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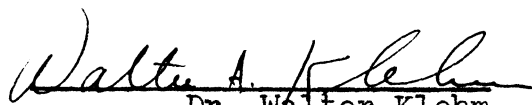
IRON ORE

by

David A. Fisher

Submitted under Plan B  
in Partial Fulfillment  
of the Requirements for the Degree,  
Master's of Science in Education

Approved by:



Dr. Walter Klehm  
Advisor

\_\_\_\_\_  
Date



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## INTRODUCTION

Many times in the past and promises to be of increasing importance in the future, mineral production has been instrumental in determining the course of history. The aggregated area underlain by mineral deposits of economic importance is only an insignificant fraction of one percent of the earth's surface, and by some accident of geology the geographic position of the individual deposits are fixed. No second crop may be expected; thus, rich diverse mineral deposits are a nation's most valuable possession. These assets must be exploited where they occur or left to the future. Although minerals of economic importance are relatively common in some sections of the country, in other great areas they are entirely lacking. Each individual deposit has its limits, and it must sooner or later be exhausted, if it is worked long enough.

Productive mineral deposits are among the most valuable resources that a nation may have, but such an asset will be coveted by many nations. The mineral policies of the government that controls these deposits

may cause serious international problems. Expatriation of the American--and British--controlled oil industry in Mexico precipitated an international crisis that might easily have lead to another landing of United States marines at Vera Cruz.<sup>1</sup>

Next to aluminum, iron is the most abundant metal in nature. Most rock contains iron, but few are rich enough or of such physical and chemical contents as to constitute iron ore. The four principal kinds of iron ore are: (1) hematite or red iron ore; (2) magnetite or magnetic ore; (3) the so-called "limonite" or brown ore, and (4) siderite or carbonate ore. Hematite is by far the most abundant and constitutes about ninety percent of the total mined.<sup>2</sup>

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<sup>1</sup> T. S. Lovering, Minerals in World Affairs, (New York: Prentice-Hall, Inc., 1943), p. 16.

<sup>2</sup> U. S. Bureau of Mines, Mineral Resources of the United States, (Washington: Public Affairs Press, 1948), p. 166.

## USES

Iron and steel form the skeleton framework within the body of modern civilization. Without steel the whole range of power-generating and power-using industries would be virtually impossible. "As much metal has been mined since 1905 as was mined in all previous history. The white population has increased threefold since 1800, but its demand for metals has increased a hundredfold in the same period."<sup>3</sup> Nevertheless, few are aware to what extent we have become dependent upon it in homes, farms, cities, machines, automobiles, trains, etc. Where iron, or steel, is not suitable for certain uses, it is alloyed with other substances to make it suitable. Each of the main types of iron-steel, cast iron, wrought iron, and iron alloys, has its specific use. Steel products exceeds all other materials in use.<sup>4</sup>

Iron ore is used primarily in the manufacture of pig iron, from which steel is derived. Large tonnages

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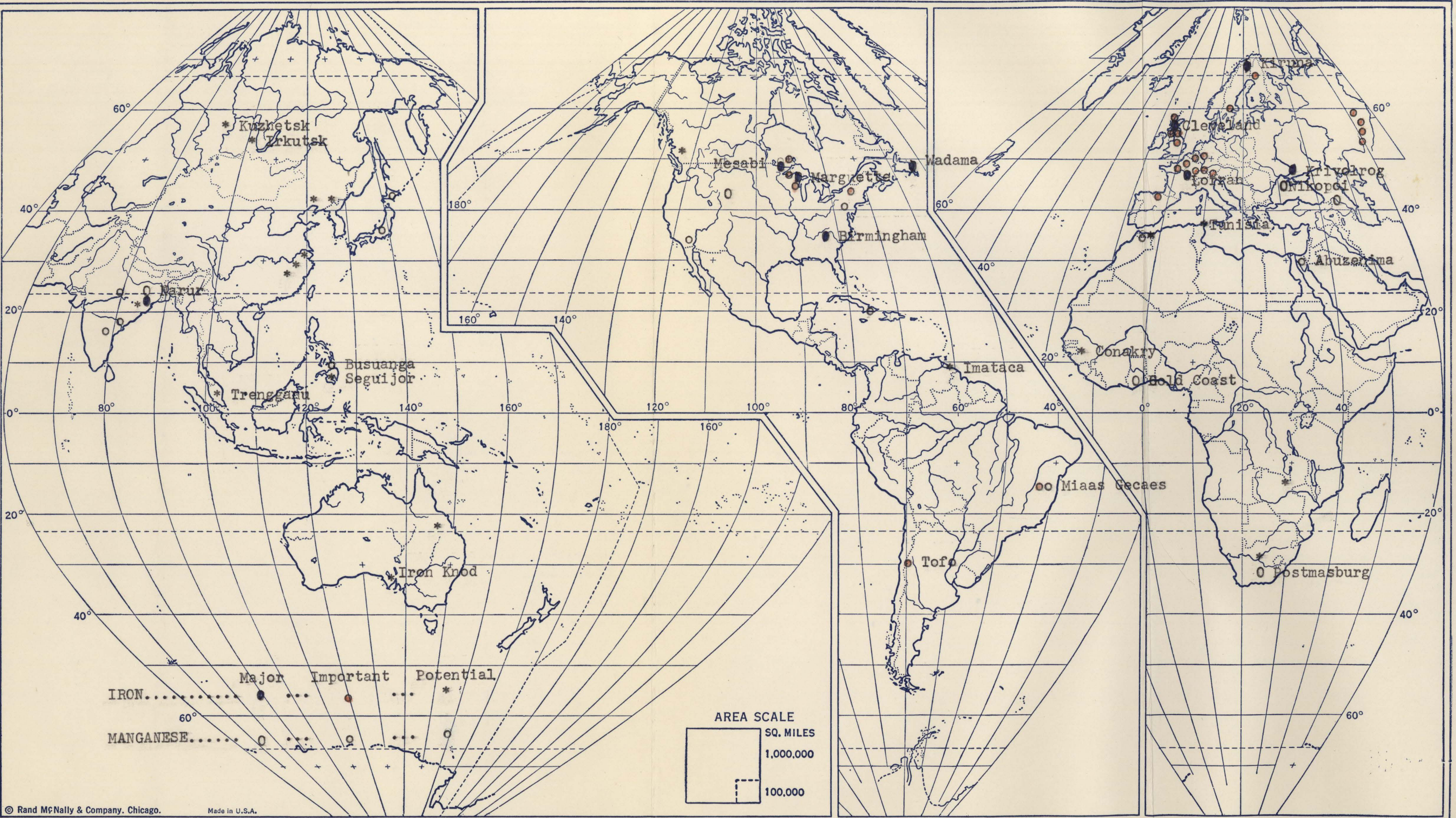
<sup>3</sup> Lovering, op. cit., p. 27.

<sup>4</sup> Alan M. Bateman, Economic Mineral Deposits, (New York: John Wiley & Sons, Inc., 1942), p. 560.

of iron ore are used in smelting non-ferrous ores and in the manufacture of ferroalloys, also, the production of pigments, cement, and hydrogen gas and in gas purification. Cement making required 30,689 tons of iron ore; paint, 8,912 tons; ferromanganese, 3,592; smelter flux, 3,863; other industries used 7,571 tons -- total, 54,627 tons.<sup>5</sup> For industry or mechanized war there is no available substitutes for iron and steel. Substitutes have generally proved to be inferior in various respects, resulting in increased weight and reduced durability in order to secure the equivalent strength. Also, they usually involve higher costs. Over 40 percent of the nation's factory workers are employed in the manufacturing of steel into beautiful and useful products.<sup>6</sup>

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<sup>5</sup> John B. DeMille, Strategic Minerals, (New York: McGraw-Hill Book Company, Inc., 1947), p. 218.  
<sup>6</sup> Ibid., p. 221.



Major Important Potential

IRON.....●.....\*

MANGANESE.....○.....\*

AREA SCALE

SQ. MILES

1,000,000

100,000

© Rand McNally & Company, Chicago. Made in U.S.A.

500 1000 1500 2000 2500 Miles

1000 2000 3000 Kilometers

Longitude East of Greenwich

Scale 1:76 665 600; one inch to 1210 miles. Sinusoidal Projection.

(Accurate on all parallels and mid-meridians)

Longitude West of Greenwich

For use with Goode's School Atlas

7 Lovering, op. cit., p. 206.



WORLD PRODUCTION OF IRON ORE BY SELECTED COUNTRIES ..... 1913 - 1948  
(million net tons)

	Approximate Metal Content	1913 - 1948												
		1913	1929	1932	1937	1940	1941	1942	1943	1944	1945	1946	1947	1948
United States .....	50	69.3	81.6	11.0	80.7	82.5	103.5	118.2	113.4	105.4	99.0	79.3	104.4	113.3
Canada .....	55	.....	.....	.....	.....	0.4	0.5	0.2	0.6	0.5	1.1	1.6	1.9	1.3
Newfoundland .....	..	1.7	1.7	0.2	1.8	1.6	1.1	1.3	0.6	0.5	.....	.....	.....	.....
Cuba .....	..	.....	.....	0.2	0.5	0.2	0.2	0.1	0.1	.....	.....	.....	.....	.....
Chile .....	60	.....	1.7	0.2	1.7	1.9	1.9	0.5	0.3	.....	0.7	0.3	1.3	1.9
United Kingdom .....	30	17.3	12.5	8.2	15.9	19.8	21.3	22.3	20.7	17.3	15.9	13.6	12.2	14.7
Luxemburg .....	30	8.0	8.4	3.5	8.6	5.4	7.5	5.6	5.8	3.2	1.5	2.5	2.2	3.7
Belgium .....	35	.....	.....	0.1	0.3	.....	.....	.....	.....	.....	.....	.....	.....	.....
France .....	33	24.1	56.1	30.4	41.7	14.0	11.7	14.1	18.6	10.2	8.6	17.9	20.6	25.3
Germany .....	25	31.5	6.8	1.5	9.4	.....	.....	.....	.....	.....	.....	4.0	4.1	8.0
Austria .....	35	3.3	2.1	0.3	2.1	3.5	3.2	3.3	3.4	3.3	.....	0.5	1.0	1.2
Czechoslovakia .....	30	.....	2.0	0.7	2.0	2.3	2.4	2.2	2.1	1.7	0.3	1.2	1.5	1.6
Poland .....	35	.....	.....	0.1	0.9	.....	.....	.....	.....	.....	0.5	0.5	0.6	.....
Hungary .....	35	.....	.....	0.1	0.3	0.3	0.3	0.4	0.4	.....	0.1	0.1	0.3	.....
Yugoslavia .....	..	.....	.....	.....	0.7	0.7	0.6	.....	.....	.....	.....	.....	.....	.....
Rumania .....	..	.....	.....	.....	0.1	0.2	0.2	0.2	.....	.....	.....	.....	.....	.....
U. S. S. R. ....	..	10.5	7.8	13.4	30.9	30.3	25.1	.....	.....	.....	.....	.....	.....	.....
Greece .....	..	.....	.....	.....	0.3	.....	.....	.....	.....	.....	.....	.....	.....	.....
Italy .....	50	.....	.....	0.5	1.1	1.4	.....	.....	.....	.....	.....	0.1	0.2	0.2
Spain .....	51	10.9	7.2	1.9	1.4	2.5	1.9	1.8	1.7	1.7	2.1	2.6	1.7	1.8
Norway .....	..	.....	.....	0.4	1.1	0.7	.....	.....	.....	.....	.....	.....	.....	.....
Sweden .....	60	8.3	12.6	3.6	16.5	12.4	11.6	10.7	11.9	8.0	4.3	7.6	9.7	12.1
Algeria .....	55	1.3	2.4	0.5	2.6	1.1	0.4	0.3	0.2	0.9	1.3	1.8	.....	.....
Tunis .....	55	.....	.....	0.2	1.1	0.4	.....	.....	.....	0.1	0.1	0.2	0.4	0.8
(British) India .....	..	0.4	2.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Japan .....	50	.....	.....	.....	0.7	1.2	1.5	2.4	2.9	3.9	1.3	0.6	0.5	0.6
Union of South Africa .....	60-65	.....	.....	.....	0.5	0.7	0.9	0.8	0.8	0.9	1.0	1.0	1.3	1.3
China .....	..	8.1	1.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

<sup>8</sup> Erich W. Zimmermann, World Resources and Industries,  
(New York: Harper & Brothers, Publishers, 1951), p. 632.

## NATIONS DEFICIENT IN IRON ORE

Germany: One of the most serious problems confronting German industry as a whole is the deficiency of iron ore. For most of her iron ore requirements, Germany depends upon imports. Manganese, chrome, tungsten, and nickle ores must also be imported, and the possibility of obtaining adequate supplies from domestic sources is remote.<sup>9</sup>

Germany's largest producer has been the Siegerland iron-mining district. Here veins of siderite are three to thirty feet wide containing thirty-five percent iron occur. The ore reserves are estimated at 100,000,000 tons. However, the output of the Peine-Salzgitter district has been greater than that of Siegerland, although the iron content of this high-phosphorus area is only thirty percent. Germany's greatest source of iron ore is the Peine-Salzgitter district.<sup>10</sup>

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<sup>9</sup> Charles Will Wright, The Iron and Steel Industries of Europe, (Washington: United States Government Printing Office, 1939), P. 6.

<sup>10</sup> Ibid., p. 7.

In Bavaria and Baden beds of iron ore are being mined and concentrated. The reserves of these mines are estimated at about 100,000,000 tons containing 48 percent iron ore. Also, the Lahn-Dill district deposits contain about 42 percent iron content. The productive iron mines are in the Thuringia-Saxony and Vogelsberges districts.<sup>11</sup>

Germany has an abundance only of non-metallic minerals within its own boundaries. Coal and potash are the outstanding assets. Germany's potash is almost a world monopoly, and coal is the basis of its industrial development, principally in the Ruhr Valley. No other large industrial nation has so small a control of essential minerals either at or abroad.<sup>12</sup>

Great Britain: In 1932 it was realized that to assure economic security and prosperity there must be effective cooperation between the steel industry and the State. As in Germany, Great Britain has had the tendency to nationalize industry and is considered as a downward step toward inefficiency and higher production costs. It may eventually be necessary, however, for the State to subsidize exports, as in Germany.

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<sup>11</sup> Wright, op. cit., p. 8.

<sup>12</sup> C. F. Leith, World Minerals and World Politics, (New York: McGraw-Hill Book Company, Inc., 1931), p. 61.

In 1935 the steel producers in Great Britain joined the International Steel Agreement -- a great step in rehabilitation of the industries export trade. The production of steel averaged over a million tons a month in 1937 for the first time in Great Britain's history. The United Steel Companies, and others, in 1938, proposed storage of pig iron in times of slack markets to stabilize production and thus render the nation less dependent on foreign sources of pig iron and scrap in times of great demand. However, Great Britain must still import ore from other countries.<sup>13</sup> "Sweden, Spain, and North Africa are the principal sources of the imported ores, followed by Sierra Leone and Norway. These are average about 52 percent in iron content and are essential for making proper blast-furnace mixtures. As many of the blast-furnace plants are near the shipping ports, the transportation problem is simplified."<sup>14</sup> The bedded deposits in the Jurassic formations that extend from just north of Oxford to Middlesborough on the east coast and include the Northampton, Leicester, Fordingham, and Cleveland mining districts are the principal sources of iron in England. These districts supply about 80 percent of the total production. When the ore is dried

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<sup>13</sup> Wright, op. cit., p. 22.

<sup>14</sup> Ibid., p. 23.

it contains 25 to 38 percent iron, averaging 30 percent. The beds range from 6 to 25 feet in thickness, and are mined largely in open-cuts by steam shovels. Also, the hematite deposits in Cumberland and South Wales supply about 20 percent of the iron ore in England.<sup>15</sup>

The great competitor of the United States in control of the world's minerals is Great Britain, but within its own boundaries it has but few minerals. There is an abundant supply of iron ore, but it is of low grade and even for domestic consumption must be supplemented by high-grade ores to the extent of nearly half (in metallic content) of the local production. However, if all the mineral resources of the British Empire were considered as a single group the combination would be a very strong one, probably superior to that of the United States.<sup>16</sup>

Italy: The output of the Italian iron mines represent about one-quarter of the iron required for the steel industry. From treatment of pyrite ash in electric furnaces, another 10 percent of the iron is derived, and the rest is obtained largely from imports of scrap iron

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<sup>15</sup> Wright, op. cit., p. 22.

<sup>16</sup> C. F. Leith, World Minerals and World Politics, (New York: McGraw-Hill Book Company, Inc., 1931), p. 56.

from the United States and France and from Domestic scrap.<sup>17</sup>

On the Island of Elba and at Cogne in the Val d'Aosta, are the principal deposits of iron ore, which together yield 90 percent of the total Italian output. "The ore deposits are large, irregular masses in the limestone---schist country rock often a few thousand feet in lateral extent and up to 20 feet in thickness. The ore is a limonite, with some hematite, and the product averages 51 percent iron, 10 percent silica, 0.07 percent phosphorus, and 0.09 percent sulfur."<sup>18</sup> These deposits are mined by open-pit methods, with aerial ropeways to transport the ore from the workings to the washing plants and onto ocean steamers.

There are also extensive deposits of oolitic iron ore in northern Sardinia 15 miles from the port of Ponte Romano in the Nurra. However, during recent years much attention has been given to the development of deposits of siderite in northern Italy and in northeast of Bergamo; these deposits extend over many square miles and are estimated to contain many billion tons of iron. Another source now being exploited is in the ancient

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<sup>17</sup> Wright, op. cit., p. 14.  
<sup>18</sup> Ibid., p. 15.

iron-slag at Boratti and at Fallonica on the mainland opposite the Island of Elba, also, there is a substantial deposit at Slrettoia near Massa.<sup>19</sup> Italy has sufficient quantities of iron ore for its own limited use of iron, lead, fluorspar, gypsum, potash, and pyrite. The Italians are not active in exploration for minerals, though they are now putting forth some effort.<sup>20</sup>

Poland: The development of Poland's iron and steel industries are based on large reserves of coking coal, extensive reserves of iron ores in the vicinity of coal mines in the southwestern part of the country, and a plentiful supply of labor. Sweden and Moracco supply most of the imports of high-grade iron ore for Poland's industries. "Poland imports about as much iron ore as is produced and exports one-fifth of her coke production."<sup>21</sup> Poland's own deposits of iron ores consist chiefly of low-content siderite ores, and for this reason imports are comparatively large.

Poland has four iron ore districts which are as follows: 1. the Czestochowa--Wielum area adjacent to the German border----contains 30 percent iron content.

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<sup>19</sup> Wright, op. cit., p. 16.  
<sup>20</sup> Leith, op. cit., p. 64.  
<sup>21</sup> Wright, op. cit., p. 38.

2. the Kielce-Radom area----averages about 28 percent iron content.
3. the scattered deposits of limonite in Silesia----averages 40 to 45 percent iron content.
4. the Olzan district----contains 30 percent iron content.<sup>22</sup>

By underground and mechanized surface mining methods, the iron ores are extracted, but the deposits usually are narrow, thus, the output per man shaft is low. The siderite ores are roasted in furnaces installed at the mines, while fine ores are subjected to sintering processes.<sup>23</sup>

Czechoslovakia: Even for the raw mineral products required for the iron and steel industries, Czechoslovakia is by no means self-sufficient. It has depended for imports on the rich iron ores of Sweden and Yugoslavia; scrap iron from Belgium, United States, and the Baltic States; coke from Poland; and manganese from Russia and South Africa.<sup>24</sup>

In Czechoslovakia there are two iron-mining districts. One district is in Bohemia near Nucice and Beroun west of Prague, where deposits of limonite and

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<sup>22</sup> Wright, op. cit., p. 39.

<sup>23</sup> Ibid., p. 40.

<sup>24</sup> Ibid., p. 28.



hematite ore occur in the Silurian slates and limestone. These deposits are usually found in synclinal folds, considerable faulted, and the beds of iron ore are up to 50 feet in thickness. The ore is mined by shafts and underground workings. The ore averages 37 percent iron. The reserve deposits are estimated at 25,000,000 tons.<sup>25</sup>

The other iron-mining district is in Slovakia west of Kosice, where several mines are producing a siderite ore containing 32 to 38 percent iron. These deposits occur in a mineralized zone about 6 miles in length in the Alpine Paleozoic rock series. The siderite veins are 3 to 100 feet wide, and they are mined from shafts 150 to 900 feet deep. The reserves of developed and probable ore are estimated at 8,000,000 tons.<sup>26</sup>

Rumania: The Rumanian Government has taken greater interests in recent years in developing its heavy industries, and much progress has been made in the production of iron ore, pig iron, steel products, coal, and coke. Technical improvements in certain branches of metallurgical operations and import restrictions that have helped to eliminate foreign competition in the domestic market

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<sup>25</sup> Wright, op. cit., p. 29.

<sup>26</sup> Ibid., p. 30.

likewise have contributed to the progress made by the iron and steel industry.<sup>27</sup>

Domestic mines contribute about 15 percent of the iron needed for the steel industry in Rumania, the balance coming largely from imports of ore, scrap, pig iron, and domestic scrap. The most important iron ore mines are the Ghelar and Veda Dobril in the region of Hunedoara, which are State-owned and provide over half of the total iron ore production of the country. Next in importance are the Leluic mines, which supply 30 percent of the iron ore, and the Ocna de Fier mines in the Caras district, which furnish about 10 percent of the total output. The grade of ore mined ranges from 36 percent for siderite ores to 48 percent for limonite ores. These iron ore reserves have been estimated at 26 million tons of known and probable ore averaging about 40 percent iron content. Rumania imports most of its iron ore from Yugoslavia.<sup>28</sup>

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<sup>27</sup> Wright, op. cit., p. 34.

<sup>28</sup> Ibid., p. 35.

## NATIONS WITH ADEQUATE OR SURPLUS IRON ORES

France: In the Lorraine Basin west of the Moselle River is where the iron and steel industry of France is concentrated, with large reserves of iron ore extending from the Belgian border to Nancy and coal fields at the German frontier east of Metz. Most of France's iron ore production comes from the Lorraine Basin, with the balance from Normandie, Anjou-Bretagne and the Pyrenees.<sup>29</sup>

"The Lorraine Basin, where the well-known minette ores occur, is made up of sedimentary beds of limestone, sandstone, and shales dipping slightly southwest or west. The areas in which these beds are rich enough to mine are limited to the Briey-Longwy, Metz-Thionville, and Nancy Basins."<sup>30</sup> This ore-bearing area covers approximately 282,000 acres. Mining has extended to a depth of 570 feet, but drilling has proved the ore to be 3,000 feet in depth and these beds range from 6 to 25 feet in width. Usually they are quite flat, faults are rare,

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<sup>29</sup> Wright, op. cit., p. 42.

<sup>30</sup> Ibid., p. 44.

and where they occur the displacement of the beds is only slight. The ore is a hydrated oolitic hematite, gray to brown, red, and even blue in color, and it usually is not hard and often earthy, with a water content of 8 to 10 percent. Two principal grades of ore are recognized: (1) the calcareous or basic ores, which are most prominent in the Briey and Thionville areas; and (2) the siliceous ores produced in the region of Longwy and in the Nancy basin.<sup>31</sup>

Efforts to secure supplies outside the boundaries of France have been largely confined to the French colonies and mandates. In this way France has acquired an exportable surplus of chromite and nickel from New Caledonia, graphite from Madagascar, and phosphates from North Africa, and has made up part of its deficiency in iron, manganese, lead, and zinc from North Africa.<sup>32</sup>

Spain: Among the iron ore producers of the world Spain is near the top. About 60 percent of the ore is exported. Her most important iron ore deposits are along the northern coast of Spain at Bilbao and Santander

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<sup>31</sup> Wright, op. cit., p. 44.

<sup>32</sup> Leith, op. cit., p. 60.

in the Province of Vezcaya and in the Provinces of Oviedo and Lugo. Most of the ore is surfaced-mined, although future production will depend more and more on extension of underground mining. The ore ranges from 48 to 58 percent in iron and is hematite and limonite. In depth, however, these ores change from the oxide to the carbonate form, and more of the lower-grade carbonate ore is now mined as the reserves of higher-grade ores are being depleted. Her vital deficiencies are coal and oil. British capital dominates most of the Spanish minerals. Spain's only effort to develop minerals outside of its boundaries is in Spanish Morocco, and even there this activity is left largely to other nations.<sup>33</sup>

Norway: During the sixteenth century was the beginning of iron ore production in Norway. The iron ore in this area averages 25 to 35 percent iron content. However, Norway imports about one-fourth of its pig iron for domestic consumption. Most of her iron comes from three sources:

1. the Sydvaranger mines at Kirkenes----produces magnetite ore with an average content of 34 to 35 percent iron.

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<sup>33</sup> Wright, op. cit., p. 73.

2. the Fosdalen mine at Nalm----is magnetite ore containing about 45 percent iron.
3. the Rodsand mine at Nettet----produces titaniferous magnetite ore containing 30 to 40 percent iron.<sup>34</sup>

"According to O. K. Kuhn, Norwegian iron ores may be grouped into four classes: Concentrating ore, which represents about 90 percent of estimated reserves; titaniferous ore, a variety of magnetite with an admixture of limenite, and second in importance with respect to reserves; direct-smelting ore; and sulfide ore."<sup>35</sup>

Sweden: "Sweden is by far the most important source of high-grade iron ore in Europe; as domestic consumption is relatively small, it is the world's second largest export country."<sup>36</sup>

The Swedish iron ore is high in content; therefore, can go direct to the blast furnaces. Some of the mines maintain ore-dressing plants for the low-grade ores, and about 15 percent of the total output is in the form of concentrates. The Gellivara mines are the principal producers of concentrates. The Kiruna and Gellivara groups of mines are among the richest in the world and the third

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<sup>34</sup> Wright, *op. cit.*, p. 77.  
<sup>35</sup> Leith, *op. cit.*, p. 65.  
<sup>36</sup> Wright, *op. cit.*, p. 51.

largest as to iron ore production. The ore of these mines range from 56 to 71 percent iron content.

The Swedish iron and steel industry was started in the Middle Ages, and was based on the iron mines in the Beryslagen area west of Upsala.<sup>37</sup> Today, the high grade iron ore in Sweden is of great importance to the future of the European steel industry. The Scandinavian countries do not possess minerals of great consequence in world perspective.<sup>38</sup>

Yugoslavia: The iron industry in Yugoslavia commenced during the World War I when, under the Austro-Hungarian Empire, the extensive iron deposits of Ljubija near Prijedor in Bosnia yielded as much as 1,000 tons a day. These mines and other at Vares, north of Sarajevo, which are operated by the State, are the principal sources of iron ore. Although 70 percent of the iron ore is exported, largely to Hungary, Yugoslavia still imports a large tonnage of pig iron and scrap. Developed and probable ore reserves of the country are estimated at 200,000,000 metric tons of magnetite, limonite, and some siderite.<sup>39</sup>

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<sup>37</sup> Wright, op. cit., p. 52.

<sup>38</sup> Leith, op. cit., p. 65.

<sup>39</sup> Wright, op. cit., p. 73.

"The mining industry of Yugoslavia is under the direct supervision of the Ministry of Mines and Forests in Belgrade. The Mines Department of this ministry is divided into two divisions. One division is responsible for issuing mining rights and concessions, the safety inspection in mines, and the collection of statistics on production, labor, and accidents. The other division is in charge of the operation and administration of the State-owned mines.<sup>40</sup>

Hungary: Hungary's requirements are easily satisfied for her iron and steel plants. Less than one-fourth of the iron that goes into the steel production is from domestic mines. Hungary is a large supplier of iron and steel products to Yugoslavia, Rumania, Bulgaria, Sweden, and other countries, in exchange for raw materials. However, in Hungary the only important industry is the metal industry.

The iron ore deposits now being worked are in the Miskolc district northeast of Budapest. The ore consists of veins and small masses of limonite and siderite. At present these are surface-mined for the most part. Most of the exports of raw and finished steel products are shipped to the Balkan States.<sup>41</sup>

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<sup>40</sup> Wright, op. cit., p. 83.

<sup>41</sup> Ibid., p. 84.



Greece: Greece has no iron and steel-producing plants but is becoming more important each year with respect to her exports of iron, nickel, and chrome ores. Germany has supplied her requirement of iron and steel products during the past. Now her principal iron ore operations on the mainland are the Larymna and Loutsi mines, also, the Lsowka Mine, all within a ten mile radius. The deposits are characteristic because of their chromite content; the ores average 48 to 50 percent iron. They occur along a serpentine belt, and are relatively flat with dips up to 30 degrees, ranging from 300 to 1,000 feet in length and 25 to 60 feet in width, and are developed to 800 feet in depth. The ore is mined principally by underground workings.<sup>42</sup>

Bulgaria: Bulgaria is not an industrial nation and has no plants for the production of iron, steel, or even nonferrous metals. It has, however, important mines producing various grades of coal and iron ore, some copper, and small amounts of lead and zinc ores. With the exception of coal all of these products are exported. However, the lack of capital and transportation facilities to many of the known mineral deposits, as well as the absence of domestic demand for mineral products, has deterred extensive mine developments in

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<sup>42</sup> Wright, op. cit., p. 73.

Bulgaria. Consequently, the iron ore production in Bulgaria has been limited to a few thousand tons a year, all from the mines near Monastir. The ore from these mines are magnetite containing 60 percent iron. Another important deposit is that at Kremikovtze near Sofia, where a bedded deposit of magnetite occurs. The bed is 6 to 15 feet thick and the ore contains 40 to 50 percent iron.<sup>43</sup>

The mining industry in Bulgaria, as in most of the Balkan States, is being financed by foreign capital, largely French and Swiss. However, the Government has become actively engaged in prospecting for oil, as well as for iron ore and the nonferrous metals since 1938.<sup>44</sup>

Soviet Union: About two-thirds of the iron ore output comes from the Krivoi Rog mines in the Ukraine and the balance from the mines in the Urals. The creation of an iron and steel industry capable of supplying all branches of the various industries with their requirements was the main objectives of the Soviet Union. For national defense it is also realized that a large iron and steel industry is highly essential.<sup>45</sup>

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<sup>43</sup> Wright, op. cit., p. 87.

<sup>44</sup> Ibid., p. 89.

<sup>45</sup> Ibid., p. 58.

In the Soviet Union the production and distribution of raw and manufactured goods are fixed each year according to a predetermined plan drawn up by the State Plan Commission and approved by the Economic Soviet and the Soviet of Peoples Commissars.<sup>46</sup>

The financing of industry in the Soviet Union resolves itself primarily into a series of bookkeeping transactions. The peasant and ultimate consumer pay the bill in the form of (1) direct or indirect taxes and (2) comparatively low wages and high prices.<sup>47</sup>

Russia's supplies of coal, iron, pyrite, gold, asbestos, salt, and chromite are adequate for domestic consumption. Copper, lead, zinc, and other minerals are known in minor amounts. The vast extent of Russia's unexplored country makes it difficult to appraise her future mineral position.<sup>48</sup>

United States: The United States is virtually self-sufficient in iron ore; there is still some export and import trade. Refer to graph showing the relation between domestic and world production (page-6).

<sup>46</sup> Wright, op. cit., p. 71.

<sup>47</sup> Ibid., p. 72.

<sup>48</sup> Leith, op. cit., p. 48.

<sup>49</sup> The Staffs of the Bureau of Mines and Geological Survey, Mineral Resources of the United States, (Washington: Public Affairs Press, 1948), p. 116.

Iron-ore production, which closely follows the demand for steel, is one of the first industries to respond to changes in industrial activities. As most ore is mined from open-cuts or shallow workings, it is relatively easy to adjust operations to economic demands. Price has little immediate effect upon iron-ore output, except that periods of high industrial activity are usually accompanied by higher prices.<sup>50</sup>

Within the United States most of the ore is produced by the companies that consume it. The Lake Superior region of Minnesota, Michigan, and Wisconsin, the hematite and limonite deposits in the Birmingham district of Alabama, (and the magnetite deposits in the Adirondack region of New York) are the principal sources of the hematite. About 80 percent of the iron ore produced annually in the United States comes from the Lake Superior region, or an annual average of 50 to 80 million tons, and the Mesabi range alone, in northeastern Minnesota, produces more than half of the total annual domestic production. The largest mines in the United States are mostly located on the Mesabi range, and over half

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<sup>50</sup> The Staffs ... Survey, op. cit., p. 116.

of the production is from open-pit mines. The Birmingham district produces 3 to 6.5 million tons annually, almost entirely from underground mines. In the Adirondack region, mines near Lake Champlain have produced ore for many years. Utah, Wyoming, and New Mexico have yielded significant production for the iron and steel plants at Provo, Utah and Pueblo, Colorado and recently there has been enlarged production for California's expanding steel plants; however, small deposits are present in most states.<sup>51</sup>

Many of the deposits of the United States, including some of those in the major districts, include large quantities of material either too poor in iron or containing such a large porportion of impurities that they cannot be used under present economic or technologic conditions. Brazil, Canada, Chile, Cuba, and northern Africa are the principal sources of imported iron-ore.<sup>52</sup>

The measured and indicated iron ore implies an assured reserve equivalent to 40 years' supply, even at wartime expanded rates of production. It is believed that virtually all this ore can be mined at prevailing or somewhat higher prices. In addition there are

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<sup>51</sup> The Staffs ... Survey, op. cit., p. 116.  
<sup>52</sup> Ibid., p. 118.

potential reserves, estimated at 53 to 75 billion tons, which, however, are of lower-grade ore. The approximate distribution of the actual and potential reserves is estimated as follows:<sup>53</sup>

District	Actual reserves <sup>1/</sup>		Potential reserves	
	Quantity	Approximate Iron content	Quantity	Approximate Iron content
	1 billion short tons	percent	1 billion short tons	percent
Lake Superior-----	<u>1/</u> 1.5	50-55	45-67	25-49
Birmingham, Ala.---	1.6	35	.6	<u>2/</u>
Northeastern <u>3/</u> ---	.8	40	1.1	<u>2/</u>
All others-----	.4	<u>2/</u>	6.2	<u>2/</u>
Total <u>4/</u> -----	4.3	45	53-75	<u>2/</u>

<sup>1/</sup> Future development may increase these high-grade reserves considerably, especially in the Lake Superior district.

<sup>2/</sup> Not available.

<sup>3/</sup> Includes northeastern New York, eastern Pennsylvania, and <sup>N</sup>ew Jersey.

<sup>4/</sup> Ernest F. Buchard, of the United States Geological Survey, and Albin C. Johnson of the United States.

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<sup>53</sup> United States Tariff Commission, Iron and Steel, (Washington: United States Government Printing Office, 1946), p. 78.

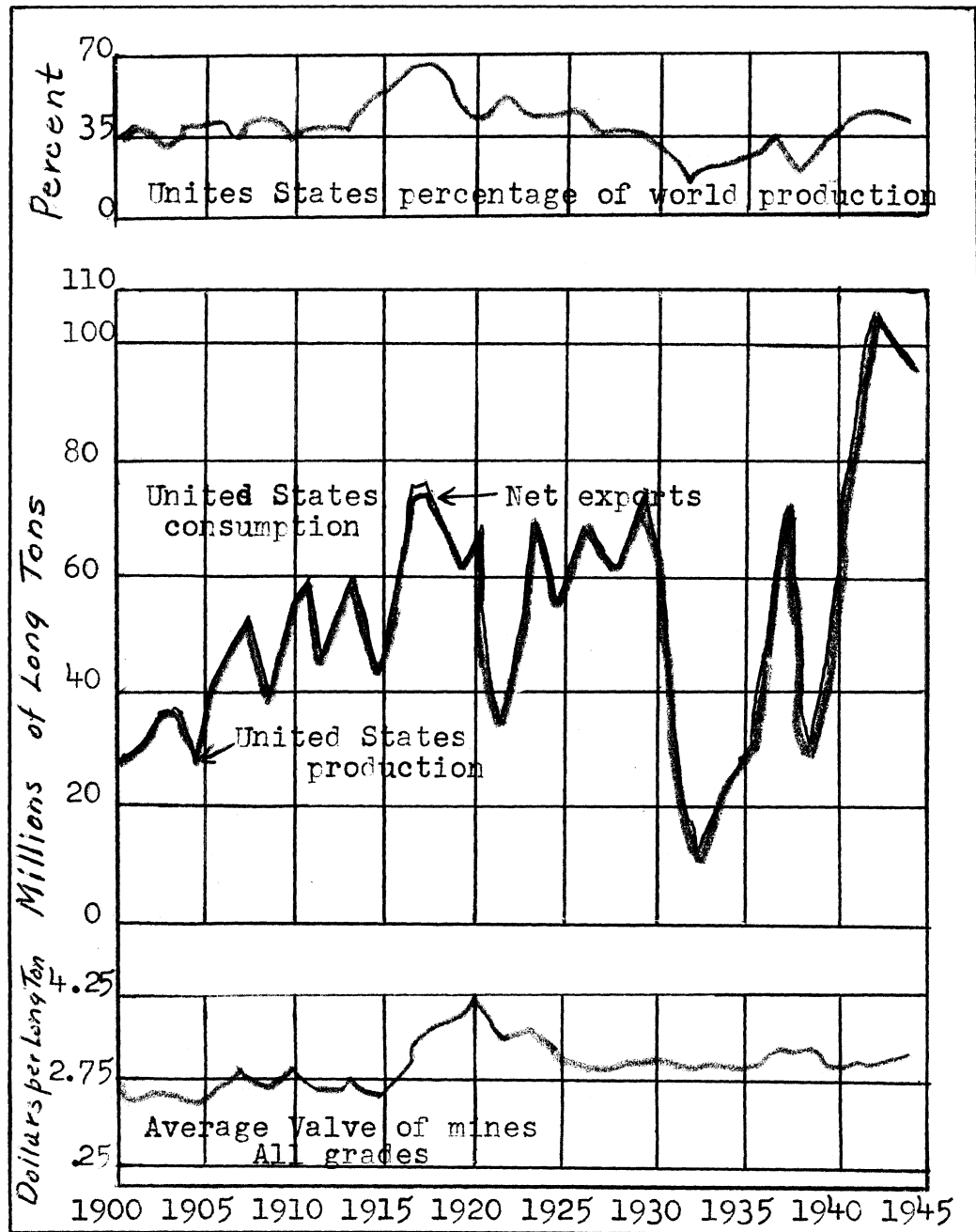
Bureau of Mines, estimate that the United States reserves of iron ore of present commercial or usable grade total about 6.2 billion tons, of which about one-third is classed as inferred ore.<sup>54</sup>

"From almost any point of view the United States is the outstanding mineral country. It is the largest owner, the largest producer, and the largest consumer of minerals. In all three ways the United States accounts for about 40 percent of the world's totals -- for some minerals, of course, much less than this, for others more. It is the only country in the world possessing adequate quantities of nearly all the principal industrial minerals."<sup>55</sup>

The United States depends almost entirely on foreign sources for several important minerals: antimony, chromite, manganese, nickel, tin, asbestos, bauxite, nitrates, platinum, and potash, and it is very largely dependent on foreign sources also for mercury, tungsten, barite, china clay, fluorspar, graphite, magnesite, mica, and pyrite. It is therefore natural that a mineral industry as large and thriving as that of the United States should undertake mineral exploitation in other parts of the world.<sup>56</sup>

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<sup>54</sup> United States Tariff Commission. op. cit., p. 78.  
<sup>55</sup> Leith, op. cit., p. 48.  
<sup>56</sup> Ibid., p. 48.



Trends in production, consumption, and price of iron ore in the United States .....1900-45.<sup>57</sup>

<sup>57</sup> The Staffs ... Survey, *op. cit.*, p. 117.



## IRON ORE IN SOUTH AMERICA

"South America has been frequently called the Land of the Future. One of the mightiest reservoirs of mineral wealth has lain, virtually untouched, in the midst of the world."<sup>58</sup> If one judges by the present volume of production, most of the mineral resources of South America are owned by foreign capital. American investment in particular being dominant. There are two notable exceptions: Bolivia, where the main ownership of the tin industry is domestic, and Chile, where the nitrate industry was until recently controlled by the government. Even then the foreign investors participated substantially.<sup>59</sup>

Although the present production of iron ore in Brazil is insignificant, the reserves are famous for their size and quality. The Itabira Iron Ore Co., Ltd., a British firm, and the Brazilian Iron and Steel Co., an American concern: these are the principle holdings.

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<sup>58</sup> H. Foster, Ores and Industry In South America, (New York: Bain and Thomas Thornton Read, 1934), p. 331.

<sup>59</sup> Ibid., p. 331.

Both have holdings in the Itabira district and the American company has additional holdings in the Sao Miguel and Santa Rita districts. A Belgian syndicate, Coupanhia Siderurgica Belga-Minerira, at the present is the principal producer of pig iron in Brazil has small holdings of ore reserves.<sup>60</sup>

Practically all of the iron ore produced in Chile comes from El Tofo, where it is mined by the Bethlehem-Chile Iron Mines Co., a subsidiary of the Bethlehem Steel Co. Among the undeveloped properties in Chile, the best known is Algarroba, owned by a Dutch-German syndicate. The largest known iron-ore deposit in Venezuela is owned by the Bethlehem corporation.<sup>61</sup>

Mineral production in South America was always typically for export, as would be expected since the dominant interests of the continent were agricultural. Minerals were merely salable raw materials. Now the raw materials have taken on national importance, this being domestic consumption.<sup>62</sup> Of the big three mineral industries of the world, coal, petroleum, and iron

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<sup>60</sup> Foster, op. cit., p. 336.

<sup>61</sup> Ibid., p. 336.

<sup>62</sup> Ibid., p. 350.

and steel production, South America has no hope of becoming of importance in the first and for the third must be mainly content to furnish ores for reduction elsewhere.<sup>63</sup> However, iron ore exists in important amounts in Brazil, and in smaller scattered deposits in Chile, Venezuela, and elsewhere. Iron ores from Chile are now being shipped to the United States, and in the near future will be exported to North Atlantic ports from Brazil.<sup>64</sup>

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<sup>63</sup> Foster, op. cit., p. 350.

<sup>64</sup> Ibid., p. 351.

## IRON ORE IN THE FAR EAST

The Far East produces a rather imposing aggregate of minerals, although it is far short of the total produced either in the United States or in Europe. However, the sources are scattered among so many nations that they do not constitute an adequate basis for independent industrial development.<sup>65</sup> The key to the industrial situation is the question of coal and iron. Japan, with the best organization, industrial development, and consuming power, has little coal and iron within its own boundaries. But Japan is attempting to make up its deficiency by the development of coal and iron in Manchuria. The coal supply is large, but not of the best grade, requiring beneficiation. In the meantime Japan has brought in iron ore in small quantities from Korea, China, Malay, and Australia. China has plenty of high-grade coal, but insufficient iron ore, and has other industrial minerals in adequate amounts. India has an abundance of high-grade iron ore but only a limited supply of coal

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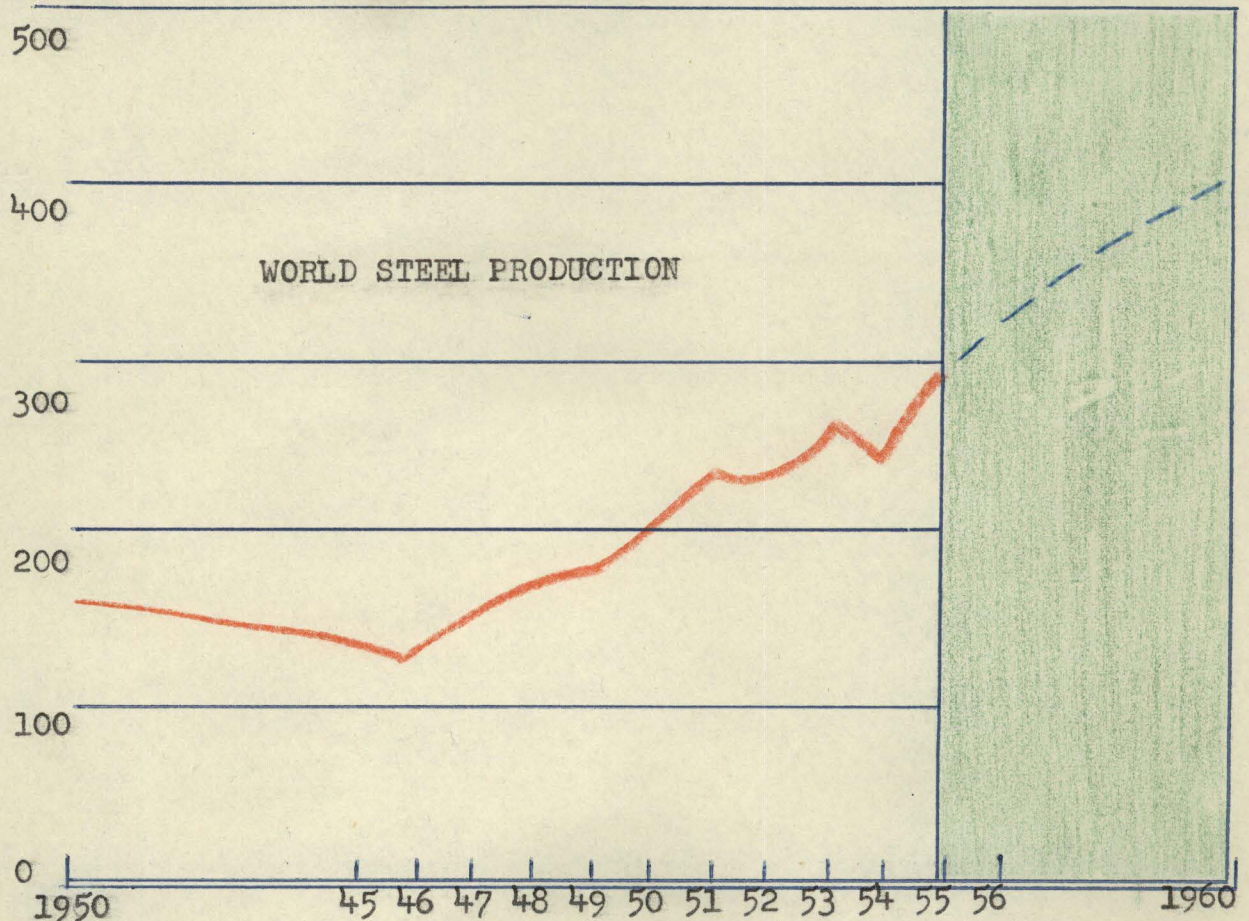
<sup>65</sup> H. F. Bain, Ores and Industries in the Far East, (New York: Council on Foreign Relations, Inc., 1933), p. 69.

of proper coking quality. The Phillipines and the Dutch East Indies have large reserves of medium-grade iron ore of a mineral content which causes difficulties in smelting, but they have no large amounts of coking coal. If the coal of north-eastern China could be brought together with the high-grade iron ores of India and possibly with the iron ores of the Phillipines and the Dutch East Indies, a large industrial advance might be possible. But the political difficulties involved are not likely to be surmounted for a long time to come.

## WORLD PROGRESS

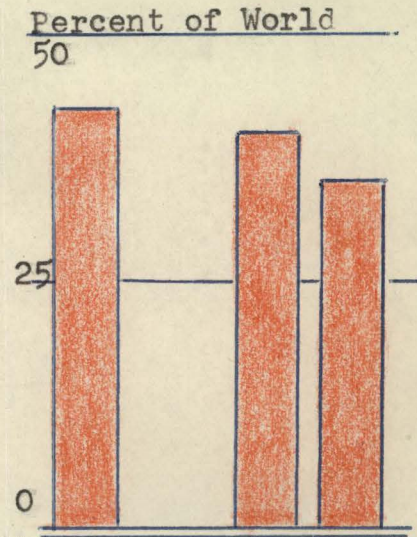
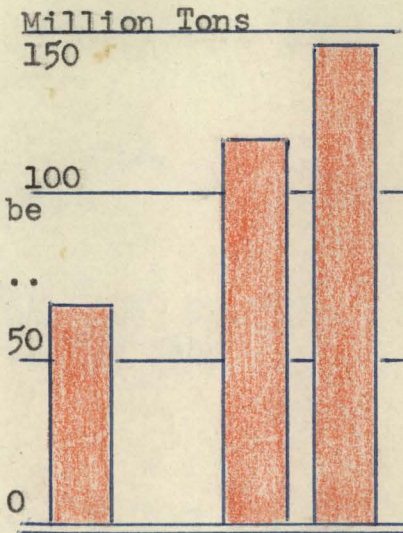
Steel production is still the best single measure of industrial advance. No other material is so broadly used in industrial products. The world has roughly doubled its production of steel since 1940. It produced about 298 million tons last year. The United States' share of the world output dropped from 42.9% to 39.3% and is steadily dropping. Many of the European nations are losing ground the same way. The Soviet Union is the big gainer; it will have 26.2% of the world total by 1960.

World Steel Makers Have Doubled Their Output.....Plan To Add 100 Million Tons Of Capacity By 1960



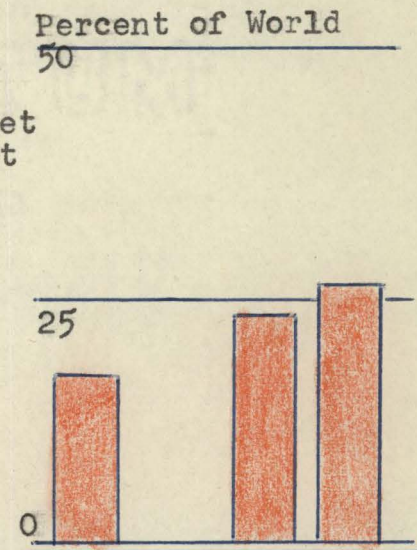
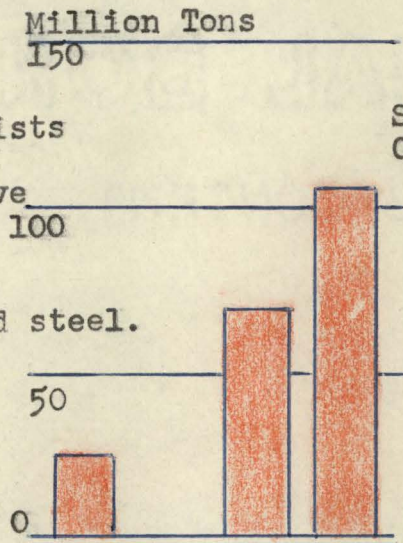
66 "Advances all Around the Globe", Business Week, (September 15, 1956), p. 31.

U.S. will still be top producer..... but its share will fall.



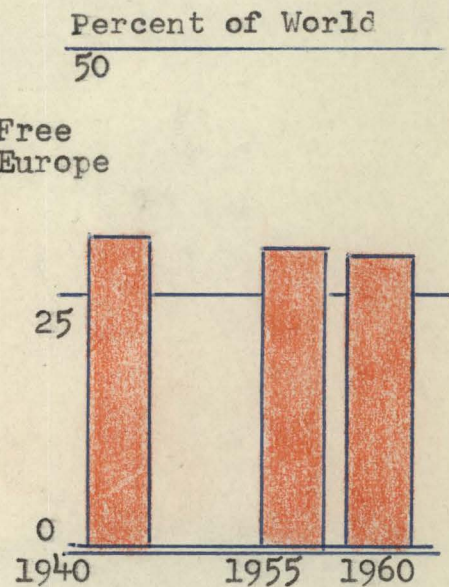
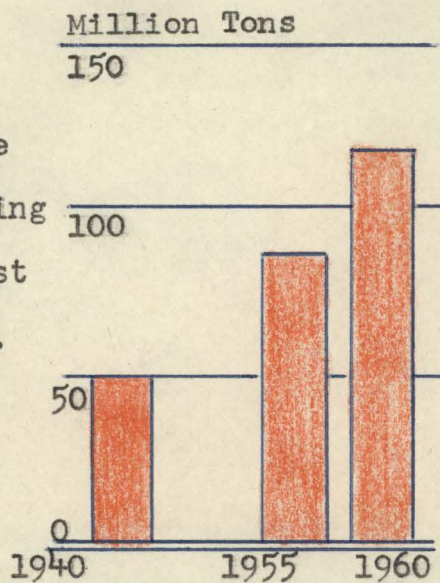
By 1960, Communists Nations will have more than a quarter of world steel.

Soviet Orbit



Western Europe is about holding its own in post war expansion.

Free Europe



## THE FUTURE

The geography of iron ore production will be slowly modified owing to increasing consumption and the exhaustion of such outstanding supplies as those of Spain and, at a considerably later date, those of the Lake Superior region. Larger production may be expected from the great reserves of the southeastern United States, and Newfoundland, and possibly also from England. Brazilian ores will be used by Europe and the United States. There will be greater importations by Europe from North Africa, and by the United States from Cuba. Iron and Steel production in the United States is likely to show some migration to the Atlantic Coast, reflecting the growing dependance on foreign iron ore supplies. India, South Africa, Russia, and Australia are likely to increase their production mainly for local uses. India, with the largest high-grade reserves on the Pacific basin may become a considerable exporter of ore. The Far East will show little increase, except possibly in the Phillippines and the Dutch East Indies in the more distant future.



There are possibilities of further discoveries of large iron ore deposits principally in the remote regions of the world. Such deposits would probably be tributary to the centers already established, but if they should prove, eventually, to be adequate for large development, it is practically certain that many years must elapse before their influence upon the geography of the iron and steel industry begins to be largely felt.

Steel will continue to form the skeleton framework within the body of modern civilization. Without steel the whole range of power-generating and power-using industries would be virtually impossible. Modern building requires enormous quantities of steel; speedy and abundant transportation are alike dependent upon steel; communication, whether by telephone, telegraph, and radio is similarly conditioned. The tools of industry and the implements of war, the thousand and one essentials and conveniences of daily life are all made in whole or in part steel.<sup>68</sup> Consequently, when the British and French governments put troops into the Suez area, they raised in Steelman's minds the possibility that automobile and major appliance manufactures in the

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<sup>68</sup> Bain, op. cit., p. 77.

United States might be rationing their customers next year. This possibility revolved, of course, around the Suez Canal, if it should be closed long to Western shipping.<sup>69</sup>

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<sup>69</sup> "Advances ... Globe", op. cit., p. 30-31.

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"Advances all Around the Globe", Business Week,  
(September 15, 1956), pp. 30-32.

## GLOSSARY

- Antimony.....An element of metallic appearance used in alloys to give hardness--the property of expanding on solidification.
- Asbestos.....A kind of mineral unaffected by fire.
- Barite.....A common mineral in metallic veins and is often called heavy spar.
- Bauxite.....A ferruginous aluminum hydroxide.
- Carbonate.....To impregate with carbonic acid or carbon dioxide.
- Chromite.....A mineral of the spinel group, composed of iron, chromium, and oxygen.
- Coke.....The residue obtained when coal is subjected to destructive distillation, it is used as a fuel.
- Ferroalloy.....A crude alloy of iron with some other metal.
- Ferromanganese.....Alloy of iron with manganese.
- Fluorspar.....The mineral fluorite.
- Graphite.....Soft, black native carbon of metallic luster.
- Gypsum.....Used as a dressing for soils, for making plaster of paris.
- Hematite.....Iron ore, red when powdered.
- Ilmenite.....Iron-black mineral composed of iron, titanium and oxygen.

- Lead.....Heavy, pliable, and inelastic metallic element.
- Limestone.....Rock consisting chiefly of calcium.
- Limonite.....Hydrous ferric oxide, and important ore of iron.
- Long ton.....2240 lb.
- Manganese.....Grayish-white metal with a reddish tinge.
- Magnetite.....Iron oxide, sometimes possessing polarity.
- Mercury.....Heavy silver-white metallic element, stays liquid at ordinary temperatures.
- Metric ton.....220.6 lb.
- Mica.....Mineral silicate crystallizing in monoclinic forms that readily separate into very thin leaves.
- Nickel.....A hard malleable, ductile; metallic element, nearly silver-white, capable of a high polish, and resistant to oxidation.
- Nitrates.....A salt or ester of nitric acid.
- Nonferrous.....Not containing, including or pertaining to iron.
- Oxide.....A binary compound of oxygen with an element or radical.
- Phosphorus.....Nonmetallic, poisonous, active element of the nitrogen group.
- Pig iron.....Crude iron, the direct product of the blast furnace.
- Platinum.....A heavy grayish-white noncorroding precious metallic element.
- Potash.....Potassium carbonate.

- Pyrite.....A common mineral of a pale brass-yellow color and metallic luster, chemically iron disulfide, burned for making sulfuric.
- Schist.....Metamorphic crystalline rock having a foliated structure.
- Sedimentary.....Deposits of sedimate.
- Short ton.....2000 lb.
- Siderite.....Native ferrous carbonate, a valuable ore.
- Silica.....Silicon dioxide, occuring in quartz.
- Siliceous.....Pretaining to, or like silica.
- Smelter flux.....Material used to seperate metal.
- Sulfide.....Compound of sulfur with an element.
- Synclinal.....Formed by strata dipping toward a common line.
- Titaniferous.....Containing titanium, a metal resembling silicon.
- Tungsten.....A metallic element of the chromium family, white and ductile when pure.
- Zinc.....A bluish-white crystalline metallic element, brittle when cold, mallable at 110-210°C. and brittle at 260°C.