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NEW MEXICO'S POSITION IN A WESTERN IRON AND STEEL INDUSTRY

One does not ordinarily think of New Mexico as an iron-producing state. The mineral production of the State is now, as in many years past, dominated by such commodities as copper, potash, or zinc. It is not generally known that New Mexico has produced iron ore every year for the past sixty years with the exception of four years from 1932 to 1935. The total production amounts to nearly seven million long tons with a value estimated at nearly $15,000,000. Of course, this is not much when compared to the great production of Minnesota, Wisconsin, or Michigan, the leading producers of iron ore in the United States. It assumes greater importance, however, when compared with production from other western states. There have been periods in the past when the western iron and steel industry depended rather strongly upon the New Mexican production.

New Mexico is predominantly a producer of raw materials and

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is likely to remain in that category for a long time. Nevertheless, industry is coming increasingly to New Mexico, and it is not impossible that a small iron and steel plant will someday be established in the State provided, among other things, that water supplies are adequate. Regardless of whether a fabricating industry is established it appears certain that a western iron and steel industry will continue to rely in varying degrees upon New Mexican iron resources.

Knowledge of our natural resources is important to future planning and development of the State. Whereas many are unaware of the New Mexico iron-mining industry, it is also true that others have overestimated the iron reserves of the State. In order to determine the iron-ore resources of New Mexico I made a survey of the State through interrupted periods from 1942-1947. The detailed results of this survey have been made available recently in a University of New Mexico bulletin. In this article the nature, extent, and past production of iron ore from New Mexico are briefly described.

Iron Deposits

MINERALOGY. The important iron-ore minerals are for the most part ordinary and generally recognizable to most laymen by their red and brown colors. The common iron-ore minerals of New Mexico are as follows:

Mineral	*Composition*	*Percent Iron*
Magnetite	$FeFe_2O_4$	72.4
Hematite	Fe_2O_3	69.9
Goethite	$HFeO_2$	62.9
Limonite	$FeO(OH) \cdot nH_2O$	59-63

Magnetite is an iron-black mineral which is attracted by an ordinary magnet. A variety known as lodestone has polarity like a magnet and is capable of "picking up" other iron objects. It is black in powdered form.

Hematite is a red-brown mineral which may be fine grained and dense, flaky, or fibrous. It is readily identified by its red-brown color in powdered form.

Goethite is a yellow-brown to dark-brown fibrous mineral less common than the others. It occurs in nodular and pendant forms and is yellow-brown in powdered form.

Limonite is a yellow ochre, yellow-brown, or dark-brown mineral that is amorphous and lusterless. The powder is yellow brown.

Magnetite and hematite are the most abundant of these minerals. Many iron-ore deposits contain some of all these minerals, but in the usual case deposits are predominantly or almost entirely composed of one mineral. Although most of the past production had been classified as magnetite in the statistical reports of the Federal Bureau of Mines, it has commonly contained considerable hematite. In view of the large low-grade sedimentary hematite deposits it is quite possible that hematite is equal in abundance to magnetite in the State.

Although the percentage and kind of iron minerals are of prime importance in determining the grade of a deposit, the associated gangue, or worthless minerals, and impurities are of utmost importance in determining the value or exploitability of a deposit. Calcite ("lime") and manganese increase the desirability of an iron ore, but quartz, sulfur, and phosphorus decrease the desirability. New Mexico iron ores contain differing amounts of impurities or gangue minerals.

Some of the ores are non-commercial because the sulfur or phosphorus is only a fraction of one percent too high. On the other hand, the ores of Boston Hill near Silver City contain only about 35 percent iron, yet their value is greater than usual because of the desirable manganese which is present in amounts up to about 15 percent. Other things being equal, a high-grade, 60 percent iron-ore deposit containing 2 or 3 percent sulfur and no lime would constitute a much poorer reserve than one averaging 45 percent iron, no sulfur, and 15 percent lime. It is perhaps of interest that some New Mexican iron ores have contained minor amounts of gold, silver, and tungsten, and that small tonnages have been mined and sold because of these metals rather than the iron.

A list of the gangue minerals found with the iron-ore minerals is too long to be included here. The principal ones, however, are listed below in approximately the order of their abundance.

Mineral	*Composition*
1. Calcite	$CaCo_3$
2. Quartz	SiO_2
3. Garnet	$(Ca,Fe)_3Al_2(SiO_4)_3$
4. Serpentine	$H_4Mg_3Si_2O_9$
5. Tremolite	$(CaFe)_2Mg_5(OH)_2(Si_4O_{11})_2$
6. Mica	$KMg_3(OH)_2Si_3O_{10}$
7. Epidote	$Ca_2(AlFe)_2(AlOH)(SiO_4)_3$

GRADE. Grade refers to the quantity of a particular metal in an ore. The iron content of New Mexico ores theoretically might contain as much as 72.4 percent iron, which is the iron content of pure magnetite, the richest form of naturally occurring iron. Actually however, ore bodies of minable size contain other than iron minerals in varying proportions and the content of iron in mineral bodies ranges from 0 to 72.4 percent.

The Colorado Fuel and Iron Corporation, the chief purchaser, generally specifies a minimum iron content in contracts with shippers. For small mines this is generally 53 percent iron. For large operations or places where the ore contains desirable constituents such as lime or manganese the minimum iron content might be as low as 48 percent. However, lower grade ores are more difficult to handle in the blast furnaces, and their mining and shipment are discouraged.

Inasmuch as the price of iron ore is only about seven cents for each one percent of iron in the ore, the operator can afford to mine only the high-grade parts of an iron ore body. The average grade of ore that has been shipped from New Mexico is 55 percent iron. At the present time ore of this grade would be worth (55 percent x 7¢) $3.85 per ton and out of this the cost of mining and freight to Pueblo, Colorado, must be paid before a profit can be realized. Individual small shipments have been as high as 64 percent iron. Many of the ore bodies that have been mined in New Mexico have not averaged overall more than 45 to 50 percent iron, yet by careful selection in mining it has been possible to ship a better than 50 percent product.

Ore is a mineral deposit from which a metal, or metals, may be extracted at a profit. According to this definition many iron deposits in New Mexico could not be ore, strictly speaking. Under present adverse conditions of the high cost of labor, materials, and transportation it is quite likely that an iron deposit would have to be better than 55 percent iron.

OCCURRENCES. Nearly all the iron ore of New Mexico is in the southern half of the State. Shipments have been made from about fifty different deposits in fourteen districts. Grant, Lincoln, Socorro, Sierra, Otero, Dona Ana, Colfax, Taos, Rio Arriba, and Santa Fe Counties contain deposits of iron, but only those of Grant, Sierra, Socorro, and Lincoln are likely to produce much ore in the future.

On a strictly scientific basis the iron ores of New Mexico may be classified into at least six or seven categories. There are, however, only three important genetic types in the State, as follows: (1) those formed by hot fluids in limestone near granitic bodies *(contact deposits)*; (2) those formed by the oxidizing and concentrating action of air and rain water near the surface of the earth *(supergene deposits)*; (3) those formed by sedimentary deposition as beds on the bottoms of ancient seas *(syngenetic sedimentary deposits)*.

The *contact* deposits are most numerous in New Mexico and are found in districts where copper, zinc, and gold have been prospected or mined. They occur in large pods or roughly tabular bodies up to several tens of feet wide and several thousand feet long. The ore mineral is dominantly magnetite and it commonly contains a gangue of garnet, serpentine, tremolite, epidote, or mica.

Many small contact deposits occur in Lincoln County near Capitan, White Oaks, and Corona. Larger deposits of this type have been mined in the Orogrande district, Otero County, and large deposits are present in the rather remote Iron Mountain district near Winston, Sierra County. The largest and most productive deposits are in the vicinity of Hanover and Fierro, Grant County. These deposits yielded iron ores almost without interruption from 1889 to 1931. In the vicinity of Fierro great open cuts, glory holes, and railroad benches mark the hillsides as a result of the long-term mining operations. Several tens of thousands of feet of underground tunnels and dark-walled mining rooms run through the deposits that lie beneath the hills. These deposits would be included among the four or five largest in the West.

The *supergene* deposits are dominated by the manganiferous iron ores of Boston Hill just west of Silver City, Grant County. The iron (35+ percent) and manganese (15+ percent) of these deposits were formerly deposited in lesser amounts of carbonates by hot fluids similar to the contact deposits. The present blanket-like bodies of ore were concentrated by the chemical action of air and rain water during the erosion of Boston Hill. The deposits were first prospected and mined for small amounts of silver contained in the ores. Later the manganiferous iron ores were mined in underground workings, but during the past decade they have been mined on a larger scale in open pits. They are the only deposits that have been mined since 1944. The operations are those of a miniature Masabi. The ore is loaded into trucks by steam shovels operating in open cuts along the low hillsides.

The *syngenetic sedimentary* deposits occur as original hematite beds near the bottom of the oldest sedimentary formation in New Mexico. This formation is known as the Bliss sandstone from its occurrence near Fort Bliss, Texas. The "iron" bed is a mass of tiny spheres about the size of fish eggs known as ooliths, and the ore is described as oolitic hematite. There are great tonnages of this low-grade ore in localized beds up to twelve feet thick in the San Andrés, Caballos, Black, Mimbres, and Silver City ranges in the vicinity of latitude 30° North.

Ores of this general type, however, form the basis of large iron and steel industries in other parts of the world. Notable among these are the Birmingham, Alabama, deposits, which are seven to twelve feet thick and average about 37 percent iron, 7.1 percent silica, and 19 percent lime. The iron and steel industry of France is based on ores of this kind in Lorraine which are three to fifteen feet thick and average about 35 percent iron, 13 percent silica, and 10 percent lime. Similar ores averaging only 22 percent iron are used in England at the present time.

The Caballos Range deposits of New Mexico are six to twelve feet thick and average 33 percent iron, 34 percent silica, and 4 percent lime. The silica would have to be removed before use in a blast furnace.

Production

NEW MEXICO ranks third in total iron ore output up to 1945. The peak of production came in 1927 when 306,695 long tons were shipped to the Colorado Fuel and Iron Corporation at Pueblo, Colorado. About 92,000 long tons of this production was manganiferous iron ore from Boston Hill near Silver City. The remainder came from the Fierro district. The peak production of regular iron ore from the Fierro district came in 1920 when the U. S. Smelting, Refining, and Mining Company shipped 233,719 long tons. During the war year of 1918 production from five districts yielded 301,125 long tons. During 1942 seven districts produced 168,937 long tons—about half from Boston Hill.

Reserves

RESERVE OF ORE refers to the quantity of ore estimated to be available by mining. Ore may be well exposed at the surface and hence that part is highly certain of existence. Its existence below the surface at greater and greater depths becomes, however, increasingly a matter of geologic speculation. From the point of view of certainty, ore reserves may be divided into two categories: (1) probable and (2) possible. Furthermore, reserves may be separated into grade categories. The current inventory of New Mexico reserves of iron ore is as follows:

1. Probable ore:	
Plus 35 percent iron	25,000,000 long tons
Minus 35 percent iron	2,000,000 long tons
2. Possible ore:	
Plus 35 percent iron	47,000,000 long tons
Minus 35 percent iron	68,000,000 long tons
Total:	142,000,000 long tons

Thus there are 72,000,000 long tons of *plus 35 percent* iron ore and 70,000,000 tons of minus 35 percent iron ore of probable and possible categories currently estimated for New Mexico. The estimates are generally conservative and further exploration or mining is likely to increase the reserves.

Western Iron and Steel Industry

THE WESTERN iron and steel industry began in 1881 with the completion of the Colorado Fuel and Iron Company's plant at Pueblo, Colorado. At first Colorado ores from the Orient district were the chief source of iron. However, most of the history of iron mining in the West has been dominated by the Sunshine mines of the Hartville district, Wyoming, which supplied the Pueblo furnaces with most of their ores from 1904 to 1943. During this interval New Mexico ores were the chief secondary supply until about 1927 when Utah became the second source. Since 1943 the large Iron Mountain deposits of southwestern Utah have dominated the western production picture with Wyoming and California second and third. The decline in New Mexico output is due to cessation of mining by the U. S. Smelting, Refining, and Mining Company.

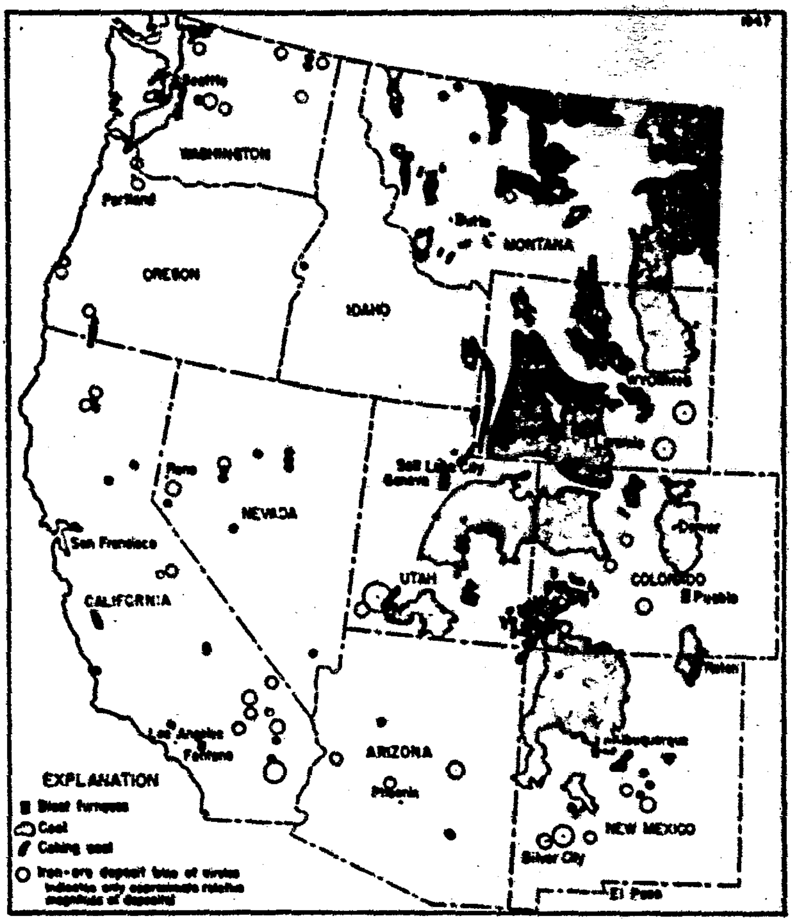

FIG. 1. Production of iron ore in Western States and the United States (1880-1945)

In addition to the Colorado plant which supplied iron rails, steel plate, etc. in the West for many decades, blast furnaces were built at Ironton, Utah, in 1924 and at Geneva, Utah, and Fontana, California, in 1942.

Recently iron and steel plants have been built in Texas. Also there are two iron and steel plants in northeastern Mexico, one in Coahuila at Monclova and the other in Nuevo Leon at Monterrey. Open hearths and rolling mills working on scrap iron have been in operation on the Pacific Coast for several decades. The war-built plants at Geneva and Fontana appear to have given a large impetus to the western industry. As of January 1, 1946, the annual blast furnace capacity of the West as a whole was 2,836,000 net tons.

The continued existence or growth of this industry depends largely upon the nature of the competition from eastern plants and the economic conditions in the West during the period of firmly establishing the new plants. With proper financial backing, good management, and fair freight rates which would enable markets to be held from the more distant eastern sources, the western industry should thrive and grow.

The blast furnaces of Utah and Colorado were located on the basis of proximity to deposits of iron and coal. The Fontana blast furnace and steel plant on the other hand is not situated according to the long established principle of location between ore and coal. It is located at great distance (810 miles) from Utah coking coal but close to iron ore, scrap iron, seaboard, and ship-building industry. Normally a blast furnace is more economically situated closer to coal than iron ore because of the lower freight rates on the latter.

The best coking coal areas are the Book Cliff field 120 miles southeast of Geneva, Utah, and the Raton field of New Mexico and Colorado. Iron-ore deposits are widely scattered in the West, but most of them are too small to support a blast furnace long enough to amortize its cost. The largest reserves are in the Iron Mountain district of Utah. The four largest districts and their reserves are as follows:

Iron Mountain, Utah	100,000,000 long tons
Fierro, New Mexico	50,000,000 long tons

Eagle Mountain, California	43,000,000 long tons
Hartville, Wyoming	10,000,000 long tons

It may be seen from Figure 2 that from the point of view of the principal raw materials central New Mexico occupies as favorable a position as Utah and Colorado for an iron and steel plant. The Middle Rio Grande Valley lies between ore in the southern part of the State and coking coal in the northern part. The distances of iron ore and coking coal from Albuquerque as compared to those of the three existing blast furnaces of the Western States are:

	Iron Ore	*Coking Coal*	*Total Distance*
Geneva, Utah	240 miles	95 miles	335 miles
Fontana, Calif.	145 "	810 "	955 "
Pueblo, Colo.	360-820 "	92 "	452-912 "
Albuquerque, N.M.	300 "	240 "	540 "

Approximately two tons of ore, one and six-tenths tons of coking coal, and nearly one-half ton of limestone flux are needed to produce one ton of pig iron. Therefore, about four tons of raw materials must be assembled to produce one ton of pig iron. Additional flux and ferro-alloys are necessary to convert pig into steel. Large supplies of water are also necessary. New Mexico occupies a very favorable position among the Western States with regard to supplies of fluxes and natural sources of ferro-alloy metals such as manganese, molybdenum, vanadium, and tungsten.

Factors deterrent to the establishment of a New Mexico iron and steel industry are as follows: (1) lack of a state or local market of sufficient size, (2) existence of competitive industries in Colorado, Utah, and California, (3) lack of scrap iron, (4) discriminatory freight rates in favor of eastern industry, and (5) uncertainty of ample water supplies.

Probably the most important consideration in connection with the feasibility of establishing a New Mexico iron and steel industry is whether a sufficient market exists in the area. Of course, the industry could not compete in the heavy steel and iron market which lies principally in the East or along the coasts. The possible or potential market includes only light-weight steel products such as tubing, re-enforcement steel and sheet metal. An economic survey should be made to determine the boundaries of the market area and its nature and size. The boundaries are determined by transportation costs and the competitive situation compared with the industries in Colorado, Utah, California, Mexico and Texico. Such a survey would not only determine the sufficiency of a market, but it would also serve to determine the most efficient size of plants to serve the market.

In California where scrap iron has been plentiful for a con-

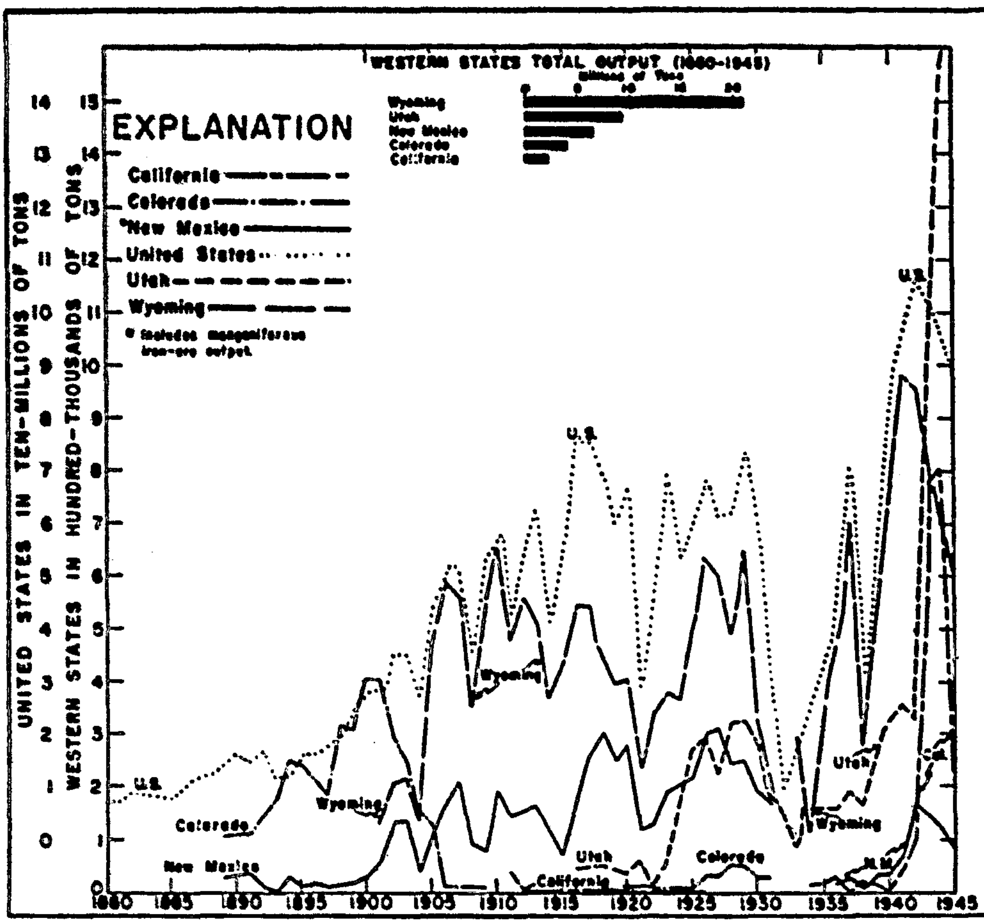

FIG. 2. Distribution of blast furnaces, coal, coking coal, and iron ore in the Western States

siderable time, steel plants have been founded on this source of material alone. It is doubtful whether scrap will accumulate in New Mexico in a usable manner for a long time to come. However, the establishment of an iron and steel industry based on iron ores probably would result sooner or later in scrap supplies which could augment the iron supplies.

There is little doubt that New Mexico as well as much of the West has been subjected to discriminatory freight rates, especially on its raw materials. The move is under way now to determine the present situation, and it does not appear that complete and unbiased information on the subject can do harm to New Mexico future development. But whether the freight rates can be adjusted to the betterment of New Mexico's economic welfare or not, as long as the raw materials are shipped hundreds or thousands of miles out of the State to be fabricated and then shipped back, the freight bill will be more than double what it might be if the iron and steel industry could be in the State.

The uncertainty of ample water supplies for industry along the Rio Grande Valley is closely linked to population increase, especially in the larger towns, and to agricultural needs. What water exists on the surface and below the surface must be divided between the urban, industrial, and agricultural needs. If the total of these needs exceeds the supply, then the growth or substantial existence of one or all of the three activities must be altered. Through the natural population expansion and the additions to populations made by location of government military and research groups in the area, the urban needs are expanding rapidly. This results in expansion of both the agricultural and industrial needs for water. Furthermore, the efforts to bring various large manufacturing industries to the Valley, in order to create a more stable foundation for the population, are on the increase. Thus, for a large water-consuming industry such as iron and steel manufacturing, it is of considerable importance to examine the water supplies of the Valley from the overall point of view as well as that of the industry. Conservation of water in the Valley and importation of water from outside of the Valley can help alleviate the uncertainty of the water supplies.

In addition, it is necessary that the site of a proposed iron and steel industry have a supply of labor and good transportation facilities. It is estimated that for every man employed in the production of raw materials from iron ore through the steel ingots, four or five are employed by manufacturing plants which use the steel.

The railroads in the West were built in the early days without markets. The markets came as a result of the railroads. The Kaiser Plant, California, and Geneva Plant, Utah, were built as the result of a war emergency, not because of existing normal markets. Yet they appear to be capable of survival and markets develop around them.

Long tunnels are driven in order to drain water from ore bodies and make them minable; ditches are dug to reclaim farm land; and rivers are damned to make power and furnish water—all at public expense. Perhaps then it is just as reasonable to build a blast furnace at public expense to "reclaim" or make available a neglected iron ore reserve and to develop local industry. A blast furnace located in New Mexico long ago would have saved about one dollar a ton in freight on 7,000,000 tons of iron ore already mined. An associated light-weight steel fabricating plant would have saved a tremendous freight bill on steel products shipped from the East.

At present in order to establish a New Mexico industry it would probably be necessary to obtain considerable public support. If supported until markets were developed and secured, its success and expansion might be assured. In the meantime, as the ores of presently producing Western States are depleted, the economic position of New Mexico's ores is perhaps improved.