future prices as indicated by long-term contracts are shown in tables 24 and 25. The difference between present and future prices is the average adjustment which suppliers in each exporting country must make to remain competitive. Prices will decrease gradually as new low-cost productive capacity is installed. In 1975 the estimated delivered price of 62-percent iron ore will be $11.70 per ton and the price of 64-percent iron pellets, $14.30 per ton. The selling price of ore from new installations cannot be expected to be much above these figures unless there is a general price inflation. However, inflation would influence both cost and prices and would have little effect on marketing patterns. Estimates of future iron ore exports by countries are shown in figure 9. The effect of the indicated price decreases on foreign countries are as follows:

Australia.--The Australian deposits, because of their great extent, high grade, shorter shipping distance to Japan, and ability to obtain the large amounts of capital needed for expansion, are considered to have the lowest potential production costs of any area. Future price levels will probably be set by competition among individual Australian shippers. Australia's share of the market is expected to increase greatly under foreseeable circumstances.

India.--India's iron deposits are comparable in extent and quality with those in Australia. The ocean shipping distance to Japan is greater, but this is balanced by shorter overland haulage routes and the existence of public-carrier transportation in the iron-producing areas. Large investments in modern equipment and harbor facilities are essential for economic production. Present iron ore prices received by Indian shippers are about equal to predicted 1975 prices. Exports should increase.

Malaysia.--Malaysian producers are currently receiving an average of $1.30 per long ton above the 1975 indicated price level. Shoals along the Malaysia coast make it impractical to construct harbors capable of berthing large ships, so cost savings will have to be made in production processes. Developed properties can continue operating until their depletion but new facilities will probably not be installed.

Brazil.--Brazilian ore in 1968 was priced at $0.60 per ton above the expected 1975 delivered Japan price. Recent port improvements and the use of large combination oil-ore carriers have lowered the ocean freight and probably further reductions can be made. It is evident that Brazilian ore will be competitively priced. Contracts in 1968 call for delivery of about 100 million tons to Japan during the next 15 years and an additional 60 million tons has been offered. Ocean shipping rates from Brazil to Japan will always be higher than from Australia because Brazil is 12,000 miles further from Japan. However, Brazilian production costs are low because of the premium grade and favorable environment of the extensive deposits, and now that excellent transportation and port facilities have been constructed, Brazilian shippers should be able to increase their exports to Japan.

Peru.--Current Peruvian contracts with Japan designate a price for ore which is $0.20 per ton above the expected 1975 price and a price for pellets $0.90 per ton above that expected in 1975. Operations have been profitable and Peruvian shippers can meet anticipated price reductions although there will be little desire for further price cutting. The producers have pioneered the use of large combination oil-carriers and ship their own ore to Japan. This gives better cost control and will help them meet competition.

Chile.--Chilean shippers receive $2.70 per ton above the indicated price level of 1975. Their freight rate of about $6.50 per ton in 65,000-ton vessels could be reduced by the use of larger carriers. However, individual iron ore deposits are medium in size and costly port improvements cannot be amortized at as low a per ton rate as for larger deposits in other countries. Cost reduction will come mainly from lower production costs and narrower profit margins. Present producers can probably absorb the expected price cut but new deposits are not likely to be exploited.

Canada (British Columbia).--The western Canadian average producer price is $0.50 per ton above the expected 1975 price. Deposits served from deep harbors have shipping rates $2.00 per ton below the regionwide average and can meet the expected price reductions. Shippers tied to small harbors will have difficulty meeting the reductions. The small tonnages shipped from individual harbors serving each deposit makes it impractical to undertake expensive harbor improvements.

Other Countries.--Various quantities of ore were shipped to Japan in 1968 from more than 15 other countries.

Iron ores from the U.S.S.R., North Korea, and mainland China were sold at prices from $0.25 per ton below the expected 1975 price to $0.60 per ton above. These shipments depend upon political as well as economic factors and their future course is difficult to predict. Large ore reserves are present in these countries.

Regional iron ore suppliers include South Korea, Philippines, Hong Kong, and Thailand. Present prices are $0.80 to $1.50 per ton above the expected 1975 level. Most producers in these countries will probably find it unprofitable to enlarge capacity for the Japanese market.

Merchant mines in the Republic of South Africa, Swaziland, Angola, and Liberia supply ore to Japan at prices from the expected 1975 price to $3.10 per ton above. These mines also ship to the United States and Europe. In some instances, the Japanese shipments consist of byproduct or surplus production. Most of the mines have good shipping facilities and could continue shipments at the reduced price levels. However, it is doubtful if many will expand production capacity in order to export more ore to Japan at the lower prices.

For information on individual foreign iron ore deposits within economic shipping distance of Japan and California the reader is referred to the bibliography at the end of this chapter. Publications listed contain information on ore reserves, ore grades, mining and metallurgical characteristics, production rates and methods, and transportation facilities.

Outlook for Exports From California and Nevada

California-Nevada exports of crude ore and pellets to Japan are made under the specifications shown in table 27.

At the contract expiration dates, mainly in the early 1970's, Japanese iron ore prices are expected to drop to the level of 1975 contracts--$11.70 delivered for 62-percent iron ore. A comparison of current contract rates and expected future prices indicates the adjustment required by U.S. shippers. The equivalent value of standard 62-percent iron ores calculated from each shipper's contract ranges from $10.70 to $11.50 per ton on an f.o.b. seacoast basis. Under present ocean freight schedules the contracts have delivered prices of $14.80 to $16.20 per dry ton, which are $3.10 to $4.50 per ton above the expected price level of 1975. The 1968 price of 64-percent iron pellets delivered in Japan is $1.90 above the expected 1975 price. Meeting these price reductions will be difficult or impossible for shippers.

Ocean shipping rates effective in 1968 ranged from $3.90 per ton in 50,000-ton ships to $5.20 per ton in 17,000-ton ships. Truck and rail transportation ranged from about $2.50 to about $5.00 per ton. When these fixed charges are applied to the 1975 delivered price, the mine value of 62-percent iron ore is reduced to approximately $1.50 to $5.00 per ton and the value of 64-percent iron pellets to about $8.00 per ton.

A price cut of $3.10 to $4.50 per ton is clearly too much for an overland long-haul shipper to absorb. A producer with shorter overland haul will have his operations made profitless, forcing closure when stripped or developed ore has been mined.

TABLE 27. - Statement of Japanese iron ore import contracts for California-Nevada shippers in 1968

Supplier	Total contract, long tons	Shipment dates	F.o.b. price, dollars per long ton	Freight dollars per long ton	Iron scale, dollars per long ton/unit	Specifications, percent				
						Fe	S	P	Cu	Size
Standard Slag Co.:										
Minnesota mine sinter.	4,000,000	1962-71	$9.70	[1]$5.20	+$0.40	62	-2.0	-0.20	-0.05	+10 mm, 15 percent maximum.
Kaiser Steel Corp.:										
Eagle Mountain mine lump.	6,000,000	1963-73	10.00	[2]$3.90	+.30	57	.40	.12	-	+1/4 inch, 80 percent minimum; 2 inch maximum.
Eagle Mountain mine fines.	4,000,000	1963-73	8.40	[2]$3.90	+.30	57	-2.50	-.12	-	-3/8 inch, 100 percent.
Eagle Mountain mine pellets.	10,800,000	1965-71	12.30	[2]$3.90	+.25	64	.02	.06	.04	+3/8 inch, 90 percent minimum; -1/2 inch maximum.

[1]In 17,000-ton capacity ship.
[2]In 50,000-ton capacity ship.

Source: Tex Report Ltd. 1968 Iron Ore Imports. Tokyo, Japan, 112 pp.

Current contracts provide for deliveries of about 12 million tons of iron ore and pellets between 1968 and 1973 (table 27). Unless favorable changes occur in the iron ore trade, exports from California-Nevada mines will decrease as existing contracts expire and will probably end completely within 6 years.

If domestic ore producers are to remain competitive, their shipping costs must be reduced drastically. This is technically possible but will require large investments in high-speed shiploading facilities, port improvements to handle 67,000-ton or larger ships, and construction of a fleet of combination oil-ore carriers to transport ore to Japan at ballast rates as a backhaul on the Persian Gulf-to-California petroleum trade.

The California-Nevada iron ore commerce differs from Japan's trade with all other suppliers in that a greater volume of bulk freight moves into the iron ore port than out of it. Iron ore carriers that haul payload only from California to Japan are returning empty, a condition which is unnecessary, as about 20,000 tons of crude oil enters California ports daily on tankers which pass within 600 miles of Japan on their voyage between the Persian Gulf or Sumatra oilfields and California markets.

On the 25,000-mile round trip between the Persian Gulf and San Francisco, a Japanese stop would add only 600 miles to the trip plus 2 days for loading and unloading a cargo of iron ore. A backhaul of iron ore could be carried to Japan by adding the 15 percent extra capital cost of the combination carrier above a straight tanker cost plus about 6 percent extra time and operating cost. Present petroleum charter rates for the haul are about $5.00 per ton in 67,000-ton ships. The additional cost of carrying ballast iron ore to Japan would be below $1.00 per ton.

If this improvement in transportation is made, California-Nevada iron ore and pellets will remain competitive in the Japanese market and large quantities of ore now considered too low grade for use could profitably be made into pellets and exported.

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CHAPTER 4.--ECONOMIC CLASSIFICATION OF CALIFORNIA-NEVADA IRON RESOURCES

One of the primary objectives of this report is to determine the available iron ore resources of the California-Nevada area. These resources form the raw material base for the California steel industry. Usually regionwide raw material inventories are expressed simply in terms of tonnage obtainable in various grade classifications. These totals indicate the ultimate production of which the region is capable; however, they fail to provide the information necessary to determine the volume of production that is economically possible.

In this estimate, resources are classified according to prices at which production, using existing technology, would be commercially feasible. Cost of production is used as a common denominator to allow the combination of resources contained in deposits of differing size, grade, and environment. Totals are expressed as equivalent quantities of 64-percent iron pellets to permit consolidation of reserves. Direct shipping ores were evaluated as shipping ore and then converted into an equivalent volume of 64-percent iron pellets and given an equivalent price. Milling ore estimates contain appropriate allowances for processing losses.

Economic criteria were developed by using operating mines as standards and the published export price of their ores, less mine-to-seaport transportation charges, as their cost of production. This f.o.b. mine price includes profit; however, since the probability of profit is essential in bringing out new production, profit must be included in the evaluation if a realistic cost level is to be determined.

Undeveloped deposits were compared with operating mines and following consideration of production problems, a comparable f.o.b. price needed for profitable operation was estimated. This price, plus the mine-to-seacoast transportation charges, is the regional price at which the resource is considered economic.

Regional Iron Ore Prices

Seacoast Prices

A statement of export contracts of California-Nevada shippers is given in table 27 (chapter 3). California prices are considerably below those at Lower Lake ports; for example 51.5-percent iron Mesabi nonbessemer ore is quoted at $10.55 per long ton at Lower Lake ports compared with $9.70 per long ton for 62-percent iron sintering ore in California. Pellets containing 64-percent iron and low contaminants are quoted at $16.10 per long ton at Lower Lake ports compared with $12.30 per long ton in California at tidewater.

Freight Rates

California and Nevada rail freight rates range from 1.0 to 1.4 cents per long-ton mile. In comparison, the rail rate for Lake Superior ores on long hauls, as from northern Minnesota to Pittsburgh, Pa., is about 1.0 cent per long-ton mile, and on short hauls, as from Cleveland, Ohio, to Pittsburgh, it is about 2.0 cents per long-ton mile. Lake Superior iron ores usually are moved by lower cost waterborne carriers with a unit cost of approximately 0.25 cent per long-ton mile. Total loading and unloading charge is about $0.48 per long ton.

Total rail freight charges from California and Nevada deposits to ocean port docks would vary from $2.10 to $5.70 per long ton. Ore from most deposits requires trucking to railroad loading points at an average cost of about 3.0 cents per long-ton mile.

Resource Estimation Methods

Information Sources

The Geological Survey, the California Division of Mines and Geology, and the Nevada Bureau of Mines have published comprehensive reports on California and Nevada iron resources. These references are listed in the respective chapters of this report. Additional unpublished information was obtained during World War II, when the U.S. Geological Survey and the Bureau of Mines completed extensive exploration of iron ore deposits in connection with the establishment of steel plants at Fontana, Calif., and Geneva, Utah, to supply the wartime ship-building program. Descriptions of the work on the more important iron deposits were published; unpublished reports on small deposits and occurrences are available for reference.

Following World War II many companies, including Kaiser Steel Corp., United States Steel Corp., Southern Pacific Co., The Standard Slag Co., Nevada Barth Co., Jackson Mountain Mining Co., J. R. Simplot Co., Utah Construction and Mining Co., Occidental Petroleum Co., Mineral Materials Co., and others successfully explored and developed significant iron ore resources and produced large tonnages of ore. The companies made the results of much of this work available to the Bureau of Mines for use in preparing this report.

Most properties included in the inventory were examined by the author, either to update prior reports or to obtain information on undescribed deposits.

Type of Ore Deposit Data Obtained

Information concerning location, ownership, history, past production, and general geology is available for nearly all iron properties. Available data on ore resources, anticipated mining conditions, and metallurgical characteristics of the ores were collected and analysed for all deposits. However, no new exploration or test work was undertaken.

Many deposits have been developed by systematic drilling or other physical test work, and their size and grade are known accurately. Tentative mining plans have been formulated for some ore bodies and beneficiation tests made. Estimates of the production potential on these properties are considered very reliable.

Available data on the majority of deposits consists of magnetic anomaly maps, and results of incomplete drilling programs or other development. This information is adequate for an estimate of inferred magnetite ore. The drilling indicates the grade of the ore body and its depth below the surface; the area and intensity of the anomaly is a measure of the lateral extent and size of the deposit. Reserve estimates of nonmagnetic ores, in the absence of systematic development, are made on the basis of geologic interpretation. The primary iron mineral in most California and Nevada deposits is magnetite; associated hematite is usually an oxidation product although in some deposits hematite is the dominant ore mineral. Both primary magnetite and hematite occur erratically in a few deposits. In these, the accompanying magnetic anomalies indicate the areal extent of the mineral occurrence but not its size or iron content.

Estimates of the stripping ratio are based on information on the dimensions and attitude of the ore body, the depth of overburden, and the surrounding topography. Data for the estimate of stoping costs for ore bodies requiring underground mining were obtained from surface exposures of the ore and walls and from reports of underground rock conditions. Visual inspection and data on the mineralogical composition of the ore were used to make estimates of milling cost and efficiency when no metallurgical test results were available.

Classification According to Production Costs

Production costs for undeveloped deposits are estimated by comparison with similar ore bodies that are being mined. The undeveloped deposit is compared, if possible, with an operating mine having similar production problems, and allowances are made for existing differences. The differing production difficulty for each production operation at the two properties is expressed by a ratio, and each ratio is applied to the f.o.b. costs at the operating property. The resulting estimate, plus the transportation cost to seacoast ports, gives a production cost for the deposit being evaluated.

The various cost factors have differing importance. For example, the concentration ratio and indicated plant size affect both mining and milling operations, but the stripping ratio affects only mining costs. Its effect on total costs is reduced to the proportion that unit mining costs have to unit overall costs. Similarly, differences in mineralogy would mainly affect beneficiating costs.

The normals used, and the variable cost factors, are considered in more detail in the section that follows.

Physical Factors Affecting Costs at Operating Mines

Unit productivity at mines is limited by natural conditions which are inherent with the individual ore deposit. No two ore bodies have the same difficulty of production. A close relationship exists between production costs and characteristics of the individual ore deposit such as overall size, grade of ore, stripping ratio in open cut mines, or stoping difficulty in underground mines, fineness of grind required for liberation, and concentration methods applicable. The character of ore bodies from which production is currently economic is illustrated by listing these factors for several representative producing mines (table 28).

TABLE 28. - Physical factors at operating mines and beneficiating plants

Factor	Open pit mines						Underground mines		
	Eagle Mountain	Groveland	Erie Mining Co.	Lac Jeanine	Atlantic City	Adams	Pea Ridge	Ozark	Jackson Mountain
Size of ore..million tons.. deposit (minimum).	100	100	500	1,000	100	500	100	10	2
Grade.......percent iron..	45	33.3	[1]22.5	30	[1]26.0	23	55	36	64
Hardness.................	Average	Average	Hard	Average	Average	Average	Average	Average	Average.
Stripping ratio (weight:weight).	3.2:1.0	0.2:1.0	0.5:1.0	0.8:1.0	1.0:1.0	0.5:1.0	-	-	-
Depth..............feet..	-	-	-	-	-	-	2,200	600	300
Ore width...........do...	-	-	-	-	-	-	200	100	100
Dip.............degrees..	-	-	-	-	-	-	90°	90°	65°
Wall strength............	-	-	-	-	-	-	Strong	Very strong	Moderately strong.
Mining method............	-	-	-	-	-	-	Long hole	Room and pillar.	Long hole sublevel.
Beneficiation:									
Ore minerals...........	Hematite Magnetite	Hematite Magnetite	Magnetite	Hematite	Magnetite	Magnetite	Magnetite Hematite	Hematite	Magnetite.
Fineness of grind[2]......	1 inch	28 mesh	-	10 mesh	325 mesh	-	200 mesh	1/2 inch	Lump ore.
Recovery method.........	Magnetic, jigs, heavy medium separation.	Spirals, flotation.	Magnetic	Spirals	Magnetic	Magnetic	Magnetic, flotation.	Jigging, tabling.	Magnetic, cobbing.

[1]Magnetite.
[2]Size at which first tailing is removed.

All mines except those producing direct shipping ore have large reserves, which allow large plants and long amortization periods. Grades of ore being treated successfully include 23-percent magnetic iron ore in deposits with a low stripping ratio but requiring grinding to 325-mesh; 33.3-percent hematite iron ore with a low stripping ratio requiring grinding to 28 mesh and concentration by spirals and flotation; 45-percent hematite and magnetite ore with a 3.2:1.0 stripping ratio that requires combination magnetic and gravity concentration methods; 55-percent magnetite ore with minor hematite, mined underground in open stopes requiring grinding to 200-mesh followed by magnetic and flotation concentration.

Plant Size

An important factor influencing costs is plant size. A large unit-cost advantage exists in larger plants. An estimate of relative operating costs in proposed plants ranging from 750,000 to 2,275,000 long tons per year on the same deposit are shown in table 29.

TABLE 29. - Influence of plant size on unit production cost of near-surface magnetite ore body

	Proportionate unit cost, ratios
Plant capacity, long tons per year:	
750,000	1.00
1,000,000	.90
1,500,000	.80
2,275,000	.76

These ratios are used to compare costs at operating plants with estimated costs at undeveloped properties containing reserves of different sizes. Small plants are economic only under favorable operating conditions such as: (1) Availability of direct shipping ore grades; (2) low concentrating ratios; (3) low stripping ratios; (4) easily treated coarse magnetite mill ore; (5) low transportation costs; and (6) low general overhead.

Plant size is limited by the ore reserves available. Capital requirements for an iron mine, concentrator, and pelletizing plant with productive capacity of 1.5 million tons per year are $25 to $30 per long ton of yearly capacity. At 1968 iron ore prices, plants at the large undeveloped deposits in California and Nevada would require 20-year amortization periods to recover the investment. To provide a margin for possible periods of low ore prices, an ore reserve life of 30 years is highly desirable.

Plant size is also limited by the size of the available market. Some deeply buried, very large, low-grade deposits would be economical to strip if high production rates could be maintained. These deposits cannot be utilized in present 1968 markets but greatly increased future demand could make them economic.

Iron resources in several mining areas in California and Nevada are in two or more properties, neither of which has reserves that are adequate to reason, the estimated recovery ratio on properties economic only at prices well above current levels has been assumed to be somewhat higher than that at most operating plants.

Estimates of milling difficulties at undeveloped properties were made by comparing estimated concentrating ratios with those at operating properties having the same type ore. The estimate for most deposits should be reasonably accurate as most unexploited ores are similar to those now being treated. Cost estimates for ores requiring unusual treatment were based on office studies. No new ore testing was done.

Open Pit Mining Costs

Open pit mining costs depend primarily upon the quantities of ore that must be mined and waste that must be stripped to produce one unit of concentrate. The ratio of waste stripped to final concentrate produced indicates the stripping difficulty. This ratio is the product of the stripping ratio of waste to crude ore and the concentration ratio. Mining and stripping costs also depend upon the character of the material involved, which can vary from soil movable by carryall scrapers to very hard rock in which drilling is slow even with large percussion drills or jet-piercing equipment. Since transportation costs are about one-third of open pit mining costs, haulage grades and distances to ore treatment plants or waste disposal areas are important factors. Cost differentials between a side-hill pit with hauls on level grades and a pit with transportation up switchbacks are substantial. Occasionally, other conditions such as unfavorable climate, isolated location, and high costs of power and supplies result in unusual costs. These factors were used in this study to modify comparisons of costs based on concentrating and stripping ratios at developed and undeveloped deposits.

To express relative mining and stripping difficulty as part of an overall production cost ratio, the proportion that mining costs comprise of the entire cost must be known. An analysis of this subject was made at the Groveland mine and mill (3). At this operation, which had a stripping ratio of 0.2 ton waste:1.0 ton ore and a concentration ratio of 2.1:1.0, when the study was made, the estimated unit milling costs were 3.1 times the unit mining and stripping costs. The hematite-magnetite ore required grinding to 28 mesh, followed by concentration in spirals and by flotation, and was about average in treatment difficulty.

An index figure, which indicates combined mining and milling difficulties, can be estimated for any deposit by adding the product of the concentrating ratio and the ratio of milling to mining cost to the product of the concentration ratio and the sum of 1.0 plus the waste-to-mill-ore stripping ratio. The index figure for the Groveland deposit is 9.0 ($2.1 \times 3.1 + 2.1 \times 1.2 = 9.0$). The same index would be obtained from an ore body where direct shipping ore was produced with an 8.0:1.0 stripping ratio. The factor (3.1) was used in this study to compare deposits with varying concentrating and stripping ratios if both mining and beneficiation difficulty at each property were considered about average. Allowances were made in the estimate for anticipated variations from average operating conditions.

support a plant of economic size alone. Estimates for these areas were prepared on the assumption that the deposits could be worked collectively with beneficiation in a central plant and mining operations transferred between ore bodies as desired. This centralization of operations requires additional and possibly large extra expenditures for in-process transportation although it promises the lowest overall costs. Modifications, such as preliminary cobbing of magnetite ores at mines, are possible. Other consolidations could include pelletization in a single plant at the steel mill or at the shiploading area.

Milling Costs

A very important factor influencing milling costs is the concentration ratio--the number of units of mine-run ore required to produce one unit of marketable concentrate. It is determined by the grade of ore and the recovery ratio.

The ore grade is an inherent feature of the deposit, although it can often be improved by careful mining practices to minimize dilution. Frequently, "high-grading," or mining only the best sections of the ore body, is necessary to reduce unit costs to a level that allows profitable operation. This practice may be undesirable from the long-term view.

The recovery ratio depends upon factors that influence the difficulty of concentration, and on economics, which determines the break-even point between the value of the extra metal recovered and the cost of additional treatment. The main inherent and technical factors are: The type of ore minerals present, which determines the beneficiation process; rock hardness, which influences crushing and grinding difficulty; and mineral particle size, which determines the fineness of grind required to liberate the iron mineral grains or to free impurities.

Magnetite is the predominant iron mineral in California and Nevada deposits and for most deposits a straight magnetic recovery method is indicated. Several important deposits contain both magnetite and hard hematite and these require a combination milling method using both magnetic and gravity methods to give the highest recovery. If the hematite content of a complex ore is low it is usually uneconomic to recover it. The overall iron recovery in these ores may be low although the recovery of magnetic iron minerals is satisfactory. Hard hematite ores containing subordinate amounts of magnetite are often treated only by gravity methods, which are equally effective on magnetite. Soft hematite ores are of little importance in California and Nevada; in other States they are upgraded in washing plants.

Recovery ratios in iron ore beneficiating plants vary depending upon the mineralogical character of the ore. On straight magnetic ores, magnetic separation methods usually achieve recoveries of 90 to 95 percent or higher; gravity and flotation methods permit recoveries ranging from 70 to 85 percent on hard hematite ores. Washing plants, used on soft ores, recover 45 to 70 percent of the iron. The recovery ratio depends to a large extent upon economics. Higher iron ore prices would permit further treatment of material discarded as final tailings and result in higher overall recovery. For this

Underground Mining Costs

Most of the world's iron ore is produced in open pit mines; however, both direct shipping ore and milling ore, with concentration ratios as high as 2.0:1.0, are being mined by underground methods. Significant quantities of direct shipping ore have been produced by underground methods in California and Nevada where f.o.b. mine prices range from $4 to $7 per long ton. Milling ore that requires lower unit costs has not been mined underground in these States, but it would be feasible under favorable conditions.

Studies indicate that in underground mines with ores having a concentration ratio of 2.0:1.0 about 45 percent of the operating costs are chargeable to beneficiation and about 55 percent to mining. On this basis, mining costs, plus their proportion of profit, could be as high as $4.18 per ton of concentrate; at a concentration ratio of 2.0:1.0, costs plus profit would be $2.09 per long ton of milling ore. Such costs are attainable if stopes do not require ground support and if large-capacity drilling, loading, and haulage equipment can be used. Room and pillar, sublevel, and other open stope methods would be practical in firm ground. Block caving would be feasible in heavily fractured ore bodies.

Based on a study of production costs at various mines, the break-even point between underground production in a favorable underground environment and open pit production is reached at a stripping ratio of about 4.0:1.0.

Pelletizing Costs

Pelletizing costs are more uniform than mining or milling costs. Concentrates, which comprise the feed for the process, are similar and the operations at all regional plants should be comparable. Costs differ because of varying charges for fuel, power, and labor because of differences in plant size and efficiency and because of ore characteristics.

The California published price for pellets is about $1.80 per long ton above the price of sinter concentrates of the same grade and regional pelletizing costs are no more than this amount. Lower costs have been reported from plants outside of California and Nevada.

Transportation Costs

Most California-Nevada iron ore is marketed at the Fontana steel plant or at ports on San Francisco Bay or Los Angeles harbor; the mine-to-market transportation charge must be added to the f.o.b. mine cost to obtain the estimated delivered price at which production from a specific ore body is feasible.

California-Nevada Iron Ore Resources

Based on collected resource and production cost data, an estimate was made of the total iron resources of California and Nevada. Table 30 shows the quantity of 64-percent iron pellets producible under 1968 technological methods and cost levels at west coast prices of $15, $20, and $25 per long ton. The resources available are mainly in the form of milling ores that probably will be beneficiated and marketed as pellets. Current shipments consist of pellets, concentrates, and direct shipping lump ores containing 57 to 62 percent iron.

TABLE 30. - California-Nevada iron ore resources

	Quantity of 64-percent iron pellets recoverable from measured, indicated, and inferred resources (cumulative), long tons
Price of 64-percent iron pellets f.o.b. San Francisco or Los Angeles ports, dollars:	
$15.00	585,000,000
20.00	1,300,000,000
25.00	1,580,000,000

Reported reserves of iron ore producible at prices exceeding $25 per long ton are small. This is due to lack of interest in low-grade iron resources rather than nonexistence of the resources. A similar tendency is apparent to a lesser extent in ores producible at prices more than $15 per long ton. At the 1968 export price of $12.30 per long ton for 64-percent iron pellets, the resources producible at less than $15 per long ton are either commercial, or nearly so, and have been more thoroughly developed than presently noneconomic deposits. Intensive development has usually increased reserves above the original estimates of inferred ore based on surface examination, geomagnetic prospecting, and exploratory drilling.

Future discoveries will add to resources but the rate of discovery will probably be lower than in the past because iron deposits are relatively easy to find. Economic deposits are usually large; the weight and physical characteristics of the ore are evident; the ores are usually more resistant to erosion than the surrounding rocks, which results in bold outcrops and surface accumulations of iron minerals; and the principal iron ore mineral in the region is strongly magnetic and can be detected by magnetic prospecting. Most outcropping iron ore deposits were located during the early period of mineral prospecting many decades before a significant market for iron ore existed in California. The most geologically promising districts were explored by ground and airborne magnetometer surveys subsequent to World War II, and the most easily discovered buried ore bodies were located.

Conclusions

The total known California-Nevada iron resources in 1968 producible as 64-percent iron pellets at less than $15 per long ton are 1.9 times the predicted total demand of 302 million tons of iron ore needed by the California iron and steel industry to the year 2000. Total reserves producible at less than $20 per long ton are over 4.0 times the predicted demand to that date.

Reserves are adequate to provide a strong resource base for the California steel industry and to continue exports at the 1967 level of 3.6 million long tons per year. However, resources producible at less than $15 per ton are insufficient to support a large increase in exports.

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CHAPTER 5.--IRON OCCURRENCES IN CALIFORNIA

History and Production

The first reported use of California iron ore was in 1869-77 when ore was shipped from the Coso and Slate Ranges in Inyo County to smelters at Darwin, Keeler, and Modoc for use as flux in treating siliceous gold-silver ores.

The first recorded use of California ores for the production of iron was at the Hotaling mine in Placer County where an estimated 40,000 tons was mined and utilized during 1881-86. All of California's known major iron districts had been discovered by 1951, including the Eagle Mountain deposit in Riverside County, the Lake Hawley and Spencer Lake deposits in Sierra County, the Pit River deposits in Shasta County, the Iron Mountain, the Beck, Cave Canyon, Iron Age, Silver Lake, and Vulcan deposits in San Bernardino County, and the Minarets iron deposit in Madera County. The Eagle Mountain area contains California's largest known reserves of iron ore.

From the closure of the Hotaling mine in 1886 until 1907, only small quantities of ore were produced in California for smelter flux and foundry use. During 1907-18 an estimated 15,000 tons of magnetite ore was produced from Shasta County deposits for use in an electric iron reduction plant at Baird, Calif. From 1918 through 1933, about 3,500 tons of iron ore was produced.

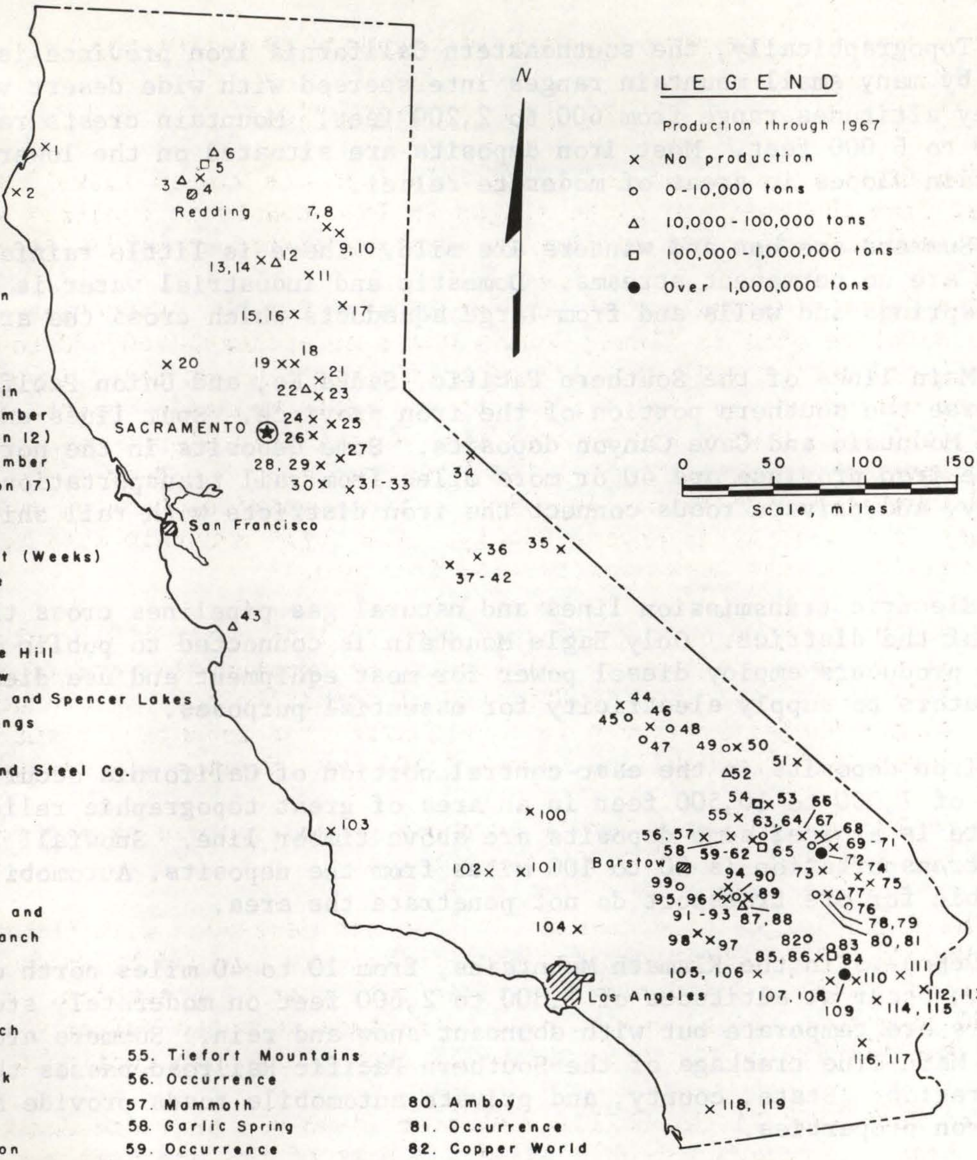
From 1934 until World War II iron ore production was mainly for use in cement and averaged about 20,000 ton per year.

The first large-scale demand for iron ore developed with the coming of World War II. A primary iron and steel plant was erected by Kaiser Steel Corp. at Fontana, Calif., and during its first full year of operation, in 1943, 636,000 long tons of ore was shipped to Fontana from the Vulcan mine near Kelso, San Bernardino County. Shipments from the Vulcan continued until 1949.

The World War II shipbuilding program (1943-45) provided demand for iron ore as heavy aggregate for ship ballast. Most of the ore used was magnetite mined in Shasta County and concentrate recovered from beach sands near Santa Cruz. In 1948 the Eagle Mountain mine commenced operation. Shipments since 1948 have increased steadily. In 1967, Skillings' Mining Review reported that shipments from the Eagle Mountain and Iron Age mines, which included nearly all the State's production, totaled 6,186,000 tons. Exports in 1967 were more than 3 million tons.

Geography

California's iron resources occur principally in the southeastern portion of the State throughout an iron-bearing province that extends about 200 miles in a north-south direction and 80 miles in an east-west direction in Riverside, San Bernardino, and Inyo Counties. Other important deposits are in the mountainous east-central part of the State and in the Klamath Mountains of northern California (fig. 11).



1. Preston
2. Centerville
3. Iron Mountain
4. Grey Rock
5. Shasta and California
6. Hirz Mountain
7. Red River Lumber Co. (Section 12)
8. Red River Lumber Co. (Section 17)
9. Bonner
10. Brown
11. Chicken Flat (Weeks)
12. Rusty Ridge
13. Martin
14. Remple
15. Barton House Hill
16. Steep Hollow
17. Lake Hawley and Spencer Lakes
18. Indian Springs
19. Dempsey
20. Yolo Iron and Steel Co.
21. Weimar
22. Hotaling
23. Clipper Gap
24. Reliance
25. Gutenberger
26. Sixtie Chaix and Simons Ranch
27. Clinton
28. Thomas
29. Ione
30. Iron Monarch
31. Ponderosa
32. Indian Creek
33. Big Trees
34. Wilson
35. Churchill Iron
36. Minarets
37. Red Top (Detroit)
38. Morning Star
39. Wedge (Last Chance)
40. Bradley
41. Hart
42. Rising Sun
43. Aptos Beach Sand
44. Le Cyr (Valley View)
45. Coso
46. Millspaugh (Big 4)
47. Iron Chief and Ferro
48. Iron Cap (Hoot Owl)
49. Mister
50. Raven
51. Kingston (Beck, Iron Gossan)
52. Black Magic (Owl Hole)
53. Iron King
54. Iron Mountain
55. Tiefort Mountains
56. Occurrence
57. Mammoth
58. Garlic Spring
59. Occurrence
60. Occurrence
61. Arrowhead Lode
62. Meir
63. Cronese
64. Cave Mountain
65. Cave Canyon
66. Old Dad Mountain (Reat, Riet)
67. Iron Hand
68. Specular
69. Providence
70. Burro
71. Cornfield Spring
72. Vulcan
73. Iron Victory
74. Occurrence
75. Occurrence
76. Ship Mountain (Paul)
77. Iron Hat
78. Occurrence
79. Black Jack
80. Amboy
81. Occurrence
82. Copper World
83. Iron Age
84. Iron Age Extension
85. Doris
86. Niggerhead
87. Morris Lode (Van Buren)
88. Bessemer
89. New Bessemer (Alarm)
90. Ebony
91. Ord
92. Man
93. Cat
94. Occurrence
95. Ord Mountain
96. Ball (Red Seal)
97. Iron King (Big Bear Lake)
98. Desert View
99. Altuda (Globerson)
100. Mount Breckenridge
101. Lake Castaic
102. San Emigdio
103. Prefumo (McKinney)
104. Titaniferous Magnetite Deposits
105. East Wide Canyon
106. Sulfide Bismuth
107. Storm-Jade Mountain
108. Iron Chief (Black Eagle)
109. Eagle Mountain
110. Desert Eagle
111. Little Maria
112. Maria Mountains
113. Lindy Loop No. 1
114. Iron Cap (Iron King)
115. Iron King (Iron Queen)
116. Churchill and Amos
117. Huddleson and Jackson
118. El Cajon
119. Lake Side.

FIGURE 11. - Iron Occurrences in California.

Topographically, the southeastern California iron province is characterized by many small mountain ranges interspersed with wide desert valleys. Valley altitudes range from 600 to 2,200 feet. Mountain crests range from 2,000 to 6,000 feet. Most iron deposits are situated on the lower portion of mountain slopes in areas of moderate relief.

Summers are hot and winters are mild. There is little rainfall and there are no permanent streams. Domestic and industrial water is obtained from springs and wells and from large aqueducts which cross the area.

Main lines of the Southern Pacific, Santa Fe, and Union Pacific railroads traverse the southern portion of the iron province. Spur lines extend to the Eagle Mountain and Cave Canyon deposits. Some deposits in the northern end of the iron province are 40 or more miles from rail transportation. State, county, and private roads connect the iron districts with rail shipping points.

Electric transmission lines and natural gas pipelines cross the southern part of the district. Only Eagle Mountain is connected to public utilities. Other producers employ diesel power for most equipment and use diesel-powered generators to supply electricity for essential purposes.

Iron deposits in the east-central portion of California occur at altitudes of 7,000 to 10,500 feet in an area of great topographic relief. The climate is alpine; some deposits are above timber line. Snowfall is heavy. Rail transportation is 50 to 100 miles from the deposits. Automobile roads suitable for ore transport do not penetrate the area.

Deposits in the Klamath Mountains, from 10 to 40 miles north of Redding, Calif., occur at altitudes of 1,300 to 2,600 feet on moderately steep slopes. Winters are temperate but with abundant snow and rain. Summers are warm and dry. Main-line trackage of the Southern Pacific Railroad passes through this iron region. State, county, and private automobile roads provide access to the iron properties.

Geology

California's iron-ore occurrences, except for one sedimentary deposit and beach-sand deposits, are of primary igneous origin. They are classed as pyrometasomatic, replacement, or hydrothermal, depending upon the extent of wall rock replacement, the mineral assemblage, and their distance from the related intrusive.

Magnetite is the predominant primary ore mineral although weathering has altered large quantities of magnetite to hematite. Oxidation usually occurs near the surface but may extend to considerable depths through action of circulating meteoric waters. Sulfur, in the form of pyrite, occurs as a primary constituent in most deposits; however, weathering generally has removed it near the surface. Phosphorus and other contaminants are seldom a problem in California ores.

Areas and Properties

The following descriptions of the principal deposits are arranged according to areas and counties. Geographical areas that have reported significant production or that are known to contain substantial iron resources are treated as units for purposes of economic evaluation. Descriptions of deposits within each economic area are included in their area. Deposits outside the main areas are reported by counties. A table listing all significant occurrences of iron properties is included. It provides data on the property name, survey location, ore production, development, mode of occurrence, reported owner, and lists the appropriate reference number in the chaper bibliography (table 31). Much of this table information is not repeated in the text.

Sources of data and methods used to estimate resources and costs are presented and explained in chapter 4. Most resources estimates of thoroughly explored properties were taken from reports of the U.S. Geological Survey or from private geologists. Resource estimates for partially explored areas were usually unavailable and estimates for these areas were made by the author using magnetic anomaly maps, results of incomplete drilling (if available), and geologic inferences. Estimates of production costs were made by the author after studying mining and metallurgical characteristics. It was assumed for the production cost estimates that all ore bodies in each area could be operated jointly at the most efficient overall production rate.

TABLE 31. - California iron properties

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	AMADOR COUNTY					
Clinton	Sec 8, T 6 N, R 12 E.	None.	Road cuts, float.	Residual limonite capping.	Unknown.	(6)
Ione (Rancho Arroyo Seco)	Secs 27, 28, T 6 N, R 9 E.	do.	Shallow pits.	do.	do.	(6)
Thomas	Secs 16, 17, T 5 N, R 10 E.	do.	Wagon drill holes, trenches.	do.	do.	(6)
	BUTTE COUNTY					
Barton House Hill	Sec 25, T 20 N, R 7 E.	do.	Road cut.	Boulders of iron ore.	do.	-
Martin	Sec 5, T 25 N, R 4 E.	do.	Trenches, test pit.	Magnetite in vein.	do.	-
Remple	Secs 8, 9, T 25 N, R 4 E.	do.	Unknown.	Magnetite float along basic dikes.	John Remple.	-
Rusty Ridge	Sec 30, T 25 N, R 5 E.	Small.	Open pit.	Magnetite replacement in shaly limestone near granite.	R. A. Frénch; S. A. Breyfoygle.	-
Steep Hollow	Sec 28, T 20 N, R 7 E.	None.	Unknown.	Hematite in wide vein.	Unknown.	-
	CALAVERAS COUNTY					
Big Trees (Calaveras, Sperry)	Secs 31, 32, T 4 N, R 14 E.	do.	Three adits.	Limonite in breccia zone.	Sperry Estate.	(8)
Indian Creek	Sec 34, T 4 N, R 13 E.	do.	Unknown.	Limonite pods in quartz-mica schist.	Unknown.	(8)
Iron Monarch (Detert)	Sec 11, T 4 N, R 10 E.	do.	Shallow pits, trenches.	Residual limonite capping.	do.	(8)
Ponderosa	Sec 2, T 3 N, R 13 E.	do.	Test pit.	Thin layers of magnetite in antigorite.	do.	(8)
	EL DORADO COUNTY					
Gutenberger	Sec 35, T 10 N, R 11 E.	do.	Unknown.	Boulder of limonite.	Gutenberger Ranch.	(7)
Reliance	Sec 18, T 10 N, R 9 E.	do.	Shallow shafts.	Magnetite vein in gabbro.	Unknown.	(7)
Sixtie Chaix and Simons Ranch	Secs 13, 14, T 8 N, R 9 E.	do.	do.	Lenses of siliceous hematite and magnetite in serpentine.	do.	(7)

	HUMBOLDT COUNTY					
Centerville	Sec 2, T 1 N, R 3 W.	do.	Unknown.	8-foot vein of low-grade hematite at ocean edge.	do.	-
Preston	Sec 28, T 6 N, R 1 E.	do.	Shallow shaft, short adit, and test pits.	11-foot vein siliceous hematite.	do.	-
	IMPERIAL COUNTY					
Churchill and Amos	Sec 33, T 9 S, R 16 E.	do.	Unknown.	Magnetite float.	do.	-
Huddleson and Jackson	Sec 33, T 9 S, R 16 E.	do.	do.	Residual limonite capping on basalt.	do.	-
	INYO COUNTY					
Coso	Secs 9, 10, 11, 14, 15, 16, T 20 S, R 39 E.	Small.	Open pits.	Hematite and magnetite veins in granite.	G. W. Dow.	(21)
Iron Cap (Hoot Owl)	Sec 21 or 29, T 22 S, R 43 E.	More than 3,000.	150-foot shaft, 300-foot adit, open cut mine.	Hematite and magnetite replacement in limestone along granite contact.	Norman A. Whittaker.	(21)
Iron Chief and Ferro	Sec 13, T 23 S, R 41 E; Sec 18, T 23 S, R 42 E.	Small.	Test pits.	Hematite veins in granite.	J. T. McCord.	(21)
Le Cyr (Valley View)	Sec 1, T 19 S, R 38 E.	None.	Adit.	Two hematite veins in brecciated limestone.	Norman A. Whittaker.	(21)
Millspaugh (Big 4)	Sec 9, T 22 S, R 42 E.	Small.	Small open cut.	Small irregular lenses of hematite and magnetite in granite.	Nathan Burton.	(21)
Mister Group	Sec 24, T 21 N, R 4 E.	300	3 short adits, open cuts.	Low-grade zone of specular hematite in granite gneiss.	Lance Smith.	(21)
Raven	Sec 20, approximate, T 21 N, R 5 E.	None.	Unknown.	Specular hematite in granite gneiss.	F. L. Collins.	(21)
	KERN COUNTY					
Lake Castaic	Sec 33, T 9 N, R 18 W.	do.	Test pits.	Small lenses of hematite and manganese oxides in limestone.	Tejon Ranch.	-
Mount Breckenridge	Sec 4, T 29 S, R 31 E.	do.	do.	Hematite in mica schist.	Unknown.	(29)
San Emigdio	Sec 17, T 9 N, R 21 W.	do.	Unknown.	Magnetite.	do.	(29)
	LAKE COUNTY					
Yolo Iron and Steel Co.	Secs 31, 32, T 15 N, R 6 W; Secs 5, 6, T 14 N, R 6 W.	Unknown.	do.	Unknown.	Yolo Iron and Steel.	-

TABLE 31. - California iron properties--Continued

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	LASSEN COUNTY					
Red River Lumber Co., Sec. 12	Sec 12, T 28 N, R 9 E.	None.	Copper prospect shallow shaft trenches.	Hematite replacement and and disseminations in diorite porphyry.	Red River Lumber Co.	-
Red River Lumber Co., Sec. 17	Secs 17, 18, T 28 N, R 10 E.	do.	Trenches.	do.	do.	-
	LOS ANGELES COUNTY					
Titaniferous magnetite	T 4 N, R 14 W; T 4 N, R 13 W; T 3 N, R 14 W; T 3 N, R 13 W; T 3 N, R 12 W.	Ilmenite (small).	More than 36 prospects.	Irregular bodies of titaniferous magnetite in anorthosite.	Various.	(3, 11)
	MADERA COUNTY					
Bradley	Sec 15, T 5 S, R 22 E.	None.	Test pits, diamond drilling.	Replacement, lenses of magnetite and martite in limy quartzite.	Ann Drury Bradley, and others.	-
Hart	Secs 14, 15, 22, 23, T 5 S, R 22 E.	do.	do.	do.	Ruth and Helen Rotherham.	(20)
Minarets	Sec 1, T 4 S, R 25 E; Sec 7, T 4 S, R 26 E.	do.	Diamond drill holes, trenches.	Lenses of magnetite in dacite.	Noble Electric Steel Co.	(3, 21)
Morning Star	Secs 1, 12, T 5 S R 22 E; Secs 6, 7, T 5 S, R 23 E.	do.	Trenches.	Lenses of magnetite and sulfides along quartzite granodiorite contact.	Vulcan Copper Co.	(20)
Red Top (Detroit)	Sec 36, T 4 S, R 23 E.	do.	do.	Magnetite replacement of limestone at granite content.	Otis Teaford.	-
Rising Sun (Dexter)	Sec 14, T 5 S, R 22 E.	do.	Diamond drill holes, trenches.	Magnetite and iron sulfides along quartzite granodiorite content.	Vulcan Copper Co.	(20)
Wedge (Last Chance)	Sec 9, T 5 S, R 22 E.	do.	Test pits, diamond drilling.	Replacement lenses of magnetite and martite in limy quartzite.	Otis Teaford.	(20)
	MONO COUNTY					
Churchill	Sec 14, T 4 S, R 33 E.	do.	Trenches.	Magnetite veins in quartzite and replacement in gabbro dike.	Z. H. Churchill.	-
Wilson	Secs 7, 18, T 7 N, R 24 E.	do.	Trenches, hammer drill holes.	Mineralized fracture zone in metavolcanic rocks.	Dieu Wilson.	-

	NEVADA COUNTY					
Indian Springs	Sec 4, T 15 N, R 7 E.	Small (for pigments).	Copper mine, pits.	Gossan from pyrite ore body.	U.S. Smelting Refining and Mining Co.	(19)
	PLACER COUNTY					
Clipper Gap	Sec 13, T 13 N, R 8 E.	Small.	Small open pit.	Hematite lens.	Pacific Gas and Electric Co.	-
Hotaling	Secs 9, 10, 15, 16, T 13 N, R 8 E.	40,000	Two shafts, open cut.	Magnetite replacements in quartzite along diabase contact.	Alvin C. Wold.	(4, 13)
Weimar	Sec 21, T 14 N, R 9 E.	None.	Unknown.	Small lens of magnetite at slate-serpentine contact.	Southern Pacific Co.	-
	PLUMAS COUNTY					
Bonner	Sec 1, T 27 N, R 10 E.	Small.	Pit, trenches.	Magnetite veins and lenses in andesite porphyry.	Jack King.	-
Brown	Sec 1, T 27 N, R 10 E.	do.	Trenches.	Magnetite in small veins and as abundant float in andesite area.	John Holstrom.	-
Chicken Flat (Weeks)	Sec 33, T 24 N, R 8 E.	None.	Unknown.	Hematite in narrow siliceous veins in schist.	S. R. Weeks.	-
	RIVERSIDE COUNTY					
Desert Eagle	Secs 31, 32, T 3 S, R 15 E.	do.	Extensive drilling.	Magnetite and hematite in limestone.	United States Steel Corp.; Kaiser Steel Corp.	(3)
Eagle Mountain	T 3 S, R 14 E; T 3 S, R 15 E.	Large.	Large open pit mine, extensive drilling.	Magnetite and hematite replacement in limestone.	Kaiser Steel Corp.	(3)
East Wide Canyon	Sec 17, T 2 S, R 6 E.	None	None.	Magnetite and ilmenite in lenses and layers in gneiss.	Southern Pacific Co.	-
Iron Cap	Sec 19, T 5 S, R 18 E.	do.	Trench and test pits.	Magnetite in shear zone with contact silicates.	J. O'Connell.	(28)
Iron Chief (Black Eagle)	Secs 30, 31, T 3 S, R 14 E; Sec 36, T 3 S, R 13 E.	do.	Sulfide gold mine and lead silver mine.	Sulfide gossan.	Kaiser Steel Corp.	-
Iron King	Secs 21, 28, T 5 S, R 18 E.	do.	Trenches.	Magnetite lenses in fault zone.	J. O'Connell.	(28)
Little Maria	Sec 29, T 3 S, R 20 E.	do.	Unknown.	Magnetite replacement in limestone.	Unknown.	-
Lindy Loop No. 1	Sec 36, T 4 S, R 22 E.	do.	Trenches and pits.	Hematite in veins along fault contact.	Alfred E. Lindburgh.	-

TABLE 31. - California iron properties--Continued

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	RIVERSIDE COUNTY--Continued					
Maria Mountains	Sec 14, T 4 S, R 22 E.	None.	30-foot adit and trenches.	Magnetite replacement in dolomite.	J. O'Connell.	-
Storm-Jade Mountain	Sec 33, T 3 S, R 13 E.	Small.	Underground.	Unknown.	Barry Storm.	-
Sulfide Bismuth	Sec 11, T 2 S, R 7 E.	None.	200-foot adit, 75-foot adit, and 100-foot shaft.	Magnetite rich sulfide body in gneiss.	Joshua Tree National Monument.	-
	SAN BERNARDINO COUNTY					
Altuda (Globerson)	Sec 1, T 7 N, R 3 W.	100	50-foot shaft pits and trenches.	Hematite veins and replacements along shear zones in metavolcanic rocks.	Nathan Globerson; Robert Gold.	(1, 32)
Amboy	Secs 7, 18, T 6 N, R 12 E.	None.	Open cut and trenches.	Small hematite lenses in limestone near granite contact.	Conn Pulos.	(32)
Arrowhead Lode	Sec 28, T 12 N, R 6 E.	do.	Trenches.	Disseminated magnetite in vein in fine-grained diorite.	Henry L. Miller, and others.	-
Ball (Red Seal)	Sec 4, T 6 N, R 2 W.	do.	Short adits and trenches.	Small magnetite replacements in dolomite.	O. H. Ball.	(1, 32)
Bessemer	Secs 27, 28, T 6 N, R 4 E.	28,000	Diamond drilling; open cut mine.	Magnetite veins and replacements in dolomite near granite contact.	Kaiser Steel Corp.	(3, 27, 30, 32).
Black Jack	Sec 30, T 6 N, R 13 E.	Small.	Open cut.	Replacements in dolomite near granite contact.	J. W. Gray.	(32)
Black Magic (Owl Hole)	Sec 9, T 18 N, R 3 E.	Several thousand.	Trenching.	Hematite replacement in limestone near granite.	Harold W. Orwig.	(32)
Burro	Secs 24, 25, T 10 N, R 13 E. Secs 19, 30, T 10 N, R 14 E.	None.	Diamond drill holes.	Magnetite and hematite replacement of limestone.	United States Steel Corp.	-
Cat	Sec 32, T 7 N, R 3 E.	do.	do.	Unknown.	do.	-
Cave Canyon	Secs 11, 12, 13, T 11 N, R 6 E.	Moderate.	Open cut mine.	Magnetite and hematite replacements in gneiss, quartzite, and limestone.	California Portland Cement Co. and Southern Pacific Co.	(3, 32)

Cave Mountain	Sec 20, T 12 N, R 6 E.	Small.	Small open pits.	Small bodies of magnetite.	Frank Thomas.	(32)
Copper World	Sec 23, T 2 N, R 11 E.	1,000	Short adit and surface cuts.	Magnetite and hematite veins in quartz diorite.	Arthur C. Becker.	(27, 32)
Cornfield Spring	Sec 11, T 10 N, R 14 E.	None.	600-foot adit.	Specular hematite replacement in limestone.	Unknown.	(15, 32)
Cronese	Sec 33, T 12 N, R 6 E.	Small.	Trenches, pits.	Magnetite and hematite replacement along fault in biotite diorite.	Southern Pacific Co.	-
Desert View	Sec 27, T 3 N, R 1 W.	None.	Gold property.	Lens of specularite in skarn.	Unknown.	(12)
Doris	Sec 36, T 1 S, R 12 E.	do.	3 adits; open cut.	Kidneys of magnetite in large fault-fissure in quartz diorite.	do.	-
Ebony	Sec 15, T 6 N, R 4 E.	Several thousand.	Open cut mine.	Magnetite veins in dolomite near granite contact.	Julius Holmes.	(3, 32)
Garlic Spring	Sec 11, T 12 N, R 3 E.	None.	Unknown.	Magnetite.	Unknown.	(32)
Iron Age	Secs 20, 29, T 1 S, R 13 E.	More than 850,000.	Large open pit mine; diamond drilling; adits.	Parallel veins of magnetite and hematite in granite.	American Exploration Co.	(14, 32)
Iron Age Extension	Sec 19, T 1 S, R 13 E.	Small.	2 adits.	Magnetite and hematite in veins in andesite near monzonite contact.	James Hill.	(27, 32)
Iron Hand	Sec --, T 12 N, R 12 E.	None.	Unknown.	Lenses of magnetite and hematite in limestone near monzonite intrusive.	Robert McCanley.	(32)
Iron Hat (Ironclad)	Secs 17, 18, 19, 20, 21, T 6 N, R 14 E.	More than 2,000.	Open cuts; haulage adits; diamond drilling.	Magnetite in irregular replacements along dolomite; granite contacts.	Riverside Cement Co.	(3, 32)
Iron King	Secs 18, 19, T 15 N, R 7 E.	None.	Trenching and stripping.	Contact metamorphic replacement of limestone breccia by hematite and magnetite.	Kaiser Steel Corp.	(3, 32)
Iron King (Big Bear Lake)	Sec 6, T 2 N, R 1 E.	do.	Unknown.	Small pods of magnetite in jointing.	W. R. Shay.	-
Iron Mountain (Silver Lake)	Secs 11, 12, 13, 14, T 15 N, R 6 E.	Moderate.	Diamond drilling; open cut mine.	Magnetite and hematite replacement in limestone, breccia.	Kaiser Steel Corp.	(3, 31, 32)
Iron Victory	Sec 2, T 8 N, R 12 E.	None.	Trenches.	Magnetite and hematite in contact metamorphic deposit.	Gustav A. Overstrom.	(32)
Kingston (Beck, Iron Gossan)	Secs 31, 32, 33, T 20 N, R 10 E.	do.	Diamond drill holes; trenches.	Magnetite and secondary hematite in limestone at amphibolite contact.	Standard Slag Co.	(3, 15, 32)

TABLE 31. - California iron properties--Continued

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	SAN BERNARDINO COUNTY--Continued					
Man	Sec 4, T 6 N, R 3 E.	None.	Diamond drill holes.	Unknown.	United States Steel Corp.	-
Mammoth Group	Sec 27, T 32 S, R 47 E; Sec 19, T 12 N, R 1 E.	do.	Unknown.	do.	Harry Koenig	(32)
Meir Group	Secs 28, 29, T 12 N, R 6 E.	do.	Trenches.	Hematite in 1- to 6-foot veins in metamorphic rock near granite contact.	Albert Droubie.	-
Morris Lode (Van Buren Group)	Sec 12, T 5 N, R 4 E; Sec 7, T 5 N, R 5 E.	More than 17,500.	Diamond drilling; extensive stripping; test pits; open cut mine.	Irregular magnetite replacements in dolomite.	Kaiser Steel Corp.	(3, 27, 30, 32).
New Bessemer (Alarm)	Sec 36, T 6 N, R 4 E; Sec 1, T 5 N, R 4 E.	None.	Trenches; inclines; test pits.	Tiny magnetite veins along granite; dolomite contact.	Unknown.	(3)
Niggerhead	Sec 25, T 1 S, R 12 E.	do.	80-foot shaft; open cuts; adit.	Hematite and magnetite veins in quartz diorite.	Henry Olson.	(27)
Old Dad Mountain (Reat, Riet)	Sec 13, T 12 N, R 10 E.	do.	Adits, pits.	Magnetite and hematite replacement in limestone near monzonite contact.	Mineral Materials Co.	(3, 32)
Ord	Secs 3, 10, 11, T 6 N, R 3 E.	do.	Diamond drill holes.	Unknown.	United States Steel Corp.	-
Ord Mountain	Secs 5, 6, T 7 N, R 2 E.	do.	Unknown.	Magnetite lenses in marble inclusions in quartz monzonite.	Southern Pacific Co.	-
Providence	Sec 34, T 11 N, R 13 E.	do.	do.	Unknown.	Unknown.	(32)
Specular	Sec 11, T 11 N, R 12 E.	200	Adit, test pits.	Vein of specular hematite in dolomite.	do.	(32)
Ship Mountain (Paul)	Secs 11. 12, T 5 N, R 15 E.	1,500	365-foot incline; 830 feet of drifts; trenches; pits.	Hematite vein in chloritic schist.	I. F. Crosby; C. A. Palmer; Earl W. Paul.	(3, 32)
Tieford Mountains	Sec 22, T 14 N, R 4 E.	None.	Two short adits; 15-foot pit.	Hematite vein in greissaid granite.	John H. Whitlock.	(32)
Vulcan	Sec 25, T 10 N, R 13 E.	2,643,000	Extensive drilling; large open cut mine.	Magnetite and hematite replacement in limestone.	Kaiser Steel Corp.	(3, 5, 23, 32).

None; occurrence	Sec 9, T 11 N, R 6 E.	None.	None.	Hematite and magnetite vein in granite gneiss.	Unknown.	-
Do.	Sec 12, T 7 N, R 17 E.	do.	Pits.	Zone of 1-foot-wide bands of magnetite in schist.	do.	-
Do.	Sec 17, T 6 N, R 12 E.	1,000	Small open pit.	Magnetite replacement in marble near syenite contact.	Southern Pacific Co.	-
Do.	Sec 18, T 12 N, R 1 E.	None.	Unknown.	Magnetite and hematite disseminations in silicified dolomitic marble.	Unknown.	-
Do.	Sec 19, T 6 N, R 14 E.	do.	5-diamond drill holes.	Magnetic anomaly.	United States Steel Corp.	-
Do.	Sec 29, T 12 N, R 6 E.	do.	30-foot adit; trenches.	Hematite stringers in mixed metamorphic and granitic rocks.	Southern Pacific Co.	-
Do.	Sec 30, T 8 N, R 16 E.	do.	Pit.	Magnetite as small irregular body in 5-foot shear zone in gneiss.	Unknown.	-
Do.	Sec 33, T 8 N, R 3 E.	do.	Pits.	Magnetite and hematite in 10-foot vein, between marble and quartz monzonite.	Southern Pacific Co.	-
	SAN DIEGO COUNTY					
El Cajon	T 15 S, R 2 E.	do.	Shallow pit; trenches; drill hole.	Small magnetite lenses along fissure zone in granite.	Edward Fletcher.	-
Lake Side Group	Sec 1, T 15 S, R 1 E.	do.	Trenches.	Float boulders of magnetite in granite area.	M. C. Harding.	-
	SAN LUIS OBISPO COUNTY					
Prefumo (McKinney)	Sec 6, T 31 S, R 12 E; Sec 1, T 31 S, R 11 E; Sec 36, T 30 S, R 11 E.	Small.	Test pits.	Sedimentary limonite.	Mrs. Ada Prefumo, G. J. Johe.	(10, 18)
	SANTA CRUZ COUNTY					
Aptos Beach Sand	Pajaro River to Soquel Pt.	10,000	Pits.	Beach sands.	Unknown.	(16)
	SHASTA COUNTY					
Hirz Mountain	Secs 5, 6, 7, 8, T 35 N, R 3 W.	Moderate.	Surface pits; magnetic survey.	Magnetite replacement of limestone along quartz diorite contact.	Don Clifton.	(3)

TABLE 31. - California iron properties--Continued

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
SHASTA COUNTY--Continued						
Shasta and California	Sec 26, T 34 N, R 4 W.	More than 300,000.	Open pit mine, diamond drilling.	Magnetite replacement of limestone along diorite contact.	Shasta Iron Co.; California Cons. Mines.	(3, 24)
Iron Mountain	Secs 34, 35, T 33 N, R 6 W.	Moderate.	Open cuts.	Magnetite as lenses in rhyolite 700 feet south of sulfide body.	Mountain Copper Co.	(17)
Grey Rock	Sec 3, T 33 N, R 4 W.	None.	Short adits; drift.	Magnetite and pyrite along limestone-igneous intrusive contact.	Unknown.	-
SIERRA COUNTY						
Lake Hawley and Spencer Lake.	Secs 11, 14, 23, T 21 N, R 11 E.	do.	None.	Magnetite in irregular lenses.	Sierra Iron Co.	(3)
YUBA COUNTY						
Dempsey	Sec 3, T 15 N, R 6 E.	Pigments.	Shafts and underground workings.	Limonite gossan from pyrite body.	K. M. Dempsey.	-

Baker-Kelso Area

Mines in the Baker-Kelso iron area of northeastern San Bernardino County occur in four main localities--30 airline miles southeast, 35 miles north, 25 miles southwest, and 15 miles northwest of Baker (fig. 12). Production has been substantial, but no mines were in operation in 1968. The ore has been used mainly at the Kaiser Steel Corp. Fontana plant; smaller quantities were consumed in the manufacture of low-heat portland cement.

The deposits are moderate in size and cannot profitably utilize the large-scale equipment necessary to achieve competitively low mining costs; however, collectively, they have iron resources adequate to maintain a large production. They could use joint concentrating and pelletizing facilities.

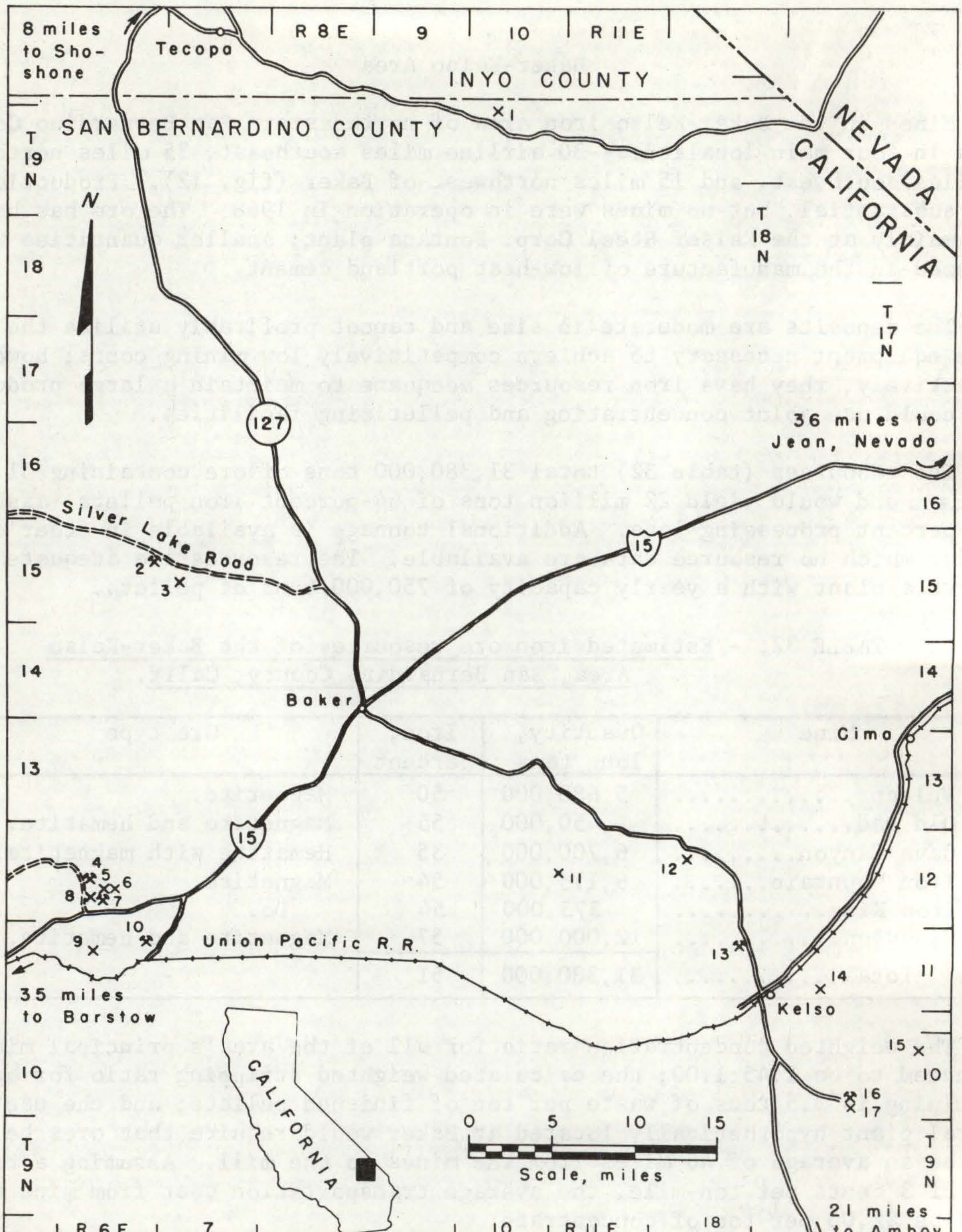
The resources (table 32) total 31,380,000 tons of ore containing 51 percent iron and would yield 22 million tons of 64-percent iron pellets, assuming a 10-percent processing loss. Additional tonnage is available in other deposits for which no resource data are available. The reserves are adequate to support a plant with a yearly capacity of 750,000 tons of pellets.

TABLE 32. - Estimated iron ore resources of the Baker-Kelso Area, San Bernardino County, Calif.

Mine	Quantity, long tons	Iron, percent	Ore type
Vulcan.............	5,680,000	50	Magnetite.
Old Dad............	450,000	55	Magnetite and hematite.
Cave Canyon.........	6,700,000	35	Hematite with magnetite.
Iron Mountain.......	6,175,000	54	Magnetite.
Iron King..........	375,000	54	Do.
Kingston...........	12,000,000	57	Magnetite and hematite.
Total...........	31,380,000	51	-

The weighted concentration ratio for all of the area's principal mines is estimated to be 1.45:1.00; the calculated weighted stripping ratio for open pit mining is 3.5 tons of waste per ton of finished pellets; and the use of a central plant hypothetically located at Baker would require that ores be trucked an average of 46 miles from the mines to the mill. Assuming a trucking cost of 3 cents per ton-mile, the average transportation cost from mine to mill would be $2.00 per ton of concentrate.

Transportation of the finished product to Los Angeles would be over 12 miles of highway and 205 miles of rail, a total mileage comparable to that of other producers. Excellent climatic conditions allow uninterrupted year-round surface operations. Electric power is available from nearby transmission lines, and natural-gas trunklines pass a few miles south of Baker. Industrial water, although limited, should be sufficient for a plant of the indicated size.



L E G E N D

1. Kingston (Beck, Iron Gossan)
2. Iron Mountain
3. Iron King
4. Cave Mountain
5. Arrowhead Lode
6. Meir Group
7. Cronese
8. Occurrence
9. Occurrence
10. Cave Canyon
11. Old Dad Mountain (Reat, Riet)
12. Iron Hand
13. Specular
14. Providence
15. Cornfield Spring
16. Vulcan
17. Burro
18. Iron Victory

FIGURE 12. - Iron Properties in the Baker-Kelso Area.

Mining costs for the consolidated operation are estimated to be considerably above those for present producers because of the relatively small size of individual ore bodies, the somewhat high stripping ratio, and the large in-process transportation charge.

Milling costs for the central plant are estimated as about equal to those in existing plants. The concentration ratio is lower than at most operating mills but the projected 750,000-ton-per-year capacity plant would be less efficient than present multimillion-ton plants. A combination magnetic and gravity beneficiating method is indicated.

Direct shipping ore was marketed from one mine until 1967. Other properties contain moderate quantities of direct shipping ore and of easily concentrated magnetite mill ore that could be marketed during periods of high demand by steel mills and cement manufacturers. The area's reserves of concentrating ore comprise a potential resource that can be processed into pellets and transported to Los Angeles at an estimated cost of about 30 percent above that being achieved in presently operating plants under 1967 economic conditions.

Cave Canyon

Location, History, and Production.--The Cave Canyon mine is about 20 miles by road southwest of Baker, in hills north of the Mojave River, at an altitude of 1,400 feet. The property has a direct railroad connection. Little production has been made during the past few years although previously a considerable quantity of ore was mined for use in low-heat portland cement. Mining was done intermittently. Large stockpiles were built up and used as needed.

Geology.--Major sedimentary and metamorphic rock units associated with the iron deposits are, in ascending age sequence: A metamorphic group of Precambrian granitic, gneissic, and slightly schistose rocks; crystalline limestone and dolomite, also of probable Precambrian age; sandstone and fanglomerate of Tertiary age; alluvium.

The formations have been intruded by both acidic and basic igneous rocks. The deposits have been strongly deformed by close folding and faulting and in places consist only of broken or pulverized material.

Iron ore occurs as replacement of limestone, dolomite, or occasionally quartzite, in zones of brecciated rock. Individual ore bodies are lenticular in shape and have steep dips.

The deposit contains two principal ore bodies and a few minor ones. The largest body has a surface length of about 1,000 feet and a width of 50 to 350 feet; an extension of 400 feet contains low-grade ore. Another ore body, one-half mile to the east, is 1,300 feet long and 50 to 200 feet wide. Smaller ore bodies occur south of the main ore bodies. The largest of these is about 225 feet long and 20 to 50 feet wide. About one-half mile southwest of the main ore body, a moderate quantity of ore occurs along a gently dipping shear zone.

Ore minerals are red hematite with minor magnetite and limonite. Gangue, 15 to 35 percent of the weight, consists mainly of unreplaced wall rock which occurs as irregular masses interspersed throughout the ore zones. Gypsum is abundant; minor malachite and chrysocolla also occur. Character samples of sorted ore contained 62.30 percent Fe, 4.16 percent SiO_2, 0.72 percent P, 0.52 percent S, 0.45 percent Al_2O_3, 2.01 percent CaO, and 0.44 percent MgO.

Nearly all of the mine's output was from an open cut on the largest ore body. The open pit covers about 6 acres and has banks 30 to 70 feet high. Other workings include several shafts, adits, and trenches.

Ore Reserves.--The U.S. Geological Survey in 1944 (3, p. 83) estimated reserves of the Cave Canyon area to be 4,105,000 tons, containing 55 percent iron of which 1,350,000 tons was considered to be recoverable at 1944 commercial prices. Subsequent drilling on an adjacent property added 166,000 tons to this total. The estimate is for ore above a depth of 200 feet.

Economic Potential.--Production of 55 percent iron ore would require extremely selective mining and might not be feasible because of the heavy fracturing and large quantities of unreplaced rock throughout the ore bodies. For this report, it is assumed that a future mining grade of 35 percent iron can be achieved and that the available tonnage would be 6,700,000 tons.

Because of the excessive fracturing, pit slopes of 1.5:1.0 are indicated and the weight-to-weight stripping ratio (to a depth of 200 feet) would be about 1.5:1.0. Beneficiation would be necessary and, as the ore is mainly hematite, a gravity method is indicated. Assuming a milling recovery of 85 percent, the mining of 2.2 tons of ore and 3.2 tons of waste would be required to produce 1 ton of 64-percent-iron concentrate.

Kingston (Beck, Iron Gossan)

Location, History, and Production.--The Kingston iron deposit (also known as the Beck or Iron Gossan) is 20 miles by road southeast of Tecopa at altitudes of 4,200 to 4,400 feet. Although there has been no production, the property has been known for many years and is covered by 26 patented claims. During 1924 Pacific Coast Steel Co. explored the downward extensions of the outcropping ore bodies with 14 diamond drill holes. This work developed a substantial tonnage of iron ore at a relatively early period in California steelmaking history, but high transportation costs have prevented utilization of this resource. The property is now controlled by the Standard Slag Co., which acquired an option on the property in 1952. Standard Slag has diamond-drilled 56 holes with a total footage of 12,872 feet and completed considerable metallurgical testing.

Geology.--The oldest rock underlying the iron area is granite gneiss, which is exposed in the canyon below the ore deposit. It is the basement rock over a wide area, surrounding the Kingston deposit. This rock is considered unreceptive to replacement and its upper contact is thought to be the lower limit of ore deposition. The upper surface of the gneiss was encountered in two drill holes at depths of 415 and 679 feet in the iron area.

The iron deposit occurs in a 100-foot-thick bed of white crystalline limestone that lies about 1,000 feet above the base of the Pahrump series, a Precambrian sequence of predominantly quartzite, dolomite, and limestone beds that unconformably overlies the granite gneiss. Large lenses of magnetite and hematite occur in the limestone along its contact with an underlying dark green amphibolite sill.

The deposits consist of two lens-shaped bodies separated along the strike by about 3,500 feet of sparsely mineralized limestone. The bodies are conformable to the bedding and have an east-west strike and steep dip. The deposit is relatively free from faulting or other features that would complicate mining operations.

The western ore body, the larger of the two, crops out over a length of 1,100 feet and a maximum width of 140 feet. The body narrows toward both ends. Drilling has cut this body to a depth of 600 feet.

The outcrop of the eastern ore body consists of two sections separated along the strike by 200 feet of barren rock. The western section is 1,100 feet long and 30 to 60 feet wide. A split from this section is 500 feet long and 30 to 40 feet wide. The eastern section is 400 feet long and 50 feet wide. Drilling has cut these ore bodies at a depth of 250 feet vertically below their outcrops.

Narrow seams of magnetite occur in bedding planes and fractures in the limestone, outside the limits of commercial ore.

Massive magnetite, partly altered to martite, and hematite make up the bulk of the deposit; the ore also contains quartz, calcite, iron silicates, and remnants of limestone and dolomite. Pyrite occurs erratically in portions of the deposit.

An average analysis of Kingston iron ore is 57.30 percent Fe, 6.50 percent SiO_2, 0.025 percent P, and 0.39 percent S.

Ore Reserves.--The U.S. Geological Survey in 1936 estimated the reserves at 12 million tons of good-grade Bessemer ore. This estimate was based on results of 14 holes drilled in 1924 (15, p. 78).

Based on published cross sections (3) and topographic maps, the stripping ratio to a depth of 400 feet is estimated to be 2.5:1.0. At this depth the stripping ratio would be 4.0:1.0, which is considered the break-even point between surface and underground mining costs.

Economic Potential.--Based on the 1936 estimate and a recovery ratio of 90 percent, sufficient resources are available to produce 9.5 million tons of 64-percent iron pellets. The concentration ratio would be 1.3 tons of ore for each ton of pellets and 3.3 tons of waste stripping would be required for each ton of pellets produced above the 400-foot level.

Unfavorable factors for exploitation are the moderate size of the deposit, which limits the use of ultralarge equipment, and the high trucking cost from the area's isolated location. The sulfur content of the ore also has been a deterrent, but pelletization would remove this impurity.

Iron Mountain (Silver Lake)

Location, History, and Production.--The Iron Mountain or Silver Lake Deposit is at the south end of the Avawatz Mountains, about 20 miles by road northwest of Baker, at an altitude of 2,225 feet. The mineralized area is covered by six patented claims owned by Kaiser Steel Corp. The deposits were mapped and studied during 1943-44 by the U.S. Geological Survey (3). In 1944, the U.S. Bureau of Mines completed a diamond-drilling program. Additional drilling later was done by Kaiser, and open pit mining was carried on during 1961-66.

Geology.--The ore-bearing horizon is an extensive breccia, more than 200 feet in thickness, consisting predominately of light-brown limestone fragments, but containing lenses of brecciated igneous and contact metamorphic rocks and iron ore that have been tightly cemented with calcium carbonate.

Iron ore occurs in lenses of solid massive magnetite and of fragmental ore which, in addition to iron oxides, contains pieces of contact metamorphic rock and partially replaced limestone. The lenses are 3 to 100 feet thick, 20 to 300 feet wide, and 50 to 1,000 feet long. The individual lenses dip from 20° to 35°, with the long dimension extending down the dip. The most important iron ore bodies occur in an area three-quarters of a mile by one-fourth of a mile. Small ore bodies occur in the surrounding area.

Magnetite is the predominant mineral but small quantities of secondary hematite and limonite are present. The principal gangue mineral is calcite. Minor quantities of pyrite occur below the zone of oxidation and small seams of gypsum occur near the surface. Some malachite and chrysocolla also are present. A composite sample contained 54.4 percent Fe, 6.1 percent SiO_2, 7.65 percent CaO, 0.045 percent P, and 0.034 percent S.

Ore reserves.--Ore reserves for the Iron Mountain deposit as estimated by the U.S. Geological Survey from Bureau of Mines drillings were 5,175,000 tons of indicated ore, and 1,000,000 tons of inferred ore, both with a grade of 54 percent iron (3, pp. 55-57).

Economic Potential.--The estimated reserve is adequate to make 4,600,000 tons of 64-percent iron pellets, assuming a recovery rate of 90 percent.

The ore can be mined by open pit methods with a stripping ratio of less than 1 ton of waste to 1 ton of ore. One ton of pellets will require processing 1.35 tons of ore and stripping an equal tonnage of waste. Unfavorable factors are the relatively small size of the ore body, the 47-mile truck haul to the railhead, and the scarcity of industrial water in the area.

These problems could be partly solved by upgrading the pit-run ore at the mine, using dry magnetic separation, and transporting the intermediate product to a central plant for final concentration and pelletization.

Iron King

The Iron King deposit is 1.5 miles southeast of the Iron Mountain deposit at an altitude of 1,900 feet. The Iron King has a geologic environment similar to that at Iron Mountain. It occupies an area about 200 feet in diameter on the summit of a low ridge, which is capped by an iron-bearing limestone breccia. No production has been made.

An estimate of ore reserves made in 1944 by the U.S. Geological Survey indicated a reserve to a depth of 100 feet of 375,000 tons of indicated ore, with a grade of 54 percent iron (3, p. 57).

Vulcan

Location, History, and Production.--The Vulcan mine is on the west slope of the Providence Mountains at an altitude of 3,900 to 4,100 feet. The deposit is 9 miles by road southeast of Kelso, a section point on the Union Pacific Railroad, 178 miles from Fontana.

The property was located in 1907 and patented in 1912. During this period an 80-foot adit was driven and 10 diamond-drill holes were completed. Sufficient ore was developed to establish the property as a potentially important source of iron ore. During World War II, Kaiser Steel Corp. selected the Vulcan deposit as the primary source of iron ore for its Fontana steel plant. The ore body was further developed by extensive diamond drilling and an adit. A plant with a daily capacity of 2,500 tons of iron ore was installed and open pit mining began. Production continued during 1942-47 with total shipments of 2,643,000 tons of ore (32, p. 100). Operations were terminated when the company's Eagle Mountain mine was opened. Small tonnages were shipped to cement plants in 1953 and 1957.

Geology.-- The following paragraphs on geology are quoted from a report by Charles Severy, former Bureau of Mines and Kaiser Steel Corp. geologist (23):

"Geologically, this region is composed of three main rocks: ancient sedimentary deposits which have since been more or less metamorphosed, intrusions of acid igneous rocks, and later intrusions and flows of rhyolites.

"The oldest sedimentary rocks in the region are Cambrian limestones and shales which have since been metamorphosed to marbles and phyllites. Unconformably above the Cambrian rocks lie other Paleozoic and Mesozoic marine metasediments. Faulted against these sediments is a large mass of quartz monzonite, undoubtedly intruded at depth and later brought to its present position by faulting. This igneous mass, probably of Jurassic age, lies to the west and southwest of the deposit. Tertiary rhyolites have intruded the sedimentary series on the north and northeast, while small rhyolitic flows are present immediately to the north of the deposit.

"The Vulcan iron deposit is an irregular mushroom-shaped replacement of limestone by magnetite and hematite along a fault contact with a quartz monzonite. On the surface, the body has maximum dimensions of 700 feet long by 325 feet wide and is ovular in shape, striking roughly east-west. It occupies two hillsides, being transected by a dry wash. The larger part of the ore body lies on the eastern slope; the smaller portion on the west, where it is terminated by a fault. There is no overburden on the deposit. In three dimensions, the deposit has a mushroom shape; with the north, east and south ore contacts with limestone, dipping inward toward the middle of the deposit at angles varying from 50° to 85°. In the center of the deposit, as explored by diamond drill holes, the ore extends to a depth of around 900 feet, simulating a stem or pipe. On the west the ore is terminated by a high angle reverse fault, striking N. 60° W., and dipping 70° to the west, which brings the iron and limestone against the quartz monzonite. No ore is found in the monzonite.

"The ore was deposited by ascending hydrothermal solutions carrying iron which was precipitated predominately as magnetite. Much serpentine was also formed. The replacement occurred bordering the fault, which, being a permeable zone, allowed the iron-rich solutions to rise along it until they encountered a limestone which was suitable for replacement. Some postmineralization movement has taken place on the fault."

Twelve hundred feet southeast of the ore body scattered outcrops of another iron zone extend for a distance of 650 feet. This zone has been explored with a few pits, a magnetometer survey, and diamond drilling. Results of the drilling are not available. Geophysical work showed a zone of magnetic intensity 75 to 125 feet wide and 800 feet long surrounding these outcrops.

The primary ore is a hard, fine- to medium-grained, grayish black magnetite with a small quantity of hematite that decreases with depth. Soft green serpentine, the most abundant gangue material, occurs as bands up to 3 feet in width and as inclusions and disseminations throughout the ore body. Calcite occurs as stringers and inclusions. Near the edge of the ore bodies and near faults, the calcite is more abundant and the magnetite-hematite ore has a blue-black color. Much pyrite is distributed throughout the ore body as small seams and disseminated grains.

Weathering has reached a depth of about 50 feet and in this zone the ore is principally hematite and limonite with a gangue of calcite and serpentine. Little pyrite is present.

The average grade of development samples was 52.23 percent Fe, 5.22 percent SiO_2, 0.058 percent P, 1.62 percent S, 1.86 percent Al_2O_3, 4.70 percent CaO, 5.17 percent MgO, 0.08 percent Mn, and 0.20 percent TiO_2.

Ore Reserves.--Reserves were estimated at 5,680,000 tons of indicated and inferred ore with an average grade of 50 percent iron (5, p. 247).

Economic Potential.--Production at the Vulcan mine was by open pit methods. The overall stripping ratio was 1.4:1.0 on a weight-to-weight basis with a pit slope of 1:1 in waste and 0.5:1 in ore. However, the horizontal cross section of the ore body decreased at depth and the stripping ratio required to continue operations on a 1:1 slope is about 7:1 and would increase with additional depth.

The resources are adequate to produce about 4 million tons of 64-percent iron pellets at 90-percent recovery. Each ton of pellets would require processing of 1.4 tons of ore. Underground mining methods are indicated and because the ore is strong, stoping costs should be about average.

Burro

The Burro prospect is on the west slope of the Providence Mountains one-half mile east-northeast of the Vulcan mine. The property was located on the basis of anomalies found by aeromagnetic surveying.

The anomalous area occurs along a limestone-quartz monzonite contact. The general geologic environment and character of the mineralization are apparently similar to those at the nearby Vulcan ore body. The anomaly was tested by deep drilling but the results are not available.

Old Dad Mountain (Reat, Riet)

The Old Dad Mountain deposit is situated on the northwest side of Old Dad Mountain at an altitude of 2,500 feet. The property has been developed by surface pits and two adits but there has been no production.

The ore deposit is underlain by a thick bed of gray to brown massive dolomitic limestone and by a series of quartzite beds and intercalated limestone. Intruded into the sediments is a monzonite mass which, near its contact, is strongly sheared and mixed with quartzite. Folding and faulting are prominent in the area.

Two principal and several minor ore bodies comprise the deposit. A large fault separates the easternmost ore body from the main limestone mass and forms the eastern boundary of the ore deposit. The eastern ore body is elongated parallel to the fault and is about 370 feet long and 70 feet wide. It is also bounded by a fault on the west. The western ore body, roughly circular in shape, is about 20,000 square feet in area. Two exploratory adits indicate that the ore continues to a depth of more than 150 feet. Other small and apparently unimportant ore exposures occur 300 feet southwest, 2,500 feet southwest, and 1,300 feet northeast of the main ore bodies.

The ore minerals are magnetite and hematite, they are gray and massive except where sheared. Principal impurities are calcite, quartz, gypsum, pyrite, and chalcopyrite. Sulfides in places comprise up to 5 percent of the ore. Waste rock constitutes 10 to 25 percent of the ore bodies.

The average analysis of two samples is 54.53 percent Fe, 9.84 percent SiO_2, 0.030 percent P, 0.056 percent S, 4.12 percent CaO, 1.40 percent MgO, and 0.86 percent Al_2O_3. A field examination indicated the sulfur content of the ore to be much higher than that shown by the analyses.

The U.S. Geological Survey estimated reserves to be 450,000 tons of ore containing 52 to 57 percent iron (3, p. 67).

Cronese

The Cronese deposit is 19 miles west of Baker at an altitude of 1,600 feet. It is one of several iron occurrences within a 4-mile long north trending belt. A small quantity of ore was shipped from the property. Two small open cuts on the same vein and separated by a 100-foot length of narrow ore are each about 150 feet long and 20 feet deep. The ore mined was 10 to 15 feet wide. The vein has walls of diorite, strikes north-northeast, and dips moderately to the west.

The ore consists of magnetite and blue-black hematite with a trace of copper oxide minerals. A selected sample analysed 63.98 percent Fe, 0.64 percent P, 0.007 percent S, and 0.12 percent TiO_2.

Cave Mountain

The Cave Mountain prospect is 1.5 miles north of the Cronese property at an altitude of about 1,600 feet. No production has been reported but judging from the extent of surface workings and the presence of ore-loading facilities, a small tonnage of ore was mined and shipped. Mine workings include two small surface cuts about 75 feet apart and a somewhat larger open cut 600 feet to the north.

Small ore bodies occur at the intersection of steep-dipping northwest striking fissures with north striking fractures. Individual ore bodies with cross sections 20 to 40 feet long by 5 to 10 feet wide were mined to a depth of about 20 feet. Other small ore bodies crop out in the area. The ore is a granular black hematite containing minor magnetite. Walls are dense greenish-gray porphyry.

Dale Area

The Dale area, in San Bernardino County, is 25 miles east of Twentynine Palms and 45 miles south of Amboy, the nearest rail shipping point (fig. 13). Nearly all production has come from the Iron Age mine.

Iron Age

Location, History, and Production.--The Iron Age mine is 27 miles by road east of Twentynine Palms at an altitude of 2,300 feet.

Property locations were first made in 1902 and three claims were patented in 1904. Only 1,500 tons (32, p. 95) of iron ore was produced before 1953,

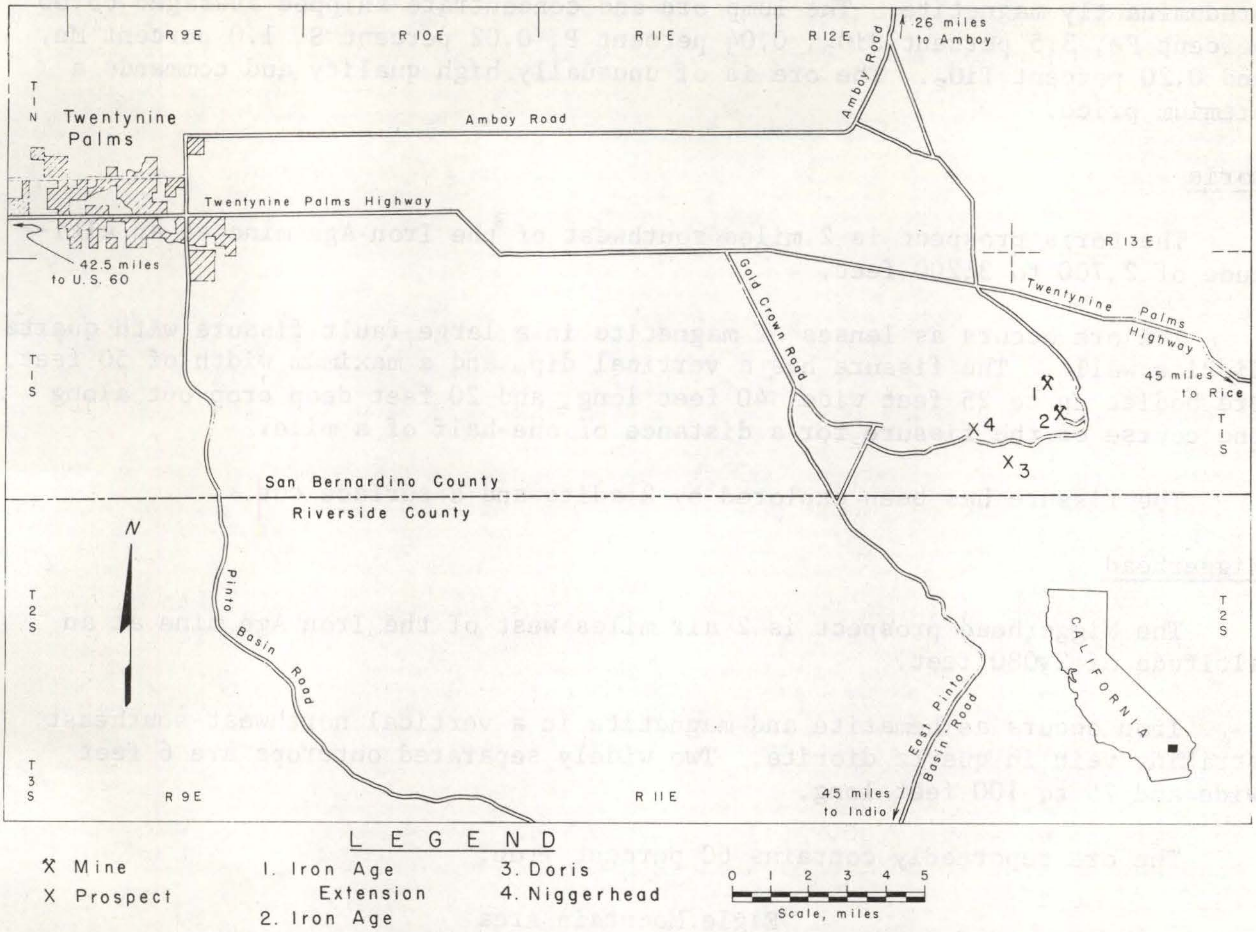


FIGURE 13. - Iron Properties in the Dale Mining District.

when Ferro Co. leased the property and produced more than 9,000 tons of lump ore (owners communication). The property was leased in 1956 to Iron Age Associates, which installed a concentrating plant and during 1956-62 produced 9,493 tons of direct shipping ore and 212,206 tons of concentrates (owners communication). The coarse concentrate was marketed as blast furnace and open-hearth lump ore; fines were used in cement manufacture. The property was acquired in 1963 by American Exploration Co. This company further developed the ore deposit by drilling, enlarged the mine, installed a larger mill, and greatly expanded production. Output in 1967 was reported in the June 22, 1968, issue of Skillings' Mining Review to have been 273,000 tons. Total output has been more than 850,000 tons.

Geology.--Iron ore occurs in numerous parallel steep-dipping veins in porphyritic granite. The largest vein is 15 to 100 feet wide and 400 feet long. The veins are sufficiently close to permit mining in a single large open pit. Mining is selective and large quantities of barren wall rock are discarded during mining.

Near the surface the ore is dense, brittle, semicrystalline hematite, much of which is pseudomorphic after magnetite. At depth the ore becomes predominantly magnetite. The lump ore and concentrate shipped averaged 65.00 percent Fe, 3.5 percent SiO_2, 0.04 percent P, 0.02 percent S, 1.0 percent Mn, and 0.20 percent TiO_2. The ore is of unusually high quality and commands a premium price.

Doris

The Doris prospect is 2 miles southwest of the Iron Age mine at an altitude of 2,700 to 3,200 feet.

The ore occurs as lenses of magnetite in a large fault fissure with quartz diorite walls. The fissure has a vertical dip, and a maximum width of 50 feet. Ore bodies up to 25 feet wide, 40 feet long, and 20 feet deep crop out along the course of the fissure for a distance of one-half of a mile.

The fissure has been explored by 2 adits and a surface cut.

Niggerhead

The Niggerhead prospect is 2 air miles west of the Iron Age mine at an altitude of 2,080 feet.

Iron occurs as hematite and magnetite in a vertical northwest-southeast striking vein in quartz diorite. Two widely separated outcrops are 6 feet wide and 75 to 100 feet long.

The ore reportedly contains 60 percent iron.

Eagle Mountain Area

The Eagle Mountain iron area in Riverside County is 15 miles north of Desert Center and 164 rail mines from the Kaiser Steel Corp. plant in Fontana (fig. 14). A company railroad extends from the Southern Pacific Railroad siding at Ferrum to the Eagle Mountain mine. An aqueduct, a high-voltage powerline, and a natural-gas pipeline cross the area. Altitudes range from 1,400 feet at the eastern end of the area to 2,000 feet at the western end and 3,000 feet at the center.

The late E. H. Harriman was the first industrialist to recognize the potential of the Eagle Mountain iron deposits. Under his direction, the claims covering the area were acquired and patented by Southern Pacific Co. early in the century. In 1940, Riverside Iron and Steel Co. obtained control of the deposit with the intention of erecting electric furnaces on the property and making high-grade iron by using petroleum coke as a reducing agent. World War II conditions forced abandonment of this plan.

During 1941-42, in connection with construction of the Kaiser Steel Corp. steel plant at Fontana, an intensive study was made by the U.S. Geological Survey of the eastern part of the district where the largest outcropping ore bodies are located. In conjunction with the study, the U.S. Bureau of Mines completed a trenching and diamond-drilling project

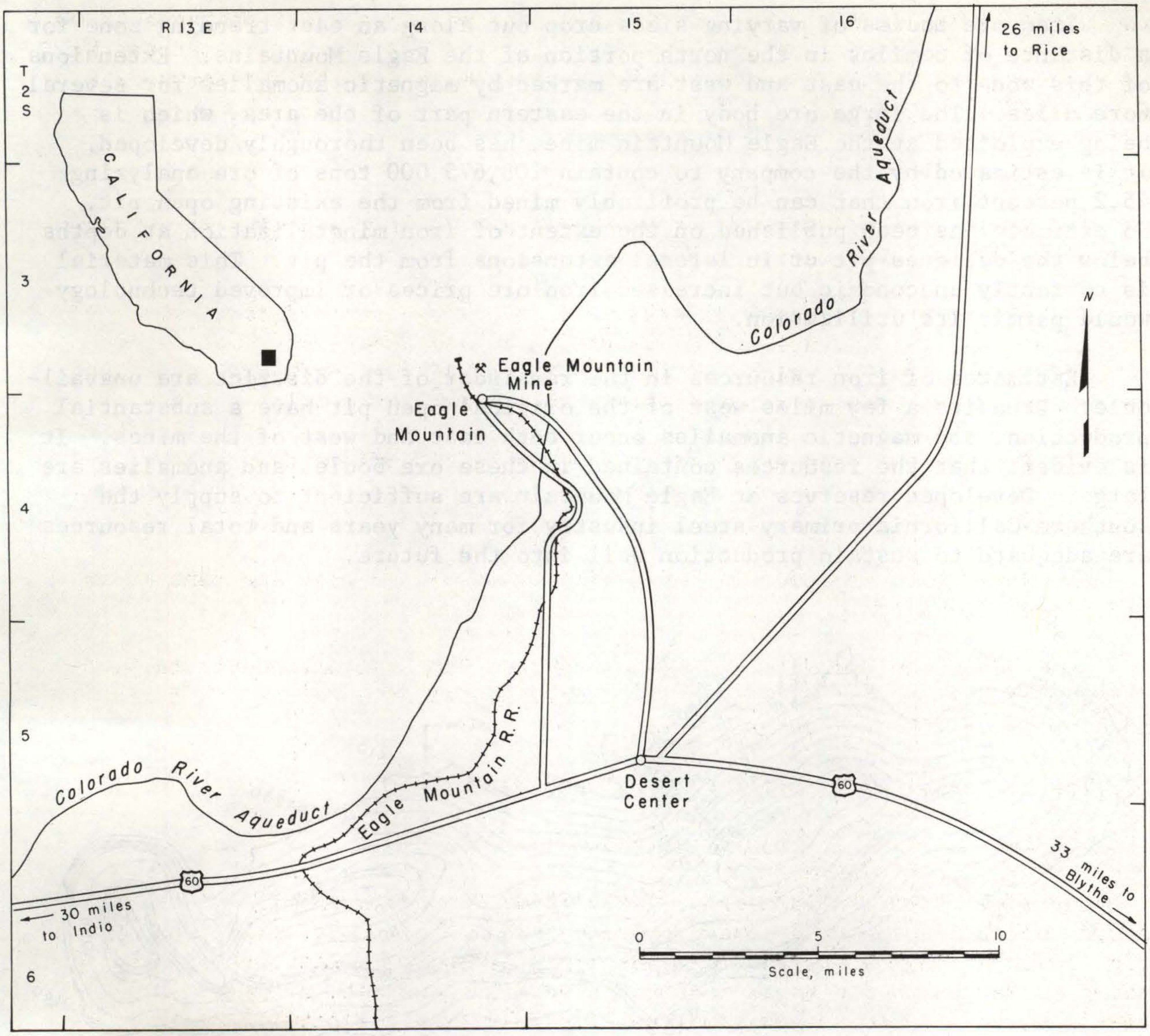


FIGURE 14. - Eagle Mountain Mine Location Map.

which developed 43 million tons of ore containing more than 30 percent iron, including 8.7 million tons of plus 50 percent, low-sulfur, direct shipping ore (3, p. 13).

In 1944 Kaiser Steel Corp. acquired the Eagle Mountain property and prepared an ore body near the eastern end of the district for large-scale mining. Production in 1967 was reported in the February 10, 1968, issue of Skillings' Mining Review to have been 5,895,000 tons. Exports were more than 3 million tons.

The area is the most important source of iron ore in California and has accounted for more than nine-tenths of the State's production. Kaiser Steel Corp. is the only producer in the area.

Iron ore bodies of varying sizes crop out along an east trending zone for a distance of 6 miles in the north portion of the Eagle Mountains. Extensions of this zone to the east and west are marked by magnetic anomalies for several more miles. The large ore body in the eastern part of the area, which is being exploited at the Eagle Mountain mine, has been thoroughly developed. It is estimated by the company to contain 108,675,000 tons of ore analyzing 45.2 percent iron that can be profitably mined from the existing open pit. No estimate has been published on the extent of iron mineralization at depths below the designed pit or in lateral extensions from the pit. This material is currently uneconomic but increased iron ore prices or improved technology would permit its utilization.

Estimates of iron resources in the remainder of the district are unavailable. Deposits a few miles west of the original open pit have a substantial production, and magnetic anomalies occur both east and west of the mines. It is evident that the resources contained in these ore bodies and anomalies are large. Developed reserves at Eagle Mountain are sufficient to supply the southern California primary steel industry for many years and total resources are adequate to sustain production well into the future.

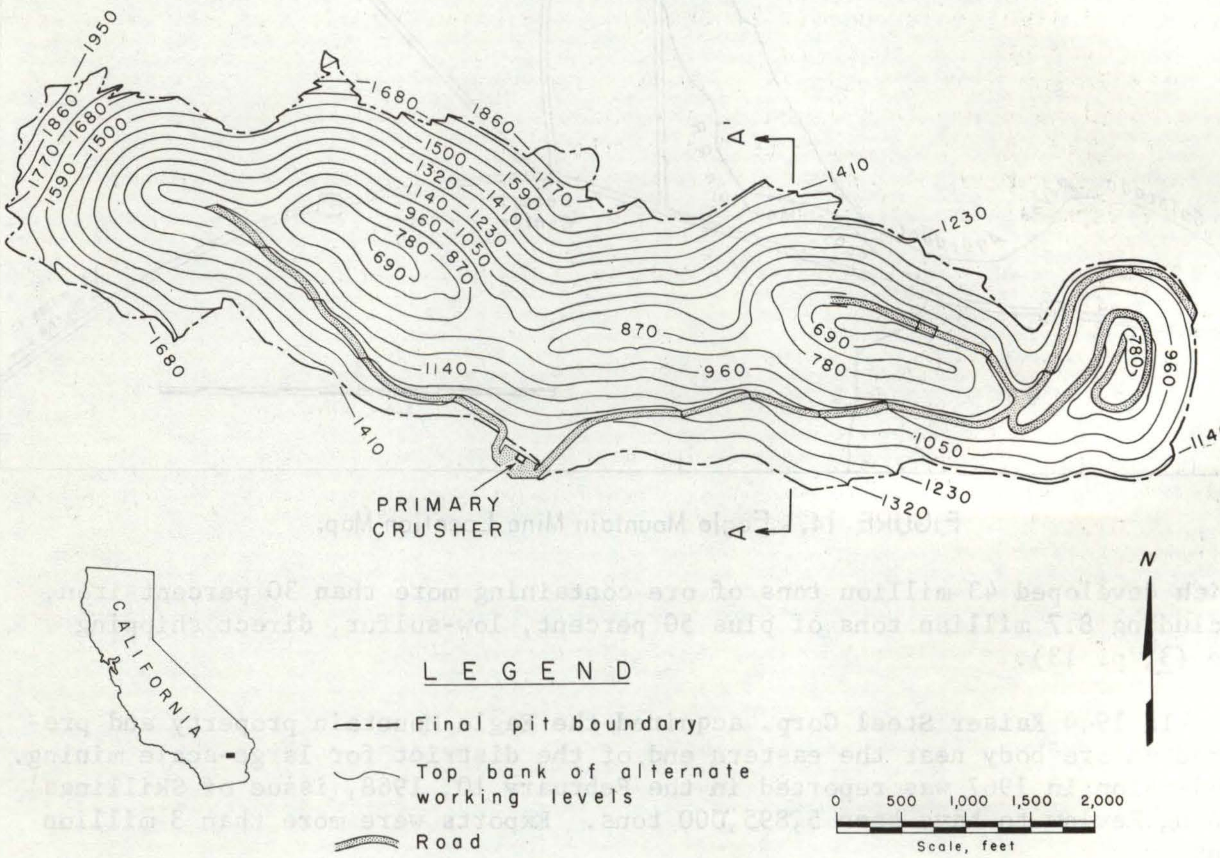


FIGURE 15. - Plan of Eagle Mountain Mine. (Adapted from Kaiser Steel Corp. map.)

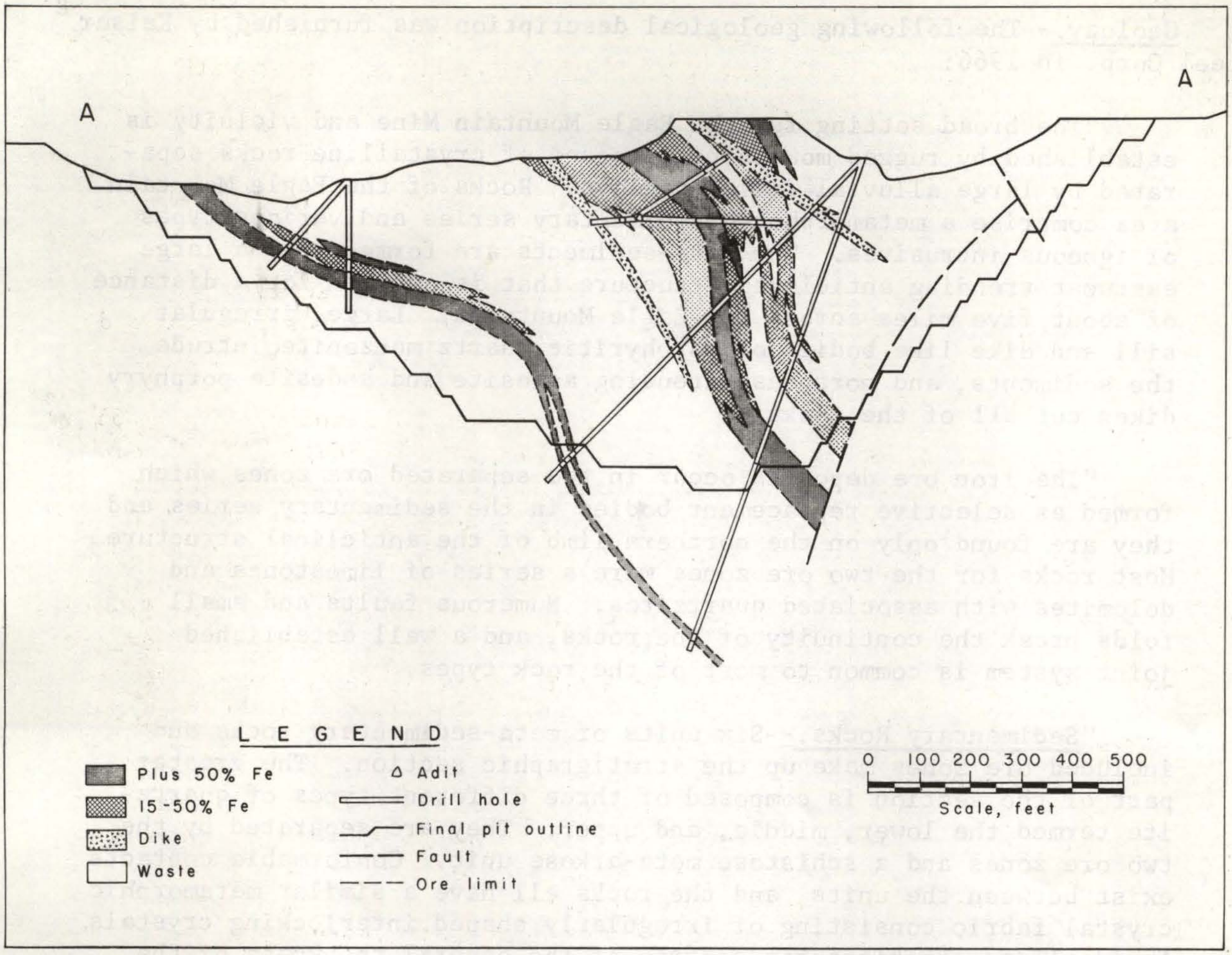


FIGURE 16. - Vertical Section of Eagle Mountain Mine. (Adapted from Kaiser Steel Corp. map.)

Eagle Mountain

Location, History, and Production.--The Eagle Mountain mine is at the eastern end of the Eagle Mountains, 15 miles north of Desert Center and 49 miles east of Indio (fig. 14). Kaiser Steel, after acquiring the Eagle Mountain iron properties, made a series of improvements that made the mine an efficient large-capacity operation. During 1947-48 a 51-mile railroad was built from the mine to the Southern Pacific Railroad siding at Ferrum, a crushing plant was installed, and open pit mining was started. Magnetic and heavy-medium separation plants were constructed in 1954 to treat the plus 1/4-inch ore; in 1957 a wet magnetic and jigging circuit was added to treat undersize material. A large blending and storage system was installed in 1959. A pelletizing plant of more than 2.0 million-ton annual capacity was commissioned in 1965.

Extensive exploration and development during 1955-58 delineated the most accessible ore bodies and indicated favorable areas for future development. Subsequently, two large pits were designed and put in production (figs. 15 and 16).

Geology.--The following geological description was furnished by Kaiser Steel Corp. in 1966:

"The broad setting for the Eagle Mountain Mine and vicinity is established by rugged mountains, composed of crystalline rocks separated by large alluvial filled valleys. Rocks of the Eagle Mountain area comprise a metamorphosed sedimentary series and various types of igneous intrusives. The meta-sediments are formed into a large eastwest trending anticlinal structure that is exposed for a distance of about five miles across the Eagle Mountains. Large, irregular sill and dike like bodies of porphyritic quartz monzonite intrude the sediments, and northeast-trending andesite and andesite porphyry dikes cut all of the rocks.

"The iron ore deposits occur in two separated ore zones which formed as selective replacement bodies in the sedimentary series and they are found only on the northern limb of the anticlinal structure. Host rocks for the two ore zones were a series of limestones and dolomites with associated quartzites. Numerous faults and small folds break the continuity of the rocks, and a well established joint system is common to most of the rock types.

"Sedimentary Rocks.--Six units of meta-sedimentary rocks and included ore zones make up the stratigraphic section. The greater part of the section is composed of three different types of quartzite termed the lower, middle, and upper. They are separated by the two ore zones and a schistose meta-arkose unit. Conformable contacts exist between the units, and the rocks all have a similar metamorphic crystal fabric consisting of irregularly shaped interlocking crystals. An idealized stratigraphic section of the general thickness of the included units is as follows.

Rock Unit	Thickness
Upper Quartzite	Undetermined
North Ore Zone	50 - 400 ft.
Middle Quartzite	150 - 400 ft.
South Ore Zone	20 - 120 ft.
Schistose Meta-Arkose	20 - 200 ft.
Lower Quartzite	1000 ft. plus

"Igneous Rocks.--By far the dominate igneous rock type in the Eagle Mountain area is the porphyritic quartz monzonite. It occurs as a large sill-like mass along the north or hanging wall zone either in direct contact with the north ore zone or in contact with the upper quartzite. Quartz monzonite constitutes the main rock type but very local variations to monzonite, quartz diorite, and diorite are present.

"Numerous andesite and andesite porphyry dikes constitutes the other common igneous rock type in the Eagle Mountain area. These dikes are usually narrow (less than 20 ft.), erratic, and trend normally northeast. Their exposures are prominent as they form small ridges cutting across the other rocks.

"<u>Ore Deposits.</u>--The iron ore deposits of Eagle Mountain occur mainly in two well-defined horizons in the sedimentary series, and they extend from beneath the alluvial covered valley floor westward a distance of over five miles across the Eagle Mountains. Local ore stringers and bands also occur in the middle quartzite and porphyritic quartz monzonite. The widest horizon termed the north ore zones lies above the middle quartzite and below the upper quartzite. The south ore zone occupies the stratigraphic interval between the middle quartzite and schistose meta-arkose. In width, the north ore zone varies from 50 ft. to 400 ft. while the south ore zone varies from 20 ft. to 120 ft. The host rocks for the ore zones were a series of limestones and dolomites with associated quartzite.

"Two stages of hydrothermal activity and a later surface oxidation period formed the ore bodies. The initial hydrothermal activity altered the original rocks to an actinolite-tremolite granofels. Following the alteration, the second stage introduced the primary ore mineral, magnetite plus pyrite, which preferentially replaced, in part, the earlier formed granofels. The released actinolite and tremolite then passed out of the immediate vicinity forming veins and replacement zones in the nearby rocks. A later near surface oxidation partially to completely converted the pyrite to hematite and goethite, with minor limonite. Also, a part of the magnetite was converted to hematite or martite and goethite.

"The alteration which essentially prepared the way for ore deposition varies in intensity forming incipient zones that partially preserved the fabric of the original host or more intense zones that completely destroyed the original fabric. A strong chemical control was instrumental in positioning the alteration into two main zones. The original north and south ore zone rocks containing abundant limestone and dolomite with lesser amounts of quartz were chemically the most amenable for the actinolite-tremolite conversion. Structurally, the altering solutions were guided through weakness zones most commonly represented by micro-shearing or granulation and by fractures. Another structural control possibly exists along small fold crests or in areas where the broad scale dip changes. These structures developed prior to the alteration and no pronounced deformation took place during the alteration period.

"Actinolite and tremolite were the main minerals formed by the alteration, but phlogopite becomes important in the intensely altered areas. This assemblage crystallized into a more or less directionless rock termed granofels that developed in a medium temperature environment. At a slightly later time but under similar thermal conditions, orthoclase formed metasomotic veins and irregularly shaped flooded areas in the country rocks. Some minor sericite and clay probably formed early in the alteration sequence.

"The chemical control of the alteration actually carried through to the ore deposition stage with the magnetite and pyrite replacing only the altered rocks. However, the ore replacement was most complete where the ore zones flattened in dip along monoclinal type folds or flexures. When the ore zone dip steepens, the replacement becomes more selective.

"The last ore forming stage involved a secondary alteration that oxidized the near surface ores. This oxidation strongly altered the pyrite to hematite, goethite or limonite and some of the magnetite to martite or goethite. It also formed the alteration minerals serpentine, gypsum, epidote, sericite, and clay. These minerals occur as narrow mono-mineralic veins or as alteration products of earlier silicate minerals. Almost complete oxidation of the pyrite extends 100 ft. to several hundred feet below surface. Beyond these depths, the oxidation closely follows the footwall and hanging wall contacts, dike contacts, and fractures. The transition from oxidized ore is very sharp usually occurring within a distance of several feet."

The primary ore is predominantly magnetite with about 3 percent pyrite; however, within 200 feet of the surface, oxidation has altered most of the magnetite to hematite and the pyrite to limonite. The magnetite occurs in small tightly interlocked grains; the hematite is red, hard, and dense. The hematite ore has a gravity of about 4.5, which with increasing amounts of magnetite approaches 5.0. The average analysis of the 108,675,000 tons of developed ore in the east open pit is 45.2 percent Fe, 15.3 percent SiO_2, 0.72 percent P, and 0.63 percent S.

Removing phosphorus and sulfur from Eagle Mountain ore has been relatively simple. Most phosphorus-containing minerals ane removed by magnetic and gravity concentration. Sulfur, which occurs as pyrite, is only partially removed during concentration. However, blending has allowed the use of most ore without exceeding sulfur specifications. Concentrates containing too much sulfur for successful blending are pelletized or sintered, which removes nearly all sulfur.

Exploration and Development.--Early exploration at the Eagle Mountain property included study by the U.S. Geological Survey and extensive trenching and diamond drilling by the U.S. Bureau of Mines (3, p. 4). Subsequently Kaiser Steel Corp. made an intensive study of the ore deposits and did more than 100,000 feet of exploratory and development drilling.

Mining and Beneficiation.--Mining and beneficiation methods at the Eagle Mountain property are of particular interest because of the unusually high efficiency of the operation (9). In 1968 Eagle Mountain ore was being sold in the Japanese market in competition with larger, higher grade, and more favorably located foreign ore bodies. Eagle Mountain ore has a concentrating ratio of 1.75:1.00 and a waste stripping to mill ore ratio of 3.20:1.00. Iron values are divided between magnetite and hematite and the ore is treated by both magnetic and gravity separation methods.

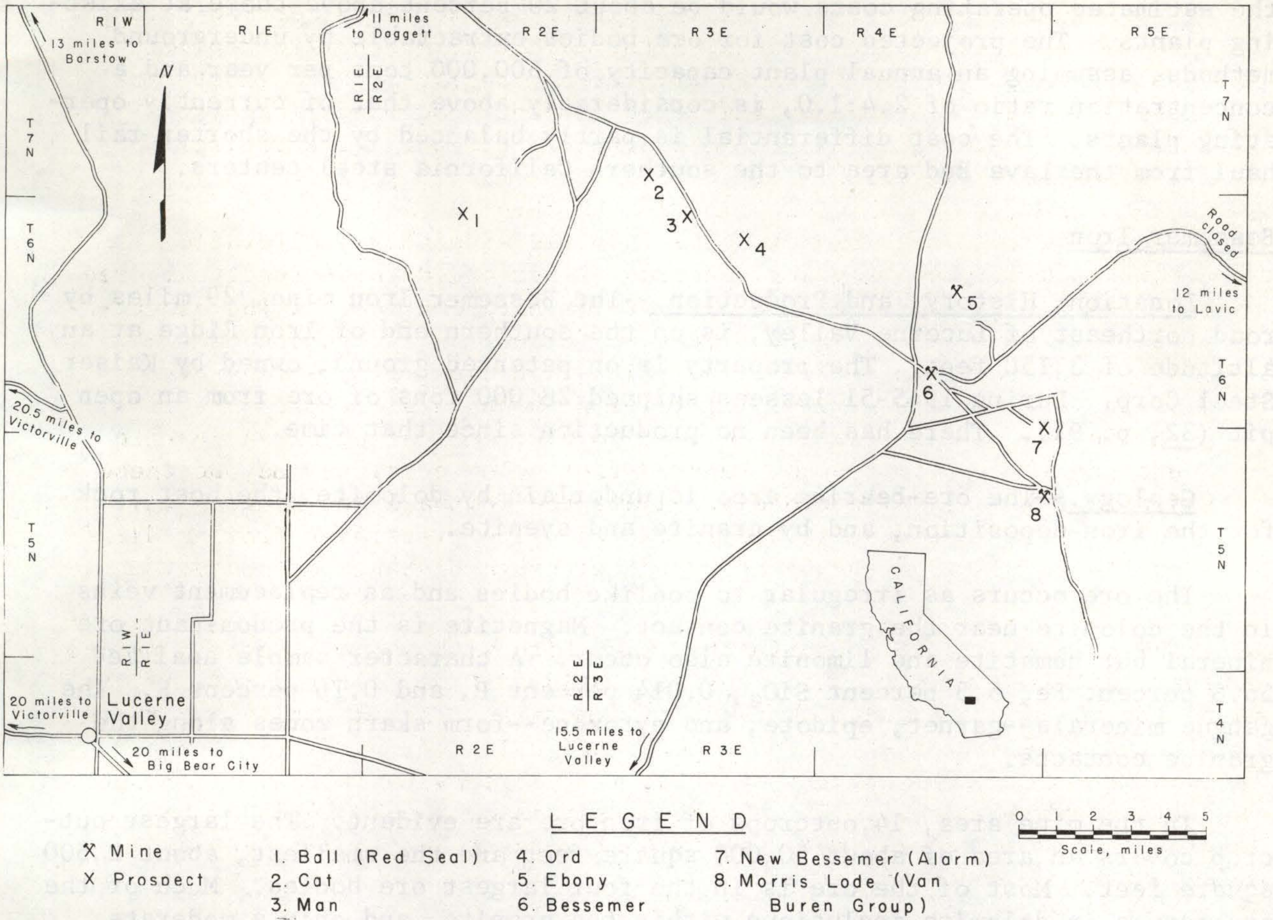


FIGURE 17. - Iron Properties in the Lava Bed Area.

Lava Bed Area

The Lava Bed iron area in San Bernardino County is 25 miles by dirt road from Daggett and 30 miles by paved and dirt road from Lucerne Valley (fig. 17). The most convenient rail shipping point is 35 miles distant near Cushenbury. More than 50,000 tons of direct shipping ore has been produced. The Morris Lode, Bessemer Iron and Man-Cat-Ord properties have also been explored and developed.

The Morris Lode-Bessemer section of the area, which extends about 5 miles north-south and 3 miles east-west, contains significant resources of iron ore suitable for open-cut mining. The Man-Cat-Ord property, 8 miles northwest of the Bessemer mine, contains resources of milling ore requiring underground mining.

Iron ore minable by open pit methods contains sufficient iron to make 16 million tons of 64-percent iron pellets at 90-percent recovery. The reserve is adequate to support a plant with an annual capacity of 500,000 tons. The average concentration ratio for the open pit ore is 2.6:1.0; the average stripping ratio of waste to final product is 0.76:1.0. Based on these figures, the estimated operating costs would be about 20 percent above those at existing plants. The projected cost for ore bodies extractable by underground methods, assuming an annual plant capacity of 500,000 tons per year and a concentration ratio of 2.4:1.0, is considerably above that of currently operating plants. The cost differential is partly balanced by the shorter rail haul from the Lava Bed area to the southern California steel centers.

Bessemer Iron

Location, History, and Production.--The Bessemer Iron mine, 29 miles by road northeast of Lucerne Valley, is on the southern end of Iron Ridge at an altitude of 3,150 feet. The property is on patented ground, owned by Kaiser Steel Corp. During 1945-51 lessees shipped 28,000 tons of ore from an open pit (32, p. 91). There has been no production since that time.

Geology.--The ore-bearing area is underlain by dolomite, the host rock for the iron deposition, and by granite and syenite.

The ore occurs as irregular to podlike bodies and as replacement veins in the dolomite near the granite contact. Magnetite is the predominant ore mineral but hematite and limonite also occur. A character sample analyzed 56.8 percent Fe, 5.3 percent SiO_2, 0.014 percent P, and 0.16 percent S. The gangue minerals--garnet, epidote, and pyroxene--form skarn zones along the granite contacts.

In the mine area, 14 outcrops of iron ore are evident. The largest outcrop covers an area of about 50,000 square feet and the smallest, about 2,500 square feet. Most of the ore is in the four largest ore bodies. Much of the ore occurs in dolomite inclusions within the granite, and only a moderate downward extent can be assumed for these ore bodies.

The largest ore body, the only one that has been mined, is in a point of dolomite which joins the main dolomite on the east. On the north and west the ore body is bordered by granite and to the south the rocks are covered by alluvium.

Exploration and Development.--In 1944, a magnetometer survey of the Bessemer area by the U.S. Bureau of Mines indicated that an anomaly of highly variable intensity existed over the main trend of the mineralized zone as exposed in surface outcrop and that this anomaly extended more than 1,000 feet to the southwest across an area covered with alluvium (30). The similarity of the anomaly over the outcrops and the overburden-covered area indicated that the valley wash may contain additional bodies of ore comparable to those occurring in the exposed areas of the mineralized zone. A hole drilled in the valley 500 feet south of the outcrops penetrated 61 feet of alluvium and cut 41 feet of siliceous dolomite containing small masses of magnetite. Core from the mineralized dolomite analyzed 42.38 percent Fe, 11.36 percent SiO_2, 0.022 percent P, and 0.020 percent S. Drilling during 1954 in the alluvium-covered portion of the anomaly intersected a bed of iron ore too narrow to be of economic interest.

Ore Reserves.--The U.S. Geological Survey estimated that the outcropping iron deposits contain 1.8 million tons of ore grading 30 to 65 percent iron, of which 240,000 tons averages more than 60 percent iron (3, p. 37).

Economic Potential.--Mining of these ore bodies by open pit methods is not economic because of the high stripping ratio required for many of the ore bodies. The inferred reserves are too small to support a beneficiation plant of economic size, except in conjunction with production from other properties in the district.

Morris Lode

Location, History, and Production.--The Morris Lode property is 4 miles southeast of the Bessemer mine at altitudes of 2,710 to 2,825 feet. Kaiser Steel Corp. purchased the property from Western Minerals Associates in 1945. In 1954, Kaiser sunk a 55-foot shaft to obtain bulk samples for metallurgical testing. In 1949-50, 17,500 tons was mined for use in cement manufacturing and in 1957 a few thousand tons was mined for use as open hearth lump.

Geology.--The mineralized area is underlain by dolomite thought to be Archean in age and by Jurassic granitic rocks which intrude it. Most of the area is covered by alluvium.

The ore occurs near the dolomite-granite contact. Magnetite is the predominant ore mineral but some primary hematite is present at depth. Earthy secondary hematite and limonite occur near the surface. The ore contains about 5 percent pyrite. Principal gangue minerals are pyroxene, garnet, and epidote. A composite character sample of drill core analyzed 43.7 percent Fe, 16.7 percent SiO_2, 0.02 percent P, 2.0 percent S, 8.5 percent CaO, 6.2 percent MgO, and 3.7 percent Al_2O_3.

Exploration and Development.--The Bureau of Mines in 1944-45 delineated a magnetic anomaly 1,000 feet wide and 1,500 feet long (30, fig. 4). Nine holes were drilled of which eight intersected 120 to 921 feet of iron ore with an average grade of 37.32 percent iron. An area approximately 20 acres in extent and of intermediate magnetic intensity surrounds the ore body. Two holes drilled in this zone encountered from 100 to 400 feet of mineralized dolomite containing over 15 percent iron.

The ore shipped was mined from a ridge in the southwest corner of the intermediate magnetic intensity zone where magnetite is exposed. An open cut was excavated on a mass of ore localized along a strong fissure with granite walls.

Economic Potential.--The ore body is covered with 30 to 90 feet of alluvium and about 50 feet of barren or low-grade rock. Most other material requiring stripping during open pit mining contains over 15 percent iron and has marginal value.

Metallurgical tests were made on samples of core reduced to 10, 28, 100, and 200 mesh. The optimum size was 100 mesh and at this grind recovery by magnetic separation was 91 percent of the iron in a concentrate which analyzed 66.00 percent Fe, 6.30 percent SiO_2, 0.01 percent P, and 0.15 percent S (30, p. 10). A magnetic separation of the 10-mesh material produced a concentrate containing 94.8 percent of the iron in a 53.3-percent iron product, indicating that it might be advantageous to cob the material magnetically before grinding. Pelletizing will reduce the sulfur content to commercial specifications.

Ebony

The Ebony property is near the crest of Iron Ridge at an altitude of 3,900 feet, 2 miles north of the Bessemer Iron mine. Production has not been reported but judging from the extent of surface working several thousand tons were mined.

The mine area is underlain by granite containing inclusions of marbleized dolomite. Two ore bodies occur in separate fissures along or near granite-dolomite contacts.

The more prominent ore body occurs in a fissure which dips steeply to the northwest. It has a granite hanging wall and a dolomite footwall. The vein contains 10 to 25 feet of ore which averages more than 50 percent iron and is composed of about 75 percent magnetite and 25 percent hematite. The ore body has been mined in an open cut 200 feet long, 25 feet wide, and about 75 feet deep.

The second ore body occurs in a fissure that parallels the more prominent vein and is 100 feet southeast of it. The ore is about 50 feet wide at one point but lenses out rapidly along the strike. Its grade is less than 50 percent iron. Near the ore body both walls are granite, but 100 feet to the northeast dolomite forms the hanging wall of the fissure. This ore body has been mined in an open pit 50 feet by 50 feet in cross section and 30 feet deep.

A crushing and screening plant was used to process the ore. Before mining was initiated the U.S. Geological survey estimated resources at 100,000 tons of ore containing 40 to 50 percent iron (3, p. 38).

Man-Cat-Ord

The Man-Cat-Ord property is 20 miles by road southeast of Daggett at an altitude of 4,100 feet. The Cat and Ord properties adjoin the Man property on the northwest and southeast, respectively. The three properties are owned by the U.S. Steel Corp.

The valley is blanketed with recent alluvium that masks the surface geology. Jurassic granite and monzonite underlie the surrounding mountains. Paleozoic quartzite and marble occur 2 miles south of the property and Triassic volcanic rocks occur 1 mile northeast. Recent faulting is prominent.

The property was discovered by aeromagnetic prospecting; it has been explored by about 25 deep drill holes.

Minarets Area

The Minarets area is in eastern Madera County about 69 airline miles northeast of Fresno (fig. 18). The area is near the summit of the Sierra Nevada at an altitude of 10,500 feet. Topographic relief is extreme and snowfall is unusually heavy at this locality. The region is inaccessible to motor vehicles.

The area has been known since the pioneer period and was first described more than 70 years ago in reports of the California State Mining Bureau, but the isolated location and alpine climate have prevented any attempt to bring it into production. The Minarets deposit contains all the area's known iron resources. The Red Top, Morning Star, Wedge, Bradley, Hart, and Rising Sun deposits shown on figure 18 are described under Madera County in the Miscellaneous Iron Properties by Counties Section and in table 31.

Minarets

Location.--The Minarets iron deposit is 18 miles by trail from the nearest automobile road at Red Meadow Ranger Station, which is 13 miles by road west of Mammoth Lakes. Pinedale, an estimated 100 miles west of the deposit by truck and trail, is the nearest rail shipping point. The iron deposit is about three-fourths of a mile southwest of the proposed Minarets Wilderness Area.

Geology.--The mineralized area is underlain by a sequence of slightly metamorphosed flows and subordinate agglomerates and tuff beds. Four areas of granite crop out near the ore body. Also present are some post-mineral dikes of diabase and fine-grained granite.

The mineralized zone occupies a prominent point on the west shoulder of Iron Mountain. It is exposed on the north slope of the ridge from altitudes of 10,000 to 10,500 feet (the high point on the ridge) and it extends down the south side of the ridge to the 10,350-foot level. The total lengthoof the exposed mineralized zone is 1,500 feet; its maximum width is 175 feet.

North and northwest of the deposit glacial moraine and talus from the ridge contain a high percentage of magnetite and cover a large part of the fairly steep terrain. The more gentle south slope is also covered with magnetite float.

The main ore body is a nearly vertical elongated lens composed of irregular layers of magnetite and of magnetite and actinolite, completely enclosed within a series of volcanic rocks.

The mineralized sheets vary in their comparative proportion of magnetite and actinolite. They are relatively uniform in character over limited areas but grade into ore of different composition along their strike and dip. Some sheets consist mainly of magnetite over considerable areas. One such sheet is 40 feet thick.

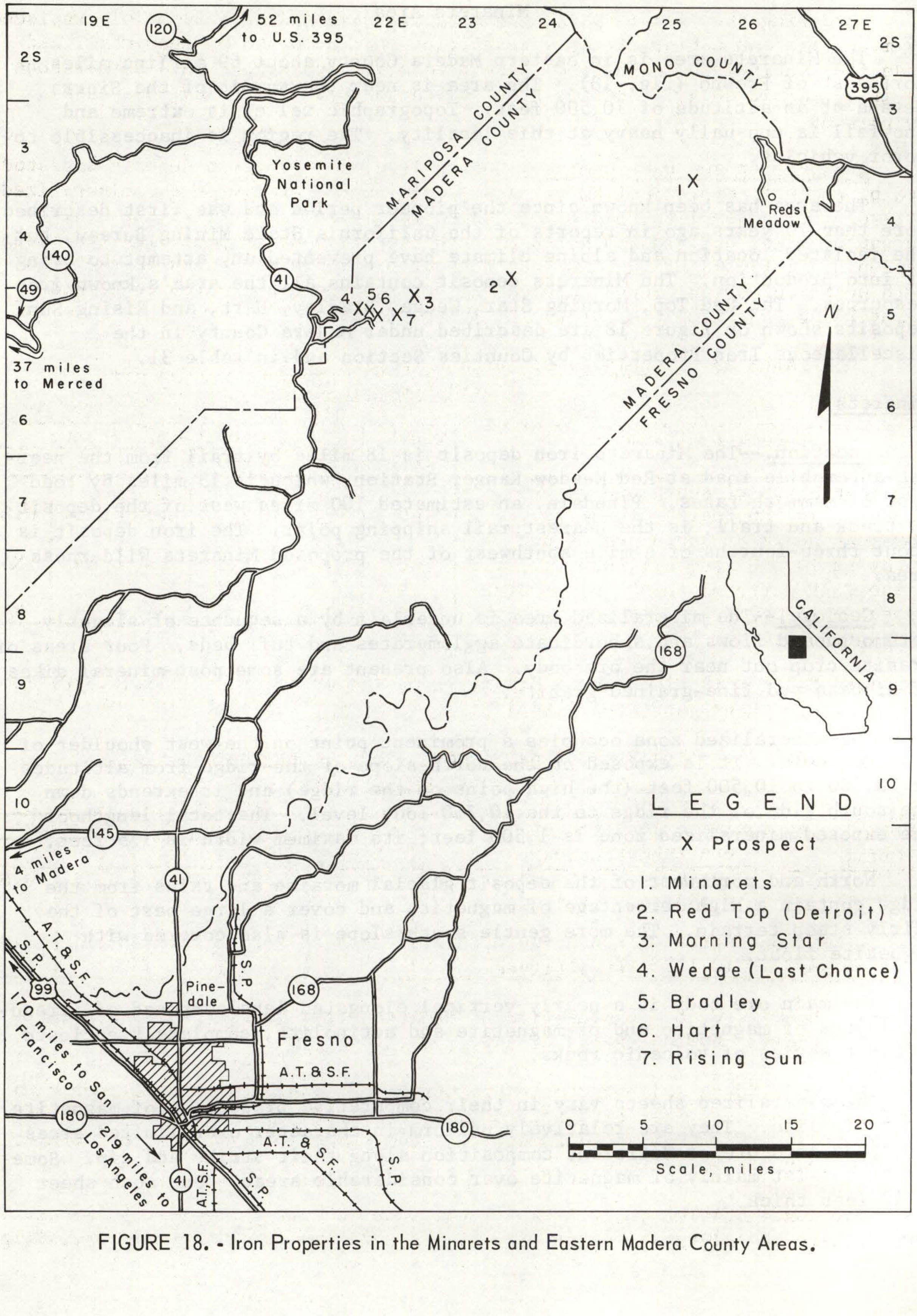


FIGURE 18. - Iron Properties in the Minarets and Eastern Madera County Areas.

Bordering the area in which the metamorphosed andesite is mainly replaced by magnetite and actinolite is a transition zone composed of recrystallized andesite, actinolite, magnetite, plagioclase, and epidote. This border zone is irregular in detail, and its iron content grades from 30 to less than 10 percent.

Exploration and Development.--During 1944, the Minarets deposit was studied by the U.S. Geological Survey and samples were taken from the mineralized outcrops. The sampling results are shown in table 33. In 1945 the U.S. Bureau of Mines drilled two holes through the ore body to determine its extent at depth. Analyses of the intersections of ore zones are given in table 34. Both holes cut border zones on each wall of the ore body, which contained about 25 percent iron over widths of 20 to 40 feet.

TABLE 33. - Analyses of surface samples, Minarets deposit, Madera County, Calif.

Location of sample	Width, feet	Composition, percent				
		Fe	SiO_2	P	S	TiO_2
300 feet north of south end of ore body at 10,500 feet altitude.........	160	59.08	8.10	0.34	0.04	0.05
500 feet north of south end of ore body at 10,400 feet altitude.........	140	60.05	6.88	NA	NA	NA
1,300 feet north of south end of ore body at 10,050 feet altitude.........	15	50.10	12.45	NA	NA	NA

NA--Not available.

Source: California Division of Mines. Iron Resources of California. Calif. Div. Mines and Geol., Bull. 129, 1948, pp. 123-124.

TABLE 34. - Analyses of drill hole samples, Minarets deposit, Madera County, Calif.

Hole number	Approximate location of main ore intersection	Width, feet	Composition, percent			
			Fe	SiO_2	P	S
1	930 feet north of south end of ore body at 9,980 feet altitude.	57.3	42.4	10.1	0.52	0.01
2	480 feet north of south end of ore body at 10,115 feet altitude.	85.3	34.3	15.7	.52	.01

Source: Severy, C. L. Exploration of Minarets Iron Deposit, Madera County, Calif. BuMines Rept. of Inv. 3985, 1946, pp. 6-7.

Economic Potential.--Estimated resources are adequate to make more than 6 million tons of 64-percent iron pellets, assuming a recovery of 90 percent of the iron. Resources of this magnitude can support a yearly production of 300,000 tons of concentrate.

The concentration ratio is about the same as that in operating plants. Preliminary metallurgical tests (22, p. 12) indicated that magnetic upgrading of ore ground to minus 43 mesh would eliminate most of the phosphorus and gangue. However, further magnetic separation after grinding to minus 200 mesh or finer is necessary to obtain a high iron concentrate.

The estimated stripping ratio is 6.0:1.0; this high ratio and the climate favor underground mining. The steep dip and firm character of the ore make the ore body suitable for sublevel stoping.

Direct mining and milling costs would probably be slightly above those of presently operating plants. Indirect costs would be high because of the isolated location and unfavorable climate.

The concentrate would have to be hauled about 100 miles by truck to reach Pinedale, the nearest rail shipment point. Of this route, 15 miles would have to be constructed. Trucking costs of $5.00 per ton are estimated. Rail transportation from Pinedale to Los Angeles or San Francisco would cost an estimated $2.50

Shasta Area

The Shasta iron area is on the east side of Shasta Lake about 12 airline miles north of Redding in Shasta County (fig. 19). Iron deposits occur at altitudes of 1,300 to 1,700 feet, 300 to 700 feet above the high water elevation of the reservoir. The Shasta and California mine contains all the area's iron resources. The Hirz Mountain and Iron Mountain mines and the Grey Rock prospect, the other properties located on figure 19, are described under Shasta County in Miscellaneous Iron Properties by County Section and in table 31.

Shasta and California

Location, History, and Production.--The Shasta and California mine lies between the McCloud River and Squaw Creek arms of Shasta Lake. The mine is accessible from Redding by 15 miles of highway, 1 mile of overwater transportation, and 1 mile of mine road. The Southern Pacific Railroad is 2 miles west of the mine but is separated from it by Shasta Lake.

Iron ore was first produced in 1892 for use as smelter flux. During 1907-18, about 15,000 tons was shipped to an electric smelting plant at Baird. From 1918 to 1942 ore was shipped intermittently to Pacific Coast furnaces at rates up to several hundred tons per month. During 1942-45 about 300,000 tons of ore was shipped for use as ship ballast. Since 1945 production has been insignificant. The deposits are owned by Shasta Iron Co. and California Consolidated Mines. In 1968, the properties of both companies were under lease to Iron Exploration Co., a joint venture of The Bunker Hill Co., Morrison-Knudsen Co., and W. R. Grace Co.

Geology.--The iron deposits occur in an irregular, steeply dipping metamorphic zone 2,000 feet long and 300 to 1,000 feet wide, which was formed in McCloud limestone along its contact with intrusive quartz diorite. The zone contains lenses of massive magnetite and some disseminated magnetite.

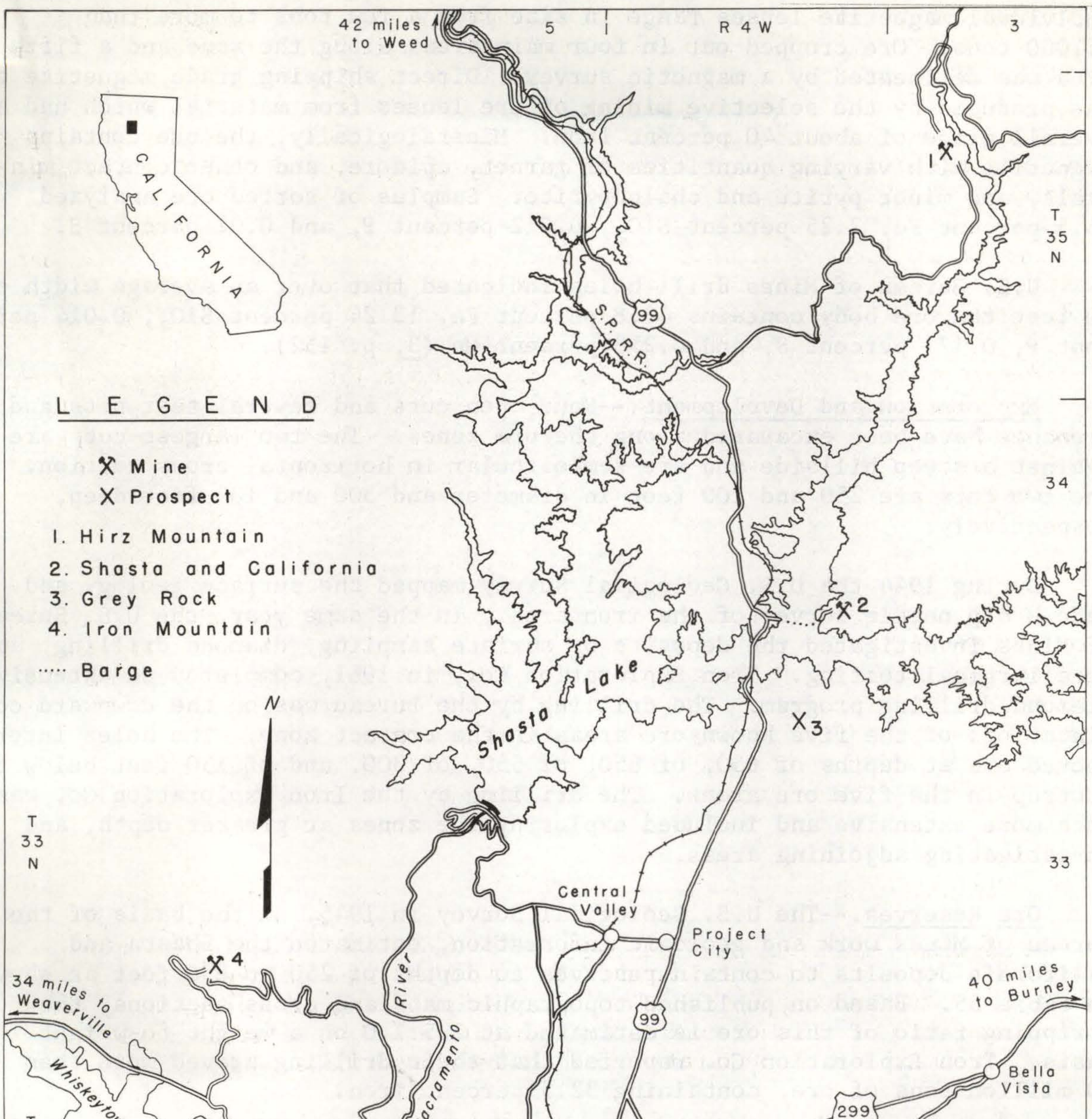


FIGURE 19. - Iron Properties in the Shasta County Area.

Individual magnetite lenses range in size from a few tons to more than 25,000 tons. Ore cropped out in four main areas along the zone and a fifth area was delineated by a magnetic survey. Direct shipping grade magnetite ore was produced by the selective mining of ore lenses from material which had an overall grade of about 40 percent iron. Mineralogically, the ore contains magnetite with varying quantities of garnet, epidote, and other contact minerals, and minor pyrite and chalcopyrite. Samples of sorted ore analyzed 66.5 percent Fe, 2.25 percent SiO_2, 0.012 percent P, and 0.02 percent S.

U.S. Bureau of Mines drill holes indicated that over an average width of 90 feet the ore body contains 40.8 percent Fe, 13.24 percent SiO_2, 0.014 percent P, 0.173 percent S, and 0.273 percent Mn (3, p. 152).

Exploration and Development.--Four open cuts and several test pits and trenches have been excavated along the ore zones. The two largest cuts are against a steep hillside and are semicircular in horizontal cross section. The two cuts are 250 and 100 feet in diameter and 300 and 100 feet deep, respectively.

During 1944 the U.S. Geological Survey mapped the surface geology and made a dip needle survey of the iron area. In the same year, the U.S. Bureau of Mines investigated the deposits by surface sampling, diamond drilling, and metallurgical testing. Iron Exploration Co., in 1961, completed an extensive diamond-drilling program. The drilling by the Bureau was on the downward continuations of the five known ore areas in the contact zone. The holes intersected ore at depths of 650, of 650, of 550, of 300, and of 150 feet below the outcrop in the five ore areas. The drilling by the Iron Exploration Co. was much more extensive and included exploring the zones at greater depth, and investigating adjoining areas.

Ore Reserves.--The U.S. Geological Survey in 1945, on the basis of the Bureau of Mines work and geologic information, estimated the Shasta and California deposits to contain reserves to depths of 250 to 850 feet as shown in table 35. Based on published topographic maps and cross sections, the stripping ratio of this ore is estimated at 2.5:1.0 on a weight-to-weight basis. Iron Exploration Co. reported that their drilling proved more than 20 million tons of ore, containing 32.5 percent iron.

TABLE 35. - Ore reserves of the Shasta and California iron deposits, Shasta County, Calif.

Cutoff grade iron, percent	Average grade iron, percent	Indicated ore, long tons
13.77	37.82	4,680,000
25.00	41.28	3,894,000
40.00	50.50	1,849,000
50.00	55.66	973,000
60.00	62.99	187,000

Source: California Division of Mines. Iron Resources of California. Calif. Div. Mines and Geol., Bull. 129, 1948, p. 153.

Beneficiation.--Beneficiation tests by the Bureau of Mines indicated that the ore is amenable to straight magnetic separation. The following results were obtained from material containing 40.0 percent iron; treatment at minus 8 mesh yielded 89.4-percent iron recovery in a product containing 59.25 percent Fe, 14.3 percent SiO_2, 0.01 percent P, and 0.21 percent S; treatment at minus 100 mesh yielded 88.4-percent recovery in a product containing 67.5 percent Fe, 4.4 percent SiO_2, 0.01 percent P, and 0.07 percent S (24, p. 11).

Miscellaneous Iron Properties by County

The following iron deposits are described in alphabetical order by counties. A small output has been reported from many of the deposits, but work has failed to develop large iron resources. The isolated location of these deposits prevents their utilization in conjunction with other deposits. The location of each occurrence is shown on figure 11.

Amador County

Clinton

The Clinton iron prospect is 2 miles south of Pine Grove at an altitude of 2,000 feet.

The iron-bearing material occurs as a capping on sandstone and consists of dark brown limonite with minor hematite. The ore is exposed in two road cuts approximately 300 feet apart. The occurrence is estimated to be 750 feet long and 75 feet wide. Its depth has not been determined but is probably shallow. The material analyzed 27.78 percent Fe, 39.88 percent SiO_2, 0.15 percent P, 0.05 percent S, and 0.90 percent Mn.

Ione (Rancho Arroyo Seco)

The Ione or Rancho Arroyo Seco prospect is about 3 miles west of Ione at an altitude of 300 feet.

Impure iron oxides are exposed on the nearly flat tops of low knolls. The ore is residual; this is the result of weathering of the Ione sandstone, which contains hematite and limonite as a cementing agent. The most prominent occurrence is 1,100 feet long, 300 feet wide, and 2 feet thick. A character sample contained 34.82 percent Fe, 18.50 percent SiO_2, 0.211 percent P, 0.066 percent S, and 0.05 percent Mn.

Butte County

Martin

The Martin iron deposit is 6 miles north of Inskip at an altitude of 5,050 feet.

Iron ore occurs as magnetite replacement of a steep, west-dipping pyroxenite dike intruded into diorite. The ore is traceable for about 500 feet by intermittent workings and outcrops and for an additional 600 feet by dip needle. Magnetite float occurs 1,000 feet south of the outcrops. The mineralized dike, where exposed in an open cut, is 8 feet wide. In places it is completely replaced by magnetite. Old workings include a shallow shaft and numerous trenches, almost completely caved. New workings consist of an open cut and shallow trenches which expose the ore zone for a length of 80 feet and a depth of 15 feet.

Rusty Ridge

The Rusty Ridge mine is 11.5 miles north of Inskip by U.S. Forest Service road and private road. Rail connections are available at Stirling City, 7 miles south of Inskip. Ore was shipped from the property in 1960.

The deposit occurs in an inclusion of metamorphosed quartzites, shaly limestone, and limestone surrounded by granite. A tabular body of magnetite has replaced a steep-dipping bed of shaly limestone. The ore is massive, hard, black magnetite which has been altered to hematite and limonite above a depth of 25 feet.

Development includes surface stripping and an open pit 175 feet long, 50 feet wide, and 60 feet deep.

Steep Hollow

The Steep Hollow iron prospect is about 10 miles by road northeast of Feather Falls at an altitude of 3,400 feet.

Hematite occurs in a moderate-dipping vein which crops out prominently along a steep slope for a length of 1,000 feet and a width of 25 to 75 feet. The ore has a low iron content and is very siliceous. Walls are quartzite and fine-grained intrusive rock.

Calaveras County

Big Trees (Calaveras, Sperry)

The Big Trees prospect, also known as the Calaveras or Sperry, is 1.3 miles northwest of Murphys. A steep, northeast-dipping zone of limonite breccia crops out over a width of 40 feet and a length of 125 feet on the rim of a steep slope. Adits driven in the slope below the outcrop encountered only minor quantities of iron ore. Similar iron deposits occur short distances west and southeast of the Big Trees prospect. The ore is reported to be low grade.

Iron Monarch (Detert)

The Iron Monarch or Detert prospect is 2.7 miles north of Valley Springs at an altitude of about 900 feet.

Limonite occurs as a flat capping overlying slaty amphibole schist. The largest occurrence is about 200 feet long, 40 feet wide, and 1.5 feet thick.

Several pits and trenches have been excavated in the occurrence.

El Dorado County

Reliance

The Reliance prospect is 3 miles north of Bass Lake at an altitude of about 1,000 feet.

Magnetite occurs in vertical veins in coarse-grained gabbro. One vein was developed by a 40-foot shaft and a test pit. At the shaft the vein contains 3 feet of fair-grade iron ore. A vein containing 1 foot of similar ore is exposed in a shallow pit about 2,500 feet south of the shaft.

Sixtie Chaix and Simons Ranch

The Sixtie Chaix and Simons Ranch prospects are about 3 miles southeast of Latrobe. The Simons Ranch occurrence is a short distance east of the Sixtie Chaix occurrence.

The occurrences consist of small lenses of highly siliceous magnetite and hematite ore within a serpentine belt. The largest lense is 10 feet wide and 75 feet long. Development consists of a 25-foot vertical shaft and trenches.

Inyo County

Coso

The Coso iron deposits are distributed over an area of several square miles southeast of Centennial Flat at altitudes of 6,600 to 7,600 feet. They are 2 miles inside the U.S. Naval Ordnance Test Station. Ore, mined from 20 or more shallow open cuts, was used for flux at the Darwin and Keeler smelters, which have been closed since before World War I. There has been no recent production from the area.

Hematite with minor magnetite occurs as segregations in granite and to a lesser extent in vertical veins in quartzite. The vein deposits are associated with diorite dikes.

The ore bodies are 5 to 20 feet wide and less than 100 feet long. Although the topography favors it, no attempt was made to develop the ore bodies with adits, and the deposits appear to have limited downward extent. The iron minerals occur in narrow stringers separated by unmineralized wall rock. Beneficiation would be required to make a marketable product. A sample of handpicked ore analyzed 64.50 percent Fe, 4.01 percent SiO_2, 0.026 percent P, and 0.006 percent S.

Iron Cap (Hoot Owl)

The Iron Cap or Hoot Owl mine is on the west side of Panamint Valley, 18 miles by road north of Trona at an altitude of 2,600 feet. Ore was shipped from the deposit in the 1880's to the Modoc smelter for flux. During 1939-41 about 3,000 tons was shipped to the San Francisco area for use in open-hearth steel manufacture (21, p. 53). A small quantity has been produced since 1962.

Massive magnetite and hematite occur in a fault block of limestone over a length of 180 feet. Approximately 75 percent of a favorable bed in the limestone has been replaced, forming an ore zone about 80 feet wide.

An undeveloped ore body occurs about 200 feet north of the developed ore. A small magnetic anomaly occurs several hundred feet further north.

The ore is a hard steel-blue aggregate containing about 60 percent hematite and 40 percent magnetite. It breaks into coarse lump suitable for open-hearth use. Gangue consists of unreplaced silicified limestone and some garnet. Shipments analyzed from 59.21 to 66.97 percent iron and 3.31 to 9.64 percent silica; the phosphorus and sulfur contents are low.

Ore was produced in 1966 by open-cut mining, but much underground development has taken place. Subsurface workings on the west end of the ore body include a 150-foot vertical shaft, 100 feet of drifting from the bottom of the shaft, and an 85-foot inclined winze. From a point at the east end of the ore zone and 75 feet below the shaft collar, a 300-foot adit was driven a total of 50 feet across the ore body without reaching the walls. A glory hole and short adit 35 feet below the surface formerly were used for ore production.

Much aeromagnetic work in the vicinity reportedly indicated moderate extensions of the iron ore zone. An aeromagnetic anomaly 1.5 miles southeast of the mine was explored by drilling. Results of this work are not available.

Iron Chief

The Iron Chief prospect is immediately south of the head of Mountain Springs Canyon at an altitude of 6,500 feet. The area is within the U.S. Naval Ordnance Test Range.

The deposit consists of numerous small hematite veins in granite that are exposed over an area of about 1.5 square miles. Numerous small test pits have been excavated. The largest developed ore body is 10 to 16 feet wide and 50 feet long. The ore is massive hematite containing 60 to 65 percent iron.

Le Cyr (Valley View)

The Le Cyr or Valley View prospect is on the northeast edge of the Coso Range at an altitude of about 5,500 feet, 12 airline miles south of Keeler.

The ore crops out in two veins of specular hematite which form prominent exposures 3 to 5 feet above the surrounding rocks. The veins are enclosed within a mass of partially silicified limestone breccia which covers the entire mountainside to the northwest and west.

The two veins are 75 feet apart; they have parallel strikes but convergent dips. The east vein is 6 feet wide and is traceable for 200 feet. The west vein is 3 to 12 feet wide and 425 feet long. Both veins are offset by steep faults that displace them into several segments.

The hematite is massive in some places; in other places it is of poor grade and diluted by lime and silica. A representative surface sample of both veins analyzed 39.1 percent Fe, 34.22 percent SiO_2, 0.024 percent P, and 0.008 percent S. A sample of sorted stockpiled ore from an adit which intersected the ore zone about 50 feet below the surface analyzed 50.10 percent Fe, 24.62 percent SiO_2, 0.014 percent P, and 0.006 percent S.

Mister

The Mister iron prospect is about 2.5 miles by road southeast of Bradbury Wells, on the east slope of the Black Mountains, at an altitude of 2,200 feet. Part of the property is in Death Valley National Monument.

The mineralized body consists of lenses, seams, and disseminations of finely divided specular hematite in granite gneiss extending throughout a 100-foot-wide and 3,000-foot-long zone. A section of this zone about 1,000 feet long and 25 to 75 feet wide, which contains the best mineralization, has been developed by three short adits and two small open cuts.

The ore is low grade but can be concentrated by screening. The minus 200-mesh portion of the ore is reported to contain from 56 to 63 percent iron and to be low in phosphorus and sulfur. About 300 tons of concentrate has been shipped (21, p. 54).

Lassen County

Red River Lumber Co. Section 12

The Red River Lumber Co. Section 12 prospect is 4 miles east of Westwood. Hematite occurs over a width of 2 or 3 feet and a length of 340 feet in an irregular vein with a steep north dip. The wall rock is diorite porphyry containing some disseminated specular hematite. The ore consists mainly of black crystalline hematite with minor red hematite. Gold, silver, and copper also occur in the vein. The deposit has been explored by three trenches and a shallow shaft.

Los Angeles County

Titaniferous Magnetite

Titaniferous magnetite deposits occur 20 miles north of Los Angeles throughout a large area in T 3, 4 N, R 12, 13, 14 W. About 100 separate occurrences have been reported; some of them contain several million tons of ilmenite-magnetite with 5 to 20 percent titanium dioxide. Despite numerous attempts to utilize this material for titanium pigments, no economic process has been devised to separate the fine-grain intermixed magnetite and ilmenite.

Ore bodies measure a few feet to several hundred yards in maximum dimension. The deposits usually occur in anorthosite, gabbro, or pyroxenite near dikes of granite, aplite, and lamprophyre. Ore boundaries of some deposits are well defined; those of others are gradational. Titaniferous magnetite is an abundant accessory mineral in the region and occurs in placer deposits in large quantities.

Madera County

Wedge (Last Chance)

The Wedge and Last Chance are adjacent deposits on a continuous zone of iron mineralization. They have a common ownership. The property is near the southwest corner of Yosemite National Park, at altitudes of 7,000 to 7,600 feet, about 5 miles northeast of Fish Camp and 53 miles north of Pinedale, the nearest rail shipping point (fig. 18).

Iron occurrences in the areas were described in reports as early as 1916; however, no production took place. Early test-pitting and trenching was done mainly to prospect for nonferrous and precious metals believed to be associated with the gossanlike iron outcrops. However, the deposits contain only minor quantities of metals (or contaminants) other than iron. Mineral Materials Co. leased the property from 1962 to 1968 and did much exploration.

The following description of the deposits was summarized from information supplied by the Mineral Materials Co.:

> "At least three bodies of iron ore occur in a northwest-trending zone that crosses the property. Individual ore bodies range from 300 to 900 feet in length, and from 10 to 150 feet in width, with surface areas of 10,000 to 150,000 square feet. The deposits that have been drilled are subtabular in shape and have a moderate steep dip. Drilling has established that the deposits continue to depths of 176 feet (the greatest depth drilled) without any significant change in cross section. The ore zone is almost entirely blanketed with 10 to 30 feet of overburden and iron ore crops out at only a few places. The ore bodies were outlined by magnetometer surveys before drilling.
>
> "The iron minerals occur as replacement of discontinuous lenses of limy quartzite, which in turn occurs in fine-grained quartzite. The ore horizon and wall rocks have been closely folded. Ore is generally found only in areas of crushed and brecciated rock and apparently these permeable zones provided channelways for ore-depositing solutions. Cross-faults exist along the ore zone and displace it for varying distances. Magnetite is the predominant primary ore mineral but near the surface it has been oxidized to

martite and goethite, and at the surface to limonite. Magnetite ore commonly contains over 60 percent iron, martite from 50 to 60 percent, and limonite less than 50 percent although in places this ore averages 58 percent iron or nearly pure limonite. Analyses of composite samples indicate the ore contains about 0.119 percent P, 0.003 percent S, 0.027 percent Cu, and 0.23 percent Mn. No silica analysis is available but since the host rock of the deposits is quartzite the non-iron oxide portion of the ore should be mainly silica."

Exploration by Minerals Materials Co. indicated about 1.5 million ton of over 50-percent iron ore. Larger tonnages of ore containing 30 to 60 percent iron were inferred. All developed ore is less than 250 feet below the surface and is minable by open-pitting with an overall stripping ratio of about 1.0:1.0 on a weight basis.

Bradley

The Bradley deposit is about one-half mile southeast of the Wedge and Last Chance property at an altitude of 7,300 to 7,900 feet. The Bradley deposit is on the same ore zone as the Wedge and Last Chance deposits and is similar in character to them. No production has taken place.

The Bradley property was also leased by Minerals Materials Co. from 1962 to 1968 and company explorations indicated more than 250,000 tons of over 50 percent iron ore having an average stripping ratio of 1.0:1.0. A larger tonnage of ore containing 30 to 60 percent iron was inferred.

Red Top (Detroit)

The Red Top or Detroit deposit (fig. 18) is 13 miles north of Bass Lake at an altitude of 9,000 feet. Bass Lake is 49 miles north of Pinedale--the nearest rail shipping point.

Magnetite crops out prominently on the top of a knoll. It is exposed over a length of about 200 feet and to a depth of 30 feet and is 30 to 80 feet wide. Tactite occurs along the southwest edge of the deposit. Granite borders the magnetite on the northeast, and granite dikes cut through both tactite and magnetite. Three trenches near the outcrop failed to encounter ore.

About one-half mile northwest, magnetite is exposed on the surface for a length of 110 feet and a width of 25 feet. Tactite is in contact with magnetite on one side of the deposit, and a few small remnants of tactite are scattered throughout the magnetite. Elsewhere on the outcrop, granite is in contact with the iron ore.

Another body of magnetite 15 feet long, 5 feet wide, and 5 feet deep occurs 300 yards west of the largest ore outcrop in a mass of tactite and marbleized limestone about 100 feet in diameter. Granite surrounds the tactite and limestone inclusion. Similar small bodies of magnetite occur further northwest.

Rising Sun (Dexter)

The Rising Sun or Dexter prospect is 8 miles by road and trail northeast of Fish Camp near the southwest corner of Yosemite National Park at an altitude of about 8,000 feet (fig. 18).

The property was originally located for copper but subsequent development showed the mineralization to be magnetite and iron sulfides. Diamond drilling to a depth of 225 feet penetrated 50 to 100 feet of iron ore near a contact of granodiorite and quartzite.

Mono County

Churchill

The Churchill prospect is in the North Fork of Milner Creek Canyon about 25 miles by road and trail northeast of Bishop.

The area is underlain by a series of Precambrian quartzites and slates that have been intruded by granite of Jurassic age. Two iron deposits are present.

The upper deposit, at an altitude of 8,000 feet, occurs in a northwest-dipping gabbro dike which cuts granite. The 6- to 8-foot-wide dike is partially replaced by magnetite for a length of more than 300 feet. In limited areas the replacement is complete but to produce a substantial tonnage of ore, the entire dike would have to be mined and the material beneficiated to commercial specifications.

The lower deposit, about 1,000 feet southwest of the dike and 500 feet lower in elevation, occurs in quartzite along the crest of a ridge. Three steeply dipping veins, two of which intersect, contain magnetite ore up to 10 feet in width with a combined length of 150 feet. Many small lenses of magnetite under 10 feet in length occur in the quartzite at this locality.

Wilson

The Wilson prospect is 20 miles by road east of Colville and 2 miles northwest of Lob Dell Lake at an altitude of 8,900 feet.

A series of trenches has delineated a zone of steep-dipping fractures that contain magnetite over a 100- to 200-foot-wide and 400-foot-long area. The overall grade of the deposit is low.

Smaller zones containing magnetite occur one-quarter of a mile and three-quarters of a mile southeast of this area.

Nevada County

Indian Springs

The Indian Springs iron deposit is about 1 mile northwest of Indian Springs at an altitude of 1,700 feet.

The ore consists of limonite and hematite derived from the oxidation of pyrite in a fine-grained, highly altered siliceous zone with diorite walls. The zone of oxidized ore is approximately 100 feet wide and can be traced for over 1,200 feet. At the northwest end of the hematite outcrop, a few hundred tons of ore was produced from an open cut and sold for pigment manufacture.

Placer County

Hotaling

The Hotaling mine is 6 miles north of Auburn at an elevation of 1,600 feet.

A blast furnace on the property operated during 1881-86 and produced 15,000 tons of pig iron. During this period the Hotaling mine produced an estimated 40,000 tons of ore containing 50 percent iron. The mine was developed by two shafts on separate but geologically related ore bodies.

The geology has been reported by the U.S. Geological Survey (13, pp. 225-227).

During 1944 the U.S. Bureau of Mines made a magnetometer survey of the area to determine the extent of the iron mineralization. No significant new mineralized zones were disclosed by the work. The strongest anomaly found surrounds the No. 2 Magnetite shaft which was in operation during the 1880's. It is unlikely that any of the other anomalies mapped contain ore bodies of economic importance.

Plumas County

Bonner

The Bonner prospect is in Moonlight Valley about 14 miles southeast of Westwood at an elevation of 5,400 feet. A zone of iron ore 4 feet wide crops out for a length of 50 feet, and float indicates an additional length of 300 feet. The vein dips steeply to the south. Both walls are of unmineralized dark andesite porphyry. The ore is black crystalline hematite with subordinate magnetite.

A test pit 20 feet deep was sunk on the vein and about 50 tons of lump ore stockpiled. The surrounding areas were explored by trenching, but no significant occurrences of iron ore were discovered.

Brown

The Brown prospect is on the south side of Moonlight Valley 15 miles southeast of Westwood at an altitude of about 5,600 feet.

Reportedly, within the property there is a 2-acre area of red soil on which there were many boulders up to one-half ton in size and consisting of pure crystalline hematite with appreciable quantities of magnetite. The boulders may have been derived from an unexposed weathered deposit in the area or from a vein in porphyry on the mountain 600 feet to the south where similar hematite is exposed. Small pieces of hematite occur in the soil between the area said to contain the boulders and the exposed vein; however, the large size of the reported hematite float suggests that a nearby buried vein may exist.

The vein on the mountain contains high-grade, hard, black crystalline hematite over a width of 8 feet and along an exposed length of 50 feet. It dips vertically.

The area of hematite boulders has been partially stripped and several shallow trenches have been excavated to the south. However, no additional occurrences were discovered.

Riverside County

East Wide Canyon Iron-Titanium

The East Wide Canyon Iron-Titanium deposit is in the Little San Bernardino Mountains, about 15 miles by road northeast of Garnet at an altitude of about 4,000 feet. The following description of the deposit was abstracted from information supplied by Southern Pacific Co.

The mineralized area is underlain by rocks of the Precambrian Chuckwalla metamorphic complex consisting mainly of dark-colored biotite-diorite gneiss which contains thin layers of biotite schist.

An iron-titanium bearing zone, which dips to the northwest, parallels the foliation. The ore body is about 1,800 feet long and 100 feet wide. The southwest end of the ore body is terminated sharply by a northwest trending postmineral fault. Several other northwest faults with minor displacements offset the mineralized zone.

Ilmenite occurs as one-twentieth to one-thirtieth mm grains uniformly distributed throughout dark-brown, massive titaniferous magnetite. The weighted average of nine sample analyses was 43.59 percent Fe, 17.68 percent TiO_2, 9.38 percent SiO_2, trace P, 0.08 percent S, and 0.55 percent V. The nonmagnetic fraction of the material, which represented 55.6 percent of the sample by weight, contained 67.6 percent of the total titanium. The nonmagnetic portion assayed 23.7 percent titanium dioxide and 38.9 percent iron; the magnetic fraction assayed 14.3 percent titanium dioxide and 51.4 percent iron.

Exploration on the property consisted of geologic mapping, a dip-needle survey, and surface sampling. The work determined the lateral extent of the ore body and indicated continuity of the tabular vein at depth.

Southern Pacific Co. estimated the deposit to contain 1 million tons of magnetite-ilmenite ore with an average grade of 43.6 percent iron and 17.7 percent titanium dioxide. The ore body is adaptable to open pit mining with a waste-to-ore ratio of 1.5:1.

The iron-titanium material is currently unmarketable. Possible future utilization could be as a source of titanium pigments with an iron ore byproduct; however, the magnetite and ilmenite are too intimately mixed to be separated economically with known beneficiation methods.

Iron Cap

The Iron Cap prospect occurs 16 miles east of Desert Center on the southwest end of the Palen Mountains at an altitude of about 700 feet.

The following unpublished description of the deposit was furnished by the California Division of Mines and Geology in 1965:

"This deposit is exposed on the sides of a shallow ravine cut in the south flank of a ridge underlain by altered metavolcanic and metasedimentary rocks. The head of the ravine lies athwart a vertical to steeply north-dipping shear zone which strikes east-west and appears to be as much as 300 feet wide. Within the shear zone the country rock is altered to a mixture of quartz, epidote and calcite, and in part replaced by irregular, lenticular masses of magnetite.

"Individual bodies of magnetite as much as 15 feet in thickness and 50 feet in lateral extent are exposed but the bulk of the iron deposit appears to comprise swarms or zones of small bodies averaging perhaps 3 feet in thickness and 15 feet in exposed length. The magnetite is fractured and as the host rock has weathered, the iron oxide bodies have crumpled to a litter of float. Thus the full extent or number of magnetite bodies is difficult to estimate. The ore bodies appear to be unevenly distributed across the full width of the shear zone and to have a lateral extent of about 400 feet. Surface indications of iron mineralization extend only 30 to 40 feet up the east slope of the ravine. The western limit of the deposit is concealed beneath a wash.

"The chief impurities in the magnetite appears to be unreplaced bodies of altered country rock, the most common constituent of which is epidote. One specimen of magnetite float contained perhaps as much as 20 percent by volume of slender prismatic apatite crystals.

"The magnetite deposit has been opened by a trench about 15 feet long and 6 feet deep at the face and by several shallow prospect pits."

Iron King

The Iron King prospect is on the southwest end of the Palen Mountains, 17 miles east of Desert Center at an altitude of 800 feet. There has been no production.

The following unpublished description of the deposit was furnished by the California Division of Mines and Geology in 1965:

"The area of the Iron King and Iron Queen claims is underlain by greenstone. The claims include a faulted and sheared zone as much as 100 feet wide which strikes about N 75° W, and dips 75° south. The lateral extent of the zone was not determined. Lenses of massive magnetite lie in the fault zone, where it is exposed on the east side of a ridge. The largest magnetite body exposed is about 60 feet thick near the base of the ridge and narrows to a termination just below the ridge crest; a surface distance of about 300 feet. The main ore body appears to be flanked by at least two smaller lenses a few tens of feet in exposed length. One of the smaller bodies is a porous mass near the hanging wall just below the ridge crest. The other is an apatite-rich lens near the footwall at about the same level. The ore bodies have gradational contacts with and contain isolated masses of greenstone. They appear to be replacement deposits. In addition to contamination by included greenstone the magnetite contains an undetermined but apparently high proportion of unevenly distributed apatite crystals.

"The deposit has been exposed in an open cut at the base of the ridge and in four evenly spaced bulldozer cuts on its east slope."

Lindy Loop No. 1

The Lindy Loop No. 1 prospect is in the Big Maria Mountains about 12 miles north of Blythe at an altitude of 1,150 feet. There has been no production.

The following unpublished description of the deposit was furnished by the California Division of Mines and Geology in 1965:

"A northwest-trending fault that dips 50° southwest separates coarse-grained limestone in the hanging wall from wollastonite-bearing carbonate rock in the footwall. Both of these rock units are members of the McCoy formation (Miller, California Journal of Mines and Geology, 1944, p. 327). A gouge zone in the fault as much as 15 feet thick contains mineralized veins composed principally of spongy hematite, altering to limonite, with stringers of dirty-green epidote and possibly some gold. Portions of the wall rock along the fault are stained blue by a secondary copper mineral, probably chrysocolla. The hematite veins are elongate, semi-tabular, and tend to pinch and swell. A kidney 2 feet in maximum width was observed. Locally the wollastonite-bearing rock has been replaced by magnetite. An irregular replacement body a few tens of feet wide occurs low on the west slope of the hill between a prospect pit and the dirt road leading from the workings.

"Several open cuts and prospect pits expose the vein along the fault zone."

San Bernardino County

Altuda (Globerson)

The Altuda or Globerson deposit is 14 miles south of Barstow at an altitude of 3,340 feet.

In 1942, 100 tons of selected iron ore was shipped to a foundry in Alhambra, Calif. The deposit is developed by a 50-foot vertical shaft, surface pits, and trenches.

The mine area is underlain by meta-dacite and meta-andesites. Small bodies of quartz monzonite prophyry intrude the volcanic rocks near the ore bodies.

Ore occurs in a series of five steep-dipping en echelon veins separated by intervals of 50 to 250 feet and also in associated wall-rock replacements. The vein system is terminated on the west by a steep, northeast-trending shear zone.

The iron mineralization in the en echelon vein system consists of lenses of dense black, siliceous, iron-impregnated rock which contains bands of hematite up to 2 feet in width. The highest grade ore body is 20 to 25 feet wide and 160 feet long. The vein filling varies from massive hematite bands with a grade of 65 percent iron to mineralized wall rock containing disseminated magnetite.

Ball (Red Seal)

The Ball or Red Seal prospect is about 6 miles by road south of Barstow in the foothills of the Sidewinder Mountains, at an altitude of 4,150 feet. Development consists of several short adits and test pits which are mainly barren of iron. There has been no production.

The iron-bearing area is within a 100-acre blue dolomite inclusion in quartz monzonite. The dolomite is heavily fractured and contains many narrow, irregular dikes of lamprophyre and quartz monzonite. Magnetite is present as pods ranging in size from tiny veinlets to lenses 2 feet wide by 10 feet long. An outcrop 30 by 60 feet in area has an overall grade of 25 percent iron. Much high-grade iron ore float is scattered on the Hillside below the outcrop.

A large area of magnetite-impregnated serpentine and chlorite, too low in grade to be considered iron ore, occurs nearby.

Black Jack

The Black Jack prospect is near the summit ridge of the Bristol Mountains about 9 miles by road northeast of Amboy at an altitude of about 2,000 feet.

Magnetite ore occurs in a moderately north-dipping dolomite inclusion in granite at the intersection of steep southeast-dipping fissures and steep northeast-dipping fracture zones. Six or more bodies ranging in size from 20 by 40 feet to 50 by 70 feet crop out over an area of about 2 acres. The ore occurs as replacements and vein fillings in otherwise barren dolomite. Mineralization is confined to a single 15-foot thick horizon in the dolomite.

A character sample of ore analyzed 55.12 percent Fe, 4.68 percent SiO_2, 0.003 percent P, 0.10 percent S, and 0.26 percent Mn.

Workings include an open cut in the northwest corner of the mineralized area, shallow pits, and surface stripping.

Black Magic (Owl Hole)

The Black Magic or Owl Hole mine is 3 miles northwest of Owl Hole Springs, 59 miles by road northwest of Baker, at an altitude of 3,000 feet. No production has been reported but apparently several thousand tons of material was mined from a 100- by 200-foot open cut, which was excavated on the outcrop. A significant tonnage of manganese ore was produced from deposits about 1 mile east of the iron ore body.

The area is underlain by light tan marble and intrusive granite. Hard, blue-black hematite ore occurs as replacement bodies conformable to the irregular but generally near-vertical dip of the marble. Narrow sills of dark fine-grained granite cut through the ore body and surrounding rock. Large outcrops of granite occur 500 feet northeast of the deposit. Iron ore crops out over a length of 800 feet and a width of 100 feet including the large mass developed by the open cut.

Copper World

The Copper World prospect is about 16 miles northeast of Twentynine Palms on the southwest slope of the Bullion Mountains.

A lenticular body of magnetite and hematite 8 to 20 feet wide and about 300 feet long with a variable but generally steep dip occurs in quartz diorite. The deposit was explored by surface cuts and a short crosscut adit. During the mid-1940's, about 1,000 tons of ore was produced (32, p. 93).

Iron Hat (Ironclad)

The Iron Hat or Ironclad mine is on the southern end of the Marble Mountains, 14 miles by road northeast of Amboy, at altitudes of 1,500 to 2,000 feet. The nearest rail shipping point is Cadiz, 6 miles to the south, on the Santa Fe Railroad. During the 1930's, about 2,000 tons of iron ore was mined from an open pit and shipped to the Llewllyn Iron Works in Torrance. A moderate tonnage was mined from two open cuts in recent years. The deposit is under lease to Riverside Cement Co.

The ore bodies are moderate in size, irregular in shape, and are scattered throughout an area 6,000 feet long and 1,000 feet wide. A body of massive ore 180 feet wide and 200 feet long on the west end of the property crops out prominently on a ridge. This ore body is localized in dolomite near a granite contact at the intersection of steep-dipping fissure zones. An open cut 65 by 55 feet in area and 50 feet deep was excavated on the highest grade portion of the ore body. The bottom of the open cut is mainly massive magnetite and hematite; the walls of the pit contain abundant garnet, epidote, and actinolite.

Another outcrop of magnetite and hematite ore about 150 feet in diameter occurs one-quarter mile to the east in a geologic setting similar to that at the west pit. This ore body has been mined in a pit 75 feet long, 50 feet wide, and 60 feet deep.

Other small areas of iron-bearing material crop out 1,000 feet southeast and 500 feet northeast of the west pit.

The average grade of two typical samples of iron ore taken by the U.S. Geological Survey was 58.40 percent Fe, 4.51 percent SiO_2, 0.017 percent P, 0.025 percent S, 0.76 percent Al_2O_3, 1.36 percent CaO, 6.46 percent MgO, and 0.24 percent Mn.

The reserves were estimated in 1945 by the Geological Survey as 85,000 tons of indicated ore and 200,000 tons of inferred ore. Subsequent mining has substantiated this estimate (3, p. 108).

Ship Mountain (Paul)

The Ship Mountain or Paul mine is 3 miles south of Siam, an abandoned siding on the Santa Fe Railroad and about 24 miles by road southeast of Amboy. The deposit is on the north slope of Ship Mountain at altitudes of 1,600 to 1,700 feet.

During 1918 about 1,500 tons of ore was shipped (32, p. 98). No production has been reported since. The property has been explored by numerous pits, trenches, and short adits. The largest ore lens was developed by a 365-foot inclined shaft and six levels, which contain about 830 feet of drifts and crosscuts. The ore horizon has been explored by surface workings for a distance of three-quarters of a mile. Two significant ore bodies were found, each about 300 feet long and 2 to 20 feet wide. The ore bodies are separated along the strike by about 900 feet of weakly mineralized breccia. Walls are of dark-green chloritic schist. The developed ore body has a strike length of 300 feet on the surface, 100 feet on the 80-foot level, and 25 feet on the 190-foot level. Only small quantities of ore were encountered below the 250-foot level. The ore body was stoped to a width of 20 feet.

Gypsum and small quantities of secondary copper minerals were deposited near faults. The ore is brecciated red to steel-gray hematite with some massive magnetite. About 30 percent of the material from stoped areas was waste rock.

An average analysis is 63.59 percent Fe, 4.38 percent SiO_2, 0.011 percent P, and 0.55 percent S (3, p. 116).

San Luis Obispo County

Prefumo (McKinney)

Iron ore occurs in the southern portion of the Rancho Canada de Los Osos Grant, 2 to 7 miles west and south of San Luis Obispo. The deposits, known as the Prefumo or McKinney, are in the San Luis Obispo Mountains at altitudes of 250 to 1,000 feet.

The iron deposits have been known for about 70 years. Their outcrops have been explored intermittently and trial shipments have been made to several steel companies. In 1924, the mineral rights to most of the iron-bearing area were consolidated and an unsuccessful effort was made to exploit the property by use of a pioneer, direct-iron-ore-reduction method.

Beds of limonite containing occasional thin seams of hematite occur in the Franciscan group of upper Jurassic sediments. The most important limonite bed has a uniform width of 10 to 11 feet and a total strike length of over 5 miles. The iron is of sedimentary origin and should persist to considerable depth. Folding and faulting have disturbed the bed.

The deposit contains moderately large resources. The average analysis of three samples from the outcrop is 46.16 percent Fe, 13.23 percent SiO_2, 0.51 percent P, and 0.64 percent S.

Shasta County

Hirz Mountain

The Hirz Mountain magnetite deposit is on the northeastern slope of Hirz Mountain at an altitude of 1,300 to 1,600 feet, about 2,000 feet west of the McCloud arm of Shasta Lake and 200 to 300 feet above the reservoir's high-water mark. The nearest rail shipping point is O'Brien siding on the Southern Pacific Railroad, 18 miles from the property.

The mineralized areas were first claimed in 1903 and relocated in 1943. During 1961-62 Don Clifton, the present owner, produced a moderate tonnage of ore which was exported to Japan.

Several pods of magnetite, the largest of which is about 20 feet wide and 40 feet long, occur in a system of steep southwest-dipping fissures (which parallel the bedding) at their intersection with fracture zones. Walls are brittle fine-grained siliceous limestone and quartz diorite. Some of the magnetite ore bodies were bottomed in an open cut at a depth of about 50 feet when quartz diorite was encountered in both walls of the fissure. The ore is hard and has a high iron content. It contains only small quantities of silica, phosphorus, and sulfur.

Mine workings consist of a series of open cuts and trenches over an area of several acres.

Iron Mountain

The Iron Mountain magnetite deposit is on the south slope of Iron Mountain 18 miles northwest of Redding at an altitude of 2,600 feet. An aerial tramway connects an adjacent copper mine with a branch line of the Southern Pacific Railroad. The deposit is owned by Mountain Copper Co.

The Iron Mountain mine has been a large producer of pyritic ore containing copper, zinc, gold, and silver and of gossan ores mined from the oxidized portions of the sulfide ore bodies. More than 9 million short tons was produced from which a large quantity of iron oxide was recovered as a byproduct of sulfur, nonferrous metal, and precious metal production. Most of the recovered iron oxide was shipped to cement manufacturers. Also, a moderate production of magnetite ore was made from a lens of massive magnetite about 700 feet south of the sulfide ore body.

The magnetite ore bodies appear to be related, at least structurally, to the heavy sulfide deposits; however, the magnetite is confined to three lenses within an area of about 4 acres. The magnetite ore is devoid of sulfur and nonferrous metals.

The area is underlain by porphyritic rhyolite, which has been altered to a pale grayish-green skarn rock containing some garnet and epidote and which is stained with limonite.

Open-cut workings have exposed the most prominent magnetite body along a strong southeast-dipping fault zone. Fractures that cut the fault zone in the mineralized area have localized the ore. The pit contains an irregular ore body 90 by 140 feet in area on the west side of the fault and 50 by 100 feet in area on the east side of the fault. Drilling indicates that the ore body extends downward at least 75 feet. Some irregular fingers of magnetite extend outward from the main ore body, but usually only a small amount of low grade ore surrounds the massive ore. The ore is dense black magnetite, a minor part of which has been oxidized to a hard dark-blue hematite. The ore has been shipped without treatment and has analyzed from 58 to 62 percent iron.

The ore body has been explored by diamond drilling and developed by open-cut mining. A pit 150 feet long and 100 feet wide, with two banks 15 feet high has been excavated.

Mountain Copper Co. estimates that about 100,000 tons of direct-shipping-grade ore with a stripping ratio of 1:1 or less has been developed. No estimate is available of the amount of ore present of lower grade or with a higher stripping ratio.

Sierra County

Lake Hawley and Spencer Lake

The Lake Hawley and Spencer Lake iron deposits are at an altitude of 6,500 feet in a summit valley of the Yuba River about 12 miles by road and trail west of Johnsville.

The deposits were described in a private report by Richthofen in 1865 and by the pioneer geologists, Clarence King and James D. Hague, in 1873. The ore exposures are covered by one 9,900- by 1,300-foot patented claim located before the mining law of 1866 was passed. The property has been explored by surface mapping and dip-needle surveying.

Iron deposits are localized on faults at their intersection with fracture zones. The wall rock is usually chlorite phyllite, and occasionally dolomite. The ore is almost entirely magnetite and chlorite or magnetite and dolomite. A composite sample of magnetite ore with phyllite gangue analyzed 38.77 percent Fe, 27.99 percent SiO_2, 0.15 percent P, and Tr of S.

An ore reserve estimate by the U.S. Geological Survey in 1947 was 175,000 tons of 26-percent iron ore above a depth of 100 feet (3, p. 191).

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CHAPTER 6.--IRON OCCURRENCES IN NEVADA

History and Production

Intensive prospecting for metallic ores in Nevada began in the 1850's and the outcrops of many of the State's iron deposits were probably noted during the first years of mining activity; however, there was little market for iron ore in the Western States at that time and iron deposits were of scant economic interest. The first reported iron ore shipment was in the late 1880's when 500 tons of ore was shipped to the Union Iron Works in San Francisco from the Buena Vista Hills district, southeast of Lovelock, Nev. An 1893 report mentions the use of a few hundred tons of this iron ore by San Francisco foundries. The ore was probably shipped by lessees from land owned by Southern Pacific Co. Other deposits on private land that have been known since the pioneer mining period include the Segerstrom-Heizer and Thomas mines in Pershing County and the Barth mine in Eureka County.

Most of the Nevada iron ore deposits occurring on public land that have had significant production were located between 1898 and 1908. These include the Buena Vista, Churchill County; Phelps Stokes, Nye County; Dayton, Lyon County; Modarelli, Eureka County; and Minnesota, Douglas County. The Iron King mine in Humboldt County was reported to have been known since 1908 but was not claimed until 1949 because of its relative isolation. The McCoy iron deposits in Lander County were not reported until the 1920's when gold and silver were found in the district; the first location for iron was not made until 1941.

In the early 1950's large iron deposits, such as the Ford mine in Pershing County, were discovered in the Buena Vista district by magnetic prospecting; in the 1960's, important deposits were discovered in the Pumpkin Hollow and Walker River districts in Lyon and Mineral Counties by aeromagnetic prospecting.

The first important Nevada iron ore production was made at the Barth mine from 1903 to 1918 when 763,000 tons was shipped to the Salt Lake City area in Utah for use as flux in smelting siliceous nonferrous ores.

During 1943-45 about 43,000 tons of iron ore was shipped to the wartime west coast shipbuilding industry for ballast, mostly from the Segerstrom-Heizer property.

The primary steel industry, which was established in California in 1943, purchased approximately 32,000 tons of mainly lump ore during 1943-50. Most of this production also came from the Segerstrom-Heizer property.

In 1951 Japanese steelmakers began purchasing substantial quantities of iron ore from Nevada mines, and these purchases have continued with considerable variation to 1968. Beginning in 1951 domestic steelmakers greatly increased their purchases of Nevada ore and small quantities were sold for cement manufacture and miscellaneous uses. Yearly production of iron ore increased from 5,000 tons in 1950 to 299,000 tons in 1951 and reached a high of 1,141,000 tons in 1965. Production in 1967 was 641,000 tons of which more than 500,000 was exported (table 36). The main producers have been the Minnesota, Phelps-Stokes, Segerstrom-Heizer, Thomas, Ford, Buena Vista, Iron King, Barth, and Modarelli mines.

TABLE 36. - Production of iron ore in Nevada, 1890-1967, by uses

(Thousand long tons)

Year	Iron and steel		Other[1]	Total
	Direct shipping	Concentrates		
Prior to 1943[2]..				780
1943...........	2		5	7
1944...........	2	-	30	32
1945...........	3	-	3	6
1946...........	3	-	-	3
1947...........	5	-	-	5
1948...........	9	-	-	9
1949...........	3	-	-	3
1950...........	3	-	-	5
1951...........	299	-	([3])	299
1952...........	908	-	4	912
1953...........	437	-	7	444
1954...........	347	-	4	351
1955...........	325	-	-	325
1956...........	917	-	-	917
1957...........	539	365	-	904
1958...........	([4])	([4])	([4])	594
1959...........	([4])	([4])	([4])	698
1960...........	([4])	([4])	([4])	740
1961...........	([4])	([4])	([4])	845
1962...........	([4])	([4])	([4])	617
1963...........	([4])	([4])	([4])	772
1964...........	([4])	([4])	([4])	911
1965...........	([4])	([4])	([4])	1,141
1966...........	([4])	([4])	([4])	1,000
1967...........	([4])	([4])	([4])	641
Total......	-	-	-	12,960

[1] Other includes ores used for smelter flux, heavy aggregate, cement, shielding, pigments, and other uses.

[2] Estimated.

[3] Less than 500 long tons.

[4] Withheld to avoid disclosing individual company confidential data.

Geography

Important iron-ore deposits occur in several mining districts in northern and western Nevada (fig. 20). These districts all have the characteristic topography of the Great Basin region, north-trending mountain ranges 10 to 20 miles wide and 100 miles or more long, separated by valleys 10 to 30 miles wide. Altitudes along the mountain crests range from 5,000 to 11,000 feet and on the valley floors from 3,800 to 6,000 feet.

Most iron deposits occur on mountain slopes at elevations ranging from 4,800 to 7,000 feet. Some deposits are close to permanent streams that provide sufficient water for culinary and industrial use. At other deposits processing water is available from wells. Ground water is fairly abundant throughout the iron districts, although often it occurs at considerable depth.

Main lines of the Southern Pacific and Western Pacific Railroads cross northern Nevada and the Hazen-to-Mina branch line of the Southern Pacific extends through the west-central portion of the State. Nearly all of the important iron deposits are within 40 miles of rail transportation; most are within 20 miles. State and county roads connect the iron districts with shipping points. Only a few people live on mining properties. Most mines are within commuting distance of established towns which serve as residential communities and supply centers for the iron mines.

A network of electric transmission lines serves towns in the iron regions, but most mines generate their power locally. Pipelines distribute natural gas throughout much of the iron area; however, none of the mines are connected to the lines.

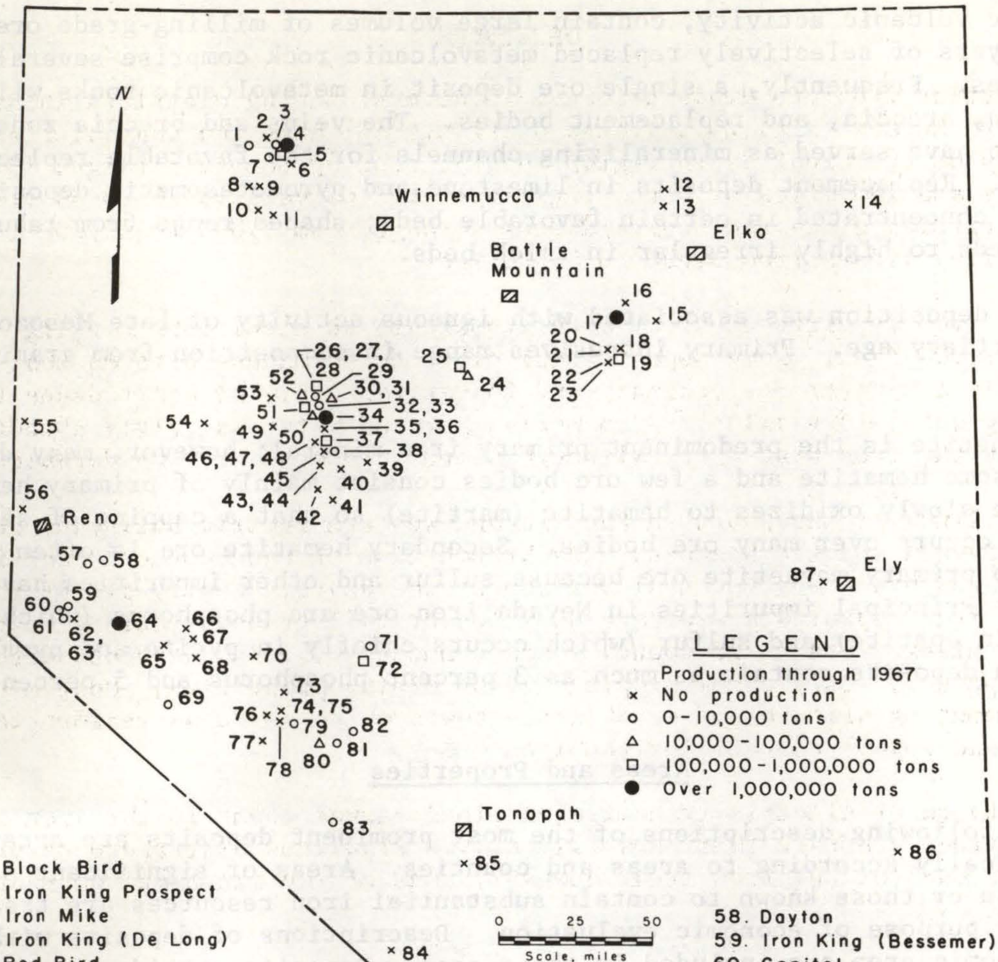
The climate is arid with considerable variation in temperature. Open pit mining and ore haulage at higher elevations are hampered occasionally by storms, but in most localities delays due to weather are unusual.

Geology

Nevada's iron ore deposits are mainly of igneous origin and are classed as hydrothermal, replacement, or pyrometasomatic, depending upon their mineralogical composition and distance from the mineralizing intrusive.

Metamorphosed volcanics, metamorphosed dolomites and limestones, or intrusives are the host rocks for the iron mineralization. Hydrothermal deposits in metavolcanic and igneous rocks predominate in the northern section of the State throughout the Cortez Mountains, Jackson Mountains, and Buena Vista Hills area, while high-temperature pyrometasomatic deposits in metamorphosed dolomites, limestones, and other sedimentary rocks are widespread in western Nevada throughout the Dayton, Buckskin Hills, Pumpkin Hollow, Walker River, and Gabbs areas.

The ore bodies have various forms. Veins are common, particularly in metavolcanic rocks, and attain widths of 100 feet or more. Breccia zones, including both those associated with faults and those associated with



1. Black Bird
2. Iron King Prospect
3. Iron Mike
4. Iron King (De Long)
5. Red Bird
6. Occurrence
7. Blackjack
8. Red Ball
9. Low
10. Occurrence
11. Occurrence
12. North Independence Mountain
13. Iron Hood (Hogle)
14. Durham
15. Bullion District
16. Occurrence
17. Barth
18. Occurrence
19. Modarelli
20. Imperial
21. Jackson
22. Frenchie Creek
23. Big Pole Creek
24. Hancock
25. McCoy (Uhalde)
26. Thomas
27. Section 29
28. Hematite
29. Beacon Hill
30. Southeast Sec. 29
31. Iron Castle
32. American Ore Co.
33. American Ore Co.
34. Segerstrom and Heizer
35. Anomaly
36. Sections 27, 34
37. Buena Vista
38. Emery-Fisk
39. White Cloud
40. Ute
41. White Rock
42. Coppereid
43. Copper Kettle
44. Black Joe
45. Anomaly
46. Southwest Anomaly
47. Iron Point
48. Section 5
49. Piute
50. American Ore Co.
51. Ford (Iron Horse)
52. Section 31
53. Tule
54. Basalt
55. Black Hawk
56. Peavine
57. Iron Blossom
58. Dayton
59. Iron King (Bessemer)
60. Capitol
61. Iron Pot
62. Iron Butte
63. Pine Nut
64. Minnesota
65. Pumpkin Hollow
66. Calico
67. Hottentot
68. Walker Lake
69. Owen
70. Whooppee (Foster)
71. Gabbs (Engle-Stouder)
72. Phelps Stokes
73. Crews
74. Gillis
75. Black Horse
76. Last Chance
77. King David
78. Black Butte
79. Iron Crown
80. Iron Gate
81. Iron Butte
82. Maddalena
83. Boak (Iron King
84. Aja
85. Klondike
86. Manhattan
87. Pilot Knob

FIGURE 20. - Iron Occurrences in Nevada.

explosive volcanic activity, contain large volumes of milling-grade ore. Thick layers of selectively replaced metavolcanic rock comprise several large ore bodies. Frequently, a single ore deposit in metavolcanic rocks will contain vein, breccia, and replacement bodies. The veins and breccia zones appear to have served as mineralizing channels for the favorable replacement horizons. Replacement deposits in limestone and pyrometasomatic deposits usually are concentrated in certain favorable beds; shapes range from tabular in narrow beds to highly irregular in thick beds.

Ore deposition was associated with igneous activity of late Mesozoic to early Tertiary age. Primary intrusives range in composition from granite to diorite.

Magnetite is the predominant primary iron mineral; however, many deposits contain some hematite and a few ore bodies consist mainly of primary hematite. Magnetite slowly oxidizes to hematite (martite) so that a capping of secondary hematite occurs over many ore bodies. Secondary hematite ore is often preferred to primary magnetite ore because sulfur and other impurities have been removed. Principal impurities in Nevada iron ore are phosphorus (which occurs chiefly in apatite) and sulfur (which occurs chiefly in pyrite and pyrrhotite). Some iron deposits contain as much as 3 percent phosphorus and 5 percent sulfur.

Areas and Properties

The following descriptions of the most prominent deposits are arranged alphabetically according to areas and counties. Areas of significant past production or those known to contain substantial iron resources are treated as units for purpose of economic evaluation. Descriptions of deposits within each economic area are included in their area. Deposits outside the main areas are reported by counties. A table listing all significant occurrences of iron properties is included. It provides data on the property name, survey location, ore production, development, mode of occurrence, reported owner, and lists the appropriate reference number in the chapter bibliography (table 37). Much of this table information is not repeated in the text.

Sources of data and methods used to estimate resources and costs are presented and explained in chapter 4. Most resource estimates of well explored properties were taken from reports of the U.S. Geological Survey or private geologists. Resource estimates for partially explored areas were usually unavailable and estimates for these areas were made by the author using magnetic anomaly maps, results of incomplete drilling (if available), and geologic inferrences. Estimates of production costs were made by the author after studying mining and metallurgical characteristics. It was assumed for the production-cost estimates that all ore bodies in each area could be operated jointly at the most efficient overall production rate.

TABLE 37. - Nevada iron properties

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	CHURCHILL COUNTY					
Anomaly (Section 11)	Sec 11, T 24 N, R 34 E.	None.	Magnetic survey	Unknown.	Unknown.	-
Anomaly (Sections 27, 34)	Secs 27, 34, T 25 N, R 34 E.	do.	do.	do.	Southern Pacific Co.	-
Black Joe	Sec 33, T 24 N, R 34 E.	do.	Shallow shaft; trenches.	Magnetite in veins in metavolcanic rocks.	Frank Green, and others.	(19)
Buena Vista	Secs 3, 4, 9, T 24 N, R 34 E.	More than 600,000.	Extensive diamond drilling; large open pit.	Magnetite in veins and disseminated in metavolcanic rocks.	United States Steel Corp.	(9, 16, 18)
Coppereid	Secs 28, 29, T 23 N, R 34 E.	None.	Extensive development for copper.	Specularite lenses in shale; quartzite; and limestone near granite contact.	Dodge Construction Co. (lessee).	(19)
Copper Kettle	Sec 28, T 24 N, R 34 E.	do.	Copper prospect.	Unknown.	Ed Bottomly.	-
Emery-Fisk	Secs 12, 13, T 24 N, R 34 E.	do.	Small pit.	Magnetite in veins.	W. M. Fisk.	(19)
Iron Point	Secs 5, 8, T 24 N, R 34 E.	do.	Diamond drilling.	Magnetite in veins and disseminated in metavolcanic rocks.	Southern Pacific Minerals Materials Co.	-
Section 5	Sec 5, T 24 N, R 34 E.	do.	do.	do.	Southern Pacific Co.	-
Southwest Anomaly	Sec 8, T 24 N, R 34 E.	do.	Magnetic survey.	Magnetite in veins and disseminations in metavolcanic rocks.	do.	-
Ute	Sec 31, T 24 N, R 35 E.	do.	Diamond drilling trenches.	Disseminated magnetite in metavolcanics.	Unknown.	(6)
White Cloud	Sec. --, T 23 N, R 37 E.	do.	Unknown.	Unknown.	do.	(6)
White Rock	Sec 6, T 22 N, R 35 E.	do.	do.	Veins and pods of magnetite and hematite in metavolcanic rocks.	Stanford A. Bunce Estate.	(19)
	DOUGLAS COUNTY					
Iron Butte	Sec 16, T 14 N, R 21 E.	do.	Trenching	Small magnetite lenses along fissure in diorite schist.	Unknown.	-

TABLE 37. -- Nevada iron properties--Continued

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	DOUGLAS COUNTY--Continued					
Minnesota	Sec 19, T 14 N, R 24 E.	More than 4,000,000.	Open cut mine.	Magnetite replacement in dolomite.	Arlie Hawkins.	(7, 17)
Pine Nut	Secs 15, 16, 21, 22, T 14 N, R 21 E.	None.	Trenching; diamond drilling.	Weak magnetite disseminations in monzonite.	U.S. Steel Corp.	-
	ELKO COUNTY					
Bullion District Prospects	Sec 33, T 31 N, R 53 E.	do.	Trenches.	Hematite replacement in limestone along shear zone and near granite contact.	Unknown.	(8, 19)
Durham	Sec 24, T 37 N, R 63 E.	do.	Trenches; adits; pits.	Hematite gossan in schist.	do.	-
Iron Hood (Hogle)	Secs 11, 12, 13, T 37 N, R 53 E.	do.	Open cut.	Magnetite replacement in dolomite along granodiorite contact.	J. A. Hogle Co.	(6)
North Independence Mountain	Sec 25, T 38 N, R 53 E.	do.	Trenches.	Replacements in siliceous dolomite.	Unknown.	-
	ESMERALDA COUNTY					
Aja	Sec. --, T 5 S, R 39 E.	do.	Unknown.	Unknown.	Minerals Concentrating Co.	-
Boak (Iron King)	Sec 7, T 3 N, R 36 E.	Small.	Adit; shaft; trenches.	Hematite as small veinlets and replacements in slate and dolomite.	C. C. Boak Estate.	(17)
Klondike	Sec 26, T 1 N, R 42 E.	None.	Unknown.	Hematite gossan from pyrite veins.	Unknown.	(1)
	EUREKA COUNTY					
Barth	Sec 7, T 31 N, R 51 E.	More than 2,000,000.	Open pit; diamond drilling; shaft.	Semitabular hematite-magnetite replacement in andesite.	Southern Pacific Co.	(19)
Big Pole Creek	Sec 34, T 29 N, R 50 E.	None.	Trenches; magnetic survey.	Small veins of magnetite and hematite in tuff.	J. R. Simplot Co.	(19)
Frenchie Creek	Sec 26, T 29 N, R 50 E.	do.	Adit; trenches.	Small magnetite lenses in shear zones in tuffs.	Unknown.	(19)
Imperial Prospect	Sec 23, T 29 N, R 50 E.	do.	Trenches; test pits.	Hematite and magnetite filling and replacement in brecciated andesite.	Ben Jackson Estate, and others.	(19)

Jackson Prospect	Sec 22, T 29 N, R 50 E.	do.	do.	Small hematite and magnetite replacements in tuff along shear zones.	Ben Jackson Estate, and others.	(19)
Modarelli (Amarilla)	Sec 30, T 29 N, R 51 E.	Almost 400,000.	Open cut mine; diamond drilling; adit; trenches.	Large hematite replacement in rhyolite.	J. R. Simplot Co.	(2, 11, 19)
Occurrence	Secs 18, 19, T 29 N, R 51 E.	None.	Unknown.	1,000-foot magnetite and hematite replacement zone in andesite.	Unknown.	-
Occurrence	Sec 34, T 32 N, R 51 E.	do.	do.	Hematite gossan in andesite.	do.	-
	HUMBOLDT COUNTY					
Black Bird	Sec 29, T 40 N, R 31 E.	Small.	Open pit.	Magnetite.	do.	-
Blackjack Prospect	Sec 6, T 39 N, R 32 E.	do.	Shallow pits.	Magnetite; hematite; and limonite in andesite.	do.	(3)
Iron King (De Long)	Sec 29, T 40 N, R 32 E.	About 1,200,000.	Open pit and underground.	Magnetite replacements in metavolcanic rocks near diorite contact.	Jackson Mountain Mining Co.	(3, 19)
Iron King Prospect	Secs 13, 24, T 40 N, R 31 E.	None.	Trenches.	Hematite and magnetite stringers and pods in metavolcanic rocks.	Ben Jackson Estate, and others.	(19)
Iron Mike	Sec 30, T 40 N, R 32 E.	Small.	Open cuts.	Pods of magnetite in andesite.	Unknown.	(3)
Low	Sec 19, T 38 N, R 31 E.	None.	Trenches; diamond drilling.	Specularite in narrow veins in metavolcanic rocks.	Walter Low Estate.	(19)
Red Ball	Sec 24, T 38 N, R 30 E.	Unknown.	Unknown.	Unknown.	Unknown.	(19)
Red Bird	Sec 32, T 40 N, R 32 E.	More than 120,000.	Open cut trenches.	Magnetite veins in metavolcanic rocks.	Luther Goodwin, Fred E. Hummel.	(19)
None; occurrence	Sec 4, T 39 N, R 32 E.	None.	Unknown.	Unknown.	Unknown.	-
Do.	Sec 31, T 37 N, R 32 E.	do.	do.	do.	do.	-
Do.	Sec 29, T 37 N, R 31 E.	do.	do.	do.	do.	-
	LANDER COUNTY					
Hancock	Sec 13, T 28 N, R 42 E.	More than 17,500.	Open pit mine.	Magnetite replacement in dolomite.	W. R. Hancock, and others.	(19)
McCoy (Uhalde-New World)	Sec 11, T 28 N, R 42 E.	More than 230,000.	Open pit mines.	do.	ARD Equipment Co.	(19)
	LINCOLN COUNTY					
Manhattan	Sec 8, T 1 N, R 66 E.	None.	Unknown.	Unknown.	Unknown.	-

TABLE 37. - Nevada iron properties--Continued

Reported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	LYON COUNTY					
Dayton	Sec 6, T 17 N, R 23 E; sec 36, T 18 N, R 22 E; Sec 31, T 18 N, R 23 E.	Small.	Diamond drilling; shafts; adits; trenches.	Magnetite and hematite replacements.	Utah Construction and Mining Co.	(4, 17)
Owen	Sec 1, T 9 N, R 26 E.	do.	Open cut; trenches.	Hematite veins and replacement in volcanic rocks.	H. D. Lewis, and others.	(17)
Pumpkin Hollow	T 12, 13 N, R 26 E.	None.	Extensive diamond drilling.	Large magnetite replacements and disseminations in series of limestones, limy shales and tuffs near monzonite contact.	United States Steel Corp.	(20)
	MINERAL COUNTY					
Black Butte	Sec 30, T 9 N, R 3 E.	do.	Trenches.	Small magnetite replacements in limestone near granite and disseminations in skarn.	Joe Malatesta, and others.	(17)
Black Horse	Sec 18, T 9 N, R 33 E.	do.	Stripping trenches.	15 feet of disseminated magnetite in skarn zone.	Henry A. Peterson.	(17)
Calico	Secs 5, 6, 8, T 13 N, R 29 E.	do.	Diamond drilling.	Magnetite replacement at diorite contact.	Occidental Minerals Corp.	(14)
Crews	Sec 9, T 10 N, R 33 E.	do.	Unknown.	Unknown.	R. L. Crews.	(6)
Gillis	Sec 8, T 9 N, R 33 E.	do.	Test pits.	Small veins of limonite; hematite and magnetite.	do.	(17)
Hottentot	Sec 2, T 12 N, R 30 E.	do.	Diamond drilling.	Magnetite replacement in diorite.	Occidental Minerals Corp.	(15)
Iron Butte	Sec 31, T 8 N, R 36 E.	Small.	Trenches.	Lens of magnetite in limestone near granite contact.	C. E. Sullivan; Leland Casey.	(17)
Iron Crown	Sec 36, T 9 N, R 33 E.	do.	Open cut	Magnetite lenses along a limestone-monzonite contact.	John Dewar; F. E. Sturdevant.	(17)
Iron Gate	Sec 33, T 8 N, R 35 E.	NA	do.	Hematite replacement bodies and small veins in dolomite.	Humboldt Ore Co.	(17)

King David	Sec 31, T 8 N, R 32 E	None.	Copper prospect; pits; trenches.	Small pods magnetite and hematite in limestone.	E. Ferretti, and others.	(17)
Last Chance	Sec 16, T 9 N, R 32 E.	do.	Unknown.	Small lenses of magnetite in limestone near granite contact.	do.	(17)
Maddalena	Sec 8, T 8 N, R 37 E.	Small.	do.	Unknown.	Unknown.	(6)
Walker Lake	Sec. --, T 12 N, R 28 E.	None.	Adit; pits.	Magnetite veins in metavolcanic rocks.	Bessie Sutter.	(17)
Whoopee (Foster)	Sec 10, T 12 N, R 31 E.	do.	Copper prospect 256-foot shaft; shallow drill holes.	Magnetite replacement in andesite along fault fissure.	Unknown.	(17)
	NYE COUNTY					
Gabbs (Engle-Stouder)	Sec 27, T 13 N, R 37 E.	Small.	Open pit.	Magnetite and hematite in veins along shear zone in metavolcanic rocks.	Mrs. Wanda Engle Stannard.	(17)
Phelps Stokes	Sec 21, T 12 N, R 37 E.	1,100,000	do.	Magnetite replacement along basic dike.	Grace Church, New York, N.Y.	(12, 17)
	ORMSBY COUNTY					
Capitol Prospect	Sec 36, T 15 N, R 20 E; Sec 1, T 14 N, R 20 E.	Small.	Trenches.	Magnetite and hematite veins in diorite.	Melville R. Colgrove.	(17)
Iron King (Bessemer, Brunswick Canyon)	Secs 21, 22, T 15 N, R 21 E.	About 1,000.	60-foot shaft; adit; trenches.	Magnetite and hematite pipes at fissure intersections in andesite.	John Ross.	(17)
Iron Pot	Secs 8, 17, 18, T 14 N, R 21 E.	Several thousand.	Open cuts; stripping.	Magnetite lenses in schist.	William E. Dial.	-
	PERSHING COUNTY					
American Ore Co. Section 10	Sec 10, T 25 N, R 34 E.	[1]4,000	Open pit.	Magnetite veins in metavolcanic rocks.	American Ore Co.	(16)
American Ore Co. (Sections 16 and 22)	Secs 16, 22, T 25 N, R 34 E.	More than 13,000.	Open pits.	do.	do.	(16)
American Ore Co. (Section 32)	Sec 32, T 26 N, R 34 E.	[1]8,000	Open pit.	do.	do.	(16)

NA--Not available.

[1]Estimate.

TABLE 37. - Nevada iron properties--Continued

Peported property name	Reported location	Production, long tons	Development	Mode of occurrence	Reported owner	Reference number in chapter bibliography
	PERSHING COUNTY--Continued					
Basalt	Sec 27, T 25 N, R 28 E.	None.	Trenching; wagon-drill holes.	Contact magnetite replacements in limestone.	C. L. Dodgson.	(19)
Beacon Hill	Sec 32, T 26 N, R 34 E.	NA	Trenching; wagon-drill holes; open cut mine.	Magnetite in fissures in metavolcanic rocks.	Mineral Materials Co.	(16)
Ford (Iron Horse)	Sec 6, T 25 N, R 34 E.	More than 800,000.	Open pit mine; diamond drill holes.	Magnetite as veins; veinlets and disseminations in metavolcanic rocks and diorite.	C. W. Hunley, and others.	(16)
Hematite	Sec 29, T 26 N, R 34 E.	[1]250,000	Open pit mine; diamond drilling.	Hematite replacements in metavolcanic rocks.	Southern Pacific Co.	-
Iron Castle	Sec 32, T 26 N, R 34 E.	Small.	Open pit.	Magnetite in veins in metavolcanic rock.	Ed. Barrington.	-
Piute	Secs 19, 24, 25, 26, 35, 36, T 25 N, R 32 E.	None.	Diamond drilling.	Magnetite replacements in metavolcanic breccia.	C. W. Hunley; E. L. Stephenson; Southern Pacific Land Co.	(6)
Sections 27 and 34.	Secs 27, 34, T 25 N, R 34 E.	do.	3 diamond drill holes.	Magnetite in veinlets and disseminations in scapolitized diorite.	Southern Pacific Co.	-
Section 29	Sec 29, T 26 N, R 34 E.	[1]180,000	Open pit mine.	Magnetite and hematite veins in metavolcanic rocks.	do.	-
Southeast Section 29	Sec 29, T 26 N, R 34 E.	[1]25,000	Open pits.	do.	do.	-
Section 31	Sec 31, T 26 N, R 34 E.	More than 20,000.	Open pits; diamond drilling.	Magnetite veins; veinlets and disseminations in altered diorite.	do.	-
Segerstrom and Heizer	Sec 15, T 25 N, R 34 E.	More than 1,200,000.	do.	Magnetite replacement veins in scapolitized metavolcanics and diorite.	do.	(13, 16)
Thomas	Sec 29, T 26 N, R 34 E.	More than 900,000.	do.	Magnetite replacement veins in metavolcanic rocks.	do.	(16)

Tule	Secs 2, 3, T 25 N, R 32 E; Secs 34, 35, T 26 N, R 32 E.	None.	Trenching; diamond drilling.	Concentrations of magnetite and pyrite in hornfels and limestone near diorite contact.	do.	
	STOREY COUNTY					
Iron Blossom	Sec 10, T 17 N, R 22 E.	Several thousand.	Open pit trenches; drill holes.	Magnetite and hematite as small veins and replacements in shaly limestone.	E. L. Berry.	(17)
	WASHOE COUNTY					
Black Hawk	Secs 21, 22, T 25 N, R 18 E.	None.	Magnetometer survey.	Magnetite vein in metavolcanic rocks.	Philip Spaulding.	(19)
Cu-Zn Peavine	Secs 9, 10, T 20 N, R 18 E.	do.	Trenches; diamond drilling.	Magnetite vein in volcanic rock.	Jess Winters.	(19)
	WHITE PINE COUNTY					
Pilot Knob	Sec 8, T 16 N, R 62 E.	Unknown.	Unknown.	Unknown.	Unknown.	(6)

NA--Not available.

[1]Estimate.

Buckskin Hills Area

The Buckskin Hills are on the eastern flank of the Pine Nut Mountains in the extreme northeastern corner of Douglas County, about 11 air miles northwest of Yerington. The Hazen-to-Mina branch of the Southern Pacific Railroad passes about 12 miles east of the mining area. Only one deposit, the Minnesota, is known, and the history of this property is the history of the area. It is the largest producer in the State, both in total production and in present rate of output.

Minnesota

Location, History, and Production. - The Minnesota mine is about 14 miles by highway northwest of Yerington at an altitude of 5,700 feet (fig. 21). The property consists of one patented claim and 12 surrounding unpatented claims.

The mine was worked originally for copper and several thousand feet of drifts and crosscuts were driven and a 200-foot vertical shaft was sunk. Only a small quantity of copper ore was shipped. During 1943-45, about 1,500 tons of iron ore was mined for use as high-density aggregate in concrete for ship ballast. The Standard Slag Co. leased the property in March 1952 and has operated it since.

A magnetic concentrating plant with a daily capacity of more than 1,000 tons of concentrate was installed in 1957. The plant was enlarged and improved in 1963. Total production through 1967 has exceeded 4 million tons of direct shipping ore and concentrate.

Geology. - The Minnesota mine area is underlain by a series of Triassic sediments which has been intruded by late Mesozoic monzonite and granodiorite and by Tertiary andesite porphyry. Iron mineralization accompanied the Tertiary igneous activity and deposits were formed in dolomite at its contact with andesite porphyry plugs. Rocks in the mine area are cut by two steeply dipping sets of normal faults that were instrumental in localizing igneous bodies and iron mineralization.

The ore consists almost entirely of magnetite with minor quantities of secondary hematite. The principal gangue mineral is unreplaced dolomite. Pyrite occurs in the ore along with small amounts of chalcopyrite. Direct shipping ore from the mine contains approximately 58 percent Fe, 6 percent SiO_2, 0.05 percent P, and 0.35 percent S. Milling ore contains about 40 percent iron.

The irregularly shaped ore body, when stripped of overburden, measured 400 by 250 feet in area. Additional small bodies occur north and south of the main body. Open-cut mining has reached a depth of 400 feet below the original outcrop, and at this level the ore zone has a maximum width of 400 feet and a length of 700 feet.

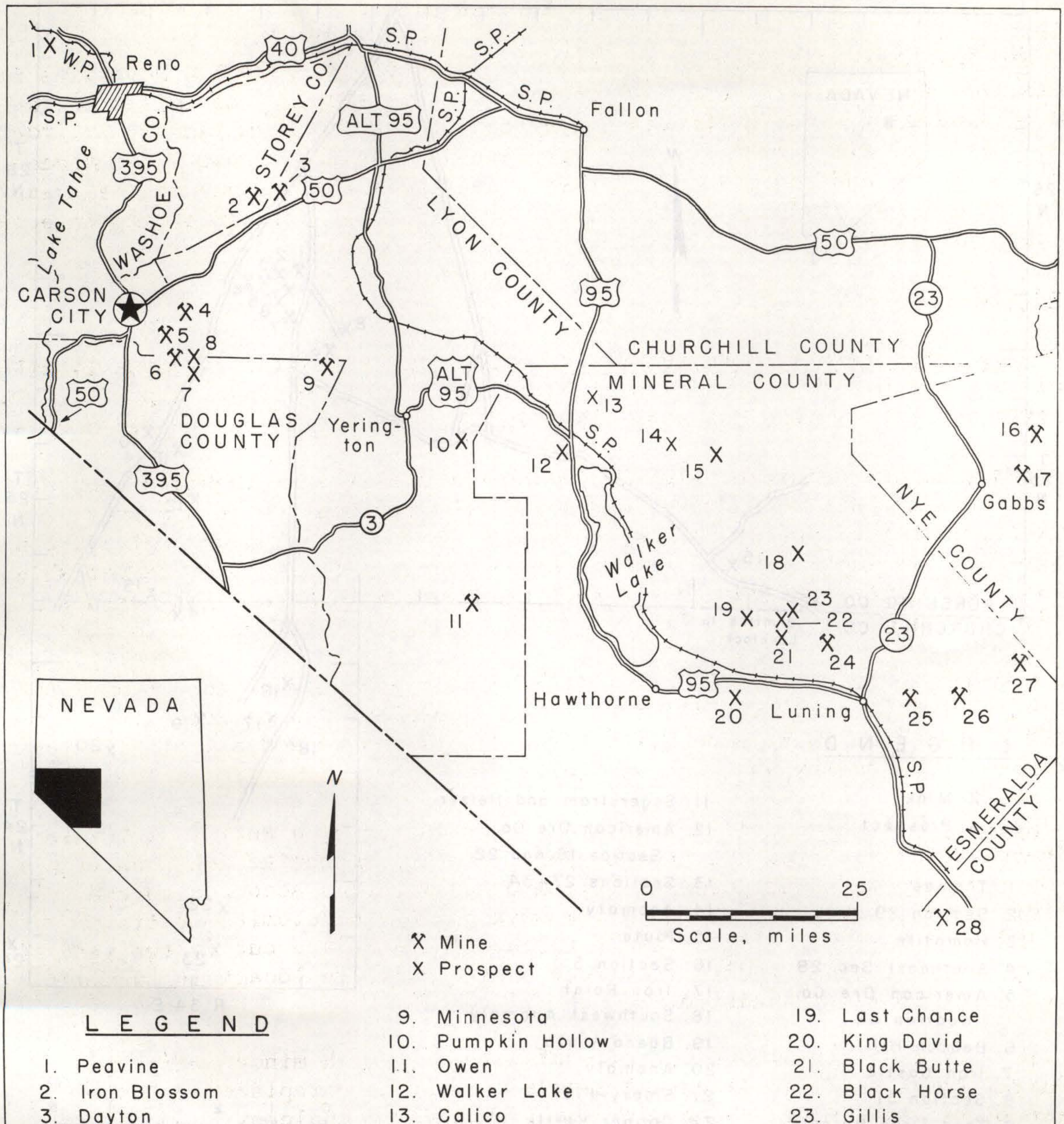


FIGURE 21. - Iron Occurrences in Western Nevada.

Ore Reserves. - No reserve estimate has been released by the company. Based on the magnetic anomaly associated with the ore body (17), a substantial resource can be assumed.

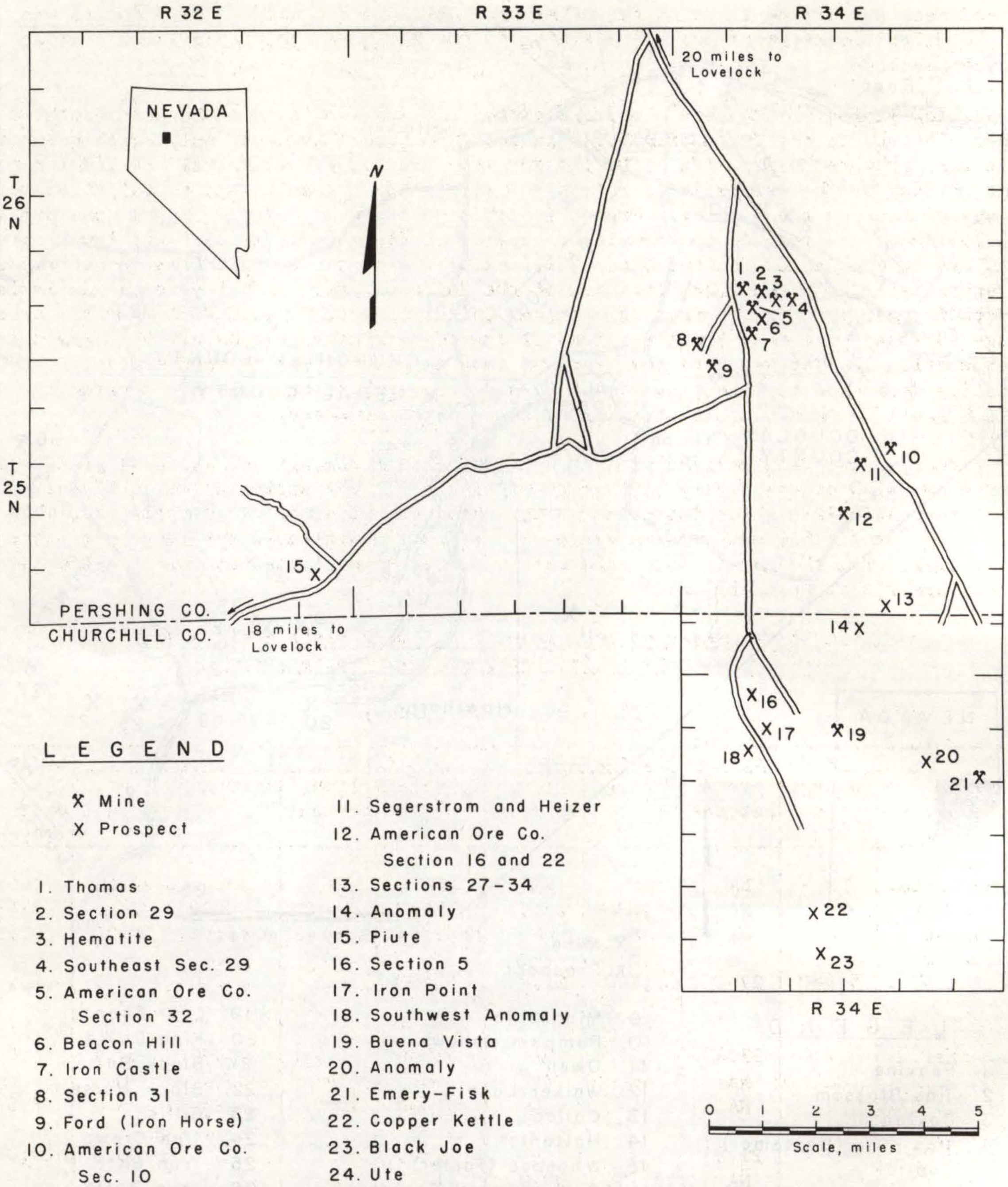


FIGURE 22. - Iron Properties, Buena Vista Hills District.

Buena Vista Hills Area

The Buena Vista Hills iron deposits are in an area about 12 miles square in southern Pershing and northern Churchill Counties (fig. 22). Most of the deposits occur in or near the hills at altitudes of 4,100 to 5,100 feet. The Piute deposit, 8 miles west of the main area, is included in this group because its mineralogy is similar to the other deposits and because it can be utilized best in conjunction with the other ore bodies in the area. The deposits are about 20 miles southeast of Colado, a siding on the Southern Pacific Railroad 6 miles north of Lovelock.

Shallow mining of iron ore commenced during the late 1880's when the Reid brothers shipped 500 tons to the Union Iron Works in San Francisco. However, only small quantities of ore were produced before 1943. Demand for iron ore for metallurgical use and for permanent ballast by the shipbuilding industry during 1943-45 resulted in an output of more than 40,000 tons in the 3 years. Production then declined to a few thousand tons per year until 1951 when a strong demand developed because of (1) a shortage of "hard lump" open-hearth ore in the Eastern United States; (2) expansion of the Pacific Coast steel industry; and, principally, (3) the rehabilitation of the Japanese steel industry which was isolated from traditional iron ore sources in mainland China. Reported production from the area through 1967 was more than 4 million tons of ore containing approximately 58 percent iron. Ore production in 1966 was more than 250,000 tons with a 59-percent iron content. In 1967 production decreased to less than 90,000 tons due to expiration of export contracts. During 1968 small shipments are continuing to domestic steelmakers.

Production has been derived from steep-dipping vein deposits of shipping grade ore and from deposits of relatively high-grade milling ore. The stripping ratio of the veins becomes increasingly high as depth increases. Moderate reserves of shipping ore, which can be mined profitably with modern equipment, are still available but large production is only possible from the area's more abundant resources of milling-grade ore. Estimated ore reserves are listed in table 38.

TABLE 38. - Estimated iron resources, Buena Vista Hills area, Churchill and Pershing Counties, Nev.

(Thousands of long tons)

Mine	Measured		Indicated		Inferred		Total ore		Stripping ratio weight to weight
	Tonnage	Iron, percent	Tonnage	Iron, percent	Tonnage	Iron, percent	Tonnage	Iron, percent	
South area:									
Buena Vista.	NA	NA	NA	NA	NA	NA	Large	20-25	1.0:1.0
Iron Point..	NA	NA	9,600	25.5	NA	NA	9,600	25.5	0.4:1.0
Southwest anomaly.	NA	NA	NA	NA	Moderate	NA	Moderate	20-30	0.8:1.0
Section 5...	5,900	27.6	1,900	21.8	900	26.2	8,700	26.2	1.1:1.0
North area:									
Hematite....	200	33.4	NA	NA	2,300	32.7	2,500	32.7	10.0:1.0
Ford........	NA	NA	NA	NA	NA	NA	Moderate	NA	NA
Sections 27, 34.	NA	NA	NA	NA	3,000	20.0	3,000	20.0	2.0:1.0
Section 29..	200	21.5	-	-	1,600	41.0	1,800	38.0	10.0:1.0
Section 31..	NA	NA	23,000	30.0	NA	NA	23,000	30.0	1.0:1.0
Segerstrom-Heizer.	560	21.5	35,000	30.0	NA	NA	35,560	29.9	1.0:1.0
Thomas......	250	33.4	600	59.0	2,000	20.0	2,850	29.4	10.0:1.0
Piute area:									
Piute.......	NA	NA	NA	NA	Large	20-50	Large	20-50	3.0:1.0

NA--Not available.

Much work has been done to develop deposits of low-grade iron ore and to study methods of making a marketable product. Reserve estimates indicate that resources in both the south and north portions of the area are adequate to amortize plants with an annual capacity of 1 million tons each of 64-percent iron pellets. Resources at the Piute deposit are adequate for a plant of 2-million-ton annual capacity. Mill tests indicated that recoveries of 87 to 94 percent of the magnetic iron ore can be attained in plants using straight magnetic separation methods. Plant-cost studies have determined that a grade of 15-percent magnetic iron is the mill cutoff figure; that is, ore containing this amount of recoverable iron can be profitably treated if only beneficiation costs are considered.

Vanadium may be recoverable from the ore. Direct shipping ores and magnetite concentrates contained from 0.20 to 0.40 V_2O_5. Similar European iron ores yield byproduct vanadium.

In the south part of the area the estimated concentration ratio is 3.25:1.00, and the estimated stripping ratio is 1.00:1.00. These ratios indicate that 3.25 tons of ore must be treated and 3.25 tons of waste must be stripped for each ton of 64-percent iron pellets produced.

In the north portion of the area similar estimates are as follows: Concentration ratio, 2.70:1.00; stripping ratio, 1.20:1.00; ore treated per ton of 64-percent iron pellets produced, 2.70 tons; and waste stripped per ton of pellets, 3.20 tons.

The Piute deposit estimates are as follows: Concentration ratio, 2.60:1.00; stripping ratio, 3.00:1.00; ore treated per ton of pellets, 2.60 tons; and waste stripped, 7.80 tons.

Freight charges for the 350-mile rail haul to San Francisco Bay would be about $4.00.

Buena Vista

Location, History, and Production. - The Buena Vista mine is on the southwestern flank of the Buena Vista Hills in Churchill County from altitudes of 4,325 to 4,800 feet.

The property consists of 16 patented claims and numerous adjacent claims held by location. The original claims were patented by John T. Reid in 1901. Minerals Materials Co. purchased the claims from Reid in 1941 and during 1951-57 produced more than 400,000 tons of direct shipping ore. Most of the ore was exported to Japan; the remainder was shipped to Pacific Coast steel manufacturers and to cement plants. In 1957, a magnetic beneficiation plant was constructed and during 1957-60 nearly 200,000 tons of concentrate was shipped to Pacific Coast consumers. An extensive development program was completed in 1958 in partnership with Southern Pacific Co.

The property was purchased by United States Steel Corp. in 1960, and a comprehensive drilling program was conducted that delineated a large reserve of milling ore.

Geology. - The mine area is underlain mainly by metavolcanic rocks of the Pennsylvanian age, Leach Formation, which are widely exposed in the East Range northeast of Buena Vista and in the Stillwater Mountains to the east. Intruded into the metavolcanic series are large masses of diorite of Jurassic age. Both the metavolcanic rocks and the diorite are host rocks for iron mineralization. Intruding the metavolcanics and the diorite are a few small irregular-shaped bodies of albitite that often contain disseminated iron minerals. The mine area has been cut by dike swarms of lamprophyric composition. The dikes contain little or no magnetite.

All but the youngest dike rocks have been altered to scapolite and hornblende.

The volcanic series has been closely folded. Premineral fault movement created large breccia zones and pipes favorable for ore deposition and formed barriers of gouge which channeled the ore-bearing solutions. Postmineral fault movement has displaced some ore bodies moderate distances.

Three varieties of iron deposits occur in the mine: (1) Tabular replacement bodies of high-grade magnetite; (2) disseminated deposits immediately adjoining mineralized faults; and (3) breccia deposits.

The tabular bodies developed along faults and fissures as vein filling and range in width from a few inches to 20 feet. Nearly all of the direct shipping ore has come from these bodies.

The disseminated deposits consist of large volumes of rock containing disseminated magnetite particles. The magnetite has a pepper-and-salt distribution throughout the mineralized layer and has been localized by preferential replacement of certain mineral grains throughout the rock. Certain beds in the metavolcanic series were more amenable to this type of replacement than others and contain the best grade ore; however, because of close folding, the shape of ore shoots is often irregular.

Ore in the wide breccia deposits ranges from material containing small fragments of host rock in a matrix of magnetite to material consisting of wall rock containing magnetite as irregular veins, blebs, and disseminations.

Direct shipping ore produced from this property has averaged 58.0 percent Fe, 9.0 percent SiO_2, 0.50 percent P, and 0.02 percent S.

<u>Exploration and Development</u>. - The U.S. Bureau of Mines in 1945 investigated the property by trenching, test-pitting, and diamond drilling. The work delineated high-grade direct shipping ore which has since been mined. Minerals Materials Co. maintained ore reserves by surface stripping, trenching, and development drilling with wagon drills.

A magnetometer survey was made of the area during 1952-53 and the great extent of the mineralized zone became apparent.

During 1957, Minerals Màterials Co. and Southern Pacific Co. formed a joint venture to investigate the iron resources. Under this program a second magnetometer survey was made of the mine area using north-south profile lines

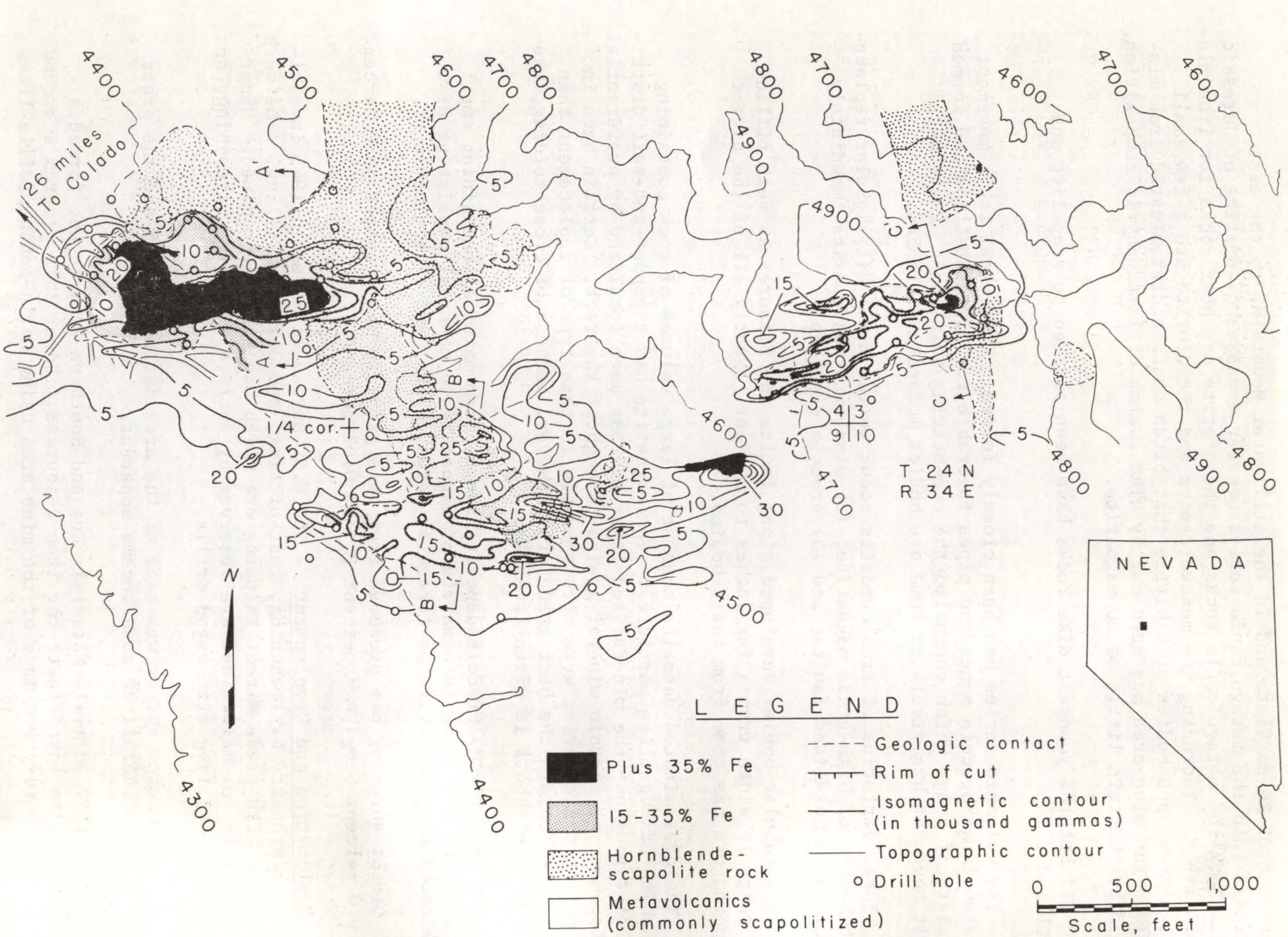


FIGURE 23. - Geologic Map of Buena Vista Iron Deposit. (Adapted from Southern Pacific Co. maps.)

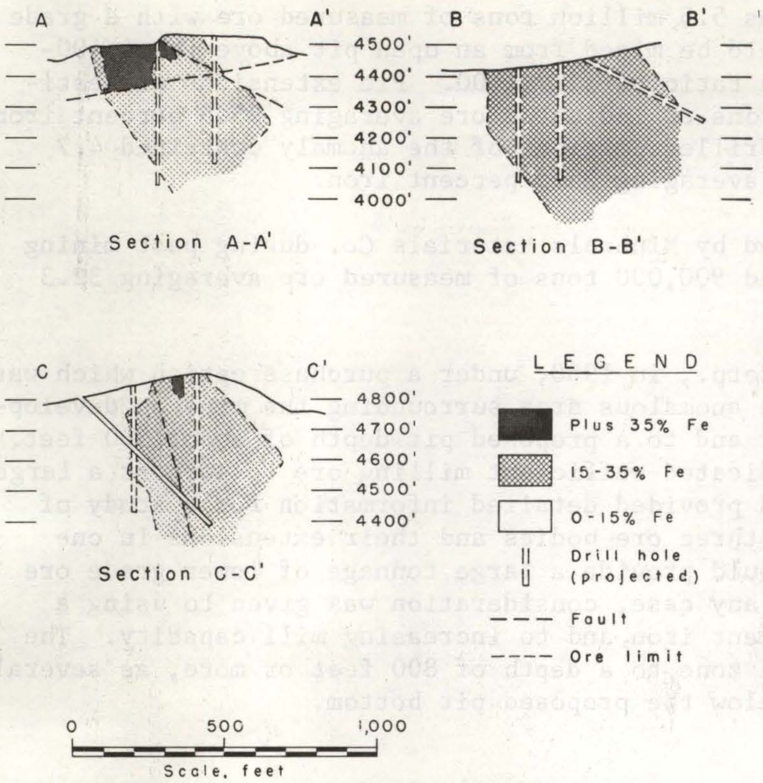


FIGURE 24. - North-South Vertical Sections of Buena Vista Iron Deposit. (Adapted from Southern Pacific Co. maps.)

spaced 200 feet apart and a 50-foot interval between stations on the profiles. This work outlined three main anomalies which were called the West, South-Central, and East anomalies.

Diamond drilling of the anomalies and associated ore bodies was done under the joint venture agreement with the following results (figs. 23 and 24):

The West ore body has a length of 1,900 feet, a horizontal width of up to 600 feet, and a depth of at least 500 feet. It has a general east trend and north dip. The margins are to some extent assay boundaries.

The South-Central ore body has a length of 1,400 feet, a horizontal width of 200 to 600 feet, and a minimum depth of 500 feet; this ore body also has a general east-west trend and dips to the north.

The East ore body has an indicated length of 1,000 feet, horizontal widths up to 400 feet, and a minimum depth of 450 feet. The deposit has an east trend and dips to the north.

Ore Reserves. - The Southern Pacific Co. and the Minerals Materials Co. joint development venture determined ore reserves and stripping ratios to be as follows (using a cutoff grade of 17.5 percent iron):

The West ore body contains 18 million tons of measured ore with a grade of 32.7 percent iron, which could be recovered in an open pit above the 4,000-foot level with a waste-to-ore ratio of 0.5:1.0 (weight to weight and including waste to be sorted from the ore body). Pit extensions are estimated to include 3 million tons of 33.3 percent iron ore.

The South-Central ore body contains 5 million tons of measured ore with a grade of 26.2 percent iron, which could be mined by open pit methods above the 4,160-foot level with a waste-to-ore ratio of 0.92:1.00. Pit extensions are estimated to include 900,000 tons of indicated ore averaging 22.1 percent iron. It also was estimated that undrilled portions of the anomaly contained 5.7 million tons of inferred ore averaging 22.1 percent iron.

The East ore body contains 5.5 million tons of measured ore with a grade of 25.5 percent iron which could be mined from an open pit above the 4,400-foot level with a waste-to-ore ratio of 1.17:1.00. Pit extensions are estimated to include 2.4 million tons of indicated ore averaging 25.5 percent iron. It also was estimated that undrilled portions of the anomaly contained 4.7 million tons of inferred ore, averaging 25.5 percent iron.

Middling piles accumulated by Minerals Materials Co. during past mining operations include an estimated 900,000 tons of measured ore averaging 32.3 percent iron.

The United States Steel Corp., in 1960, under a purchase option which was later exercised, redrilled the anomalous area surrounding the mine on development spacing of about 200 feet and to a proposed pit depth of about 500 feet. This comprehensive program indicated sufficient milling ore to support a large-scale beneficiation plant, and provided detailed information for a study of the feasibility of mining the three ore bodies and their extensions in one large open pit. Since this would provide a large tonnage of lower grade ore which would require moving in any case, consideration was given to using a lower cutoff grade, of 15 percent iron, and to increasing mill capacity. The drilling also extended the ore zone to a depth of 800 feet or more, as several holes were continued in ore below the proposed pit bottom.

Section 5

Location, History, and Production. - The Section 5 ore body is in Churchill County in the southwest portion of the Buena Vista Hills at altitudes of 4,200 to 4,400 feet. The property, owned by Southern Pacific Co., has been prospected by geophysics and drilling. There has been no production.

The following description of the geology, exploration, development, and reserves of the Section 5 ore deposit is based on information furnished by the Southern Pacific Co.:

Geology. - The property is largely blanketed by alluvium and lake terrace sand and gravel that cover bedrock to depths of from 1 to 80 feet (figs. 25 and 26). Five rock types occur: (1) Diorite and gabbro, which have been almost entirely replaced by scapolite and hornblende; (2) a medium-grained rock, tentatively classed as monzonite-albitite, which is mildly scapolitized and contains secondary hornblende and magnetite; (3) hydrothermally altered metavolcanic rock; (4) dense scapolitized hornblende diorite; and (5) andesitic and lamprophyric dikes which cut ore and other rocks.

Faulting is mainly premineral with relatively minor postmineral movement. Ore is localized along prominent faults and the close relationship between faulting and ore deposition is a common feature of the Buena Vista Hills area. A prominent, probably premineral zone of east-west shears crosses the south portion of the area and partially limits magnetite mineralization, south of this zone.

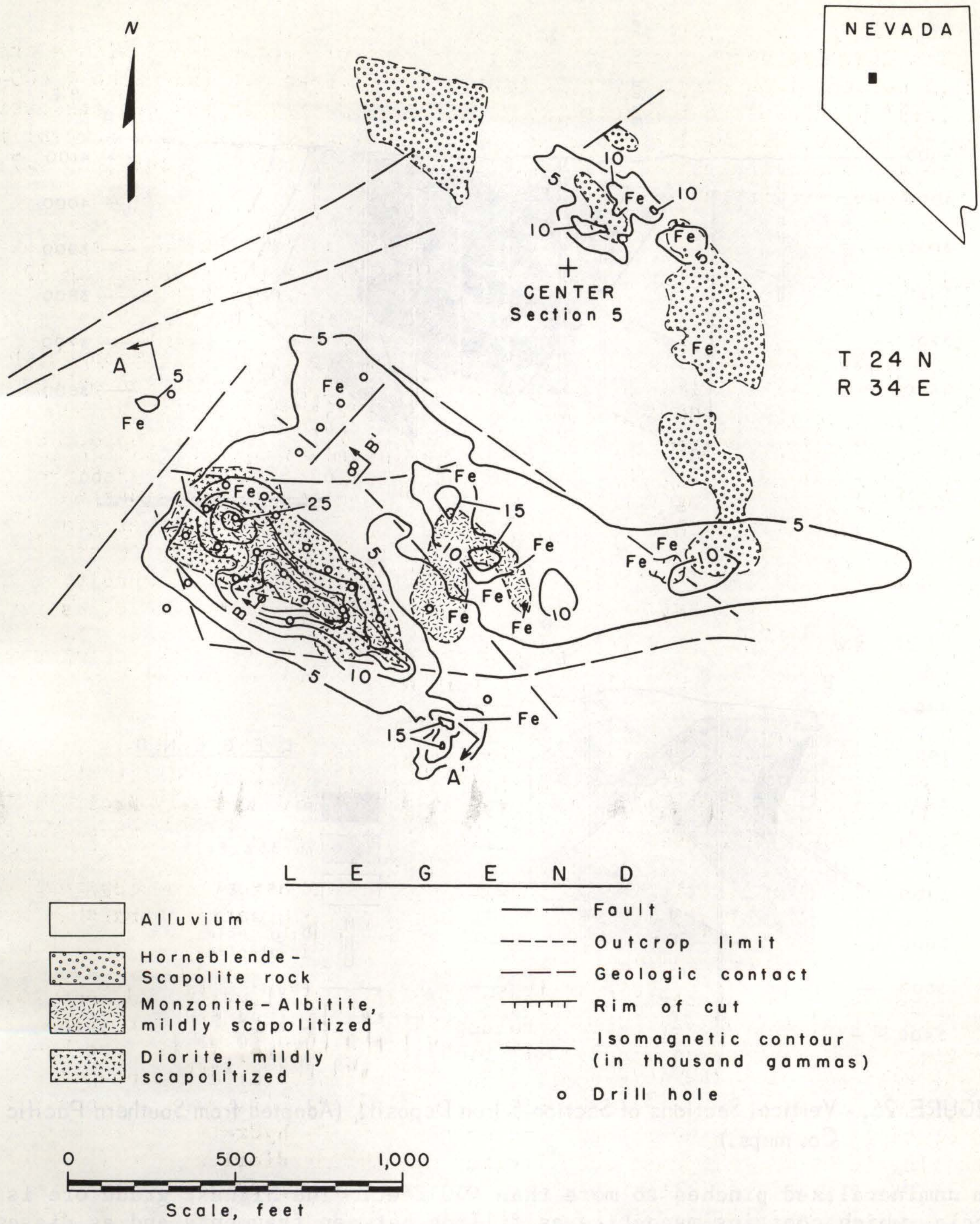


FIGURE 25. - Geologic Map of Section 5 Iron Deposit. (Adapted from Southern Pacific Co. maps.)

Disseminated magnetite ore was deposited in monzonite-albitite and scapolite-hornblende rocks along a 2,200-foot long, west-trending zone which contains areas of mild premineral brecciation. The width of this zone ranges

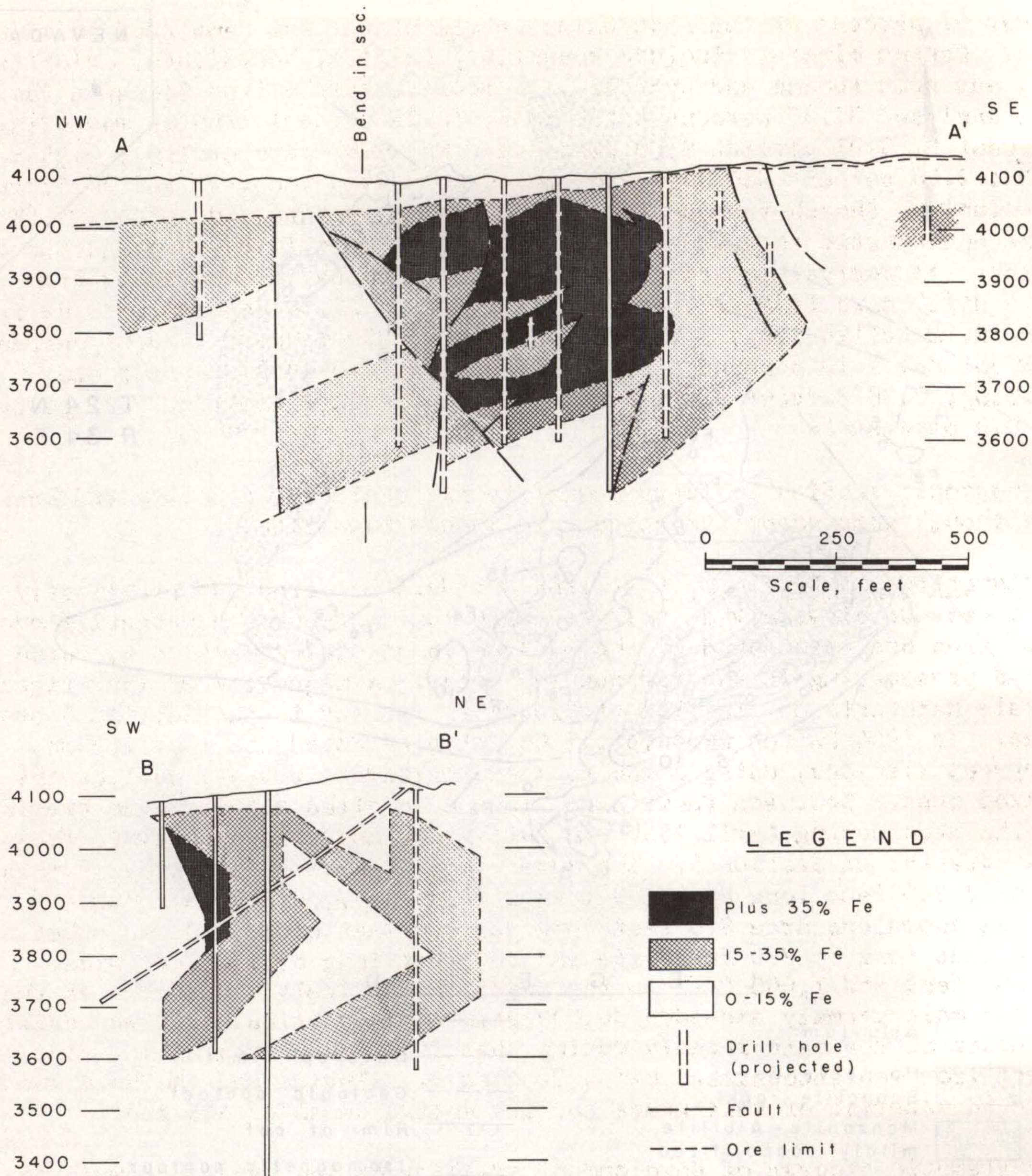


FIGURE 26. - Vertical Sections of Section 5 Iron Deposit. (Adapted from Southern Pacific Co. maps.)

from unmineralized pinches to more than 400 feet. The highest grade ore is in breccia, which contains magnetite as filling between fragments and as disseminations in the fragments. Disseminated magnetite mineralization roughly halos the main breccia zone. Postmineral dikes that contain ferrous silicate minerals, but no magnetite, intrude the mass. The zone terminates abruptly to the west against a dense mass of fine-grained scapolitized diorite and to the northeast it grades into medium-grained monzonite-albitite.

About 97 percent of the iron oxide is magnetite; the remainder is mainly hematite. Gangue minerals include scapolite, calcite, hornblende, chlorite, apatite, and some sphene and pyrite. A composite sample from Southern Pacific drilling analysed 37.37 percent total iron; 36.33 percent iron as magnetite; 0.19 percent P; 0.01 percent S; 0.02 percent Mn; 0.88 percent TiO_2; 0.25 percent V_2O_5; 2.08 percent MgO; 3.15 percent CaO; 0.44 percent F; and 36.62 percent insoluble. Phosphorus and titanium occur as apatite and sphene, both of which are nonmagnetic and can be reduced to acceptable levels by magnetic concentration. An analysis of concentrate produced by Davis tube tests from Section 5 drill core is 44.27 percent ferric iron; 21.38 percent ferrous iron; 2.18 percent metallic iron; 3.28 percent SiO_2; 0.006 percent P; 0.01 percent S; 0.24 percent Mn; 1.15 percent Al_2O_3; 0.47 percent CaO; 0.39 percent MgO; 0.21 percent TiO_2; 0.38 percent V_2O_5; 0.0 percent Zn; 0.0 percent Cu; 0.07 percent Ni; and 0.0 percent Pb.

Microscopic studies indicate magnetite has replaced scapolite and hornblende although some scapolite appears to be postmagnetite.

Exploration and Development. - Iron ore does not crop out prominently on Section 5 because of widely distributed alluvium. However, substantial quantities of iron ore were found at the surface in adjoining Section 4, which stimulated prospecting in the surrounding areas. A magnetometer investigation by Minerals Materials Co. in 1952 disclosed an anomaly in the Section 5 ore body area. In 1954 United Geophysical Co. also surveyed the locality on widely spaced stations, using a mobile magnetometer to roughly outline the mineralized zone. Southern Pacific Co. made a detailed magnetometer examination of the area during April 1957 and outlined a magnetic anomaly in the southwest quarter of Section 5. The zone of 5,000 gammas intensity of this anomaly is 2,200 feet long by 1,200 feet wide. The 7,500 gamma contour encloses an anomalous area 870 feet long and 400 feet wide, and two other areas 800 feet long by 200 feet wide and 300 feet long by 150 feet wide, located 500 feet and 1,000 feet to the east, respectively. Readings at the apex of the main anomaly exceeded 30,000 gammas. A vertical hole was drilled at the center of the main anomaly during June 1957. Rock containing plus 30 percent iron was encountered below 26 feet of alluvium and the hole was continued in material of this grade for its entire depth of 465 feet.

A systematic program of development drilling during 1957-58 completed 30 holes totaling 14,287 feet. Twenty holes were located in the main anomalous area and 10 holes were spaced around the periphery of the anomaly in material that would have to be stripped if the ore body were mined. About 42 percent of the total footage drilled penetrated plus-20-percent iron-bearing rock. Holes were drilled to a proposed pit depth of 500 feet and were generally bottomed in ore. The deepest hole was stopped at a depth of 780 feet while in 30 percent iron ore.

Ore Reserves. - Based on these drill data, Southern Pacific Co. estimated ore reserves to a depth of 500 feet as follows: 5.9 million tons of measured ore containing 27.6 percent iron; 1.9 million tons of indicated ore with a grade of 21.8 percent iron; a total of 7.8 million tons averaging 26.2 percent iron. An additional 0.9 million tons of ore with the same iron content is inferred in undrilled portions of the anomaly.

Economic Potential. - A stripping ratio of 1:1 has been calculated by Southern Pacific Co. for the recovery of 7,800,000 tons of ore from the main anomaly ore body. A rough estimate (by the author) of the stripping ratio for the undrilled portion of the anomaly is 2.2:1.0.

Preliminary metallurgical tests made from drill cores indicated that the ore could be most economically concentrated by a magnetic method and that a recovery of 84 percent of the total iron could be attained. On this basis it would require about 3 tons of ore to make 1 ton of 64-percent iron pellets. Grinding to 150 mesh would probably also be required. To produce 1 ton of pellets would require mining and beneficiating 3 tons of ore and stripping 3 to 7 tons of waste.

Iron Point and Southwest Anomaly

Location, History, and Production. - The Iron Point ore body and the adjoining Southwest anomaly are in the southwest portion of the Buena Vista Hills iron ore area in Churchill County at altitudes of 4,125 to 4,175 feet. The deposits are owned jointly by Southern Pacific Co. and United States Steel Corp. There has been no production.

The following account of the geology and exploration and development of the Iron Point ore body and Southwest anomaly is a condensation of information furnished by the Southern Pacific Co.

Geology. - Aside from four tiny outcrops of mineralized metavolcanic rocks containing about 30 percent magnetite, the property is completely covered with Lake Lahontan terrace sands and gravels to an extreme depth of 100 feet and an average depth of about 25 feet.

Insufficient holes have been drilled to justify a discussion of the sub-overburden rock distribution or structure. The drill holes, which were located on magnetic anomalies, penetrated mainly hornblende-scapolite alterations of metavolcanic rocks that contain magnetite mineralization as disseminations, veins, and breccia filling. A substantial amount of hematite was in the upper portions of two of the six holes drilled.

Exploration and Development. - The favorable location of the area, only one-half mile west of the Buena Vista mine, resulted in its investigation at a relatively early date with magnetic methods.

The first exploration was made in 1954 by United Geophysical Co., which conducted a geophysical survey across the property and outlined an anomaly in which two shallow holes were drilled. The first hole was 35 feet deep and failed to penetrate the thick overburden; the second was 67 feet deep, and disseminated magnetite mineralization estimated at 20 to 25 percent iron was encountered.

Dodge Construction Co. later did additional magnetic work and drilled two holes to 75- and 105-foot depths. The holes intersected metavolcanic rocks containing 25 to 30 percent iron as magnetite, including 12 feet of about 50 percent iron.

During June 1958, Southern Pacific Co. conducted geophysical work, followed by diamond drilling. First, a detailed magnetic survey was made over the anomalous areas using north-south profiles with a profile interval of 200 feet and occupying stations at 50-foot intervals along the profiles.

The survey outlined two anomalies--the Iron Point and the Southwest. The Iron Point anomaly, as measured inside the 4,000 gamma contour, is 1,700 feet long and 700 feet wide, with a maximum intensity of more than 12,000 gammas. The Southwest anomaly is 1,100 feet long and 400 feet wide and has a maximum intensity of 7,800 gammas. A gravimetric survey of the Southwest anomaly outlined an anomaly of 0.41 milligals over an area corresponding to the magnetic anomaly. Because of interference from the Buena Vista mine and mill it was impractical to complete a gravity survey of the Iron Point ore body.

The Iron Point ore body was explored with six diamond drill holes having a total footage of 2,067 feet.

<u>Ore Reserves</u>. - Based on the drilling and geophysical results, Southern Pacific Co. estimated the Iron Point deposit to contain 9.6 million tons of ore grading 25.51 percent iron.

The ore body's length is 1,235 feet and its width is 390 to 700 feet. The ore, which is overlain by 20 to 85 feet of overburden, extends to depths of 240 to 350 feet. The holes were all bottomed in waste and penetrated from 15 to 170 feet of rock containing 7 to 15 percent iron below the ore. Open pit mining of this ore body would require moving an estimated 2.2 million tons of gravel and 1.7 million tons of waste rock, a total stripping of 3.9 million tons, making a ratio of 0.4 ton of waste to 1.0 ton of ore.

The Southwest anomaly has not been tested by drilling or trenching. A moderate resource is assumed on the basis of geophysics.

<u>Economic Potential</u>. - No beneficiation tests of the Iron Point and Southwest anomaly ores have been made but the ores are probably similar to those of the adjoining Section 5 and Buena Vista ore bodies and should be amenable to magnetic concentration after fine-grinding, with a recovery of approximately 84 percent. It would require an estimated 3.0 tons of ore to make 1.0 ton of 64-percent iron pellets. The waste stripping required to make 1.0 ton of pellets would be 1.2 tons at the Iron Point and 2.4 at the Southwest anomaly.

<u>Emery-Fisk</u>

The Emery-Fisk prospect is 2.5 airline miles southeast of the Buena Vista mine on a northwest spur of the Stillwater Range, at an altitude of 4,600 feet.

The property is underlain by scapolitized diorite and metavolcanic rocks. Abundant iron ore float is scattered throughout the area. A prominent area of iron-containing material 10 to 15 feet wide by 70 feet long, crops out on the property and a trench 0.5 mile to the southwest of this locality has exposed a 6-foot vein of massive magnetite for a length of 50 feet. Dip-needle exploration has indicated that the area contains other small discontinuous veins and lenses of magnetite. Much apatite occurs in the ore.

Coppereid

The Coppereid prospect is 9 airline miles south of the Buena Vista mine. The property lies on the west flank of the Stillwater Range, on a ridge separating White Cloud Canyon on the north from Clipper Canyon on the south.

The property was located for copper and was extensively explored during 1906-12. Development included several shafts, short adits, and a main adit 3,050 feet long which interesected the deposits 1,200 feet below the surface. No production was recorded.

The mine area is underlain by a series of conglomerate, quartzite, shale, and limestone intruded by granite. The sediments have been intensely folded, and near the granite they are recrystallized and metamorphosed. Lenses of specularite, of mixed specularite and pyrite, and of pyrite occur along shear zones in the sedimentary rocks.

Discontinuous specularite lenses, some as large as 80 by 40 feet in horizontal cross section, crop out on the ridge between White Cloud and Clipper Canyons at an altitude of 6,100 feet and 0.5 mile to the south in Clipper Canyon at an altitude of 5,400 feet. The long exploration adit reportedly crosscut 100 feet of specularite and pyrite 1,200 feet below the iron outcrops on the ridge and about vertically beneath them. The mineralized material had a reported analysis of 43.0 percent Fe, 8.0 percent insoluble, and 32.0 percent S. No phosphorus or copper were detected. Three analyses from near-surface adits averaged 48.6 percent Fe, 19.3 percent insoluble, 0.18 percent P, and 0.10 percent S. Copper was not determined.

The specularite-pyrite material from the adit cannot be treated economically unless sufficient quantities are present to make the installation of a roaster and acid plant feasible or unless valuable concentrations of copper occur in the ore.

Sections 27 and 34

Location, History, and Production. - The Sections 27 and 34 deposit is in the Buena Vista Hills near the boundary of Pershing and Churchill Counties. It is owned by Southern Pacific Co. There has been no production.

The following description of the Sections 27 and 34 ore bodies was taken from information furnished by the Southern Pacific Co.

Geology. - The area is underlain by scapolitized diorite which has been intruded by dikes of andesite porphyry. Several zones of magnetite mineralization, 20 to 25 feet wide, have been traced over 1,500 feet by means of outcrops, float, and magnetic surveys. Magnetite occurs in the zones as disseminated grains, veinlets, breccia fillings, and coatings on fracture surfaces. Several pod-shaped masses of high-grade magnetite containing apatite-rich bands occur within the mineralized zones. However, these contain only limited quantities of ore. A typical sample of magnetite mineralization in diorite breccia analyzed 22.8 percent Fe, 49.9 percent insoluble, 0.02 percent P, and 0.01 percent S.

Exploration and Development. - The first development work was a magnetometer survey of the area by Ford Motor Co. in 1951-52. An anomaly was discovered and in 1952 two diamond drill holes, with depths of 217 feet and 147 feet, were drilled in the northern and central portions of the anomaly. The holes failed to encounter direct shipping ore although they indicated the presence of a zone of low-grade material. In the fall of 1957, Southern Pacific Co. checked the earlier geophysical work and extended the survey southerly into Section 34. A weak anomaly was discovered and subsequently was tested with an inclined diamond drill hole 245 feet deep. The hole encountered material with an average grade of less than 20 percent iron.

Ore Reserves. - Southern Pacific Co. estimated that the ore deposit is 1,200 feet long, 125 feet wide, and at least 200 feet deep. The deposit is estimated to contain 3 million tons of ore with an average grade of 20 percent Fe.

Thomas

Location, History, and Production. - The Thomas mine is in the northern part of the Buena Vista Hills, in Pershing County, at an altitude of 4,200 feet. It is 18 miles south of Colado. Southern Pacific Co. owns the property.

The first iron ore shipped from the Buena Vista district during World War II came from this mine. A small amount of ore was shipped to consumers on the west coast in 1942 during a period of scrap shortage. No other production was made until 1950 when a partnership of H. S. Thomas and Roy S. Blair leased and operated the property. This partnership was dissolved in 1952, but Mr. Thomas continued to operate the mine as Nevada Iron Ore Co. The Southern portion of the property was subleased to Parker Brothers Construction Co. in 1953. Production during the 1950-57 period was more than 200,000 tons of iron ore. Mr. Thomas subleased the property in 1957 to Dodge Construction Co. and more than 200,000 tons was produced during 1957-62. The property was leased in 1962 to Nevada Barth Co., which tested the downward extensions of the ore body with diamond drilling and during 1963-67 produced more than 500,000 tons of ore. The ore was sold to Japanese and domestic consumers.

Geology. - The following section is based on information furnished by the Southern Pacific Co.

The mine area is underlain by gray-green metavolcanic rocks of intermediate composition. In the southeastern part of the area strong scapolite-hornblende alteration is evident. The ore zone contains small dikes of medium-grained light-gray diorite which have only scant iron content.

Iron ore was deposited in a large fault zone 150 to 200 feet wide which dips steeply east. The fault and ore zone are traceable for 2,000 feet on the surface and for an additional 1,300 feet by magnetic surveying. The width of ore is adequate for mining over a length of 1,200 feet.

The ore body consists of several closely spaced magnetite-hematite veins 2 to 40 feet wide. The veins pinch and swell, split and rejoin, and intersect many smaller veins. The vein walls usually are well defined although the mineral deposition is discontinuous along both the strike and dip. The rock between the veins, which may be only slightly altered, usually contains fine veinlets of magnetite. Most of the mineralized structures have moderate to steep dips but mineralized low-angle faults also are found. Postmineral faults, both low and high angle, have displaced the veins, occasionally to a considerable extent. Many premineral faults also show evidence of postmineral movements.

Mine-run ore contains 58 to 64 percent Fe, 3 to 5 percent SiO_2, 0.02 to 0.20 percent P, and 0.01 to 0.12 percent S. The proportion of hematite to total iron oxide is highly variable and ranges from 15 to 80 percent.

Exploration and Development. - Iron ore cropped out prominently on the property and during early operations little development was necessary. Later geologic studies and magnetometer surveys of the area were made and diamond drilling on fairly close spacing was completed along the length of the ore body and to a depth of about 400 feet. The open pit excavated along the ore zone is about 1,200 feet long, up to 200 feet wide, and 150 feet deep.

Ore Reserves. - Reserves within 300 feet of the surface were estimated by Nevada Barth Co., on the basis of 1963 drilling, at 600,000 tons with a grade of 59 percent iron. In addition, the mine dumps contain 250,000 tons of material averaging 33.4 percent iron. Additional reserves of low-grade material are inferred to be 2.0 million tons with a grade of 20 percent iron.

Section 29

Location, History, and Production. - The Section 29 mine is about 1,000 feet east of the Thomas pit at an altitude of 4,230 feet. It is owned by Southern Pacific Co. and leased to Nevada Iron Ore Co. and to Nevada Barth.

The mine first produced in 1953 and during 1953-54 about 18,000 tons of lump ore was shipped. Operations were shifted mainly to the Hematite pit, 500 feet southeast, during 1955-58, but in 1959 mining in the Section 29 pit was resumed. Operations have continued since. Production from the pit has been reported with the output of the Hematite pit and some nearby small pits, but its estimated share including 1967 has been about 180,000 tons.

Geology. - The following section on geology was summarized from information furnished by the Southern Pacific Co.

The pit operation has exploited two intersecting veins. One vein strikes north-northeast and dips east; the second vein strikes north-northwest and is vertical. Both veins are mineralized and have been mined from their intersection northward. The country rock is an altered metavolcanic.

Shipping grade ore occurs in lenses and pods throughout the veins. Most of the ore is localized at intersections of transverse fissures with the veins. The ore contains about 60.0 percent Fe, 9.0 percent SiO_2 plus Al_2O_3, 0.04 percent P, and 0.01 percent S. The iron occurs one-third as hematite and two-thirds as magnetite.

Exploration and Development. - Development consists of open pit workings.

The north-northeasterly striking vein is mined in a pit 70 feet deep and 600 feet long. The pit is about 30 feet wide over much of its length but widens to 80 feet where two cross fissures intersect the vein.

The north-northwesterly striking vein is mined in a pit about 75 feet deep, 500 feet long, and 75 feet wide. A transverse fissure is also mined in an extension from this pit.

Ore Reserves. - No reserve figures are available. An estimated 180,000 tons of 60-percent iron ore was produced above the 75-foot level and about 200,000 tons averaging 21.5 percent iron was placed in the dump. If ore reserves are inferred to a depth of 400 feet, the estimated reserve is about 750,000 tons containing 60 percent iron and about 850,000 tons of ore averaging 21.5 percent iron.

Hematite

Location, History, and Production. - The Hematite mine, which is near the Section 29 pit, was operated by Nevada Iron Ore Co. and Nevada Barth Co. under leases from Southern Pacific Co. Initial production was made in 1955 and during this year about 14,000 tons of ore was mined. Operations through 1958 produced an estimated 250,000 tons.

Nearly all of the following information was abstracted from information furnished by the Southern Pacific Co.

Geology. - The host rock is a metavolcanic which, at the surface in the vicinity of the ore body, is generally altered to soft gray rock composed of kaolin, chlorite, and subordinate epidote. Iron ore occurs in veins ranging from less than 1 inch to over 10 feet in width. Walls are well defined although the veins tend to pinch and swell. Usually, the larger vein structures can be traced several hundred feet. Ore from the pit differs from other ore in the area because of the high hematite-to-magnetite ratio. Gangue minerals usually are sparse, and the sulfur and phosphorus contents are low. A sample of direct shipping ore analyzed 63.5 percent Fe, 0.08 percent P, and 0.01 percent S.

Exploration and Development. - The ore deposit cropped out prominently, and open pit mining was started on the exposure. A magnetometer survey of the area failed to delineate the ore zone satisfactorily because of the preponderance of hematite. An inclined, diamond-drill hole, which intersected the ore zone about 100 feet below the pit bottom and crosscut the adjoining ground, indicated the ore-bearing structures continue to at least this depth.

Ore Reserves. - Based on a study of the surface and the single drill hole, Southern Pacific Co. estimated the area surrounding and underlying the Hematite pit contains 2.3 million tons of 32.7-percent iron ore. The middling dump contains 200,000 tons of 33.4-percent iron ore.

Southeastern Section 29

Location, History, and Production. - The Southeastern Section 29 ore bodies are distributed over a 1,200- by 600-foot area one-half mile southeast of the Thomas mine at an altitude of 4,275 feet.

The deposits are on ground owned by Southern Pacific Co. and were leased to Nevada Iron Ore Co. and Nevada Barth Co. Production has been an estimated 25,000 tons of 60-percent iron ore and was included in production records of the Thomas and Section 29 mines.

The following description of the ore deposits was abstracted from information furnished by the Southern Pacific Co.

Geology. - The host rock of these deposits is a scapolite-hornblende replacement of metavolcanic rock which has been chloritized over most of the area. Magnetite, with minor hematite, occurs as tabular bodies in veins that have frequently been cut into segments by postmineral faulting. The ore consists mainly of vein filling with little replacement of fissure walls. A strong fissure apparently provided the main channelway for mineralizing solutions.

Exploration and Development. - Development consists of open pit mining and trenching of outcrops. All work is within 30 feet of the surface. A detailed geophysical survey using magnetic and gravity methods was completed in the area. A magnetic anomaly about 500 feet long and 250 feet wide was delineated in the southeast portion of the property.

American Ore Co. Section 32

The American Ore Co. Section 32 mine is about one-half mile southeast of the Thomas mine. The deposit was located by Edwin Marker and Lyle and Wayne Stoker, who leased the property to Bratton and Blair. The lessees produced about 2,000 tons of ore for ship ballast in 1943 (16, p. 29). American Ore Co. of Detroit, Mich., purchased the property in 1950 and following preliminary exploration and some production, leased it in 1952 to Parker Brothers

Construction Co. The mine was operated by Parker Brothers until late 1952. This property, together with a deposit in Section 10 about 4 miles to the southeast, produced 10,000 tons of lump ore with a grade of 60 percent iron (16, p. 29), which was shipped to Youngstown, Ohio. An estimated 6,000 tons of the production was mined from the Section 32 mine. No additional production has been reported.

The host rocks in the Section 32 deposit are metavolcanics that have been intruded by diorite. All rocks have been scapolitized. Magnetite ore of shipping grade occurs in portions of a vertical fissure zone about 20 feet wide. Cross fractures apparently localized the ore bodies and postmineral fault movements broke and offset the lenses of magnetite. Magnetometer surveys of the deposit have indicated no large anomaly associated with it.

Ore was mined in an open pit 40 feet deep and 700 feet long.

Beacon Hill

The Beacon Hill prospect is three-quarters of a mile southeast of the Thomas mine. It was located in 1952 by Charles Dodgson who discovered a magnetic anomaly on the property. It was subsequently purchased by Minerals Materials Co. and explored in 1953 by trenching and 19 wagon drill holes to a depth of 70 feet. A vein 15 feet wide was mined over a length of 500 feet. Production has been included with that from the Nevada Iron Ore Co. lease in adjoining Section 29.

The vein is an extension of the structure mined on the adjacent American Ore Co. property. The vein contains a 10-foot width of magnetite ore in the bottom of the pit. Two parallel zones, each 200 feet long and 20 feet wide, occur approximately 100 feet and 200 feet south of the main vein. They contain magnetite mineralization with a grade of about 15 percent iron.

Ford (Iron Horse)

Location, History, and Production. - The Ford or Iron Horse mine is 1.5 miles southwest of the Thomas mine at an altitude of 4,150 feet.

The property was located in 1952 by C. W. Hunley and others, who started producing high-grade ore. Ford Motor Co. leased the property in the same year and conducted a detailed magnetic survey which disclosed a promising anomaly. Five holes drilled on the anomaly indicated the existence of a commercial-sized body of high-grade ore, and several thousand tons of lump ore subsequently was mined and shipped to Dearborn, Mich. The lease then was assigned to Nevada Iron Ore Co., and, after a small tonnage of ore was produced, the property was subleased to Parker Brothers Construction Co. The latter lessee produced nearly 100,000 tons of lump ore averaging 66 percent iron in 1954 and early 1955 and shipped it to Youngstown, Ohio. Following expiration of the sublease, Nevada Iron Ore Co. operated the property until June 1955, when it again was subleased, this time to Dodge Construction Co. During 1955-61, Dodge shipped nearly 700,000 tons of mainly lump ore to foreign and domestic steel producers. Total production, more than 800,000 tons of ore, came from above the 200-foot level.

Geology. - The property is overlain by a thin blanket of Lake Lahontan sediments through which a few outcrops of scapolitized metavolcanic rocks protrude. The ore deposits consist of tabular bodies of high-grade magnetite that dip steeply to the north. The main vein varies in width from 10 to 60 feet over a length of 600 feet. Several parallel veins up to 10 feet wide occur across a section of about one-quarter of a mile. Much magnetite is also

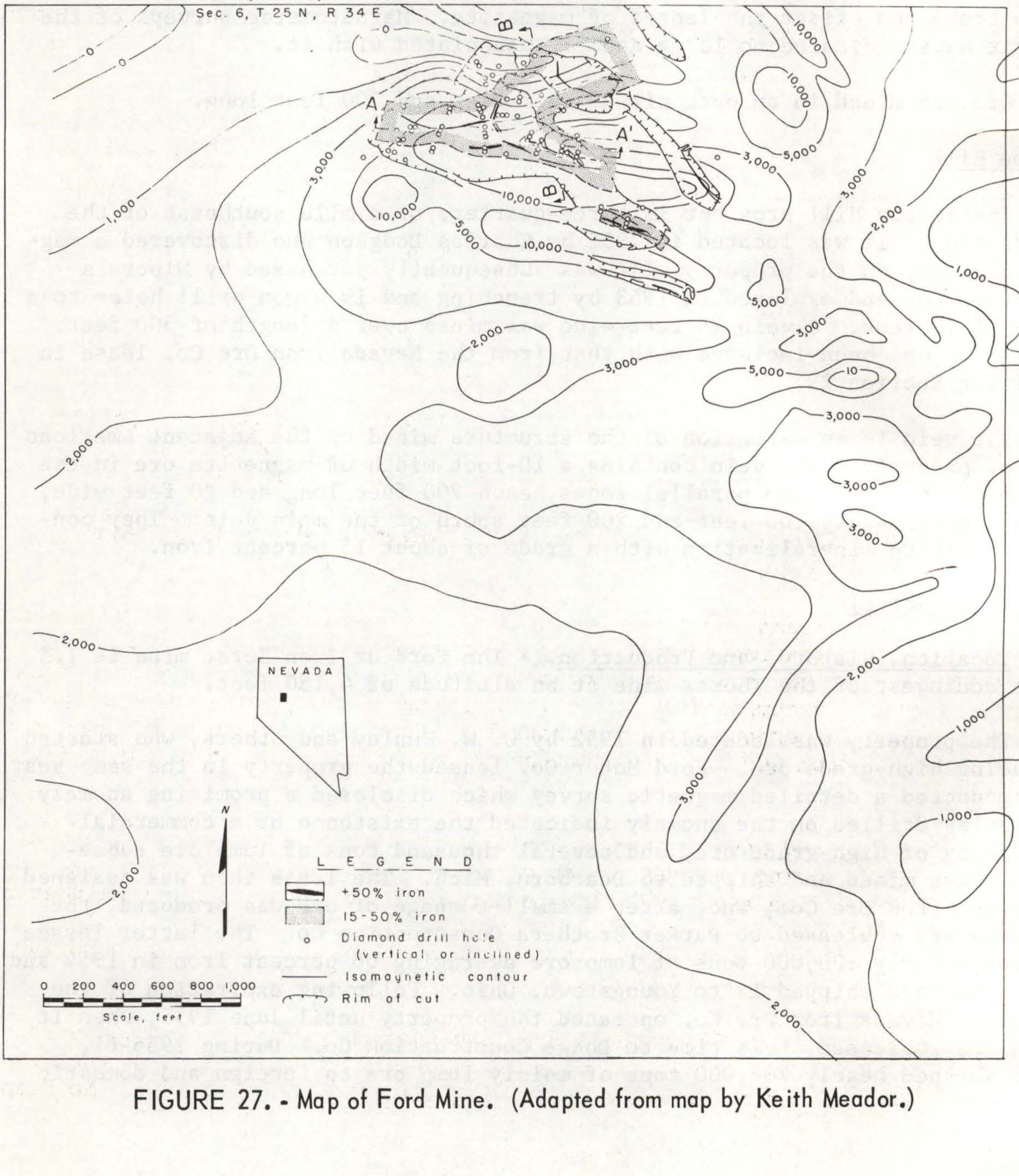


FIGURE 27. - Map of Ford Mine. (Adapted from map by Keith Meador.)

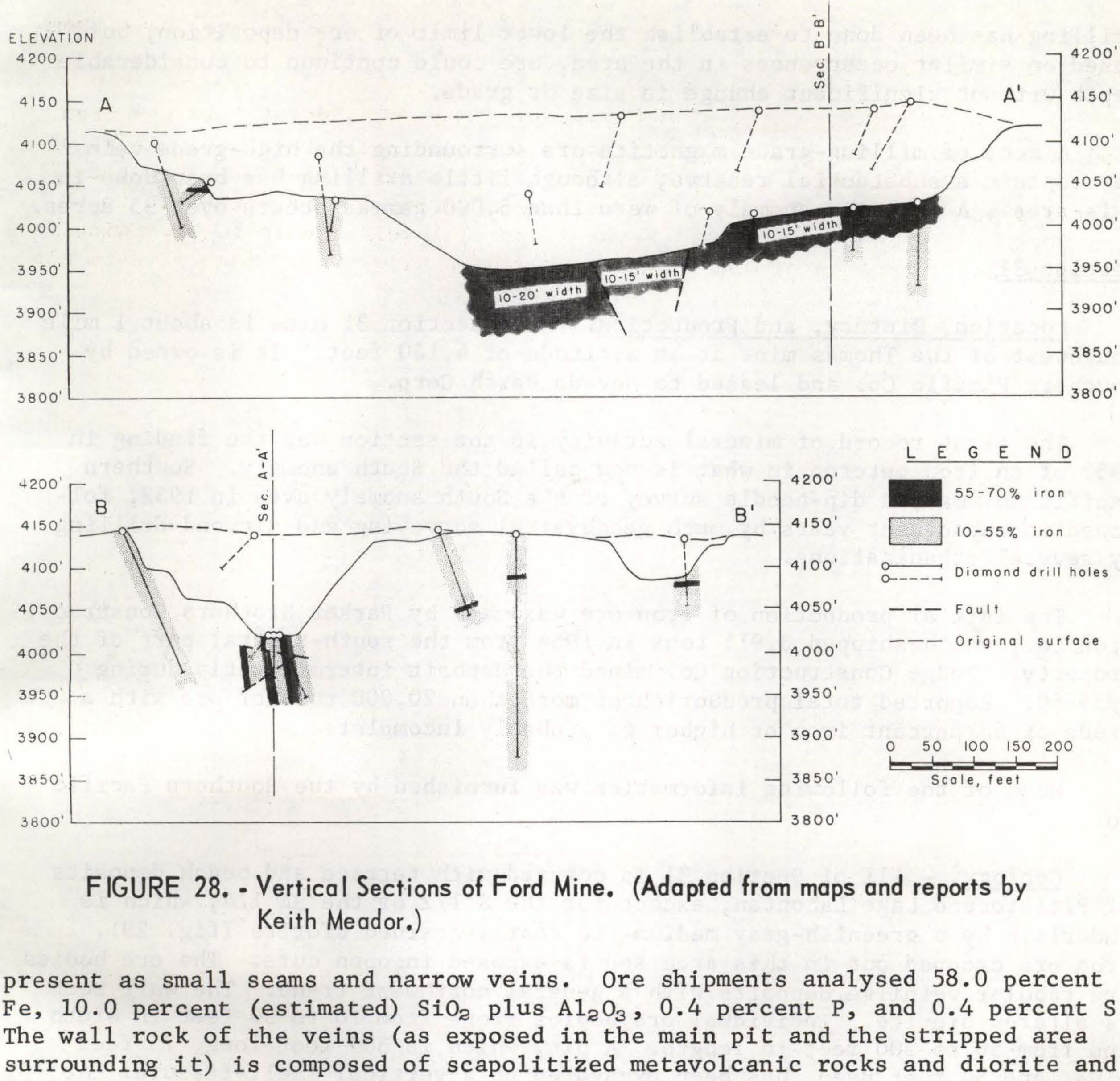


FIGURE 28. - Vertical Sections of Ford Mine. (Adapted from maps and reports by Keith Meador.)

present as small seams and narrow veins. Ore shipments analysed 58.0 percent Fe, 10.0 percent (estimated) SiO_2 plus Al_2O_3, 0.4 percent P, and 0.4 percent S. The wall rock of the veins (as exposed in the main pit and the stripped area surrounding it) is composed of scapolitized metavolcanic rocks and diorite and contains about 15 percent iron as magnetite. Four smaller ore bodies occur in parallel veins from 200 to 1,000 feet north of the main ore body (figs. 27, 28).

Exploration and Development. - Exploration by core drilling was done at various periods during 1952-62. Much of the drilling was shallow and was concentrated in the mine area to delineate direct-shipping ore. The remainder of the property has been explored by a magnetic survey and a few drill holes. Mine openings consist of an open pit 1,200 feet long, 500 feet wide, and 200 feet deep and of three smaller pits.

Ore Reserves. - No resource figures are available for the Ford deposit. Drilling, which extended 75 feet below the 200-foot level, indicated that the high-grade veins continue to that depth with little change in width. No deep drilling has been done to establish the lower limit of ore deposition, but, based on similar occurrences in the area, ore could continue to considerable depth without significant change in size or grade.

A zone of milling-grade magnetite ore surrounding the high-grade veins may contain a substantial reserve, although little drilling has been done in this area. A magnetic anomaly of more than 5,000 gammas occurs over 33 acres.

Section 31

Location, History, and Production. - The Section 31 mine is about 1 mile southwest of the Thomas mine at an altitude of 4,140 feet. It is owned by Southern Pacific Co. and leased to Nevada Barth Corp.

The first record of mineral activity in the section was the finding in 1952 of an iron outcrop in what is now called the South anomaly. Southern Pacific Co. made a dip-needle survey of the South anomaly area in 1952, followed in subsequent years by much geophysical surveying and diamond drilling by several organizations.

The initial production of iron ore was made by Parker Brothers Construction Co., which shipped 3,911 tons in 1954 from the south-central part of the property. Dodge Construction Co. mined the deposit intermittently during 1955-60. Reported total production of more than 20,000 tons of ore with a grade of 58 percent iron or higher is probably incomplete.

Much of the following information was furnished by the Southern Pacific Co.

Geology. - All of Section 31 is covered with terrace and beach deposits of Pleistocene Lake Lahontan, except for the S 1/2 of the SE 1/4, which is underlain by a greenish-gray medium- to coarse-grained diorite (fig. 29). Iron ore cropped out in this area and is exposed in open cuts. The ore bodies are tabular veinlike deposits with a general northwest trend. The wall rock is altered diorite. Individual ore bodies range from 10 to 50 feet in width and from 50 to 300 feet in length. A pit, which is 300 feet long, 75 feet wide, and 50 feet deep, has been excavated on a vertical fault-fissure. At the ends of the pit the fault is about 30 feet wide and is composed of three strands, each of which contains lenticular masses of magnetite up to 5 feet in width and several hundred tons in size. Another pit, 300 feet long, 75 feet wide, and 60 feet deep, on the same northwest fault-fissure has been excavated 400 feet farther to the northwest. Here, magnetite occurs in the fissure zone at intersections with steep west-dipping fissures. About 300 feet north of the two pits a parallel northwest fissure has been mined in a pit 300 feet long, 100 feet wide, and 60 feet deep. The ends of the pit at this locality contain small pods of magnetite in steep dipping fissures.

Postore faults with minor offsets are common in all pits. There is little disseminated magnetite in the wall rocks exposed.

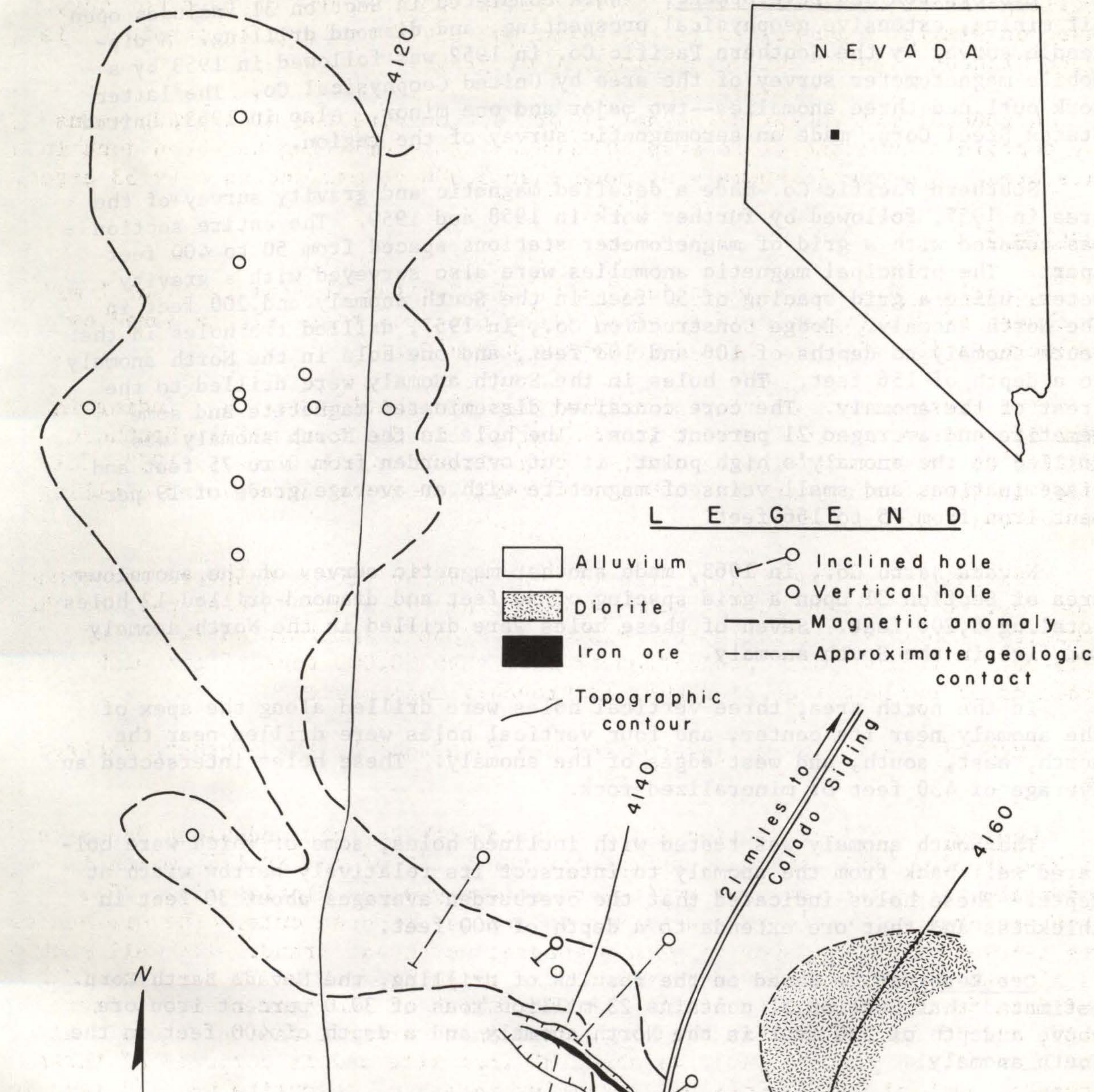


FIGURE 29. - Map of Section 31 Iron Deposit. (Adapted from Southern Pacific Co. map.)

Exploration and Development. - Work completed in Section 31 includes open pit mining, extensive geophysical prospecting, and diamond drilling. A dip-needle survey by the Southern Pacific Co. in 1952 was followed in 1953 by a mobile magnetometer survey of the area by United Geophysical Co. The latter work outlined three anomalies--two major and one minor. Also in 1953, United States Steel Corp. made an aeromagnetic survey of the region.

Southern Pacific Co. made a detailed magnetic and gravity survey of the area in 1957, followed by further work in 1958 and 1959. The entire section was covered with a grid of magnetometer stations spaced from 50 to 400 feet apart. The principal magnetic anomalies were also surveyed with a gravity meter, using a grid spacing of 50 feet in the South anomaly and 200 feet in the North anomaly. Dodge Construction Co., in 1957, drilled two holes in the South anomaly to depths of 106 and 108 feet, and one hole in the North anomaly to a depth of 156 feet. The holes in the South anomaly were drilled to the crest of the anomaly. The core contained disseminated magnetite and some hematite and averaged 21 percent iron. The hole in the North anomaly was drilled at the anomaly's high point; it cut overburden from 0 to 75 feet and disseminations and small veins of magnetite with an average grade of 19 percent iron from 75 to 156 feet.

Nevada Barth Co., in 1963, made another magnetic survey of the anomalous area of Section 31 upon a grid spacing of 50 feet and diamond-drilled 12 holes totaling 5,206 feet. Seven of these holes were drilled in the North anomaly and five in the South anomaly.

In the north area, three vertical holes were drilled along the apex of the anomaly near its center, and four vertical holes were drilled near the north, east, south, and west edges of the anomaly. These holes intersected an average of 430 feet of mineralized rock.

The South anomaly was tested with inclined holes, some of which were collared well back from the anomaly to intersect its relatively narrow width at depth. These holes indicated that the overburden averages about 30 feet in thickness and that ore extends to a depth of 400 feet.

Ore Reserves. - Based on the results of drilling, the Nevada Barth Corp. estimated that Section 31 contains 23 million tons of 30.0 percent iron ore above a depth of 520 feet in the North anomaly and a depth of 400 feet in the South anomaly.

Economic Potential. - The ore in the North anomaly is minable by open pit methods with a stripping ratio of 1:1. Only the upper portion of the South anomaly is suitable for open pit mining because of its narrow width. If mined to a depth of 500 feet, the stripping ratio would be about 5:1. An alternative plan would be to mine the North area with an open pit and to mine as much of the South ore body as is economic from the same pit. The remaining ore could be recovered in a sublevel stope started from the end of the open pit.

Assuming 10-percent treatment losses, it would be necessary to mine and treat about 3.5 tons of ore and to strip 3.5 tons of waste to produce 1 ton of 64-percent iron pellets.

Segerstrom-Heizer

Location, History, and Production. - The Segerstrom-Heizer mine lies on the northern flank of the Buena Vista Hills at altitudes of 4,250 to 4,525 feet.

The property is owned by Southern Pacific Co. and leased to Charles H. Segerstrom and John M. Heizer. Since 1941 it has been subleased to various operators. Production by Dodge Construction Co. and others through 1945 was approximately 50,000 tons of ore. About 650,000 tons was shipped from intermittent operations through 1955. Dodge Construction Co. shipped more than 50,000 tons to domestic consumers during 1957-61 and Nevada Barth Co. produced more than 450,000 tons for shipment to Japan from 1962 through 1966. Total production was more than 1.2 million tons.

Geology. - The following section on geology is based mainly on information furnished by the Southern Pacific Co.

The Segerstrom-Heizer mine and surrounding area is underlain by the following rock types in order of probable age: (1) Metavolcanic rocks; (2) diorite; (3) monzonite; (4) Tertiary volcanic rocks; and (5) Pleistocene Lake Lahontan deposits and recent alluvium. More than one-half of the area is covered by unconsolidated deposits and most of the remaining ground is blanketed with shallow overburden. In the mining area, bedrock is usually covered by less than 10 feet of soil (fig. 30).

Pennsylvanian metavolcanic rocks make up approximately half of the area's bedrock. They commonly show scapolite-hornblende alteration and frequently contain disseminated magnetite ore.

Diorite is the second most widespread rock and forms the walls for many of the ore bodies. The fine-grained diorite resembles metavolcanic rock and usually shows small amounts of scapolite alteration. Diorite masses in the mine area usually contain less than 20 percent iron as magnetite; diorite occurring at a distance from the mine area contains less than 3 percent iron as magnetite. Dikes are present in a few places and may be related to the diorite intrusion.

Monzonite occurs in a number of small masses, mainly southeast of the mine. Most of the monzonite contains about 3 percent iron as disseminated magnetite grains.

The highest level of Pleistocene Lake Lahontan reached 4,380 feet and much of the area below this altitude is covered with Pleistocene gravel, sand, and silt. Small quantities of magnetite pebbles and sand are present in the unconsolidated sediments.

Faulting is prominent and appears to have been the primary control of mineralization. In the pits two fault trends are dominant: Northeast to east with dips to the north and north to northwest with west dips. A northeast-trending, northwest-dipping fault is traceable throughout the length of the

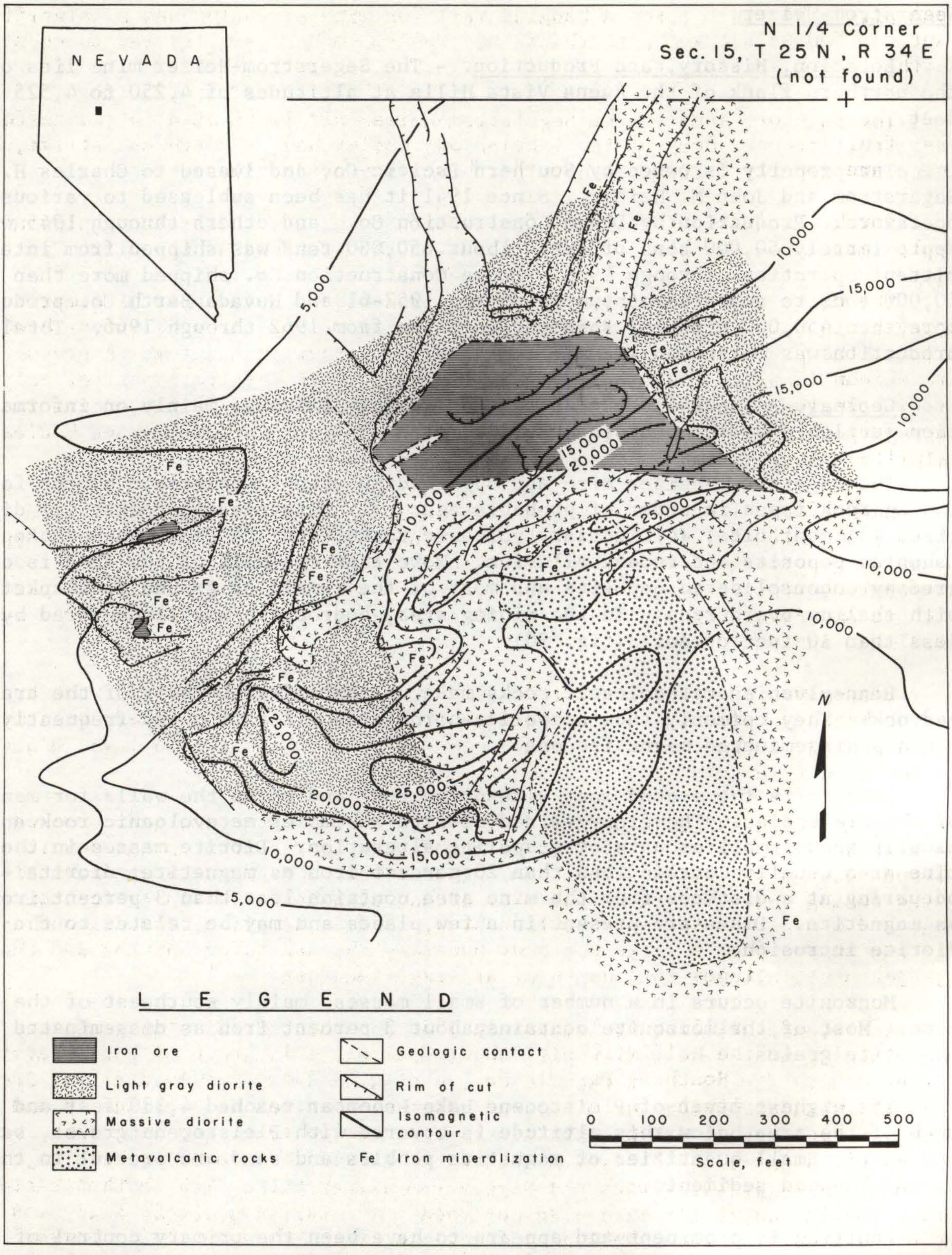


FIGURE 30. - Geologic Map of Segerstrom-Heizer Iron Deposit. (Adapted from Southern Pacific Co. map.)

open pit. The fault forms a hanging wall for mineralization and no significant ore bodies are known north of this fault. Other parallel faults occur farther south in the pit.

The main ore zone in the Segerstrom-Heizer pit is related to the northeast fault trend. Some of the tabular ore bodies have a northwest strike, but these are usually narrow and have not been very productive.

North-to-northwest striking faults offset the ore bodies and a prominent fault terminates the high-grade ore body in the east end of the pit.

The chief ore mineral is magnetite, with lesser quantities of hematite; however, in some thin veins and in occasional portions of thick veins, hematite is the predominant mineral. Limonite and other iron oxidation products are common locally. In massive ore bodies, chlorite, pyrite, apatite, actinolite, hornblende, scapolite, and calcite may be present. Pyrite occurs in segregations and can be avoided by selective mining. In lower grade bodies, chlorite and wall rock are the most abundant gangue materials.

Much of the iron ore occurs as replacement veins in slightly to completely scapolitized diorite and metavolcanic rock. Rock type does not appear to be as important as structural features, particularly faulting, in the depositional control of the massive ore bodies. A large area in the south part of the pit and extending southeast contains magnetite occurring in narrow veins, veinlets, and small masses.

Disseminated ore occurs principally in scapolitized rock, and rock type was probably a major factor in the formation of this class of ore. Disseminated grains and bunches also enrich some material where the dominant mineralization occurs in veins and veinlets.

Exploration and Development. - The Segerstrom-Heizer ore body cropped out as scattered exposures of high-grade magnetite. Early development consisted of open cuts which yielded the first production. The property was investigated during World War II by the U.S. Bureau of Mines. The investigation included a magnetometer survey, trenching, surface sampling, and diamond drilling and proved that a large ore body underlay the scattered outcrop and that massive ore continues to a depth of at least 500 feet.

Additional drilling by lessees in 1956 encountered shipping grade ore in the vicinity of the Half Mile pit, about one-half mile south of the Segerstrom-Heizer mine. The Southern Pacific Co., during 1958-59, surveyed all of Section 15 (which contains the mine) and adjacent portions of Sections 10 and 14, with a magnetometer, using a profile spacing of 200 feet, and a station interval on the profiles of 50 feet. This work outlined an anomalous area adjacent to and roughly parallel with the Segerstrom-Heizer pit on its southeast side. Other smaller anomalies were also outlined. A detailed geologic study was made and trenching and sampling of favorable areas was completed. Nevada Barth Co. later tested these areas by drilling and found a substantial tonnage of milling ore.

Present mining operations (at a depth of 200 feet in the bottom of the pit) are confined to a body of high-grade magnetite ore measuring about 300 by 60 feet.

Ore Reserves. - A magnetic anomaly having an intensity of 15,000 gammas or more extends 1,800 feet east-west and up to 600 feet north-south in the vicinity of the Segerstrom-Heizer pit. Based on this anomaly and on the trenching and drilling, reserves of the pit were estimated by Nevada Barth Co. as 35.0 million tons of iron ore containing an average of 30 percent iron. An additional 560,000 tons of material containing 21.5 percent iron is present on middling dumps. Narrow widths of shipping ore occur in the Half Mile and in other pits, but production has been stopped because of high stripping ratios.

Economic Potential. - The relatively small cross section of the direct shipping-grade ore body will necessitate a high stripping ratio as depth increases. Judging by the shape of its magnetic anomaly, the deposit of milling ore should be compact and have a stripping ratio of about 1:1 to a depth of 400 feet.

To produce a ton of 64-percent iron pellets from this ore, 2.4 tons of ore would have to be processed and an equal weight of waste would have to be stripped.

American Ore Co., Section 10

The Section 10 mine is one-half of a mile northeast of the Segerstrom-Heizer pit. American Ore Co., Detroit, Mich., purchased the property in 1950. Mine production was started in 1952 by the company but later in the year mining was contracted to Parker Brothers Construction Co. Operations were terminated in the same year after an estimated production of 4,000 tons of ore which averaged 60 percent iron (16, p. 29).

The pit is in an area of weakly scapolitized diorite on the trend of a prominent northeast-striking, northwest-dipping structure, which extends from the nearby Segerstrom-Heizer mine. In the Section 10 mine pit, a series of fractures cut the northeast zone, which at this point is about 75 feet wide and contains four veins of magnetite. Each vein is 4 to 5 feet wide. The pit is about 150 feet long, 100 feet wide, and 50 feet deep.

American Ore Co., Sections 16 and 22

American Ore Co. properties in Sections 16 and 22 are about three-quarters of a mile southwest of the Segerstrom-Heizer mine on the north end of the Buena Vista Hills at altitudes of 4,300 to 4,500 feet. The property was purchased by American Ore Co. in 1950 and leased in 1959 to Consolidated Mineral Corp. During 1959-62, Consolidated produced more than 13,000 tons of direct shipping ore and concentrate.

The area is underlain by fine-grained, greenish metavolcanic rocks which contain intrusions of fine- to medium-grained, dark-green diorite. Magnetite occurs in steep west-dipping veins. Little disseminated magnetite is in the wall rocks.

The most northerly mine working is an open pit about one-half mile southwest of the Segerstrom-Heizer mine. A cut 250 feet long, 25 feet wide, and 60 feet deep was opened on a 10-foot vein containing masses of magnetite. A fissure with a south dip intersects the vein in the pit and contains up to 5 feet of magnetite. Five hundred feet south of the pit on the strike of the vein is a small pit from which lenses of magnetite 1 to 3 feet in width were mined.

About 1,500 feet farther south is another pit, 300 feet long, 70 feet wide, and 60 feet deep. Here, magnetite occurs in a 10-foot-wide north-striking vein at its intersection with an east-west fissure. The fissure, which also contains magnetite, has been mined for a length of 100 feet.

Results of magnetometer surveys in the area indicate the deposits are limited in extent. The high stripping ratio which is necessary in open pit mining of narrow veins has prevented further production.

Piute

Location, History, and Production. - The Piute property is in Pershing and Churchill Counties, about 19 miles southeast of Lovelock at an altitude of 4,000 feet.

The portion of the property in Sections 24, 26, and 36 is owned by C. W. Hunley (80 percent) and by E. L. Stephenson (20 percent). The portion in Sections 19, 25, and 35 is owned by Southern Pacific Co. There has been no production (fig. 31).

Geology. - The Piute iron deposit is overlain by sandy alluvium, recent sediments, and about 800 feet of Tertiary volcanic rocks.

The pre-Tertiary rocks, which contain the deposits, do not crop out near the property and all knowledge concerning their composition has been obtained from two drill holes which have penetrated them. The mineralized horizon in the Piute deposit consists of metamorphosed sedimentary and volcanic rocks.

Diamond drill core from the Piute ore body shows a zone of heavy brecciation cemented by secondary albite, calcite, magnetite, and other vein minerals. Much of the breccia in the drill cores has been replaced by magnetite, often in a highly selective manner. Magnetite also occurs as solid massive replacements and as irregular stringers, blebs, and disseminated grains. The average analysis of ore in the lower 275 feet of drill hole No. 1 was 32.17 percent total Fe, 31.00 percent magnetic Fe, 0.14 percent P, and 0.11 percent S.

Each of the two holes drilled was in the center of an anomaly and each cut much brecciated rock. The breccia zone in the center of each ore body probably formed the channel through which mineralization was effected. The outlying portions of each ore body may be composed of ore formed by the selective replacement of certain horizons and by deposition in veins. This relationship was noted in the deposits in the Buena Vista Hills that have been exposed by open pit workings.

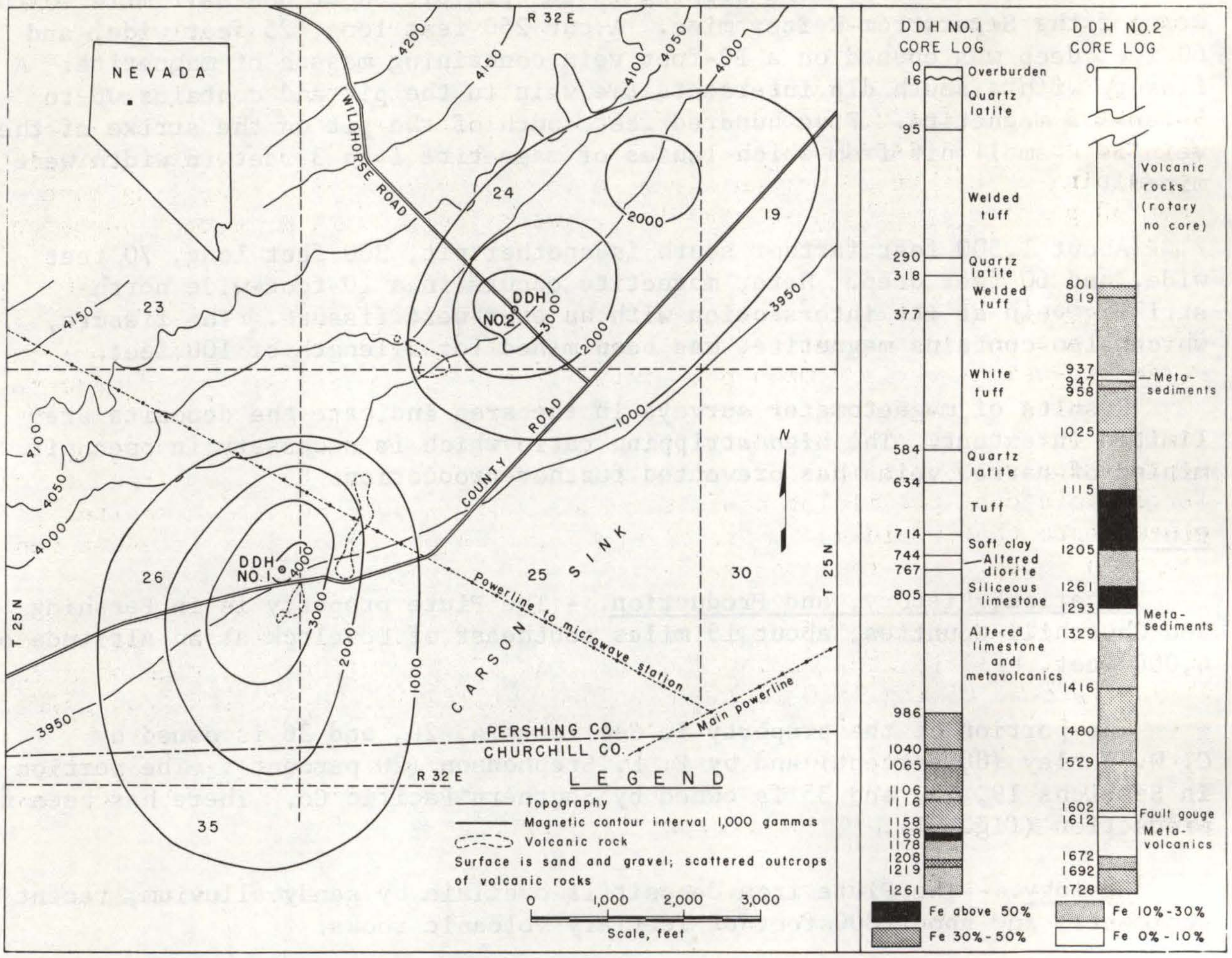


FIGURE 31. - Map and Drill Sections of Piute Iron Deposit. (Adapted from maps by E. H. Stephenson and W. S. Moore Co.)

Exploration and Development. - The deposit was found in 1952 as a result of dip-needle prospecting. Subsequently, the area was surveyed with a magnetometer and two large anomalies were delineated (fig. 31).

Diamond drill hole No. 1 was drilled vertically at the peak of the southwest anomaly. The hole cut 744 feet of barren Tertiary volcanic rocks and 242 feet of barren metavolcanic rocks and then intersected a zone of mineralized metasedimentary and metavolcanic rock. The hole was bottomed at a depth of 1,261 feet in material with a grade of 25 percent iron. The 275 feet of iron mineralization encountered was cored and averaged 32 percent iron.

Diamond drill hole No. 2 was drilled vertically at the peak of the northeast anomaly. The hole penetrated 785 feet of barren Tertiary volcanics before encountering iron-mineralized metasedimentary and metavolcanic rocks. The hole was continued to a depth of 1,728 feet and bottomed in 34 percent iron. The 943-foot mineralized section averaged 28 percent magnetic iron.

The 335-foot section from 958 to 1,293 feet averaged 38.8 percent iron, and the 90-foot section from 1,115 to 1,205 feet averaged 59.4 percent iron.

Ore Reserves. - The size and grade of the deposit can be inferred from the areas of magnetic anomalies and from the thicknesses of ore encountered in the two holes. This information indicates an enormous quantity of material containing more than 20 percent iron, a very large quantity averaging more than 30 percent iron, and substantial quantity containing more than 50 percent iron.

Economic Potential. - The top of the ore bodies is 800 feet or more below the surface and consequently the stripping ratio would be at least 3 to 1 on a weight-to-weight basis. Open pit mining of the entire deposit would require the breaking of 10.4 tons of material in the pit and treatment of about 2.6 tons of ore in the mill for each ton of 64-percent iron pellets produced. Approximately 150 million tons of barren rock would have to be stripped before large-scale open pit mining could commence. This would require a capital expenditure that would be impossible to amortize at the present iron-ore consumption rate in the regional market.

Underground mining by somewhat selective methods would allow production of 1 ton of pellets from mining and treating of approximately 2 tons of ore. If underground mining were confined to ore with a plus-50-percent iron grade, a ratio of 1 ton of pellets to 1.5 tons of ore mined and treated could be maintained. Drill hole No. 2 contained 90 feet of continuous core containing 59.4 percent iron, and it is possible that additional drilling would develop adequate reserves of plus-50-percent iron ore.

Metallurgical testings was done by W. S. Moore Co. on the core recovered from the two holes. Results are shown in table 39.

TABLE 39. - Concentration test of Piute ore

Sample	Total Fe	Magnetic Fe	SiO_2	Al_2O_3	P	S	TiO_2	Recovery
Heads...........	47.2	43.7	-	-	-	-	-	-
Concentrate from 100-mesh grind..	68.4	-	1.74	-	-	-	-	94.4
Concentrate from 200-mesh grind..	66.7	-	1.88	1.64	0.061	0.011	Trace	92.6

Source: Report of mill testing by W. S. Moore Co.

Dayton Area

The Dayton iron area is 20 miles northeast of Carson City in northwestern Lyon and southwestern Storey Counties at altitudes of 4,600 to 5,000 feet. The Hazen-to-Mina branch of the Southern Pacific Railroad is 16 miles east of the area (fig. 21). The rail shipping distance from Dayton to San Francisco is 330 miles.

Nearly all known iron ore reserves are on the Dayton iron property. Minor resources occur at the Iron Blossom mine, 3 miles west of the Dayton iron deposit, and at prospects in surrounding localities.

Only a small production has been made from the area because the quantity of shipping-grade ore is limited. Development has indicated substantial tonnages of lower grade material that can be upgraded by beneficiation.

Dayton Iron

Location, History, and Production. - The Dayton Iron Deposit is 2.5 miles north of U.S. Highway 50 and 15 miles northeast of Dayton. Nine patented claims, which cover most of the developed area, are owned by Robert G. Gillis and Mortimer Fleishhaker, with the Crocker-Citizens National Bank of San Francisco acting as agent under a trust agreement. Deposits on adjoining land are owned by Southern Pacific Co. The entire property was leased in 1951 to Utah Construction and Mining Co. A small quantity of iron ore was produced for ship ballast during World War II.

Geology (4, 17). - The Dayton hematite-magnetite deposit is of contact metamorphic origin and occurs near a granite contact in a folded and metamorphosed series of limestone and chloritic rocks. The ore-bearing series has been folded into a south-pitching anticline with northwest to west strikes on the west limb and northeast to north strikes on the northeast limb. The core of the anticline is now occupied by granite, which is surrounded in turn on the south and east by about 200 feet of iron-bearing interbedded limestone and nonlimy metamorphic rocks and by an indeterminate thickness of unmineralized fine-grained quartzite.

The limestone in mineralized areas is coarse-grained and contains chloritic material. The nonlimy metamorphic rocks are composed of chlorite, quartz, calcite, mica, epidote, garnet, and feldspar. Their original composition is uncertain.

Faulting is of secondary importance. On the southwest corner of the ore body a fault contact separates granite and sedimentary rocks. A few small faults occur in the ore body.

Magnetite occurs as bands or lenses of ore, and as disseminations varying in size from individual grains of 200 mesh to aggregates of one-half of an inch or more throughout layers of metamorphic rocks. Weathering has oxidized the magnetite to hematite and extends to depths of 50 to 125 feet.

Most hematite and magnetite occurs in the nonlimy metamorphic rocks although some beds in the limestone have been replaced by magnetite and constitute ore. Pyrite in concentrations of 1 to 10 percent and with an average of 5 to 6 percent is associated with the magnetite in primary ore. Sulfur in the oxidized zone has been mainly removed by weathering or redeposited as gypsum. An average of the analyses of several composite samples of better-than-average grade ore is 50.1 percent Fe, 8.3 percent SiO_2, 0.02 percent P, 3.36 percent S, 6.8 percent CaO, 2.70 percent Al_2O_3, 1.61 percent MgO, 0.015

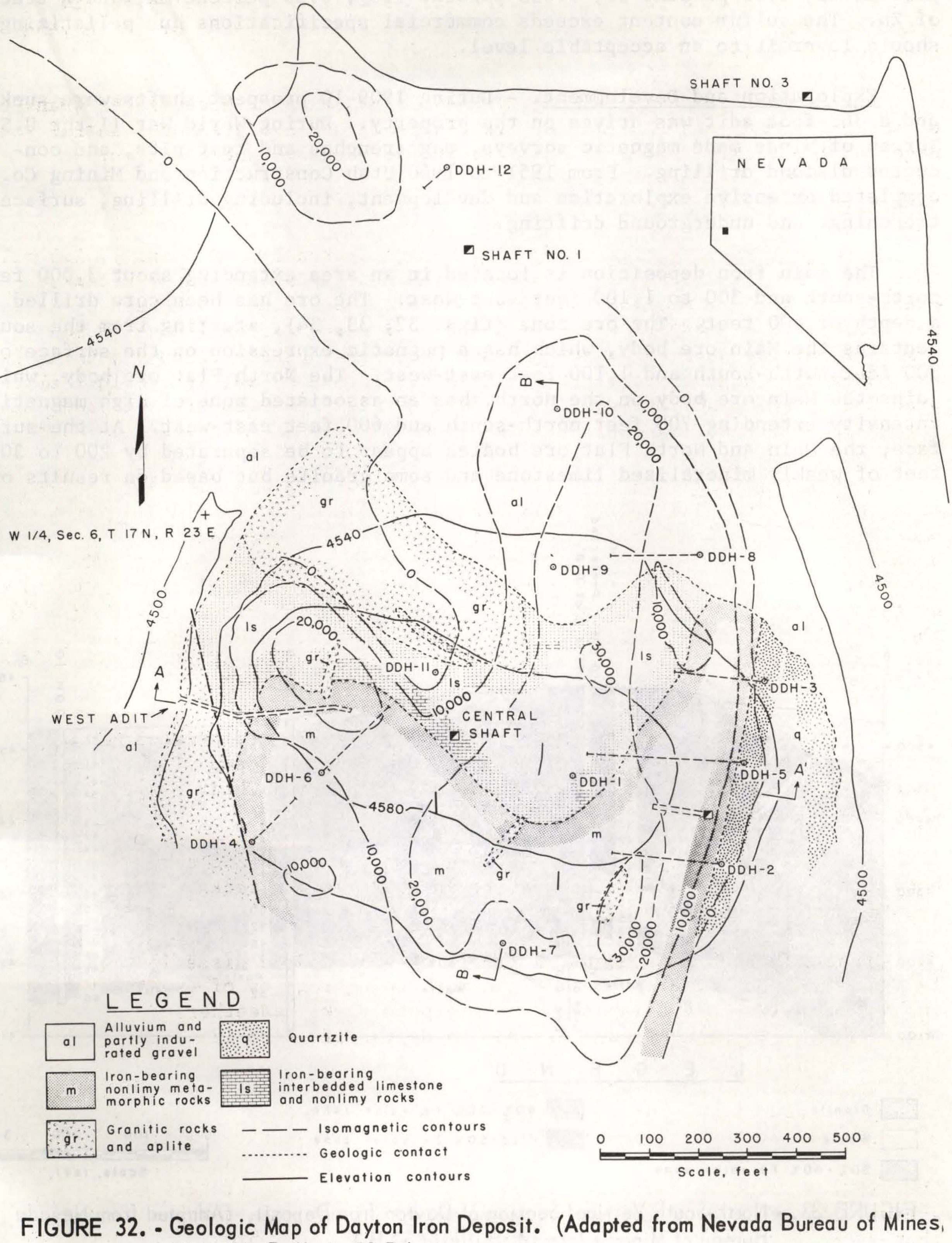


FIGURE 32. - Geologic Map of Dayton Iron Deposit. (Adapted from Nevada Bureau of Mines, Plate 14, Bulletin 53 B.)

percent Cu, 0.02 percent Pb, 0.025 percent TiO_2, 0.10 percent Mn, and a trace of Zn. The sulfur content exceeds commercial specifications but pelletizing should lower it to an acceptable level.

Exploration and Development. - During 1909-10 prospect shafts were sunk and a 360-foot adit was driven on the property. During World War II the U.S. Bureau of Mines made magnetic surveys, dug trenches and test pits, and conducted diamond drilling. From 1951 to 1960 Utah Construction and Mining Co. completed extensive exploration and development, including drilling, surface trenching, and underground drifting.

The main iron deposition is located in an area extending about 3,000 feet north-south and 300 to 1,100 feet east-west. The ore has been core drilled to a depth of 400 feet. The ore zone (figs. 32, 33, 34), starting from the south, contains the Main ore body, which has a magnetic expression on the surface of 800 feet north-south and 1,100 feet east-west. The North Flat ore body, which joins the Main ore body on the north, has an associated zone of high magnetic intensity extending 700 feet north-south and 600 feet east-west. At the surface, the Main and North Flat ore bodies appear to be separated by 200 to 300 feet of weakly mineralized limestone and some granite but based on results of

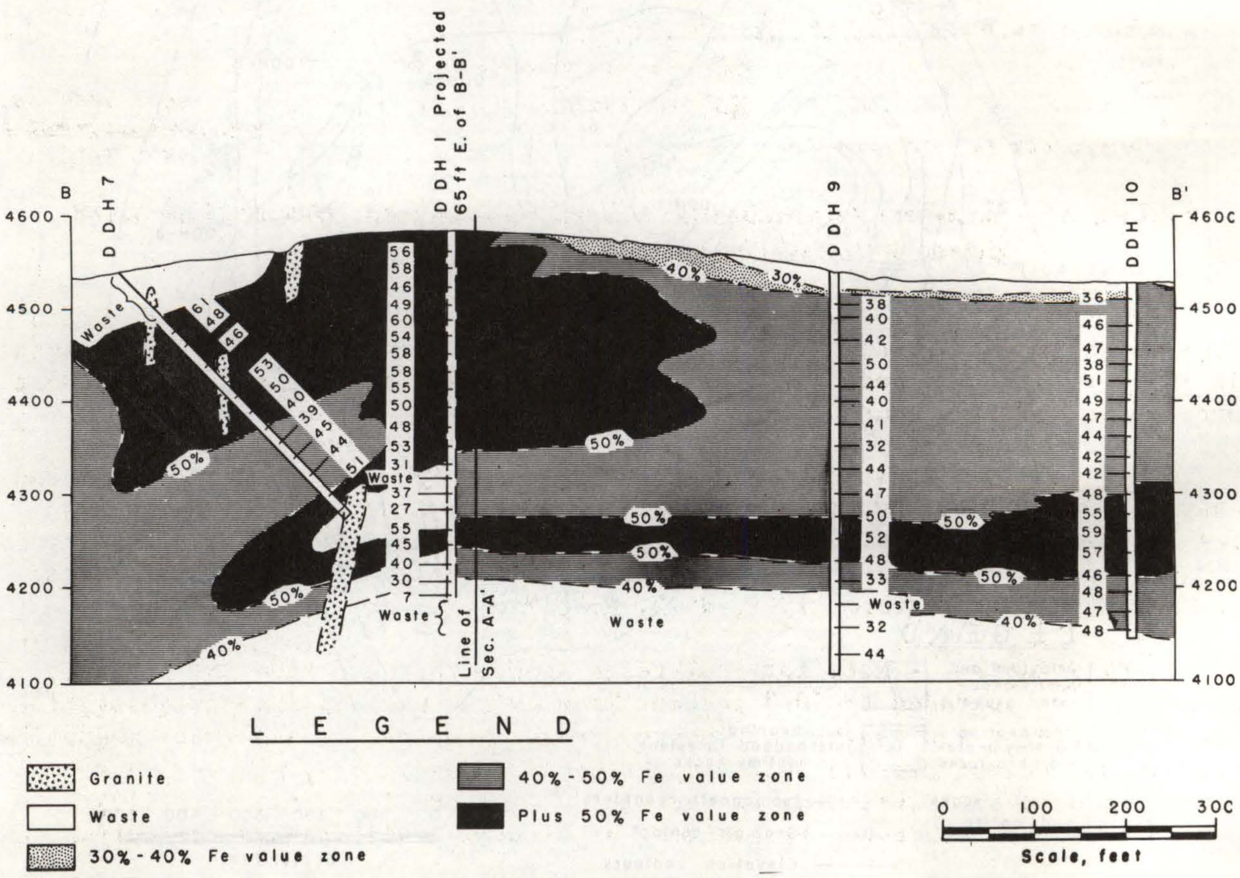


FIGURE 33. - North-South Vertical Section of Dayton Iron Deposit. (Adapted from Nevada Bureau of Mines Plate 14, Bulletin 53 B.)

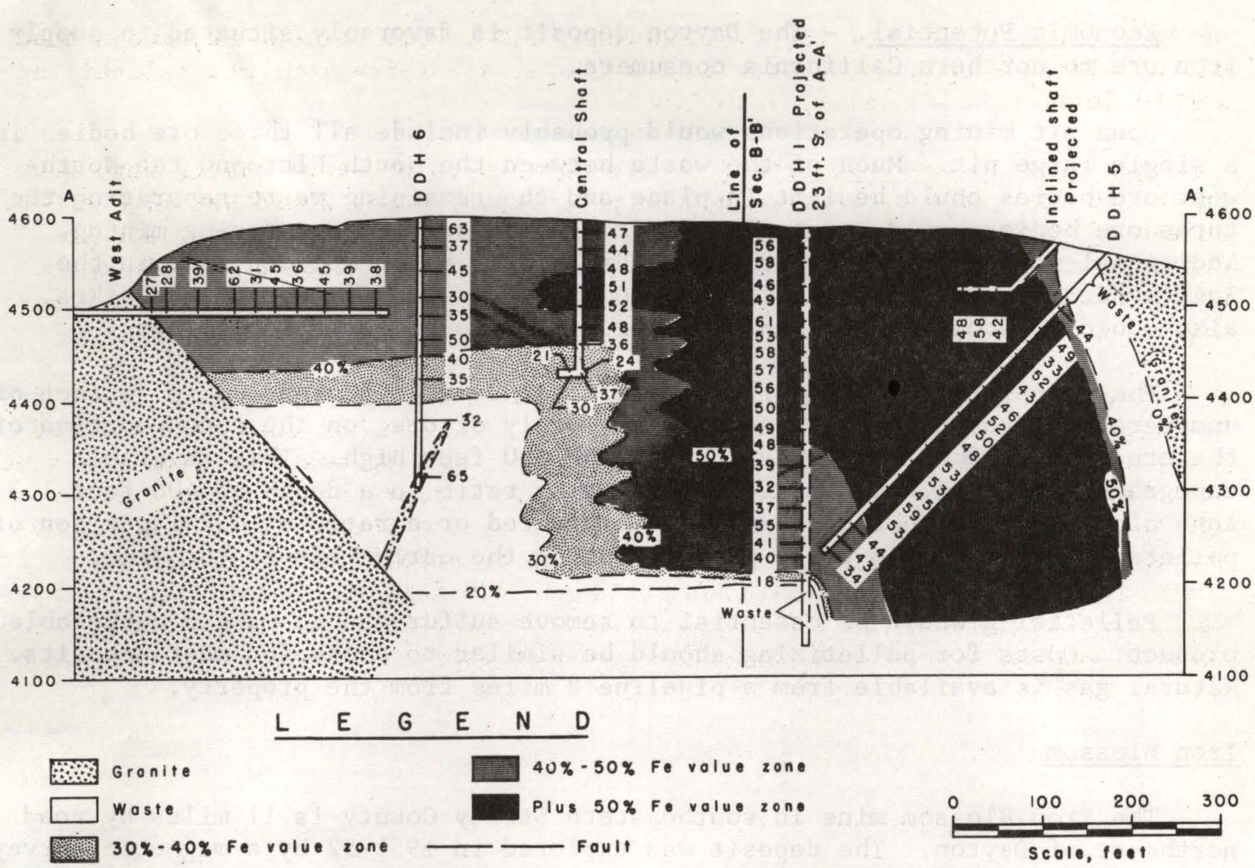


FIGURE 34. - East-West Vertical Section of Dayton Iron Deposit. (Adapted from Nevada Bureau of Mines Plate 14, Bulletin 53 B.)

the magnetic survey they may be continuous at depth. Northwest of the North Flat magnetic anomaly and separated by 200 feet of low susceptibility material is the Northwest ore body which has an anomaly 1,100 feet southeast-northwest and 300 to 400 feet southwest-northeast.

Ore Reserves. - Based on the Bureau of Mines investigation the estimated average grade of the Dayton ore body is 42 percent iron. This grade allows for segregating large blocks of waste in the ore zone. In 1964 Utah Construction Co. estimated that the deposit contained 45 million tons of ore (Bureau of Mines Minerals Yearbook 1964, v. 3, p. 647).

Beneficiation. - Metallurgical tests showed that ore from the oxidized zone could be upgraded to 60.3 percent iron by log washing and screening, followed by jigging and tabling of the undersize material. The primary magnetite ore was not tested because bulk samples were not available; however, a magnetic method of beneficiation is indicated. The ore is nearly self-fluxing and is low in phosphorus. Pelletizing or sintering will remove the sulfur.

Based on an average ore grade of 42 percent iron, a final product grade of 64 percent iron, and 90-percent recovery, the concentration ratio of Dayton ore is 1.70:1.

Economic Potential. - The Dayton deposit is favorably situated to supply iron ore to northern California consumers.

Open pit mining operations would probably include all three ore bodies in a single large pit. Much of the waste between the North Flat and the Northwest ore bodies could be left in place and the remaining waste separating the three ore bodies could be segregated from the bordering ore during mining. Additional waste, which occurs in the ore bodies as unreplaced beds in the interbedded iron-bearing sedimentary rocks and as granite and aplite dikes, also could be economically separated from the ore bodies during mining.

The deposit is covered with several feet of alluvium and up to 50 feet of unmineralized rock. A hill, consisting mainly of ore, on the south portion of the ore zone is about 15 acres in area and 100 feet high. This favorable topographic feature would make the stripping ratio to a depth of 400 feet 1.3 tons of waste to each ton of mill ore extracted or a ratio of 2.2:1 per ton of pellets. A lower ratio would prevail during the early life of the mine.

Pelletizing would be essential to remove sulfur and to make a marketable product. Costs for pelletizing should be similar to those for most deposits. Natural gas is available from a pipeline 2 miles from the property.

Iron Blossom

The Iron Blossom mine in southeastern Storey County is 11 miles by road northeast of Dayton. The deposit was explored in 1951-52 by a magnetic survey, trenches, bulldozer cuts, and shallow drill holes. During 1962 several thousand tons of ore from open cut operations was shipped by Nevada Ore Refining Co. A small tonnage was shipped in 1964 for cement manufacture.

Numerous small bodies of shipping-grade magnetite and hematite ore occur as filling in steep, narrow fissures and as lenticular bodies in selectively replaced beds in a gently dipping shaly limestone series. Most of the beds in the limestone series do not contain iron ore. Granite has intruded and metamorphosed the limestone and is apparently related to the iron deposition.

The average of the analyses of three samples, as reported by Reeves (17) is 62.3 percent Fe, 0.23 percent P, and 0.16 percent S.

Open cuts and trenches have developed an area 250 feet long and 100 feet wide.

Gabbs Area

The Gabbs iron area is 6 airline miles northeast of Gabbs, Nye County, on the west slope of the Paradise Range at altitudes of 6,000 to 7,000 feet. Rail shipments are made from Luning, 29 miles south of Gabbs.

The area's production came principally from the Phelps-Stokes mine, an important producer during 1949-57. Nearly all existing ore reserves are on this property.

Phelps-Stokes

Location, History, and Production. - The Phelps-Stokes mine is in the mouth of Bell Canyon on the west slope of Paradise Range at an altitude of 6,000 feet.

The claims were located for iron in 1902 and patented in 1907. The U.S. Bureau of Mines explored the deposit in 1944 and the work indicated the presence of a commercial ore body. The Standard Slag Company leased the property and during 1949-57 produced about 1.1 million tons of shipping-grade ore and concentrate. Only a small tonnage has been shipped since.

Geology. - The oldest rocks in the mine area are late Paleozoic metavolcanics which crop out immediately northeast of the ore body. Bordering the metavolcanics is a thick dolomite member of the Upper Triassic Luning Formation which underlies most of the mine area. The attitude of the dolomite varies, but it approximates an east-west strike and a steep south dip. The contact between the metavolcanics and dolomite is a strong thrust-fault zone with a northwest-southeast strike and a northeast dip. A layer of limy shale from 200 to 300 feet in thickness occurs in the dolomite. The ore body is in the portion of dolomite below the shale.

Quartz monzonite of probable late Mesozoic age crops out 1,000 feet southeast of the ore body, and small associated aplite dikes cut the dolomite. A later intrusion, to which the ore deposit seems to be related, occurs along the thrust fault and has a dikelike shape with a width up to 100 feet and a length of several hundred feet. It has been heavily altered and consists of feldspar, quartz, augite, carbonate minerals, and chlorite.

The ore body consists of two replacements in dolomite, each an acre or more in area, connected by a 400-foot long replacement vein 25 to 50 feet wide. The magnetic anomaly associated with the ore body has a similar, although less pronounced, shape; the 10,000 gamma contour is 1,500 feet long, with widths of 300 to 450 feet near the ends and a constriction to 200 feet near the center.

The east section of the ore body is localized at the intersection of the replacement vein structure and the northwest thrust fault, with one wall being formed by the large altered dike; the west section of the ore body occurs at the intersection of the replacement vein structure and a strong northeast-striking, northwest-dipping normal fault. The replacement vein structure parallels the bedding of the dolomite.

Magnetite is the principal ore mineral; a minor quantity of associated hematite is also present. Primary ore below the zone of oxidation contains more than 3 percent sulfur, which occurs as pyrite and pyrrotite. Sulfur has been removed from the oxidized ore. Gangue minerals are chlorite, sericite, actinolite, phlogopite, calcite, and unreplaced remnants of dolomite. Character samples of Bureau of Mines surface and drill hole composites contained 47.5 percent Fe, 7.42 percent SiO_2, 0.072 percent P, and 4.45 percent S for primary ore, and 54.6 percent Fe, 7.34 percent SiO_2, 0.03 percent P, and 0.03

percent S for oxidized ore. The grade of ore produced was maintained above 58.0 percent iron by selective mining, and in 1957 by magnetic beneficiation.

Exploration and Development. - Exploration by the Bureau of Mines included magnetometer surveying, trenching, and diamond drilling. Subsequent mining resulted in an irregularly shaped pit 1,200 feet long, 100 to 400 feet wide, and 300 feet deep. Considerable diamond drilling has been done by Standard Slag Co.

Ore Reserves. - No ore reserve estimate is available. Drilling indicated that the ore body continues 300 feet below the bottom of the pit without significant change, but its extent at greater depth has not been determined.

Economic Potential. - Future mining operations could be expected to continue the open pit with little basic change except for the use of larger equipment units to increase productivity.

The stripping ratio at the present pit depth is about 2:1 (weight-to-weight); at a depth of 1,000 feet the estimated ratio would be 6:1. Underground methods would be an alternative when the stripping ratio exceeds 4:1.

Magnetic concentration probably would be used exclusively because of the predominance of magnetite. Sulfur, an undesirable constituent in direct shipping ore, would be eliminated by magnetic separators and by sintering or pelletizing the concentrate.

The indicated concentration ratio, assuming a 10-percent beneficiation loss, would be 1.75:1.0 and the waste-to-final-product ratio would vary from 3.5:1.0 at the present pit level to 7.0:1.0 at the point where a shift to underground operations would be indicated. Transportation costs would be relatively high because of the 39 miles of truck and 410 miles of rail haul required.

Eagle Stouder

The Eagle-Stouder property is about 10 airline miles northeast of Gabbs on the steep west slope of the Paradise Range, at an altitude of 7,000 feet. The deposit is on two claims which were patented in 1922. A small production was made during 1961-62.

Magnetite with some hematite occurs in grayish-green metavolcanic rocks along shear zones, the largest of which is 100 feet wide and 400 feet long. The minable iron ore reportedly is confined to small lenses in narrow veins.

Jackson Mountains Area

The Jackson Mountains iron area is in west-central Humboldt County, 45 airline miles northwest of Winnemucca at an altitude of 7,000 to 8,000 feet. The nearest shipping point is the Western Pacific Railroad siding at Jungo, 32 miles by road south of the mine area.

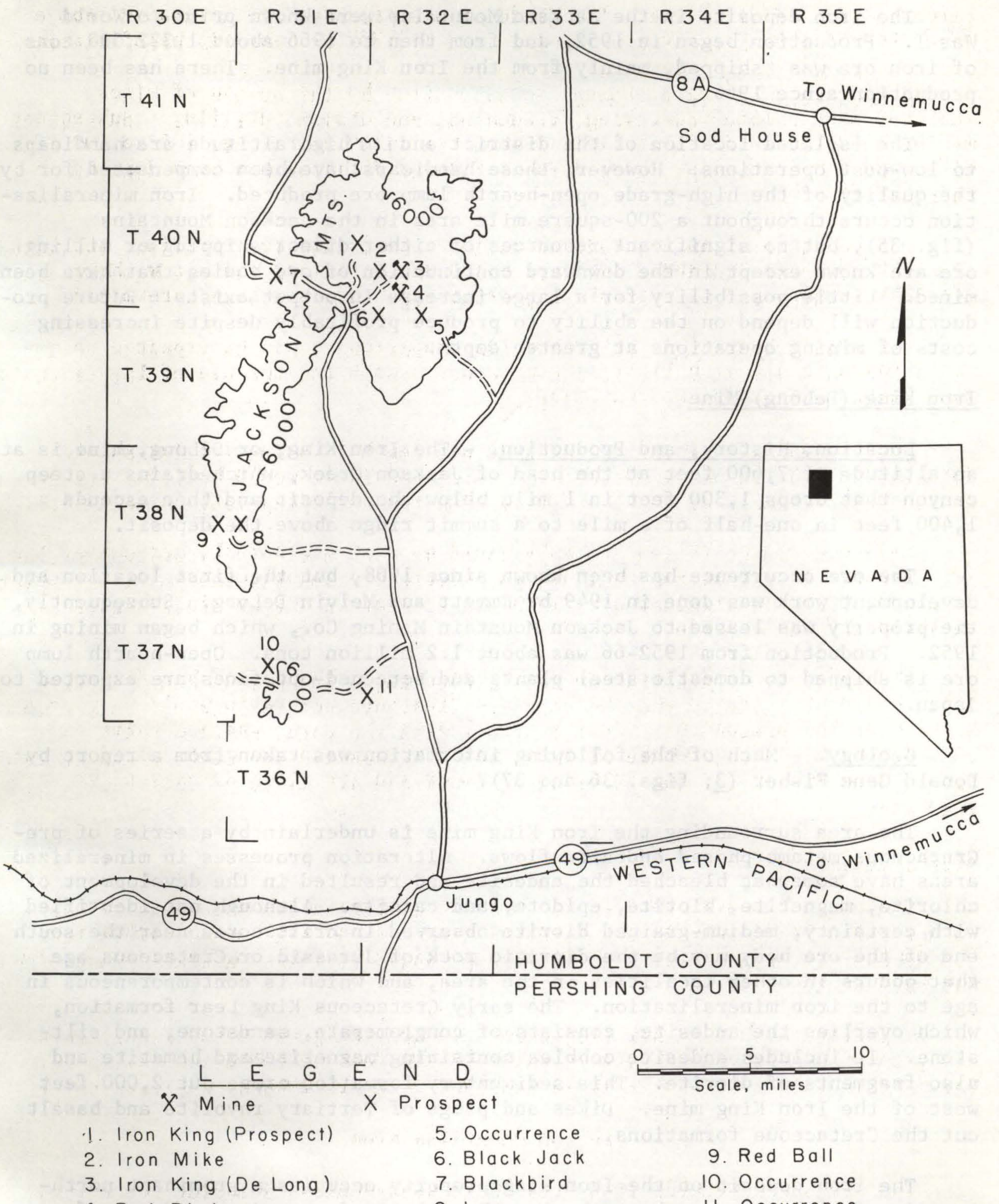


FIGURE 35. - Iron Properties in Jackson Mountains Area.

The iron deposits in the Jackson Mountains were known prior to World War I. Production began in 1952, and from then to 1966 about 1,332,000 tons of iron ore was shipped, mainly from the Iron King mine. There has been no production since 1966.

The isolated location of the district and its high altitude are handicaps to low-cost operations. However, these handicaps have been compensated for by the quality of the high-grade open-hearth lump ore produced. Iron mineralization occurs throughout a 200-square mile area in the Jackson Mountains (fig. 35), but no significant resources of either direct shipping or milling ore are known except in the downward continuation of ore bodies that have been mined. Little possibility for a large increase in output exists. Future production will depend on the ability to produce profitably despite increasing costs of mining operations at greater depth.

Iron King (DeLong) Mine

Location, History, and Production. - The Iron King, or DeLong, mine is at an altitude of 7,600 feet at the head of Jackson Creek, which drains a steep canyon that drops 1,300 feet in 1 mile below the deposit and then ascends 1,400 feet in one-half of a mile to a summit ridge above the deposit.

The ore occurrence has been known since 1908, but the first location and development work was done in 1949 by Emmett and Melvin DeLong. Subsequently, the property was leased to Jackson Mountain Mining Co., which began mining in 1952. Production from 1952-66 was about 1.2 million tons. Open-hearth lump ore is shipped to domestic steel plants and screened-out fines are exported to Japan.

Geology. - Much of the following information was taken from a report by Donald Gene Fisher (3; figs. 36 and 37).

The area surrounding the Iron King mine is underlain by a series of pre-Cretaceous metamorphosed andesite flows. Alteration processes in mineralized areas have somewhat bleached the andesite and resulted in the development of chlorite, magnetite, biotite, epidote, and calcite. Although not identified with certainty, medium-grained diorite observed in drill cores near the south end of the ore body may be the dioritic rock of Jurassic or Cretaceous age that occurs in other localities in the area, and which is contemporaneous in age to the iron mineralization. The early Cretaceous King Lear formation, which overlies the andesite, consists of conglomerate, sandstone, and siltstone. It includes andesite cobbles containing magnetite and hematite and also fragments of diorite. This sedimentary formation crops out 2,000 feet west of the Iron King mine. Dikes and plugs of Tertiary rhyolite and basalt cut the Cretaceous formations.

The iron deposit on the Iron King property occupies a prominent north-trending fault zone over a strike length of 1,250 feet and to a depth of more than 500 feet (a continuation of the structure may also contain the Red Bird mine one-half mile south). Associated ore bodies were formed along parallel north-striking faults and in splits from the main zone. A system of

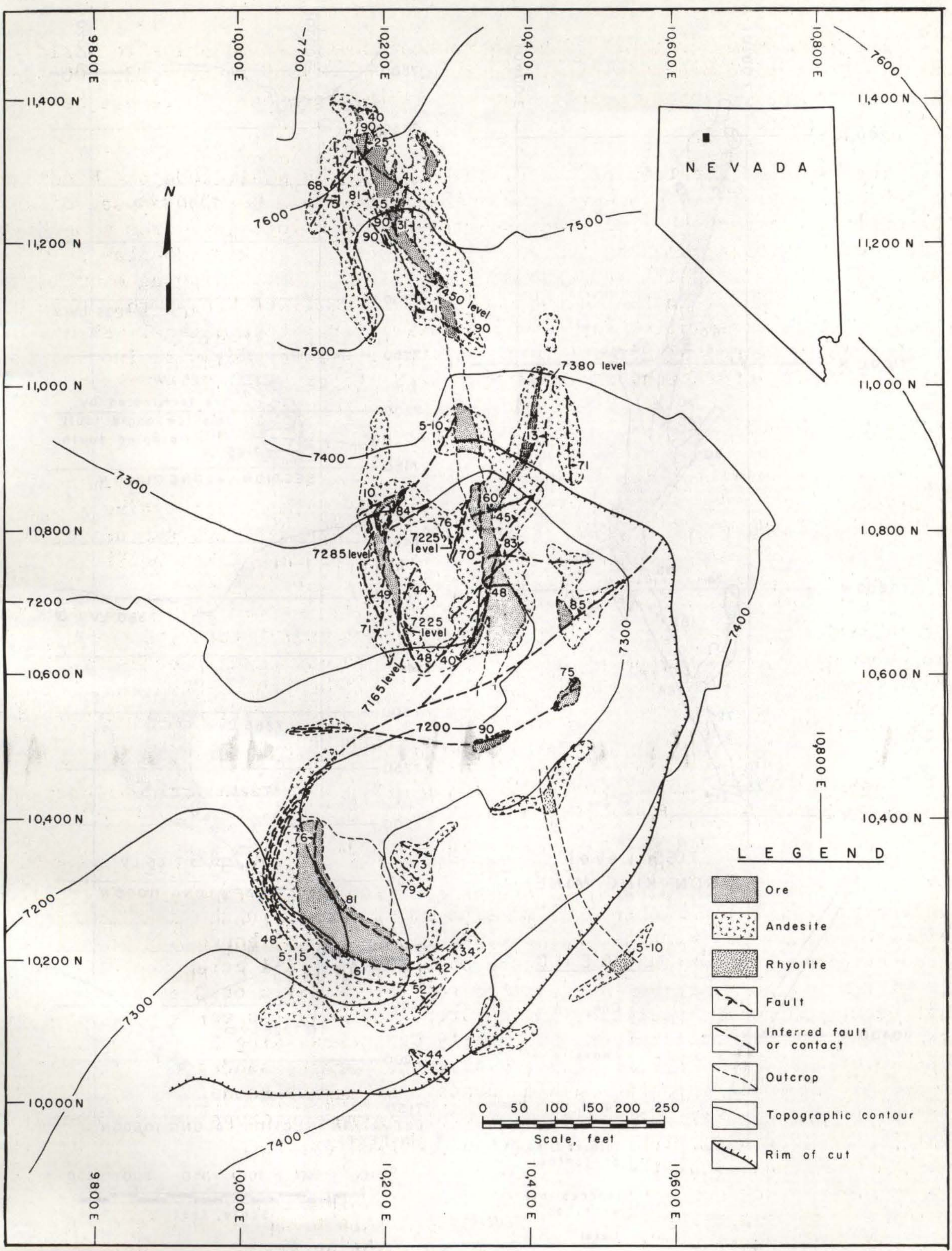


FIGURE 36. - Geologic Map of Iron King Mine. (Adapted from map by Donald Gene Fisher.)

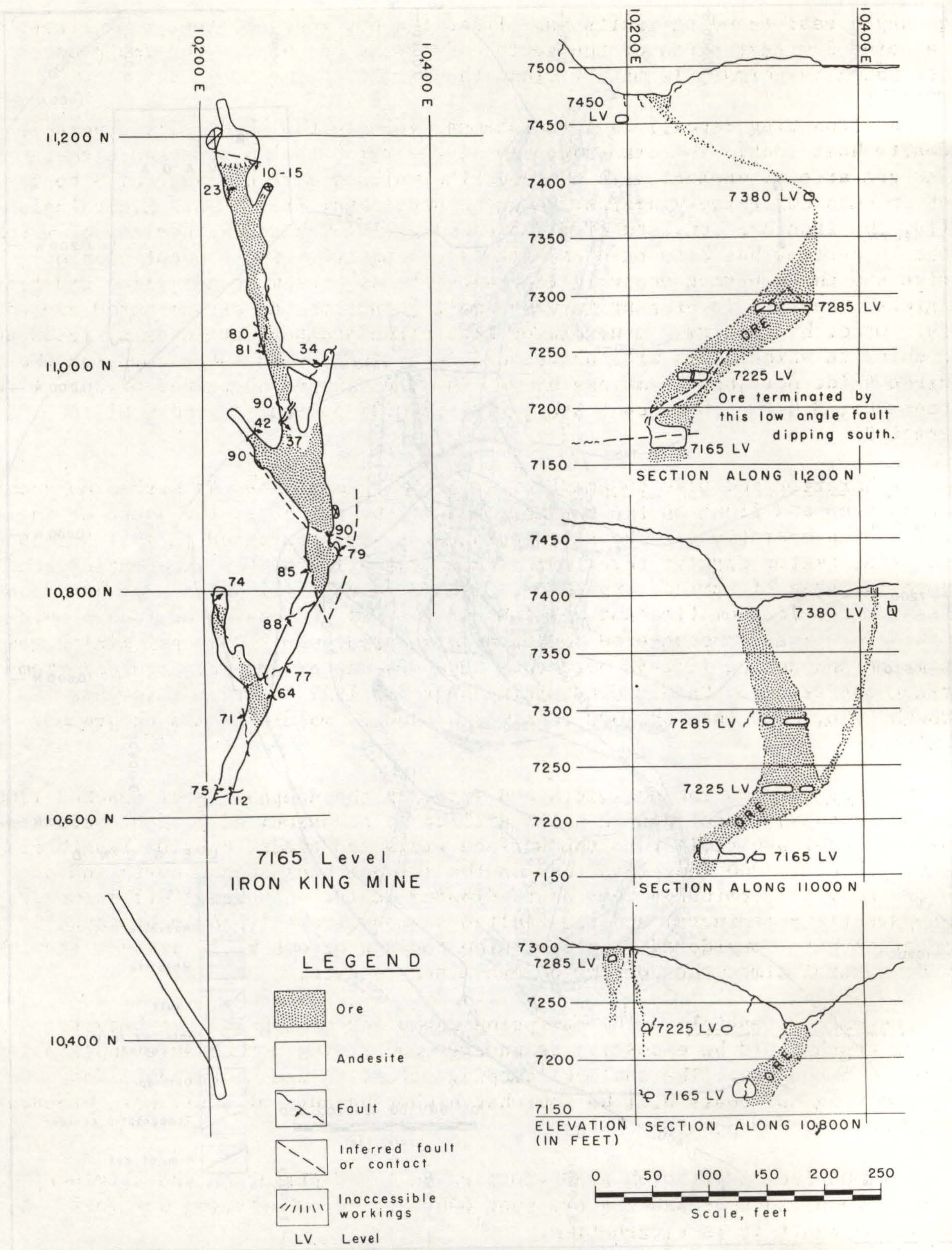


FIGURE 37. - Level Plan and Vertical Sections of Iron King Mine. (Adapted from maps by Donald Gene Fisher.)

high-angle east-trending faults has offset the ore zone 300 feet to the west at a point 300 feet north of the south end of the ore body. The fault movement, which is normal, is mainly along the strike.

The Iron King deposit is a replacement vein in the chemically favorable andesite host rock. The ore ranges in width from 0 to 125 feet and either makes gradational contact with the andesite walls over a distance of 3 to 5 feet or cuts off sharply against gouge in premineral fractures. Mineralogically, the iron ore consists of a dense equigranular black magnetite, of which about 10 percent has been oxidized to black hematite. Small quantities of pyrite and chalcopyrite occur in the magnetite as disseminated grains and tiny veinlets. Apatite is present in very small quantities as disseminated crystals. Other hydrothermal minerals or alteration products are quartz, feldspar, and chlorite which along with unreplaced inclusions of andesite comprise the noniron oxide portion of the ore body. The ore shipped contained 62.0 to 65.0 percent Fe, 3.0 to 5.0 percent SiO_2, 0.01 to 0.08 percent P, and 0.01 to 0.05 percent S.

Exploration and Development. - The Iron King ore body was marked by prominent outcrop and float on the northern end of the ore zone, the scene of the first mining operations. The surrounding area was prospected in 1951 and 1953 with magnetometer surveys that indicated an extension of the ore-bearing zone beyond the area of surface exposure. Eight diamond-drill holes were put down to test magnetic anomalies and sections of the ore body below surface showings of the ore. These encountered bodies of high-grade ore. Open pit mining was initiated and during 1952-58 more than 500,000 tons of ore was produced from surface operations. Underground mining began in 1959 and from this year through 1966, more than 680,000 tons was produced, mainly from underground workings.

Ore Reserves. - The ore-width and grade on the deepest level reached (300 feet below the surface) and in holes drilled to a maximum of 75 feet below the 300-foot level are similar to the surface width and grade, but the length of the ore shoot is 200 feet less than on the surface because the north end of the ore body is terminated by a south-dipping fault. However, this structure is apparently postmineral and the faulted segment probably could be found if production were considered feasible. The tonnage of ore below present stoping may be several times the tonnage of ore mined to date.

Economic Potential. - The stripping ratio for mining the ore body to greater depth would be excessive so underground mining methods are applicable for most of the ore. The sublevel stoping method in use is suitable for deeper mining but costs will be somewhat higher because of additional preparation, haulage, and pumping charges.

A 4,000-foot adit, with a 600-foot raise for ventilation and services, would be required to reach the ore zone 600 feet below existing workings. A production shaft is an alternative.

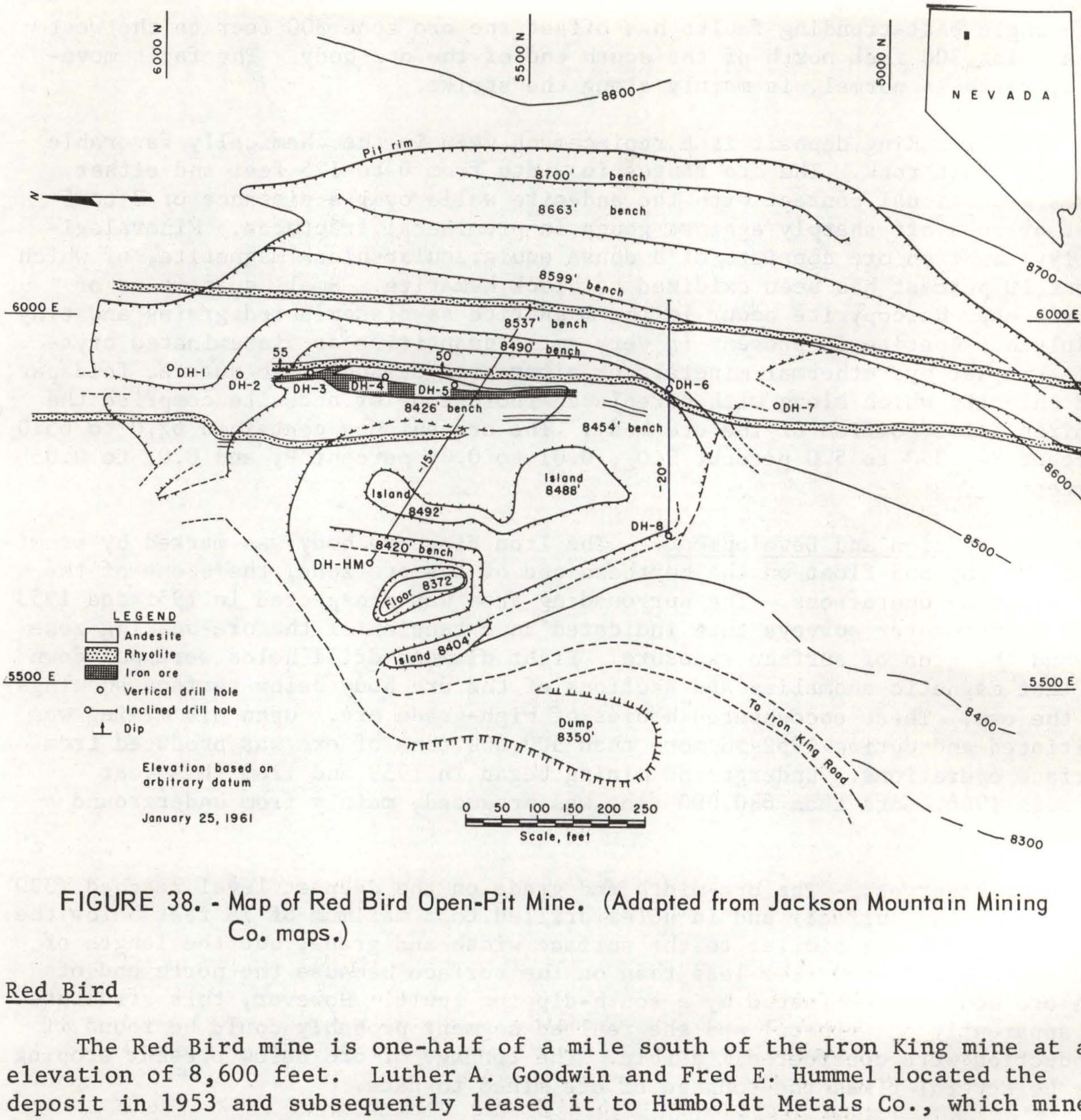


FIGURE 38. - Map of Red Bird Open-Pit Mine. (Adapted from Jackson Mountain Mining Co. maps.)

Red Bird

The Red Bird mine is one-half of a mile south of the Iron King mine at an elevation of 8,600 feet. Luther A. Goodwin and Fred E. Hummel located the deposit in 1953 and subsequently leased it to Humboldt Metals Co., which mined more than 120,000 tons of ore during 1956-61 (19, p. 83). Jackson Mountain Mining Co. produced from the mine in 1966.

The Red Bird ore body is apparently on the same north-trending fault zone as the Iron King deposit, and it has a similar geologic environment. The area is underlain by pre-Cretaceous andesite. Magnetite occurs in a steeply east-dipping fracture zone about 100 feet wide which has been developed for a length of 800 feet. The main ore body is about 400 feet long and 5 to 80 feet wide. Other smaller veins of magnetite also occur in the fracture zone (figs. 38 and 39).

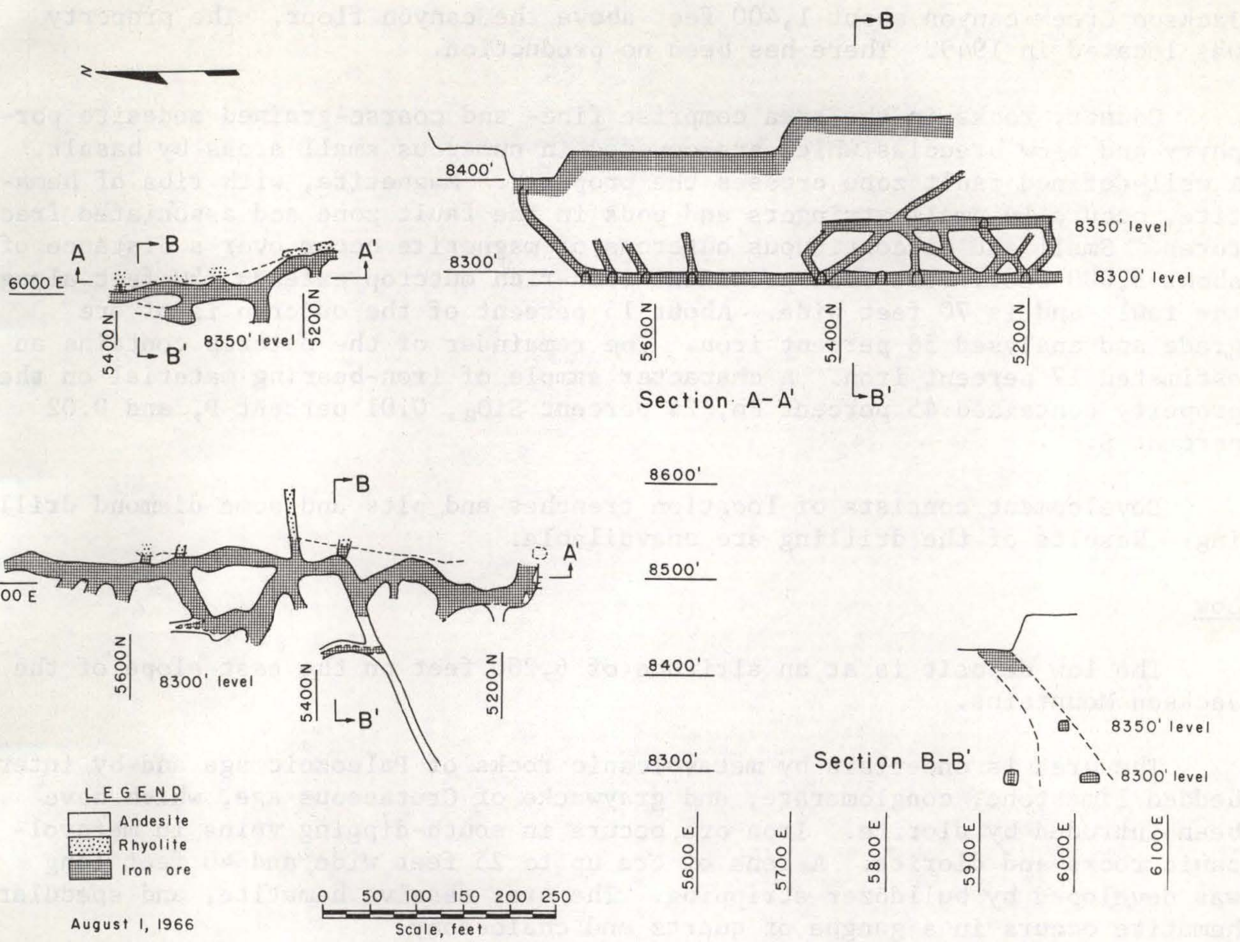


FIGURE 39. - Level Maps and Vertical Sections of Red Bird Mine. (Adapted from Jackson Mountain Mining Co. maps.)

Magnetite is confined mainly to veins. Steep-dipping postmineral east- and southeast-trending faults cut the ore bodies and offset them as much as 30 feet. The ore, except for slight oxidation, is massive magnetite, which was marketed as open-hearth lump ore. It contained 60.0 to 64.0 percent Fe, 3.0 to 5.0 percent SiO_2, 0.05 to 0.10 percent P, and 0.01 to 0.05 percent S. Ore was mined in an open pit during 1956-61. The 1966 production was made from a level 100 feet below the bottom of the pit. Underground mining methods became necessary because subsidence of unstable ground on a steep slope above the pit made further stripping impractical.

The Red Bird ore body continues below the lowest workings with no significant change in size or grade.

Iron King (Ben Jackson) Prospect

The Iron King prospect is 2 miles northwest of the Iron King mine. It is at an altitude of more than 8,000 feet on the west rim of the North Fork of

Jackson Creek canyon about 1,400 feet above the canyon floor. The property was located in 1949. There has been no production.

Country rocks in the area comprise fine- and coarse-grained andesite porphyry and flow breccias which are covered in numerous small areas by basalt. A well-defined fault zone crosses the property. Magnetite, with ribs of hematite, occurs in small stringers and pods in the fault zone and associated fractures. Small and discontinuous outcrops of magnetite occur over a distance of about 5,000 feet. The most prominent iron-rich outcrop extends 150 feet along the fault and is 70 feet wide. About 15 percent of the outcrop is of ore grade and analysed 58 percent iron. The remainder of the outcrop contains an estimated 17 percent iron. A character sample of iron-bearing material on the property contained 45 percent Fe, 24 percent SiO_2, 0.01 percent P, and 0.02 percent S.

Development consists of location trenches and pits and some diamond drilling. Results of the drilling are unavailable.

Low

The low deposit is at an altitude of 6,200 feet on the east slope of the Jackson Mountains.

The area is underlain by metavolcanic rocks of Paleozoic age and by interbedded limestone, conglomerate, and graywacke of Cretaceous age, which have been intruded by diorite. Iron ore occurs in south-dipping veins in metavolcanic rocks and diorite. A lens of ore up to 25 feet wide and 40 feet long was developed by bulldozer stripping. The ore, massive hematite, and specular hematite occurs in a gangue of quartz and chalcedony.

The deposit has been developed by more than 1,000 feet of bulldozer cuts and trenches and by diamond drilling. There has been no production.

McCoy Area

The McCoy area is in northwestern Lander County, 27 miles southwest of Battle Mountain, on the east slope of the Fish Creek Mountains at altitudes of 5,300 to 5,400 feet (fig. 40).

Iron-ore production began in 1943 and continued intermittently through 1966. Over 250,000 tons of direct-shipping ore was produced.

Magnetometer surveys of the area have failed to locate new deposits, and indicated reserves consist mainly of the downward continuations of partially mined ore bodies. Rapidly increasing stripping ratios with depth have made mining costs too high to permit production at 1967 prices. Increased prices might justify future production, but resources are limited.

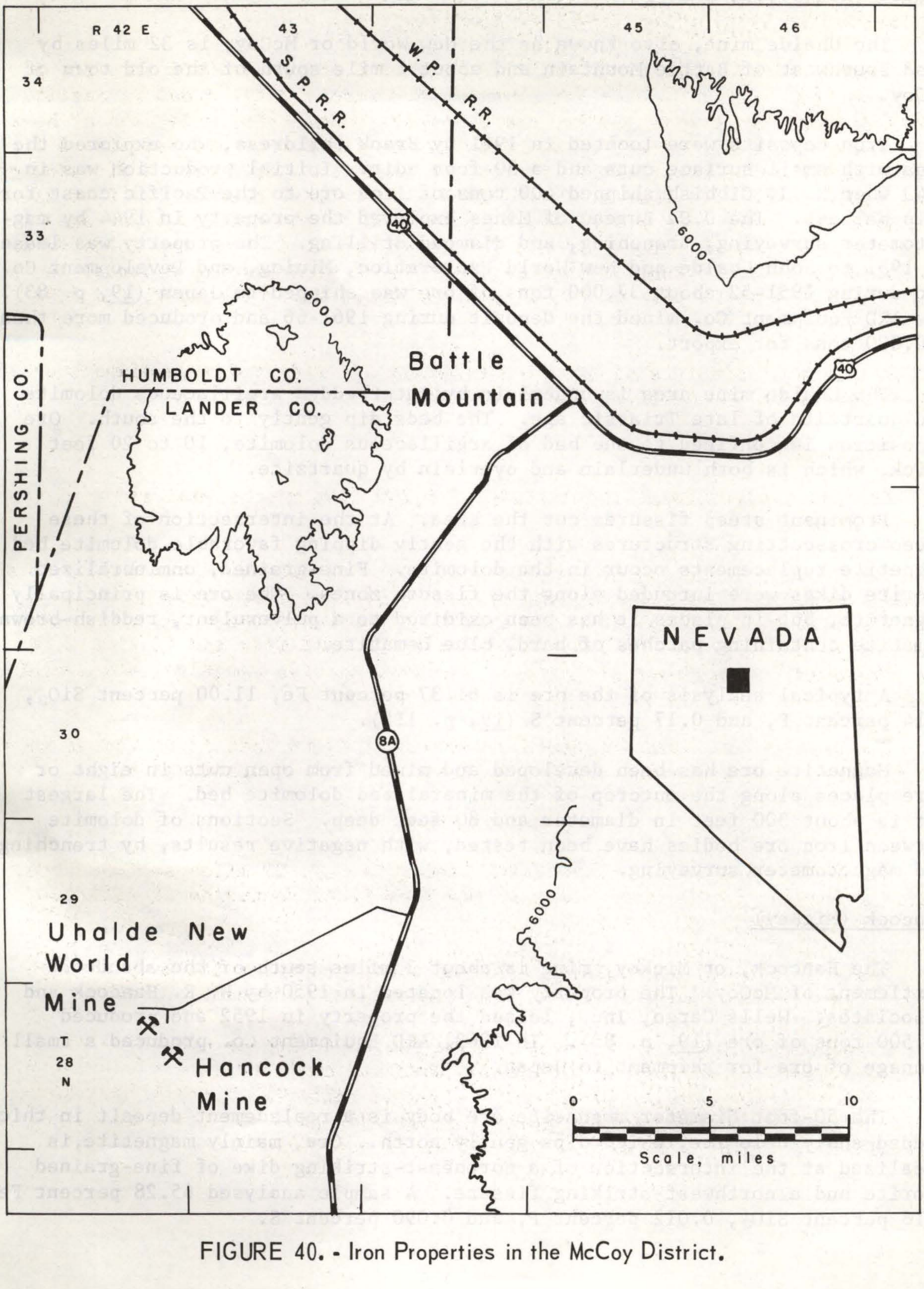


FIGURE 40. - Iron Properties in the McCoy District.

Uhalde (New World, McCoy)

The Uhalde mine, also known as the New World or McCoy, is 32 miles by road southwest of Battle Mountain and about 1 mile south of the old town of McCoy.

Iron deposits were located in 1941 by Frank Childress, who explored the area with small surface cuts and a 30-foot adit. Initial production was in 1943 when R. J. Gibbish shipped 400 tons of iron ore to the Pacific coast for ship ballast. The U.S. Bureau of Mines explored the property in 1944 by magnetometer surveying, trenching, and diamond drilling. The property was leased in 1951 to John Uhalde and New World Exploration, Mining, and Development Co.; and during 1951-52 about 37,000 tons of ore was shipped to Japan (19, p. 83). The ARD Equipment Co. mined the deposit during 1961-66 and produced more than 190,000 tons for export.

The Uhalde mine area is underlain by interbedded argillaceous dolomite and quartzite of late Triassic age. The beds dip gently to the south. Ore deposition is confined to one bed of argillaceous dolomite, 10 to 20 feet thick, which is both underlain and overlain by quartzite.

Prominent steep fissures cut the area. At the intersection of these steep crosscutting structures with the gently dipping favorable dolomite bed, magnetite replacements occur in the dolomite. Fine-grained, unmineralized diorite dikes were intruded along the fissure zones. The ore is principally magnetite, but in places it has been oxidized to a pulverulent, reddish-brown hematite containing patches of hard, blue hematite.

A typical analysis of the ore is 61.37 percent Fe, 11.00 percent SiO_2, 0.14 percent P, and 0.17 percent S (19, p. 115).

Magnetite ore has been developed and mined from open cuts in eight or more places along the outcrop of the mineralized dolomite bed. The largest pit is about 300 feet in diameter and 80 feet deep. Sections of dolomite between iron ore bodies have been tested, with negative results, by trenching and magnetometer surveying.

Hancock (Mickey)

The Hancock, or Mickey, mine is about 2 miles south of the abandoned settlement of McCoy. The property was located in 1950 by W. R. Hancock and associates. Wells Cargo, Inc., leased the property in 1952 and produced 17,500 tons of ore (19, p. 83). In 1963, ARD Equipment Co. produced a small tonnage of ore for shipment to Japan.

The 50-foot diameter magnetite ore body is a replacement deposit in thick-bedded shaly dolomite, which dips gently north. Ore, mainly magnetite, is localized at the intersection of a northeast-striking dike of fine-grained diorite and a northwest-striking fissure. A sample analysed 65.28 percent Fe, 2.18 percent SiO_2, 0.012 percent P, and 0.090 percent S.

An open pit about 80 feet in diameter and 50 feet deep was excavated on the deposit.

Palisade Area

The Palisade area in northern Eureka County comprises two districts: Barth, 6 miles west of Palisade, and Amarilla (Modarelli), 26 miles south of Palisade (fig. 41).

The Barth and Modarelli (originally called the Amarilla) mines both have made significant production, but the ores are high in phosphorus.

All economically significant ore bodies in the Palisade area are on the Barth and Modarelli properties. Total resources are estimated to be adequate for a plant producing 1 million tons of 64-percent iron pellets annually. The overall stripping ratio is estimated at 1.07:1.00.

The average concentrating ratio of Palisade ore is 1.6:1.0, and the overall stripping-to-product ratio is 1.7:1.0. These ratios are lower than at most operating plants. The factors that have limited production from these deposits are the long shipping distance from Palisade to California ports or steel centers (526 miles from Palisade to San Francisco) and the high phosphorus content of the ores. The ores have been blended with low phosphorus ores to yield a usable product, but large-scale utilization will not be achieved until an economic process has been perfected that will remove phosphorus from the concentrates.

The U.S. Bureau of Mines has studied ways to reduce the phosphorus in these ores. Preliminary tests (2) indicated that either flotation or leaching with hydrochloric or sulfuric acid could reduce the phosphorus content of Modarelli ore from 0.56 to 0.30 percent with a loss of about 5 percent of the iron concentrate. This phosphorus content is above present non-Bessemer specification of 0.18 percent P, but the lower content would simplify blending and allow the ores to be more fully utilized. The 1968 price of iron ore containing 0.30 percent phosphorus is about $0.40 per ton less than that of low-phosphorus ore.

Barth

Location, History, and Production. - The Barth mine is in northern Eureka County at an altitude of about 4,800 feet. The trackages of both the Southern Pacific and Western Pacific Railroads pass within 1,000 feet of the ore body, and a spur extends to the crushing and screening plant. The open pit mine is adjacent to the Humboldt River, which was diverted to allow surface mining operations. The land containing the Barth deposit was included in the grant to Central Pacific Railroad Co. to assist in construction of the first transcontinental railroad. This company and its corporate successor, Southern Pacific Co., have been the only owners of the property. During 1903-10 the mine was operated under a lease by American Smelting and Refining Co. and Produced 763,000 tons of ore. Its average grade was 56 percent Fe, 6 percent CaO, and 4.5 percent insoluble (owner's communication). No analysis of phosphorus

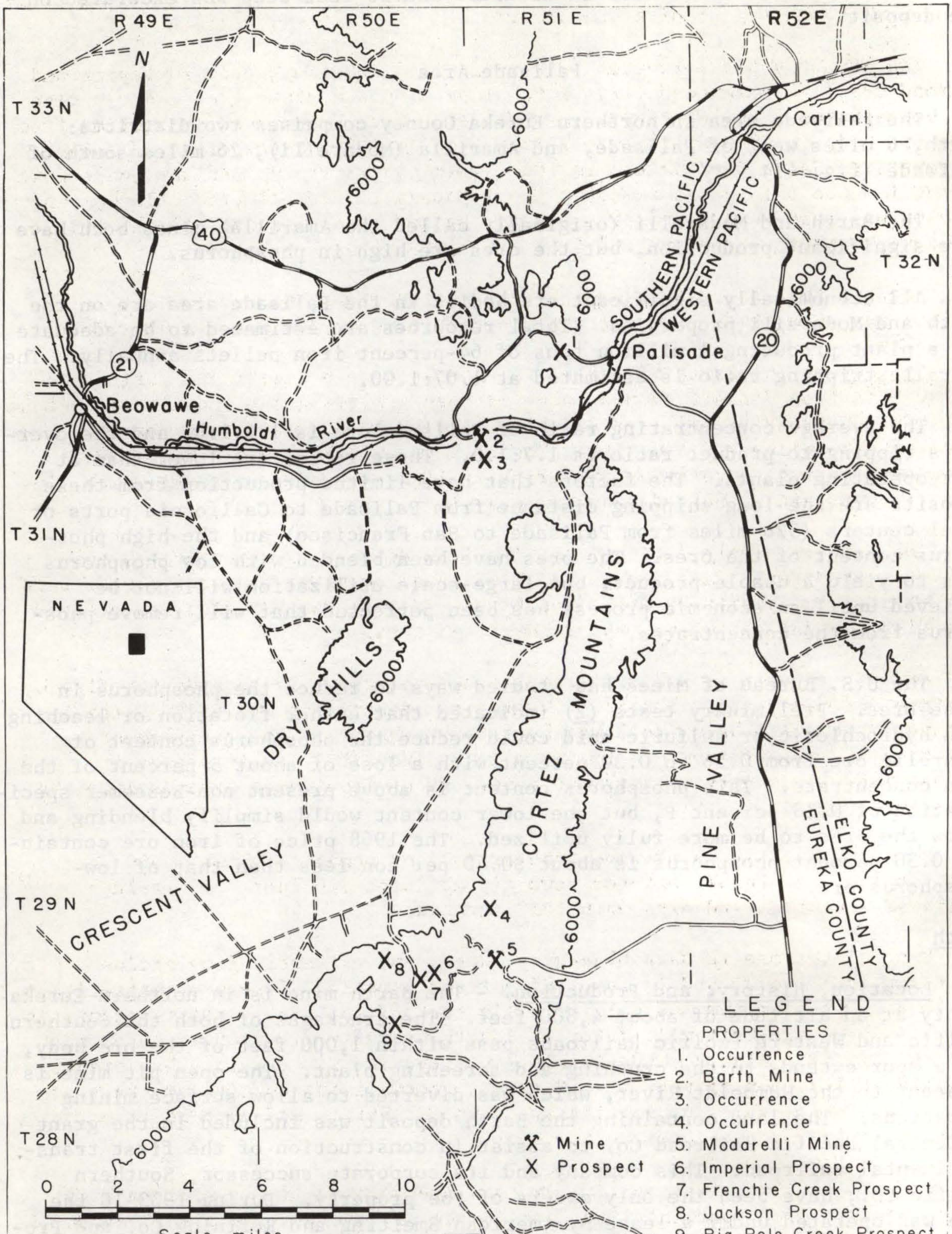


FIGURE 41. - Iron Properties in the Palisade Area.

or sulfur content is available. The ore was used as a flux for smelting siliceous nonferrous and precious metal ores.

The property was idle from 1910 until 1954, when magnetic surveying and diamond drilling disclosed large extensions of ore northwest of the old mine and beneath the Humboldt River. Nevada Barth Corp. commenced production from this ore body in 1960. All output from 1960 to 1966 was exported to Japan. Shipments to Japan were halted in 1967, when contracts expired and subsequent production was shipped to domestic steel companies. Total production during 1960-68 was more than 1.2 million tons. In addition, considerable quantities of high-phosphorus iron ore and iron ore fines were stockpiled.

Most of the information on geology, exploration, and development which follows was summarized from information furnished by Southern Pacific Co.

Geology. - The Barth mine area is underlain by andesite and latite flow rocks. The iron deposit occurs in a fractured, olive-green andesite flow that contains a network of dull-red hematite streaks and numerous pseudomorphs composed of serpentine and hematite. The rock is brittle and exhibits crude columnar jointing. Overlying this rock is light-lavender andesite which, in turn, is overlain by bedded sand and gravel.

The area is highly faulted, and the iron deposit is structurally controlled. Premineral fault gouge and kaolinization along fracture planes were instrumental in localizing ore deposition. Postmineral faulting has created some displacement throughout the mineralized area.

The ore deposit is a massive replacement of the olivine andesite flow by hematite and magnetite. Possibly the mineral deposition was in two stages with early hematite being followed by later magnetite. The replacement is selective and mainly confined to the olivine andesite, but in places it extends into the overlying rock and a network of iron veins extends into the andesite footwall.

The main deposit, a massive tabular body of hematite about 1,000 feet long and 140 feet thick, extends down dip at least 500 feet. It strikes northwest-southeast and dips about 45° northeast.

Most of the ore is dark blue-gray, hard, and extremely fine grained. It is called "steelrock" and is about 85 percent hematite, 5 percent magnetite, and 10 percent aluminum and calcium silicates and apatite. Apatite occurs as crystals about one-half millimeter in length unevenly distributed throughout the ore. It is a highly undesirable impurity, and its presence has greatly hampered utilization of the ore. Near the footwall the apatite crystals are larger, and small veins of apatite are common. Pyrite and pyrrhotite occur in places near the footwall of the ore body.

The ore is classified as lump or hard ore because of its uniform high grade (average 62-63 percent iron) and degree of hardness and also because it breaks into relatively large fragments when blasted and does not produce a high percentage of fines.

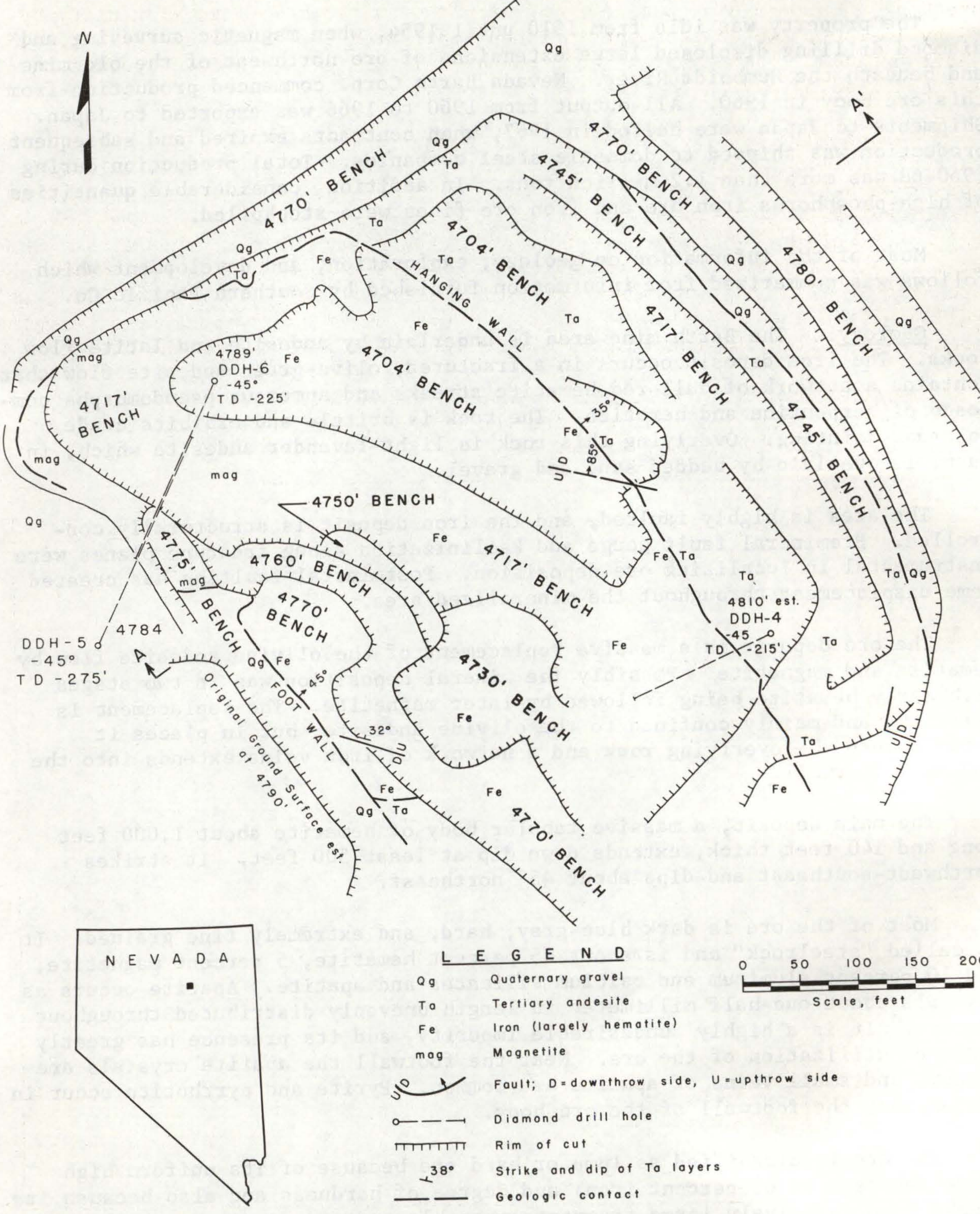


FIGURE 42. - Map of Barth Mine. (Adapted from Nevada Barth Co. map.)

<u>Exploration and Development</u>. - Initial production at the Barth mine came from a shallow open pit on the 100-foot-wide by 200-foot-long outcrop of the ore body. Later mining was done underground, by block caving, with entry by a 7- by 14-foot, two-compartment inclined shaft from the bottom of the pit. The shaft extended about 500 feet down the 45° dip of the ore body. Production was confined mainly to the area near the shaft.

Before 1912, American Smelting and Refining Co. churn-drilled three holes east of the mine. Results indicated that the outcropping ore body extended into that area and contained minable ore. In March 1954, Southern Pacific Co. discovered a large anomaly west of the old workings by means of a magnetic survey. Six holes were diamond-drilled by Southern Pacific Co. to test the anomaly. The drilling proved that the Barth ore body extends across the anomalous area and that in this area iron ore continued to a depth of at least 190 feet. Early in 1955 the deposit was leased to John M. Heizer and associates. Twelve holes were drilled by the lessees to more accurately delineate the ore body.

Nevada Barth Corp. obtained a sublease from John Heizer in 1960, diverted the Humboldt River to give access to the deposit, stripped the ore body, and commenced production (figs. 42 and 43).

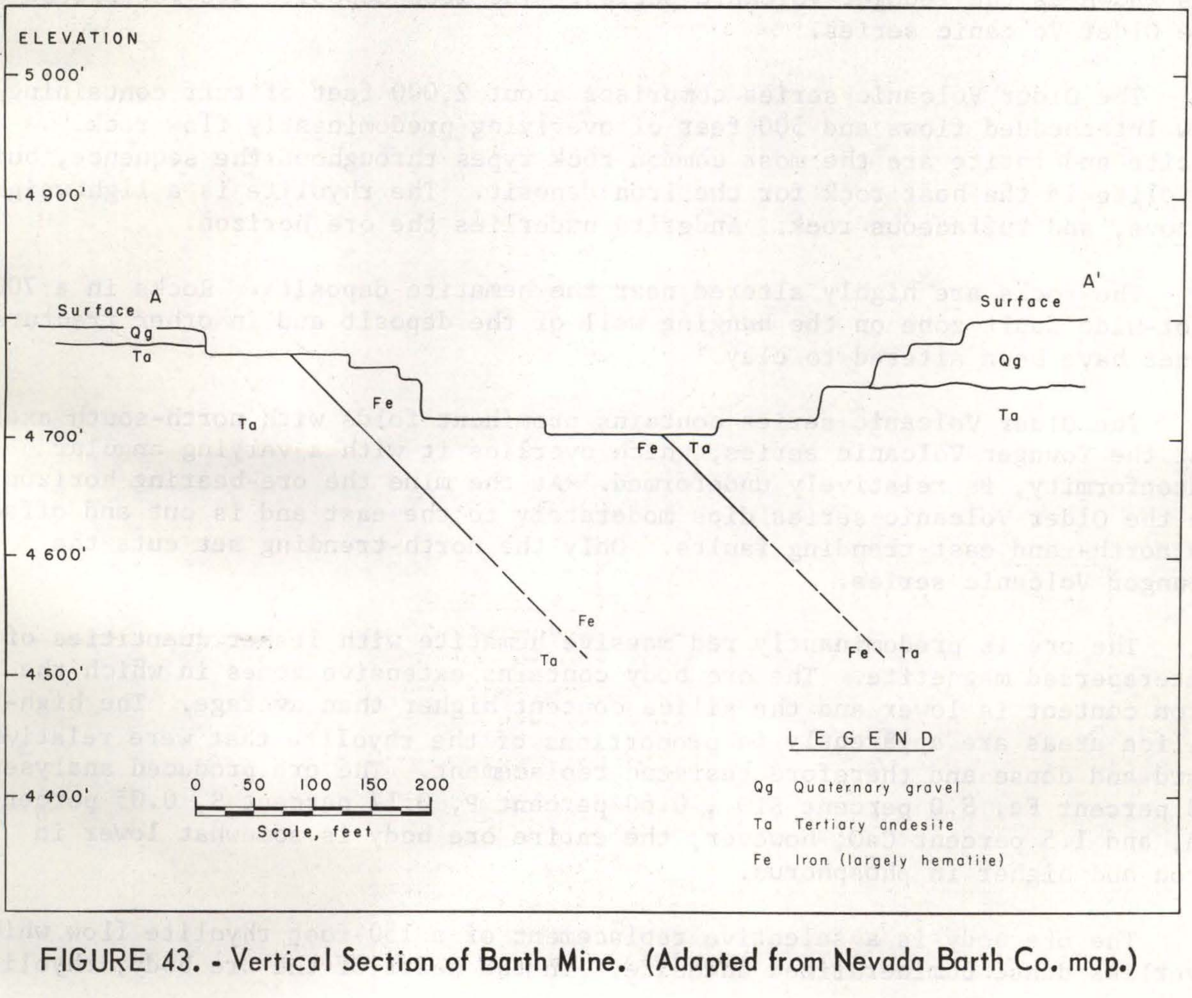


FIGURE 43. - Vertical Section of Barth Mine. (Adapted from Nevada Barth Co. map.)

Modarelli (Amarilla)

Location, History, and Production. - The Modarelli mine is 26 miles by road south of Palisade at an elevation of 6,600 feet.

The deposit was discovered in 1903 by Amos Plummer and located in 1905 by Mark L. Requa. The original seven claims were surveyed and patented in 1907. Following a long period of inactivity, the property was purchased by Nicolas Modarelli and Sons for delinquent taxes; and in 1951 it was leased to J. R. Simplot Co. by the Modarelli estate. An additional 36 claims were located by Simplot.

During 1951-59 nearly 400,000 tons of ore containing 58 percent iron was produced from the property.

Geology. - The following information was taken from published reports (11, 19) and from information furnished by the J. R. Simplot Co.

The Modarelli-Frenchie Creek area is underlain by volcanic rocks known as the Older Volcanic series and by an overlying unconformable series of volcanics known as the Younger Volcanic series. The iron deposits are restricted to the Older Volcanic series.

The Older Volcanic series comprises about 2,000 feet of tuff containing a few interbedded flows and 500 feet of overlying predominantly flow rock. Dacite and latite are the most common rock types throughout the sequence, but rhyolite is the host rock for the iron deposit. The rhyolite is a lightweight, porous, and tuffaceous rock. Andesite underlies the ore horizon.

The rocks are highly altered near the hematite deposits. Rocks in a 700-foot-wide fault zone on the hanging wall of the deposit and in other fracture zones have been altered to clay.

The Older Volcanic series contains prominent folds with north-south axes, but the Younger Volcanic series, which overlies it with a varying angular unconformity, is relatively undeformed. At the mine the ore-bearing horizon in the Older Volcanic series dips moderately to the east and is cut and offset by north- and east-trending faults. Only the north-trending set cuts the Younger Volcanic series.

The ore is predominantly red massive hematite with lesser quantities of interspersed magnetite. The ore body contains extensive zones in which the iron content is lower and the silica content higher than average. The high-silica areas are apparently in proportions of the rhyolite that were relatively hard and dense and therefore resisted replacement. The ore produced analysed 58 percent Fe, 8.0 percent SiO_2, 0.60 percent P, 0.12 percent S, 0.05 percent Mn, and 1.5 percent CaO; however, the entire ore body is somewhat lower in iron and higher in phosphorus.

The ore body is a selective replacement of a 150-foot rhyolite flow which overlies dense unmineralized andesite. In the heart of the ore body, rhyolite

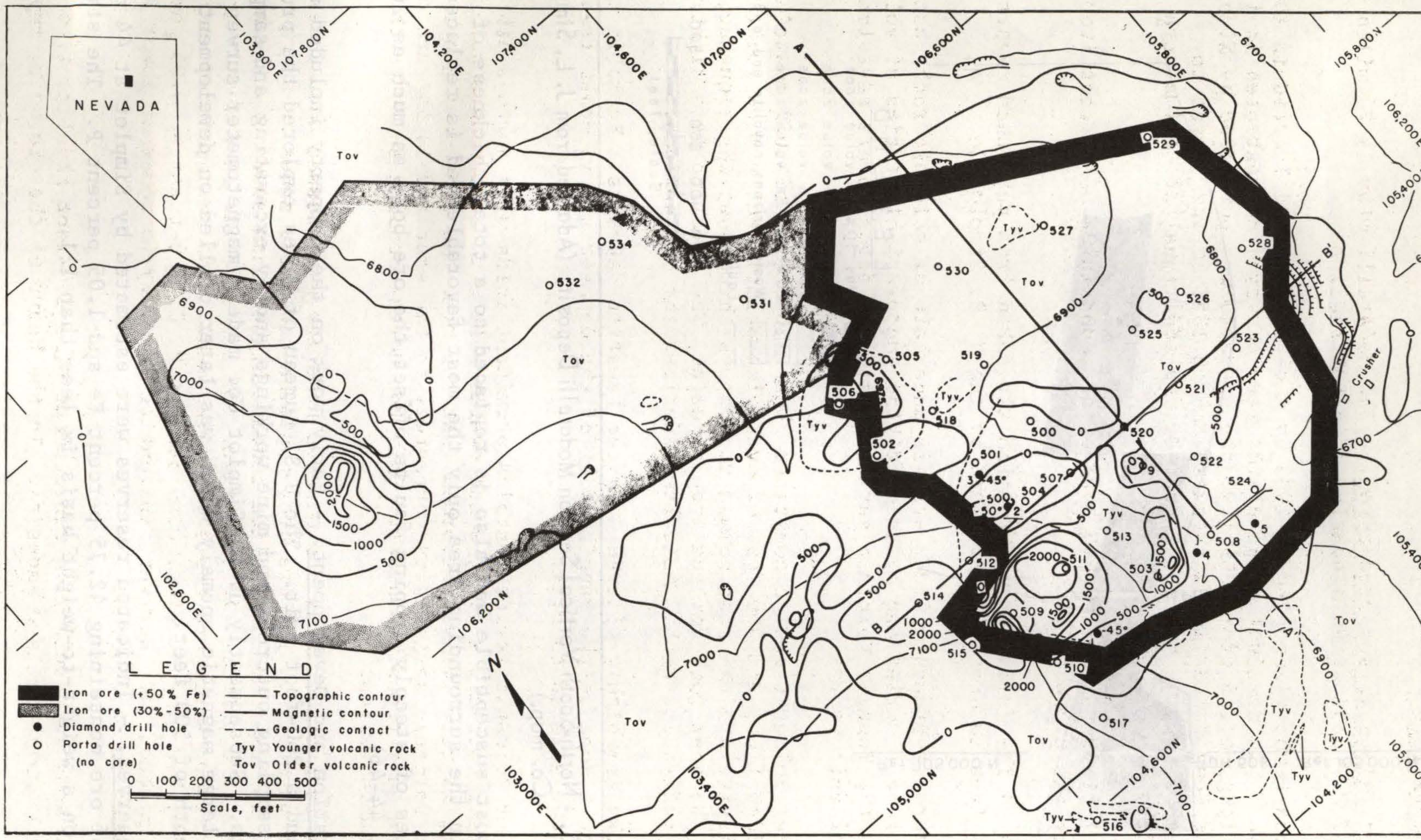


FIGURE 44. - Map of Modarelli Deposit. (Adapted from J. L. Simplot Co. map.)

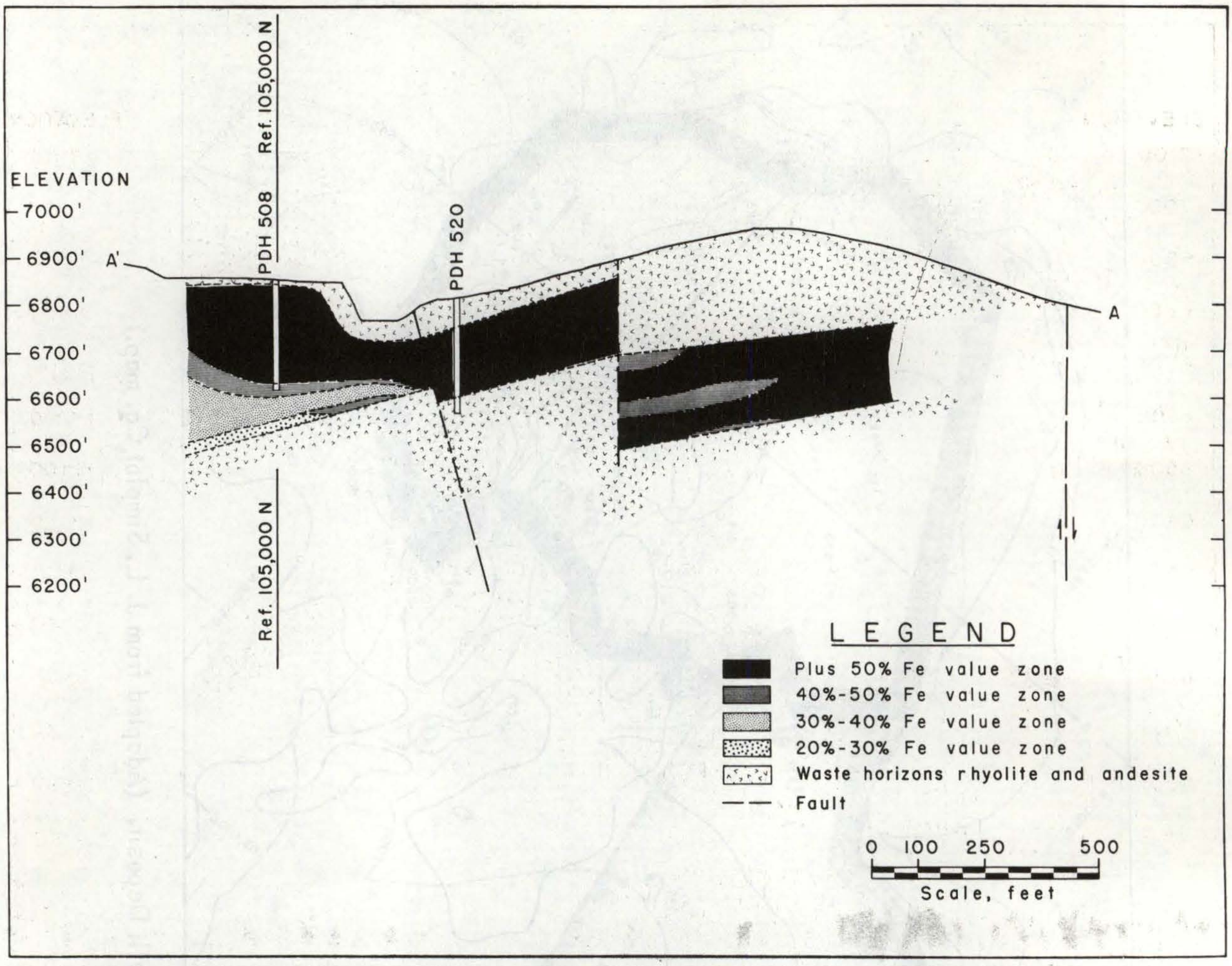


FIGURE 45. - North-South Vertical Section Modarelli Deposit. (Adapted from J. L. Simplot Co. map.)

above the most susceptible bed also is replaced to a total thickness of 350 feet; but in the surrounding area only the most favorable bed is replaced.

A series of steeply dipping faults offset the ore body as much as 200 feet (figs. 44-46).

Exploration and Development. - Early work on the property included several pits and a 260-foot adit. The U.S. Bureau of Mines explored the property in 1945 by sampling outcrops and mine workings and by excavating and sampling 77 test pits. Subsequently J. R. Simplot Co. made a magnetometer survey and outlined a large magnetic anomaly which was later drilled on development spacing to a depth of 500 feet.

Ore Reserves. - Indicated reserves were estimated by Simplot at 44 million tons of ore containing 42.75 percent Fe and 1.05 percent P. The stripping ratio on a weight-to-weight basis is less than 1:1.

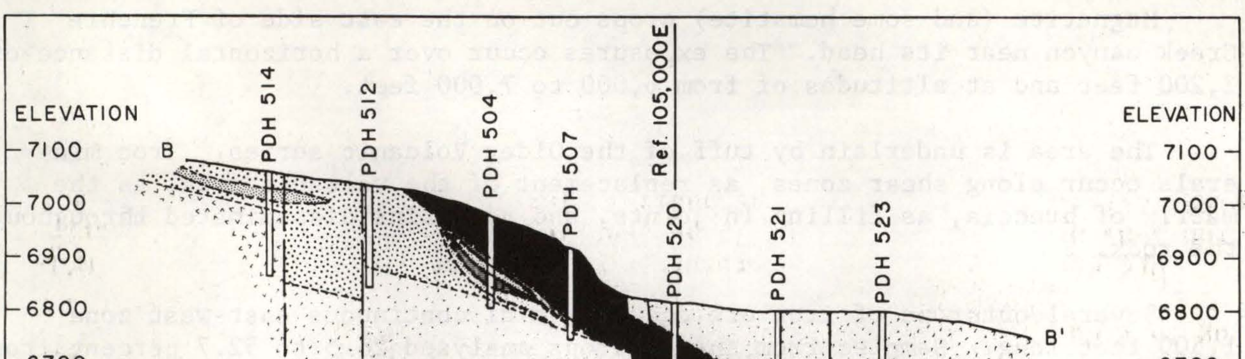


FIGURE 46. - East-West Vertical Section Modarelli Deposit. (Adapted from J. L. Simplot Co. map.)

Big Pole Creek

The Big Pole Creek deposit is on the divide between Big Pole and Frenchie Creeks at an altitude of 7,500 feet, southwest of the Modarelli mine. The prospect is controlled by J. R. Simplot Co.

The deposit consists of several closely spaced parallel veins of magnetite and hematite in tuff of the Older Volcanic series. The largest ore body is about 20 feet wide and 300 feet long. Magnetometer surveys indicate the iron deposit is confined to a zone about 600 feet long and from 30 to 100 feet wide.

Frenchie Creek

The Frenchie Creek prospect is about 2 miles west of the Modarelli mine and separated from it by a 1,500-foot-high ridge.

Magnetite (and some hematite) crops out on the east side of Frenchie Creek canyon near its head. The exposures occur over a horizontal distance of 2,200 feet and at altitudes of from 6,000 to 7,000 feet.

The area is underlain by tuff of the Older Volcanic series. Iron minerals occur along shear zones, as replacement of the volcanic rock, as the matrix of breccia, as filling in joints, and as grains disseminated throughout the rock.

Several outcrops of iron ore occur in a discontinuous east-west zone 1,500 feet long. Samples from the outcrops analysed 28.5 to 52.7 percent iron. Surrounding these outcrops are mineralized areas containing 5 to 10 percent iron.

Development consists of magnetometer surveys, trenches, and a 100-foot adit.

Imperial

The Imperial prospect is about one-quarter of a mile north of the Frenchie Creek prospect.

Dark blue hematite and magnetite occur along a nearly vertical shear zone, as the matrix of andesite breccia and as replacement of the volcanic wallrock. Ore crops out over an area of about 400 square feet. A small area of low-grade iron bearing andesite surrounds the outcrop.

The property has been explored by trenches and one drill hole.

Jackson

The Jackson prospect is on the west side of Frenchie Creek canyon about 1 mile west of the Frenchie Creek prospect.

Hematite and magnetite occur as a replacement of tuff of the Older Volcanic series along a north-trending shear zone. The replaced zone, which has been developed over a length of 200 feet, is about 120 feet wide. The magnetite and hematite replacement is concentrated in narrow layers of the tuff.

Pumpkin Hollow Area

The Pumpkin Hollow deposit is 8 airline miles southeast of Yerington at an altitude of 4,900 feet (fig. 47).

The United States Steel Corp. located more than 180 claims in the area following the discovery in 1960 of a large magnetic anomaly by means of aeromagnetic exploration. Subsequently, the company did considerable drilling and other exploration. In 1969 U.S. Steel applied for mineral patents on claims covering portions of the anomaly reported to contain 250 million tons of ore grading somewhat under 40 percent iron and about 0.3 percent copper. Ore was stated to occur in four separate bodies, three of which were amenable to open

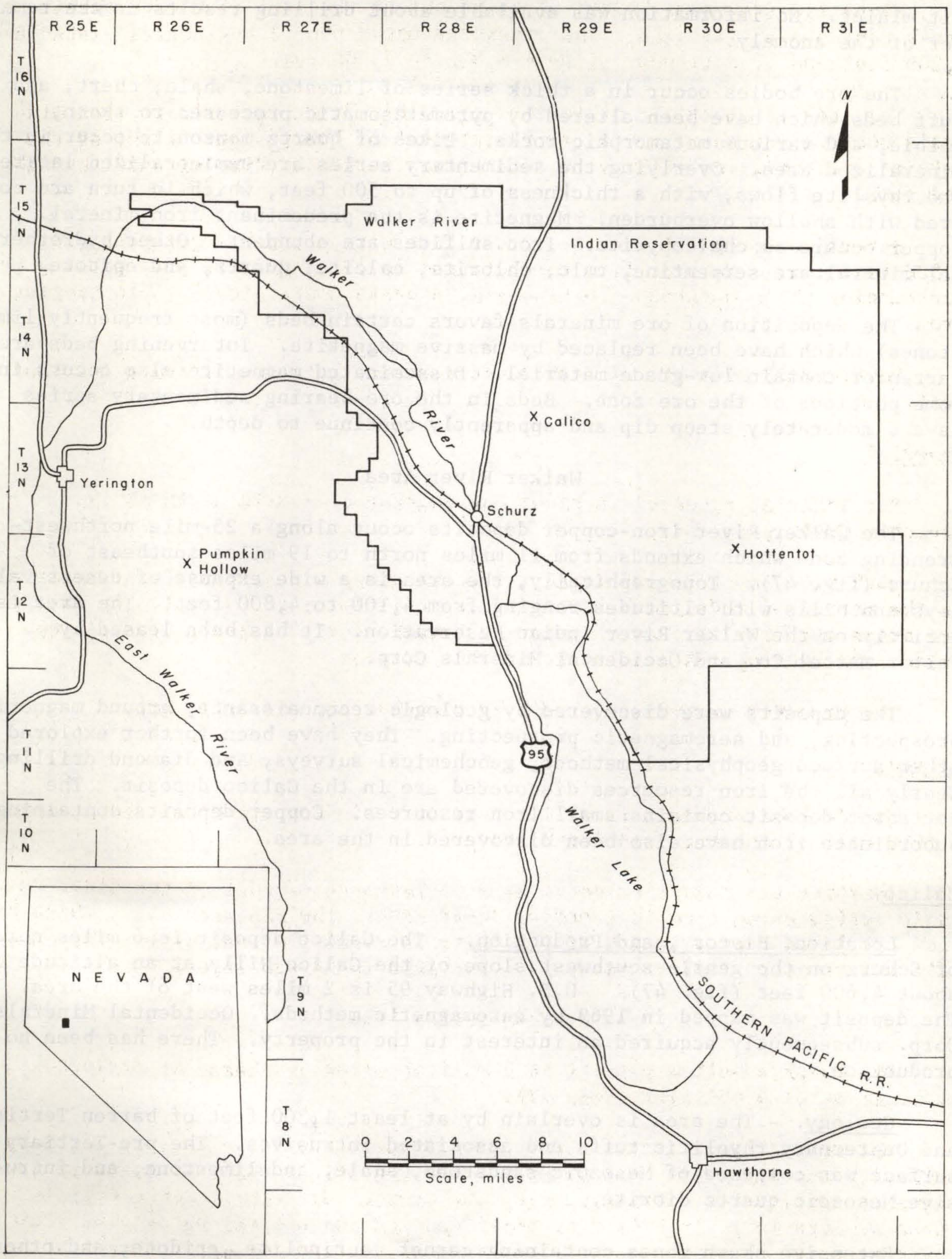


FIGURE 47. - Pumpkin Hollow and Walker River Areas. (Adapted from report by Edmond F. Lawrence and Robert L. Redmond, pres. at SME fall meeting 1967.)

pit mining. No information was available about drilling results in the remainder of the anomaly.

The ore bodies occur in a thick series of limestone, shale, chert, and tuff beds which have been altered by pyrometasomatic processes to skarn, marble, and various metamorphic rocks. Dikes of quartz monzonite occur in the mineralized area. Overlying the sedimentary series are unmineralized latite and rhyolite flows, with a thickness of up to 500 feet, which in turn are covered with shallow overburden. Magnetite is the predominant iron mineral. Copper occurs as chalcopyrite. Iron sulfides are abundant. Other hydrothermal mineral are serpentine, talc, chlorite, calcite, quartz, and epidote.

The deposition of ore minerals favors certain beds (most frequently limestones) which have been replaced by massive magnetite. Intervening beds are barren or contain low-grade material. Disseminated magnetite also occurs in some portions of the ore zone. Beds in the ore-bearing sedimentary series have a moderately steep dip and apparently continue to depth.

Walker River Area

The Walker River iron-copper deposits occur along a 25-mile northwest-trending zone which extends from 11 miles north to 19 miles southeast of Schurz (fig. 47). Topographically, the area is a wide expanse of desert valleys and hills with altitudes ranging from 4,100 to 4,800 feet. The area is entirely on the Walker River Indian Reservation. It has been leased by Walter Martel Co. and Occidental Minerals Corp.

The deposits were discovered by geologic reconnaissance, ground magnetic prospecting, and aeromagnetic prospecting. They have been further explored by other surface geophysical methods, geochemical surveys, and diamond drilling. Nearly all the iron resources discovered are in the Calico deposit. The Hottentot deposit contains small iron resources. Copper deposits containing subordinate iron have also been discovered in the area.

Calico

Location, History, and Production. - The Calico deposit is 6 miles north of Schurz on the gentle southwest slope of the Calico Hills at an altitude of about 4,600 feet (fig. 47). U.S. Highway 95 is 2 miles west of the area. The deposit was mapped in 1963 by aeromagnetic methods. Occidental Minerals Corp. subsequently acquired an interest in the property. There has been no production.

Geology. - The area is overlain by at least 1,300 feet of barren Tertiary and Quaternary rhyolitic tuffs and associated intrusives. The pre-Tertiary surface was composed of Mesozoic sandstone, shale, and limestone, and intrusive Mesozoic quartz diorite.

Extensive skarn zones containing garnet, actinolite, epidote, and other contact minerals developed in the sediments at their intrusive contacts. Large quantities of magnetite and notable quantities of pyrite, pyrrhotite, and chalcopyrite occur in the contact zones.

The deposit is adjacent to a northwest-trending fault zone which has a large lateral movement. Small faults parallel to this zone cut the ore deposit but show only minor horizontal displacements. Small northeast-trending faults also cut the deposit.

Drill holes in the contact zones intersected thicknesses of 1,210 to 2,325 feet of magnetite and chalcopyrite-bearing material containing an average of 24.5 percent iron and 0.076 percent copper. The holes were bottomed in material containing from 14 to 23 percent iron and 0.05 to 0.17 percent copper. Wall rocks are mainly skarn, hornfels, and quartz diorite.

Exploration and Development. - Following the aeromagnetic survey of the Calico magnetic anomaly a ground magnetometer survey was made. Observations were taken at intervals of 25 to 200 feet along northeast-southwest lines that were spaced from 100 to 750 feet apart. The ground survey outlined an area 6,000 feet long and 1,900 feet wide in which the magnetic intensity was more than 2,200 gammas. The maximum intensity was 3,400 gammas (fig. 48).

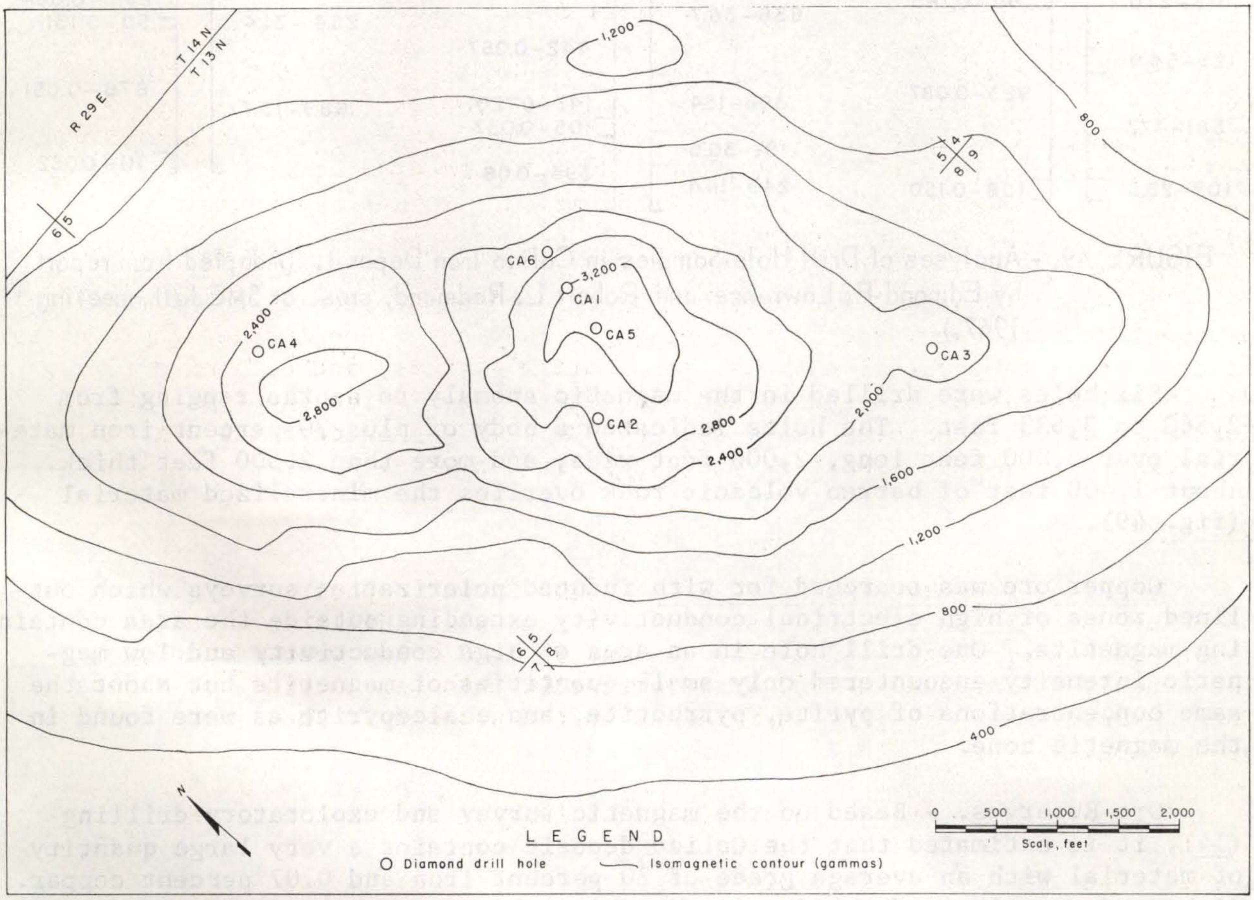


FIGURE 48. - Calico Magnetic Anomaly and Drill Hole Locations. (Adapted from report by Edmond F. Lawrence and Robert L. Redmond, pres. at SME fall meeting 1967.)

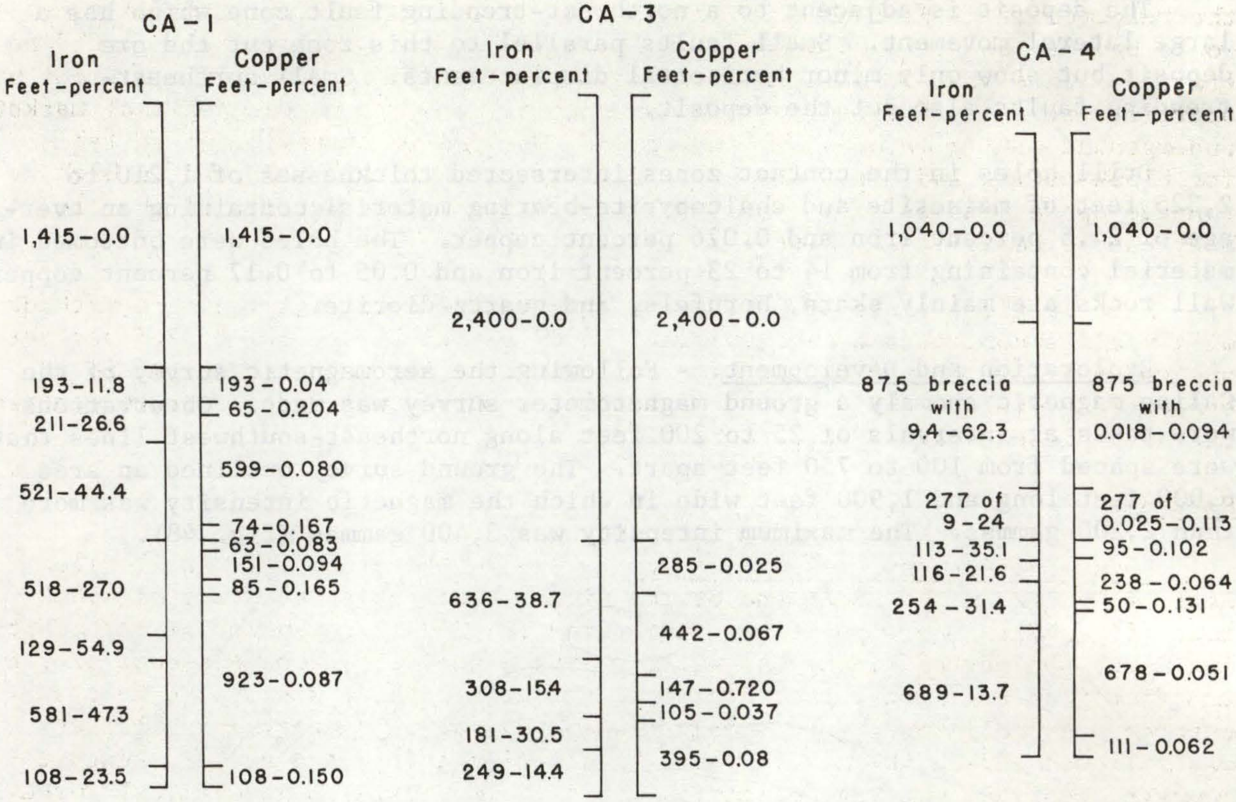


FIGURE 49. - Analyses of Drill Hole Samples in Calico Iron Deposit. (Adapted from report by Edmond F. Lawrence and Robert L. Redmond, pres. at SME fall meeting 1967.)

Six holes were drilled in the magnetic anomaly to depths ranging from 2,560 to 3,633 feet. The holes indicated a body of plus-20-percent iron material over 5,000 feet long, 2,000 feet wide, and more than 2,500 feet thick. About 1,400 feet of barren volcanic rock overlies the mineralized material (fig. 49).

Copper ore was searched for with induced polarization surveys which outlined zones of high electrical conductivity extending outside the area containing magnetite. One drill hole in an area of high conductivity and low magnetic intensity encountered only small quantities of magnetite but about the same concentrations of pyrite, pyrrhotite, and chalcopyrite as were found in the magnetic zone.

Ore Reserves. - Based on the magnetic survey and exploratory drilling (14), it is estimated that the Calico deposit contains a very large quantity of material with an average grade of 20 percent iron and 0.07 percent copper. High-grade portions of the deposit contain a large tonnage of ore with an average grade of 44 percent iron.

Economic Potential. - Open pit mining operations would be uneconomic because of the thick capping of barren rock. The overall stripping ratio for the resource of 20 percent iron is 3.5:1.0. About 900 million tons of rock would have to be stripped before large-scale open pit ore production could be started. This would entail an enormous capital expenditure which could not be amortized at the indicated consumption rate of iron ore in the regional market. Underground mining methods are indicated. The ore is stated to be suitable for block-caving and costs should be similar to those now achieved in high-tonnage operations of this type. Only the higher grade portion of the ore body can be economically mined.

Metallurgical tests on drill-core samples indicate that magnetic methods will yield a concentrate containing 62 to 69 percent iron, 1.9 to 2.5 percent sulfur, and less than 0.02 percent copper. Flotation methods will yield a concentrate yielding 65.3 percent iron plus a bulk sulfide concentrate containing 12.6 percent copper (14, p. 8).

Hottentot

Location, History, and Production. - The Hottentot deposit is 12 miles east of Schurz on the north end of the Gillis Range at an altitude of 4,800 feet (fig. 47). The deposit was discovered in 1963 by personnel of Idaho Mining Corp. and Martel Mining Co. while making a geologic reconnaissance of the area for iron and iron-copper deposits. Magnetite float was traced to a small outcrop. A preliminary ground magnetic survey gave encouraging results and was followed during the next 2 years by detailed ground and aerial magnetic surveys, geologic mapping, electrical resistivity surveys, geochemical surveys, and diamond drilling. An interest in the property was subsequently acquired by Occidental Minerals Corp. There has been no production.

Geology. - The area is composed principally of Tertiary and Quaternary flows and tuffs and of basaltic and andesitic intrusions. A few small areas of Mesozoic diorite and metamorphosed Mesozoic sediments crop out.

The deposit occurs adjacent to a strong northwest-trending fault zone, which shows a displacement along the strike of over 2,000 feet. Many small north-striking and east-striking faults also cut the mineralized area.

Magnetite, partially oxidized to hematite, occurs in pods and lenses in the diorite. Small amounts of pyrite, actinolite, chlorite, quartz, and calcite are present. Walls are silicified fine-grained diorite.

Exploration and Development. - A detailed ground magnetometer survey was made over an area that extends about 1 mile north-south and 1.5 miles east-west. An extensive aeromagnetic survey was made of the same area and the surrounding land. Three anomalies were delineated with areas of 30, 2, and 0.5 acres and intensities of 2,000, 4,000, and 3,000 gammas, respectively. Self-potential and resistivity surveys also were conducted over the area, but no nonmagnetic anomalies were found. A hole drilled in the 2,000-gamma anomaly intersected an ore zone 32 feet thick containing about 50 percent iron ore at a depth of 713 feet. Holes drilled in the 4,000- and 3,000-gamma anomalies intersected from 63 to 177 feet of ore averaging 50 to 58 percent iron at depths of 41 to 177 feet (15).

Miscellaneous Occurrences by County

The following iron occurrences, on which some development was done but from which little or no production was made, are listed by counties. No significant resources have been developed in them and their combined production potential is small. The location of each occurrence is shown in figure 20. Occurrences in western Nevada are also shown in figure 21.

Douglas County

Iron Butte

The Iron Butte deposit is in Brunswick Canyon, 14 miles by road southeast of Carson City.

Small magnetite bodies occur in diorite schist along a fissure that dips steeply to the south.

Three mineralized lenses, from 15 to 50 feet long and 6 to 12 feet wide, occur over a length of 250 feet.

Elko County

Iron Hood (Hogle)

The Iron Hood or Hogle deposit is about 31 miles northwest of Elko at an altitude of 7,000 feet (fig. 50). The property consists of 14 claims owned by J. A. Hogle Co. and leased to Albert Huber and Associates. The area has been intensively prospected for copper.

A surface cut and stripping exposed garnet skarn and magnetite over a length of 600 feet and a width of 15 to 40 feet. Several massive magnetite bodies, 600 to 2,000 square feet in area, occur in the skarn. Garnet and magnetite have replaced gray silicious dolomite along its contact with a large granodiorite intrusive. The magnetite bodies are localized by steeply northwest-dipping fractures. The contact and the skarn and magnetite body trend northwest by west. The dip of the contact and the attitude of the limestone bedding are obscured by overburden.

Magnetite is the predominant iron mineral. It occurs massively in small replacements and in grains disseminated throughout portions of the garnet skarn. Iron outcrops show heavy copper staining. An analysis of the massive iron ore is 65.00 percent Fe, 3.75 percent SiO_2, 0.15 percent P, and 0.020 percent S.

A magnetometer survey of the area indicated the presence of a compact, fairly uniform zone of magnetite surrounding the open cut. Other small magnetic anomalies exist along the extensive dolomite-granodiorite contact but have not been developed.

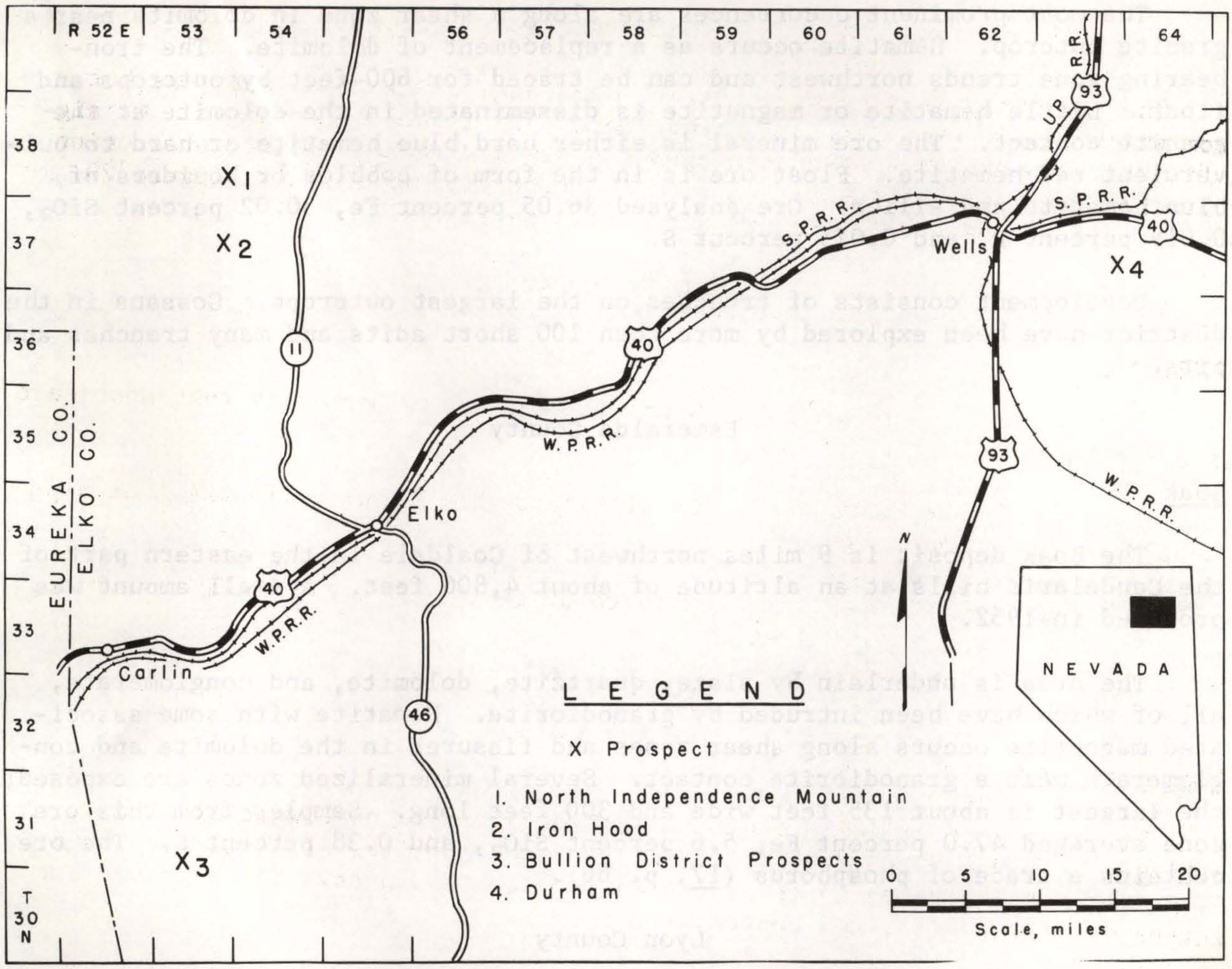


FIGURE 50. - Iron Properties in Elko County.

North Independence Mountain

The North Independence Mountain prospect is on the top of two ridges about 33 miles by road northwest of Elko (fig. 50). Both ridges are underlain by prominently bedded silicious dolomite, which has been folded into a northwest-trending anticline.

Hematite float and small outcrops of hematite are traceable for 1,000 feet in a northeast direction. The hematite is somewhat cellular but strong enough to form lump ore. Development consists of several bulldozer trenches.

Railroad (Bullion) District

The Railroad or Bullion district is 32 miles by road southwest of Elko (fig. 50). The district produced gold, silver, copper, lead, and zinc valued at more than $1.7 million during 1869-1956. The iron occurrences are three-quarters of a mile west of the precious and nonferrous metal area at an altitude of 7,300 feet.

The most prominent occurrences are along a shear zone in dolomite near a granite outcrop. Hematite occurs as a replacement of dolomite. The iron-bearing zone trends northwest and can be traced for 600 feet by outcrops and float. Little hematite or magnetite is disseminated in the dolomite at the granite contact. The ore mineral is either hard blue hematite or hard to pulverulent red hematite. Float ore is in the form of cobbles or boulders of blue hematite and silica. Ore analysed 36.05 percent Fe, 30.02 percent SiO_2, 0.019 percent P, and 0.075 percent S.

Development consists of trenches on the largest outcrops. Gossans in the district have been explored by more than 100 short adits and many trenches and pits.

Esmeralda County

Boak

The Boak deposit is 9 miles northwest of Coaldale in the eastern part of the Candelaria hills at an altitude of about 4,800 feet. A small amount was produced in 1952.

The area is underlain by slate, quartzite, dolomite, and conglomerate, all of which have been intruded by granodiorite. Hematite with some associated magnetite occurs along shear zones and fissures in the dolomite and conglomerate near a granodiorite contact. Several mineralized zones are exposed; the largest is about 135 feet wide and 300 feet long. Samples from this ore zone averaged 47.0 percent Fe, 5.6 percent SiO_2, and 0.38 percent S. The ore contains a trace of phosphorus (17, p. 66).

Lyon County

Owen

The Owen prospect is 25 miles by road south of Yerington at an altitude of about 5,500 feet.

A shallow open pit has exposed hard blue hematite with minor magnetite in a fissure zone over a length of 200 feet and a width of 40 feet. The fissure zone dips moderately to the northwest. Walls consist of fine-grained volcanic rock.

Northwest of the pit a cut was made on a 7-foot-wide vein of hematite and magnetite that dips steeply to the southeast.

About 300 tons of broken hematite ore with an average grade of 40 percent iron is in the bottom of the pit.

Mineral County

Black Butte

The Black Butte prospect is at an altitude of 7,100 feet at the southeast end of the Gillis Range, 12 miles northwest of Luning.

Iron minerals occur in limestone of the Luning formation near a granitic intrusion. Low-grade magnetite reportedly occurs in large skarn bodies. A mineralized zone, 600 feet long, is reported to contain 40 percent iron over a sampled width of 40 feet.

Black Horse

The Black Horse property is at the southeast end of the Gillis Range at an altitude of about 7,000 feet.

Magnetite occurs in a skarn zone in limestone near its contact with quartz monzonite. Stripping has exposed a body of magnetite 250 feet long and 11 feet wide.

Iron Butte

The Iron Butte mine is on the northeast side of the Gabbs Valley Range at an altitude of 7,800 feet. Small quantities of ore were produced in 1952 and during 1960-62.

Iron ore occurs in a 300-foot-wide vertical limestone remnant of the Luning formation. Granite surrounds the limestone. The ore body is apparently a selective replacement of a favorable bed along a bedding fissure near the granite contact. The ore zone is traceable for 500 feet and ranges in width from 10 to 40 feet. The western 200 feet of the zone is about 40 feet wide and contains magnetite-hematite ore with a grade of 58.8 percent iron. The remainder of the zone narrows appreciably and consists of veinlets and pods of intermixed magnetite and tactite. Skarn minerals have been developed in the limestone between the ore horizon and the granite; other irregular bodies of skarn occur along the contact. Small pods of chalcopyrite, partly oxidized to malachite and azurite, occur along a fault in the limestone inclusion.

Iron Crown

The Iron Crown prospect is at the southeast end of the Gillis Range at an altitude of 5,000 feet, about 8 miles northwest of Luning. Several hundred tons of ore was shipped from the property in 1952.

Magnetite occurs in a 400-foot-long by 20-foot-wide metamorphic zone in limestone that is in fault contact with granitic rocks.

An ore body consisting of bands and lenticular pods of magnetite, which replaces limestone adjacent to the fault contact, has been developed by trenches and outcrops over a width of 10 feet, a length of 250 feet, and a depth of 30 feet.

Iron Gate

The Iron Gate mine is in the western part of the Gabbs Range at an altitude of 5,700 feet, 5.5 miles by road from Luning. About 500 tons of ore were produced in 1944, and about 8,000 tons in 1952 (17, p. 36). Ore was also produced during 1960-62.

Ore occurs in dolomite whose bedding dips steeply to the northwest. Granite is exposed near the deposits. The largest ore body is localized at the intersection of bedding plane fissures with a steep east-striking fissure zone. The hematite ore body extends 200 feet along the bedding and is about 20 feet wide. Along the dolomite horizon to the northeast is a series of small lenses of hematite which are conformable to the bedding and similar in attitude to the main ore body. Other small discontinuous lenses and veins occur in the surrounding area. The ore is dense and hard and is suitable for lump use; shipments averaged 59 percent Fe.

An open pit on the largest ore body is 200 feet long, 25 feet wide, and 30 feet deep.

Walker Lake

The Walker Lake prospect is about 3 miles south of Schurz at an altitude of 4,400 feet.

Metavolcanic rocks of the Triassic Excelsior formation underlie the region. Recent travertine deposits are on the surface. Iron minerals are confined to a fractured area 1,000 feet north-south by 400 feet east-west which contains a few percent of iron as magnetite, mainly in small seams and veins.

A small ore body occurs along a vertical north-striking fissure. The fissure contains an 8-foot width of magnetite, and there is an additional 20 feet of replacement ore in the west wall of the fissure. This occurrence has been developed to a depth of 20 feet by a shaft and has been traced by trenching 40 feet to the north where 6 feet of ore is present. A crosscut was started east of the fissure to intersect the ore at depth, but it was stopped after 50 feet of progress.

Whoopee (Foster)

The Whoopee, or Foster, prospect is 18 miles by road northeast of Schurz at an altitude of 4,700 feet.

The area is underlain by andesite flows, marbleized limestone, and granite. Iron minerals are associated with a prominent iron-stained fault fissure several feet wide that dips moderately to the northwest. The fissure is traceable for 1,500 feet across the property. At least one andesite flow has been selectively replaced by magnetite along the fault fissure in zones of cross fracturing.

Magnetite mineralization with a grade of 30 to 50 percent iron crops out over a 50-foot diameter area in the hanging wall of the fault fissure at the south end of the property. Holes drilled to an estimated depth of 30 to 40 feet on this outcrop indicated little change in grade.

Three other magnetite outcrops occur along the fault fissure. The northernmost outcrop is 100 feet in diameter and has been eroded to a thickness of 8 to 15 feet. A moderate-size dump containing considerable magnetite adjoins a 256-foot vertical shaft about 200 feet to the east of the fissure.

Ormsby County

Capitol

The Capitol prospect is about 7 miles southeast of Carson City at an altitude of 4,500 feet.

A steep, north-dipping vein with walls of diorite contains a body of magnetite and hematite at its intersection with steep cross fractures. The partly mined oreshoot is 40 feet long and is reported to have a maximum width of 15 feet. It narrows on each end to less than 3 feet in width. The pit face, 15 feet east of the main cross fracture, contains about 10 feet of magnetite ore with an estimated grade of 50 percent iron. A sample cut west of the face reportedly contained 64.3 percent Fe, 0.01 percent S, and 0.01 percent P (17, p. 66). The vein has been strongly sheared by cross faulting. Several shallow trenches across the extension of the vein contain only scant magnetite.

Iron King (Bessemer, Brunswick Canyon)

The Iron King deposit, also known as the Bessemer or Brunswick Canyon, is about 10 miles by road southeast of Carson City at an altitude of 5,140 feet. During 1907 and 1920 trial shipments of iron ore were made and in 1944 about 500 tons was produced for ship ballast. The ore was mined through an adit and a 60-foot shaft. During 1952-53, a reported 500 tons of ore was shipped from open pit operations (17, p. 36).

The area is underlain by andesite and trachyte flows and flow breccia. Ore bodies are small pipes of magnetite and hematite formed at the intersections of steep northwest-striking fissures and steep north-striking fissures. The principal ore body reportedly is 60 feet long and 10 feet wide at the surface and increases to 22 feet in width at the adit level.

Iron Pot

The Iron Pot and related claims, controlled by D. F. H. Development Co., are in Ormsby and Douglas Counties about 15 miles southeast of Carson City at an altitude of 6,600 feet. Several thousand tons of ore was shipped in 1961.

Magnetite occurs as high-grade pods and lenses in schist along cross fractures and in bedding planes. Pit faces contain ore lenses up to 100 square feet in area.

Ore was mined in three open cuts. A portable magnetic separator was used to concentrate the ore.

Pershing County

Basalt

The Basalt property is in the Trinity Mountains at an altitude of 4,600 feet, about 36 miles by road southwest of Lovelock.

The prospect is underlain by folded limestone intruded by small bodies of diorite. Several pods of magnetite crop out in an area of about 2 acres. They occur as selective replacements of certain limestone beds that have a steep dip. The ore pods are near diorite contacts and the magnetite is associated with garnet-epidote tactite. Intense postmineral faulting has broken the magnetite bodies into many small segments. A small amount of scheelite occurs in the tactite.

A magnetometer survey outlined an anomaly 300 feet long and 50 feet wide with an intensity of 5,000 to 10,000 gammas. Wagon-drill holes indicated the ore extends downward for at least 100 feet, with little change in grade.

Tule

The Tule deposits are in the West Humboldt Range 12 miles by road southeast of Lovelock at an altitude of about 5,000 feet. The deposits are distributed over a 700-acre area owned by Southern Pacific Co. There has been no production.

The following description is based on information furnished by the Southern Pacific Co.

The West Humboldt Range is largely composed of Triassic and Jurassic sedimentary rocks intruded by Cretaceous diorite and gabbro. In the Tule area, black to gray shale and argillite with minor limestone and hornfels interbeds comprise the major portion of the sedimentary sequence. Magnetite and pyrite occur in limestone and hornfels, near a diorite contact. Subsequent weathering has developed prominent gossans of hematite and limonite over these iron- and sulfur-rich areas. Core drilling below the gossans encountered concentrations of magnetite and pyrite in the hornfels and pyrite in the limestone. Dip needle surveys found anomalies both over and away from the gossans.

At least 15 gossans, up to 150,000 square feet in area and up to 10 feet in thickness, have been noted. Samples of the gossans contained from 17.9 percent Fe and 12.6 percent S to 60.0 percent Fe and 0.62 percent S. A sample of average gossan material analysed 35.9 percent Fe, 19.7 percent SiO_2, 2.6 percent Al_2O_3, 3.36 percent S, and 1.64 percent CaO.

Insufficient exploration has taken place to determine the grade and extent of the material below the gossans. Diamond drilling to a maximum depth of 186 feet beneath the most prominent gossans encountered pyrite in all five holes drilled and magnetite in three of the holes. About 20 percent of the drill footage intersected concentrations of magnetite. The magnetite content of the mineralized sections ranged from 20 to 60 percent iron with an average of about 35 percent iron.

Based on the drilling, iron ore production would require stripping about 10 tons of waste, mining 10 tons of mineralized rock, and beneficiating about 2 tons of selected ore for each ton of 64-percent-iron pellets produced.

Washoe County

Winters (Peavine)

The Winters or Peavine prospect is on Peavine Mountain about 16 miles by road northwest of Reno at an altitude of about 7,000 feet.

Magnetite, with some secondary hematite, occurs in a steep east-dipping fissure, which contains an oreshoot about 300 feet long and 8 to 20 feet wide. North of the oreshoot the continuation of the fissure is marked by narrow showings of magnetite and small quantities of float ore. The fissure continues to the south with only slight evidence of mineralization. The wall rocks are slightly altered fine-grained lava flows. An ore analysis furnished by the owner is 62.4 percent Fe, 5.84 percent SiO_2, 0.40 percent S, 0.48 percent P, 0.03 percent Cu, 0.77 percent Zn, and 0.10 TiO_2.

The occurrence was explored by trenching, wagon drilling, and diamond drilling. Subsurface ore intersections cut by shallow drill holes are similar in size and grade to those at the surface.

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