U.S. GEOLOGICAL SURVEY CIRCULAR 930-B

International Strategic Minerals Inventory Summary Report—Chromium

Prepared as a cooperative effort among earth-science and mineral-resource agencies of Australia, Canada, the Federal Republic of Germany, the Republic of South Africa, and the United States of America

Major geologic age units

Age			Million years before present
Holocene	QUATERNARY	CENOZOIC	0.1
Pleistocene			2
Pliocene	TERTIARY		5
Miocene			24
Oligocene			38
Eocene			55
Paleocene			63
Late Cretaceous	Cretaceous	MESOZOIC	96
Early Cretaceous			138
Jurassic			205
Triassic			~240
Permian		PALEOZOIC	290
Pennsylvanian	Carboniferous		~330
Mississippian			360
Devonian			410
Silurian			435
Ordovician			500
Cambrian			~570
PRECAMBRIAN	Late Proterozoic	PROTEROZOIC	900
	Middle Proterozoic		1600
	Early Proterozoic		2500
		ARCHEAN	

International Strategic Minerals Inventory Summary Report—Chromium

By John H. DeYoung, Jr., Michael P. Lee, and Bruce R. Lipin

U. S. GEOLOGICAL SURVEY CIRCULAR 930–B

Prepared as a cooperative effort among earth-science and mineral-resource agencies of Australia, Canada, the Federal Republic of Germany, the Republic of South Africa, and the United States of America

1984

Department of the Interior

WILLIAM P. CLARK, *Secretary*

U.S. Geological Survey

Dallas L. Peck, *Director*

Library of Congress Catalog-card No. 84–601094

*Free on application to Distribution Branch, Text Products Section,
U. S. Geological Survey, 604 South Pickett Street, Alexandria, VA 22304*

FOREWORD

Earth-science and mineral-resource agencies from several countries started the International Strategic Minerals Inventory in order to gather cooperatively information about major sources of strategic mineral materials. This circular summarizes inventory information about major deposits of chromium, one of the mineral commodities selected for the prototype phase of the inventory.

The report was prepared by John H. DeYoung, Jr., and Michael P. Lee of the U.S. Geological Survey (USGS). Chromium inventory information was compiled by J. M. Duke, Canadian Department of Energy, Mines and Resources (EMR), Geological Survey of Canada; Ian Goldberg, South African Department of Mineral and Energy Affairs (MEA), Minerals Bureau; Erik C. I. Hammerbeck, MEA, Geological Survey; Silvia M. Heinrich, USGS; Bruce R. Lipin (chief compiler), USGS; C. Roger Pratt, Australian Bureau of Mineral Resources, Geology and Geophysics (BMR); and A. G. Sozanski, EMR, Mineral Policy Sector. Additional contributions to the report were made by A. B. T. Werner and Jan Zwartendyk, EMR, Mineral Policy Sector; Ian Goldberg; Lee C. Ranford, BMR; and Aldo F. Barsotti, Edward H. Boyle, John F. Papp, and Paul R. Thomas, U.S. Bureau of Mines.

Director

CONTENTS

ILLUSTRATIONS

TABLES

INTERNATIONAL STRATEGIC MINERALS INVENTORY SUMMARY REPORT

CHROMIUM

By John H. DeYoung, Jr., Michael P. Lee, and Bruce R. Lipin

ABSTRACT

Major world resources of chromium, a strategic mineral commodity, are described in this summary report of information in the International Strategic Minerals Inventory (ISMI). ISMI is a cooperative data-collection effort of earth-science and mineral-resource agencies in Australia, Canada, the Federal Republic of Germany, the Republic of South Africa, and the United States of America. This report, designed to be of benefit to policy analysts, contains two parts. Part I presents an overview of the resources and potential supply of chromium on the basis of inventory information. Part II contains tables of some of the geologic information and mineral-resource and production data that were collected by ISMI participants.

PART I—OVERVIEW

INTRODUCTION

The reliability of future supplies of so-called strategic minerals is of concern to many nations. This widespread concern has led to duplication of effort in the gathering of information on the world's major sources of strategic mineral materials. With the aim of pooling such information, a cooperative program named International Strategic Minerals Inventory (ISMI) was started in 1981 by officials of the governments of the U.S.A., Canada, and the Federal Republic of Germany. It was subsequently joined by the Republic of South Africa and Australia. The United Kingdom will participate in future ISMI resource studies.

The objective of ISMI reports is to make publicly available, in convenient form, nonproprietary data and characteristics of major deposits of strategic mineral commodities for policy considerations in regard to short-term, medium-term, and long-term world supply. This report provides a summary statement of the data compiled and an overview of the supply aspects of chromium in a format designed to be of benefit to policy analysts.

The term "strategic minerals" is imprecise. It generally refers to mineral ore and derivative products that come largely or entirely from foreign sources, that are difficult to replace, and that are important to a nation's economy, in particular to its defense industry. Usually, the term implies a nation's perception of vulnerability to supply disruptions and of a need to safeguard its industries from the repercussions of a loss of supplies.

Because a mineral that is strategic to one country may not be strategic to another, no one list of strategic minerals can be prepared. The ISMI Working Group decided to commence with chromium, manganese, nickel, and phosphate.

The information used was the best at hand in various agencies of the participating countries that contributed to the preparation of this report. Those agencies were the Bureau of Mines and the Geological Survey of the U.S. Department of the Interior; the Geological Survey and the Mineral Policy Sector of the Canadian Department of Energy, Mines and Resources; the Federal Institute for Geosciences and Natural Resources of the Federal Republic of Germany; the Geological Survey and the Minerals Bureau of the Department of Mineral and Energy Affairs of South Africa; and the Bureau of Mineral Resources, Geology and Geophysics of the Australian Department of Resources and Energy.

Deposits (or districts) are selected for the inventory on the basis of their present or expected future contribution to world supply. Some deposits that do not meet this general "major deposit" criterion are included in the inventory because participants suggested that these deposits might have particular significance.[1] These deposits are listed in the summary data tables of this report (tables 9 and 10 in Part II), but have not been included in the resource and production tables in Part I of this report.

The ISMI record collection and this report on chromium have adopted the international classification system for mineral resources recommended by the United Nations Group of Experts on Definitions and Terminology for Mineral Resources (Schanz, 1980). The terms, definitions, and resource categories of this system were established in 1979 to facilitate international exchange of mineral-resource data; the Group of Experts sought a system that would be compatible with the several systems already in use in several countries. Figure 1 shows the U.N. resource classification used in this report. The term "reserves," which many would consider to be equivalent to r1E or R1E, has been interpreted inconsistently and thus has been deliberately avoided in the U.N. classification. Category R3, undiscovered deposits, is not dealt with in this report.

USES AND SUPPLY ASPECTS

About 10 million metric tons of chromite[2] ore and concentrates are consumed each year by the world's metallurgical, chemical, and refractory industries. Traditionally, chromite ore was classified according to its expected industrial end use, namely as metallurgical, refractory, chemical, or foundry-grade material. Because of changes in ferrochromium production technology and in the use of ferrochromium in steelmaking, however, end use is no longer a common basis for classifying chromite. Current nomenclature for chromite ores reflects the composition of the mineral chromite in a given deposit, rather than end use.

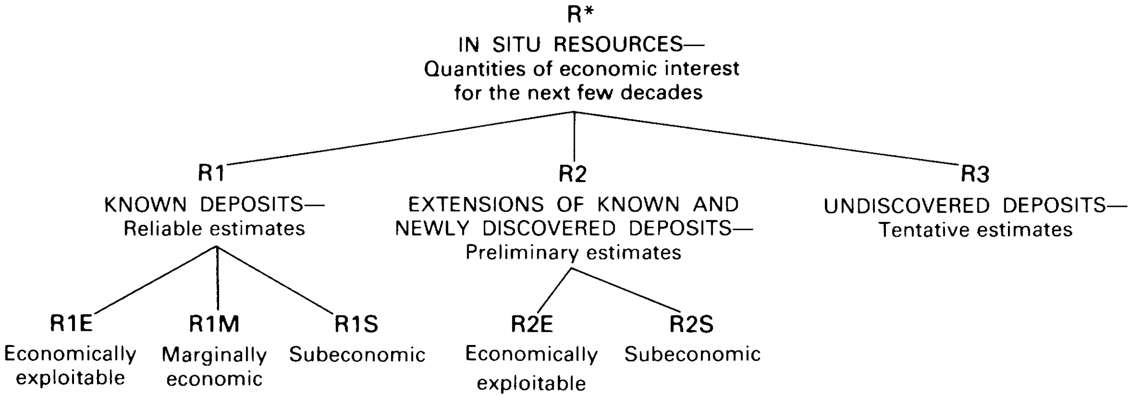
The mineral chromite has the general chemical formula $(Mg, Fe^{+2}) (Cr, Al, Fe^{+3})_2O_4$, in which ratios of the elements vary widely. Thus, Mg and Fe^{+2} can substitute for each other in all proportions, and the same is true, with a few restrictions, of Cr, Al, and Fe^{+3}. For this inventory, ores have been classified as high-chromium, high-iron, or high-aluminum. Table 1 lists the characteristics of these three ore classes with regard to geology, composition, and major use.

High-chromium ores, with high chromium-to-iron ratios, are used mainly for metallurgical applications—principally for making ferrochromium. High-iron chromite, previously used mostly for the production of chromium-base chemicals, is now finding increased use in making low-chromium ferrochromium and is being used to make refractories. The high-iron ores are also being used as foundry sands. High-aluminum chromite ores with relatively low iron and silica are used mainly for refractory purposes, primarily in the manufacturing of magnesite-chromite and chromite-magnesite brick (Canada Department of Energy, Mines and Resources, 1982). Chromium is used in several forms including chromite, chromium metal, ferrochromium, chromic acid and other chemicals, chromite refractory bricks, and chromite foundry sands. The distribution of chromium consumption by major uses in the United States from 1977 through 1981 was 58 percent metallurgical, 23 percent chemical, and 18 percent refractory (Papp, 1983, p. 212). This distribution differs from that in Japan, industrialized countries in western Europe, and countries with centrally planned economies. The United Nations estimates world chromium consumption to be 76 percent metallurgical, 13 percent refractory, and 11 percent chemical (United Nations Economic and Social Council, 1979).

Chromium's major metallurgical use is as an alloying element to produce stainless, heat-resistant, high-strength, and oxidation-resistant steels; there is no satisfactory substitute for chromium in stainless steel. Generally, a chromium-to-iron ratio in ore of greater than 2:1 is desirable for the production of high-chromium-content ferrochromium. Lower grade, less expensive ferrochromium called "charge chrome" is being used in increasing amounts for the manufacture of stainless steel in new steelmaking processes. Because of

[1] No information is provided on deposits that were once significant but whose resources are now considered to have been depleted.

[2] Chromite is the only mineral mined for chromium. In this report, chromite is used to indicate chromite ore and concentrates derived from chromite ore.



*The capital "R" denotes resources *in situ*; a lower case "r" expresses the corresponding *recoverable* resources for each category and subcategory. Thus, r1E is the recoverable equivalent of R1E. This report deals only with R1 and R2, not with R3.

FIGURE 1.—United Nations resource categories used in this report (modified from Schanz, 1980, p. 313).

TABLE 1.—*Classification of chromite ore by geologic deposit type, composition, and principal use*

[Modified from Mikami (1983), Thayer and Lipin (1978), and Papp (1983)]

Class of ore	Geologic deposit type	Composition of ore (by weight) and Cr:Fe ratios	Principal use
High-chromium --	Podiform, stratiform	46–55% Cr_2O_3 Cr:Fe>2:1	Metallurgical
High-iron -------	Stratiform	40–46% Cr_2O_3 Cr:Fe 1.5–2:1	Metallurgical, chemical
High-aluminum --	Podiform	33–38% Cr_2O_3 22–34% Al_2O_3 Cr:Fe 2.0–2.5:1	Refractory

these processes, some chemical-grade ores are now suitable for metallurgical purposes.

Chromite refractory bricks are used in the lining of steelmaking furnaces; conversion to basic-oxygen and bulk-electric steelmaking methods in Western countries is reducing the demand for refractory-grade (high-aluminum) chromite. The chemical industry produces chromium chemicals for use in electroplating, leather tanning, and the manufacture of paints and pigments.

As is shown in subsequent sections of this report, chromium resources and production are not uniformly distributed around the world. The geological factors that control the distribution of chromium deposits, coupled with the geographical history of economic development, have required many industrialized nations that are major chromium consumers to import chromium (in the form of ores, concentrates of chromite, and ferrochromium) from developing countries.

The pattern of world chromite production was influenced, primarily during the late 1950's, by the establishment of captive mines[3] in southern Africa by U.S. companies. This strategy, designed to ensure reliable supplies (McDivitt and Manners, 1974, p. 59–61), slowed development of chromite resources in countries that gave less encouragement to foreign control of mining operations.

Several aspects of chromium supply are especially noteworthy:

- The economic condition of the world steel industry plays a major role in determining the demand for chromium.
- Exploitable chromite resources are concentrated in a limited number of countries, especially South Africa and Zimbabwe.
- Eight industrialized countries[4] that mine little or no chromite have a significant (an estimated 27 percent in 1982) but lessening role in ferrochromium production (Brown, 1983, p. 331–336). Plants to convert chromite into ferrochromium, which is used in quantity in steelmaking, were initially sited, for technological and economic reasons, near steelmaking facilities in industrialized countries. The 1970's saw a marked shift in the location of new ferrochromium plants toward countries endowed with readily available

[3]A captive mine is a mine that produces solely for the parent company or that company's subsidiary.

[4]France, Italy, Japan, Norway, Spain, Sweden, the United States, and West Germany.

sources of chromite. This shift was due to a variety of reasons including the need to close obsolete ferrochromium production facilities in industrialized nations, the lower energy and labor costs in countries with readily available sources, and the possibility of lowering transportation costs by cutting the volumes of material shipped.

In 1977, Japan accounted for some 16 percent of world ferrochromium output, South Africa for 15 percent, the United States for 8 percent, France plus Italy for 6 percent, and Sweden for 5 percent (Schottman, 1981, p. 315–320). By 1982, the contribution of Japan to world ferrochromium production was estimated to have dropped to 13 percent, that of the United States to 3 percent, and that of France plus Italy to 1 percent; South Africa's contribution had risen to 23 percent and Sweden's to 7 percent (Brown, 1983, p. 331–336). The share of the world's largest ferrochromium producer, the Soviet Union, fell from 25 to 23 percent from 1977 to 1982.

- Some chromite and ferrochromium production capacity is state-owned[5] and production from these operations may be maintained when application of profit-motive criteria would normally result in mine closure.
- Chromite supplies have been disrupted. From 1950 to 1960, the Soviet Union stopped shipments of chromite to the United States because of the Korean conflict. During some or all of the period 1966 through 1980, when United Nations sanctions were in force, some countries halted imports from Rhodesia (now Zimbabwe).
- Chromite and ferrochromium stockpiles have been established by several countries for strategic or economic reasons.
- Strategic considerations have resulted in research being carried out on chromium substitution and conservation.
- Substitution possibilities exist in some alloy, refractory, paint, and pigment applications, but no satisfactory substitutes are known for chromium.
- Production research carried out in recent years has focused on such fields as exploration methods for the discovery of new chromite deposits, ways to use lower grade or high-iron types of chromite, and procedures for recovering chromium from laterite deposits. The AOD (argon-oxygen decarburization) process and other new processes for steelmaking were developed in the late 1960's. The installation of these processes in steelmaking plants has resulted in the use of "charge chrome" produced from material that was formerly unusable for metallurgical purposes. This development is one of the main reasons for the expansion of the chromite mining industry in South Africa.

  Plasma smelting, a new technology developed by the Swedish steel producer, SKF Stål (Metal Bulletin Monthly, 1984), among others, is being tested and refined by a South African company, Middelburg Steel and Alloys, in cooperation with the South African Council for Mineral Technology—Mintek (Papp, 1983, p. 212). This technology permits the use of chromite fines as feed for ferrochromium production without the need for agglomeration. Implementation of this more flexible technology could lead to a reassessment of what are currently thought of as noneconomic chromite deposits throughout the world.
- Concerns in various countries about security of supply have encouraged supply diversification. For this reason, Vöest-Alpine AG of Austria promoted the recent construction of a ferrochromium smelter in the Philippines (Papp, 1983, p. 209). In 1982, construction of new or expanded ferrochromium production facilities also continued in Greece, India, and Turkey; consideration was being given to the establishment of plants in Madagascar and in Papua New Guinea.
- Attention is being given to the possibility of increasing demand for chromium. The South African government's Chromium Centre, which is supported by the South African chromium industry, aims to stimulate research and development on new uses for chromium.
- Eight major world producers[6] of chromite and ferrochromium recently established a

[5]For example, in Albania, Finland, Madagascar, Sudan, and the Soviet Union.

[6]S.A. Manganese Amcor Ltd. of South Africa; FACOR India; Ferroleghe SpA of Italy; Ferrochrome Philippines Inc.; Ferroaleaciones Españolas S.A. of Spain; Hellenic Ferroalloys of Greece; Axel Johnson Ore & Metals AB of Sweden; and India Metals & Ferroalloys Ltd.

nonprofit technical organization, the Chromium Association, under the auspices of the Paris-based Manganese Center (Kraus, 1984). The objectives of this association are to collect, evaluate, and distribute information to its members on worldwide production and consumption trends for chromium as well as to promote research and new applications for chromium products.

DISTRIBUTION OF CHROMITE DEPOSITS AND DISTRICTS

The world map in figure 2 shows the locations of major chromite deposits and districts. The Soviet Union is the only one of the four major steel producers (Soviet Union, U.S.A., Japan, and western Europe) that fills its chromite needs from domestic sources. The districts shown in Finland and Greece satisfy only a small portion of the chromite demand of the European steel industries. Figure 3 shows other chromite deposits and districts. One of those deposits in South Africa is a platinum producer that may produce chromite as a by-product; the other deposits shown are subeconomic (some are former producers).

Major chromite deposits in this report are of three geologic deposit types: stratiform deposits, podiform deposits, and laterite deposits. Stratiform-type chromite deposits occur as parallel zones or seams in large, layered igneous-rock complexes. These complexes were intruded or emplaced in continental interiors and are noted for their regularity of layering and extensive lateral continuity. Only layered complexes more than 1.9 billion years old are known to contain economic deposits of chromite. The chromite ores in stratiform deposits are commonly high-iron, although there are some exceptions (see table 9 in Part II). Examples of stratiform-type chromite deposits are the Bushveld Complex in the Republic of South Africa, the Kemi intrusion in Finland, and the Great Dyke in Zimbabwe. Podiform chromite deposits (also called "Alpine-type") occur in portions of oceanic crust and mantle that have been thrust up onto continents or island chains. Identified podiform chromite deposits are located (1) in major tectonic belts such as the Ural Mountains (Soviet Union), Appalachian Mountains (North America), and the so-called Tethyan mountain chains (Albania, Greece, and Turkey), and (2) in island-arcs similar to those found in the western Pacific Ocean (Philippines) and the Caribbean basin (Cuba).

The host rock for podiform-type chromite deposits is peridotite. Deposits are seldom older than 1.1 billion years. Podiform deposits contain high-chromium and high-aluminum chromite and occur in irregular shapes such as pods and lenses; their distribution within a mineralized zone is erratic and unpredictable. Chromite also occurs in iron- and nickel-rich laterites formed by the weathering of peridotite. The low chromium content of laterites, however, has prevented recovery of chromite from this type of deposit.

Chromite occurs in one other deposit type, placers, but there are no identified placer deposits that are important enough, in terms of present or probable near-future production, to be included in this inventory. Some chromite ore has been mined from chromite-bearing sediments that were formed by erosion of stratiform-type deposits, specifically those in the Bushveld Complex in South Africa and the Great Dyke in Zimbabwe. No separate production and resources data for these deposits, however, are available to the ISMI inventory. Some data on these sedimentary (eluvial) chromium resources may be contained in the production and resource data for their parent stratiform-type deposits.

Figure 2 shows eight stratiform-deposit locations (representing 32 deposit and district records) and eight podiform-deposit locations (representing 19 inventory records). Figure 3 shows five locations representing 10 deposit and district records of stratiform deposits and one location of a laterite district in Papua New Guinea. Because production of chromite from these deposits is not foreseen in the near future, data on these deposits and districts have not been included in the resource and production tables in Part I of this report.[7]

Figure 4 shows the global distribution of major chromite deposits and districts and also indicates the economic class (GNP per capita) of countries where deposits are located. The global distribution of other chromite deposits and districts by World Bank economic classes is shown in figure 5.

[7]Only one of the deposits shown in figure 3 is presently being mined—the platinum-mineral operation (Western Platinum mine) in the UG2 chromitite layer of the western Bushveld. In the year ending September 30, 1983, 1,950,000 metric tons (t) of Merensky Reef and UG2 Reef ores were extracted from the Western Platinum mine, yielding 6,656 kg of platinum-group elements, 1,943 t of nickel, 1,210 t of copper, and 21 t of cobalt. Since the first UG2 stopes came into production in January 1983, the company has been evaluating the recovery of a chromite concentrate (Mining Journal, 1983).

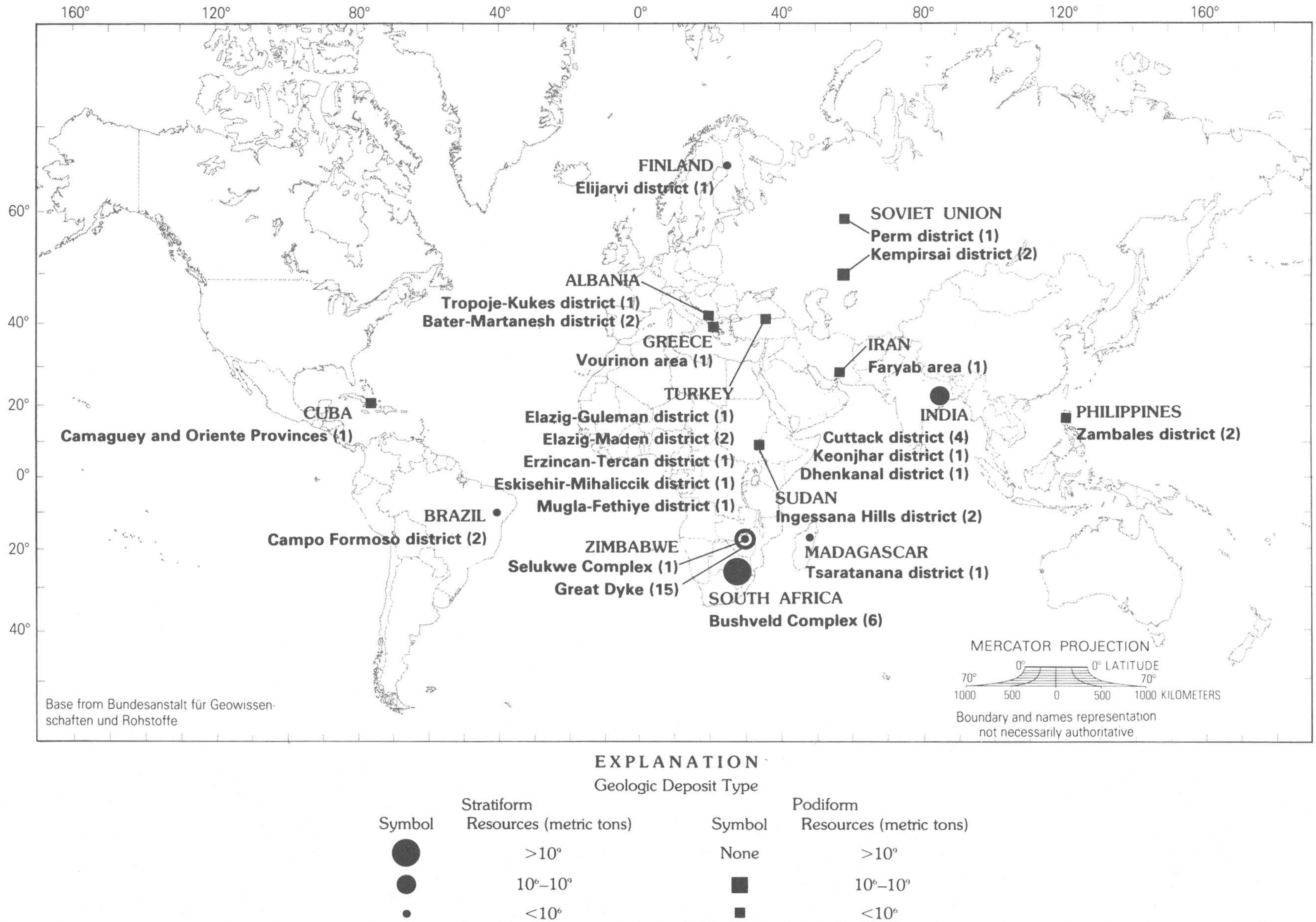
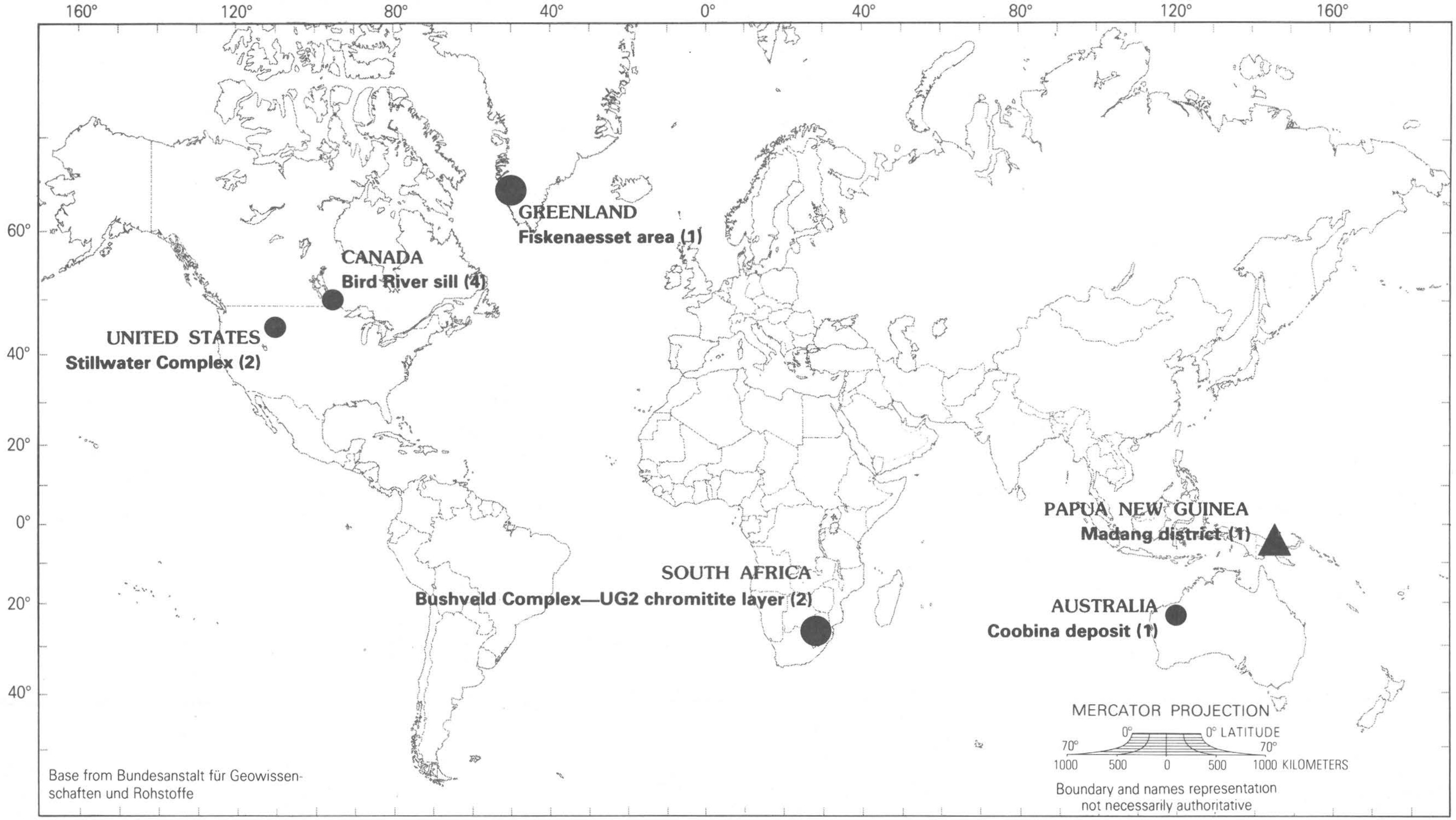


FIGURE 2.—Location, deposit type, and estimated resources of major chromite deposits and districts in the world. Numbers in parentheses indicate number of records (deposits and districts) for each location. Location names are from the tables in Part II.



EXPLANATION

Geologic Deposit Type

Symbol	Stratiform Resources (metric tons)	Symbol	Laterite Resources (metric tons)
● (large)	$>10^9$	▲	$>10^9$
● (small)	10^6–10^9	None	10^6–10^9

FIGURE 3.—Location, deposit type, and estimated resources of other chromite deposits and districts in the world. Numbers in parentheses indicate number of records (deposits and districts) for each location. Location names are from the tables in Part II.

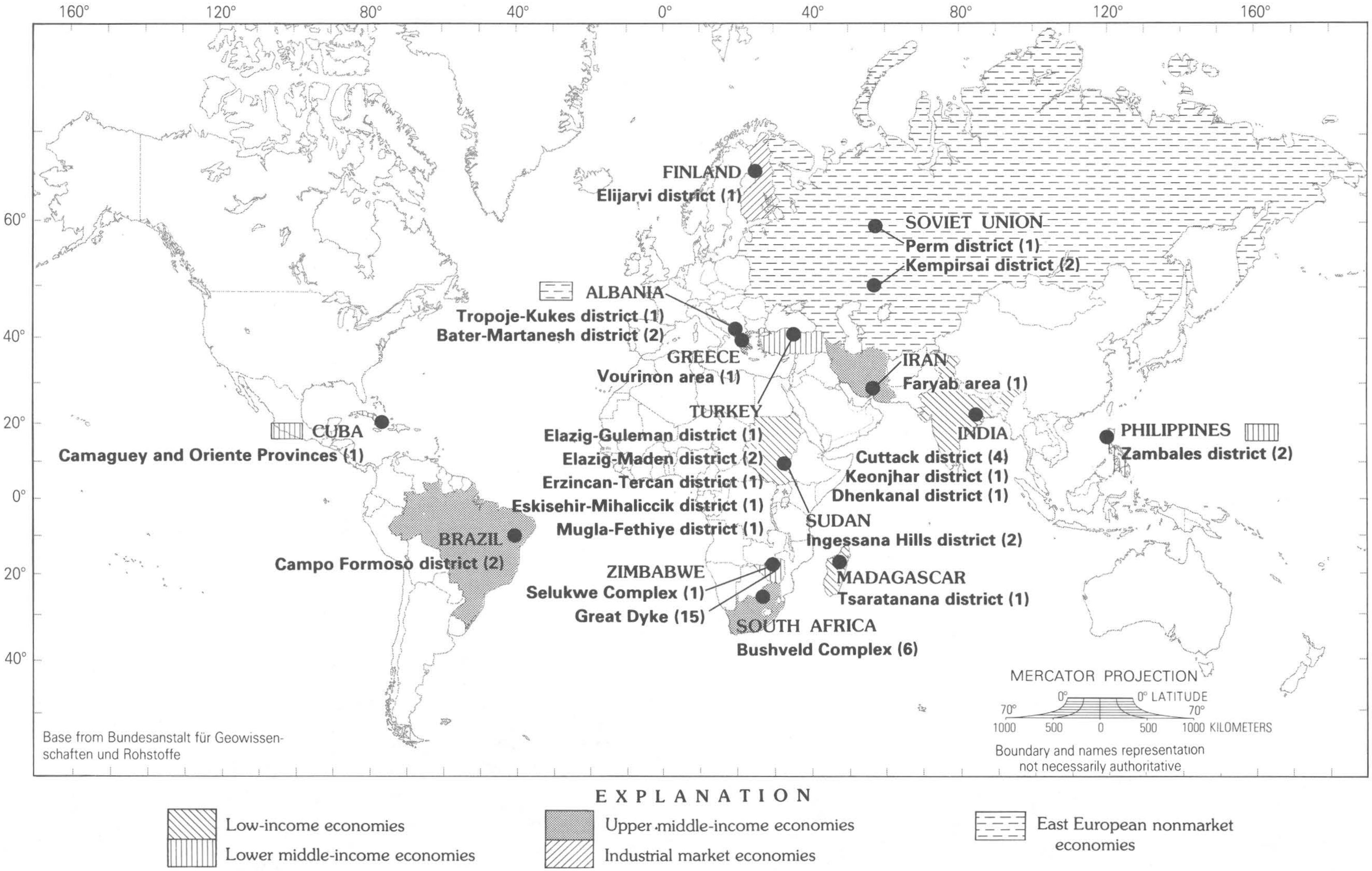


FIGURE 4.—Economic classification of the World Bank (1983, p. 148–149) for countries where the world's major chromite deposits and districts occur. Numbers in parentheses indicate number of records (deposits and districts) for each location. Location names are from the tables in Part II.

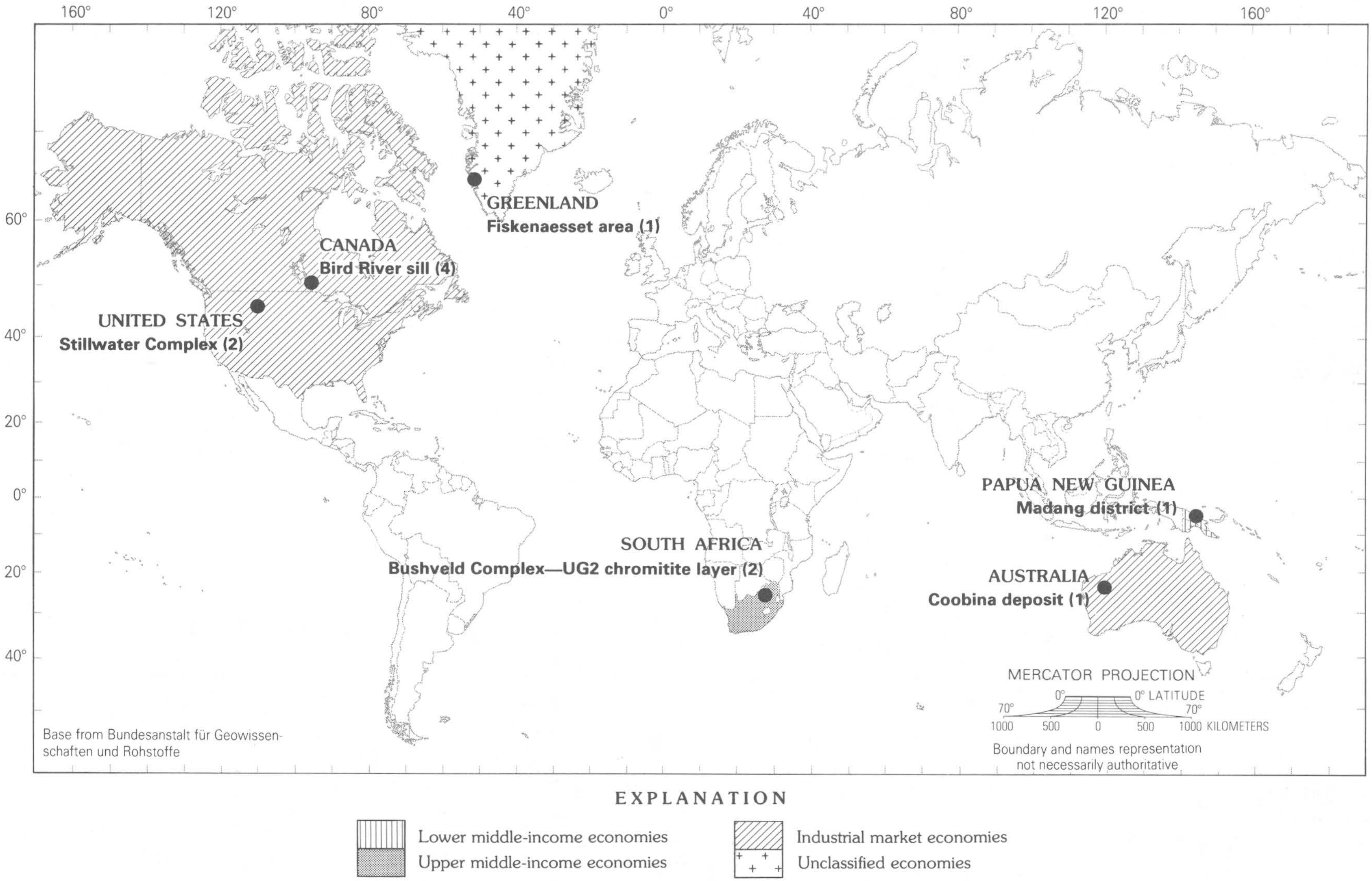


FIGURE 5.—Economic classification of the World Bank (1983, p. 148–149) for countries where other chromite deposits and districts occur. Numbers in parentheses indicate number of records (deposits and districts) for each location. Location names are from the tables in Part II.

Stratiform-type chromite deposits account for about 65 percent of the number of deposits and districts that are shown in figure 2. These deposits account for almost 90 percent of the identified, economic resources (R1E), in terms of reported chromite-ore resource, and for about 98 percent of resources in other categories for major chromite deposits (table 2).[8] In addition to geologic deposit-type differences, chromite ores are, as stated earlier, classified by their chromium, iron, or aluminum content. Table 2 also shows cumulative production from major chromite deposits; cumulative production has been small compared to resources. The distribution of deposits and resources by class of ore is shown in tables 3 and 4. More than half of the resources in stratiform deposits are classified as high-iron; these resources are mostly from the Steelpoort sector of the eastern Bushveld Complex, South Africa. Ninety-three percent of high-chromium resources are from stratiform deposits, mostly in the western Bushveld Complex (Rustenburg sector), South Africa, and the Great Dyke, Zimbabwe. High-chromium resources for podiform deposits are principally from the Kempirsai area of the Soviet Union. Most of the resources for high-aluminum podiform deposits are in the Masinloc Chromite Operation in the Philippines.

Table 5 shows the distribution of resources (tons of *in situ* material) of major chromite deposits among the World Bank country economic classes from figure 4. Upper middle-income countries have most of the chromite resources of the major deposits (71 percent of R1E and 85 percent of resources in other categories), while having only 10 of the 51 major deposits and districts in the inventory. Most of these resources are in the Bushveld Complex in South Africa. Lower middle-income countries (Zimbabwe, Turkey, the Philippines, and Cuba) have 25 of the 51 major deposits and districts and rank second in resources (about 11 percent of R1E and 14 percent of resources in other categories). Most of the remainder of the resources in major deposits are in low-income-economy countries (India, Madagascar, and Sudan) and eastern European nonmarket-economy countries (the Soviet Union and Albania). Table 5 indicates, as discussed earlier, that the location of chromite resources is not coincident with the regions of consumption (steelmaking centers and chemical industries). It is estimated on the basis of data from Roskill Information Services (1982) and Papp (1983) that between 65 and 75 percent of chromium content of ores and concentrates produced in 1980 was involved in that year's trade as ore and ferroalloys.

The addition to world chromite resources in major deposits by discovery of new deposits is shown in figure 6. The discoveries of chromite in the Bushveld Complex in the Republic of South Africa and the Great Dyke in Zimbabwe (formerly Rhodesia) in the early 1920's account for the large increase in resources that is the dominant feature of figure 6. Subsequent, relatively smaller additions to resources were made by discoveries in Albania and the Soviet Union in the late 1930's and in India and Finland in the 1950's. Conclusions drawn from this figure should take account (1) of the uncertainty of discovery date due to difficulties in defining "discovery"; (2) of the limited validity of assigning all of a deposit's (or district's) resources to the initial discovery date, as done in figure 6; and (3) of the different standards used to report resource data from different deposits.

The latest discovery date shown in table 10 of Part II is 1968 (Ramu River nickel-chromium laterite deposit, Papua New Guinea).[9] The absence of subsequent discoveries may result from curtailed exploration due to low chromium demand rather than to a lack of undiscovered resources.

After the time when a deposit or district is discovered, development and production activities increase the amount of information about the mineral deposit(s), resulting in changes in resource estimates. The Bushveld Complex provides a good example of the problem of assigning present-day resource estimates for a deposit to the date of its discovery. As noted above, most of the large amount of chromite resources shown in figure 6 as having been "discovered" during the 1920–39 period is accounted for by about 6 billion metric tons of resources in the Bushveld Complex in South Africa (1.2 billion metric tons of R1E resources and 4.8 billion metric tons of resources in other categories). The size of the Bushveld resources was not understood when a comprehensive summary of geological investigations in the Complex was first published (Hall, 1932). (The occurrence of chromite had

[8]Resource estimates for the years given in table 10 of Part II are used to calculate these resource totals in Part I.

[9]This deposit is not included in figure 6 because it is not listed as a major deposit in the tables in Part II.

TABLE 2.—*Chromite resources in and cumulative production from the world's major deposits and districts, by geologic deposit type and resource category*

[Figures are in thousand metric tons of resource]

Geologic deposit type[1]	Number of records	Resource category: R1E[2]	Resource category: All other R1 and R2[3]	Cumulative production[4]
Stratiform ---------	32	1,300,000 (17–51% Cr_2O_3)[5]	5,410,000 (17–51% Cr_2O_3)	>93,300 (17–51% Cr_2O_3
Podiform ----------	19	>155,000 (17–50% Cr_2O_3)	93,200 (17–48% Cr_2O_3)	>104,000 (metallurgical grades)
Total[6] --------	51	>1,460,000	5,500,000	>197,000

[1]Deposit types of the world's major chromite deposits are shown in figure 2.
[2]Reliable estimates from identified deposits with economically exploitable resources (fig. 1).
[3]Includes resources in the R1M, R1S, R2E, and R2S categories (fig. 1).
[4]Reported cumulative production; years for individual mines are listed in table 10 of Part II. This is a minimum estimate of cumulative production because no estimates have been added for those deposits that have no cumulative production data reported in table 10 of Part II. Note that production figures are not comparable to *in situ* resource figures because production only represents the recoverable portion of those resources.
[5]Includes 4.8 million metric tons of resource in eluvial deposits associated with the stratiform-deposit resources of the Impinge claims, Zimbabwe.
[6]Figures may not add to totals shown due to rounding.

TABLE 3.—*Chromium records in the world's major deposits and districts, by geologic deposit type and class of ore*

Geologic deposit type	Number of records	Number of records by class of ore: High-chromium	High-iron	High-aluminum
Stratiform ---------	32	28	4	---
Podiform ----------	19	16	1	2
Total --------	51	44	5	2

TABLE 4.—*Chromite resources in the world's major deposits and districts, by class of ore*

[Figures are in million metric tons of resource]

Geologic deposit type	Class of ore[1]					
	High-chromium		High-iron		High-aluminum	
	R1E[2]	All other R1 and R2[2]	R1E[2]	All other R1 and R2[2]	R1E[2]	All other R1 and R2[2]
Stratiform ----	650 (17–51% Cr_2O_3)[3]	2,230 (17–51% Cr_2O_3)	654 (26–45% Cr_2O_3)	3,180 (35–45% Cr_2O_3)	---	---
Podiform -----	>141 (17–51% Cr_2O_3)	84 (17–48% Cr_2O_3)	2 (20–40% Cr_2O_3)	4 (20–40% Cr_2O_3)	12 (refractory grades)	5 (refractory grades)
Total[4] --	>791	2,320	656	3,180	12	5

[1]Classes of chromite ore are described in table 1.
[2]Resource categories are defined in figure 1; all other R1 and R2 category includes R1M, R1S, R2E, and R2S.
[3]Includes 4.8 million metric tons of resource in eluvial deposits associated with the Impinge claims, Zimbabwe.
[4]Figures may not add to totals shown due to rounding.

been first reported on geologic maps in 1865 (Coertze and Coetzee, 1976, p. 117).) When prospecting was done in the Rustenburg sector early in this century, the estimates of resources were still very small compared to the estimates given in table 10 of Part II. As development and mining operations progressed along the margins of the Complex during the 1911–20 period, estimates of resources in the Bushveld Complex became larger. About 200 million metric tons of resources of all classifications were estimated in 1937 (Kupferbürger and others, 1937, p. 45); that figure increased to about 2.3 billion metric tons by 1977 (von Gruenewaldt, 1977, p. 89) and to over 5.6 billion metric tons by 1983 (this report). All of these resources have been assigned to the 1920 discovery date in table 10 of Part II and are shown in the 1920–39 period on figure 6 because year-by-year resource estimates for deposits and districts are not consistently available and are not included in ISMI records.

TABLE 5.—*Chromite resources in the world's major deposits and districts, by economic class of country and resource category*
[Figures are in thousand metric tons of resource]

Economic class[1]	Number of records	Resource category[2]			
		R1E	Percent	All other R1 and R2	Percent
Low-income	9	>90,500	6	27,300	0.5
Lower middle-income	25	159,000	11	763,000	14
Upper middle-income	10	1,040,000	71	4,690,000	85
Industrial market	1	50,000	3	---	---
Eastern European nonmarket	6	>123,000	8	19,500	.4
Total[3]	51	>1,460,000	100	5,500,000	100

[1]Based principally on GNP per capita and, in some instances, other distinguishing economic characteristics (World Bank, 1983, p. 148-149). Countries where major chromite deposits and districts occur are by class: low-income economies—India, Madagascar, Sudan; lower middle-income economies—Cuba, the Philippines, Turkey, Zimbabwe; upper middle-income economies—Brazil, Greece, Iran, South Africa; industrial market economies—Finland; and eastern European nonmarket economies—Albania, the Soviet Union. A sixth economic class, high-income oil exporters, is not listed because those countries do not have identified major chromite deposits.
[2]Categories are defined in figure 1.
[3]Figures may not add to totals shown due to rounding.

CHROMITE PRODUCTION

The 51 chromite deposits and districts in the International Strategic Minerals Inventory occur in 14 countries (fig. 7); these countries collectively account for more than 94 percent of the world's cumulative production of chromite since 1901. The data plotted in figure 7 include a small, indeterminable amount of ore from mines that are not in the inventory.

Figure 8 shows the production of chromite from each of the countries included in the figure 7 totals. Because of increases in production from South Africa and Albania for the years shown, the proportion of world chromite production accounted for by the Soviet Union has fallen.

Information on 1982 production and cumulative production from 1901 through 1982 for countries with deposits in the inventory is shown in table 6. These production data have been grouped by World Bank economic class in table 7. About 47 percent of 1982 production and about 34 percent of cumulative production since 1901 has been from eastern European nonmarket-economy countries (largely the Soviet Union). The upper middle-income-economy class of countries (South Africa, Brazil, Iran, and Greece) accounts for 33 percent of 1982 production and 29 percent of production since 1901. Lower middle-income-economy countries (Zimbabwe, Turkey, the Philippines, and Cuba) have accounted for 31 percent of cumulative production since 1901.[10]

[10]As noted in table 7, no major chromite deposits or districts have been identified in high-income oil-exporting countries. However, chromite mining started in the Sohar area of Oman in 1983, and discovery of chromium deposits in the Fujaira region of the United Arab Emirates was announced in 1982 (Papp, 1983, p. 211 and 213).

Chromite is produced from surface and underground mining operations. Table 8 shows the distribution of resources by mining method. The Bushveld Complex, which contains both surface and underground mines, constitutes the major part of resources reported for the largest resource entry in this table, the upper middle-income countries.

In studies of industrial market structure some approaches used to measure market concentration focus directly on observable dimensions, such as number of suppliers. The market concentration ratio, defined as the percentage of total industry sales or output contributed by the largest few firms (Scherer, 1970, p. 50–51), can be adapted as a measure of a country's control of mineral production. Figure 9 shows the four-country and eight-country concentration ratios for 1913 and 1980 production of several nonfuel mineral commodities. By these measures, chromium ranks high among those mineral commodities controlled by a few producing countries, although this concentration has decreased from 1913 to 1980.

Present and probable future production of chromite from the major deposits included in the International Strategic Minerals Inventory is shown on the map in figure 10. Several present major producers (Bushveld Complex, Kempirsai district, Elijarvi district (Kemi mine), and others) will probably continue to be large suppliers through 2020. Decreases in output from deposits with declining production may be compensated for by increases from these present major producers. Those chromite deposits shown in figure 3 were not producers in 1982, and it is not probable that any of them will contribute significantly to world chromite production by 2020.

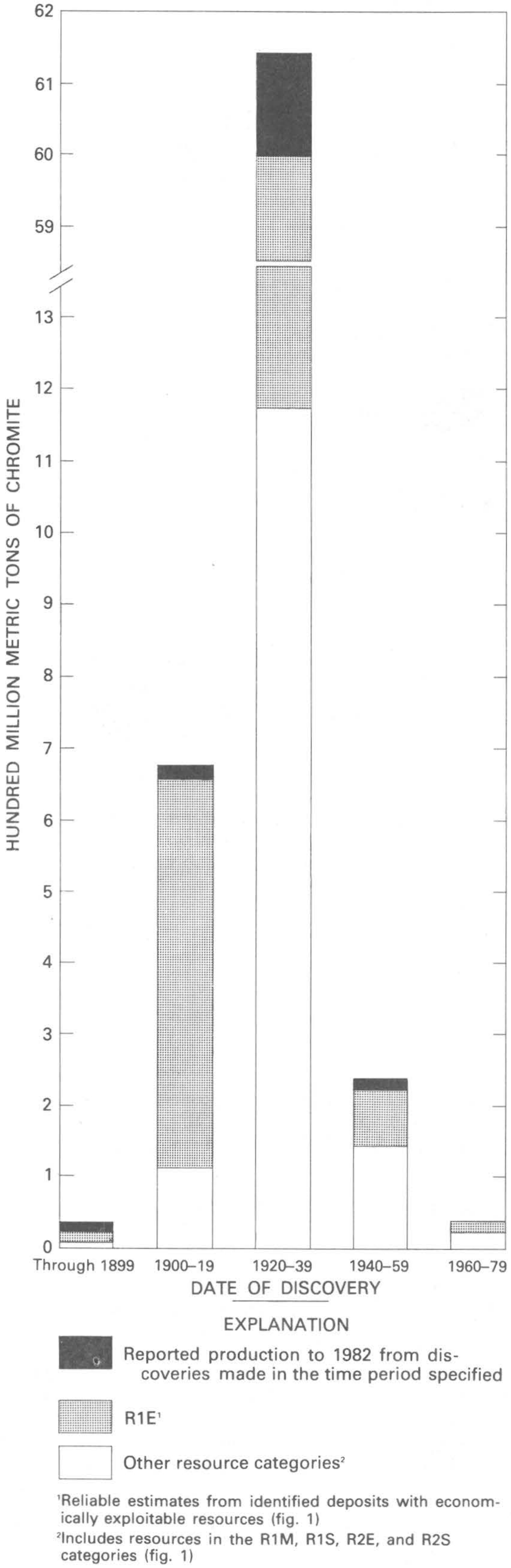


TABLE 6.—*Estimated cumulative and annual production of chromite for each country having a major chromite deposit or district*

[Figures are in thousand metric tons]

Country[1]	Cumulative production 1901–82[2]	Annual production 1982[2]
Soviet Union	55,000 (1)	3,400 (1)
South Africa	50,000 (2)	2,200 (2)
Zimbabwe	22,000 (3)	430 (5)
Turkey	21,000 (4)	370 (7)
Philippines	18,000 (5)	350 (8)
Albania	15,000 (6)	1,200 (3)
India	7,300 (7)	340 (9)
Brazil	4,100 (8)	950 (4)
Finland	3,700 (9)	400 (6)
Cuba	3,700 (10)	30 (13T)
Iran	3,400 (11)	40 (12)
Greece	2,000 (12)	40 (11)
Madagascar	2,000 (13)	90 (10)
Sudan	470 (14)	30 (13T)

[1]Includes all countries with major deposits and districts in the International Strategic Minerals Inventory.

[2]Cumulative production calculated from reported production ([United Kingdom] Imperial Mineral Resources Bureau, 1921–49; [United Kingdom] Institute of Geological Sciences, 1950–73; U.S. Bureau of Mines, 1927–34, 1933–83; U.S. Geological Survey, 1902–27); 1982 production from Papp (1983, p. 213). Numbers in parentheses denote production ranking of country.

TABLE 7.—*Estimated cumulative and annual production of chromite by economic class of country*[1]

[Figures are in thousand metric tons]

Economic class[2]	Cumulative production 1901–82[3]	Annual production 1982[4]
Low-income	9,800 (4)	460 (4)
Lower middle-income	65,000 (2)	1,200 (3)
Upper middle-income	60,000 (3)	3,200 (2)
Industrial market	3,700 (5)	400 (5)
Eastern European nonmarket	70,000 (1)	4,600 (1)
Total[5]	208,000	9,900

[1]Includes only countries having major chromite deposits and districts. See table 6.

[2]Based principally on GNP per capita and, in some instances, on other distinguishing economic characteristics (World Bank, 1983, p. 148–149). A sixth economic class, high-income oil exporters, is not listed because those countries do not have identified major chromite deposits.

[3]Reported production from countries in indicated economic class ([United Kingdom] Imperial Mineral Resources Bureau, 1921–49; [United Kingdom] Institute of Geological Sciences, 1950–73; U.S. Bureau of Mines, 1927–34, 1933–83; U.S. Geological Survey, 1902–27). Cumulative production not included here (from countries not listed in table 6) represents less than 6 percent of cumulative world production, which is predominantly from New Caledonia. Cumulative world chromite production is estimated to have been in excess of 4 million metric tons before 1901 (Thayer and Lipin, 1978). Numbers in parentheses denote production ranking of economic class.

[4]Estimated production (Papp, 1983, p. 213). Numbers in parentheses denote production ranking of economic class.

[5]Figures may not add to totals shown due to rounding.

FIGURE 6 (left).—Chromite resources in the world's major deposits and districts according to their date of discovery. If the year of discovery was not reported, the year of first production was used instead. Years of discovery are listed in table 10 of Part II.

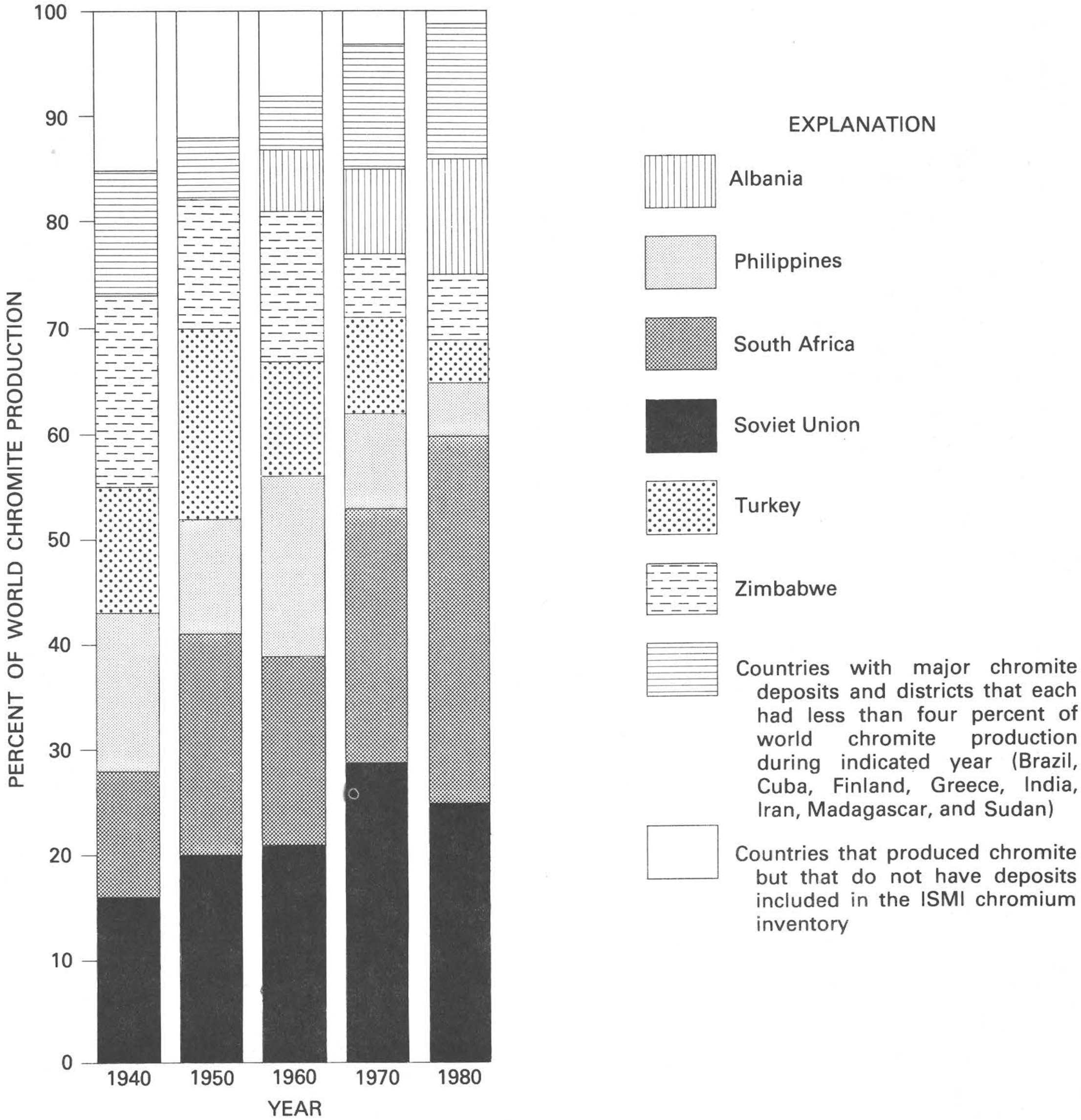


FIGURE 7.—Proportions of total world production of chromite accounted for by countries with major deposits and districts in the ISMI chromium inventory; selected years 1940–80. Reported production ([United Kingdom] Imperial Mineral Resources Bureau, 1948; [United Kingdom] Institute of Geological Sciences, 1950–73; U.S. Bureau of Mines, 1943–83) for those countries listed in table 5.

TABLE 8.—*Chromite resources*[1] *in the world's major deposits and districts, listed by mining method and economic class of country*

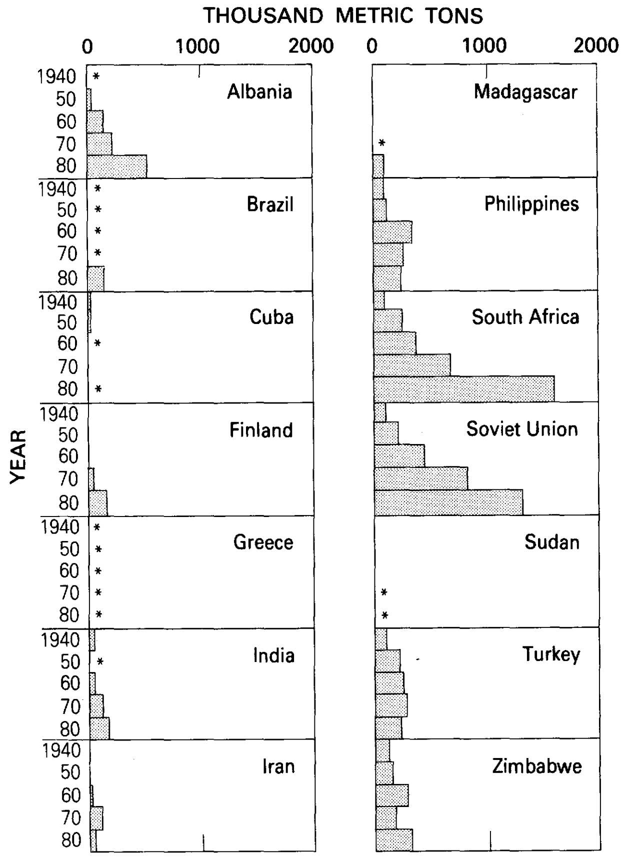
[Figures are in thousand metric tons of resource]

Economic class[2]	Mining method			Not reported
	Surface	Underground	Surface and underground	
Low-income	22,700	---	>95,000	---
Lower middle-income	191,000	178,000	552,000	1,990
Upper middle-income	4,000	5,520,000	85,200	124,000
Industrial market	50,000	---	---	---
Eastern European nonmarket	>25,000	6,000	112,000	---
Total[3]	>293,000	5,700,000	>843,000	126,000

[1]Includes resources in the R1 and R2 categories (fig. 1).

[2]Based principally on GNP per capita and, in some cases, on other distinguishing economic characteristics (World Bank, 1983, p. 148–149). A sixth economic class, high-income oil exporters, is not listed because those countries do not have identified major chromite deposits.

[3]Figures may not add to totals shown due to rounding.



*Reported production of less than 50,000 metric tons.

FIGURE 8.—Chromite production in countries with major deposits and districts in the ISMI chromium inventory; selected years 1940–80. Reported production ([United Kingdom] Imperial Mineral Resources Bureau, 1948; [United Kingdom] Institute of Geological Sciences, 1950–73; U.S. Bureau of Mines, 1943–83) for those countries listed in table 5.

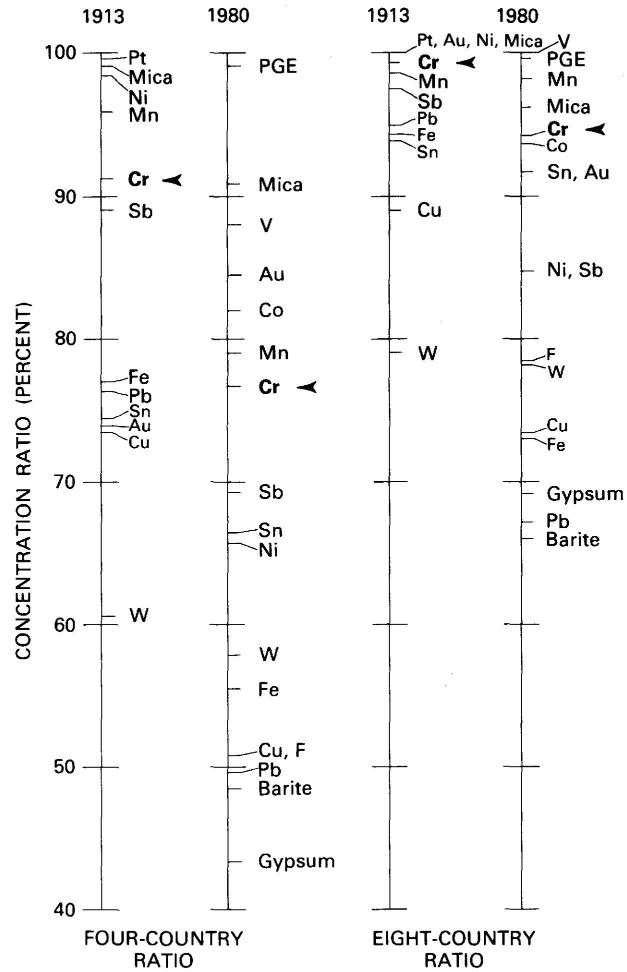


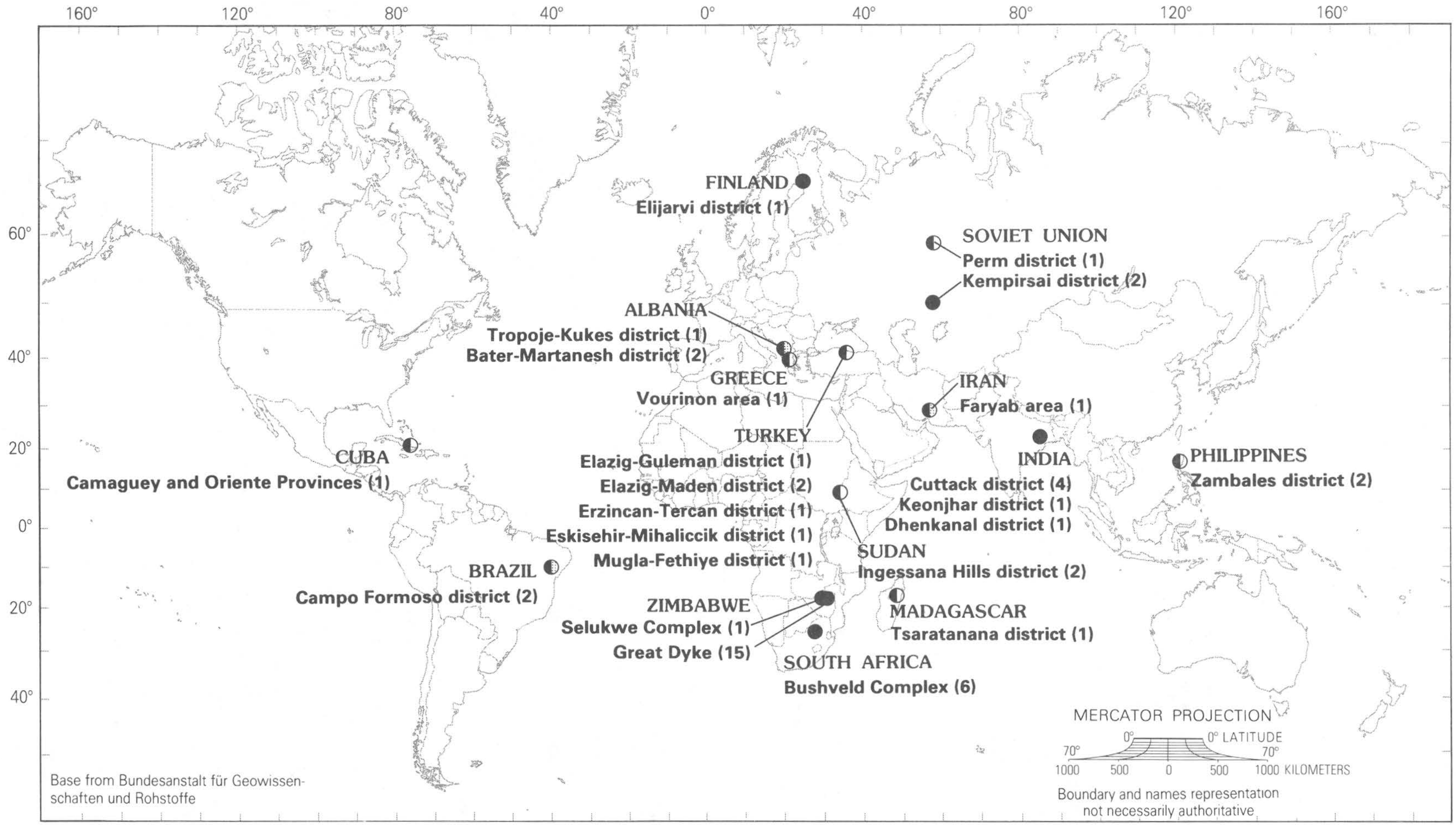
FIGURE 9.—Concentration ratios for selected nonfuel mineral commodity production in 1913 and 1980. The ratios are percent of total world production for the indicated commodities, designated by chemical-element symbols (PGE for platinum-group elements), for the four or eight countries with the largest reported production of that commodity in 1913 and 1980. (Sources of data: U.S. Geological Survey, 1921; U.S. Bureau of Mines, 1982).

The amount of production from podiform and stratiform deposits provides a clue to future geographic distribution of chromite production. Thayer and Lipin (1978, p. 144) found that world chromite production from stratiform deposits exceeded that from podiform deposits for the first time in 1976. They estimate that with increased levels of chromite production and the eventual depletion of resources in podiform deposits, production from stratiform deposits, especially those resources in South Africa and Zimbabwe, will represent an increasing share of world chromite production.

CONCLUSIONS

Because there are no satisfactory economic substitutes for chromium in making stainless steel, industrialized countries not possessing domestic deposits consider chromium as highly strategic to their economic well being and industrial development. In an attempt to maintain economic or strategic stability, some countries that have little or no chromite mining have resorted to either stockpiling chromium (as ore, concentrates, or ferrochromium) or conducting research on ways to process low-grade ores.

By far, most of the world's major resources are centered in southern Africa, principally in the Republic of South Africa (Bushveld Complex) and in Zimbabwe (Great Dyke). Other significant deposits are in India and the Soviet Union. Several



EXPLANATION

- ● Producer in 1982; probably a significant producer in 2020
- ◐ Producer in 1982; probably an insignificant producer or exhausted by 2020
- ◍ Producer in 1982; information insufficient to permit any forecast as to future production

FIGURE 10.—Major chromite deposits and districts, their present production status, and their probable production status in 2020.

current producers, such as Albania, Brazil, Madagascar, the Philippines, and Turkey, are not industrialized enough to make total direct domestic use of the ores and they engage in extensive international trade in chromite and ferrochromium.

The recent recession in the world's steel industry has resulted in low demand for chromium, which in turn resulted in increased competitiveness among exporting countries, in particular those with relatively small outputs. Forecasts of increases in stainless steel production have led to expectations of a 35-percent increase in South African ferrochromium production from 1982 to 1984 (Preece, 1984); most of this ferrochromium will be exported. In the longer term, for at least the next four decades, countries in southern Africa and the Soviet Union will likely remain the world's major sources of primary supply of chromium.

PART II—SELECTED INVENTORY INFORMATION FOR CHROMITE DEPOSITS AND DISTRICTS

Tables 9 and 10 contain information from the International Strategic Minerals Inventory record forms for chromite deposits and districts. Only selected items of information about the location and geology (table 9) and mineral production and resources (table 10) of the deposits are listed here; some of this information has been abbreviated because of space limitations.

Summary descriptions and data are presented in the tables as closely as possible to the way that they were reported in the inventory records. For instance, significant digits for amounts of production or resources have been maintained as reported. Data that were reported in units other than metric tons have been converted to metric tons for comparability. Chromite deposits listed here include unpredictable, small podiform ore bodies as well as stratiform deposits that cover very large areas. The differences between these two widely different deposit types hinder the mine-by-mine study of chromite exploration, development, and production. Some of the data in the tables are more aggregated than in the inventory records, such as cumulative production totals that for some mines have been reported by year or by groups of years. Some of the abbreviations used in the inventory records forms have been used in these tables; they are explained in the footnotes.

TABLES 9 AND 10

Site name	Latitude	Longitude	Deposit type	Host rock[1]
				ALBANIA
Kalimash mine (Tropoje-Kukes district)	42° 06'N	20° 23'E	Magmatic, podiform	Serpentinized dunite; EJUR
Bulquize mine (Bater-Martanesh district)	41° 30'N	20° 16'E	-do-	-do-
Todo Manco mine (Bater-Martanesh district)	41° 25'N	20° 10'E	-do-	-do-
				AUSTRALIA
Coobina deposit[4]	23° 30'S	120° 17'E	Magmatic, stratiform, massive, disseminated	Serpentinite; Coobina ultramafic complex; ARCH
				BRAZIL
Limoeiro mining area (Campo Formoso district)	10° 31'S	40° 20'W	Magmatic, stratiform, disrupted, massive, disseminated	Serpentinized dunite; Serra de Jacobina; ARCH-EPROT
Pedrinhas mining area (Campo Formoso district)	10° 31'S	40° 20'W	-do-	-do-
				CANADA
Bird Lake chrome deposit[4] (Bird River sill)	50° 28'N	95° 23'W	Magmatic,stratiform, massive, disseminated	Peridotite (serpentinized); Bird River sill; ARCH
Chrome Group deposit[4] (Bird River sill)	50° 27'N	95° 34'W	-do-	-do-
Euclid M.C. deposit[4] (Bird River sill)	50° 34'N	95° 22'W	-do-	-do-
Page Group deposit[4] (Bird River sill)	50° 29'N	95° 31'W	-do-	-do-
				CUBA
Camaguey and Oriente Provinces	21° 30'N- 20° 30'N	77° 45'W- 75° 16'W	Magmatic, podiform, disrupted	Serpentinized peridotite; Zaza and Cauto belts; LCRET

1/ Includes some or all of the following items (separated by semicolons): main host rock type, formation name, and host rock age. Only reported items are listed. See footnote 2 for age abbreviations.

2/ Age abbreviations and prefixes:

MIOCENE	MIO	SILURIAN	SIL	EARLY	E
MESOZOIC	MES	PRECAMBRIAN	PREC	MIDDLE	M
CRETACEOUS	CRET	PROTEROZOIC	PROT	LATE	L
JURASSIC	JUR	ARCHEAN	ARCH		
PALEOZOIC	PAL				

Age of mineralization[2]/	Tectonic setting[2]/	Local environment	Principal mineral assemblages[3]/	Comments	Reference
	ALBANIA—continued				
EJUR(?)	Convergent margin	Ultramafic portion of ophiolite	---	Occurs in Balkan-Asia Minor ultramafic province	Rossi (1979a, p. 19-31)
-do-	-do-	-do-	---	-do-	Do.
-do-	-do-	-do-	---	-do-	Do.
	AUSTRALIA—continued				
ARCH	ARCH inlier-stable craton	Ultramafic intrusion	SRPN, CLRT, TALC, CRMT, MGNT	More than 200 individual lenses or concentrations	Bye (1975)
	BRAZIL—continued				
ARCH-EPROT	Stable PREC craton	Disrupted, layered igneous intrusion	ANGR, CLRT, TALC, CRMT, MGNT; CRSL, Cr-CLCL	8-km chromite zone at base of quartzite fault scarp	Hedlund and others (1974)
-do-	-do-	-do-	-do-	Ore body traced 8 km within a serpentine belt 15 km long and 1 km wide	Do.
	CANADA—continued				
ARCH	Greenstone belt	Synvolcanic intrusion	CRMT, SRPN, CLRT, TMLT	---	Bannatyne and Trueman (1982)
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	-do-	---	Do.
	CUBA—continued				
---	Convergent margin	Ultramafic portion of ophiolite	CRMT, SRPN, OLVN, PRXN	100 primary deposits; chromite associated with nickeliferous laterites in Oriente Province	Rossi (1979b)

3/ Abbreviations for mineral names (after Longe and others, 1978, p. 63-66):

AMPHIBOLE	AMPB	CLINOPYROXENE	CLPX	ILMENITE	ILMN	RUTILE	RUTL
ANTIGORITE	ANGR	DOLOMITE	DLMT	LIMONITE	LMON	SERPENTINE	SRPN
BIOTITE	BOTT	ENSTATITE	ENST	MAGNETITE	MGNT	SILICATES	SLCT
BRONZITE	BRNZ	FORSTERITE	FRSR	OLIVINE	OLVN	SPINEL	SPNL
BRUCITE	BRUC	FUCHSITE	FCST	ORTHOPYROXENE	OPRX	SULFIDES	SLPD
CHLORITE	CLRT	GARNIERITE	GRNR	PENTLANDITE	PNLD	TREMOLITE	TMLT
CHROMITE	CRMT	GOETHITE	GTHT	PLAGIOCLASE	PLGC	UVAROVITE	UVRT
CHRYSOTILE	CRSL	HEMATITE	HMTT	PYROXENE	PRXN		
CLINOCHLORE	CLCL	HORNBLENDE	HBLD	PYRRHOTITE	PYTT		

4/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

Site name	Latitude	Longitude	Deposit type	Host rock[1]
				FINLAND
Kemi mine (Elijarvi district)	65° 47'N	24° 43'E	Magmatic, stratiform, massive	Serpentinized peridotite; Kemi intrusion; EPROT
				GREECE
Vourinon area	40° 10'N	21° 32'E	Magmatic, podiform	Serpentinized dunite; Vourinon ophiolite complex; JUR
				GREENLAND
Fiskenaesset area[4]	63° 06'N	50° 40'W	Magmatic, stratiform, massive, disrupted	Anorthosite; Fiskenaesset Complex; ARCH
				INDIA
Bhimtanagar mine (Cuttack district)	21° 02'N	85° 45'E	Magmatic, stratiform, disrupted	Serpentinized dunite; Dharwar system; PREC
Kalarangi mining area (Cuttack district)	21° 02'N	85° 45'E	-do-	Serpentinized dunite; Mahagiri Quartzite-Iron Ore Series; PREC
Kaliapani mine (Cuttack district)	21° 03'N	85° 45'E	-do-	Serpentinized dunite; Dharwar system; PREC
Saruabil mine (Cuttack district)	21° 04'N	85° 48'E	-do-	-do-
Boula mining area (Keonjhar district)	21° 35'N	85° 35'E	-do-	Serpentinized dunite; Boula-Nausahi; PREC
Kathpal deposit (Dhenkanal district)	21° 01'N	85° 43'E	-do-	Serpentinized dunite; PREC
				IRAN
Shahriar, Shahin, and Amir mines (Faryab area)	27° 32'N	57° 19'E	Magmatic, podiform	Serpentinized dunite; CRET
				MADAGASCAR
Andriamena mining area (Tsaratanana district)	17° 25'S	47° 30'E	Magmatic, stratiform disrupted	Serpentinized dunite; Andriamena system; PREC

1/ Includes some or all of the following items (separated by semicolons): main host rock type, formation name, and host rock age. Only reported items are listed. See footnote 2 for age abbreviations.

2/ Age abbreviations and prefixes:

MIOCENE	MIO	SILURIAN	SIL	EARLY	E
MESOZOIC	MES	PRECAMBRIAN	PREC	MIDDLE	M
CRETACEOUS	CRET	PROTEROZOIC	PROT	LATE	L
JURASSIC	JUR	ARCHEAN	ARCH		
PALEOZOIC	PAL				

3/ Abbreviations for mineral names (after Longe and others, 1978, p. 63-66):

AMPHIBOLE	AMPB	CLINOPYROXENE	CLPX	ILMENITE	ILMN	RUTILE	RUTL
ANTIGORITE	ANGR	DOLOMITE	DLMT	LIMONITE	LMON	SERPENTINE	SRPN
BIOTITE	BOTT	ENSTATITE	ENST	MAGNETITE	MGNT	SILICATES	SLCT
BRONZITE	BRNZ	FORSTERITE	FRSR	OLIVINE	OLVN	SPINEL	SPNL
BRUCITE	BRUC	FUCHSITE	FCST	ORTHOPYROXENE	OPRX	SULFIDES	SLPD
CHLORITE	CLRT	GARNIERITE	GRNR	PENTLANDITE	PNLD	TREMOLITE	TMLT
CHROMITE	CRMT	GOETHITE	GTHT	PLAGIOCLASE	PLGC	UVAROVITE	UVRT
CHRYSOTILE	CRSL	HEMATITE	HMTT	PYROXENE	PRXN		
CLINOCHLORE	CLCL	HORNBLENDE	HBLD	PYRRHOTITE	PYTT		

ISMI records for chromite deposits and districts—Continued

Age of mineralization[2]/	Tectonic setting[2]/	Local environment	Principal mineral assemblages[3]/	Comments	Reference
	FINLAND—continued				
EPROT	Stable PREC craton	Layered igneous intrusion	CRMT, SRPN, CLRT; TALC, DLMT	Eight major ore bodies, in lens or tabular form, extending over 4.5 km	Kahma and others (1962)
	GREECE—continued				
---	Island arc	Ultramafic portion of ophiolite	Cr-SPNL, OLVN, ORPX, SRPN	30 reported ore bodies	Zachos (1953)
	GREENLAND—continued				
---	PREC shield	Metamorphosed, disrupted layered complex	CRMT, HBLD, PLGC; RUTL, BOTT; MGNT; SLPD, ILMN	Complex with 200-km strike length; 380 m thick	Ghisler (1976)
	INDIA—continued				
PREC	Stable PREC craton	Disrupted, layered ultramafic complex; deeply weathered	CRMT, SRPN, ORPX, TALC, GTHT, TMLT, LMON	Platinum-group-element chemistry similar to podiform-type deposits	Banerjee (1971)
-do-	-do-	-do-	---	-do-	Do.
-do-	-do-	-do-	---	-do-	Do.
-do-	-do-	-do-	CRMT, OLVN, GTHT, SRPN	-do-	Do.
-do-	-do-	-do-	SRPN, CRMT	-do-	[5]/IGS (1974, p. 24-28)
-do-	-do-	-do-	CRMT, SRPN	-do-	Do.
	IRAN—continued				
CRET(?)	Convergent margin	Ultramafic portion of ophiolite	---	Irregular lenses, pipes, beds, and masses	Duke (1982, p. 151-153)
	MADAGASCAR—continued				
PREC	---	---	CRMT, TALC, CLRT	Ore body consists of 10-12 bands generally trending N. 30-40° W. Eluvial chromite reported	Murdock (1963, p. 74-79)

4/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

5/ India Geological Survey.

Site name	Latitude	Longitude	Deposit type	Host rock[1]
				PAPUA NEW GUINEA
Ramu River laterite deposit[4] (Madang district)	05° 33'S	145° 11'E	Laterite	Dunite; Marum basic belt; MMIO
				PHILIPPINES
Acoje mine (Zambales district)	15° 43'N	120° 04'E	Magmatic, podiform, massive, disseminated	Serpentinized dunite; Zambales ultramafic complex; CRET
Masinloc Chromite Operation (Zambales district)	15° 34'N	120° 04'E	Magmatic, podiform	-do-
				SOUTH AFRICA
Steelpoort sector (eastern Bushveld)	24° 32'S	30° 08'E	Magmatic, stratiform, massive	Pyroxenite; Dwars River subsuite; EPROT
UG2 chromitite layer[4] (eastern Bushveld)	24° 46'S	30° 10'E	Magmatic, stratiform, disseminated	Pyroxenite; UG2 chromitite layer; EPROT
Potgietersrus sector (northern Bushveld)	24° 21'S	28° 58'E	Magmatic, stratiform, massive	Pyroxenite; Zoetveld subsuite; EPROT
Mankwe-Bafokeng sector--Bophuthatswana (western Bushveld)	25° 11'S	26° 55'E	-do-	Pyroxenite; Schilpadnest subsuite; EPROT
Nietverdiend-Lehurutshe sector--Bophuthatswana (western Bushveld)	25° 05'S	26° 15'E	-do-	-do-
Nietverdiend-Marico sector (western Bushveld)	25° 00'S	26° 12'E	-do-	Pyroxenite; Vlakfontein subsuite; EPROT
Rustenburg and Zwartkop sectors (western Bushveld)	25° 40'S	27° 14'E	-do-	Pyroxenite; Schilpadnest subsuite; EPROT
UG2 chromitite layer[4] (western Bushveld)	25° 42'S	27° 27'E	Magmatic, stratiform, disseminated	Pyroxenite; UG2 chromitite layer; EPROT
				SOVIET UNION
Saranovsk deposit--Northern and Southern Massifs (Perm district)	59° 00'N	58° 45'E	Magmatic, podiform, massive	Serpentinized dunite; Saranovsk ultramafic complex; ESIL
XL Years of the Kazakh-Melodezhnoe deposit (Kempirsai area)	50° 15'N	58° 38'E	Magmatic, podiform	Serpentinized dunite; Kempirsai ultramafic complex; PAL-MES
XX Years of the Kazakh SSR deposit (Kempirsai area)	50° 15'N	58° 30'E	-do-	-do-

1/ Includes some or all of the following items (separated by semicolons): main host rock type, formation name, and host rock age. Only reported items are listed. See footnote 2 for age abbreviations.

2/ Age abbreviations and prefixes:

MIOCENE	MIO	SILURIAN	SIL	EARLY	E
MESOZOIC	MES	PRECAMBRIAN	PREC	MIDDLE	M
CRETACEOUS	CRET	PROTEROZOIC	PROT	LATE	L
JURASSIC	JUR	ARCHEAN	ARCH		
PALEOZOIC	PAL				

Age of mineralization[2]/	Tectonic setting[2]/	Local environment	Principal mineral assemblages[3]/	Comments	Reference
PAPUA NEW GUINEA—continued					
MMIO	Island arc	Ultramafic portion of ophiolite	GRNR, hydrated Ni-Mg SLCT, CRMT	Three lateritic layers: Cr-rich, Ni-Co rich, Ni-rich	Holmes and Hall (1975)
PHILIPPINES—continued					
CRET(?)	Ophiolite	Harzburgite-dunite transition zone in ophiolite	CRMT, PYTT, TMLT, PNLD, SRPN	>40 ore bodies occur in a 350-m-wide mineralized zone	Stoll (1958)
-do-	-do-	-do-	SRPN, CRMT, OLVN	Ore bodies form a 2.4-km belt; maximum dimensions: thickness: 80m; length: 600m; width: 300m	Do.
SOUTH AFRICA—continued					
EPROT	Anorogenic	Layers in a strati-form intru-sion	CRMT, PLGC, PRXN	---	von Gruenewaldt (1977)
-do-	Intracratonic (anorogenic)	-do-	CRMT, PLGC, PRXN; SLPD	Located 300 m below the Merensky Reef	Do.
-do-	-do-	-do-	CRMT, PRXN	Stratigraphically lower than chromite in eastern and western Bushveld	Do.
-do-	-do-	-do-	CRMT, PRXN, PLGC	Chromite layer occurs in three groups	Do.
-do-	-do-	-do-	-do-	Stratigraphically lower than other chromite in western Bushveld	Do.
-do-	-do-	-do-	CRMT, PRXN	-do-	Do.
---	-do-	-do-	CRMT, PRXN, PLGC	Chromitite layers occur in three groups	Do.
EPROT	-do-	-do-	CRMT, PLGC, PRXN; SLPD	Located 40 m below the Merensky Reef	Do.
SOVIET UNION—continued					
ESIL(?)	Convergent margin	Ultramafic portion of ophiolite	Cr-SPNL, OLVN, PRXN; SRPN	Three ore bodies	Smirnov (1977, p. 204-206)
PAL-MES(?)	-do-	-do-	Cr-SPNL,FRSR, MGNT; BRUC, SRPN	23 vein-like ore bodies	Pavlov and others (1968)
-do-	-do-	-do-	-do-	60 vein-like ore bodies	Do.

3/ Abbreviations for mineral names (after Longe and others, 1978, p. 63-66):

AMPHIBOLE	AMPB	CLINOPYROXENE	CLPX	ILMENITE	ILMN	RUTILE	RUTL
ANTIGORITE	ANGR	DOLOMITE	DLMT	LIMONITE	LMON	SERPENTINE	SRPN
BIOTITE	BOTT	ENSTATITE	ENST	MAGNETITE	MGNT	SILICATES	SLCT
BRONZITE	BRNZ	FORSTERITE	FRSR	OLIVINE	OLVN	SPINEL	SPNL
BRUCITE	BRUC	FUCHSITE	FCST	ORTHOPYROXENE	OPRX	SULFIDES	SLPD
CHLORITE	CLRT	GARNIERITE	GRNR	PENTLANDITE	PNLD	TREMOLITE	TMLT
CHROMITE	CRMT	GOETHITE	GTHT	PLAGIOCLASE	PLGC	UVAROVITE	UVRT
CHRYSOTILE	CRSL	HEMATITE	HMTT	PYROXENE	PRXN		
CLINOCHLORE	CLCL	HORNBLENDE	HBLD	PYRRHOTITE	PYTT		

4/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

Site name	Latitude	Longitude	Deposit type	Host rock1/
				SUDAN
Ingessana Hills mining area (Ingessana Hills district)	11° 17'N	34° 00'E	Magmatic, podiform	Serpentinized dunite; Basement Complex group; PREC
Nile mining operation (Ingessana Hills district)	11° 17'N	34° 00'E	-do-	-do-
				TURKEY
Uckopru deposit (Mugla-Fethiye district)	36° 21'N	29° 15'E	Magmatic, podiform, massive, disseminated	Serpentinized dunite; PAL
Guleman mining area (Elazig-Guleman district)	38° 25'N	39° 54'E	-do-	-do-
Kefdag mining area (Elazig-Maden district)	38° 23'N	39° 40'E	-do-	-do-
Soridag mining area (Elazig-Maden district)	38° 23'N	39° 40'E	-do-	-do-
Kavak mining area (Eskisehir-Mihaliccik district)	39° 52'N	31° 30'E	-do-	-do-
Kopdag mining area (Erzincan-Tercan district)	40° 01'N	40° 28'E	Magmatic, podiform	-do-
				UNITED STATES
Benbow mine4/ (Stillwater Complex)	45° 22'N	109° 49'W	Magmatic, stratiform, massive, disseminated	Serpentinized dunite; Stillwater Complex; ARCH
Mouat mine4/ (Stillwater Complex)	45° 23'N	109° 54'W	-do-	-do-

1/ Includes some or all of the following items (separated by semicolons): main host rock type, formation name, and host rock age. Only reported items are listed. See footnote 2 for age abbreviations.

2/ Age abbreviations and prefixes:

MIOCENE	MIO	SILURIAN	SIL	EARLY	E
MESOZOIC	MES	PRECAMBRIAN	PREC	MIDDLE	M
CRETACEOUS	CRET	PROTEROZOIC	PROT	LATE	L
JURASSIC	JUR	ARCHEAN	ARCH		
PALEOZOIC	PAL				

3/ Abbreviations for mineral names (after Longe and others, 1978, p. 63-66):

AMPHIBOLE	AMPB	CLINOPYROXENE	CLPX	ILMENITE	ILMN	RUTILE	RUTL
ANTIGORITE	ANGR	DOLOMITE	DLMT	LIMONITE	LMON	SERPENTINE	SRPN
BIOTITE	BOTT	ENSTATITE	ENST	MAGNETITE	MGNT	SILICATES	SLCT
BRONZITE	BRNZ	FORSTERITE	FRSR	OLIVINE	OLVN	SPINEL	SPNL
BRUCITE	BRUC	FUCHSITE	FCST	ORTHOPYROXENE	OPRX	SULFIDES	SLPD
CHLORITE	CLRT	GARNIERITE	GRNR	PENTLANDITE	PNLD	TREMOLITE	TMLT
CHROMITE	CRMT	GOETHITE	GTHT	PLAGIOCLASE	PLGC	UVAROVITE	UVRT
CHRYSOTILE	CRSL	HEMATITE	HMTT	PYROXENE	PRXN		
CLINOCHLORE	CLCL	HORNBLENDE	HBLD	PYRRHOTITE	PYTT		

Age of mineralization[2]/	Tectonic setting[2]/	Local environment	Principal mineral assemblages[3]/	Comments	Reference
SUDAN—continued					
PREC	Stable PREC craton	Ultramafic portion of ophiolite	---	Three deposits contained in meta-sedimentary complex 25 km in diameter	Vail (1978, p. 49-50)
-do-	-do-	-do-	---	150-m chromite lens	Do.
TURKEY—continued					
PAL	Convergent margin	Harzburgite-dunite transition zone in ophiolite	CRMT, OLVN, TMLT, Cr-CLCL, SRPN	Belt extends over 120 km, covering 3,000 sq km; 23 reported occurrences in district	[6]/ MTA (1966)
-do-	-do-	-do-	CRMT, SRPN, OLVN; Cr-CLCL, UVRT, RUTL, FCST	Eight reported occurrences in district	Do.
-do-	-do-	-do-	CRMT, OLVN, SRPN, MGNT; Cr-CLCL	14 reported occurrences in district	Do.
-do-	-do-	-do-	CRMT, SRPN, OLVN; Cr-CLCL, UVRT, RUTL, FCST	Ore bodies are continuous along strike	Do.
-do-	-do-	-do-	CRMT, OLVN, SRPN; LMON, MGNT, CLRT, TMLT	23 reported occurrences; includes three ore bodies	Do.
-do-	-do-	-do-	CRMT, OLVN, SRPN; Cr-CLCL, UVRT	---	Do.
UNITED STATES—continued					
ARCH	Stable PREC craton	Layered mafic intrusion	CRMT, OLVN, CLPX, ORPX	Ore-body aggregate length is 1,725 m	Page (1977)
-do-	-do-	-do-	-do-	---	Do.

[4]/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

[5]/ India Geological Survey.

[6]/ Maden Tetkik ve Arama Enstitüsü (Turkey Mineral Research and Exploration Institute).

Site name	Latitude	Longitude	Deposit type	Host rock[1]
				ZIMBABWE
Bee mine (Great Dyke)	17° 51'S	29° 53'E	Magmatic, stratiform, massive	Serpentinized dunite; Hartley Complex; ARCH
Caesar mine (Great Dyke)	17° 30'S	30° 43'E	-do-	-do-
Cambrai mine (Great Dyke)	19° 20'S	30° 10'E	-do-	-do-
Divide mine (Great Dyke)	17° 38'S	30° 45'E	-do-	-do-
Glenapp mine (Great Dyke)	17° 00'S	30° 45'E	-do-	-do-
Impinge claims (Great Dyke)	16° 55'S	30° 49'E	-do-	-do-
Netherburn mine (Great Dyke)	19° 16'S	30° 11'E	-do-	-do-
Noro mine (Great Dyke)	17° 03'S	30° 45'E	-do-	-do-
Rutala mine (Great Dyke)	18° 24'S	30° 27'E	-do-	-do-
Sutton and Rod Camp mines (Great Dyke)	17° 25'S/ 17° 29'S	30° 37'E/ 30° 34'E	-do-	-do-
Umsweswe mine (Great Dyke)	18° 30'S	30° 25'E	-do-	-do-
Vanad mine (Great Dyke)	17° 48'S	30° 45'E	-do-	-do-
Windsor mine (Great Dyke)	17° 48'S	30° 45'E	-do-	-do-
York mine (Great Dyke)	18° 58'S	30° 18'E	-do-	-do-
York West mine (Great Dyke)	19° 12'S	30° 15'E	-do-	-do-
Selukwe[7] Peak and Railway Block mines (Selukwe Complex)	19° 43'S/ 19° 39'S	30° 01'E/ 30° 00'E	Magmatic, stratiform, disrupted, massive	Serpentinized dunite; Sebakwian Group; ARCH

1/ Includes some or all of the following items (separated by semicolons): main host rock type, formation name, and host rock age. Only reported items are listed. See footnote 2 for age abbreviations.

2/ Age abbreviations and prefixes:

MIOCENE	MIO	SILURIAN	SIL	EARLY	E
MESOZOIC	MES	PRECAMBRIAN	PREC	MIDDLE	M
CRETACEOUS	CRET	PROTEROZOIC	PROT	LATE	L
JURASSIC	JUR	ARCHEAN	ARCH		
PALEOZOIC	PAL				

3/ Abbreviations for mineral names (after Longe and others, 1978, p. 63-66):

AMPHIBOLE	AMPB	CLINOPYROXENE	CLPX	ILMENITE	ILMN	RUTILE	RUTL
ANTIGORITE	ANGR	DOLOMITE	DLMT	LIMONITE	LMON	SERPENTINE	SRPN
BIOTITE	BOTT	ENSTATITE	ENST	MAGNETITE	MGNT	SILICATES	SLCT
BRONZITE	BRNZ	FORSTERITE	FRSR	OLIVINE	OLVN	SPINEL	SPNL
BRUCITE	BRUC	FUCHSITE	FCST	ORTHOPYROXENE	OPRX	SULFIDES	SLPD
CHLORITE	CLRT	GARNIERITE	GRNR	PENTLANDITE	PNLD	TREMOLITE	TMLT
CHROMITE	CRMT	GOETHITE	GTHT	PLAGIOCLASE	PLGC	UVAROVITE	UVRT
CHRYSOTILE	CRSL	HEMATITE	HMTT	PYROXENE	PRXN		
CLINOCHLORE	CLCL	HORNBLENDE	HBLD	PYRRHOTITE	PYTT		

ISMI records for chromite deposits and districts—Continued

Age of mineralization[2]/	Tectonic setting[2]/	Local environment	Principal mineral assemblages[2]/	Comments	Reference
ZIMBABWE—continued					
ARCH	Stable craton	Layered intrusion	CRMT, FRSR, ENST, Fe oxides; SRPN, CRSL	Eluvial chromite reported	Worst (1960)
-do-	-do-	-do-	CRMT, FRSR, ENST/ BRNZ, Fe oxides; SRPN, CRSL	---	Mining and Engineering (1980)
-do-	-do-	-do-	-do-	---	Worst (1960)
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	-do-	Eluvial chromite reported	Do.
-do-	-do-	-do-	-do-	-do-	Do.
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	-do-	Eluvial chromite reported	Do.
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	CRMT, FRSR, ENST/ BRNZ; SPRN, CRSL	---	Do.
-do-	-do-	-do-	CRMT, FRSR, ENST/ BRNZ, Fe oxides; SRPN, CRSL	---	Do.
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	-do-	---	Do.
-do-	-do-	-do-	CRMT, OLVN, MGNT, ILMN, SRPN, TALC-carbonate, CLRT, ANGR	---	Cotterill (1969)

4/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

5/ India Geological Survey.

6/ Maden Tetkik ve Arama Enstitüsü (Turkey Mineral Research and Exploration Institute).

7/ Selukwe has recently been renamed Shurugwi.

TABLE 10.—*Selected production and mineral-resource information*

Site name	Year of discovery	Mining method[1/]	Year of first production	Commodities[2/]
				ALBANIA
Kalimash mine (Tropoje-Kukes district)	1937	S,U	About 1961-65	Cr(Cr)
Bulqize mine (Bater-Martanesh district)	1937	S,U	1938	Cr(Cr)
Todo Manco mine (Bater-Martanesh district)	Post-1937	S,U	About 1970-75	Cr(Cr)
				AUSTRALIA
Coobina deposit[6/]	1925	S	1952	Cr(Cr)
				BRAZIL
Limoeiro mining area (Campo Formoso district)	1907	S	1975	Cr(Cr)
Pedrinhas mining area (Campo Formoso district)	1907	S,U	1962	Cr(Cr)
				CANADA
Bird Lake chrome deposit[6/] (Bird River sill)	1942	N	None	Cr(Fe)
Chrome Group deposit[6/] (Bird River sill)	1942	N	-do-	Cr(Fe)
Euclid M.C. deposit[6/] (Bird River sill)	1943	N	-do-	Cr(Fe)
Page Group deposit[6/] (Bird River sill)	1942	N	-do-	Cr(Fe)
				CUBA
Camaguey and Oriente Provinces	---	S,U	1909/ 1840-50	Ni, Fe, Cr(Al), Co, Mn

1/ S, surface; U, underground; N, not yet producing.

2/ Chromite ore-class indicated by chemical symbol in parentheses: Cr, high chromium; Fe, high iron; Al, high aluminum. PGE is platinum-group elements.

3/ Includes some or all of the following items (separated by semicolons): annual production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and year of production (or range of years used to estimate average annual production).

Annual production[3]/	Cumulative production[4]/	Resources[5]/	Comments
	ALBANIA—continued		
100; 1983	See Bulquize mine	R1E, R2E (see Bulquize mine)	Six major operations in district
1,320; 37-56%; 1982	15,223; 1938-82	6,500; R1E; 42-43%; 1979 15,000; R2E; 42-43%; 1979	Production and resources for entire country; Albania produces 9% of all world chromite
See Bulquize mine	See Bulquize mine	R1E, R2E (see Bulquize mine)	Largest chromite mine in Albania
	AUSTRALIA—continued		
2.8; 43.5%; 1953-57	14.6; 43.5%; 1952-57	1,965; R1M; ~40%; 1978	Inactive operation
	BRAZIL—continued		
100; 38-46%; 1978	105; 17%; 1962-71	4,000; R1E; 17%; 1983 R1M (see Pedrinhas mining area)	Ore body is concealed by thick overburden
120 (concentrate); 1978	---	13,000; R1E; 21%; 1983 20,000; R1M; 17-21%; 1983	R1M is for Limoeiro and Pedrinhas properties; ore mined is about 37-44% Cr_2O_3
	CANADA—continued		
None	None	5,800; R1M; 7%; 1982	Undeveloped property
-do-	-do-	2,100; R1M; 18.2%; 1982	-do-
-do-	-do-	9,100; R1M; 4.6%; 1982	-do-
-do-	-do-	1,600; R1M; 25.2%; 1982	-do-
	CUBA—continued		
27; 36%; 1982	>3,630; mostly refractory grade; 1918-82	3,000; R1E; 36%; 1978 5,000; R2E; 36%; 1978	Annual and cumulative production for entire country; resource estimates are for entire country and are uncertain due to limited exploration; exports exceed production due to reliance on stockpiled ores

4/ Includes some or all of the following items (separated by semicolons): cumulative production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and years for reported cumulative production.

5/ Includes, for various resource categories, some or all of the following items (separated by semicolons): resource in thousand metric tons; U.N. resource classification (Schanz, 1980); grade in percent Cr_2O_3; and year of estimate.

6/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

Site name	Year of discovery	Mining method[1]/	Year of first production	Commodities[2]/
				FINLAND
Kemi mine (Elijarvi district)	1959	S	1967 (pilot plant)/1969	Cr(Fe)
				GREECE
Vourinon area	1890	U	1952	Cr(Cr)
				GREENLAND
Fiskenaesset area[6]/	1964	N	None	Cr(Fe), V, Ti
				INDIA
Bhimtanagar mine (Cuttack district)	1950	S,U	1952	Cr(Cr)
Kalarangi mining area (Cuttack district)	---	S,U	---	Cr(Cr)
Kaliapani mine (Cuttack district)	1950	S,U	1968	Cr(Cr)
Saruabil mine (Cuttack district)	1950	S,U	---	Cr(Cr)
Boula mining area (Keonjhar district)	---	S	1944	Cr(Cr)
Kathpal deposit (Dhenkanal district)	1950	S,U	---	Cr(Cr)
				IRAN
Shahriar, Shahin, and Amir mines (Faryab area)	1957	S,U	1967	Cr(Cr)
				MADAGASCAR
Andriamena mining area (Tsaratanana district)	1954	S	1967	Cr(Cr)

1/ S, surface; U, underground; N, not yet producing.

2/ Chromite ore-class indicated by chemical symbol in parentheses: Cr, high chromium; Fe, high iron; Al, high aluminum. PGE is platinum-group elements.

3/ Includes some or all of the following items (separated by semicolons): annual production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and year of production (or range of years used to estimate average annual production).

Annual production[3]/	Cumulative production[4]/	Resources[5]/	Comments
	FINLAND—continued		
632; 27%; 1981	8,600; 27%; 1966-82	50,000; R1E; 26%; 1982	Low-grade, friable ores; mostly for domestic consumption
	GREECE—continued		
42; 53-56%; 1982	1,170; 1952-82	3,000; R1E; 17-20%; 1982 3,200; R2E; 17-20%; 1982	Metallurgical-grade ores; grade in some areas as much as 35% Cr_2O_3
	GREENLAND—continued		
None	None	100,000; R2S; 38%; 1976	Low-grade ores; rich in Al and Fe; concentrates may be suitable for the manufacture of chromium chemicals
	INDIA—continued		
270; >47%; 1980-81	7,296; 1952-82	69,320; R1E; 33%; 1982 23,960; R1M; 30%; 1982	Annual production for six mines in the district; cumulative production for India; resources for the entire Cuttack district. 90% of all Indian chromite production comes from mines in Orissa State.
See Bhimtanagar mine	See Bhimtanagar mine	R1E, R1M (see Bhimtanagar mine)	SiO_2-rich ore
-do-	-do-	-do-	Metallurgical-grade ores
-do-	-do-	-do-	-do-
76; 40-58%; 1977	-do-	9,410; R1E; 36%; 1982 3,310; R1M; 35%; 1982	Production for two mines in Orissa State; resources for entire Keonjhar district
312; 59-61%; 1977	-do-	252; R1E; 1979	Production for two mines in Dhenkanal district
	IRAN—continued		
<190; 46-51%; 1978	3,419; 1960-82	2,200; R1E; 45-51%; 1974 50,000; R2E; 1976	Operation possibly inactive since 1979; cumulative production for Iran; R2E is for Faryab area
	MADAGASCAR—continued		
194; 40%; 1975-76	2,000; 1967-82	10,000; R1E; 31%; 1982	Cumulative production for Madagascar

4/ Includes some or all of the following items (separated by semicolons): cumulative production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and years for reported cumulative production.

5/ Includes, for various resource categories, some or all of the following items (separated by semicolons): resource in thousand metric tons; U.N. resource classification (Schanz, 1980); grade in percent Cr_2O_3; and year of estimate.

6/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

Site name	Year of discovery	Mining method[1]	Year of first production	Commodities[2]
				PAPUA NEW GUINEA
Ramu River laterite deposit[6] (Madang district)	1968	N	None	Ni, Cr(Fe), Co, Fe
				PHILIPPINES
Acoje mine (Zambales district)	---	U	1937	Cr(Cr)
Masinloc Chromite Operation (Zambales district)	1925	S,U	1932	Cr(Al)
				SOUTH AFRICA
Steelpoort sector (eastern Bushveld)	?	U	1923	Cr(Fe)
UG2 chromitite layer[6] (eastern Bushveld)	1908	N	---	PGE, Cr(Fe), Au, Ni
Potgietersrus sector (northern Bushveld)	Early 1960's	U	1963-64	Cr(Cr)
Mankwe-Bafokeng sector--Bophuthatswana (western Bushveld)	About 1920	U	---	Cr(Fe)
Nietverdiend-Lehurutshe sector--Bophuthatswana (western Bushveld)	---	---	---	Cr(Fe)
Nietverdiend-Marico sector (western Bushveld)	---	U	About 1920	Cr(Cr)
Rustenburg and Zwartkop sectors (western Bushveld)	About 1920	U	About 1920	Cr(Cr)
UG2 chromitite layer[6] (western Bushveld)	1908	U	1983	PGE, Ni, Cu, Co, Cr(Fe)
				SOVIET UNION
Saranovsk deposit--Northern and Southern Massifs (Perm district)	About 1797	U	Early 1800's	Cr(Fe)
XL Years of the Kazakh-Melodezhnoe deposit (Kempirsai area)	1936	S,U	---	Cr(Cr)
XX Years of the Kazakh SSR deposit (Kempirsai area)	1936	S	---	Cr(Cr)

1/ S, surface; U, underground; N, not yet producing.

2/ Chromite ore-class indicated by chemical symbol in parentheses: Cr, high chromium; Fe, high iron; Al, high aluminum. PGE is platinum-group elements.

3/ Includes some or all of the following items (separated by semicolons): annual production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and year of production (or range of years used to estimate average annual production).

4/ Includes some or all of the following items (separated by semicolons): cumulative production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and years for reported cumulative production.

Annual production3/	Cumulative production4/	Resources5/	Comments
	PAPUA NEW GUINEA—continued		
None	None	128,000; R1S; 3.3%; 1982	Undeveloped property
	PHILIPPINES—continued		
330; 48%; 1979	2,440; metallurgical grade; 1946-76	2,850; R1E; 18%; 1982	More than 40 ore bodies
154 (concentrate); refractory grade; 1982	>15,000; refractory grade; 1932-80	9,000; R1E; 31%; 1983	Largest high-alumina podiform chromite deposit in the world
	SOUTH AFRICA—continued		
1,780; 44%; 1980-82	26,349; 43%; 1923-82	370,000; R1E; 40-45%; 1983 1,595,000; R1S; 35-45%; 1983 370,000; R2E; 40-45%; 1983	Production refined locally to ferrochromium; South Africa's major producing operation; platinum-group-element potential
---	---	R1M (see UG2-western Bushveld)	Platinum-group-element potential
78; 43%; 1980-82	987; 44%; 1963-82	19,000; R1E; 42-48%; 1983 14,000; R1S; 1983	Metallurgical-grade ores
309; 43%; 1980-82	2,193; 45%; 1972-81	233,000; R1E; 40-45%; 1983 856,000; R1S; 1983 233,000; R2E; 40-45%; 1983	---
57; 1980-82	171; 1980-82	1,000; R1E; 40-45%; 1983 55,000; R1S; 40-45%; 1983 68,000; R2E; 40-45%; 1983	---
128; 45%; 1980-82	2,769; 46%; 1933-82	1,000; R1E; 40-45%; 1983 55,000; R1S; 40-45%; 1983 68,000; R2E; 40-45%; 1983	Property inactive 1943-52
1,090; 42-45%; 1980-82	21,659; 44%; 1923-82	390,000; R1E; 40-45%; 1983 916,000; R1S; 30-40%; 1983 390,000; R2E; 40-45%; 1983	Platinum-group-element potential
---	---	5,420,000; R1M; 38%; 1980	Platinum-group-element mining only at Western Platinum mine; R1M for UG2 chromitite layer in eastern and western Bushveld; ore grade 3.5-19 g/t platinum
	SOVIET UNION—continued		
330; 30-40%; 1981	>7,000; through 1982	1,500; R1E; 20-40%; 1977 7/ 4,500; R2E; 20-40%; 1977 7/	Believed to account for 10% of Soviet production and 6% of Soviet resources
2,300; 30-56%; 1980	52,000; 1936-82	90,000; R1E; >50%; 1977 7/	Annual production for Donskoye complex; 94% of Soviet chromite resources are in Kazakhstan
See XL Years of the Kazakh-Melodezhnoe deposit	See XL Years of the Kazakh-Melodezhnoe deposit	>25,000; R1E; >50%; 1977 7/	Only supplier of high quality ore in the Soviet Union

5/ Includes, for various resource categories, some or all of the following items (separated by semicolons): resource in thousand metric tons; U.N. resource classification (Schanz, 1980); grade in percent Cr_2O_3; and year of estimate.

6/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

7/ Soviet Union resources reported as "measured reserves," "total reserves," and reserves in "categories A+B+C" are classified as R1E in this report; R2E is used in this report for those resources reported as "gross reserves" where a measured reserve category is reported separately. The Soviet Union's "A+B+C" categories are explained in Bachmann (1979).

TABLE 10.—*Selected production and mineral-resource information*

Site name	Year of discovery	Mining method[1]	Year of first production	Commodities[2]
				SUDAN
Ingessana Hills mining area (Ingessana Hills district)	1960	S,U	1962	Cr(Cr)
Nile mining operation (Ingessana Hills district)	---	S	1969	Cr(Cr)
				TURKEY
Uckopru deposit (Mugla-Fethiye district)	---	---	Pre-1914	Cr(Cr)
Guleman mining area (Elazig-Guleman district)	---	S,U	1860	Cr(Cr)
Kefdag mining area (Elazig-Maden district)	1936	U	---	Cr(Cr)
Soridag mining area (Elazig-Maden district)	1936	U	1949	Cr(Cr)
Kavak mining area (Eskisehir-Mihaliccik district)	About 1900	U	Pre-1914	Cr(Cr)
Kopdag mining area (Erzincan-Tercan district)	Post-1945	S,U	1955	Cr(Cr)
				UNITED STATES
Benbow mine[8] (Stillwater Complex)	About 1905	U	1942	Cr(Fe), PGE
Mouat mine[8] (Stillwater Complex)	About 1905	U	1941	Cr(Fe), PGE
				ZIMBABWE
Bee mine (Great Dyke)	1929	S	1929	Cr(Cr)
Caesar mine (Great Dyke)	---	U	About 1950	Cr(Cr)
Cambrai mine (Great Dyke)	1919	U	1919	Cr(Cr)
Divide mine (Great Dyke)	1920	S,U	1920	Cr(Cr)

1/ S, surface; U, underground; N, not yet producing.

2/ Chromite ore-class indicated by chemical symbol in parentheses: Cr, high chromium; Fe, high iron; Al, high aluminum. PGE is platinum-group elements.

3/ Includes some or all of the following items (separated by semicolons): annual production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and year of production (or range of years used to estimate average annual production).

Annual production[3]/	Cumulative production[4]/	Resources[5]/	Comments
	SUDAN—continued		
23; 56%; 1980-81	250; 56%; 1962-78	>1,500; R1E; 48-52%; 1974	Production for Jebel Jam mine, principal operation; R1E for entire district
See Ingessana Hills mining area	20; 1969-78	R1E (see Ingessana Hills mining area)	Operation includes two mines
	TURKEY—continued		
9.6; 49-51%; 1968	80; 47%; 1956-66	851; R1E; 34%; 1979 1,141; R1M; 34%; 1979	High Fe-oxide content; continuous operation since 1956
200; metallurgical grade; 1975	2,000; 49-52%; 1860-1975	<50; R1E; 48%; 1978 12,000; R1M; 33-48%; 1981	Annual production for all five district mines; existing reserves limited; R1M for Elazig-Guleman district; district contains two-thirds of all Turkish chromite deposits
<10 (concentrate); 42%; 1976	---	4,800; R1E; 30-38%; 1978 400; R2E; 30-38%; 1978	---
See Guleman mining area	80; 1949-75	800; R1E; 44-48%; 1978 2,000; R2E; 44-48%; 1978	---
65 (concentrate); 31%; 1968	763; 1931-59	2,800; R1E; 30%; 1982	One of the largest privately owned deposits in Turkey
---	103; 1955-58	1,000; R1E; 43%; 1982	Last production in 1958
	UNITED STATES—continued		
28 (concentrate); 41%; 1943	73 (concentrate); 41%; 1942-43	797; R1S; 20%; 1957 692; R2S; 20%; 1957	Inactive operation
94 (concentrate); 38%; 1958-61	962 (concentrate); 39%; 1943, 1953-61	2,140; R1S; 22-24%; 1957 1,550; R2S; 22-24%; 1957	Inactive since 1961
	ZIMBABWE—continued		
17; 48%; 1957	---	18,834; R1E; 47%; 1982 172,186; R1M; 48%; 1982	Two seams outcrop; overburden treated to recover chromite
95; 48%; 1980	---	3,552; R1E; 51%; 1982 19,296; R1M; 51%; 1982	Mine rehabilitated in 1975
11.4; 48-50%; 1957-58	200; 48-50%; 1922-60	9,391; R1E; 47%; 1982 8,272; R1M; 47%; 1982	Chromite varies from hard and lumpy to friable
4.84; 41-52%; 1957-58	---	3,552; R1E; 51%; 1982 17,536; R1M; 51%; 1982	Three seams mined; coarse-grained ore; two operations combined

4/ Includes some or all of the following items (separated by semicolons): cumulative production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and years for reported cumulative production.

5/ Includes, for various resource categories, some or all of the following items (separated by semicolons): resource in thousand metric tons; U.N. resource classification (Schanz, 1980); grade in percent Cr_2O_3; and year of estimate.

6/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

Site name	Year of discovery	Mining method[1]	Year of first production	Commodities[2]
ZIMBABWE				
Glenapp mine (Great Dyke)	1917	S,U	1919	Cr(Cr)
Impinge claims (Great Dyke)	1917	U	1919	Cr(Cr)
Netherburn mine (Great Dyke)	1927	S,U	---	Cr(Cr)
Noro mine (Great Dyke)	1917	S,U	1919	Cr(Cr)
Rutala mine (Great Dyke)	---	S,U	---	Cr(Cr)
Sutton and Rod Camp mines (Great Dyke)	1923	S,U	About 1950	Cr(Cr)
Umsweswe mine (Great Dyke)	---	S,U	---	Cr(Cr)
Vanad mine (Great Dyke)	---	U	About 1950	Cr(Cr)
Windsor mine (Great Dyke)	---	S,U	---	Cr(Cr)
York mine (Great Dyke)	---	S,U	1952	Cr(Cr)
York West mine (Great Dyke)	---	S,U	1953	Cr(Cr)
Selukwe[8] Peak and Railway Block mines (Selukwe Complex)	1904	U	1906/1918	Cr(Cr)

1/ S, surface; U, underground; N, not yet producing.

2/ Chromite ore-class indicated by chemical symbol in parentheses: Cr, high chromium; Fe, high iron; Al, high aluminum. PGE is platinum-group elements.

3/ Includes some or all of the following items (separated by semicolons): annual production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and year of production (or range of years used to estimate average annual production).

4/ Includes some or all of the following items (separated by semicolons): cumulative production in thousand metric tons of material mined (unless other processing stage is indicated); grade of reported material in percent Cr_2O_3; and years for reported cumulative production.

Annual production[3]	Cumulative production[4]	Resources[5]	Comments
	ZIMBABWE—continued		
111; 49%; 1957	---	6,480; R1E; 50%; 1982 10,400; R1M; 50%; 1982	Annual production for African Chrome Mines operations; R1E and R1M for Glenapp and Ivo properties; mining in one seam
See Glenapp mine	---	6,144; R1E; 50%; 1982 4,752; R1E; 20%; 1982 (eluvial) 12,096; R1M; 50%; 1982	Mining in six seams; overburden treated to recover chromite
0.51; 48%; 1957-58	---	14,087; R1E; 47%; 1982 12,406; R1M; 47%; 1982	Mining confined to upper seams
See Glenapp mine	---	8,976; R1E; 51%; 1982 16,141; R1M; 51%; 1982	R1E and R1M for Glenapp, Hay, and Noro properties; overburden treated to recover chromite
8.8; 50%; 1958	---	10,800; R1E; 46%; 1982 272,880; R1M; 46%; 1982	Mining in one seam
69; 1957-58	---	15,480; R1E; 50%; 1982 60,960; R1M; 50%; 1982	Annual production for Rhodesian Vanadium Corporation operations; R1E and R1M for Sutton and Rod Camp mines; mining in two seams
15; 41-52%; 1957-58	50; through 1955	1,974; R1E; 46%; 1982 35,966; R1M; 46%; 1982	Mining in two seams; hard to lumpy ores
See Sutton and Rod Camp mines	---	4,032; R1E; 51%; 1982 8,952; R1M; 51%; 1982	Mining in three seams
3.95; 50%; 1957-58	---	13,306; R1E; 51%; 1982 19,310; R1M; 51%; 1982	R1E and R1M are for Windsor and York West properties
---	10; 41-51%; 1952-58	734; R1E; 50%; 1982 490; R1M; 50%; 1982	Metallurgical grade ores
1.4; 47%; 1957	4; 47%; 1953-58	R1E, R1M (see Windsor mine)	Mining in one seam
350; 50%; 1981	>10,000; metallurgical grade; 1907-81	11,500; R1E; 47%; 1982 76,000; R1M; metallurgical grade; 1982	Annual production from Selukwe Peak and Railway Block operation represents 70% of Zimbabwe production capacity; cumulative production for Selukwe Complex; R1E and R1M for Selukwe Peak and Railway Block operations

5/ Includes, for various resource categories, some or all of the following items (separated by semicolons): resource in thousand metric tons; U.N. resource classification (Schanz, 1980); grade in percent Cr_2O_3; and year of estimate.

6/ Deposits or districts in the International Strategic Minerals Inventory that have not been included in the resource or production totals of Part I of this report because production is not foreseen in the near future.

7/ Soviet Union resources reported as "measured reserves," "total reserves," and reserves in "categories A+B+C" are classified as R1E in this report; R2E is used in this report for those resources reported as "gross reserves" where a measured reserve category is reported separately. The Soviet Union's "A+B+C" categories are explained in Bachmann (1979).

8/ Selukwe has recently been renamed Shurugwi.

REFERENCES CITED

Bachmann, H., 1979, Internationale Entwicklungslinien der Klassifikation von Lagerstättenvorräten mineralischer Rohstoffe: Zeitschrift für Angewandte Geologie, band 25, heft 4, p. 113–119.

Banerjee, P. K., 1971, The Sukinda chromite field, Cuttack district, Orissa: India Geological Survey Records, v. 96, no. 2, p. 140–170.

Bannatyne, B. B., and Trueman, D. L., 1982, Chromite reserves and geology of the Bird River sill, Manitoba: Manitoba Department of Energy and Mines, Mineral Resources Divison Open-File Report 82-1, 73 p.

Brown, R. E., 1983, Ferroalloys, *in* U.S. Bureau of Mines, Minerals yearbook 1982, v. I, Metals and minerals: Washington, D.C., U.S. Government Printing Office, p. 321–342.

Bye, S. M., 1975, Chromite mineralization within the Coobina Ultramafic, *in* Knight, C. L., ed., Economic geology of Australia and Papua New Guinea, v. 1, Metals: Australasian Institute of Mining and Metallurgy, Monograph 5, p. 205–206.

Canada Department of Energy, Mines and Resources, 1982 [1983], Chromium—An imported mineral commodity: Canada Department of Energy, Mines and Resources Mineral Bulletin MR 196, 71 p. (Bound together with a 78-p. French version.)

Coertze, F. J., and Coetzee, C. B., 1976, Chromium, *in* Coetzee, C.B., ed., Mineral resources of South Africa (5th ed.): South Africa Geological Survey Handbook 7, p. 117–122.

Cotterill, Peter, 1969, The chromite deposits of Selukwe, Rhodesia, *in* Wilson, H. D. B., ed., Magmatic ore deposits: Economic Geology, Monograph 4, p. 154–187.

Duke, V. W. A., 1982, Chromium—A mineral commodity review: South Africa Minerals Bureau Internal Report 86, 317 p.

Ghisler, Martin, 1976, The geology, mineralogy and geochemistry of the pre-orogenic Archean stratiform chromite deposits at Fiskenaesset, West Greenland: Berlin-Stuttgart, Gebrüder Borntraeger, Monograph Series on Mineral Deposits 14, 156 p.

Hall, A. L., 1932, The Bushveld igneous complex of the central Transvaal: South Africa Geological Survey Memoir 28, 554 p.

Hedlund, D. C., and others, 1974, Stratiform chromite at Campo Formoso, Bahia, Brazil: U.S. Geological Survey Journal of Research, v. 2, no. 5, p. 551–562.

Holmes, K. D., and Hall, R. J., 1975, Marum nickeliferous laterite, Madang District, P.N.G., *in* Knight, C. L., ed., Economic geology of Australia and Papua New Guinea, v. 1, Metals: Australasian Institute of Mining and Metallurgy, Monograph 5, p. 1011–1017.

India Geological Survey, 1974, Geology and mineral resources in the states of India, part III—Orissa: India Geological Survey Miscellaneous Publication 30, 51 p.

Kahma, A., Siikarla, T., Veltheim, V., Vaasjoki, O., and Heikkinen, A., 1962, On the prospecting and geology of the Kemi chromite deposit, Finland: Helsinki, Bulletin de la Commission Géologique de Finlande 194, 89 p.

Kraus, J. R., 1984, Chromium Association is set up as international information hub: American Metal Market, v. 92, no. 98 (18 May), p. 7.

Kupferbürger, Wilhelm, Lombaard, B. U., Wasserstein, B. O., and Schwellnus, C. M., 1937, The chromite deposits of the Bushveld igneous complex—Transvaal: South Africa Geological Survey Bulletin 10, 48 p.

Longe, R. V., and others, 1978, Computer-based files on mineral deposits—Guidelines and recommended standards for data content [prepared by the Mineral Deposits Working Committee, National Advisory Committee on Research in the Geological Sciences]: Canada Geological Survey Paper 78-26, 72 p.

McDivitt, J. F., and Manners, G., 1974, Minerals and men (2d ed.): Baltimore, Johns Hopkins Press, 175 p.

Metal Bulletin Monthly, 1984, SKF Steel—Pinning hopes on plasma: Metal Bulletin Monthly, no. 157, January, p. 46–52.

Mikami, H. M., 1983, Chromite, *in* Lefond, S. J., ed., Industrial minerals and rocks (nonmetallics other than fuels) (5th ed.), v. 1: New York, American Institute of Mining, Metallurgical and Petroleum Engineers, p. 567–584.

Mining and Engineering, 1980, Rhodall flotation draws attention to chrome: Mining and Engineering, v. 45, no. 6 (June), p. 10–13. (Published in Harare, Zimbabwe.)

Mining Journal, 1983, Western Platinum UG2 expansion: Mining Journal, v. 301, no. 7738 (9 Dec.), p. 429.

Murdock, T. G., 1963, Mineral resources of the Malagasy Republic: U.S. Bureau of Mines Information Circular 8196, 147 p.

Page, N. J, 1977, Stillwater Complex, Montana—Rock succession, metamorphism and structure of the complex and adjacent rocks: U.S. Geological Survey Professional Paper 999, 79 p.

Papp, J. F., 1983, Chromium, *in* U.S. Bureau of Mines, Minerals yearbook 1982, v. I, Metals and minerals: Washington, D.C., U.S. Government Printing Office, p. 201–215.

Pavlov, N. V., Kravchenko, G. G., and Chuprynina, I. I., 1968, Kromity Kempirsayskogo plutona [Chromites of the Kempirsai pluton]: Moscow, Akademiya Nauk SSSR, Institut Rudnyikh Mestorozhdenniya, Petrografii, Mineralogii i Geokhimii, 178 p.

Preece, Howard, 1984, African exports of ferrochrome equal to output: American Metal Market, v. 92, no. 11 (17 Jan.), p. 1, 11.

Roskill Information Services, [1982], The economics of chromium (4th ed. 1982): London, Roskill Information Services [556 p.].

Rossi, Gian, 1979a, A review of the mineral industry of South Africa with special reference to chrome ore: South Africa Minerals Bureau Internal Report 37, 134 p.

_____1979b, Cuba—A review of its chrome ore industry: South Africa Minerals Bureau Internal Report 42, 90 p.

Schanz, J. J., Jr., 1980, The United Nations' endeavor to standardize mineral resource classification: Natural Resources Forum, v. 4, no. 3, p. 307–313.

Scherer, F. M., 1970, Industrial market structure and economic performance: Chicago, Rand McNally College Publishing Co., 576 p.

Schottman, F. J., 1981, Ferroalloys, *in* U.S. Bureau of Mines, Minerals yearbook 1980, v. I, Metals and minerals: Washington, D.C., U.S. Government Printing Office, p. 307–321.

Smirnov, V. I., ed., 1977, Ore deposits of the USSR, v. I: London, Pitman Publishing Co., 352 p.

Stoll, W. C., 1958, Geology and petrology of the Masinloc chromite deposit, Zambales, Luzon, Philippine Islands: Geological Society of America Bulletin, v. 69, no. 4, p. 419–448.

Thayer, T. P., and Lipin, B. R., 1978, A geological analysis of world chromite production for the year 2000 A.D.: American Institute of Mining, Metallurgical and Petroleum Engineers, Council of Economics Proceedings (for meeting of Feb. 26–Mar. 2, 1978), p. 143–152.

Turkey Mineral Research and Exploration Institute, 1966, Chromite deposits of Turkey: Turkey Mineral Research and Exploration Institute Publication 132, 108 p. (Foreign edition of Maden Tetkik ve Arama Enstitüsü Yayinlarindan.)

[United Kingdom] Imperial Mineral Resources Bureau, 1921–49, The mineral industry of the British Empire and foreign countries—Statistical summary [1913–47]: His Majesty's Stationery Office, 13 v. (Continued by Institute of Geological Sciences, Statistical summary of the mineral industry.)

[United Kingdom] Institute of Geological Sciences, 1950–73, Statistical summary of the mineral industry—World production, exports, and imports [1942–71]: Her Majesty's Stationery Office, 24 v.
United Nations Economic and Social Council, 1979, Prospects for the economic development of chromium ores and the demand for chromium over the next 10 to 15 years: United Nations Economic and Social Council Report E/C.7/103, 33 p.
U.S. Bureau of Mines, 1927–34, Mineral resources of the United States, 1924[-1931]: Washington, D.C., U.S. Government Printing Office, 16 v. (Continued as U.S. Bureau of Mines Minerals yearbook.)
__________ 1933–83, Minerals yearbook (1932–81): Washington, D.C., U.S. Government Printing Office, 113 v.
U.S. Geological Survey, 1902–27, Mineral resources of the United States [1901–23]: Washington, D.C., U.S. Government Printing Office, 45 v. (Continued by U.S. Bureau of Mines.)
__________ 1921, World atlas of commercial geology – Part I, Distribution of mineral production: Washington, D.C. [144 p.].
Vail, J. R., 1978, Outline of the geology and mineral deposits of the Democratic Republic of the Sudan and adjacent areas: [United Kingdom] Institute of Geological Sciences, Overseas Geology and Mineral Resources no. 49, 66 p.
von Gruenewaldt, Gerhard, 1977, The mineral resources of the Bushveld Complex: Minerals Science and Engineering, v. 9, no. 2, p. 83–95. (Published by National Institute of Metallurgy, South Africa.)
World Bank, 1983, World development report 1983: New York, Oxford University Press, 214 p.
Worst, B. G., 1960, The Great Dyke of Southern Rhodesia: Southern Rhodesia Geological Survey Bulletin 47, 234 p.
Zachos, K. E., 1953, Chromite deposits of Vourinon (Kozani) area, *in* Ereunai oryktou pluton tes Helladous (The mineral wealth of Greece), v. III: [Greece] Institute for Geology and Subsurface Research, p. 47–82. (Foreign version bound in Institouton Geologias kai Ereunon Hypedaphous.)

ADDITIONAL REFERENCES ON CHROMIUM RESOURCES

Anthony, M., and Brown, T. L., 1980, Availability of chromium, *in* Jones, M. J., ed., Availability of strategic minerals: London, Institution of Mining and Metallurgy, p. 33–37.
Apostolides, G. A., and Papathanasiou, C., 1983, Technology and economics of the mining, beneficiation, and smelting of chromite concentrates in an integrated state-owned ferrochrome complex: (London) Institution of Mining and Metallurgy Transactions (Section C: Mineral Processing and Extractive Metallurgy), v. 92, Sept., p. C117–C128.
Buchanan, D. L., 1978, Chromite production from the Bushveld Complex and its relationship to the ferrochromium industry: University of the Witwatersrand (Johannesburg), Bureau of Mineral Studies Report 3, 22 p.
Central Treaty Organization (CENTO), 1963, Symposium on chrome ore: Papers of the Ankara Symposium, Sept. 1963, Turkey Mineral Research and Exploration Institute (Maden Tetkik ve Arama Enstitüsü), 272 p.
Chromium Review, 1983– , no. 1– : Randburg, South Africa, Council for Mineral Technology (Mintek) on behalf of Chromium Centre.
Grebe, Willi-Herbert, and others, 1975, Untersuchungen über Angebot und Nachfrage mineralischer Rohstoffe, VII. Chrom: Hannover (Germany, Federal Republic), Bundesanstalt für Geowissenschaften und Rohstoffe, 147 p.
Institution of Mining and Metallurgy, 1980, Chromium—Discussions and contributions: (London) Institution of Mining and Metallurgy Transactions (Section A: Mining Industry), v. 89, April, p. A99–A105.
Irvine, T. N., ed., 1975, Chromium—Its physiochemical behavior and petrologic significance: Geochimica et Cosmochimica Acta, v. 39, no. 6/7 (June/July), p. 779–1077. (23 papers from a Carnegie Institution of Washington Geophysical Laboratory Conference.)
Jackson, W. A. D., 1983, Soviet chromite ores—Output and export, *in* Jensen, R. G., Shabad, Theodore, and Wright, A. W., eds., Soviet natural resources in the world economy: Chicago, University of Chicago Press, p. 529–535.
Lipin, B. R., 1983, Low-grade chromium resources, *in* Shanks, W. C., III, ed., Unconventional mineral deposits (Cameron volume): New York, American Institute of Mining, Metallurgical and Petroleum Engineers, p. 47–60.
Lipin, B. R., and Thayer, T. P., 1980, The outlook for small chromite mines, *in* Meyer, R. F., and Carman, J. S., eds., The future of small scale mining: New York, United Nations Institute for Training and Research (UNITAR), p. 191–196.
Maden Tetkik ve Arama Enstitüsü, 1980, Türkiye maden envanteri [Mineral inventory of Turkey]: Maden Tetkik ve Arama Enstitüsü Yayinlarindan 179, 569 p.
National Materials Advisory Board, Committee on Contingency Plans for Chromium Utilization, 1978, Contingency plans for chromium utilization: National Materials Advisory Board Publication NMAB-335, 347 p.
Papp, J. F., 1983, Chromium: U.S. Bureau of Mines Mineral Commodity Profile, 21 p.
Thayer, T. P., 1973, Chromium, *in* Brobst, D. A., and Pratt, W. P., eds., United States mineral resources: U.S. Geological Survey Professional Paper 820, p. 111–121.
Visser, D. J. L., and von Gruenewaldt, Gerhard, eds., 1970, Symposium on the Bushveld Igneous Complex and other layered intrusions: Geological Society of South Africa Special Publication 1, 763 p. (39 papers from a symposium held in Pretoria, July 7–14, 1969.)
Woodtli, Robert, ed., 1963, Methods of prospection for chromite: Proceedings of the Athens Seminar, April 16–30, Organization for Economic Cooperation and Development (OECD), 244 p.

INTERNATIONAL STRATEGIC MINERALS INVENTORY SUMMARY REPORTS

This circular is one of several reports on selected mineral commodities to be published in the U.S. Geological Survey 930 series. The circulars published to date are listed below; year of publication is shown in parentheses. Copies are available free on application to Distribution Branch, Text Products Section, U.S. Geological Survey, 604 South Pickett Street, Alexandria, VA 22304 U.S.A.

DeYoung and others—INTERNATIONAL STRATEGIC MINERALS INVENTORY SUMMARY REPORT—CHROMIUM—U.S. Geological Survey Circular 930-B