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The Manganese Industry of the U.S.S.R.

By Vasilli V. Strishkov and Richard M. Levine

BUREAU OF MINES ★ UNITED STATES DEPARTMENT OF THE INTERIOR

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NOTE.--At the time of report preparation, sources reported a joint-venture contract between the Soviet Union and Brazil's Cia Vale do Rio Doce (CVRD) for construction of a ferromanganese plant in Brazil.

Subsequent information does not confirm completion of negotiations or the proposed terms of the contract. The discussions of this venture, which are contained in the last paragraph of the "Introduction" and of the "Conclusions" sections of this report, should not be considered final.

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UNITED STATES DEPARTMENT OF THE INTERIOR
Donald Paul Hodel, Secretary

BUREAU OF MINES
David S. Brown, Acting Director

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PREFACE

This study of the Soviet manganese industry is intended to aid in assessing the present and future role of this leading world producer upon world supply of this strategic metal. Manganese is essential in the production of iron and steel, and no adequate substitute has been found. Manganese ore, however, is only mined in large quantities in a few countries of the world, and no manganese ore is presently commercially mined in the United States. For over 40 yr the U.S.S.R. has been the world's largest manganese producer. Its production is triple that of the world's second largest producer—the Republic of South Africa. The state of the Soviet manganese industry is a matter of growing concern. Its reserves of high-grade manganese ore are being depleted and, in recent years, the country has imported manganese ore and contracted to import ferromanganese, although continuing its exports, primarily to CMEA countries.

CONTENTS

ILLUSTRATIONS

TABLES

TABLES —Continued

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

h	hour
h/d	hour per day
h/yr	hour per year
kg	kilogram
kg/mt	kilogram per metric ton
km	kilometer
km^2	square kilometer
kW	kilowatt
kW·h/mt	kilowatt hour per metric ton
m	meter
mm	millimeter
m^3	cubic meter
m^3/mt	cubic meter per metric ton
mt	metric ton
mt/d	metric ton per day
mt/yr	metric ton per year
MV	megavolt
rev/h	revolution per hour
V	volt
yr	year

THE MANGANESE INDUSTRY OF THE U.S.S.R.

By Vasilii V. Strishkov[1] and Richard M. Levine[2]

ABSTRACT

This Bureau of Mines report on the Soviet manganese industry presents information on reserves, mining, technology, ferroalloy production, trade, and consumption. It examines the Soviet manganese industry from its historical origins to the present and provides an outlook for the future. This report demonstrates that in all likelihood the Soviet manganese industry will experience increased difficulty. Although the U.S.S.R. is the world's largest producer of manganese ore, its reserves of high-grade ore are being depleted, resulting in the need to import ore in recent years and, in 1987, to contract to engage in a joint venture, that would enable it to import Brazilian ferromanganese. Furthermore, at the same time that high-grade manganese ore reserves were being depleted, the Soviets rapidly expanded electric-furnace ferromanganese production capacity, thereby increasing the need for high-grade manganese concentrate. Soviet production in the future will probably be based on extensive reserves of the lower grade carbonate ore, for which the Soviets have not yet mastered the necessary processing technology. In addition, Soviet consumption of manganese in steelmaking per ton of steel produced is more than double the amount consumed in industrially advanced countries. The U.S.S.R.'s future supply of manganese of domestic origin will depend on both mastering the technology for processing the lower grade carbonate ore and on introducing improvements in mining, beneficiation, ferroalloys production, and steelmaking to reduce manganese consumption.

[1]Soviet Union specialist.
[2]Foreign mineral specialist, Division of International Minerals, Bureau of Mines, Washington, D.C.

SUMMARY

All Soviet manganese production and trade is state controlled and operated. Annual, 5-yr, and longer term plans are developed by the Government to guide the course of the manganese industry. The annual plan carries the force of law, and enterprises produce to fulfill plan targets rather than produce in response to market forces. The Soviet Union's principal goal in manganese production is achieving self-sufficiency and providing for its Council for Mutual Economic Assistance (CMEA)[3] partners.

Over 95% of Soviet manganese ore production now comes from two locations, the Nikopol' basin in the Ukrainian S.S.R., which provides over 70% of total ore production, and the Chiatura deposit in the Georgian S.S.R., which provides over 25%. Output from these deposits, although chiefly oxide ores, includes some of the lower grade carbonate ores. A small amount of manganese ore is produced from deposits in the Kazakh S.S.R. Additional deposits in the Ural Mountains, from which manganese had been mined, are no longer in operation. Deposits of the lower grade carbonate ore occur in Siberia and other parts of the country, but are not presently being exploited nor do they appear to be of any great significance.

Economic reserves of manganese ore in 1985 are estimated at over 2.2 billion mt, 80% of which is located in the Nikopol' basin and 9% of which is located in the Chiatura deposit. The more easily used oxide and oxidized manganese ores comprise about 15% of total reserves with the remainder being carbonate ore. The richest oxide and oxidized ores are being rapidly depleted and could be entirely depleted within 18 yr.

Over 60% of Soviet manganese ore presently is mined from open pits. The Soviet manganese industry uses equipment ranging from state of the art to outmoded, and labor productivity is low compared with that of advanced industrial countries. Much of the needed state-of-the-art equipment is not available from domestic sources in the quantities required.

Although manganese ore was originally produced in Czarist Russia mainly for export, since the Soviet Union began rapid industrialization in the 1930's, it has been producing manganese ore mainly for its own consumption. The Soviet Union has long been self-sufficient in manganese ore and has been able to export from 10% to 20% of its output to its CMEA partners and to world markets. Since the mid-1970's, however, the Soviet Union has practically ceased shipments of manganese ore and ferromanganese to non-CMEA countries.

In the early 1980's, the Soviets began importing manganese ore to compensate for decreasing production of high-grade ore and, in 1987, the Soviets contracted a joint venture with Brazil's Cia. Vale do Rio Doce (CVRD), which would enable the Soviets to import 75,000 mt/yr of ferromanganese from Brazil. It is unlikely in the near future that the Soviets will resume exporting large quantities of manganese ore to market economy countries. The Soviet Union claims that it does not now have surplus ferromanganese to sell on world markets.

INTRODUCTION

This Bureau of Mines report examines the Soviet manganese industry from its historical origins through the present and provides projections for the future. It presents a summary of published reports on, and detailed analysis of, reserves, mining, processing, technology, ferroalloy production, and trade. The bulk of the information presented in this study was obtained from Soviet publications. Where Soviet data are lacking, estimates were made based on all available sources of information. This report is considered by the authors to be a comprehensive treatment of the Soviet manganese industry based on published literature.

Although this report has been included in the Bureau's Mineral Issues series, no attempt has been made to specifically identify and evaluate within the text the mineral policy issues involved. This hinges on the U.S.S.R.'s historic and traditional position as the world's preeminent producer of manganese ore, and on the fact that, at least in short term, no other producer or group of producers could adequately provide sufficient additional manganese to substitute for the quantity produced in the Soviet Union. The criticality of the situation is primarily the result of the depletion of high-grade reserves in the U.S.S.R., and the fact that much of the remaining low-grade reserve or resource is of the metallurgically difficult-to-process carbonate ore. The situation is heightened by the external and internal politico-economic problems that presently prevail in the case of the world's second-ranked producer, the Republic of South Africa.

While Soviet-produced manganese is today used largely within the U.S.S.R. itself and in the steel industries of countries that are linked to the U.S.S.R. by membership in CMEA, any substantial reduction in Soviet output, unless matched by a reduction in demand within this group of countries, could produce severe dislocations in the supply-demand balance in the market economy world, particularly considering the South African situation.

[3]Bulgaria, Cuba, Czechoslovakia, German Democratic Republic, Hungary, Mongolia, Poland, Romania, and Vietnam.

CHAPTER 1.—DEFINITION OF TERMS AND WORLD SIGNIFICANCE OF THE SOVIET MANGANESE INDUSTRY

DEFINITION OF TERMS

Manganese ore falls into four general classifications determined largely by adaptability to the principal categories of use—metallurgical, chemical, battery, and miscellaneous. The ferrous industry accounts for the consumption of over 85% of the total manganese ore used in the Soviet Union, mainly in the production of ferromanganese and pig iron. The chemical and electrochemical industries consume about 4%, and the nonferrous industry (and others) consume 11% of the total. The relatively small tonnage of special grade ore, which is essential for use in dry cells and chemicals, has not been separated statistically in this broad review.

Soviet specifications for marketable manganese ores produced in the Chiatura (Georgia) and Nikopol' (Ukraine) mining and beneficiation complexes require that they shall have a manganese content of 25% to 57%. Detailed specifications are given by grade in table 1.

Manganese stands with chromium as one of the most used and most useful ferroalloy elements. In order to obtain high-grade ferromanganese (80% Mn) the Fe-Mn ratio in the ore should not be more than 1:8. To smelt a 70% alloy, ore with an Fe-Mn ratio of 1:6 may be used. Phosphorus content in manganese ores used for ferromanganese smelting should not exceed 0.0035% per 1% Mn.

First-grade Chiatura and A-grade Nikopol' concentrates are usually used in the production of ferroalloys in electric furnaces. For the aluminothermic production of manganese metal, ores should be very rich and free from admixtures. Moreover, not more than 0.091% Fe and 0.002% P per 1% Mn should be contained in the ore.

Different methods used for the production of metallic manganese require different ore characteristics, but ordinary manganese ores are suitable for silicothermic production of metallic manganese.

The Soviet Union has somewhat different standards for exported manganese ore than those for production. The manganese ores of the Chiatura and Nikopol' deposits exported by the U.S.S.R. should meet the specifications given by grade in table 2.

[1]Italic numbers in parentheses refer to items in the list of references at the end of this chapter.

Table 1.—Soviet specifications for marketable-grade manganese ore, percent

Mining area, ore type, and Soviet grade classification number	Av Mn	Av SiO_2	Max P	Moisture
Chiatura:				
Peroxides:				
I	57	7	0.20	8
II	54	8	.20	8
III	50	8	.20	8
Concentrates:				
I	50	10	.20	8
II	47	15	.20	9
III	40	20	.20	15
IV	30	32	.20	15
Nikopol', concentrates:				
A	47	NS	.19	14
I	43	NS	NS	16
II	34-33	NS	NS	19
III	25-34	NS	NS	22

NS Not specified in source.
Source: Reference 2.

The Soviet Union also exports peroxide type manganese ores used in the chemical industry as a raw material for the production of potassium permanganate and manganese compounds; in the manufacture of dry cell electric batteries; in the glass industry for decoloring and staining glass; in the ceramic industry for colored glazing or as a brown dye; and in driers in varnishes and paints.

Exports of peroxide from the Chiatura manganese basin should meet the following specifications: Manganese peroxide, minimum 84%; silica, 6% to 7%; iron, maximum 1.2%; and moisture, 7% to 8%.

The principal differences in definitions between those used in this report and those in standard Bureau of Mines practice is in the classification of reserves. According to the Soviet classification scheme approved in 1982 *(8)*[1] deposits of all solid mineral materials are classified under two cross-imposed systems, one relating to the economic viability of the material in question, and the other relating to the reliability of the information on the quantity of material in place.

Under the first system, the Soviets separate deposits into one of two categories, "balansovyye" or "zabalansovyye." The former word literally translated means balance, this term referring to the fact that materials so classified are included in studies relating to mineral reserves in place that are suitable for exploitation. This balansovyye material, in effect, is that which currently is regarded as viable for economic development or exploitable. The other category term, zabalansovyye, translates literally as beyond balance, the term implying that materials so classified are not regarded as suitable for economic exploitation at the present. Manganese ore in place must have a minimum manganese content of 10% to qualify for the balansovyye category.

The second classification system relating to the reliability of information on the quantity of material in place assigns each occurrence to one of seven categories, the traditional A, B, C_1, and C_2, and three more, P_1, P_2, and P_3. The first four categories are regarded as reserves by the Soviets, but some materials reported in each of these classes may not correspond to the Western concept of reserves (i.e., material economically exploitable under present market prices with existing technology). That is, some of the materials in A, B, C_1, or C_2 categories may be regarded as zabalansovyye. The final three categories, prognoznyye resursy (prognosticated resources), together with zabalansovyye material from categories A, B, C_1, and C_2, correspond very roughly to the Western term "resources."

Mining and construction of mining enterprises and the appropriate capital investment are authorized on the basis of the economic (balansovyye) reserves in place in categories $A + B + C_1$, which must be in prescribed ratios. Reserves

Table 2.—Soviet specifications for exported manganese ore, percent

Mining area and Soviet grade classification number	Min Mn	Max SiO_2	Max P	Max moisture
Chiatura: I and II	46	11	0.2	8
Nikopol':				
I	43	17	.25	16
II	34	28	.25	22

Source: Reference 11.

in the C_2 category are also taken into account in project planning for mining enterprises, to provide a general perspective of the development, but they do not constitute a justification for project planning.

All of these four categories (A, B, C_1, and C_2) are based on the data obtained on an exploration grid of prescribed density (or by its equivalent) and on certain types of chemical and other tests according to regulations. Density of the grid, in each of the reserves categories, is different for different kinds of ore and for five different types of ore bodies, depending on geological formation.

According to Soviet classification, the reserves and resources of solid mineral raw materials in place are divided into explored (razvedannyye)—A + B + C_1 categories and perspective (perspektivnyye)—C_2 category. The categories P_1, P_2, and P_3 are prognosticated resources (prognoznyye resursy). The appropriate specifications for each of these four categories are as follows:

A—The reserves in place are known in detail. The ore body boundaries are outlined by trenching, exploratory boreholes, or exploratory workings; the depositional environment, the proportion of different commercial grades of the ore, and the hydrogeologic conditions of the exploitations are ascertained; quality and technological properties of the ore are ascertained in detail, assuring the reliability of the projected beneficiation and production operations.

B—The reserves in place are explored. The ore bodies are outlined by exploratory workings or by exploratory boreholes; the depositional environment is known; types and industrial grades of the ore are ascertained but without details of their distribution; quality and technological properties of the ore are known sufficiently well to assure the correct choice of the system for its beneficiation; general conditions of the exploitation and the hydrogeologic environment, as a whole, are known in fair detail.

C_1—The reserves in place are estimated by a sparse grid of exploratory boreholes or exploratory workings. This category also includes reserves adjoining the boundaries of the A and B categories of ore as well as the reserves of the very difficult deposits in which the distribution of the values or of mineral cannot be ascertained even by a dense exploratory grid; quality, types, industrial grades, and technology of beneficiation are ascertained tentatively by means of analyses and laboratory tests and by analogy with known deposits of the same type; general conditions of exploitation and general hydrogeological environment of the deposit are known tentatively.

C_2—The reserves in place adjoining the explored reserves of A plus B plus C_1 categories and reserves indicated by geologic and geophysical evidence confirmed by boreholes.

Depending on the nature of deposits, various boring and excavation methods are used in the determination of ore reserves for all solid minerals in the Soviet Union. The major groups into which deposits are divided follow:

First Group Deposits—These deposits are simple in form, and have large dimensions and uniform distribution of minerals (such as coal deposits, many deposits of iron ore, and disseminated copper deposits). The high category reserves of such deposits can be determined by boring with a normal density grid of boreholes. Excavation is used only for controlling the data of samples from boreholes and for taking bulk samples.

Second Group Deposits—This group includes large deposits of different and sometimes complicated forms, with uneven distribution of mineral content. A combination of both drilling and exploratory workings is required to determine ore reserves. With a normal grid of boreholes, only B category reserves might be revealed by drilling. With close-spaced drilling, and control by exploratory workings, it is possible to establish A category reserves.

Third Group Deposits—These include deposits of medium dimensions with irregular distribution of ore minerals, such as vein or dyke deposits. Reserves of A and B categories can be revealed only with the help of openings. Drilling alone can establish reserves only of C_1 category.

Fourth Group Deposits—These include deposits similar to group 3 but with smaller ore bodies of more complicated forms. It is impossible to establish category A reserves under a normal grid of openings. Exploratory openings and underground drilling are needed to determine ore reserves of category B.

Fifth Group Deposits—These are small pocket deposits of categories A and B which could not be established by systematic prospecting. Only category C reserves can be established.

Virtually all manganese deposits are classified as falling in groups 1 and 2. The State Commission for Mineral Reserves [Gosudarstvennaya Kommissiya po Zapasam (G.K.Z.)] or, in the case of small projects, the Territorial Commission for Mineral Reserves [Territorial'naya Kommissiya po Zapasam (T.K.Z.)], of the Ministry of Geology of the U.S.S.R. certifies the reserves in question as adequate for planning purposes.

As previously noted, U.S. and Soviet categories of mineral reserves do not entirely coincide. U.S. measured, indicated, and inferred categories cannot be precisely matched to the Soviet A, B, C_1, and C_2 categories. Evaluations of Soviet mineral reserves in U.S. terms require an understanding of the Soviet classification system; the Soviet category A may be taken as equivalent to the U.S. category of measured ore, and category B corresponds fairly well to the U.S. category of indicated ore. This is ore in place that is computed from information similar to that for the previous category, but of a lesser degree of detail or certainty.

The U.S. category of inferred ore is based on geologic evidence, with or without some supporting measurements. This category differs most from the corresponding Soviet categories—C_1 and C_2. The Soviet categories both require that geologic and geophysical evidence be confirmed by boreholes. Since the early 1960's, the Soviets have not reported categories A, B, and C_1 separately; they are all considered adequate for planning purposes. These are referred to as razvedannye, or explored. It should now be noted that it is possible that some manganese ore may be classified as A, B, or C, and yet fall within the zabalansovyye (or uneconomic) category. This is not common, but it can occur.

Finally, resources, rather than reserves, are referred to as prognoznyye resursy, or prognosticated resources, and are placed in three categories, P_1, P_2, and P_3, representing progressively lower orders of reliability of knowledge of the deposits. In the United States, these are all in the category of inferred resources.

A simplified chart of reserve classification categories of Soviet manganese ore is presented in figure 1, which also shows the relationship of the reserve categories to materials produced, including both marketable output and losses, as well as to materials that cannot be recovered for technical reasons.

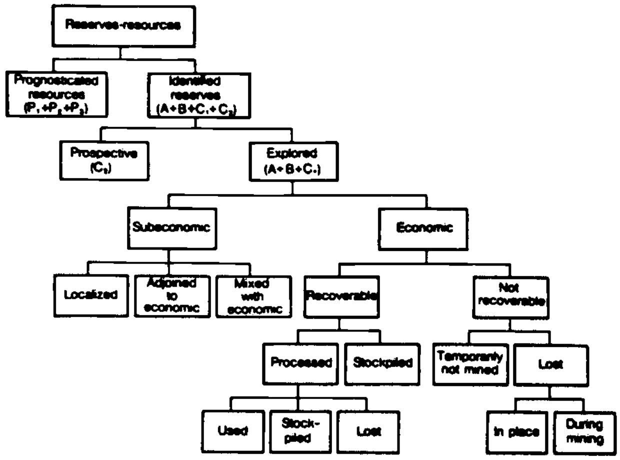

Figure 1.—Soviet reserve-resource classification for solid minerals.

World and National Significance of the Soviet Manganese Industry

Among the major steel producing countries of the world, the U.S.S.R. is the only one that is self-sufficient in manganese. The Soviet Union is not only the world's largest producer of manganese but is also the largest consumer and a substantial exporter. The average consumption of manganese per metric ton of crude steel produced in the Soviet Union is at least double that in advanced industrial countries (7).

In 1984, with a marketable output of 10.1 million mt (over 24 million mt of crude ore with an average grade of 20% to 23.4% Mn), the U.S.S.R. was the world's largest producer of manganese. Although production was down from the peak of 10.24 million mt posted in 1979, output in 1984 was nearly half of the world production (approximately 23 million mt). In 1984, Soviet production was followed by the Republic of South Africa (3.0 million mt), Brazil (2.7 million mt), Gabon (2.1 million mt), China (1.6 million mt), and India (1.1 million mt).

Although the U.S.S.R. is the largest producer of manganese ore in the world, the majority of its production is consumed domestically and exported to other Council for Mutual Economic Assistance (CMEA) countries. Exports to the West, as ore or ferromanganese, are small. Total exports of manganese ore decreased from 1.32 million mt in 1979 to 1.08 million mt in 1984. In 1984, only a small quantity was shipped to market economy countries. About 1 million mt was exported to CMEA nations; workers from these countries are employed in the Soviet manganese industry as a part of the trade agreement

Exports of manganese ore to Western countries have declined because of increasing consumption in the U.S.S.R. and in East European countries and because of a shortage of high-quality ores. As a result, the U.S.S.R. has, for the first time, begun purchasing substantial quantities of manganese ore from the free market, with the possibility of importing as much as 500,000 mt/yr in the foreseeable future.

In Africa, the U.S.S.R. purchased manganese concentrate from Gabon. Reportedly, this material has a high manganese content and the Soviet Union has been experiencing a decline in its high-grade concentrate production, which is centered in the Chiatura basin in Georgia. Australia and Brazil also are suppliers of manganese ore and/or concentrate to the U.S.S.R.

With estimated explored exploitable reserves of ore in place (in Soviet categories $A + B + C_1$) of 2,208 million mt in 1985, with an average manganese content of 15% to 20%, the U.S.S.R. accounts for about 18% of the world reserve total of about 10,900 million mt, behind the Republic of South Africa (about 78%), but considerably ahead of Australia, Brazil, and India. The Soviet reserves include 325 million mt of oxide ores and 1,883 million mt of carbonate ores. Reserves of high-grade ore are located in the Chiatura manganese basin in Georgia.

From the domestic viewpoint, the Soviet manganese mining industry is significant only to the Ukraine and Georgia. About 80% of total output came from the Ukrainian S.S.R. Nikopol' basin, and virtually all the remainder came from the Georgian S.S.R. Chiatura basin. From the viewpoint of foreign exchange earnings, manganese contributes far under 1% of total export sales value. Manganese exports, however, in nonhard-currency transactions, are significant to the East European countries. Although detailed employment data are lacking, the manganese mining industry is undoubtedly a significant employer in Georgia and less significant in the Ukraine. It should be borne in mind however, that manganese is essential to the Soviet steel industry, a very large employer in the Ukraine and a significant one elsewhere.

The principal Soviet manganese basin, the Nikopol' in the Ukraine, has reserves many times greater than the Chiatura, but the ore grade is lower and the deposit is little more than 2 m thick and under as much as 80 m of overburden. Two complexes, the Ordzhonikidze and Marganets, operate in the Nikopol' basin, containing 19 underground mines, 10 open pits, and 6 concentrators, that produced 7.2 million mt of concentrate in 1984. A third complex, the Tavricheskiy, for development of the Bol'shoy Tokmak deposit, is under development. More than 70% of the Nikopol' ore comes from open pit operations. Of the total amount of concentrates, about 48% had a manganese content of over 45% Mn; the balance contained 25% to 34%. The Nikopol' basin is the principal supplier of manganese concentrate to Hungary, Poland, German Democratic Republic, and Czechoslovakia.

The Chiatura manganese basin in Georgia, the richest in the U.S.S.R., produced 2.8 million mt of concentrate in 1984 from 24 underground mines and open pits and 9 concentrators. Over 80% was extracted from underground mines. Of the total amount of concentrates, 66% contained 48.7% Mn and the rest contained 25.6%. Small amounts of manganese ore are produced at the Dzhezdy, Atasu, and Ushkatyn Mines in Kazakhstan. The Dzhezdy manganese ore dressing plant, which was put into operation in 1965, produced low-grade concentrate for the Nikopol' (Ukraine) and Yermak (Kazakhstan) ferroalloys plants. Kazakhstan's manganese ore is sulfur free and does not contain other impurities.

Table 3 shows Soviet production, trade, and apparent consumption of marketable manganese ore and its relation to world output for the 1900–84 period.

Table 3.—Role of the U.S.S.R. in world manganese ore supply and salient Soviet manganese statistics

Year	World marketable production: Total, 10^3 mt	World marketable production: U.S.S.R. share, %	Salient Soviet statistics, 10^3 mt: Production: Crude ore[1]	Production: Marketable	Exports	Imports	Apparent consumption[2]
1900	1,318	57.3	1,060	755.1	440.9	0	314
1910	2,036	39.0	1,115	793.5	667.5	0	126
1911	1,598	38.4	820	581.2	634.9	0	(3)
1912	1,903	48.7	1,310	926.4	1,007.8	0	(3)
1913	2,303	54.1	1,750	1,245.3	1,193.8	0	52
1914	1,868	48.6	1,270	907.0	751.5	0	156
1915	1,414	38.0	750	537.5	0	0	537
1916	1,881	25.1	660	471.8	1.5	0	470
1917	2,109	18.6	550	393.3	0	0	393
1918	1,782	7.1	176	126.3	0	0	126
1919	1,211	5.4	92	65.6	0	0	66
1920	1,703	7.4	175	125.3	0	0	125
1921	1,146	1.0	17	12.0	28.8	0	(3)
1922	1,182	7.1	117	84.0	195.7	0	(3)
1923	1,625	13.8	315	223.5	413.9	0	(3)
1924	2,043	20.9	600	426.8	[4]494	0	(3)
1925	2,594	26.1	950	676.4	[4]527	0	149
1926	3,049	33.7	1,450	1,028.6	[4]673	0	356
1927	3,182	26.5	1,190	843.8	[4]785	0	59
1928	2,868	24.5	980	702	515	0	187
1929	3,730	37.8	1,970	1,409	1,037	0	372
1930	3,470	39.9	1,930	1,385	769	0	616
1931	2,190	40.4	1,240	884	742	0	142
1932	1,242	67.0	1,170	832	401	0	431
1933	1,731	59.0	1,430	1,021	655	0	386
1934	2,916	62.4	2,640	1,821	737	0	1,084
1935	4,005	59.6	3,450	2,385	645	0	1,740
1936	5,196	57.8	4,350	3,002	606	0	2,396
1937	6,092	45.2	4,000	2,752	1,001	0	1,751
1938	5,292	43.0	3,290	2,273	446	0	1,827
1939	4,728	47.6	3,260	2,252	447	0	1,805
1940	5,411	41.7	[5]3,800	2,557	263	0	2,294
1941	4,302	28.3	1,800	*1,216	[7]177	0	1,039
1942	3,855	15.5	[6]597	[6]597	[7,8]316	0	[8]581
1943	3,629	17.6	[6]638	[6]638	[7,8]6	0	[8]632
1944	2,972	20.6	[6]612	[6]612	[7,8]7	0	[8]605
1945	3,446	42.7	[5]2,700	1,470	[7]137	0	1,333
1946	3,699	46.8	3,100	1,730	281	0	1,449
1947	4,124	49.4	3,480	2,039	319	0	1,720
1948	4,519	50.0	3,610	2,261	621	0	1,640
1949	6,203	46.7	3,720	2,896	328	0	2,568
1950	7,006	48.2	[5]4,700	3,377	277	0	3,100
1951	8,654	47.6	6,000	4,118	177	0	3,941
1952	9,857	44.7	6,600	4,403	371	0	4,032
1953	10,971	42.3	7,180	4,641	460	0	4,181
1954	10,552	43.5	7,300	4,589	615	0	3,974
1955	10,814	43.9	[5]7,800	4,743	852	0	3,891
1956	11,794	41.9	8,400	4,938	918	0	4,020
1957	12,933	39.8	9,000	5,148	806	0	4,342
1958	12,402	43.3	9,670	5,366	833	0	4,533
1959	12,982	42.7	10,280	5,546	979	0	4,567
1960	14,329	41.0	[5]11,100	5,872	973	0	4,899
1961	13,579	44.0	11,600	5,972	896	0	5,076
1962	14,232	45.0	12,800	6,402	963	0	5,439
1963	14,723	45.3	13,600	6,663	986	0	5,677
1964	16,087	44.1	14,900	7,096	979	0	6,117
1965	17,743	42.7	[5]16,300	7,576	1,020	0	6,556
1966	18,002	42.8	16,750	7,706	1,218	0	6,488
1967	16,940	42.4	16,100	7,175	1,250	0	5,925
1968	16,899	38.8	15,100	6,564	1,150	0	5,414
1969	17,124	38.3	15,900	6,551	1,200	0	5,351
1970	18,222	37.5	16,300	6,841	1,200	0	5,641
1971	21,089	34.7	17,550	7,318	1,400	0	5,918
1972	20,821	37.6	18,850	7,819	1,300	0	6,519
1973	21,747	37.9	20,000	8,245	1,300	0	6,945
1974	22,456	36.3	19,950	8,155	1,482	0	6,673
1975	24,656	34.3	20,800	8,459	1,411	0	7.048
1976	24,597	35.1	21,100	8,636	1,342	0	7,294
1977	22,874	37.6	21,100	8,595	1,352	0	7,243
1978	22,642	40.0	22,000	9,057	1,186	0	7,871
1979	26,276	39.0	24,800	10,244	1,317	0	8,927
1980	26,386	37.0	[5]23,700	9,750	1,255	0	8,495
1981	23,492	38.9	22,200	9,150	1,194	0	7,956
1982	24,127	40.7	23,800	9,821	1,144	0	8,677
1983	21,857	45.2	24,100	9,876	1,079	[9]207	9,005
1984	23,089	43.7	24,600	10,100	1,081	[9]333	9,352

*Estimated.
[1] Estimated, except where noted.
[2] Calculated; does not take into account changes in stocks, for which no data are available.
[3] Using the standard formula for apparent consumption (production plus imports minus exports plus withdrawals for stocks minus additions to stocks) and available data (with no stock change information available), apparent consumption is a negative number. Presumably there were stocks accumulated in prior years that made it possible for exports to exceed production. Actual consumption, if any, was minimal.
[4] 12-month period beginning October 1 of prior year and ending September 30.
[5] Reported figure.
[6] Excludes production, if any, by German forces occupying Soviet manganese producing areas. Note that crude ore production and marketable ore production are equal, reflecting the capture and/or damage of Soviet beneficiation capacity.
[7] Trade not officially reported; data presented are summation of imports reported by most, if not all, trading partner countries.
[8] Reported imports by trading partners in 1942 includes 300,000 mt by Germany; presumably this was obtained from mines and/or stockpiles controlled by occupying German forces, and thus this quantity has not been subtracted from production in calculating apparent consumption. Similarly, 2,000 mt shipped to German-occupied Norway in 1943 and 7,000 mt shipped in 1944 have not been subtracted from production in those years, because this material presumably was taken from German-occupied territory of the U.S.S.R.
[9] Reported exports by trading partner countries.

Sources: Soviet data—1900, 1910, and 1964-67, reference 4; 1913, 1928-40, and 1945-63, reference 9; 1968-84, reference 6; 1914-27, references 1 and 5; 1940-44, references 3 and 10. For 1900-84 world total and Soviet share thereof—Bureau of Mines.

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CHAPTER 2.—MANGANESE SOURCES

Ninety-nine percent of present Soviet production of manganese ore is obtained from two areas. One major producer, Nikopol', in the Ukraine, produced 72% of the Soviet output of manganese ore in 1984. The second significant area, Chiatura, in the Georgian S.S.R., supplied the major portion of high-grade concentrate for production of ferromanganese and supplied ores to manganese-deficient areas in the U.S.S.R. and for export.

As the steel industry of the U.S.S.R. was expanded toward the east, emphasis was directed toward the discovery of local sources of high-grade manganese ore to eliminate the long haul from Chiatura. Thus the Dzhezdy and Atasu manganese deposits in Kazakhstan supplied 1% of Soviet total 1984 production of manganese ore to consumers in Kazakhstan and Central Asia.

The location of these and other potential Soviet manganese deposits are shown in figure 2.

The Nikopol' deposit is ideally located near the Ukrainian steel plants, and its output is primarily for the domestic uses and exports to East European (CMEA) nations. Nikopol' and Chiatura, however, are 2,000 to 6,000 km from steel plants in the Urals and Siberia, which produce about half of the Soviet steel. The long haul of a million metric tons or more of manganese ore, or its equivalent in ferromanganese, is a burden on the inadequate railway system.

GEOLOGY AND MINERALOGY

Manganese is widely distributed in nature, and ranks 15th among the elements that make up the Earth's crust. Manganese is a component of a large number of minerals (more than 100), but only a few of them form commercial manganese ore. A list of the most important ore-forming minerals in the Soviet manganese deposits and their principal properties is given in table 4.

Oxides constitute the most important manganese ore minerals in the Soviet Union. Most extensively distributed are those minerals in which tetravalent manganese predominates (pyrolusite, psilomelane). Pyrolusite forms large deposits associated with other manganese-bearing minerals; it corresponds among manganese-bearing ores to anhydrous manganese dioxide and is one of the more common of the specifically identified manganese oxide minerals.

The principal specific manganese carbonate ore mineral is rhodochrosite, which is a member of an isomorphous series with the carbonates of iron, calcium, magnesium, zinc, and cobalt. Although the most common manganese silicate mineral is rhodonite, the oxysilicate, braunite, is the only silicate manganese ore mineral commonly used, which contains from 60% to 69% Mn but is naturally impure and contains up to 10% SiO_2.

Table 4.—Most important ore-forming minerals in Soviet manganese deposits

Mineral	Color	Specific gravity	Composition	Mn content, %
Pyrolusite	Black	4.8-5.6	MnO_2	63.2
Manganite	Steel gray	4.2-4.4	[1]$Mn_2O_3 \cdot 3H_2O$	[1]60.4
Braunite	Brownish black	4.7-4.9	[2]Mn_2O_3	[2]69.6
Psilomelane	Steel gray	3.9	$4MnO_2 \cdot R \cdot O \cdot 2H_2O$	45-60
Rhodochrosite	Pink	3.3-3.6	$MnCO_3$	47.8
Rhodonite	..do	3.5-3.7	$MnO \cdot SiO_2$	41.9
Hausmanite	Brownish black	4.7-4.8	Mn_3O_4	72.0
Manganese glance.	Iron black	3.9-4.1	MnS	63.2

[1] As reported in source, Bureau of Mines uses $Mn_2O_3 \cdot H_2O$ with Mn content of 62.4%.

[2] As reported in source, Bureau of Mines uses $3Mn_2O_3 \cdot MnSiO_3$ with Mn content of 63.6%.

Source: Reference 5.

In the Soviet Union, more than 95% of high-grade ores of manganese are in sedimentary deposits. Lacustrine, hydrothermal, and residual deposits of manganese are insignificant. According to reference 11 (pp. 113-115), the following manganese-bearing associations have been recognized in the U.S.S.R.

1. The quartz-glauconite, sand-clay association, which includes the lower Oligocene deposits of the Ukraine (Nikopol', Bol'shoy-Tokmak), Georgia (Chiatura), and Mangyshlak; the upper Pliocene Laba deposits in the northern Caucasus; the group of Paleocene deposits on the eastern slopes of the northern Urals, the Lower Cambrian Oldakit deposit in the Barguza-Vitim area of ore shows east of Lake Baikal, the upper Proterozoic Nizhneudin deposit in the Sayan area, etc. The scale of the ore occurrences is massive.

2. The carbonate associations of the geosynclines and platforms, which include the following deposits: Usa (Lower Cambrian, Kuznetsk Alatau area), Ulutelyak (Lower Permian, Aral region), and Sagan-Zabe (Archean, Lake Baikal region). The manganiferous associations of this type are characterized by moderate scale ore occurrences.

3. The carbonate-chert association with the following typical deposits: Karazhal (Upper Devonian, central Kazakhstan) and Takhta-Karacha (Silurian, Uzbekistan). The scale of ore occurrences is moderate.

4. The group of volcanogenic-sedimentary associations has been subdivided into two types: the spilite-keratophyre-chert type (deposits of the Magnitogorsk region in the Urals, Lower-Upper Devonian) and the porphyry chert type (Durnov deposit, Salair, Lower-Middle Cambrian). Ore occurrences are small.

5. The manganiferous ferruginous-siliceous association (jaspilite); in the region of the Malyykhingan, upper Proterozoic ore segregations of manganese have been developed, the reserves of which are moderate.

The approximate extent of the main reserves of manganese ore in the Soviet Union on January 1, 1966, is given in table 5.

Table 5.—Main Soviet reserves of manganese ore in place,[1] by ore type, percent

Deposit, area, and ore type	Ore type share of deposit reserves, %	Mn content, %	
		Range	Average
Nikopol' (Ukraine):			
Oxide	51.0	23 -29	26
Carbonate-oxide	12.6	20 -27.3	23.8
Carbonate	36.4	17.3-24.7	19.7
Bol'shoy Tokmak (Ukraine):			
Oxide	4.5	NS	34.3
Carbonate	95.5	NS	24.5
Chiatura (Georgia):			
Oxide	45.8	25 -43	36.2
Carbonate	40.0	20 -26.8	22
Oxidized	14.2	24.5-38	28.8
Usa (Kemerovo Oblast', Siberia):			
Carbonate	94.0	18.7-19.6	18.8
Oxide	6.0	26.5-27.7	27.1

NS Not specified in source. [1] On January 1, 1966.

Source: Reference 12.

DESCRIPTION OF INDIVIDUAL DEPOSITS

There are over 70 manganese deposits in the Urals, Kazakhstan, Siberia, and other regions of the U.S.S.R. However, the extensive deposits in the Ukraine and Georgia have overshadowed all others together in output and recorded reserves. The principal deposits are situated in the Ukraine (Nikopol', Bol'shoy Tokmak, and Ingulets) and in Georgia (Chiatura and Adzhameti-Chkhari). Deposits of lesser importance are in Kazakhstan (Dzhezdy, Atasu, and Ushkatyn), the Urals (Polunochnoye) and Siberia (Usa).

Table 6.—Average composition of oxide and carbonate ores, percent

	Oxide	Carbonate
Mn	26-28	10 -30
Fe	2-3	2 - 3
SiO_2	28-30	11 -57
Al_2O_3	4-5	None
CaO	4-5	4 -12
MgO	2-5	1 - 3
P	.2	.1- .4

Source: Reference 7, pp. 150 and 250.

Nikopol'

The Nikopol' group of deposits (south Ukranian basin) to which the deposits of Bol'shoy Tokmak and Ingulets also belong, is the largest Soviet manganese basin. The Nikopol' and Ingulets deposits are located in the Dnepropetrovsk Oblast' (west of the Dnieper River), while Bol-shoy Tokmak is east of the Dnieper River in Zaporozhye Oblast' (fig. 3).

The Nikopol' manganese-ore basin is a portion of the vast south European Oligocene basin, to which the Chiatura (Georgia) and Mangyshlak (Kazakhstan) manganese deposits also belong. The deposits were discovered in 1883 and production began in 1886. The total area of explored deposits is about 500 km². The ore bed is almost horizontal or with a slight (up to 5°) dip south or southwest. The ore is at 10- to 100-m depth. The thickness of ore varies from 0.5 to 5 m, and on the average is 1.5 to 2.5 m thick. The manganese ore layer is characterized by interstratification of the ore with sand-silt clay sediments (fig. 4).

The principal manganese ore minerals are the oxides pyrolusite, manganite, and psilomelane and the carbonates manganocalcite and calcium rhodochrosite. The gangue minerals are quartz, opal, feldspar, clay, calcite, dolomite, sandstone, and calcium phosphate.

The manganese content in oxide ores varies between 10% and 45%; in carbonates it is up to 30%. Silica content in both ore types is high. Only oxide ores containing over 17% Mn and carbonates with over 13% Mn were mined in the Nikopol' ore basin up to 1965. All of the run-of-mine ore is concentrated.

The oxidized ores are quite homogenous. Their average composition is given in table 6. The average composition of the carbonate ores is much less constant (table 6).

Other manganese deposits in the Ukrainian S.S.R., unmined at present, are Khoshchevat and Burshtyn. The Khoshchevat deposit occurs on the left bank of the River Bug in Odessa Oblast'. Manganiferous iron ore, 18% Mn and 28% Fe content, occurs in a mineralized zone 10 km long by 0.8 km wide. Individual lenses range from 2 to 8 m in thickness and up to about 40 m in length. The deposit contains over 3 million mt of possible manganiferous iron ore.

The Burshtyn deposit in Ivan Franco Oblast' is characterized by two types of ore: the carbonate ore, containing 0.5% to 30% Mn, and the oxidized ore, containing 30% to 40% Mn.

Chiatura

Although published ore reserves are not as large as these of Nikopol', the Chiatura deposits were once considered the world's largest deposits of metallurgical grade manganese. It is also the country's principal source of battery grade manganese. These Georgian manganese deposits have been well known for many years as they have long been the largest world producer of high-grade manganese ore. The deposits were discovered in 1849 but were not worked until 1879, when foreign interests started operation. The Kvirila bed is about 350 m above sea level. The pit heads of the mines are located on a much dissected plateau between 350 and 800 m above sea level, near the town of Chiatura, and are connected to the Transcaucasian railroad by a 40-km-long spur from the Sharapani railroad station. The rail distance from the mines to the port of Poti on the Black Sea is 132 km and to Tbilisi 145 km.

The Chiatura sedimentary deposits are similar to those in the Ukraine, occurring in a horizontal bed of Oligocene age, 1.5 to 4 m thick with an average thickness of 2 m, of which 1 to 1.5 m is high-grade ore, covering an area of some 150 km². It is sometimes undulatory and is at places faulted, with throws varying from 3 to 20 m. Manganese derived from nearby granite and quartz porphyry source rocks was dissolved, transported, and precipitated as replacement in Oligocene sediments. The manganese horizons often intercalated with beds of unreplaced sandstones and clays. The bed is underlain by limestone, and occasionally sandstone, and overlain by sandstones and sometimes other Miocene and Oligocene sedimentary rocks. The overburden reaches a maximum thickness of 200 m.

Three types of ore are distinguished in the Chiatura deposit:

1. *Primary oxides ores.*—Principal ore minerals are pyrolusite, psilomelane, and manganite containing an average of 28.9% Mn in the ore. The most valuable oxide ores are developed mainly in the western and especially in the central parts of the Chiatura deposits (Perevisi, Shukrut, Zeda-Rgani, and other plateaus). These ores contain on the average 28.9% Mn (*1*).[1]

2. *Carbonate ores.*—Rhodochrosite, calcium rhodochrosite, and manganocalcite are the principal ore minerals. They are mainly developed in the northwestern sectors, where they occur principally in the upper portion of the ore-bearing horizon. These ores grade on the average 22.5% Mn (*1*) and vary from 10% to 30% Mn, 2% to 4% Fe, 0.1% to 0.3% P, and 20% to 32% CO_2 (*10*).

3. *Carbonate oxidized ores.*—Encountered in the weathered zones, these ores consist primarily of hydrous oxides-vernadite. These oxidized ores are the products of hypergene oxidation and they occur in sectors where carbonate ores are exposed on the surface. The amounts of principal components in these ores are as follows: 27.2% Mn (average) (7, p. 260), 2% to 5% Fe, and 8% to 35% SiO_2 (*11*, p. 140).

The three manganese deposits of Adzhameti-Chkari are located about 30 km west of Chiatura. The ore-bearing formation resembles that of Chiatura. The total thickness of the ore horizon ranges between 0.6 and 3.0 m, but excluding the beds of barren rock, the actual ore thickness is only 0.2 to 1.2 m.

[1] Italic numbers in parentheses refer to item in the list of references at the end of this chapter.

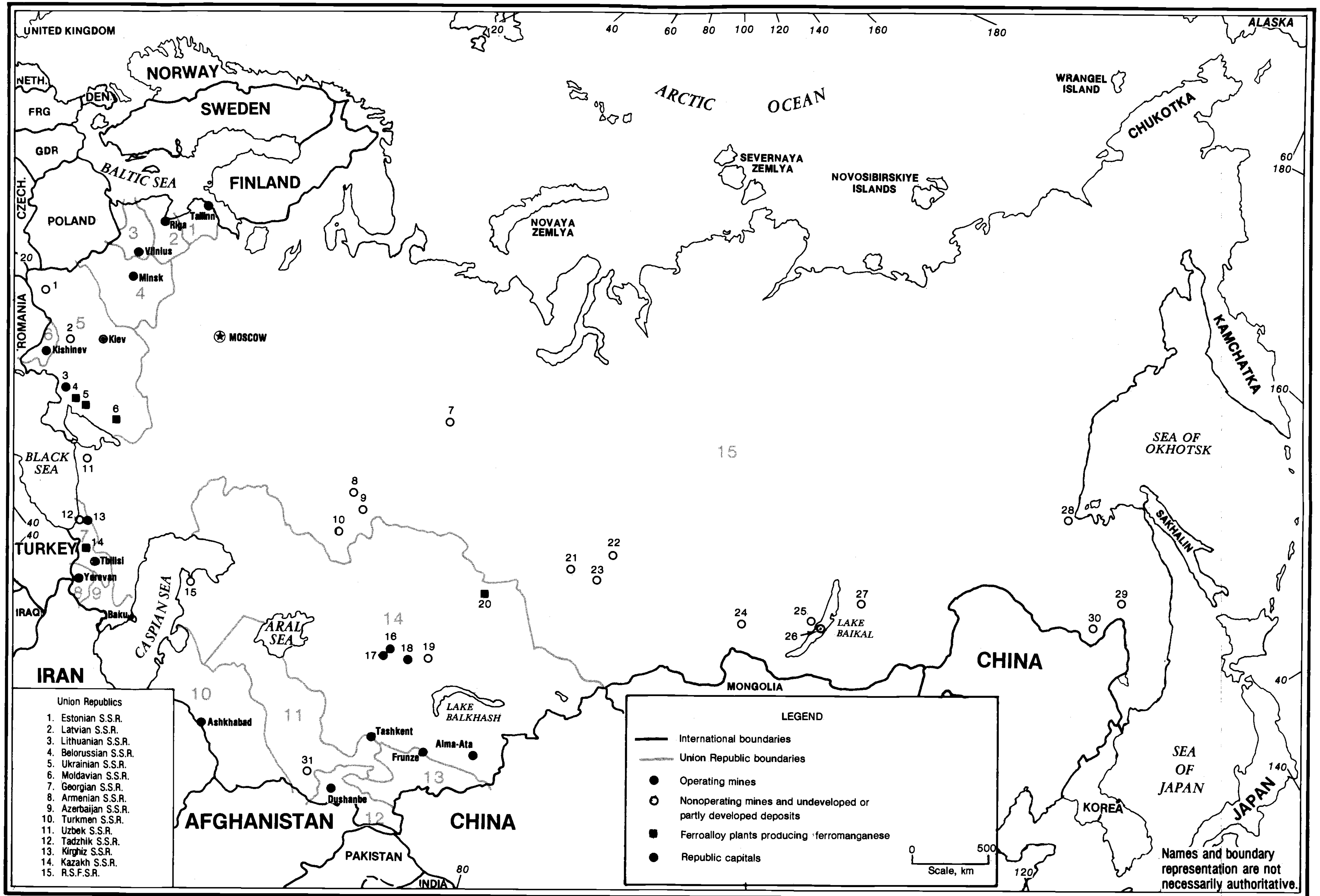
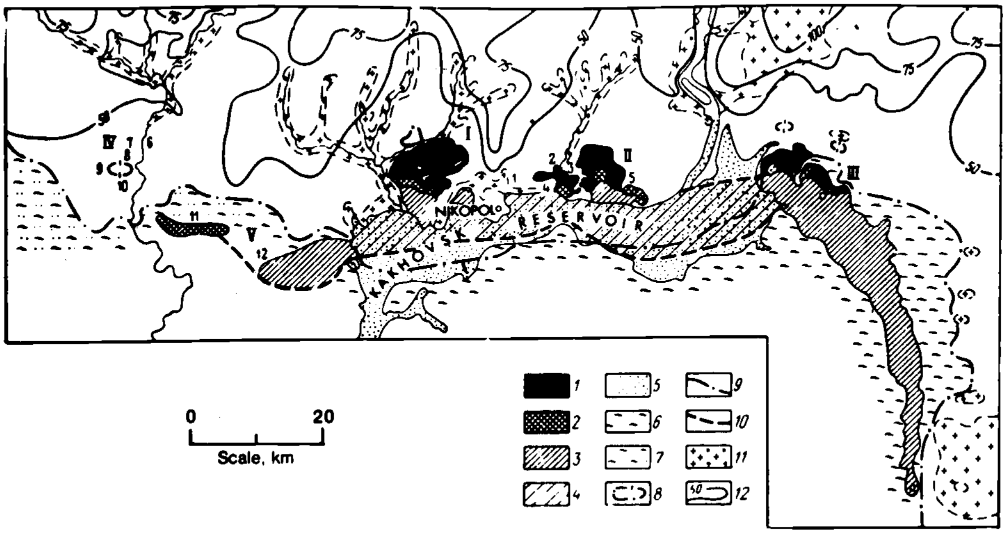


Figure 2.—General location map, Soviet manganese industry.

Manganese mines, beneficiation plants, deposits, and ferroalloy plants known to produce ferromanganese: 1—Burshtyn deposit, 2—Khoshchevat deposit, 3—Nikopol' basin mines, deposits, and beneficiation plants (Marganets, Orzhonikidze, and Tavricheskiy complexes-South Ukrainian basin), 4—Nikopol' ferroalloy plant, 5—Zaporozh'ye ferroalloy plant, 6—Almaz'yan ferroalloy plant, 7—Northern Urals manganese basin deposits (Polunochnoye, Berezovo, Burmanto, Tyn'in, Novo-Berezovo, Yekaterinin, Yurkin, Loz'va, Ivdel, Visher, Marsyata, Kolin), 8—Ulutelyak deposit, 9—Magnitogorsk area deposit group (Niagulov, Yalimbetov, Mamilya, Faizula), 10—Akkermanov deposit, 11—North Caucasus Laba deposits, 12—Adzhameti-Chkari deposits, 13—Chiatura area mines, deposits, and beneficiation plants (mining associations and administrations)—Dimitrov, Lenin, Ordzhonikidze, Stalin, Z. Pataridze, and Kalinin, 14—Zestafoni ferroalloys plant, 15—Mangyshlak deposit, 16—Karsakpai mines, deposits, and beneficiation plant group (Dzhezdy-Ulutau, Promezhutochnoy, Naizatas), 17—Ushkatyn Mine, 18—Atasu mines and deposits group (Karazhal, Bol'shoy Ktay, Keretat, Dal'niyvostok, Dzhumart, Kamys, Shointas), 19—Murdzhik deposit, 20—Yermak ferroalloys plant, 21—Durnov deposit; 22—Mazul' and Porozhin deposits, 23—Usa deposit; 24—Sayan area deposit group (Nizhneudin, Nikolaevo, Kettsk, Kamensk), 25—Sagan-Zaba deposit, 26—Ol'khon Island deposit, 27—Barguza-Vitim zone of manganese ore shows, 28—Uda deposit, 29—Vandan deposit, 30—Malyykhingan deposit group (South Khingan, Ir-Nimin, Poperechnoye, Okhrin, Serpukhovo, Bidzhan), 31—Zeravshan deposit group (Dautash, Takhta-Karacha).

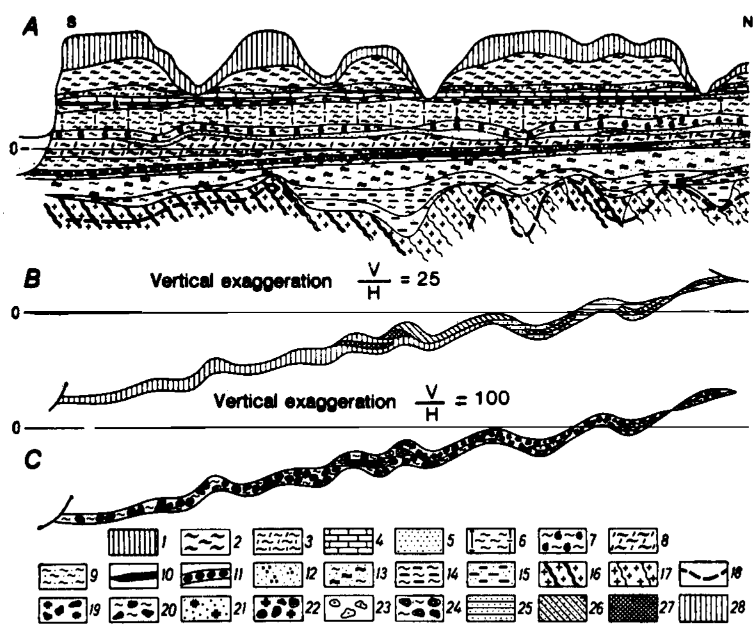


Legend: *1*—dioxide ore, *2*—dioxide and carbonate ores, *3*—carbonate ore, *4*—area in which carbonate ores have been partly or completely eliminated by erosion during post-Oligocene time, *5*—Dnepr terrace (Kakhovsk dam), *6*—Oligocene clays, *7*—Oligocene sandy clays, *8*—islands of Oligocene sediments, *9*—northern boundary of continuous field of Oligocene sediments, *10*—assumed southern boundaries of accumulations of Oligocene sediments and carbonate ores, *11*—outcrops of crystalline rocks on surface and below Quaternary sediments, *12*—structural contours on surface of Precambrian rocks.

Ore-bearing areas: I—West Nikopol', II—East Nikopol', III—Bol-shoy-Tokmak, IV—Krivoi Rog (Ingulets) group, V—Dnepr-Ingulets watershed.

Ore sectors: 1—Maksimo-Timoshevsk, 2—Znamensk and Novoselovka, 3—Nikolaevo, 4—Komintern-Mar'evsk, 5—Grushev-Basan, 6—Novoselovka village, 7—Zelenaya gully, 8—Vizirka station, 9—Ingulets sector, 10—Nikolo-Kozel, 11—Vysokopel, 12—Novo-Vorontsov.

Figure 3.—Distribution of manganese ore areas in the South Ukrainian basin (*11*, p. 118).



Key: 1—Loam, 2—red-brown clays, 3—dark-gray marly clays, 4—limestone-coquina, 5—quartzose sands, 6—marly clays, 7—dark-gray detrital clays, 8—clays with marly seams, 9—greenish gray clays, 10—oxide ores, 11—carbonate ores, 12—quartz-glauconite sands, 13—silts, 14—carbonaceous clays, 15—carbonaceous sands, 16—polymigmatites, 17—plagiogranites and their migmatites, 18—boundary of weathering crust of crystalline rocks, 19—manganese lump-concretion ore in sooty-clay matrix, 20—oxide lump-concretion ore in clay and sand, 21—concretion-oolite ore in sooty-clay matrix, 22—mixed oxide carbonate ore, 23—concretionary carbonate ore with manganite pisolites, 24—concretions of carbonate ore in clay, 25—polypermanganite ore, 26—manganite psilomelane ore, 27—manganocalcite-manganite ore, 28—manganocalcite ore.

Figure 4.—Geological section (*A*), mineral composition (*B*), and fabrics (*C*) of ore layer of the Grushev-Basan sector of the Nikopol' manganese basin (*11*, p. 125).

Kazakhstan Deposits

Apart from the south Ukrainian and the Chiatura manganese basins, the only other presently mined deposits in the U.S.S.R. are located in Kazakhstan. There are three groups of deposits: Atasu (Karazhal), Dzhezdy-Ulutau, and Ushkatyn. At present the following deposits are mined: Dzhezdy (underground) and Promezhutochnoye (surface) of the Dzhezdy-Ulutau group, the Karazhal West and Bol'shoy Ktay deposits of the Atasu group, and the Ushkatyn open pit of the Ushkatyn deposit. The average manganese content of the oxide ores in these deposits is not more than 26%, with from 6% to 13% Fe (*4*, pp. 8-9).

The Atasu group of deposits in Karaganda Oblast' are Upper Devonian. From east to west these deposits are Murdzhik, Shointas, Bol'shoy Ktay, Karazhal East, Karazhal West, Dzhumart, and Dal'niy Vostok. This group of deposits is far less important than the Georgian and Ukrainian deposits. The thickness of the ore horizon ranges from tens of centimeters to 7 to 10 m. Depth ranges between 200 and 1,200 m, and the ore bodies extend from hundreds to several thousand meters each along the strike. Complicated fold structures make mining difficult.

The Karsakpai or Dzhezdy-Ulutau group of manganese deposits, also in Karaganda Oblast' of Kazakhstan, is the source of ore for the Dzhezdy, Promezhutochnyy, and Haysa-Tas mines.

The Mangyshlak deposit is isolated in the desert on a peninsula on the eastern coast of the Caspian Sea, 2 km east of Fort Shevchenko. The oxide ores contain 4% to 47% Mn and 2% to 6% Fe. This large deposit consists mostly of carbonate ores with 16% to 23% Mn and 1% to 4% Fe (*11*, p. 146).

Ural Deposits

There are many manganese deposits in the southern Urals in the vicinity of Sverdlovsk and Chelyabinsk. Only a few of these deposits have proven to be important, even under the stress of wartime. Most of these low-grade deposits, averaging about 20% Mn, have been worked out.

The manganese deposits of the northern Urals are associated with marine sediments of lower Paleocene age and form a 200-km chain along the eastern slope of the Urals. At present, about 20 medium and small deposits, which are separated from each other by distances of 5 to 35 km, are known in this zone. The principal deposits are Polunochnoye, Beresovo, Yurkin, and Marsyata. The lesser deposits include Burmantovo, Tyn'in, Loz'va, Ivdel, Visher, and Kolin.

The Polunochnoye manganese deposit in the Serov district is the biggest in the northern Urals. Horizontal beds are exposed for about 2 km along both banks of the Polunochnoye River; 0.6 m thick on the right bank, 3 to 10 m thick on the left bank. Ore minerals are pyrolusite, psilomelane, and carbonates. The oxide ore carries 18% to 25% Mn, 35% to 45% SiO_2, and 4% to 6% Fe; the carbonate ore, 1% to 26% Mn, 26% to 53% SiO_2, and 4% to 5% Fe.

The Marsyata manganese deposit is the best known and explored Urals deposit and the principal producer in the past. It is located near Marsyata railroad station 55 km north of Serov. The deposit contains approximately 22% Mn and 3% Fe. The layer thickness is 0.8 to 1.8 m. It had been a principal supplier to the Magnitogorsk steel plant. This deposit is no longer in production and it may be worked out.

Small manganese deposits are found in the middle and southern Urals, of which the manganous limestone deposit of Ulutelÿak in Bashkirian A.S.S.R. is the largest. The deposit consists of carbonate ore that contains 2% to 3% Mn and oxidized ore with 6% to 9% Mn. The deposits of the Magnitogorsk group in Cheylyabinsk Oblast' are mainly manganese silicate with 15% to 25% Mn. All deposits had enriched zones of oxidized ores with 30% to 45% Mn. These zones were worked out during the World War II period. The deposits of this group are no longer of economic importance.

Siberian Deposits

In Western Siberia the deposits of manganese ore are Usa in Kemerovo Oblast' and Durnov in Altay Kray. The east Siberian manganese deposits include Mazul' and Porozhin in Krasnoyarsk Kray, Sagan-Zaba and Nizhneudin in Irkutsk Oblast', and Taloy-Usoy and Ikat-Gargin in the Buryat A.S.S.R.

The Usa deposit is the largest in Siberia. It is in the Kemerovo Oblast' near the middle course of the River Usa, a right-hand tributary of the Tom', 110 km from Kuznetsk. The deposit includes manganese carbonates intercalated with bands of a manganese silicate forming three lenslike segregations, 215, 170, and 370 m in thickness, extending 4.6 km along the strike. The manganese content varies from 3.91% to 11.12%.

The Mazul' deposit is 12 km southwest of Achinsk on the Trans-Siberian railroad. The deposit has 10 ore bodies, 4 of which are very large. The ore is found in layers or in pockets 3 to 28 m thick and averaging about 18% Mn, 16% Fe, and 0.3% P. The Mazul' deposit was the main World War II emergency supply source for the Kuznetsk steel industry.

A number of small manganese deposits are reported in Siberia, mostly in the Buryat A.S.S.R. in the vicinity of the Petrovsk steel plant southeast of Lake Baikal. One of these deposits is on Olkhon Island in Lake Baikal; others include the Taloy-Usoy and Ikat-Gargin occurences in the Barguza-Vitim zone of manganese ore shows.

Soviet Far East Deposits

A number of small manganese deposits are reported in the Soviet Far East. The largest of these are Ir-Nimin, Malyykhingan, and Bidzhan. The Lower Cambrian Ir-Nimin deposit occurs in the Uda-Shantar ore region of the Okhotsk area in Nizhne-Amur Oblast' of Khabarovsk Kray. The ore bodies can be traced along strike for hundreds of meters, with a thickness from 1 to 10 m. The braunite ore contains 28% to 30% Mn, but massive and fine-grained types of ore have a manganese content from 32% up to 55%.

The Malyyhingan deposits in Amur Oblast' (Poperechnoye, Okhrin, Serpukhovo, etc.) are characterized by a mixed iron-manganese mineralization. The ore-bearing field with sparsely distributed ore bodies occupies an area of 450 km² and is 6 to 8 km wide and 60 km long. The seam of manganese ores can be traced along strike for several hundred meters. The thickness of the iron-manganese layer is 1 to 9 m. The manganese content fluctuates from 13.9% in braunite-hematite ore to 21.55% in braunite ore.

Other Manganese Deposits

A number of small manganese deposits are reported in other regions of the Soviet Union. The largest of these are the group of deposits of the Zeravshan Range (Uzbekistan-Tadzhikistan) and Laba in the North Caucasus. Several low-grade manganese deposits of Upper Silurian age are located along a 250-km zone of the Zeravshan Range. The separate lenses are 15 to 300 m long and their thicknesses range from 0.5 to 10 m.

The Laba manganese deposit in Krasnodar Kray is sedimentary, consisting of a sandstone layer, from 0.5 to 1 m in thickness, in which psilomelane and pyrolusite are the cementing materials. The ore carries 17% to 24% Mn, 40% to 45% SiO_2, and 3% to 4% Fe (the balance unreported). The deposit was worked in the 1930's but no prospects exist for economic use in the forseeable future.

MANGANESE RESERVES

The present size of Soviet reserves of manganese ore is not completely clear, because of imprecise information on grade of material. The U.S.S.R. claims the world's largest reserves, but at the same time it is becoming increasingly aware of the difficulty of locating new economic deposits. As a result of the shortage of high-quality ore, the U.S.S.R. has begun purchasing significant quantities from the free markets. In order to provide an historical basis for examining more recent Soviet reserve data, table 7 is provided.

Exploration has revealed more than 200 manganese deposits and outcrops in the Urals, Kazakh S.S.R., Siberia, and other regions of the Soviet Union; however, the extensive deposits in the Ukrainian district of Nikopol' and the Chiatura mines, in Georgia, have overshadowed all others collectively in output and recorded resources. Small and low-grade deposits were exploited principally to supply local blast furnaces.

Soviet explored exploitable reserves of manganese ore in place (categories A + B + C_1) increased from 67.9 million mt in 1917 to 200 million mt in 1929 and to 395 million mt in 1936, but decreased to 311 million mt in 1941 (*2*, p. 102). During the 1946-51 period, exploration work in manganese ore continued and total explored exploitable reserves were increased from 330 million mt in 1946 to 578 million mt in 1951 (*2*, p. 211.)

In considering the Soviet reserves of manganese ore classified as exploitable (categories A + B + C_1), it should be noted that Soviet standards for grades and thickness of layers of materials included in the estimate have often been changed. According to conditions established by the U.S.S.R. Ministry of Ferrous Metallurgy in August 1952, the minimum content of manganese in ore of the Chiatura basin was 17% for oxide ore, 18% for carbonate, and 23% for other types of manganese ores. The minimum content of manganese in carbonate ore of the Nikopol' basin was to be 13%, or 5% below that of Chiatura (*7*, pp. 269-272). In contrast, in May 1964, the U.S.S.R. State Commission for Mineral Reserves (G.K.Z.) approved new grade standards for calculation of explored exploitable reserves of manganese ore of the Chiatura basin. According to these standards the minimum content of manganese in all types of manganese ore was established at 10% and average content in an ore body was to be not less than 15% Mn for all types of ores and 45% MnO_2 for battery grade ore (*7*, pp. 219-272). The same standards have been established also for the manganese ores of the Nikopol' basin.

During the 1951-65 period, exploratory work continued in the Nikopol' group of manganese deposits, especially in the parts of the Bol'shoy Tokmak field and other deposits. As a result of this exploration and the inclusion of poor manganese ores (10% to 17% Mn content for oxide ores and 10% to 12% Mn for carbonate) and thin seams of ore, the explored exploitable reserves increased from 578 million mt in 1951 to 1,665 million mt in 1956 and to 2,599 million mt in 1961; they decreased to 2,565 million mt in 1966.

There were 67 explored manganese deposits in the U.S.S.R. on January 1, 1966, containing manganese ore reserves in place in categories A + B + C_1 of 2,564.6 million mt of ore (see table 8).

Table 7.—Soviet reserves of manganese ore in place in categories A+B+C_1+C_2,[1] thousand metric tons

Location	*Reserves*
R.S.F.S.R.:	
Bashkir A.S.S.R.	4,868
Sverdlovsk Oblast'	2,712
Chelyabinsk Oblast'	25
Azov-Black Sea region	33,900
West Siberian and Krasnoyarsk region	1,776
Orenburg Oblast'	17
Buryat A.S.S.R.	50
Kazakh S.S.R.	33,535
Ukrainian S.S.R.	467,469
Azerbaydzhan, Georgian, and Armenian S.S.R.	164,888
Total	709,240
Reserves, by cateogory:	
A+B+C_1	394,740
C_2	314,500
Total	709,240

[1] As of January 1, 1936.

Source: Reference 8.

Table 8.—Distribution of manganese ore reserves in place[1] and ore production, by region

	Deposits	A+B reserves, 10^6 mt	A+B+C_1 reserves: 10^6 mt	A+B+C_1 reserves: Share of total, %	C_2 reserves, 10^6 mt	1965 crude ore production, share of national total, %
R.S.F.S.R.:						
Sverdlovsk Oblast'	12	15.7	50.2	2.0	0	0.05
Bashkir A.S.S.R.	9	1.2	2.9	.1	.3	0
Orenburg Oblast'	1	.4	1.9	.07	1.9	0
Kemerovo Oblast'	1	29.1	98.5	3.8	0	0
Khabarovsk Kray	1	1.9	6.4	.25	2.5	0
Total	24	48.3	159.9	6.2	4.7	.05
Ukrainian S.S.R.:						
Dnepropetrovsk Oblast'	18	625.5	1,046.4	41.2	6.8	70.0
Zaporozhye Oblast'	1	149.9	1,109.5	43.1	307.1	0
Total	19	775.4	2,155.9	84.3	313.9	70.0
Georgian S.S.R.	15	89.9	178.3	6.8	5.3	29.15
Kazakh S.S.R.:						
Karaganda Oblast'	8	12.2	69.8	2.7	4.2	.8
Semipalatinsk Oblast'	1	.5	.7	Neg	.2	0
Total	9	12.7	70.5	2.7	4.4	.8
Grand total	67	926.3	2,564.6	100.0	328.3	100.0

Neg Negligible. [1]As of January 1, 1966.

Source: Reference 7, p. 248.

The principal commercial types of Soviet manganese reserves in place are in oxide and carbonate ores. On January 1, 1966, carbonate and oxide-carbonate ore accounted for over 70% of the total explored exploitable reserves, but that ore suitable for ferromanganese and the chemical industry constituted less than 30% of the total. Table 9 shows the distribution of the Soviet manganese reserves and production by ore type.

Survey of available Soviet literature on manganese deposits in the U.S.S.R. indicates that the most recent information pertaining to the manganese reserves in the Soviet Union was published in 1975 and represented the situation at the start of 1971 (*3*). Table 10 shows the distribution of reserves by region on January 1, 1971.

According to reference 3, there were 52 explored manganese deposits in the U.S.S.R. on January 1, 1971. These deposits collectively had explored exploitable reserves (in Soviet categories A + B + C_1) aggregating 2,544.1 million mt of ore in place containing not less than 10% and on the average 15% or more manganese, but only 892.2 million mt in categories A + B or 35% of the Soviet total in categories A + B + C_1. Reference 3 (p. 27) indicated that Soviet reserves represented 74% of total world manganese reserves in 1970 (world reserves—3,460 million mt and Soviet—2,563 million mt), which is slightly different from the reserve figure given in table 10. Over 91% of explored exploitable reserves of manganese ore were to be found in the western part of the country in the Ukraine and Georgia. The Ukraine alone possesses more than 82% of the explored exploitable ores of the U.S.S.R.

There are a number of relatively small deposits of manganese carbonate ores (up to 20% Mn) in the Serov-Ivdel district of the Urals, in Western Siberia, and in the Soviet Far East. There are also deposits of easily upgraded oxidized ores in Kazakhstan, such as Dzhezdy, Atasu, and Mangyshlak Peninsula. These deposits are exploited from time to time for the needs of regional plants.

Mining activities from 1971 to 1984 resulted in substantial reductions in the Chiatura and Nikopol' manganese reserves, lowering the total reported 1971 reserves by an estimated 336 million mt. Of this amount, 305 million mt was used to produce 125 million mt of marketable ore (on the average about 2.45 mt of crude ore per metric ton of marketable) and 31 million mt (10%) was lost during mining, these losses consisting mainly of ore left in pillars in underground mines. On the basis of 1971 reported exploitable reserves and withdrawals from reserves, the total in-place explored exploitable (categories A + B + C_1) manganese reserves of the Soviet Union on January 1, 1985, can be calculated at about 2,208 million mt ranging from a cutoff grade of 10% to about 27% Mn, with an average grade of 15% to 20%. There were 52 explored manganese deposits in the U.S.S.R. on January 1, 1985.

Estimated 1985 reserves include both oxide and carbonate ores. As shown in table 9, the explored exploitable reserves of oxide and oxidized ores in categories A + B + C_1 amounted to 757.1 million mt on January 1, 1966. During the 1970's, exploratory work in the Bol'shoy Tokmak field of Zaporozh'ye Oblast' resulted in the addition of only carbonate ores to Soviet reserves. Therefore, mining activities during the 1966-84 period resulted mostly in the reduction of Chiatura and Nikopol' oxide manganese ores.

For the production of 160 million mt of marketable manganese ore during the 1966-84 period, it was necessary to deliver 392 million mt of crude ore to beneficiation plants; an additional 40 million mt (about 10%) was lost during mining. Therefore, mining activities during this period resulted in depletion of manganese reserves by 432 million mt.

Table 9.—Distribution of manganese ore reserves in place[1] and ore production, by ore type

Ore type	Av Mn content, %	Explored exploitable reserves: A+B+C_1, 10^6 mt	Explored exploitable reserves: A+B+C_1, Share of total, %	Explored exploitable reserves: C_2, 10^6 mt	1965 crude ore production, share of national total, %
Oxide	27.5	726.5	28.3	11.7	82.5
Oxidized	27.0	30.6	1.1	1.1	2.1
Carbonate and oxide carbonate	23.0	1,800.2	70.3	313.4	15.4
Silicate	18.4	4.8	.2	2.2	0
Ferruginous manganese ore	9.6	2.5	.1	0	0
Av or total	24.2	2,564.6	100.0	328.4	100.0

[1] As of January 1, 1966.

Source: Reference 7, p. 249.

Table 10.—Distribution of manganese ore reserves in the Soviet Union, by region[1]

Region	Deposits	A+B reserves, 10^6 mt	A+B+C_1 reserves, 10^6 mt	A+B+C_1 reserves, Share of total, %	C_2 reserves, 10^6 mt
R.S.F.S.R.:					
Urals (Sverdlovsk Oblast')	12	15.7	50.2	2.0	0
Western Siberia (Kemerovo Oblast')	1	29.1	98.5	3.8	0
Soviet Far East (Khabarovsk Kray)	1	1.9	6.4	.3	2.5
Total	14	46.7	155.1	6.1	2.5
Ukrainian S.S.R.:					
Dnepropetrovsk Oblast' (Nikopol')	15	629.6	985.1	38.8	6.8
Zaporozhye Oblast' (Bol'shoy Tokmak)	1	149.9	1,109.5	43.6	307.1
Total	16	779.5	2,094.6	82.4	313.9
Georgian S.S.R.:					
Chiatura	14	54.3	218.3	8.6	13.0
Other	2	.5	9.2	.3	2.2
Total	16	54.8	227.5	8.9	15.2
Kazakh S.S.R. (Karaganda Oblast')	6	11.2	66.9	2.6	6.5
Grand total	52	892.2	2,544.1	100.0	[2]395.1

[1] As of January 1, 1971. [2] As reported in source, detail adds to 338.1 mt.

Source: Reference 3, p. 34.

The share of oxide and oxidized ores in total national mining of manganese ore decreased from 84.6% in 1965 (see table 9) to an estimated 80% in 1984. Therefore, mining activities during 19 yr from 1966 through 1984 resulted in the depletion of 365 million mt of the richest oxide and oxidized manganese ore of the Chiatura and Nikopol' basins.

On the basis of the 1966 reported exploitable oxide and oxidized manganese reserves and withdrawals from reserves, the total in-place explored exploitable oxide and oxidized manganese reserves of the Soviet Union on January 1, 1985, can be calculated at about 392 million mt. The balance of 1,816 million mt consists of manganese carbonate ores.

It is important to bear in mind when examining the question of the magnitude of Soviet reserves that the Soviets have used the foregoing reserve figures in planning their mine and concentrator development programs during the 1970's and early 1980's. These reserve figures reflect the basis for their investments in mine and beneficiation plants as well as for actual development work described subsequently in this report. Just as it would be illogical to apply Soviet standards for evaluating the potential of a mineral deposit to any deposit outside the U.S.S.R. and its CMEA associates, so too it would be illogical to apply Western standards of evaluating the commercial potential of a deposit to Soviet or other CMEA deposits. Simply put, these figures represent, as best can be determined, the Soviet manganese reserves because these are the figures that the Soviets use for planning.

In conclusion, three points should be stressed: (1) the 2,208 million mt figure does not include reserves in the C_2 category, which may not be more than 15% of the total of the A + B + C_1 categories; (2) the figure does not include material in zabalansovyye category (see chapter 1), which may not be more than 10% of reserves in balansovyye category; and (3) although the figures contain very substantial reserves in the Chiatura and Nikopol' basins, mining activities there during the 1966-84 period have significantly reduced supplies of the richer oxide ore amenable to production of ferromanganese.

The reduction of the supplies of rich oxide ore has been noted in the Soviet literature. For example, Pravda (*9*) reports: "Shortage of manganese ore already is 'troubling' the work of large ferroalloys plants in Nikopol' and Zaporozh'ye... The large losses of manganese have been, and are at the same level...." The shortage of manganese ore reserves in Chiatura is aggravated by large losses that occur in mining, 10.5%; by excessive dilution in mining, 31%; and by low recovery in concentration, 71% to 75% (*6*).

The reserves of oxide manganese ore at the Chiatura and Nikopol' basins are already not large. Calculation shows that these reserves will be depleted in about 18 yr if present production levels are maintained. There is need for development of mines as well as facilities for concentration of the difficult-to-process lower grade carbonate ores in Chiatura, Nikopol', and, especially, Bol'shoy Tokmak manganese basins. The mining of carbonate ores, which has already started, will increasingly provide the raw material base for the Soviet ferromanganese industry; the carbonate ores of the Bol'shoy Tokmak basin will be the overwhelmingly dominant source of supply.

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CHAPTER 3.—TECHNOLOGY AND PRODUCTION

PROSPECTING AND EXPLORATION

There were more than 20,000 explored mineral deposits in the U.S.S.R. on January 1, 1984, of which 52 are recorded as manganese deposits. Over 5,000 deposits of various minerals including 34 manganese deposits were being exploited in 1984. Up to 40% of capital investment in industry is spent on exploration and mining of minerals, but there are no specific details for manganese alone. Expenditure on total geological prospecting from 1950 to 1980 increased by a factor of 8, and in 1980 it amounted to about 5 billion rubles. This amount is projected to increase annually by 5% to 8%. Extensive prospecting and exploration for practically all commodities are carred out on a large scale. However, Soviet publications indicate that manganese is not a perennial high-priority item in the exploration program. For example, expenditure on manganese prospecting during the years from 1959 to 1963 decreased by 57.5% (*44*).[1]

There were over 500,000 employees in the geological and prospecting organizations in 1984, including over 120,000 graduate specialists with university or technical education. The U.S.S.R. Ministry of Geology had 36 research

[1] Italic numbers in parentheses refer to items in the list of references at the end of this chapter.

institutes and 2 design establishments with a total staff of over 40,000 persons in 1984. Every year the Ministry of Geology alone completes more than 20 million m of core drilling, over 3 million m of petroleum and gas wells, and about 300,000 m of various underground mining workings. The geologists have at their disposal more than 10,000 drilling rigs.

Since the revolution, the Soviet Union has extended a large effort to locate new manganese deposits; its success has been limited. The two largest manganese deposits, Chiatura in Georgia and Nikopol' in the Ukraine, were discovered in 1849 and 1883, respectively. Soviet geologists have been able to increase the total reserves only by carbonate ores of the Bol'shoy Tokmak (Nikopol' area) deposits, which were found in 1939. The last relatively large deposit is reported to have been discovered in 1939, the Atasu group in Kazakhstan, which has been exploited since 1956. A great number of small low-grade, mostly manganese carbonate deposits have been discovered east of the Urals. Extensive geologic studies of known manganese deposits and occurrences in the U.S.S.R. by two generations of Soviet geologists have been unsuccessful.

Currently, manganese deposits are being investigated with exploratory boreholes spaced 50 to 200 m along the strike and 30 to 200 m along the dip. To provide full information on the geological structure and the qualitative characteristics of the ore, the large amount of exploratory drilling (with a spacing of 30 by 60 m) is conducted on some deposits. Table 11 provides data on the density of the reconnaissance grid used for the manganese deposits in the U.S.S.R.

Despite evidences of relative success in exploration of manganese deposits, Soviet personnel have expressed dissatisfaction regarding actual performance of exploration work parties, noting specific problems including the following (*52*): (a) a significant number of boreholes drilled were sited outside the limits of commercial mineralization, and therefore, they did not contribute significant information on the ore body; (b) results of drilling were underevaluated in estimating reserves; (c) cores recovered were of poor quality owing to poor drilling techniques; (d) exploration teams did not do sufficient geophysical research; (e) general documentation on and description of core samples and other workings were poor quality. In another instance (*47*), it was noted that geologists were receiving neither the correct type nor sufficient quantities of exploratory drilling equipment from the responsible agency, the U.S.S.R. Ministry of Chemical and Petroleum Machine Building.

Table 11.—Spacing of reconnaissance grid[1] in exploration of manganese deposits, by reserve category, meters

Deposit type and name	A, along —		B, along —		C_1, along—	
	Strike	Dip	Strike	Dip	Strike	Dip
Flat dipping beds:						
Nikopol'	150	150	300	300	600	600
Bol'shoy Tokmak	100	100	200	200	600	600
Chiatura	200	200	400	400	600-700	600-700
Steep beds:						
Ivdel	NS	NS	75	50	300	100
Yurkin	NS	NS	100	50	300	100
Marsyata	NS	NS	70-100	50	200	50
Yuzhno-Berezov	NS	NS	75	50- 25	200	50
Usa	50-60	30- 60	60- 90	90	100-120	120-150
Zapadno-Karazhal	100	50- 75	200	100-150	400	200-300
Dzhezdy	NS	NS	50	50-100	100	100

NS Not specified in source.
[1] Distance between boreholes or mining works.

Source: Reference 36.

The Soviet Union has an interest in oceanic sources of manganese; this is apparent from the activities of Soviet oceanographic vessels in several oceans.

MINISTRY OF GEOLOGY

Under the complex Soviet system of industry-oriented ministries, this Ministry has primary responsibility for preliminary and detailed exploration for all minerals. The following is a brief outline of the history and activities of this organization. Soviet sources provide few specifics on manganese exploration, but manganese exploration is conducted within this organizational framework.

Immediately after the revolution in 1917, the Geological Prospecting Trust (Soyuzgeorazvedka) was formed. This trust was later reorganized into the Geological Prospecting Department, and in 1938, the Committee on Geology was set up under the National Economic Council (Sovnarkhoz S.S.S.R.) which in turn was under the Council of Ministers. In 1946, the Ministry of Geology was established, and in 1953, the Ministry was reorganized into the Ministry of Geology and Conservation of Mineral Resources and in 1965 reorganized again into the Ministry of Geology, which is today the highest state geological body in the U.S.S.R.

The Ministry carries out all broad-scale geological work in the Soviet Union. In addition, other ministries, such as coal, petroleum, gas, ferrous metallurgy, nonferrous metallurgy, chemical, and building materials have their own geological departments in order to study deposits that concern them in particular.

The main functions of the Ministry of Geology are as follows: (a) Systematic geological study and mapping of the whole country; (b) extensive searching and prospecting for new deposits, including the determination of the ore reserves of these deposits for possible development; (c) detailed prospecting of known mineral-bearing areas and preparation for their exploitation; and (d) correlation of all geological data throughout the U.S.S.R. In addition to these functions, the Ministry prepares plans for the development of newly discovered deposits and mining areas for the State Planning Committee.

Because of the vastness of the country, the Ministry of Geology carries out its work through several main regional (territorial) geological departments, including some ministries of geology in the union republics. Parallel to the territorial departments, but working independently, are the territorial commissions on mineral reserves. After a mineral-bearing area has been carefully surveyed and prospected, a regional department submits its report to the appropriate commission on reserves, which then checks the reliability of the data.

In keeping with the 5-yr plans of the Government, the Ministry of Geology works out its survey and prospecting program for each 5-yr plan period, from which program an annual prospecting program is decided. Lists of the country's mineral reserves are drawn up and revised every year.

The Ministry of Geology also controls the rate of exploitation of deposits, endeavors to reduce losses in mining, and sees that all components of complex ores are utilized.

In addition to the Ministry of Geology, the Ministry of Ferrous Metallurgy has a geological department that carries out more detailed work, such as (a) further prospecting of iron ore, manganese, and chromite deposits being mined for the purpose of discovering additional ore reserves and/or of putting resources in higher categories: (b) detailed geological mapping of known manganese deposits on a scale of 1:10,000 or larger in order to obtain a clearer view of each deposit and to help in directing mining operations; (c) study of the mining geology of manganese areas; (d) study of the reserves of all useful associated minerals in the ores; calculation and revision of ore reserves, which are needed in planning for production; and (e) hydrogeological and other geological investigations of mining areas.

Under the U.S.S.R. Council of Ministers is the State Commission on Mineral Reserves. Its functions are (a) checking reserve calculations, regardless of which ministry carried out prospecting work; (b) determining the degree and reliability of the study as well as whether the deposit is ready for industrial operation, in accordance with the established classification of reserves and with the necessary proportion of reserves of different categories; (c) deciding whether useful associated minerals of an ore deposit might be recovered; and (d) providing methodical guidance and control to territorial commissions on mineral reserves.

MINING

An overriding concern is the governmental mandate that the industry provide an adequate amount of manganese for national self-sufficiency and required export, despite high costs. Success in planned production is assessed primarily by quantity of output; considerations of quality and economic efficiency play secondary roles. Under these circumstances, efficient mechanization of mining operations is severely restricted. Mining and concentration are made difficult by varying geological conditions within the same deposit, and by the need to mine oxide and carbonate ores separately.

Mine managers may mechanize operations only to the extent permitted by approved planned directives and by budgetary appropriations specifically earmarked for this purpose. Managers must accept whatever machines are supplied according to the plan, regardless of their quality and fitness, simply because there is only one supply source. Soviet mine managers, unlike their Western counterparts, are not worried that competitive costs may force their enterprise out of existence, but that they must meet their planned quantitative production quota. The concern for additional machinery is only to insure fulfillment of quota. Research and construction in mining is limited mainly to solving local problems and to eliminating bottlenecks.

Manganese mining in the Soviet Union is concentrated in the Nikopol' basin in the Ukrainian S.S.R. and in Chiatura in the Georgian S.S.R. Small operations exist in Kazakhstan. In 1984, 57 open pits and underground mines and 18 concentration plants produced 10.1 million mt of marketable (an estimated 24.6 million mt of crude) manganese ore. Approximately 75% of all ore was mined by open pit method.

The principal Soviet manganese basin, the Nikopol', has reserves many times greater than those of the Chiatura basin, but the ore is little more than 2 m thick and is under an average of 80 m of overburden. Two complexes, the Ordzhonikidze and Marganets, operate in the Nikopol' basin, containing 19 underground mines, 10 open pits, and 6 concentrators in operation in 1984. About 80% of the Nikopol' ore comes from open pit operations. The Chiatura manganese basin in Georgia operated 24 underground mines and open pits and 9 concentrators. Over 80% was extracted from underground mines. Small amounts of manganese ore were produced at the Dzhezdy and Atasu mines in Kazakhstan. The Dzhezdy manganese ore-dressing plant processed low-grade ore for the Nikopol' (Ukraine) and Yermak (Kazakhstan) ferroalloy plants.

Surface mining of manganese ore (see table 12) accounted for only 1.32% of the Soviet production in 1952, but increased to 76% in 1983.

Open Pit

The open pits of the Soviet manganese industry as a rule are mechanized enterprises; annual production levels vary from 0.1 to 1.2 million mt of crude ore. A multibench mining method is used, with a bench height of 10 to 35 m. The open pits are scheduled for operation on a three-shift-per-day, 7-day-week work schedule.

Eight mines, all open pit, and three concentrators are operated by the Ordzhonikidze mining and concentrating complex (GOK) on the Nikopol' west field of the Ukraine. The Nikopol' east field, with both open pit and underground mines, is operated by the Marganets mining and concentrating complex. The manganese open pits at the Ordzhonikidze GOK are the best equipped and have the most technologically advanced equipment in the U.S.S.R.

Overburden in open pits of the Ordzhonikidze GOK ranges in thickness from 10 to 110 m, with a waste (cubic meter) to ore (metric ton) ratio ranging from 12.6:1 to 21:1. Here a combination of shovel-truck, shovel-rail, and dragline for stripping and shovel-truck for ore removal are used. The Shevchenko open pit uses two-wheel-type excavators. The wheels are 11.4 m in diameter and each has 10 buckets. The wheel excavators weigh 3,200 mt. The units can dig 40 m above the base and 10 m below it. They can take a cut 90 m wide using a 270° swing. At the Bogdanov open pit, large draglines with bucket capacities of 14 to 20 m^3 and boom lengths of 60 to 100 m are used to strip the overburden. The ore itself is loaded with 4.5- to 6-m^3-capacity shovels into 40-mt-capacity dump trucks or 80-mt-capacity railroad cars, hauled by 150-mt electric locomotives. Table 13 lists the type of equipment and the number of each in use at the Ordzhonikidze GOK surface mining operation in 1972, when output totaled 7.1 million mt of crude ore.

Design technical details on manganese open pits of the Nikopol' basin are given in table 14.

Development of surface mining by basin is shown in table 15.

Table 12.—Surface mining of manganese ore, percent

Year		Year	
1952	1.3	1968	56.4
1955	10.8	1970	61.5
1960	29.5	1980	65.5
1965	55.0	1983	76.0

Source: References 3, 19, 21.

Table 13.—Excavation and haulage equipment at Ordzhonikidze GOK open pit mines in 1972

	Units		Units
Shovels:		Draglines—Continued	
EKG-4 and EKG-4.6	52	ESh-25/100	1
E 2503	20	Wheel excavators (imported and domestic	7
Draglines:		Electric rail locomotives	30
ESh-6/60	6	Railroad dumpcars	300
ESh-10/60	9	Trucks:	
ESh-14/75	4	KrAZ-222	200
ESh-15/90	8	BelAZ-540	27
ESh-20/72	2		

Source: Reference 17.

Table 14.—Design details of manganese open pits of the Nikopol' basin

Open pit	Av thickness, m: Overburden	Av thickness, m: Manganese seam	Overburden-ore ratio (m^3/mt)	Pit length, m	Annual production: Crude ore, 10^6 mt	Annual production: Overburden, 10^6 m^3	Total capital investment, 10^6 rubles	Output per person shift, mt
Shevchenko . . .	57.0	1.85	16.7	2,200	1.2	21.0	30.0	12.0
Grushev	61.2	2.1	15.5	1,700	1.2	18.6	49.5	5.1
Zaporozhye . . .	56.7	1.73	18.2	2,200	1.2	21.5	43.5	12.0
Severnyy	64.5	1.71	21.0	2,000	1.2	25.5	61.8	11.8
Chkalov	59.7	1.64	19.7	2,000	1.2	24.3	27.1	8.9
Bogdanov	63.0	1.76	18.1	4,000	1.2	21.7	27.3	7.9
Alekseyev	33.0	1.6	12.6	2,200	1.2	15.1	21.8	20.9
Basan	55.0	1.36	19.8	1,400	.6	12.0	NA	9.7

NA Not available.

Source: Reference 12.

Table 15.—Surface mining of manganese ore at Nikopol' and Chiatura

Year	Total production, 10^3 mt	Surface mining: 10^3 mt	Surface mining: Share of total, %	Year	Total production, 10^3 mt	Surface mining: 10^3 mt	Surface mining: Share of total, %
NIKOPOL'							
1952 . . .	2,100	40	1.32	1960 . . .	5,580	2,490	44.70
1953 . . .	2,300	60	3.23	1961 . . .	6,590	3,160	48.00
1954 . . .	2,600	200	7.70	1962 . . .	7,620	4,250	55.90
1955 . . .	2,830	300	10.80	1963 . . .	8,260	4,780	58.50
1956 . . .	3,170	510	16.00	1964 . . .	9,070	5,600	61.80
1957 . . .	3,790	1,060	28.90	1965 . . .	10,200	7,010	68.80
1958 . . .	4,180	1,430	34.30	1970 . . .	NA	NA	74.10
1959 . . .	4,740	1,890	39.90				
CHIATURA							
1955 . . .	4,420	180	4.17	1963 . . .	5,560	1,260	22.6
1958 . . .	5,200	400	6.2	1964 . . .	6,060	1,420	23.4
1959 . . .	5,210	500	9.7	1965 . . .	6,060	1,560	25.8
1960 . . .	5,410	760	14.3	1966 . . .	5,670	1,340	24.1
1961 . . .	5,340	880	16.4	1967 . . .	5,520	1,220	21.8
1962 . . .	5,430	990	18.3	1968[1] . .	2,500	490	19.4

NA Not available. [1] 1st half.

Source: References 15 and 33 (pp. 297 and 299).

The following 10 open pits were in operation at the Nikopol' manganese basin in 1983; Grushev and Basan (Marganets GOK), Bogdanov, Shevchenko, Alekseyev, Zaporozhye, Chkalov No. 1, Severnyy, Aleksandrov, and Chkalov No. 2 (Ordzhonikidze GOK).

It was planned to decrease production of manganese ore at Chiatura by surface mining from 25.8% in 1965 to 20% in 1966, 18% in 1967, 17% in 1968, 14% in 1969, and to 13% in 1970 (*33*, p. 273).

Underground

About 25% of all Soviet manganese ore mined was obtained from underground workings at the Nikopol' and Chiatura basins in 1984. The underground operations in Kazakhstan are, and will probably remain, insignificant.

Underground mining is practiced at the Marganets GOK in the eastern part of the Nikopol' basin and in Chiatura. Ore lost during mining operations is between 10% and 14% of ore in place. Since 1955, new undergroud mines in Nikopol' have been developed with a capacity of 150,000 to 300,000 mt/yr. Although there are plans for modernization that have been reported, the underground mines here remain small and not up to modern standards. Drilling and blasting are by conventional methods and some loading is done with small machines, in some cases with gathering conveyors between loading machines and 2-m^3 haulage car trains. The narrow gauge locomotives are electrified. Both room-and-pillar and longwall mining are being used. The length of the longwall face is 40 to 60 m in Chiatura and 60 to 100 m in the Nikopol' basin. The daily three-shift output from a face is 250 to to 350 mt. Only 21% of drifting was mechanized in 1977.

At some underground mines of the Marganets GOK in the Nikopol' basin, crosscuts and some haulage workings are supported with steel ring supports. At the operating longwalls of these mines, the roof is supported by movable shields. The cost of metallic roof support accounts for about one-third of total production cost of ore. In addition to steel rings, rings of reinforced concrete are introduced at crosscuts. For every 1,000 mt of manganese ore produced at these mines, 5 to 8 mt of metallic supports presently are not recovered.

The underground mining of manganese ore in the Ukraine is complicated by unfavorable geological conditions. In the majority of mines, the workings are subject to violent flooding and great rock pressure, which limit their productive capacity, encumber the mechanization of fundamental productive processes, disrupt the planned working of the mines, and cause an increased loss of ore in the mines. Consequently, the underground method of mining ore in the Nikopol' basin is characterized by a low production capacity, a short life of the mine (up to 10 yr), low utilization of machinery and productivity of workers, great expenditures of materials and labor, large losses of ore, and a high production cost.

According to reference 11, productivity of underground workers at the Nikopol' mines, in metric tons per 8-h person shift was as follows: 1940, 2.85; 1950, 2.86; 1951, 2.92; 1952, 2.92; 1953, 2.83; 1954, 2.77; 1955, 2.98; 1956, 2.78; and 1957, 2.8. This low productivity of underground workers has continued to the present. As a result, Soviet underground manganese mines employed on the average about one underground worker per 1,000 mt of annual crude ore output.

BENEFICIATION

There were 16 manganese concentrators in operation in the U.S.S.R. in 1984, which produced an estimated 10.1 million mt of marketable ore (concentrate) from 24.6 million mt of crude ore. Total capacity of all concentrators was about 25 million mt of crude ore per year. Nikopol' has six concentrators with a total annual capacity of about 17 million mt of crude ore and Chiatura has nine concentrators with a total annual capacity of about 8 million mt. The Dzhezdy concentrator in Kazakhstan, which was put into operation in 1965, produced a small quantity of concentrates in 1984.

All ore is beneficiated, usually by crushing, screening, washing, and sizing of the product. Fines are upgraded by electromagnetic separation and/or flotation. Some concentrate is agglomerated. Processing of manganese ore by flotation was introduced at the Bogdanov concentrator in the Nikopol' basin in 1967 and in Chiatura in 1968.

Ore treatment at the Chkalov concentrator in the Nikopol' basin for example, can be summed up as follows: (a) Crushing of crude ore to 50 mm, in two stages (primary and secondary), in jaw crushers; (b) screening and separation into fractions; (c) desliming in rectangular tanks; (d) tertiary crushing to 12 mm; (e) concentration of the 3- to 12-mm fraction by jigging in jigs with moving screens; (f) concentration of 0.5- to 3-mm fraction by magnetic separation, with the concentrates drawn off by jigging; (g) concentration of the minus 0.5-mm fraction by flotation in two stages (carbonate tailings, then flotation of manganese oxides).

During the 1883-1917 period, the Nikopol' basin produced 3.653 million mt of manganese concentrates. In the 1921-41 period, several manganese concentrators were in operation in the Soviet Union. In 1941, all manganese concentrators in the Nikopol' basin were destroyed during the retreat of the Soviet Army. In 1944, the concentrator at the Voroshilov Mine resumed operations. The Aleksandrov concentrator at the Ordzhonikidze GOK was rehabilitated in 1946. The following new manganese concentrators in the Nikopol' basin were then constructed: Maksimov (1946), TsOF (1949), Bogdanov (1959), Bogdanov agglomeration plant (1962), Grushev No. 1 (1961), Chkalov, first stage (1965), second stage (1972), Grushev No. 2 (1978). At the present time six large manganese concentrators are in operation at the Nikopol' basin: Grushev, TsOF, and Maksimov at the Marganets GOK and Bogdanov, Chkalov, and Aleksandrov at the Ordzhonikidze GOK.

Soviet specifications for manganese concentrates produced in the Nikopol' basin require a manganese content of 25% to 52%. Detailed specifications are given by grade in table 16.

The recovery efficiency of the Nikopol' beneficiation plants for 1966 is shown in table 17. The actual recovery in 1984 was below that of 1966 (*43*, p. 225). As a result of this the average manganese content in Soviet concentrates decreased from 32.8% in 1965 to 30% in 1984.

Quantitative statistics on the operation of some manganese beneficiation plants of the Nikopol' basin are shown in table 18.

In 1984, nine manganese concentrators were in operation in the Chiatura basin: TsOF-1, TsOF-2, NOF Darkveti, KOF Darkveti, Perof', OF No. 29, OF No. 25-bis, TsDF, and TsFF. The new (1962) TsDF (Dovodochnaya) concentrator for treating about 1,400 mt/d of middlings averaging 26% Mn, gets its feed from other concentrators by railroad cars. The Darkveti carbonate ore concentrator (KOF Darkveti), built in 1961 at a cost of 5 million rubles, has been idle for a long time because metallurgical plants have not used carbonate concentrate. The carbonate ores run between 15% and 16% Mn and are beneficiated to 25% to 27% Mn. The oxide ores run between 23% and 25% Mn and can be beneficiated up to 50% Mn.

The TsFF, the first flotation concentrator, was built in 1969 in Chiatura, and produces oxide and carbonate concentrates from slimes. However, the recovery of this plant is low, only about 24% to 25% (*43*, p. 228).

The beneficiation of Chiatura ores, reportedly, has yielded 13% to 14% of grade I concentrate with manganese content of 49% to 50%, 7% to 7.5% of grade II with 44.3% to 45% Mn content, 0.6% to 0.7% of grade III concentrate with 36.2% to 37.2% Mn content, and over 37% of grade IV

Table 16.—Soviet specifications for Nikopol' manganese concentrate, percent

Raw material and Soviet concentrate classification	Min Mn	Av moisture
Oxide and mixed ore:		
Pyrolusite	52	5
A[1]	47	14
I	43	16
II	34	22
III	25	25
Carbonate ores: I	25	22
Slimes: I	22	NAp

NAp Not applicable. [1]P–Mn ratio not to exceed 0.00425.

Source: Reference 43, p. 140.

Table 17.—Recovery of manganese into concentrate in the Nikopol' basin, 1966, percent

Product	Output	Mn content	P content	SiO_2 content	Share of total Mn recovered at form
Grade A	1.41	49.00	0.190	8.0	2.7
Grade I	21.38	41.69	.204	13.5	37.4
Grade II	12.24	36.52	.206	24.6	17.5
Grade III	5.33	28.71	.182	36.7	6.0
Carbonate grade I	9.58	29.87	.183	17.8	11.2
Av concentrate	49.94	38.26	.197	19.3	74.8
Slimes	50.06	12.85	.148	51.5	25.2
Crude ore	100.00	25.53	.173	35.4	100.0

Source: Reference 13.

Table 18.—Operation of Nikopol' manganese beneficiation plants, 1970

	Ts OF	Maksimov	Grushev
Crude ore processing . . 10^3 mt/yr	1,595.7	384.6	2,792.3
Working time . . . h/d	20.3	15.4	22.5
Idle time . . . h/yr	1,227	910	537
Power consumption, kW·h/mt:			
Crude ore	7.0	6.1	8.2
Concentrate	16.5	13.4	18.6
Crude ore consumed per metric ton conc produced . . . mt	2.350	2.213	2.269
Water consumption, m^3/mt:			
Crude ore	8.0	9.5	9.7
Concentrate	18.7	21.1	22.1
Personnel:			
Management staff	16	7	28
Other	249	96	344
Total	265	103	372

Source: Reference 53.

concentrate with 23.5% to 28% Mn content. The remainder was not accounted for. Only the Perof' and OF No. 29 concentrators produced battery (I-III) grades.

The crude ore of the Dzhezdy, Ushkatyn, and Promezhutochnoye deposits, in Kazakhstan, has a manganese content of 18% and is treated by the Dzhezdy concentrator, which produced concentrate with 30% to 35% Mn content and a recovery of not more than 50% (*20*).

The total recovery of manganese in concentrates at the Nikopol' and Chiatura beneficiation plants fluctuates from 68% to 75%. However, only 51% to 54% of manganese is recovered in high-grade concentrates with manganese content of 45% to 49%. More than 15% to 27% of products are concentrates of low grades, which cannot be used in production of alloys because of low manganese content and high phosphorus content (*43*, p. 226). The decline in quality of marketable ore (concentrate) produced in the U.S.S.R. can be seen from the data in table 19.

MANGANESE ORE PRODUCTION

The U.S.S.R. has long been known for its manganese. It has large reserves, production, use, and export. It possesses two of the world's largest manganese deposits—Nikopol' in the Ukraine and Chiatura in the Caucasus—both long known and long mined. They are both so near the Black Sea that manganese, in particular from Chiatura, is a natural export for the Soviet Union and a leading one. About 99% of total output and practically all ore for export come from these two producing areas. Minor producing deposits in Kazakhstan are tributary to steel plants in that republic. The U.S.S.R. has a third large manganese (mostly carbonate) deposit (Bol'shoy Tokmak) in the Nikopol' area that has not yet been developed.

For the internal use of the Soviet steel industry, the Nikopol' deposit has an ideal location by the Ukrainian steel plants. Its output is primarily for the requirements of the country and for exports to the East European countries. Nikopol' and Chiatura, however, are 2,000 to 6,000 km from steel plants in the Urals and from the Kuznetsk steel plant in Siberia, respectively. The plants in these two areas comprise about one-half of the Soviet steel industry. To annually haul millions of tons of manganese ore, or its equivalent in ferromanganese, over these distances is a burden for an inadequate railway system. To avoid as much of this burden as possible, the Urals and the vicinity of Kuznetsk were actively prospected for workable manganese deposits. There was some success, but output from these areas will be but a very small part of total output.

The carbonate ores of the Soviet manganese deposits run between 15% and 16% Mn and are beneficiated to 25% to 27% before roasting. The oxide and oxidized ores run between 20% and 25% Mn and can be beneficiated to 42% to 49%. All manganese ores in the U.S.S.R. for metallurgical use need beneficiation.

Table 19.—Decline in quality of marketable ore (concentrate), manganese content, percent

Year		*Year*		*Year*	
1960	32.8	1977	34.6	1981	30.0
1965	32.6	1978	32.5	1982	30.8
1970	35.9	1979	31.0	1983	30.2
1975	34.8	1980	30.2	1984	29.7
1976	34.6				

Source: Reference 39.

Before the Revolution

Before the revolution, manganese ore output in Russia was centered mainly at the rich Chiatura deposit. Small quantities of manganese ore were mined also in the Ukraine and the Urals. The first manganese ore in Russia was mined at the Chiatura deposit in 1879 (discovered in 1846-49). Subsequently, mining began in the Urals in 1882 and then, in 1885, production was started in the Nikopol' basin (discovered in 1883). Russia had long been recognized as one of the world's principal suppliers of manganese ore, and since 1890 Russian output had furnished approximately 35% of the world's requirement. From the 1880's to 1913, Russian annual production of manganese ore accounted for between 40% and 53% of world output. In 1913, Russia produced over 1.2 million mt of marketable manganese ore and the industry employed 8,980 workers (*2*).

As previously mentioned, the Chiatura deposit was discovered in 1846-49 but was not worked until 1879 when foreign interests started the operation. In 1900, the first (Darkveti) and in 1901 the second (Rgan) concentrators were constructed in Chiatura. In 1907, the third beneficiation plant (Chomakhidze-Samcharadze) was put into operation at this deposit. During the 1900-10 10-yr period, four manganese concentrators were constructed in Chiatura. Production of marketable ore at Chiatura increased from 0.17 million mt in 1890 to 0.97 million mt in 1913.

Production of manganese ores in Chiatura for selected years is shown in table 20.

The Pokrovskiye Margantsovye Kopi, the first underground manganese mine in the Nikopol' basin, became operational in 1885. At the beginning of the 1900's, there were nine small underground mines producing manganese ore in this basin. Output of marketable manganese ore at Nikopol' reached 252,700 mt in 1913. Nine underground mines employed a total of 3,291 workers that year (*9*, p. 44). During the 1885-1918 period, the Nikopol' basin produced over 3.6 million mt of marketable manganese ore. Before the revolution, manganese ore was produced from several mines in the Urals and from the Usa deposit in Siberia.

1917 Through 1945

The revolution and Soviet takeover of power in 1917 was followed by the nationalization of privately owned mines. While Russian production of manganese ores held up during the pre-World War I period, it declined during World War I and collapsed during the Civil War years (1918-21). With the establishment in 1921 of the New Economic Policy (NEP), which permitted private industry in the Soviet Union, manganese mining operations were resumed under private ownership, and production of manganese in 1929 surpassed even the 1913 level.

Table 20.—Production of marketable and crude manganese ores at Chiatura, thousand metric tons

Ore type		*Ore type*		*Ore type*	
Marketable:		Marketable—Con.		Crude—Con.	
1879	0.9	1913	965.8	1940	2,156.0
1880	8.5	1915	257.8	1942	199.6
1885	59.7	1920	12.0	1945	1,434.6
1890	171.6	1925	498.6	1950	2,715.6
1895	118.2	1928	250.3	1955	4,420.0
1900	661.7	Crude:		1960	5,418.2
1905	342.2	1930	1,329.9	1965	6,029.4
1910	554.2	1935	1,558.6		

Source: Reference 14.

After the restoration of the economy in 1928, and in keeping with the 14th Party Congress decree, the Government embarked on an ambitious program of industrialization and collectivization of the country. The first 5-yr plan marked the beginning of the fundamental changes in the Soviet economy; it covered the period from October 1, 1928, through December 31, 1932. Industrialization was carried out by broad use of forced labor made up in large measure of private farmers in a program officially designated "Liquidation of kulaks as a class." They were transferred to new regions for construction of industrial projects, including manganese industry projects, where they virtually all died during 1929-32. This resulted in a major decline in productivity and, at the same time, the discipline of a market economy collapsed. As a result, production of manganese ore did not again reach the 1929 level until 1934.

For very many years, the U.S.S.R. has been the largest producer of manganese ore in the world, as shown in table 3 (chapter 1) although it has only at times been the largest exporter of this commodity.

There are five mining districts in the U.S.S.R. producing manganese ore in the 1930-37 period; the two largest were the Nikopol' district in the Ukraine and the Chiatura district in Georgia, which together yielded 93% of the total output in 1935. The Nikopol' district had the larger output in 1932 and 1933, while in 1934 and 1935 the Chiatura mines gave a somewhat larger production. The other districts were in West Siberia and at Orenburg in Middle Volga and Bashkiria in the south Urals, but these were still in the development stage.

In 1937, crude ore mined at Nikopol' varied from 20% to 36% Mn content, the average was about 30%. Where possible to do so, the lumps of rich manganese ore were hand sorted before going to the concentration plant, and this resulted in a substantial quantity of direct shipping ore. At the beneficiation plants, the ore was crushed and washed in log washers and jigs and concentrated with Harz or Hancock jigs and tables, producing a concentrate varying from 40% to over 50% Mn. About 3 mt of crude ore was required to make 1 mt of concentrate. In 1939, the Nikopol' basin employed 3,395 workers and produced 667,365 mt of marketable manganese ore (*9*, p. 159). It is estimated that the output of crude ore per person shift was 1.5 mt. There were 20 small underground mines and 4 concentrators (with a total annual capacity of 1.73 million mt of crude ore) in operation in the Nikopol' basin in 1940.

During the 1930's, all mining in Chiatura was done from tunnels. A longwall retreating system of mining was used and a large quantity of mine timber was required to support the roof. At the mouth of tunnels there were usually storage bins and cableways extending to concentrating plants in the valley. These plants consisted of log washers or jigs, screens, and tables, and a concentrate varying from 25% to 52% Mn was made. The largest of these plants had a crude ore capacity of 2,000 mt/d.

The seven underground mines of Chiatura, which employed 3,464 workers, produced 1.37 million mt of marketable manganese ore in 1939 (*9*, p. 159). Ore containing 45% to 50% Mn, graded as the first-class ore, was utilized for the manufacture of electric-furnace ferromanganese. Low-grade ore containing at least 25% Mn was used for blast furnaces in the production of blast-furnace ferroalloys and pig iron.

During the 1930's, because of the demand for manganese ore at the new iron and steel centers in the Urals and in Siberia, certain newly discovered deposits were being developed in Bashkiria, Kazakhstan (in the Sverdlovsk Region in the Urals), and in West Siberia. The mines in West Siberia started with an output of 64,000 mt in 1934 and 131,000 mt in 1938; in Bashkiria 22,000 mt was produced in 1934 and 29,000 mt in 1935; and at Kazakhstan 10,000 mt was mined in 1935. The ore bodies in these locations are not bedded but occur in brecciated zones and in veins in Devonian jaspers or quartzites.

On the outbreak of the Soviet-German war, manganese was mined near Nikopol' in Dnepropetrovsk Oblast' of the Ukraine, near Chiatura in Georgia, at places in the Urals, and near Mazul in Krasnoyarsk Kray on the edge of the Kuznetsk Basin. Distribution of production in 1940 is given in table 21.

In 1940, as in previous years, the manganese ore production in the Urals and Sibera was insufficient for the requirements of Ural and Siberian metallurgy. Operations in the Urals and Siberia had to transport more manganese ore from Georgia and Ukraine than they themselves produced.

After the outbreak of the Soviet-German war, Germany occupied Nikopol' in August 1941 and held it until February 1944. Thus, according to 1940 production distribution, 34.9% of annual production capacity was lost. According to reference 14, at some time during World War II, "production of manganese ore at Chiatura ceased," although German forces never occupied this area. Under these circumstances, great efforts were made to expand manganese mining in the Urals and in Siberia. Expansion there was possible because during prewar years unsuccessful attempts at expansion had resulted in the opening of various mines and even in the accumulation of mined ore. These mines however, were but little worked or abandoned before World War II because of a preference for better ore transported from Chiatura and Nikopol'. By September 1941, the Magnitogorsk metallurgical complex had completely stopped the use of Georgian manganese (*45*).

By October 1941, the Kuznetsk metallurgical plant had also transferred entirely to local manganese ore instead of that from Chiatura (*46*). Expansion of Ural manganese ore production continued in 1942 with new small mines being opened.

Manganese is known to have been mined in 1942 at Achinsk and Mazul in Krasnoyarsk Kray; at Marsyata and Polunochnoye near Serov in Sverdlovsk Oblast', near Ufaley in Chelyabinsk Oblast', from the new small wartime mine at Ulu-Telyak, from old small mines in Bashkir A.S.S.R., from small mines opened in 1942 near Chkalovo and near Orsk in Orenburg Oblast', and at a small mine opened in May 1942 at Dzhezdy in Kazakhstan. Production of crude manganese ores in the Urals, Siberia, and Kazakhstan was distributed as shown in table 22.

Information on wartime manganese ore output is so scarce that it is very difficult to estimate total production. During the war, production increased in the Urals, Siberia, and Kazakhstan. Nevertheless, with Nikopol' in German hands and Chiatura cut off, the total production of the country was not adequate for industrial needs.

Table 21.—Distribution of manganese production, 1940, percent

Area	
Ukraine	34.9
Georgia	59.8
Urals	2.9
Siberia	2.4
Total	100.0

Source: Pravda. Moscow, Mar. 12, 1941.

Table 22.—Production of crude manganese ore in the Urals, Kazakhstan, and Siberia, 1941-45, thousand metric tons

Area and mine	1941	1942	1943	1944	1945
Urals:					
Polunochnoye	6.0	113.5	307.2	309.7	198.6
Marsyata	10.0	41.0	50.0	60.0	0
Kazakhstan: Dzhezdy	0	83.1	160.6	138.1	113.6
Siberia: Urazovo	0	32.0	20.1	3.8	0
Total	16.0	[1]296.6	537.9	511.6	[1]376.2

[1]As reported in source, difference between listed detail and total not accounted for; possible error in source.

Source: Reference 23.

The difference between Soviet production and demand was made up by manganese included in land-lease supplies, not as ore or ferroalloy, but as a component in goods provided by the United States, the United Kingdom, and Canada. These materials have never been reported in official trade returns of the U.S.S.R., thereby overinflating the importance of intensified efforts within the country. About 98% of the U.S. exports to the Soviet Union between June 1941 and September 1945 consisted of lend-lease supplies. Table 23 shows the major categories of supplies that included some manganese and amounts reportedly shipped.

War material, including a number of products containing manganese, furnished by the United Kingdom to the U.S.S.R., free of monetary compensation after the U.S.S.R. entered the war against Germany, was regularized in an agreement signed on June 27, 1942 (*66*), but also was not reported in official trade books. By the end of May 1943, a total of 4,690 complete aircraft had been sent to the U.S.S.R. by the United Kingdom, with appropriate supplies of spare parts, including engines, airframes, and numerous articles of equipment. Other supplies shipped by the United Kingdom to the U.S.S.R. included 1,042 tanks, and 195 guns of various calibers with 4,644,930 rounds of ammunition, all presumably containing some manganese. These products imported from Western countries made up a significant portion of the manganese consumed by the U.S.S.R. during the 1941-45 period.

1946 Through 1985

During the immediate postwar period, the Soviet Union's production of manganese and ferromanganese had been sufficient to supply all its domestic requirements; the country had also been both the major source of manganese for its Council for Mutual Economic Assistance (CMEA) partners and an important supplier to market economy countries.

Postwar planning in the U.S.S.R. called for a sharp increase in production of manganese to meet the needs of the steadily expanding iron and steel industry. Reconstruction was accomplished in a relatively short period and by 1949 production had equaled its prewar peak of about 3 million mt. Production in 1955 was 40% greater than in 1950. Production in the Urals, Kazakhstan, and Siberia had been greatly stimulated by the German invasion and was gradually increasing, but not in proportion to the increases at Chiatura and Nikopol' or to the expansion of production of pig iron and steel. Ores of metallurgical grade produced in the Urals, Kazakhstan, and Siberia totaled approximately 200,000 mt, less than one-half the requirements of local steel plants. Deficiencies were covered by shipping high-grade concentrates from Chiatura or ferromanganese from southern ferroalloy plants.

Table 23.—Major categories and amounts of lend-lease supplies

Category	
Aircraft and equipment	14,018
Vehicles (including tanks and trucks)	466,968
Naval and marine equipment	[1]5,367,000
Marine engines	7,617
Industrial machinery and equipment	$1,095,140,000
Materials and metal products:	
Steel and steel products ... mt	2,349,406
Wire ... miles	1,018,855

[1]Gross registered metric tons of shipping.

Source: Reference 66.

Following the German retreat in the spring of 1944, the wrecked mines were reconditioned and, in 1945, Nikopol' basin produced about 25% of the manganese ore mined in the U.S.S.R. By 1947 the district's annual productive capacity of about 1 million mt of crude ore was fully restored. By 1948 the four concentrating plants, in operation before the war, were repaired, and plans were made for the building of new concentration plants.

After restoration of facilities at Nikopol', problems of productivity were noted. In 1955, the Nikopol' mines were severely criticized in the press for low labor productivity, for delays in introducing new equipment, and for not adequately developing open pits. Underground mining only was used at Nikopol' until 1952, when in an effort to increase production, open-pit mining began. However, because of the thickness of the overburden, there was a great amount of earth to be stripped off. The Nikopol' output, because of its low grade, was consumed primarily in domestic industries, although in some years Nikopol' concentrate comprised a large quantity of exported manganese material.

Mining at Chiatura in the 1940-50 decade accounted for more than 50% of the national total. The longwall retreating method was used in the underground mines. In 1950, in spite of the rugged terrain, after 3 yr of stripping overburden, the first open pit was started and others subsequently came into production. Complete mechanization of underground manganese mines was a goal of the 1951-55 5-yr plan. Drilling, ore breaking, and mine transport had been mechanized but about one-half of the ore was still loaded manually.

In 1965, manganese production of the U.S.S.R. came from six deposits: Nikopol', Chiatura, and Polunochnoye in the Urals, and Dzhezdy, Karazhal, and Bol'shoy Ktay in Kazakhstan. The Nikopol' and Chiatura districts produced 98.2% of total national production and only 1.8% was supplied by the mines in Kazakhstan and northern Urals. Reference 33 (p. 248) shows that in 1965, 82.5% of total production was oxide ore, 2.1% was oxidized carbonate ore, and only 15.4% was unaltered carbonate ore. In 1963, the manganese content in crude ore mined varied from 23.3% to 29.33% and that in concentrate from 36.35% to 40.57%. Recovery of manganese into concentrate was from 68% to 77.29% (*5*). Over 43% of the total crude ore extracted in 1963 came from surface mining. During the 1959-63 period, new facilities for production of 4.7 million mt of crude ore were put into operation.

In 1966, the Soviet Union produced 16.8 million mt of crude manganese ore (7.7 million mt of concentrate). Over 60% of total production came from the Nikopol' basin. Open pit production at this basin increased from 10.8% in 1955 to 72.7% in 1966. During the 1952-66 period, the following 11 open pits were put into operation: Bogdanov, Shevchenko, Alekseyev, Chkalov, Aleksandrov, Grushev, Basan, Maryev, Novoselov, Vostochnyy, and Alekseyev. The

Bogdanov, Grushev, and Chkalov beneficiation plants in Nikopol' were put into operation in 1959-66. The Nikopol' basin employed 727 graduate engineers and 1,674 technicians in 1967 (*38*).

There were 18 underground mines, 10 open pits, and 6 concentration plants in operation in the Nikopol' basin in 1969, where the ore averaged 26.4% Mn. Concentration by gravity and agglomeration yielded a 71% to 75% recovery. Of total concentrate production, 45% to 48% had a manganese content of about 45%, with the balance containing around 34% Mn. Tailings contained 12% to 15% Mn. More than 70% of ore mined in the Nikopol' basin was obtained by open pit methods. The annual capacity of the underground mines increased from 120,000 mt of crude ore in 1954 to 250,000 mt in 1965 and to 300,000 mt in 1972 (*18*).

Production of marketable manganese ore in Chiatura increased from 0.83 million mt in 1929 to about 3 million mt in 1965. About 80% of total production came from underground mining through adits driven from canyon walls. Open pit mining was growing in importance and was used for all mining with less than 35 m of overburden; maximum underground depth was about 120 m. There were eight ore beneficiation plants in operation in 1968, varying in crude ore capacity from 800 up to 5,000 mt/d. The average manganese contained in crude ore mined in Chiatura decreased from 45% in 1934 to 32.4% in 1959, 22.55% in 1963 and 18.5% (planned) in 1970. The average manganese content in Chiatura concentrate decreased from 52% in 1934 to 40% in 1954, 39% in 1964, and 41% in 1965 and 1966 (*33*, p. 275).

Growth of the manganese industry during 1981-85 occurred through expansion of existing enterprises as well as through construction of new enterprises. Increases in manganese output during 1981-85 came from carbonate ores that are lower grade and more difficult to concentrate than oxide ores. During 1981-85, the Government planned to begin exploitation of the Bol'shoy Tokmak carbonate ore deposit of the Nikopol' basin in the Ukraine, but the first reported ore shipment occurred in 1986. This deposit is to serve as a base for the construction of the Tavricheskiy mining and concentration complex in Zaporozh'ye Oblast'. The Bol'shoy Tokmak deposit is divided into northern, central, and southern sectors; exploitation is to begin in the northern sector where the majority of reserves are concentrated. Soviet-reported production of marketable ore was about 9.9 million mt in 1983 and increased to 10.1 million mt in 1984.

The Bol'shoy Tokmak deposit in the Nikopol' basin is lower in grade and deeper than the other Nikopol' deposits and there were unforeseen delays in bringing the deposit on-stream. As a result of these delays, the extraction of oxide ore elsewhere in the Nikopol' basin was continued intensively.

Losses in the 1970's were large, 10% to 12% in underground mining, 24% to 30% in beneficiation, and up to 25% in the production of ferromanganese and pig iron (*51, 70*). Insufficient concentration and processing resulted in losses of up to one-half of the manganese in slime from concentration and in slag from metallurgical processing. The manganese content of the slag was approximately 16%, and manganese in the slag generally was not recovered. Rather high manganese content slag is being used with asphalt for road paving, giving some roads a reddish color. As a result of antiquated and technologically unsound metallurgical practices, an additional waste of manganese occurred during steel production. Lack of ore hindered production at the large ferroalloy plants in Nikopol' and Zaporozh'ye and in the entire ferrous metallurgy sector (*48*).

The reported production of marketable manganese ore by mining regions for 1928-1984 is shown in table 24. The table shows that in 1984 over 71% of the total production of 10.1 million mt of marketable manganese ore came from Nikopol', about 28% from Chiatura, and only about 1% was from other areas (mines in Kazakhstan). The qualilty of ore produced and metal content of concentrate is decreasing steadily, as was shown earlier by table 19. The average manganese content in Soviet concentrates was slightly under 30% in 1984.

Two mining and beneficiation complexes (GOK), the Ordzhonikidze and Marganets, operate in the Nikopol' basin, containing 19 underground mines, 10 open pits, and 6 concentrators in operation in 1984. More than 75% of the Nikopol' ore comes from open pit operations. The Marganets complex mined the eastern sector and the Ordzhonikidze complex mined the western sector of the basin. At present, there are three concentrators and the following eight open pits in operation at Ordzhonikidze GOK: Aleksandrov, Alekseyev, Bogdanov, Chkalov No. 1, Chkalov No. 2, Severnyy, Shevchenko, and Zaporozhye. There are 3 concentrators, 2 open pits (Basan and Grushev) and 19 underground mines in operation under Marganets GOK. Because of the large amount of overburden in surface mining, the production costs in underground mining of manganese ore here is competitive with that of open-pit mining.

Table 24.—Production of marketable manganese ore (concentrate) in the U.S.S.R., by region, 1928-84

Year	Gross weight, 10^3 mt				Mn in conc	
	Nikopol'	Chiatura	Other	Total	10^3 mt	%
1928 . . .	531	171	0	702	NA	NA
1932 . . .	443	389	0	832	NA	NA
1937 . . .	957	1,650	145	2,752	NA	NA
1940 . . .	893	1,449	215	2,557	NA	NA
1941 . . .	[e]500	[e]700	16	1,216	NA	NA
1942 . . .	0	[e]300	[e]297	[1,e]597	NA	NA
1943 . . .	0	[e]100	[e]538	[1,e]638	NA	NA
1944 . . .	0	[e]100	[e]512	[1,e]612	NA	NA
1945 . . .	206	850	414	1,470	NA	NA
1950 . . .	903	1,837	637	3,377	NA	NA
1955 . . .	1,620	2,952	171	4,743	NA	NA
1960 . . .	2,725	3,036	111	5,872	1,933	32.8
1965 . . .	4,651	2,873	52	7,576	2,485	32.6
1966 . . .	5,020	2,610	76	7,706	2,567	33.0
1967 . . .	4,685	2,396	94	7,175	2,485	34.6
1968 . . .	4,786	1,708	70	6,564	2,378	36.2
1969 . . .	4,897	1,588	66	6,551	2,386	36.1
1970 . . .	5,202	1,569	70	6,841	2,446	35.9
1971 . . .	5,615	1,600	103	7,318	2,552	34.8
1972 . . .	5,900	1,840	79	7,819	2,682	34.1
1973 . . .	6,456	1,708	81	8,245	2,839	34.1
1974 . . .	6,200	1,819	136	8,155	2,848	34.8
1975 . . .	6,537	1,835	87	8,459	2,951	34.8
1976 . . .	6,695	1,853	88	8,636	2,992	34.6
1977 . . .	6,596	1,928	74	8,598	2,964	34.6
1978 . . .	6,851	[e]2,150	[e]56	9,057	2,945	32.5
1978 . . .	7,428	[e]2,770	[e]46	10,244	3,162	31.0
1980 . . .	6,920	[e]2,770	[e]60	9,750	3,040	30.2
1981 . . .	6,366	2,736	48	9,150	2,761	30.0
1982 . . .	7,031	2,736	54	9,821	2,957	30.8
1983 . . .	7,166	[e]2,660	50	9,876	2,976	30.2
1984 . . .	[e]7,200	[e]2,800	[e]89	10,089	2,994	29.7

[e]Estimated. NA Not available. [1] Crude ore.

Sources: References 16, 23, 25, 33 (p. 222), 39, 40-42, 49 (p. 160), 50, 54-55, 71.

Development of the Tavricheskiy GOK in the Bol'shoy Tokmak field continued behind schedule in 1984. It will include five underground mines, each with an annual capacity of 1.5 million mt of crude ore. The first underground mine was under development in 1984. The mines being developed at the Bol'shoy Tokmak field will extract carbonate ore.

The Chiatura manganese basin produced around 2 million mt of concentrates in 1984 from 24 underground mines and open pits and 9 concentrators managed by six mining administrations. Over 80% was extracted from underground mines. Small amounts of manganese ore were produced at the Dzhezdy and Atasu mines in Kazakhstan. The Dzhezdy manganese ore dressing plant, which was put into operation in May 1965, processed low-grade ore for the Nikopol' (Ukraine) and Yermak (Kazakhstan) ferroalloys plants. Kazakhstan's manganese ore is sulfur-free and does not contain other impurities. Production of marketable manganese ore (concentrate) for 1928-84, by region, is shown in table 24.

Future Prospects

Basically the Chiatura and Nikopol' manganese basins contain mostly carbonate ores. High-quality oxide ore makes up no more than 15% of the total reserves and forms the largest part of the extracted ores. Oxide ores at the Ordzhonikidze and Marganets GOK's of the Nikopol' basin will be depleted in 15 to 20 yr. Nonetheless, under all foreseeable circumstances, the U.S.S.R. is, and will remain, the largest producer of manganese ore in the world during the 1985-95 decade.

Most of the manganese ore of Chiatura has been depleted during the over 100 yr of extensive operations. The early mining operations removed the highest grade ore, therefore so-called secondary mining operations are now being conducted, to recover the leftovers still in place after the operations conducted before 1930. Operations are now recovering all ore that contains not less than 10% Mn. These operations are and will be further complicated by the necessity to mine old workings. The operations in Chiatura will continue in the future, though their contribution to the total output of manganese ore in the Soviet Union will decline. The bulk of the production will come from the Nikopol' and Bol'shoy Tokmak fields, both of the Nikopol' basin.

The mining operations in Kazakhstan will increase production of manganese ore in the future, but these operations will remain of local importance only. In the future, it is possible to use the carbonate ore of the Usa, Mazula, and other carbonate deposits in Siberia and the Urals.

The Soviet manganese industry is facing serious problems. Deposits of high-grade manganese content have become increasingly depleted, and the industry had encountered difficulties in beneficiating carbonate ores. Growth rate in Soviet output of manganese during the 1980's (see figure 5) will be limited by declining ore grades in existing mines, low productivity, and the inability to offset these factors with increased labor.

It is considered that the balance between domestic supply and demand will be maintained, but exports of manganese ores will continue to go primarily to CMEA countries. The change from the production of oxide ores to

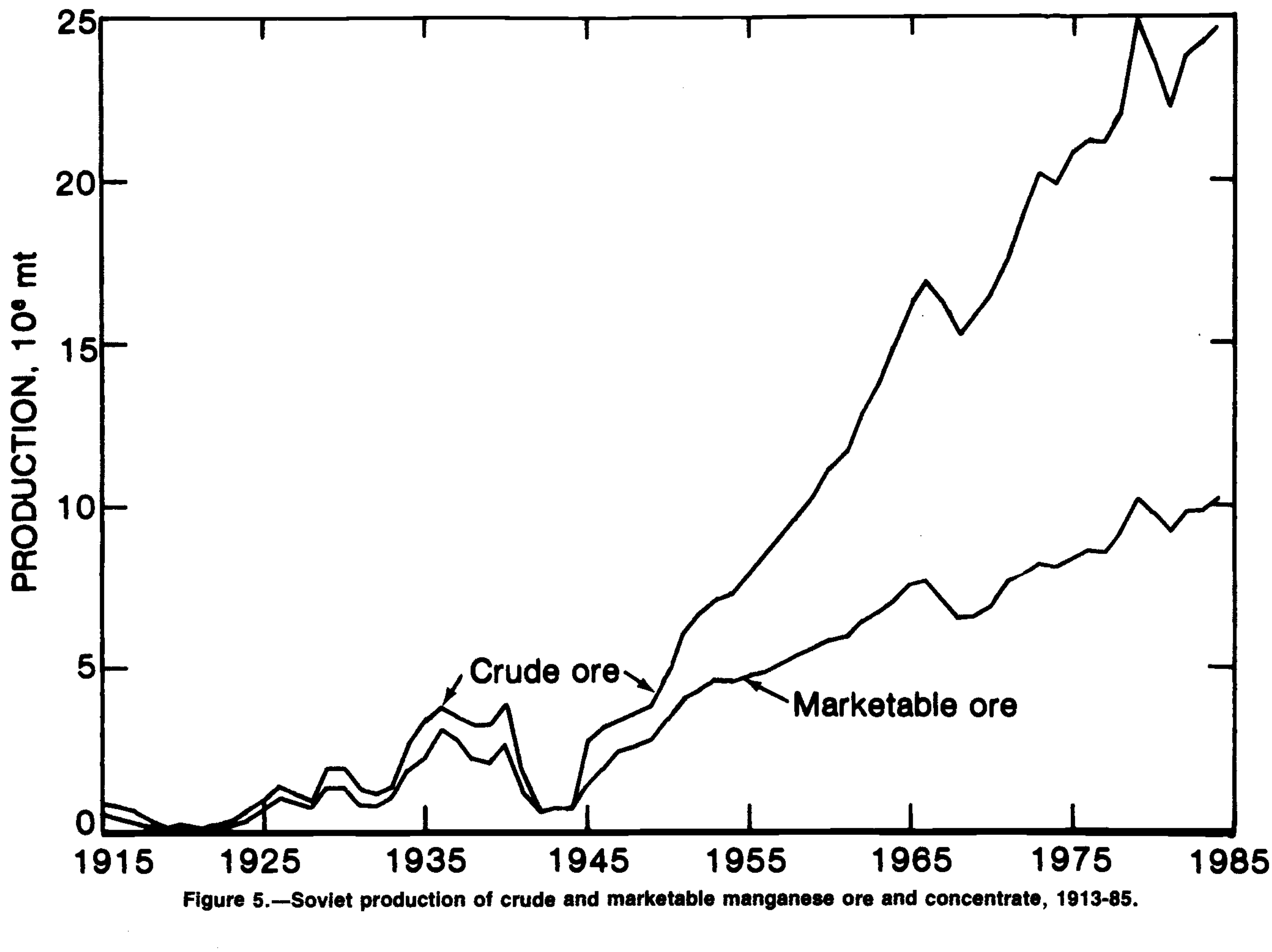

Figure 5.—Soviet production of crude and marketable manganese ore and concentrate, 1913-85.

the production of carbonate ore will force the Soviet ferromanganese industry and similar industries in the CMEA nations to adapt to using feedstock derived from the carbonate ores, as opposed to the present feedstock based on oxide ores. Import of high-grade ore for blending purposes may continue.

FERROMANGANESE

Technology

The strategic value of the various minor ingredients that go to extend the usefulness of steel in modern industry is virtually as important as the steel itself. The U.S.S.R. is at present adequately supplied with most minor ingredients, but is dependent upon imports for a part of its requirement for molybdenum and tungsten.

Manganese is one of the most widely used alloying materials in the Soviet steel production. Over 85% of the Soviet manganese consumption is in iron and steel production. Manganese is also used in Soviet nonferrous metallurgy; it is a component of many aluminum- and copper-based alloys. Furthermore, manganese is used as a protective covering for metals.

In 1985, there were 16 electric-furnace ferroalloy plants known to be in operation in the U.S.S.R., including 5 that contributed to total national electric furnace ferromanganese production, which was estimated at 675,000 mt for that year. The electric-furnace ferromanganese producing plants were located at Zestafoni, Nikopol', Zaporozhye, Yermak, and Almazyan. Other electric-furnace ferroalloy plants, not producing ferromanganese, include facilities at the following locations (see figure 2): Aktyubinsk, Chelyabinsk, Chusov, Izhevsk, Klyuchev, Moscow Hard Alloy Complex, Novokuznetsk, Novolipetsk, Satkin, Serov, and Stakhanov.

The amount of manganese used in the Soviet steel industry per metric ton of steel produced is far higher than in other major steel producing countries, apparently averaging 13 kg in 1984, and at times reaching 20 to 30 kg. In the United States, it amounts to about 5 kg of manganese per metric ton of raw steel produced. In addition to inefficiencies in mining, processing, ferroalloy production, and steelmaking, higher manganese consumption in the U.S.S.R. is due to (a) low-grade manganese ores; (b) low manganese content of Soviet iron ore; (c) high sulfur content of Soviet coke; and (d) relatively higher manganese content steel produced in the U.S.S.R. The manganese content in pig iron for steelmaking varies from 0.5% to 2.75% and that of foundry pig from 0.1% to 1.3%. A part of the marketable manganese ore from Nikopol' is used in the manufacture of spiegeleisen and metallurgical products other than ferromanganese in Soviet iron and steel plants. The average manganese content in spiegeleisen is 20%.

The manganese ore consumption pattern in Soviet ferrous metallurgy in 1984 was approximately up to 65% of the total in pig iron for steel and blast-furnace ferromanganese; less than 5% of the total in pig iron for castings; small quantities for spiegeleisen; and about 30% of the total for production of electric-furnace ferroalloys and manganese metal. There are no programs for secondary manganese recycling.

The following commodities containing manganese as a major element have found application in Soviet steel production:

1. High-carbon ferromanganese.
2. Spiegeleisen.
3. Silicomanganese.
4. Medium-carbon ferromanganese.
5. Low-carbon ferromanganese.
6. Manganese metal.

High-Carbon Ferromanganese

High-carbon ferromanganese, used mainly for deoxidation of steel, is one of the most extensively used alloys. Most of the high-carbon ferromanganese made at present in the U.S.S.R. is smelted in blast furnaces. The blast-furnace ferromanganese and spiegeleisen produced in the U.S.S.R. have to conform to the GOST (All-Union State Standard). The chemical composition of these alloys, conforming to GOST, is given in tables 25 and 26. The composition of high-carbon ferromanganese smelted in electric furnaces, conforming to GOST, is given in table 27.

The smelting of high-carbon ferromanganese and spiegeleisen in a blast furnace is essentially similar to the production of pig iron. Consumption of manganese ore per metric ton of ferromaganese produced in Soviet blast furnaces ranges from 2,500 to 3,000 kg.

High-carbon ferromanganese is also produced in the U.S.S.R. in submerged arc electric furnaces. From 2,300 to 2,550 kg of manganese concentrate (48% Mn) and 290 kg of manganese sinter are used for the production of a metric ton of high-carbon ferromanganese. Recovery of manganese is from 59% to 61% (*8*).

High-carbon ferromanganese is smelted in electric furnaces by a continuous process; slag and metal are tapped at regular periods of 2 to 2.5 h. The slag tapped from the furnace is poured into pots, or is granulated and then directed to silicomanganese smelting. The metal is tapped

Table 25.—Composition of Soviet blast-furnace high-carbon ferromanganese, percent

Grade and official grade code	Mn content	Si	Deleterious elements, not to exceed— P: Group A[1]	P: Group B[1]	S
Mn-5	>75.0	2.0	0.35	0.45	0.03
Mn-6	70.0-75.0	2.0	.35	.45	.03
Mn-7	70.0-75.0	1.0	.35	.45	.03

[1] Furnaces.

Source: Reference 10 (p. 69).

Table 26.—Composition of Soviet spiegeleisen, percent

Grade and official grade code	Mn content	Si	Deleterious elements, not to exceed— P	S
ZCh1	20.1-25.0	2.0	0.22	0.03
ZCh2	15.1-20.1	2.0	.20	.03
ZCh3	10.0-15.1	2.0	.18	.03

Source: Reference 9.

Table 27.—Composition of Soviet electrothermic high-carbon ferromanganese, percent

Grade and official grade code	Mn, not less than—	C	Deleterious elements, not to exceed— Si	P	S
FMn78A	78	7.0	2.0	0.05	0.03
FMn78K	78	7.0	1.0	.35	.03
FMn78	78	7.0	2.0	.35	.03
FMn75K	75	7.0	1.0	.35	.03
FMn75	75	7.0	2.0	.45	.03

Source: Reference 10 (p. 76).

into a ladle from which it is poured into unlined steel molds or into casts by means of small teeming machines.

Silicomanganese

Five grades of silicomanganese are produced in the U.S.S.R., conforming to GOST (table 28).

All the grades indicated in table 28 are used in the production of steel, while in the production of medium-carbon ferromanganese, only grades CMn26 and CMn20 are used. In addition to the silicomanganese grades indicated in table 28, silicomanganese containing 85% to 88% Si is also smelted. This is not a commercial grade, but is used only in the production of metallic manganese.

In the production of 1 mt of commercial grade CMn14 silicomanganese, from 1,950 to 2,050 kg of manganese concentrate (48% Mn) is used. Recovery of manganese is from 69% to 71%. Submerged arc furnaces of the same design as are used for smelting ferrosilicon and high-carbon ferromanganese are also used for smelting silicomanganese.

When silicomanganese is smelted from slag of high-carbon ferromanganese (40% Mn, 30% SiO_2), or from a mixture of slag with the ore, the electric power consumption is higher, while the extraction of manganese is lower, than when ore alone is used. The reason for these variations is that there is less manganese and more silicon in the slag charged to the furnace.

Table 28.—Composition of Soviet silicomanganese, percent

Grade and official grade code	Si[1]	Mn, not less than—	Deleterious elements, not to exceed— C	P Group A[2]	P Group B[2]	S
CMn26	26.0	60.0	0.2	0	0.05	0.03
CMn20	20.0-25.9	65.0	1.0	.1	.25	.03
CMn17	17.0-19.9	65.0	1.7	.1	.35	.03
CMn14	14.0-16.9	65.0	2.5	.2	.35	.03
CMn10	10.0-13.9	65.0	3.5	.2	.35	.03

[1]As reported. [2]Furnaces.

Source: Reference 10, p. 86.

Medium- and Low-Carbon Ferromanganese

Medium- and low-carbon ferromanganese smelted in the U.S.S.R. correspond by chemical composition to the specifications of GOST (table 29).

For the production of 1 mt of medium-carbon (FMn1.5) ferromanganese, from 1,340 to 1,420 kg of manganese concentrate (48% Mn) and from 950 to 1,050 kg of silicomanganese are used. Recovery of manganese is from 59% to 63%.

Characteristics of typical Soviet ferroalloys furnaces are shown in table 30.

Table 29.—Composition of Soviet medium- and low-carbon ferromanganese, percent

Grade and official grade code	Mn, not less than—	C	Deleterious elements, not to exceed— Si	P	S
Low-carbon: FMn0.5	85	0.5	2.0	0.3	0.03
Medium carbon:					
FMn1.0A	85	1.0	1.5	.1	.03
FMn1.0	85	1.0	2.0	.3	.03
FMn1.5	85	1.5	2.5	.3	.03

Source: Reference 10, p. 76.

Three-phase rotary furnaces with magnesite lining and a 2,500-kW transformer are used in one Soviet plant for smelting medium-carbon ferromanganese. The operating voltage of the furnace ranges between 111 and 178 V. The internal diameter of the bath is 2,500 mm, and its depth is 965 mm. The useful length of the self-baking electrodes of 500-mm diameter is 2,350 mm. The rotating speed of the bath is 5 rev/h. The maximum angle of slope in the tapping direction is 30°, and in the opposite direction it is 4°. The furnace is equipped with bracket-type electrode holders with telescoping extensions. The electrodes are lowered from the working platform by means of a pneumatic spring device.

Table 30.—Characteristics of Soviet electric ferroalloy furnaces

	PKO-2.5	PKO-3.5	PKO-10.5	PKO-16.6, PKO-16.5	PKZ-24	PKZ-33	PKZ-48	PKZ-63
Capacity ... MW	2.5	3.5	10.5	16.5	24.0	33.0	48.0	63.0
Voltage ... V	178-89	371-260	250-100	210-100	245-155	250-130	137.0-238.5	175-325
Electrode diam ... mm	300-450	300-450	800	1,200	1,200	1,500	[1]2,800 by 650	1,900
Bath diam ... mm	2,700	2,700	4,000	6,200	7,200	8,700	[1]20,340 by 6,000	12,200
Bath depth ... mm	1,200	1,300	1,700	2,300	2,600	3,000	2,850	4,240
Angle of slope in tapping direction ... deg	30	30	30	NA	NA	NA	NA	NA

NA Not available. [1]As reported, possibly a rectangular furnace.

Source: Reference 8, p. 212.

Manganese Metal

Six grades of metallic manganese are smelted in the U.S.S.R. The compositions of the grades are given in table 31.

Grades Mr00 and Mr0 are produced by electrolysis of sulfates of manganese, and grades Mr1 and Mr2 by the electric furnace method. Grades Mr3 and Mr4 manganese are obtained by the aluminothermic method, though lately the electric furnace method has been substituted for it. The substitution ensures the production of a better quality at lower production costs.

Production

Before the Revolution

The ferroalloys known to have been produced in prerevolutionary Russia are ferromanganese, spiegeleisen, low-grade ferrosilicon (silvery pig iron), and some type of ferrochromium. Ferromanganese has been produced in Russia in crucibles, using manganiferous iron ores, since the beginning of the 19th century. Starting in 1876, the production of ferromanganese from similar material was set up in a blast furnace at the Nizhniy Tagil metallurgical plant in the Urals. Electric-furnace plants at Satka and Porogi in the Urals produced ferrosilicon with 30% to 45% Si. The annual production capacity of the Satka plant was 5,000 mt. Production of steel and blast furnace ferromanganese in Russia in 1903-14 is shown in table 32.

1917 Through 1945

There is no authoriative mention of ferromanganese production through the Civil War period (1918-21) or the period of the New Economic Policy.

Except for the World War II years, no ferroalloys have been reported imported by the U.S.S.R. since 1935. The first 5-yr plan (1928-32) recognized the need for electric-furnace ferroalloys, especially for special and quality steels. The first electric-furnace production of ferroalloys (ferrochromium, ferrosilicon, and ferrotungsten), started in 1931 at the Chelyabinsk ferroalloys plant in the Urals (*28*). The plant had an annual capacity of 50,000 mt. The second planned electric-furnace production (66,000 mt/yr capacity) of ferroalloys (ferrochromium and ferrosilicon) started in 1933 at the Zaporozhye ferroalloy plant in the Ukraine (*30*). By 1934, the Zestafoni electric-furnace ferroalloy (ferromanganese) plant in Georgia, with an annual capacity of 50,000 mt, was operating. Electric-furnace production of ferroalloys in the U.S.S.R. in the 1930-40 period is shown in table 33.

Production of manganese and its alloys traditionally occupied third place behind ferrosilicon and ferrochromium with respect to the total electric-furnace output of ferroalloys in the U.S.S.R. The largest portion of ferromanganese production for many years was by blast furnace, despite the theoretical economic advantage of electric furnaces. This use can be explained by the shortage of electric power in the areas of ferromanganese production only. Production of ferromanganese (table 33) increased from a reported 1,008 mt in 1933 to an estimated 17,000 mt in 1934 and to an estimated 34,000 mt in 1940. (Reported planned quota was 21,000 mt in 1934 and 34,000 mt in 1940.)

The Soviets have published little information on electric-furnace ferromanganese production. The Government has regarded statistics on the electric-furnace production of all ferroalloys for any year subsequent to 1937 as a state secret although ferroalloy output for 1930-38 was published in sources shown in table 33. Therefore, for those years for which published Soviet statistics are available, the data on ferromanganese production were based on published data as shown in table 33. From these data, figures on manganese alloys production were developed using available published information on planned growth and actual achievements given in percent. Expansion of ferroalloy plant capacity was emphasized in the third 5-yr plan (1938-42), which was called the Five-Year Plan for Special Steels, but actual production of ferroalloys was reportedly much below (unspecified) goals.

The outbreak of World War II immediately aggravated the shortage of skilled labor and the general shortage of all labor continued through the war. Only 15% to 20% of the original workers and engineers remained at the mining and smelting operations; the balance were drafted into the armed forces (*7*). Military actions brought some manganese industry operations to a halt. The Zaporozhye ferroalloy plant in the Ukraine was put out of action com-

Table 31.—Chemical composition of Soviet metallic manganese, percent

Grade and official grade code	Mn not less, than—	Impurities, not to exceed— Si	P	Al	Fe	Cu	C	S
Mr00	99.95	0	0.005	0	0	0	0.02	0.01
Mr0	99.70	0	.01	0	0	0	.10	.10
Mr1	95.0	.8	.05	0	2.5	0	.10	0
Mr2	93.0	1.8	.07	0	3.0	0	.20	0
Mr3	91.0	3.5	.45	1.0	2.0	2.5	.12	0
Mr4	88.0	4.0	.50	1.5	3.0	4.0	.15	0

Source: Reference 37.

Table 32.—Production of steel and blast-furnace ferromanganese in Russia, 1903-14, thousand metric tons

Year	Steel	Ferro-manganese	Year	Steel	Ferro-manganese
1903	2,680	18.5	1909	3,540	30.4
1904	2,908	31.5	1910	3,140	29.6
1905	2,760	34.4	1911	3,950	33.8
1906	2,710	48.2	1912	4,500	31.7
1907	2,840	38.8	1913	4,900	36.9
1908	2,870	29.4	1914	4,400	38.1

Source: Reference 33, p. 188.

Table 33.—Soviet electric-furnace ferroalloy production, 1930-40, thousand metric tons

Year	Total ferroalloys		Ferromanganese	
	Actual production	Planned quota	Actual production	Planned quota
1930	0	NA	0	NA
1931	4.65	NA	0	NA
1932	15.0	NA	0	NA
1933	20.0	NA	1.0	NA
1934	66.0	NA	[e]17.0	21.0
1935	116.0		[e]29.0 NA	NA
1936	125.5	NA	[e]33.0	NA
1937	123.8	153.0	[e]31.0	NA
1938	125.0	170.0	[e]32.0	NA
1939	[e]127.0	153.4	[e]33.0	NA
1940	[e]130.0	NA	[e]34.0	34.0

[e]Estimated (Bureau of Mines). NA Not available.

Source: References 27, 29, 31-32, 56.

pletely. During some time of the World War II period, production of manganese alloys at the Zestafoni plant in Georgia ceased. Under these circumstances, efforts were made to use crude manganese ore that was mined in the Urals and in Siberia. For the production of blast-furnace ferromanganese at the Magnitogorsk metallurgical complex (the largest in the U.S.S.R.), crude manganese ore was used during the 1941-45 period. The chemical composition of this ore is shown in table 34.

Production of ferromanganese alloys declined during the war and output of these alloys in 1945 was below that of 1940, despite the increased demand during the war period. The difference between production and demand was made up by lend-lease supplies provided by the United States, the United Kingdom, and Canada. According to Stal' (*62*), the 1940 level of ferroalloys production at the Zaporozhye plant in the Ukraine was again reached only in 1951. Production of ferroalloys at this plant resumed only in 1948 (*60*).

1946 Through 1985

The electric-furnace production of manganese and its alloys in the Soviet Union increased, compared with the 1940 level, by 44% by 1946, by 222% by 1950, and by 402% by 1955 (*9*). Production of electric-furnace manganese and its alloys in 1955 is estimated as 171,000 mt. Almost all of the production of ferromanganese in the U.S.S.R. was divided about equally between Zaporozhye and Zestafoni. In 1955, Soviet steel production consumed 3.3 million mt of marketable manganese ore (*58*). Table 35 gives consumption of marketable manganese ore for production of a ton of ferromanganese and silicomanganese.

An important change in the production of manganese alloys in 1950-56 was the replacement of the aluminothermic method of manufacturing metallic manganese by the electric-furnace method. During this time, the first sections for the production of electrolytic manganese were put into operation at the Zaporozhye and Zestafoni ferroalloy plants. Production of silicomanganese at the Zaporozhye ferroalloys plant began in 1954.

In the 1956-60 period, over 70% of Soviet blast-furnace ferromanganese was produced in large blast furnaces (960-1,100 m^3). Characteristics of these blast furnaces are shown in table 36.

Table 34.—Chemical composition of crude manganese ore used at Magnitogorsk metallurgical complex, 1941-45, percent

Source of ore	Mn	SiO_2	Fe	Al_2O_3	CaO	MgO	P
Chiatura (Georgia)	48.00	11.50	1.63	2.00	1.27	0.49	0.18
Urazov (Urals)	31.80	33.80	4.70	4.97	7.85	.97	.07
Dzhezdy (Kazakhstan)	38.25	14.75	3.69	5.75	1.82	.49	.22
Polunochnoye (Urals)	31.40	23.75	3.69	4.98	1.40	.81	.10
Novo-Troitsk (Urals)	23.40	49.00	NS	NS	NS	NS	NS
Kusimov (Urals)	22.90	44.00	4.80	NS	NS	NS	NS
Chiatura agglomerate	40.20	NS	7.93	NS	NS	NS	NS

NS Not specified in source.

Source: Reference 57.

Table 35.—Marketable manganese ore required for production of ferromanganese and silicomanganese, metric tons

Ore grade	Ferromanganese			Silicomanganese (oxide)
	Blast furnace	Electric furnace		
		Oxide	Carbonate	
Grade A	1.60	NS	NS	NS
Grade I	NS	2.05	NS	NS
Grade II	.75	NS	NS	2.23
Grade III	NS	NS	NS	.18
Carbonate agglomerate	NS	NS	2.25	0
Total	2.35	2.05	2.25	2.41

NS Not specified in source.

Source: Reference 59.

Table 36.—Principal characteristics of Soviet blast furnaces for production of ferromanganese

Blast furnace No	1	2	3	4	5	6	7	8	9	10	11
Volume m^3	1,110	1,033	1,020	1,007	994	960	652	595	593	394	365
Charge Mn content. %	44.30	41.29	41.43	44.25	41.59	41.25	41.39	44.25	39.71	42.00	42.21
Production mt/d	460.0	463.7	506.0	465.0	472.0	455.6	283.0	280.0	244.0	189.0	215.6
Consumption per metric ton of ferromanganese produced, kg:											
Concentrate	2,302	2,496	2,810	2,281	3,039	2,807	3,150	2,260	2,676	2,613	2,309
Coke	1,424	1,820	1,925	1,462	1,905	1,953	2,071	1,900	2,001	2,193	1,935
Ferromanganese Mn content %	73.4	70.32	70.4	76.1	69.23	70.57	71.20	73.20	70.68	72.39	72.38
Slag composition, %:											
SiO_2	31.5	31.6	32.8	32.5	33.0	32.4	32.19	30.4	30.58	29.6	0
CaO	31.4	44.44	39.0	39.4	37.0	40.5	34.5	41.5	48.31	44.30	0
MgO	4.1	7.66	7.5	2.3	7.26	4.5	7.0	6.0	5.23	4.24	5.43
MnO	18.2	6.65	11.7	14.2	14.2	13.4	12.35	9.3	5.72	10.43	8.14

Source: Reference 61.

During the 1959-65 period, Soviet electric-furnace production of silicomanganese increased by 100%, high-carbon ferromanganese production by 20%, and medium-carbon ferromanganese by 50%. It was planned to increase electric-furnace production of manganese alloys in 1970 by 130% over that of 1965 (*26*). Estimated output of electric-furnace manganese alloys increased from 171,000 mt in 1955 to 256,000 mt in 1965, or by about 50%. During the 1960-65 period the Zestafoni ferroalloys plant was under renovation. By 1965, this plant had at least four smelting shops including at least two closed electric furnaces. A large expansion was planned, but there had been considerable delays.

In the 1960-70 period, production of manganese alloys began at the Nikopol' plant in the Ukraine and at the Yermak plant in Kazakhstan. The designed capacity of each plant was 150,000 mt of ferroalloys per year (six furnaces at each plant). The Zestafoni plant in Georgia became the Soviet Union's leading plant for manganese smelting. The construction of this enterprise's second stage had been completed, which made it possible to double production. Closed electric furnaces had been installed and the plant's third stage was being built.

Reported blast-furnace production of ferromanganese was 888,000 mt in 1973. According to reference 6, production of electric-furnace ferromanganese in 1973 was 37.4% of that produced by blast furnaces, or 332,000 mt. The major producers were the Nikopol', Zaporozhye, and Zestafoni ferroalloy plants. Consumption of manganese ore per metric ton of pig iron for steel reportedly decreased from 6 kg in 1956 to 4 kg in 1973 (*1*). Subsequently, as the grade of ore consumed fell, this trend apparently reversed, and it appears that by 1984 the figure was about 9 kg. The Soviets are now using large quantities of very low grade ore directly in pig iron production.

During the 1971-80 period, the Soviets planned to bring on-stream new ferromanganese production facilities. They intended to reach an agreement with U.S. companies on the construction of ferroalloys plants, with repayment in production, and were also negotiating similar projects with several West European and Japanese companies. These plans were not fulfilled, but nevertheless Soviet production of electric-furnace ferromanganese increased each year by 3% to 4%. The capacity of the Yermak ferroalloy plant doubled by 1980; in 1977, the first electric furnace (No. 12) with an annual capacity of 50,000 mt was put in operation at this plant (*34*). Estimated production of electric-furnace ferromanganese increased from 332,000 mt in 1973 to 415,000 mt in 1980. The large electric melting furnaces at the Yermak ferroalloy plant, which were put into operation in the 1976-80 period, were used only at 67% of capacity, so the plant regularly failed to fulfill State-planned quotas (*35*).

The Soviet Union greatly expanded its electric-furnace ferromanganese capacity following a contract signed with Japan in 1977 to supply six 120,000-mt-capacity electric furnaces. Delivery began in 1980 and the last furnace was installed in 1983. The furnaces are used mostly for production of ferromanganese but some silicomanganese is also produced. Estimated output of electric-furnace ferromanganese increased from 415,000 mt in 1980 to 675,000 mt in 1985.

Large losses of manganese from that contained in marketable ores are suffered in current ferromanganese production processes. Insufficient concentrations and processing resulted in losses of up to one-half of the manganese in slime from concentration and in slag from metallurgical processing. The manganese content of the slag is approximately 16% and manganese in the slag generally is not recovered (*4*; *43*, p. 227; *48*; *51*). In 1985 the total losses of manganese during mining (7%), beneficiation (24%), production of ferroalloys (30%), production of pig iron (33%), and production of steel (50%) resulted in utilization of only 27% of manganese available in Nikopol' and Chiatura deposits (*64*). In addition, the ore with less than 10% Mn content is not mined.

Specifics on facilities producing silicomanganese and manganese metal are not available; it may be that the production of these materials is confined to the plants noted as ferromanganese producers, but this is by no means assured.

The reported Soviet production of pig iron, and blast-furnace ferromanganese and estimated production of electric-furnace ferromanaganese for selected years from 1913 to 1985, inclusive, is shown in table 37.

Future Prospects

Analysis of data from Soviet and other sources suggest that the manganese industry faces a number of serious problems. In recent years there has been a significant drop in manganese ferroalloys technical-economic production indicators owing to a steady decline of manganese ore quality. From 1976 to 1981, the Mn-SiO_2 ratio in the raw materials used at the Nikopol' ferroalloys plant for silicomanganese production declined from 2.3:1 to 1.4:1 and the recovery of manganese into alloy dropped from 77.2% to 72.2% (*63*).

Future growth of manganese ferroalloys production is contingent upon the resolution of three problems:

First, manganese ferroalloys in the U.S.S.R. are produced from only easily concentratable ore from the Chiatura and Nikopol' deposits (averaging 26% Mn), which represents only 14.6% of total manganese reserves in the U.S.S.R. Therefore, requirements for high-quality concentrates are consequently met with increasing difficulty. Furthermore, 70% of all ore in Chiatura is mined by underground methods and 40% of this ore is produced from secondary mining operations (*22*, p. 39). In the Nikopol' basin, more than 60% of the explored economical manganese reserves are in thin seams; consequently, during underground extraction the quality of ore is lowered 30% to 60% by dilution (*22*, p. 41).

Second, manganese ores are largely located in the western and southern regions of the country (over 91%) and only less than 9% are located in the eastern areas (including the Urals), where nearly half of the country's steel is smelted. The transportation of several million tons of manganese ore over the Soviet railroad network is a major problem. The long haul of manganese ore from Chiatura is costly.

Third, experience of high-capacity closed (RPZ-63) and hermetically closed (RKG-75) ore reducing electric furnaces at the Nikopol' and Zestafoni ferroalloy plants shows that they can be used at only 50% to 60% of rated capacity.

Table 37.—Reported Soviet production of pig iron and blast-furnace ferromanganese, and estimated production of electric-furnace ferromanganese for selected years, thousand metric tons

Year	Total pig iron and blast-furn- ferroalloy	Distribution of total pig iron and blast-furnace ferroalloy production[1]				Electric-furnace ferro-manganese[e]	Total ferro-manganese
		Pig iron for steel	Foundry pig iron	Spigel-eisen	Blast-furnace ferromanganese		
1913	[2]4,216	2,651	596	49	26	0	26
1928	3,282	2,516	705	25	36	0	36
1932	6,161	4,128	1,851	99	52	0	52
1937	14,487	11,366	2,766	110	159	31	190
1940	14,902	11,792	2,606	151	190	34	224
1945	8,803	6,499	1,942	40	154	25	179
1950	19,175	15,066	3,477	83	251	109	360
1953	27,415	22,322	4,325	104	322	140	462
1955	33,310	26,979	5,392	83	431	171	602
1956	39,600	28,913	5,823	71	470	174	644
1957	37,040	29,870	6,090	92	516	177	693
1958	39,600	32,326	6,234	61	562	180	742
1959	49,972	34,994	6,815	71	568	192	760
1960	46,757	38,472	6,961	81	643	200	843
1961	50,893	42,018	7,430	97	699	214	913
1962	55,265	45,579	8,072	90	812	225	1,037
1963	58,691	48,366	8,617	91	821	232	1,053
1964	62,377	51,594	8,977	81	916	248	1,184
1965	66,184	[e]55,600	[e]8,978	[e]90	[e]910	256	1,166
1966	70,264	59,832	8,979	93	902	268	1,170
1967	74,812	64,147	9,308	91	911	280	1,191
1968	78,788	67,792	9,588	75	944	293	1,237
1969	81,635	71,521	8,930	86	879	305	1,184
1970	85,933	75,649	9,160	102	968	316	1,284
1971	89,254	79,044	9,203	124	856	321	1,177
1972	92,327	[e]82,300	[e]9,000	[e]90	[e]870	327	1,197
1973	95,933	86,225	8,712	83	888	332	1,220
1974	99,868	90,167	8,709	107	859	344	1,203
1975	102,968	93,803	8,156	104	878	355	1,233
1976	105,384	96,560	7,800	(4)	800	367	[5]1,167
1977	107,368	98,692	7,800	(4)	800	380	[5]1,180
1978	110,702	102,490	7,500	(4)	600	392	[5]992
1979	108,998	101,255	7,000	(4)	600	405	[5]1,005
1980[3]	107,282	99,958	[e]6,600	(4)	600	415	[5]1,015
1981[3]	107,766	100,576	[e]6,500	(4)	600	430	[5]1,030
1982[3]	106,723	99,706	[e]6,400	(4)	600	450	[5]1,050
1983[3]	110,453	102,958	[e]6,700	(4)	700	500	[5]1,200
1984[3]	110,893	103,469	[e]6,700	(4)	600	600	[5]1,200
1985	[e]109,977	102,840	[e]6,400	(4)	600	675	[5]1,275

[e]Estimated.

[1] Difference between this category and the sum of the distribution is the quantity of other blast-furnace ferroalloys (ferrosilicon and ferrophosphorous) produced, except in the case of data for 1913.

[2] Includes 886,000 mt of material not distributed by type in source and 8,000 mt of ferrosilicon. (Presumably most of this undistributed material was pig iron, both for steel and for foundry use.)

[3] Because data for total and pig iron for steel were obtained from a source that reported precisely to the nearest 1,000 mt, while the data on foundry pig iron, spiegeleisen, and blast-furnace ferromanganese were obtained from a source that rounded to the nearest 100,000 mt, except for pig iron for steel, the detail is not as precise as in other years.

[4] Included with blast-furnace ferromanganese.

[5] Includes spiegeleisen (100,000 mt or less each year).

Sources: For all data for 1913-55 and 1958-62 (*49*, p. 167); for all data for 1956-57 (*39*); for all data for 1963-64 and 1966-68 (*68*), for all data for 1969-71 and 1973-75 (*67*); total of blast-furnace products and data for pig iron for steel for 1965, 1972, and 1976-84 (*65*), foundry pig iron, spiegeleisen, and blast-furnace ferromanganese for 1976-84 (*69*); total blast-furnace products for 1985 (*24*); Bureau of Mines estimates for foundry pig iron, spiegeleisen, and blast-furnace ferromanganese for 1965, 1972, and 1985, for electric-furnace ferromanganese for 1913-85, and for foundry pig iron for 1985.

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CHAPTER 4.—FOREIGN TRADE

All foreign trade in manganese ore and alloys is conducted by the All-Union Ministry of Foreign Trade. Producing enterprises are not allowed to engage in foreign trade. Subordinate to the Ministry of Foreign Trade are specialized foreign trading companies called associations (ob'yedineniye). The associations concerned with manganese trade are Soyuzpromeksport, which is responsible for exports and imports of manganese ore, and Promsyr'yeimport, which is responsible for exports and imports of ferroalloys. A reform of the foreign trade system occurred in 1986, allowing some ministries and enterprises to engage directly in foreign trade, but this reform has not yet extended to foreign trade in ferrous metals.

Prior to World War I, Russia was the world's largest exporter of manganese ore. Over 95% of the exported ore was from the Chiatura deposit in Georgia with the remainder coming from the Nikopol' deposit. In 1913, Germany was the major consumer of Russian manganese ore followed by the United Kingdom, Belgium, the United States, France, and Austria.

The disruptions caused by World War I, the revolution, and the Civil War resulted in a sharp decrease in manganese ore production and consequently of manganese ore exports. In 1923, exports were approximately one-third their prewar level. Recovery, however, ensued, and by 1927 export levels had risen to approximately two-thirds their prewar level.

During the first 5-yr plan, 1928-32, manganese ore production rose, but manganese ore exports fell as the Soviets had need of this manganese production for their rapidly expanding steel sector. Manganese ore production continued to increase through the 1930's, but manganese ore exports had decreased by 1940 to less than the 1923 level.

In the years just prior to World War II, the United States was the principal recipient of Soviet manganese exports, accounting for about two-fifths of the total in 1938 and 1939, and for nearly three-fifths of the total in 1940, as shown in table 38. These quantities approximated a third of total U.S. imports. Other principal immediate prewar destinations were France, Germany, and Poland.

Table 38.—U.S.S.R. exports of marketable manganese ore, by country, thousand metric tons

	1913	1923-24[1]	1924-25[1]	1925-26[1]	1926-27[1]	1930	1933	1938	1939	1940	1946	1947	1948	1949	1950	1951
Austria	[2]—	—	—	—	7.6	—	—	—	—	—	—	—	—	—	—	—
Belgium-Luxembourg	202.7	26.7	46.7	82.1	72.1	14	22	63	15	2	—	—	—	—	—	—
Bulgaria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Czechoslovakia	—	—	—	—	—	8	2	23	13	—	—	9	77	72	57	25
France	56.0	84.9	25.7	40.9	80.7	117	156	45	108	—	—	—	—	—	—	—
Germany	88.8	8.1	45.4	42.3	73.0	93	65	61	9	107	NAp	NAp	NAp	NAp	NAp	NAp
German Dem. Rep	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	—	—	—	20	25	50
Germany, Fed. Rep. of	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	NAp	—	—	—	—	—	—
Italy	4.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Japan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Netherlands	387.1	80.2	87.9	102.3	244.8	45	3	12	8	—	—	—	—	—	—	—
Norway	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Poland	—	9.6	3.0	23.5	21.4	25	54	17	39	—	30	51	81	140	74	70
Sweden	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Turkey	42.5	33.3	45.5	32.7	32.5	—	—	—	—	—	—	—	—	—	—	—
United Kingdom	276.8	60.0	59.8	69.9	26.2	15	1	2	8	—	—	—	—	—	—	—
United States	135.3	—	204.1	278.6	214.5	186	93	197	185	150	249	230	422	49	56	—
Yugoslavia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Others (undisclosed)	0	191.0	8.8	0.7	11.9	266	259	26	62	4	2	29	41	47	65	32
Total	1,193.8	493.8	526.9	673.0	784.7	769	655	446	447	263	281	319	621	328	277	177

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Austria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Belgium-Luxembourg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bulgaria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	97
Czechoslovakia	96	87	102	95	117	97	84	94	80	90	107	104	130	141	149	186	177	150
France	—	16	28	104	98	57	82	107	116	108	99	106	103	90	116	65	99	89
German Dem Rep	102	49	86	177	165	174	150	178	158	179	216	209	174	171	198	216	108	177
Germany, Fed. Rep. of	—	—	—	4	40	39	63	100	79	78	66	65	—	27	21	—	29	16
Italy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Japan	—	—	—	—	—	—	—	—	—	—	—	—	—	92	106	100	107	138
Netherlands	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Norway	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40
Poland	100	141	215	233	282	179	231	263	286	192	236	242	252	249	317	304	318	364
Sweden	—	—	—	7	15	16	17	27	8	21	10	25	37	27	26	30	26	37
Turkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
United Kingdom	—	36	119	120	147	179	115	105	149	129	99	100	138	122	134	104	71	44
United States	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yugoslavia	—	—	—	5	17	12	10	15	12	4	—	—	—	—	—	—	—	—
Others (undisclosed)	73	131	65	107	37	53	81	90	85	95	130	135	145	101	151	245	215	48
Total	371	460	615	852	918	806	833	979	973	896	963	986	979	1,020	1,218	1,250	1,150	1,200

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Austria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Belgium-Luxembourg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bulgaria	80	110	103	108	130	126	127	108	78	103	125	117	77	81	74
Czechoslovakia	153	252	265	331	329	341	356	320	373	423	397	372	346	295	300
France	109	99	93	9	—	—	—	—	—	—	—	—	—	—	—
German Dem. Rep.	175	193	172	165	150	179	185	186	170	182	135	130	107	85	68
Germany, Fed. Rep. of	43	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Italy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Japan	124	111	96	38	194	112	75	110	19	—	—	—	—	—	—
Netherlands	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Norway	37	26	10	52	65	57	5	—	—	—	—	—	—	—	—
Poland	365	360	417	465	495	484	482	502	446	518	490	493	535	539	549
Sweden	47	47	40	17	37	26	18	5	—	—	—	—	—	—	—
Turkey	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
United Kingdom	42	27	12	14	—	—	—	—	—	—	—	—	—	—	—
United States	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yugoslavia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Others (undisclosed)	25	175	92	101	82	86	94	121	100	91	108	82	79	79	90
Total	1,200	1,400	1,300	1,300	1,482	1,411	1,342	1,352	1,186	1,317	1,255	1,194	1,144	1,079	1,081

—Trade not reported. NAp Not applicable.
[1] Data for 12-month period beginning October 1 and ending September 30.
[2] Austro-Hungarian Empire.

Sources: 1913, 1923-24, and 1926-27—Godovoy Obzor Mineral'nykh Resursov S.S.S.R. za 1926/27 (Annual Review of Mineral Resources in the U.S.S.R., 1926-27), Leningrad, 1928, p. 559; all other years—Vneshnyaya Torgovlya S.S.S.R. (Foreign Trade of the U.S.S.R.), Moscow, various issues.

During World War II, there was a sharp decrease in manganese ore production caused by the German occupation of the Ukraine (where the Nikopol' deposit is located) and output in other producing areas was adversely affected by the war. These reductions in output evidently led to a sharp decline in exports beginning in the second half of 1941. Although official Soviet data have never been published, the United States recorded the following imports from the U.S.S.R., in thousand metric tons: 1941—29, 1942—16, 1943-4, 1944—nil, and 1945—137. Two other countries reported importing manganese ores from the Soviet Union during 1942-44, but these imports—300,000 mt by Germany in 1942, 2,000 mt by German-occupied Norway in 1943 and 4,000 mt in 1944—presumably were shipments from the German occupied areas of the U.S.S.R., quite likely from ore stockpiled there prior to the war.

Immediately following World War II, exports were resumed at their 1940 level, with the United States as the dominant destination through 1948. With the heightening of the cold war and the advent of the Korean war, exports to the United States were sharply curtailed apparently as a deliberate effort to deny strategic supplies of manganese to the West generally and to the United States specifically. Shipments to the United States dropped to zero in 1951 and were never resumed. Total export shipment levels fell sharply in 1949-51, as deliveries to other nations failed to compensate for the drastic reductions in shipments to the United States. By 1952, exports again began to increase, with CMEA countries as the major recipients, and by 1959 reached almost 1 million mt annually, with an upturn in deliveries to non-CMEA countries of Europe, chiefly the United Kingdom, France, and the Federal Republic of Germany. During the 1960's, Soviet total export levels generally grew, suffering a small decline in 1968-70. During this period, exports to CMEA countries climbed almost steadily, while shipments to non-CMEA countries and to undisclosed destinations fluctuated. Among the non-CMEA destinations, Japan became a significant separately reported destination in 1965, and by 1967 was the leading non-CMEA recipient. In the early 1970's, exports continued to increase, with shipments to CMEA countries increasing more significantly than in the 1960's and those to non-CMEA and unidentified destinations turning downward. Soviet manganese ore exports peaked in 1974, and thereafter generally declined, with slight recoveries in 1977 and 1979, through 1984, at which time export levels were 26% below the 1974 peak. The reduction was most evident in the case of shipments to specifically identified non-CMEA countries, which fell from 296,000 mt in 1974 to 19,000 mt in 1978, and to nil thereafter. Exports to specifically identified CMEA countries fluctuated, but peaked in 1979, at 1.226 million mt, falling below 1 million mt in 1984 for the first time since 1972. Exports to undisclosed destinations fluctuated during the 1975-84 period, varying from a high of 121,000 mt in 1977 to a low of 79,000 mt in both 1982 and 1983. A significant portion of the amount sent to undisclosed destinations was evidently exported to Japan, based on that country's import data.

Beginning in the 1970's, the Soviet Union was either unwilling or unable to meet European demand, this presumably in part owing to the declining grade of ore in the Soviet Union and an inability to significantly raise ferromanganese output above the levels required to meet indigenous demand and that of other CMEA countries. In addition, the rapid rise in petroleum prices in the 1970's provided the Soviets with greatly increased hard currency earnings from petroleum exports, which gave them greater latitude in conserving or diverting to other uses, mineral resources that had previously been exported to meet hard currency earning goals.

The role played by declining ore grade may well be reflected by the commencement of significant imports of high-grade manganese ores in 1983, which not only continued but also increased in 1984, as shown in table 39.

In the case of ferromanganese, total Soviet exports increased over those of the previous year in every year from 1956 through 1973 except for a very slight drop in 1967 as shown in table 40. Following 1973, the overall upward trend generally continued through 1982, but there were several single-year downturns (1974, 1976, and 1979, the latter estimated). In 1955, slightly over half of the small export total was destined for non-CMEA countries; from that year on, CMEA countries took an almost constantly increasing tonnage as well as an increasing share of the total. Trade with market economy countries, never large, was curtailed beginning in the mid-1970's and approached (if it did not reach) zero by 1981.

Although some Western recipients of Soviet ferromanganese distributed these imports by carbon content, official Soviet sources reporting ferromanganese exports do not further distinguish material of this type either as to its carbon content (high, medium, or low) or as to the type of furnace in which it was produced (blast or electric). From the location of ferroalloy plants with respect to export shipment routes and destinations, from the nature of demand by recipient countries, and from other factors, it is believed that most, if not all of the ferromanganese exported in recent years has been produced by electric furnaces, but there are no statistics to confirm this, nor to separate exports to CMEA countries by carbon content.

The Soviet Union's East European CMEA partners have long been receiving a portion of their ore and ferromanganese imports from market economy countries, as is illustrated in tables 41 and 42. The Soviet Union rapidly expanded its ferromanganese production in the early 1980's with the addition of Japanese-built furnaces, and it is estimated that the Soviet Union during this period significantly increased ferromanganese exports to its CMEA partners. In 1984, the Soviets stated that they would not have any additional ferromanganese above the current level available for export for several years. In 1987 the Soviets contracted with Brazil's Cia. Vale do Rio Doce (CVRD) to assist in constructing a 150,000-mt/yr ferromanganese plant in northern Brazil, with the Soviet Union providing financing and receiving 70% of the output for at least 12 yr. This contract can be viewed, in part, as another indication of the developing chronic shortfall of Soviet high-grade manganese ore.

The Soviets have at times exported battery grade ore, silicomanganese, and manganese metal, but complete data for these exports are lacking. Small exports of battery grade ore have gone to both market and non-market economy countries. Incomplete data indicate that the Soviets have sporadically shipped fairly significant quantities of silicomanganese and small quantities of manganese metal to market and non-market economy countries.

There has been considerable discussion in the West concerning whether the Soviets will remain long-term manganese ore importers, or whether this is only a temporary situation. The Soviets state that their manganese import needs stem from a combination of the depletion of traditional sources, a rise in domestic demand, and increased requirements for high-quality material. The Soviet supply situation is dependent on new capacity being put into operation at Nikopol' as well as the development of deposits in Kazakhstan and Siberia.

Ore from all prospective sources must be upgraded if it is to compensate for the loss of high-grade Chiatura ore, and much of the low-grade ore is difficult-to-process carbonate ore. Therefore, the Soviet supply situation is dependent, in part, on the successful application of technology for processing carbonate ore.

Table 39.—U.S.S.R. imports of high-grade manganese ore[1]

Origin	1983	1984
Australia	104	113
Brazil	0	101
Gabon	104	119
Total	208	333

[1] Compiled from export statistics of trading partner countries.

Table 40.—U.S.S.R. exports of ferromanganese, by destination,[1] metric tons

Destination	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Argentina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Austria	1,000	300	600	1,800	1,600	2,800	4,400	2,900	2,000	1,100	1,400	1,800	500	1,100	1,200
Belgium-Luxembourg	7,500	7,900	3,700	2,600	2,900	900	3,000	2,000	4,400	6,100	3,300	1,500	—	—	—
Bulgaria	[2]535	—	—	—	—	[2]2,463	—	—	[2]2,536	[2]2,114	[2]7,127	—	[2]2,572	[2]1,096	[2]811
Canada	—	[3]500	—	—	—	—	—	—	—	—	—	[3]48	—	—	—
China	—	—	[e]4,000	[e]7,000	[e]3,500	[e]6,000	[e]3,000	[e]1,000	—	—	—	—	—	—	—
Cuba	—	—	—	—	—	—	—	—	[e]500	—	[e]500	[e]1,000	—	[e]1,000	[e]1,000
Czechoslovakia	[e]5,000	[e]5,000	[e]10,000	[e]10,000	[e]10,000	[e]10,000	[e]10,000	[e]15,000	[e]13,000	[e]11,000	[e]5,000	[e]20,000	[e]20,000	[e]24,000	[e]35,000
Denmark	200	100	200	200	—	—	—	—	[3]94	—	—	[3]100	[3]100	—	—
Egypt	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[4]3,153
German Dem. Rep.	[e]500	[e]500	[e]500	[e]200	[e]500	[e]1,000	[e]500	[e]500	[e]500	[e]1,000	[e]1,000	[e]2,000	[e]2,000	[2]2,000	[e]2,000
Germany, Fed. Rep. of	—	—	—	—	—	—	—	—	—	—	—	—	—	[3]55	—
Finland	1,600	1,000	1,800	1,100	1,300	1,900	1,100	1,500	700	700	1,400	1,400	1,800	1,100	1,000
Hungary	[e]2,000	5,000	[e]10,000	[e]5,000	[e]5,000	[e]5,000	[e]5,000	[e]5,000	[e]5,000	[e]6,000	9,000	12,500	10,900	19,300	8,800
Italy	—	—	—	—	—	—	[3]6,240	[3]3,918	[3]4,199	[5]3,352	[5]5,994	[3]7,867	[5]6,914	[5]6,286	[5]6,700
Korea, North	—	—	—	—	—	—	—	—	—	—	4,300	4,000	4,800	4,700	4,500
Netherlands	—	—	—	—	—	—	326	—	—	—	[5]652	[5]347	[3]2	—	—
Poland	[e]500	[e]500	[e]500	[e]500	[e]500	[e]2,000	[e]1,000	[e]500	[e]500	[e]1,000	[e]1,000	[e]1,000	[e]1,000	[e]1,000	[e]2,000
Romania	[e]2,000	[e]5,000	[e]5,000	[e]13,000	[e]13,000	[e]13,000	[e]13,000	[e]15,000	16,000	23,400	18,600	24,200	28,700	29,400	33,900
Sweden	2,000	5,000	4,400	600	2,800	2,800	3,300	3,100	6,700	3,300	6,600	4,200	5,500	4,200	5,000
Switzerland	1,400	500	500	—	200	200	100	1,000	1,500	300	700	—	—	—	—
Turkey	—	—	—	—	—	—	—	—	—	—	—	[5]1,809	—	—	—
United Kingdom	—	—	—	—	—	—	—	—	—	[5]29	[5]230	[5]454	[5]799	[5]1,066	[5]683
United States	—	—	—	—	—	—	—	—	—	[3]50	—	—	—	—	—
Vietnam, North	—	—	—	—	800	800	—	—	—	—	—	—	—	—	—
Yugoslavia	—	—	—	—	—	—	—	[3]111	[3]37	—	[3]203	[3]99	—	—	—
Undistributed[6]	1,365	100	500	3,700	8,400	1,937	634	4,171	1,234	155	294	3,076	1,413	897	1,753
Total	25,600	31,400	41,700	45,700	50,500	50,800	51,600	55,700	58,900	59,600	67,300	87,400	87,000	97,200	107,500

Destination	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Argentina	—	—	—	1,700	200	—	—	—	—	—	—	—	—	—	—
Austria	1,075	765	1,470	1,308	763	449	—	—	—	—	—	—	—	—	—
Belgium-Luxembourg	—	—	—	[3]1,404	[5]104	—	—	—	—	—	—	—	—	—	—
Bulgaria	[2]1,161	[2]1,184	[2]1,171	[2]1,248	[2]1,253	[2]1,632	[2]1,116	[2]955	[2]1,166	[2]972	[2]1,771	[2]1,250	[2]1,176	[2]2,050	[3]1,242
Canada	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
China	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cuba	[e]1,000	[e]1,000	[e]1,000	[e]1,000	—	[e]1,000	[e]2,000	[e]2,000	[e]2,000	[e]2,000	[e]2,000	[e]2,000	[e]2,000	[e]2,000	[e]2,000
Czechoslovakia	[e]42,000	[e]35,000	[e]35,000	[e]35,000	[e]30,000	[e]35,000	[e]30,000	[e]35,000	[e]40,000	[e]45,000	[e]45,000	[e]55,000	[e]55,000	[e]50,000	[e]45,000
Denmark	[3]100	[3]5	[3]982	[3]76	[3]35	[5]150	—	—	—	—	—	—	—	—	—
Egypt	[4]1,569	[4]1,032	—	—	—	—	—	—	—	—	—	—	—	—	—
German Dem. Rep.	[e]2,000	[e]2,000	[e]3,000	[e]3,000	[e]5,000	[e]5,000	[e]5,000	[e]5,000	[e]5,000	[e]10,000	[e]15,000	[e]30,000	[e]30,000	[e]30,000	[e]30,000
Germany, Fed. Rep. of	[5]122	—	[3]45	—	—	—	—	—	—	—	—	—	—	—	—
Finland	1,113	1,571	1,073	1,838	1,245	1,771	786	[5]623	[5]908	[5]1,235	[5]65	—	—	—	—
Hungary	12,800	20,200	16,600	17,811	18,639	21,798	23,181	[7]24,329	[7]19,876	[7]21,616	[7]26,819	[7]23,581	[7]25,941	[7]24,120	[7]24,584
Italy	[5]4,680	[5]3,671	[5]6,633	[5]8,074	[5]3,915	[5]3,500	[5]3,950	[5]5,050	[5]355	—	—	—	—	—	—
Korea, North	4,892	4,857	4,470	4,595	3,894	3,762	4,937	—	—	—	—	—	—	—	—
Netherlands	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Poland	[e]3,000	[e]5,000	[e]5,000	[e]10,000	[e]10,000	[e]10,000	[e]10,000	[e]10,000	[e]15,000	[e]8,000	[e]15,000	[e]20,000	[e]30,000	[e]25,000	[e]27,000
Romania	33,900	33,100	37,800	36,383	37,387	39,270	42,185	[e]45,000	[e]50,000	[e]40,000	[e]43,000	[e]43,000	[e]45,000	[e]36,000	[e]35,000
Sweden	3,491	4,255	2,635	5,412	1,501	1,944	1,615	[5]80	—	—	—	—	—	—	—
Switzerland	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Turkey	[3]3,410	[3]1,223	[3]2,877	[3]3,373	[3]1,627	[3]1,293	—	—	—	—	—	—	—	—	—
United Kingdom	[5]892	[5]205	[5]175	[3]850	—	—	—	—	—	—	—	—	—	—	—
United States	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vietnam, North	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yugoslavia	—	[3]6,333	—	—	—	—	—	—	—	—	—	—	—	—	—
Undistributed[6]	1,295	3,399	9,769	1,928	2,737	2,631	530	1,963	695	1,177	1,345	169	883	830	174
Total	118,500	124,800	129,700	135,000	118,300	129,200	125,300	[e]130,000	[e]135,000	[e]130,000	[e]150,000	[e]175,000	[e]190,000	[e]170,000	[e]165,000

[e]Estimate.

—Either no export or no published figure available in Soviet export source or source showing imports of country in question. It is possible there could have been unreported shipments.

[1] Compiled primarily from Vneshnyaya Torgovlya S.S.S.R. (U.S.S.R. Foreign Trade), Moscow, annual series. All data not identified as estimated or from another source are from this source.

[2] V'nshna T'rgoviya na Narodna Republika B'lgariya (Bulgarian Foreign Trade), Sofia, annual series.

[3] Organization for Economic Cooperation and Development, Foreign Trade, Series C, Commodity Trade; Imports, Detailed Analysis by Products, annual series.

[4] U.A.R. Foreign Trade According to the Standard International Trade Classification, Revised, Central Agency for Public Mobilization and Statistics, Egypt, annual series.

[5] Statistical Office of the United Nations, World Trade Annual, Walker, New York, annual series.

[6] Calculated, difference between detail given and reported or estimated total, for each year.

[7] Kulkereskedelmi Statisztikai Evkonyv (Foreign Trade Statistics Yearbook), Budapest, annual series.

Table 41—Changes in Eastern Bloc[1] manganese ore trade with market economy countries (MEC's), thousand metric tons

Year	Min East Bloc net imports[2]			Max East Bloc net imports[2]		
	Max exports to MEC's	Min imports from MEC's	Net total	Min exports to MEC's	Max imports from MEC's	Net total
1970 ..	535	59	476	474	NA	NA
1971 ..	568	68	500	455	NA	NA
1972 ..	446	137	309	314	NA	NA
1973 ..	277	115	162	215	218	-3
1974 ..	413	180	233	413	253	160
1975 ..	313	183	130	296	253	43
1976 ..	182	122	60	166	237	-71
1977 ..	231	273	-42	177	427	-256
1978 ..	104	295	-191	47	456	-409
1979 ..	75	333	-258	52	411	-359
1980 ..	94	474	-380	66	557	-491
1981 ..	84	349	-265	53	464	-411
1982 ..	82	414	-332	62	575	-513
1983 ..	83	408	-325	52	690	-638
1984 ..	91	631	-540	56	860	-804

NA Not available.
[1] Includes Soviet Union, Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, and Romania.
[2] Owing to the fact that for a portion of the trade data, destination or origin of shipments is not specified, maximum and minimum net exports are presented.

NOTE.—Based on trade reports of importing and exporting countries.

Table 42.—Reported East European[1] ferromanganese imports from market economy countries, metric tons

Year		Year		Year	
1963 ...	4,844	1970 ...	6,583	1977 ...	7,773
1964 ...	21,300	1971 ...	7,088	1978 ...	2,712
1965 ...	18,004	1972 ...	11,396	1979 ...	67,819
1966 ...	25,563	1973 ...	19,817	1980 ...	25,315
1967 ...	4,799	1974 ...	38,196	1981 ...	21,990
1968 ...	2,561	1975 ...	9,146	1982 ...	21,027
1969 ...	5,498	1976 ...	41,649	1983 ...	21,329

[1] Includes Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, and Romania.

NOTE—Based on reported figures from exporting countries. With the exception of Hungary and Bulgaria, the East European countries either do not report ferromanganese imports or do not report ferromanganese imports by country of origin.

CHAPTER 5.—CONSUMPTION AND STOCKPILING

Although detailed data on the use of manganese in the Soviet Union are lacking, Soviet manganese use, in general, corresponds to that of other countries in the world. However, the Soviet Union does not employ manganese as efficiently in steelmaking as advanced industrial countries, nor does it produce the quantity or quality of alloyed steels required by the Soviet economy.

The principal use for manganese is in steelmaking. Manganese is essential for the production of virtually all steels and cast irons. Over 90% of the world's manganese output is used in iron and steel production. There are no satisfactory substitutes for manganese in steelmaking. Initially, manganese was used as a deoxidizer and desulfurizer, enabling steel produced by the Bessemer process to be workable. Manganese still plays a significant role in this usage. Now, however, use of manganese as an alloying element to increase strength, hardness, durability, and machinability of steel is becoming more important.

Besides being used in ironmaking and steelmaking, manganese has a number of other important uses. It plays an important role as an alloying element for several nonferrous alloys such as aluminum and copper alloys. It has long been used in the form of manganese dioxide in the common carbon-zinc dry cell battery. Manganese has a number of chemical uses. It is used as a deoxidant in the production of hydroquinone, which is used in photographic developers, and in the production of rubbers and plastics. Manganese sulfate, a byproduct of hydroquinone production, and manganous oxide are used as soil conditioners. Potassium permanganate is a powerful oxidant, frequently used for water treatment and purification. Small amounts of manganese are used in making manganese-zinc ferrites for electronics, and several forms of manganese are used in manufacturing welding rod coatings and fluxes.

Commercially, manganese ore is subdivided according to its characteristics into three classes: metallurgical, battery grade, and chemical grade. Commercially exploited ores vary widely in their manganese content and level of associated minerals, and different compositions of ores are used for different purposes.

Steel generally contains from 0.3% to 1.0% Mn. Steels with over 10% Mn content are used in wear-resistant applications such as railroad tracks and mining and crushing equipment. Manganese alloys are consumed in steelmaking in the form of high-carbon ferromanganese and silicomanganese, although some specific steel products require higher purity medium- or low-carbon ferromanganese or manganese metal.

The U.S.S.R. iron and steel industry accounts for 85% of the nation's manganese ore consumption, the remainder is used in the variety of other applications previously specified. In 1984, steel industry consumption of manganese was as follows: about 65% for production of pig iron for steel and blast-furnace ferromanganese, less than 5% for foundry pig iron manufacture, a small amount for speigelisen production, and the remaining 30% for production of electric-furnace ferroalloys and manganese metal.

The Soviets report[1] that the average manganese consumption per metric ton of steel is double the amount used in the United States and other advanced market economy countries, where production equals about 5 kg/mt. Computations based on other Soviet data indicate that the 1984 Soviet figure is in the range of 13 kg/mt. It is considered possible for the U.S.S.R. to reduce its manganese consumption per metric ton of steel produced to nearer Western levels by switching from open hearth furnaces, which still comprise over 50% of steel production, to oxygen converter and electric furnaces and by employing more advanced steelmaking processes. In addition, there is no program for recycling manganese.[2]

The U.S.S.R. apparently maintains strategic stockpiles to meet defense needs for a 2- to 3-yr period, but data on

[1] Pravda. Moscow, July 30, 1981, p. 2.
[2] Work cited in footnote 1.

Table 43.—U.S.S.R. apparent consumption[1] of marketable manganese ore, thousand metric tons

Year		Year		Year		Year	
1900 ..	314	1928 ..	187	1947 ..	1,720	1966 ..	6,488
1910 ..	126	1929 ..	372	1948 ..	1,640	1967 ..	5,925
1911 ..	(2)	1930 ..	616	1949 ..	2,568	1968 ..	5,414
1912 ..	(2)	1931 ..	142	1950 ..	3,100	1969 ..	5,351
1913 ..	52	1932 ..	431	1951 ..	3,941	1970 ..	5,641
1914 ..	156	1933 ..	366	1952 ..	4,032	1971 ..	5,918
1915 ..	537	1934 ..	1,084	1953 ..	4,181	1972 ..	6,519
1916 ..	470	1935 ..	1,740	1954 ..	3,974	1973 ..	6,945
1917 ..	393	1936 ..	2,396	1955 ..	3,891	1974 ..	6,673
1918 ..	126	1937 ..	1,751	1956 ..	4,020	1975 ..	7,048
1919 ..	66	1938 ..	1,827	1957 ..	4,342	1976 ..	7,294
1920 ..	125	1939 ..	1,805	1958 ..	4,533	1977 ..	7,243
1921 ..	(2)	1940 ..	2,294	1959 ..	4,567	1978 ..	7,871
1922 ..	(2)	1941 ..	1,039	1960 ..	4,899	1979 ..	8,927
1923 ..	(2)	1942 ..	581	1961 ..	5,076	1980 ..	8,495
1924 ..	(2)	1943 ..	632	1962 ..	5,439	1981 ..	7,956
1925 ..	[3]149	1944 ..	605	1963 ..	5,677	1982 ..	8,677
1926 ..	[3]356	1945 ..	1,333	1964 ..	6,117	1983 ..	9,005
1927 ..	[3]59	1946 ..	1,449	1965 ..	6,556	1984 ..	9,352

[1] Based on marketable manganese ore production plus imports minus exports.
[2] Apparent consumption is a negative number. Presumably there were stocks accumulated in prior years that made it possible for exports to exceed production. Actual changes in consumption were probably proportional with the changes in steel production during this period.
[3] Exports calculated for 12-month period beginning October 1 of prior year and ending September 30 of year stated.

the stockpiles are a state secret. Although the U.S.S.R. is basically self-sufficient in manganese, it is probable that manganese is stockpiled because practically all manganese comes from just two locations. Without stockpiles, the U.S.S.R. would be vulnerable to a loss of its manganese supply. This occurred in World War II when the Nikopol' basin fell under German occupation and supply routes from Chiatura were out.

Table 43 provides figures for apparent consumption of marketable manganese ore for 1900 and 1910-84; table 44 supplies figures on apparent consumption of ferromanganese.

Table 44.—U.S.S.R. apparent ferromanganese consumption[1], metric tons

Year		Year	
1955	576,400	1972	1,067,300
1960	792,200	1973	1,085,000
1961	861,400	1974	1,084,700
1962	981,300	1975	1,103,800
1963	994,100	1976	[2]1,041,700
1964	1,104,400	1977	[2]1,050,000
1965	1,098,700	1978	[2]857,000
1966	1,082,600	1979	[2]875,000
1967	1,104,000	1980	[2]865,000
1968	1,139,800	1981	[2]855,000
1969	1,076,500	1982	[2]860,000
1970	1,165,500	1983	[2]1,030,000
1971	1,052,200	1984	[2]1,035,000

[1] Based on estimated ferromanganese production plus imports minus exports.
[2] Includes a relatively small amount of spiegeleisen.

CHAPTER 6.—INFRASTRUCTURE

Since the first 5-yr plan it has been Soviet policy to produce all minerals required for industrial development. Being richly endowed in minerals, including manganese, the Soviet Union has been able to pursue mineral development, although at great cost, as part of its general program of avoiding foreign dependency. Economic principles of comparative advantage have had little influence on Soviet decisions regarding mineral production. For each plan period it is generally attempted to increase production of needed minerals.

Figures 6 and 7 show the organizational structure of manganese production within the U.S.S.R. manganese industry. Plans for the development of the national economy are drawn up in accordance with directives from the leadership of the Communist Party of the Soviet Union (CPSU) which establishes national economic goals. The U.S.S.R. Government planning agency, GOSPLAN, issues instructions for operational plans to realize these goals. The industiral ministries, which administer all industrial production in the Soviet Union, act in accordance with instructions from GOSPLAN to formulate an operational plan. After formulation, this plan is sent to the U.S.S.R. Supreme Soviet for formal ratification. It is then considered a law with which all economic units must comply.

Manganese production is administered by the Union-Republic Ministry of Ferrous Metallurgy. A number of crucial functions regarding the manganese industry such as trade, construction of new capacity, supply of energy, machinery, and other materials, etc., fall under the jurisdiction of a number of other ministries. The Ministry of Ferrous Metallurgy is responsible for fulfilling the national plan for manganese production, and is the highest administrative echelon for enterprises of the manganese industry. Despite a large number of plan indicators that enterprises are supposed to fulfill, the most significant indicator, to which the other indicators are often sacrificed, is gross output in tons. In manganese production this indicator is gross output of marketable manganese ore.

Labor in the Soviet manganese industry is affected by factors that affect labor in the Soviet Union as a whole. The Soviet Union has been experiencing a labor shortage in the 1980's. This problem will persist into the 1990's because the growth rate of the labor force is less than in preceding decades because of declining birth rates. The problem is coupled with the fact that participation in the labor force has virtually reached its limit, as practically all women and men of working age, as defined by the Soviets, are employed, and given the current situation in agriculture, there is no longer a large surplus of able-bodied workers to extract from that sector.

The labor shortage is further aggravated by the fact that a large percentage of the new entrants to the labor force come from the less industrialized areas of Soviet Central Asia and Kazakhstan. Based on current evidence, migration of workers from Soviet Central Asia and Kazakhstan to the labor-deficient regions will not be of sufficient magnitude to compensate for labor shortages. Currently there is no legal labor draft besides the occasional use of students and soldiers, and there is no use of forced labor on the scale that existed in the past.

To compensate, in part, for the labor shortage, the Soviets are trying to switch from an extensive growth

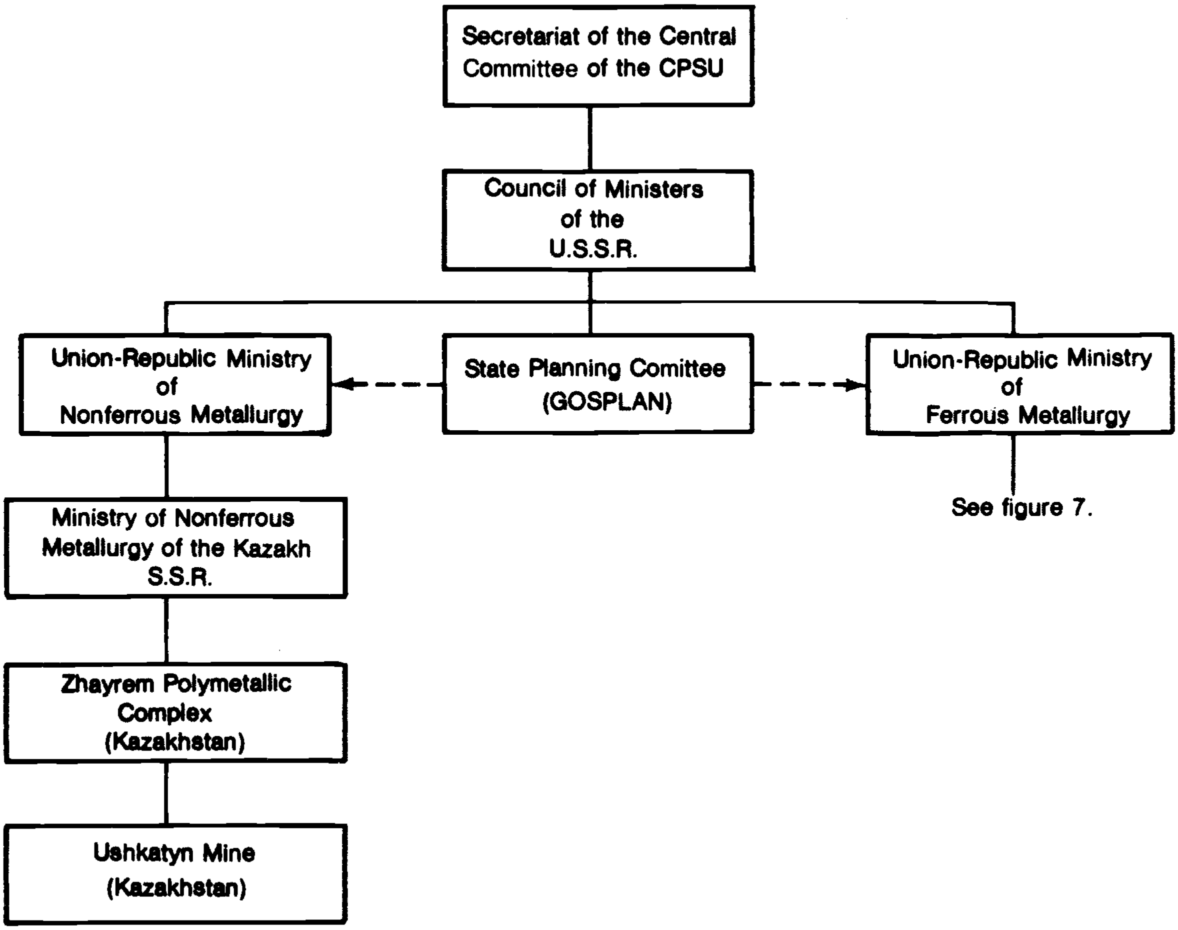

Figure 6.—Organizational outline of manganese production within the U.S.S.R. nonferrous metallurgy industry.

strategy that relies on greater quantities of inputs, including labor, to increase production, to an intensive growth strategy involving a better utilization of inputs. To accomplish this, the Soviets have been planning large increases in labor productivity. During the 1981-85 period, industrial labor productivity was planned to increase 23% to 25%. Published results, however, show that labor productivity in the ferrous metallurgy sector actually declined in 1981 and 1982, although it registered a 4% increase in 1983.

To direct workers to areas of priority production where there is a perceived labor recruitment problem, the Soviet system now relies on incentives in the form of better wages, pensions, and other benefits. It has been necessary to make these incentives quite attractive in the mining sector as the work is considered undesirable for a number of reasons; incentives increase as the degree of desirability decreases. Despite wages that are almost double the Soviet average, it has been difficult to attract young people to mining. Furthermore, there is often a high turnover of young people in the mining sector, which diminishes the average worker's skill level. Adding to this labor shortage in mining is the fact that some underground miners may retire at age 50.

These factors that affect the mining sector as a whole, also, to some extent, affect manganese mining. Manganese mining is centered in the western part of the country and does not experience the extreme difficulties in attracting labor as do operations in remote Siberian areas where mineral resources are being developed. The major expansion in manganese production is planned to come from the Bol'shoy Tokmak carbonate ore deposit in the Nikopol' basin in the Ukraine, and there will be the usual problems in attracting new workers. However, miners may also be transferred from depleted mines in the Nikopol' basin to Bol'shoy Tokmak and this would solve, in part, the labor problem at Bol'shoy Tokmak. The present labor shortage should not severely affect the Chiatura deposit in the Georgian S.S.R because production at Chiatura is declining.

Possible areas for limited expansion of manganese production include the manganese deposits in Kazakhstan. The labor supply situation in Kazakhstan is better than in other parts of the country, but there will still be a problem of attracting the local workers to mining, which is compounded by the reluctance of the local population in that region to leave their rural home areas for industrial jobs. If the Soviets proceed, as stated, to develop Siberian manganese deposits, then they will encounter the severe labor problems that already exist at other mineral development sites in Siberia, and this would greatly increase the cost of development.

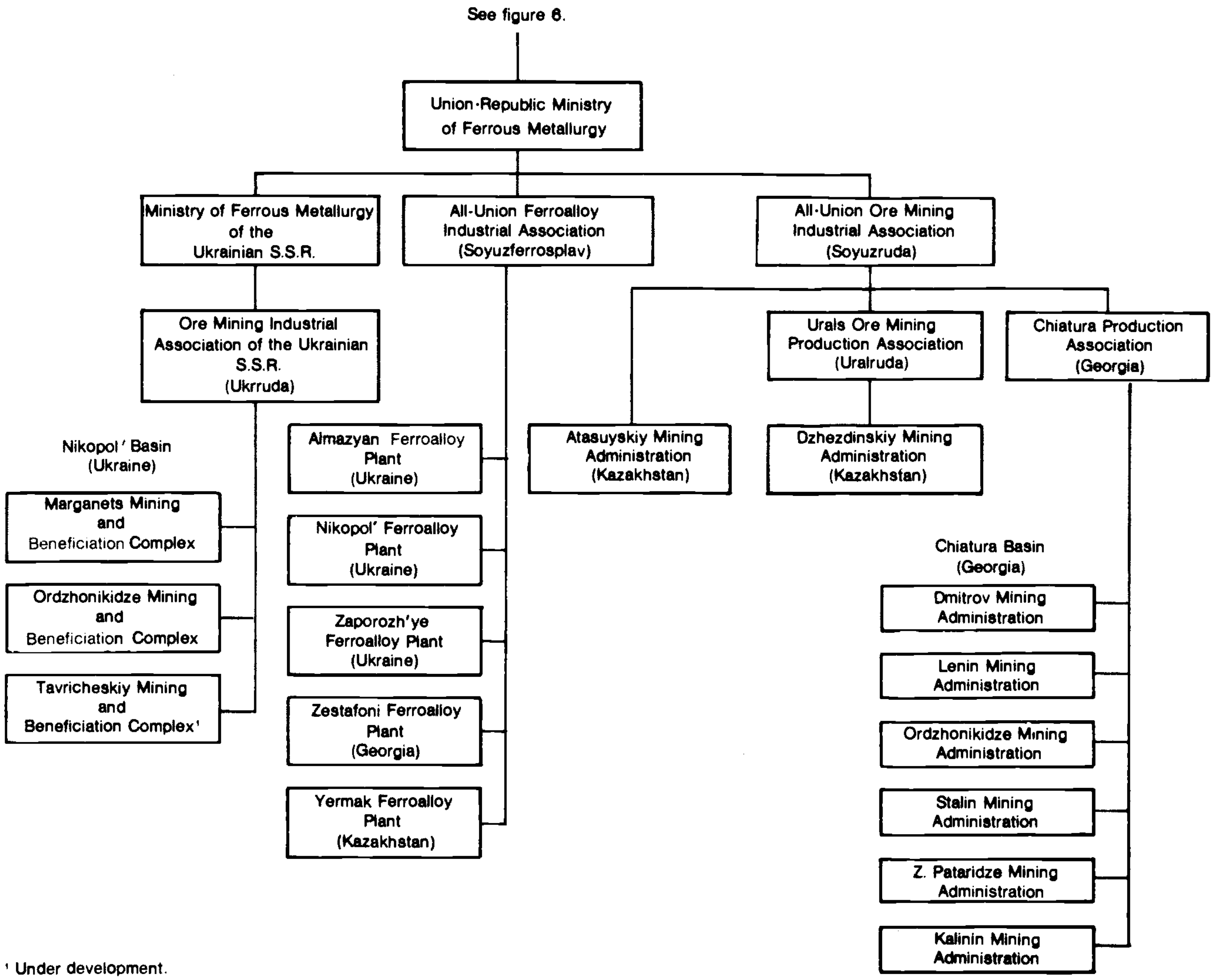

Figure 7.—Organizational structure of manganese production within the U.S.S.R. ferrous metallurgy industry.

Marketable manganese ores (concentrates) and ferromanganese are transported to metallurgical plants by railroad, and long-distance transportation is often required. Table 45 shows the proximity of the significant manganese mining areas to the major iron and steel plants. Over three-fourths of the ore from the Nikopol' basin, which produces the majority of Soviet manganese, is used by steel and ferroalloy plants in the Ukraine as well as metallurgical plants in the Donets basin, which is in that region. Nevertheless, the rest of the manganese ore and ferromanganese is shipped considerable distances to metallurgical plants in other parts of the country.

While the Chiatura deposit in the Georgian S.S.R. supplies the Zestafoni ferroalloys plant and the Rustavi steel plant, which are in Georgia, Chiatura ore is also shipped long distances to the Urals and Kazakhstan, where local production is not adequate, as well as to the Nikopol' area to meet high-quality ore requirements. Ferromanganese from the Zestafoni plant supplies metallurgical enterprises throughout the country. The small amount of manganese production in Kazakhstan is used to supply metallurgical plants in that region. In East Siberia, plans were discussed[1] to develop the Porozhinskoye deposit and to construct the nearby East Siberian ferroalloys plant, which is to be oriented towards ferromanganese production. This plant is to be located near the planned Srednyeyeniseyskaya powerplant that is to be built on the Yenisey River just below its confluence with the Angara River. It was originally intended to ship ore for the ferroalloys plant thousands of kilometers from the Nikopol' basin, but it was now declared possible to obtain suitable ore from the nearby Porozhinskoye deposit at which exploration work was declared completed.[1] It is still, however, possible that a percentage of the ore for this proposed plant will come from Nikopol' and other developed deposits. Actual development of the Porozhinskoye deposit and ferroalloy plant might not occur in the immediate future, if at all.

Owing to the fact that the Nikopol' and Chiatura deposits and four of the five electric-furnace ferromanganese plants are located in the western part of the country with

[1] Pravda. Moscow, May 30, 1984, p. 2.

Table 45.—Distance from Soviet manganese mining areas to major iron and steel plants, kilometers

From Nikopol' Basin (Ukrainian S.S.R.) to—	
Ukrainian S.S.R. plants:	
Krivoy Rog	75
Dnieprodzerzhinsk	120
Dniepropetrovsk	190
Zaporozh'ye	65
Kramatorsk	380
Konstantinovka	360
Yenakiyevo	320
Makeyevka	300
Donetsk	320
Zhdanov	320
R.S.F.S.R. (European) plants:	
Taganrog	440
Staryy Oskol	600
Lipetsk	850
Moscow	1,100
Cherepovets	1,800
R.S.F.S.R. (Urals) plants:	
Nizhniy Tagil	2,200
Zlatoust	2,200
Chelyabinsk	2,300
Magnitogorsk	2,600
R.S.F.S.R. (Siberia) plants:	
Novokuznetsk	4,200
Petrovsk Zabaykal'sk	4,600
Komsomol'sk on Amur	7,000
Kazakh S.S.R. plants:	
Karaganda	3,500
Temirtau	3,450
From Chiatura deposit (Georgian S.S.R.) to—	
Ukrainian S.S.R. plants:	
Krivoy Rog	1,450
Donets Basin	1,250
R.S.F.S.R. (European) plants: Lipetsk	1,400
R.S.F.S.R. (Urals) plants:	
Nizhniy Tagil	3,100
Chelyabinsk	2,800
Magnitogorsk	2,650
R.S.F.S.R. (Siberia) plants:	
Novokuznetsk	4,400
Komsomol'sk on Amur	8,700
From Kazakhstan deposits to—	
Kazakh S.S.R. plant: Karaganda	210
Urals (R.S.F.S.R.) plant: Magnitogorsk	1,340
Siberia (R.S.F.S.R.) plant: Novokuznetsk	1,300

good access to the Black Sea and to existing railroad networks, long-distance domestic rail transportation is not usually required for exporting ore or ferromanganese either to Eastern Europe or to world markets. Although manganese concentrates and ferromanganese make up only a few tenths of 1% of the total volume of railroad freight transport, manganese shipments still pose a burden on the railroad system. Owing to problems in the management of the railroad system such as shortages of freight cars, unmet schedules, losses in handling, etc., there are inherent problems in any railroad operation.

There are no major problems in supplying energy to manganese production complexes and ferromanganese enterprises. The Ordzhonikidze and Marganets mining complexes, as well as the ferromanganese enterprises in the Ukraine, are near large hydroelectric powerplants on the Dnieper River. The Chiatura complex and the Zestafoni ferroalloy plant receive electric power form an integrated circuit connected to both hydroelectric powerplants and regional thermal electric powerplants. The manganese operations in Kazakhstan obtain adequate energy from thermal electric powerplants.

CONCLUSIONS

In 1981, pursuant to the tasks set forth for the 1981-85 plan period, it was stated that development of the U.S.S.R. metallurgical industry required a significant increase in manganese extraction, and also a significant increase in the production of manganese alloys while also improving their quality.[1]

Since 1981 there has been a significant increase in ferromanganese production without a concomitant increase in manganese ore extraction. Rather, the Soviets have been faced with decreasing production of high-grade ore owing to depleted reserves and have annually imported several hundred thousand metric tons of high-grade ore. Planned developments are of lower grade ore, much of which is carbonate ore for which the Soviets have not yet successfully mastered the necessary processing technology.

In the next decade, the Soviet Union will be able to increase production of manganese ore, but will probably continue imports of high-grade ore and could begin importing ferromanganese; the U.S.S.R. will still, however, remain a net exporter of ferromanganese. The Soviets can greatly improve their manganese supply situation by introducing technological changes in steelmaking, which would reduce their manganese consumption levels to ones comparable to those of the industrially advanced market economy countries, as well as by reducing the manganese losses that occur during all stages of mining, beneficiation, steelmaking, and ferroalloys production.

Although the Soviet Union still supplies its CMEA partners with manganese ore and ferromanganese, exports of manganese ore to other countries have been greatly reduced and exports of ferromanganese have ceased. Soviet manganese ore exports to its CMEA partners in 1984 was about what it was a decade ago, and the East European countries during this period have been increasing manganese ore imports from the market economy countries.

The situation is different regarding ferromanganese exports to the CMEA countries. Electric-furnace ferromanganese production has doubled in the past 10 yr, and the Soviets have significantly increased ferromanganese exports to CMEA. Regarding resumption of ferromanganese exports to the market economy countries, the Soviets stated in 1984 that they have only a limited surplus of ferromanganese that they would export to their CMEA partners, and that no additional ferromanganese would be available for export for several years. In addition, in 1987 the Soviets contracted with Brazil's Cia Vale do Rio Doce (CVRD) to aid in the construction of a 150,000-mt/yr ferromanganese plant in Brazil in exchange for over 100,000 mt/yr of the output. This contract with CVRD can be regarded, in part, as another indication of a developing long-term shortfall in supply of high-grade Soviet manganese ore.

[1] Lakorin, B.N. Fizikokhimiya i Metallurgiya Margantsa (Physical Chemistry and Metallurgy of Manganese). Moscow, 1983, pp. 2-4, 183-185.

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