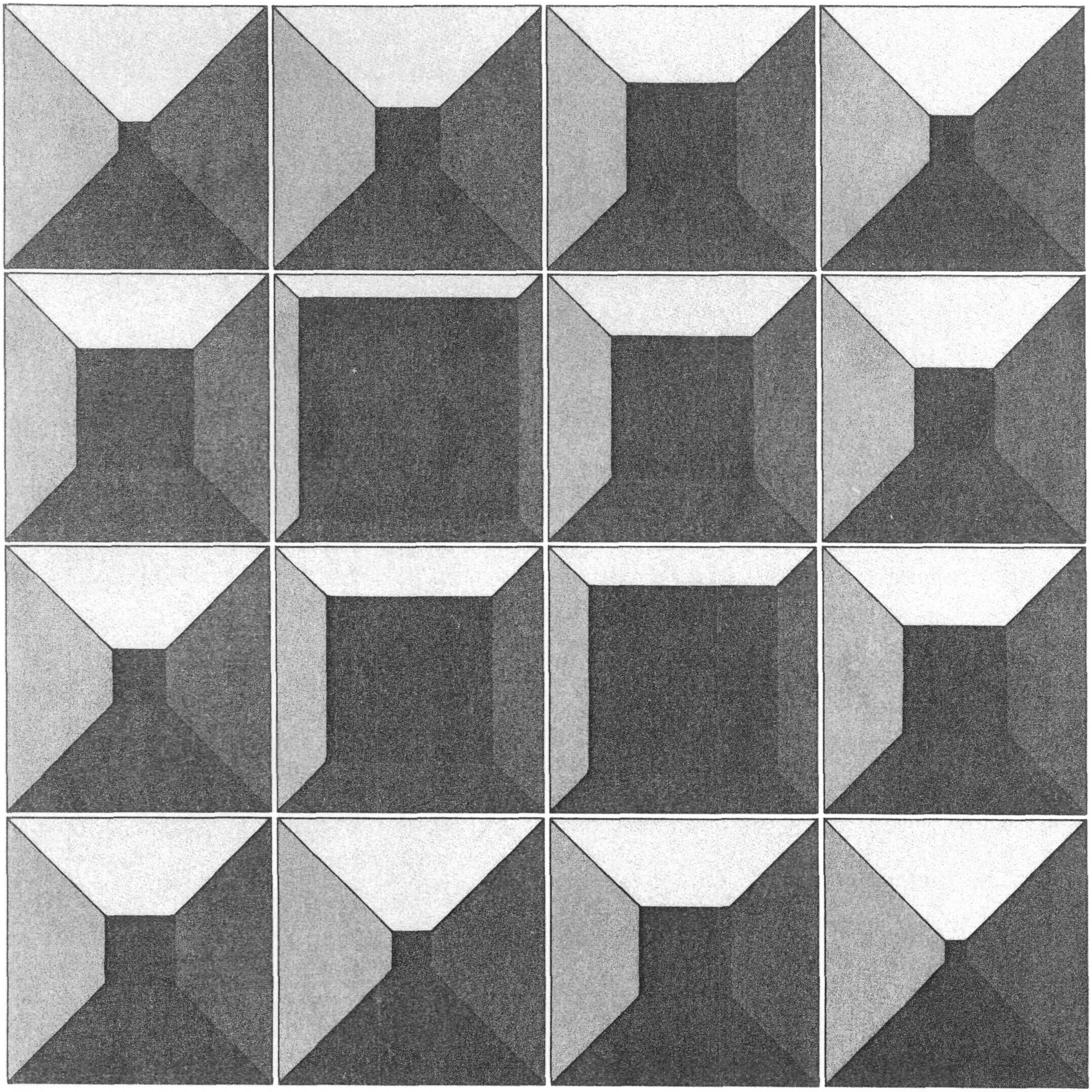
A CBO Study

August 1983

# Strategic and Critical Nonfuel Minerals: Problems and Policy Alternatives

Congress of the United States
Congressional Budget Office



# STRATEGIC AND CRITICAL NONFUEL MINERALS: PROBLEMS AND POLICY ALTERNATIVES

The Congress of the United States
Congressional Budget Office

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

## PREFACE

The United States' dependence on foreign nonfuel minerals has caused concern about U.S. vulnerability to a disruption of these imports. Many of the minerals are held in the National Defense Stockpile, but the stockpile is incomplete and new acquisitions have not been made for several years. The Congress is also considering reauthorization of the Defense Production Act. Title III of this act allows the President to undertake measures to promote domestic production of these minerals.

At the request of the Senate Committee on Commerce, Science, and Transportation, the Congressional Budget Office (CBO) has prepared this analysis of strategic and critical minerals. In keeping with CBO's mandate to provide objective analysis, the report makes no recommendations.

The paper was prepared within CBO's Natural Resources and Commerce Division, under the supervision of David L. Bodde and Everett M. Ehrlich. Robert J. Barbera, Emily Fox, and Mollie F. Quasebarth contributed to the various drafts. CBO wishes to thank Dr. Jacob Kaplan and Dr. Leonard Fischman for their assistance and guidance in the preparation of this report. Dr. Charles W. Berry of the Colorado School of Mines, Dr. John Morgan of the Bureau of Mines, and Dr. John J. Schanz, Jr., of the Congressional Research Service, all provided valuable services, although they are in no way responsible for the final contents. Patricia H. Johnston edited the manuscript. Kath Quattrone and Mary Pat Gaffney typed the early drafts and Deborah Dove prepared the report for publication.

Alice M. Rivlin
Director

August 1983

## CONTENTS


| | | Page |
|---|---|---|
| PREFACE | . . . . . . . . . . . . . . . . . . . . . . . . . | iii |
| SUMMARY | . . . . . . . . . . . . . . . . . . . . . . . . . | ix |
| CHAPTER I. | INTRODUCTION . . . . . . . . . . . . . . . . . . | 1 |
| | The Nature of The Problem: Dependence Vs. Vulnerability . . . . . . . . . . . . . . . . . . . | 2 |
| | Plan of This Paper . . . . . . . . . . . . . . . . | 3 |
| CHAPTER II. | BACKGROUND. . . . . . . . . . . . . . . . . . . | 5 |
| | U.S. Imports of Metals and Minerals . . . . . . . . | 5 |
| | The National Defense Stockpile . . . . . . . . . . . | 7 |
| CHAPTER III. | ANALYSIS OF SELECTED STRATEGIC MATERIALS | 17 |
| | Chromium . . . . . . . . . . . . . . . . . . . . . | 18 |
| | Cobalt. . . . . . . . . . . . . . . . . . . . . . . | 23 |
| | Manganese . . . . . . . . . . . . . . . . . . . . . | 29 |
| | Platinum-Group Metals . . . . . . . . . . . . . . | 34 |
| CHAPTER IV. | ANALYSIS OF SELECTED BULK MINERALS . . . . | 41 |
| | Aluminum . . . . . . . . . . . . . . . . . . . . . | 41 |
| | Copper . . . . . . . . . . . . . . . . . . . . . . | 47 |
| | Lead . . . . . . . . . . . . . . . . . . . . . . . | 52 |
| | Zinc. . . . . . . . . . . . . . . . . . . . . . . . | 57 |
| CHAPTER V. | POLICY OPTIONS . . . . . . . . . . . . . . . . . | 63 |
| | Stockpiles . . . . . . . . . . . . . . . . . . . . . | 64 |
| | Subsidization of Domestic Production . . . . . . . | 69 |
| | Other Options . . . . . . . . . . . . . . . . . . . | 72 |

## TABLES


| | | Page |
|---|---|---|
| TABLE 1. | U.S. NET IMPORT RELIANCE FOR STRATEGIC AND CRITICAL NONFUEL MINERALS, 1979 TO 1981 . . . | 6 |
| TABLE 2. | SELECTED STRATEGIC STOCKPILE GOALS, NET U.S. IMPORTS, AND CANADIAN-MEXICAN SHARE OF U.S. IMPORTS. . . . . . . . . . . . . . . . . | 12 |
| TABLE 3. | SOURCES OF U.S. CHROMIUM IMPORTS FOR 1981. . | 20 |
| TABLE 4. | SOURCES OF U.S. COBALT IMPORTS FOR 1981 . . . | 25 |
| TABLE 5. | SOURCES OF U.S. MANGANESE IMPORTS FOR 1981 . | 31 |
| TABLE 6. | SOURCES OF U.S. PLATINOID IMPORTS FOR 1981 . . | 36 |
| TABLE 7. | SOURCES OF U.S. BAUXITE AND ALUMINA IMPORTS FOR 1981. . . . . . . . . . . . . . . . . | 45 |
| TABLE 8. | SOURCES OF U.S. COPPER IMPORTS FOR 1981 . . . | 50 |
| TABLE 9. | SOURCES OF U.S. LEAD IMPORTS FOR 1981 . . . . | 55 |
| TABLE 10. | SOURCES OF U.S. ZINC IMPORTS FOR 1981. . . . . | 60 |


## APPENDIX TABLE


| | | |
|---|---|---|
| TABLE A-1. | STATUS OF THE NATIONAL DEFENSE STOCKPILE FOR STRATEGIC MINERALS. . . . . . . . . . . . | 81 |

## SUMMARY


The United States is a net importer of 64 "strategic and critical" minerals and metals. 1/ Varying levels of reserves are held in the National Defense Stockpile, the cornerstone of U.S. minerals policy.

U.S. import dependence is almost total for minerals such as chromium, cobalt, manganese, bauxite, and the platinum-group metals. Moreover, U.S. dependence on imported minerals is increasing, partly because of increased consumption and partly because of the declining competitiveness of U.S. mineral resources in international markets. Apart from iron and steel, the United States ran a $2 billion deficit in minerals trade in 1982. The 1970s witnessed two oil price shocks resulting from actions by the OPEC cartel and the interruption of Zairian cobalt production caused by political insurrection. These events focused attention on U.S. dependence on foreign minerals as a significant policy problem.

Dependence on foreign minerals creates risks for the U.S. economy and for national preparedness in the event of war. It raises concerns that the flow of minerals may be interrupted or that foreign mineral producers may form an OPEC-type organization to raise prices. But, while there are risks inherent in U.S. dependence on imported minerals, there are significant benefits as well. Many of these minerals are not found in the United States or could be produced here only at costs far above existing market prices. Prohibiting or limiting exports, or otherwise raising prices to levels at which U.S. production could be sustained, would severely penalize industries using the minerals--among them the automotive, steel, aircraft, and machine tool industries. Moreover, the properties of many of these minerals enhance technological advances, as in microelectronics and fiber optics.

Thus, any strategy to improve national policy for strategic and critical minerals must balance the benefits realized by their importation against the risks posed. In addition, policymakers must consider the need for these minerals in planning for defense contingencies. Thus, policymakers should


---

1. Strategic and critical materials are defined as those that are needed to supply the military, industrial, and civilian needs of the United States during a national defense emergency and whose supplies are dependent on imports. Strategic and Critical Materials Stockpiling Revision Act of 1979 (Public Law 96-41).



23-960 O - 83 - 2 : QL 3

focus on U.S. vulnerability to the risks of importing minerals rather than on simple dependence. This analysis examines U.S. vulnerability to supply disruptions of eight major minerals: aluminum, chromium, cobalt, copper, lead, manganese, platinum (and the other "platinum-group" metals), and zinc. These minerals were selected to illustrate the range of problems and circumstances surrounding minerals policy.

## DETERMINANTS OF MINERALS VULNERABILITY

The dangers posed by mineral import dependence are either that their supply will be interrupted or that a mineral monopoly or cartel will manipulate prices and supplies to its advantage and at great cost to the U.S. economy. The probability of the occurrence of either event varies by mineral. The cost of such an interruption or price spike also varies by mineral, depending on its uses and the possibility of employing substitutes or conservation techniques. The risks posed by any imported mineral involve, therefore, both supply and demand factors. The supply factors include:

- The potential for a price-setting monopoly in the production or refining of the metal;
- The possibility for interruptions in the supply of the metal because of political instability or logistical difficulty;
- The potential for obtaining alternative supplies during any supply disruption; and
- The availability of stocks (such as the platinum found in jewelry or the lead in automobile batteries) that could be recycled in an emergency.

The demand factors consider how serious a disruption would be to the economy and include:

- How critical the uses of the mineral are and in which economic sectors these uses are concentrated; and
- The potential for substitutes in those uses.

The eight minerals analyzed in this report vary widely across these characteristics. Over half of the U.S. imports of chromium and platinum-group metals and about one-third of manganese come from South Africa. Although South Africa is a reliable trading partner and seems an unlikely organizer of a producers' cartel or embargo, the potential for political instability in that nation creates the risk of a possible interruption of these metals' supplies. Cobalt raises similar concerns because of its origins in Zaire, where one major supply disruption has already occurred.

The risk posed by potential import disruptions of these four minerals is augmented by the importance of and lack of substitutes for many of their uses. For example, chromium and cobalt are essential to the production of jet engines, in which they impart strength and heat-resistance. On the other hand, both chromium and cobalt are used in a variety of applications which cannot be considered entirely strategic and for which substitutions are possible. For example, chromium is needed to produce stainless steel, but much civilian stainless steel production could be deferred in time of emergency. Cobalt's uses in magnets and paints could also be deferred or substituted for. In addition, because of these more common uses, significant amounts of cobalt and chromium can be recovered from scrap or, in the case of chromium, from recycling existing stocks of stainless steel.

Manganese is necessary in the production of all types of steel to reduce sulfur content. Because of its cheapness, there has been little effort to develop substitutes, as has occurred for chromium and cobalt. In the event of a disruption of manganese production, a variety of alternative supply sources might become available, however.

The platinum-group metals--platinum, palladium, rhodium, ruthenium, osmium, and iridium--have a variety of important applications, including the use of platinum in catalytic converters in automobile pollution-control devices. But the existence of a large stock of converters allows for significant recycling of platinum in the event of a crisis. These metals are also important in electronic applications, such as high-voltage relays. For both platinum and manganese, the capacity of refining furnaces is as important a security issue as is the availability of ore supplies.

The so-called "bulk" minerals--aluminum, copper, lead, and zinc--are widely used throughout the economy. They have more substitutes and are produced in more diverse and secure nations than the four minerals just discussed. In the cases of lead, zinc, and copper, significant U.S. resources exist, and would probably enter or reenter production if world supplies were disrupted. Moreover, these metals, together with steel, compete with other minerals in a wide variety of uses in construction, electronics, packaging, and machinery. None of them appears to pose a major vulnerability risk.

## POLICY OPTIONS

The United States has a considerable range of policy options to reduce its dependence on nonfuel imported minerals and limit the impact of any shortages that might result from such dependence. This paper examines the following policy options:

- o Increase the National Defense Stockpile;
- o Build economic stockpiles;
- o Subsidize domestic production;
- o Diversify sources of supply;
- o Encourage exploration and production on public lands;
- o Intensify metals and materials research and development; and
- o Utilize foreign policy initiatives.

In the short term, the most important options are stockpiling and domestic production. Other options are directed at long-term U.S. minerals security.

## Stockpile Options

Stockpiles are named for their purposes: defense stockpiles are intended for use during a military emergency, while economic stockpiles are buffer stocks intended to smooth out transient supply disruptions (as might the Strategic Petroleum Reserve). Current minerals policy consists of a National Defense Stockpile to support military and essential civilian needs in time of war or other national emergency. It is not an economic stockpile designed to bridge markets during localized interruptions of mineral flows.

The National Defense Stockpile. About $11 billion would be needed in new appropriations to meet all of the goals set by the Federal Emergency Management Agency (FEMA) for the defense stockpile. This figure includes purchases of copper, nickel, zinc, and lead worth $3.2 billion--metals that pose a minimal vulnerability risk, given the existence of domestic reserves and nearby supplies. Moreover, the $11 billion figure is based on FEMA's estimates of the mineral demands associated with a three-year mobilization effort. If this goal was reduced to the one-year goal set by President Nixon in 1973, the sale of excess inventories of some metals could be sufficient to finance fulfilling the goals for the others. In addition, this figure is based on current market prices. It is likely to increase, along with metals prices, as the recovery progresses. One way to reduce future procurement costs would be to emphasize purchases of minerals produced in South Africa and Zaire--such as chromium, platinum, manganese, and cobalt--where the risks of disruption appear to be the greatest.

Economic Stockpiles. The National Commission on Supplies and Shortages, established by President Ford, endorsed the creation of an economic stockpile in its 1976 report. Such a stockpile would be used to supplement mineral supplies when they were disrupted for political or logistical reasons. Several other industrial nations have economic stockpiles, including Sweden, Switzerland, and Japan. This type of stockpile could be created by government purchases or by tax or credit incentives to induce private users to increase their inventories. Specifically, defense contractors could be encouraged to hold larger inventories. The advantages of private stockpiling are that private companies could tailor their inventories more appropriately to evolving requirements and would rotate them to ensure freshness. The disadvantages include the federal government's dependence on private actors for reliable information and control of inventories, and the ensuing potential for abuse.

Alternatively, the National Defense Stockpile could be used as an economic as well as defense stockpile. The defense stockpile is designed to provide the material needed for a conventional military buildup, with stockpile goals set under the assumption that all foreign mineral supplies would be cut off for three years. This stockpile, of course, would be useless in a nuclear war, and a conventional war of that duration and scope (involving a three-year cessation of all foreign trade) appears highly unlikely. The Congress might wish to consider allowing use of the defense stockpile during localized disruptions of individual minerals, just as the Strategic Petroleum Reserve was established to bridge oil import disruptions. It could build an economic stockpile by assigning priority to purchases of those minerals in greatest jeopardy, particularly those imported from southern and central Africa. These changes in stockpiling policy would require new legislation.

## Subsidizing Domestic Production

Title III of the Defense Production Act of 1950 authorizes the President to guarantee loans and take other measures designed to expand production of strategic minerals in the interest of the national defense. During the Korean War, this authority resulted in sizable increases in domestic production of aluminum, copper, tungsten, and other metals. But this production was achieved at a significant cost--by 1959, subsidized production acquired by the government at a cost of $1.4 billion was worth only $0.8 billion at market prices.

The disadvantage of this option is its potential cost. In the case of cobalt, for example, a previous Congressional Budget Office report suggested that the subsidy required to induce domestic cobalt production was conceivably larger than the market price itself. 2/ This disadvantage is minimized, however, when domestic reserves are only marginally inferior to competitive foreign ones. This is generally truer for the "bulk" minerals--such as copper, lead, and zinc--for which U.S. vulnerability is low. While assisting domestic mineral production would provide some relief to a depressed industry and its affected communities, the added costs of producing minerals from domestic resources would be imposed on other sectors of the economy.

## Other Options

Other options available to the Congress could be employed to ease the nation's long-term vulnerability to minerals disruption.

Diversification. Diversifying sources of supply offers both U.S. metal-using industries and the economy as a whole greater assurance that damage from supply contingencies could be contained. Diversification would provide alternative supplies during a disruption and lower the probability of a successful cartel manipulating minerals markets. U.S. policy has traditionally encouraged U.S. investment in resource industries of developing nations, but such policy does not discriminate in favor of investments that represent true diversifications. A policy of supply diversification could be pursued either through U.S. bilateral aid or through multilateral lending facilities, such as the World Bank.

Access to Public Lands. About one-third of U.S. land area is public lands, and half of this amount is closed to minerals exploration and development. Providing access to these lands is controversial, given the inherent conflict between development and aesthetic preservation. A survey (perhaps done by the U.S. Geological Survey) of public lands resources could minimize the conflict between wilderness preservation and minerals development by better defining the mineral wealth of public lands. 3/

Research and Development. Research and development (R&D) in the area of minerals exploration, production, and materials application can and

---

2. Congressional Budget Office, Cobalt: Policy Options for a Strategic Mineral (September 1982).

3. The details of such a survey can be found in Assessing the Mineral Potential of the Public Lands, Congressional Research Service Report Number 82-XXX 5(May 1983).

has limited U.S. vulnerability to shortages of imported minerals. The substitution of ceramic magnets for cobalt ones and the development of new replacements for metals (such as graphite) are examples of these innovations. Federal research funds for materials, however, are dominated by fuels and renewable resources. The Administration's proposed increase in research and development funding for fiscal year 1984 might reverse this trend. If not, the Congress might wish to consider legislation to promote R&D for minerals and metallurgical science.

Foreign Policy Initiatives. The international character of mineral flows makes mineral vulnerability a foreign policy issue. Expanding and diversifying minerals supplies might be best accomplished within the context of the international development agencies, but such a program would require U.S. leadership.

A separate foreign policy issue concerns the stability of major minerals producers, particularly South Africa. South Africa has been a reliable supplier of minerals, but its long-term stability is clouded by the issue of its racial policies. A successor regime could tamper with the stability of minerals supplies if it came to power on unfriendly terms with the United States and other Western nations. The impetus to do so, however, would be tempered by its need for foreign exchange.

In general, a review of foreign policy focused on the sources of U.S. concern about the stability of mineral supplies, could suggest diplomatic efforts that would stabilize and diversify mineral imports without significant budgetary costs. New policy initiatives could be implemented through trade agreements or other steps to assure the security of minerals supplies.

## CHAPTER I. INTRODUCTION

The United States uses a fourth or more of most of the world's nonfuel minerals. Although it produces domestically a much larger proportion of its requirements than any other industrialized country, except the Soviet Union, it is nonetheless a major importer of raw and processed minerals. 1/ Apart from iron and steel, the United States ran a $2 billion deficit in minerals trade in 1982.

The term "dependence" is often used to describe the problem posed by such imports. The perception of dependence arose from the experience of two World Wars and the Korean War, during which production of essential equipment for military and civilian purposes was threatened by shortages of imported raw materials. Because of their importance in times of national emergency, these minerals came to be viewed as "strategic and critical." The most recent definition of strategic and critical materials appears in the Strategic and Critical Materials Stock Piling Revision Act of 1979 (Public Law 96-41), as follows:

> The term "strategic and critical materials" means materials that (a) would be needed to supply the military, industrial, and essential civilian needs of the United States during a national emergency, and (b) are not found or produced in the United States in sufficient quantities to meet such need.
>
> The term "national emergency" means a general declaration of emergency with respect to the national defense made by the President or by the Congress.

Concerns about the national security implications of dependence on imported minerals supplies were heightened by the oil shocks of the 1970s, occasioned by the embargo by Arab producing countries and the Iranian Revolution, with their attendant rapid increases in oil prices. Expropriations of producing properties, political instability in producing countries (as affected Zaire's cobalt supplies in 1978), and proposals to tie mineral prices

---

1. It is also noteworthy that the United States is an important exporter of about 20 minerals and metals--for example, molybdenum, magnesium, rare earth metals, boron, bromine, helium, scrap steel, and phosphate rock, as well as metallurgical coal.



23-960 O - 83 - 3 : QL 3

to industrial prices (as a part of a "New International Economic Order") reenforced fears about the reliability of Third World sources of mineral supplies.

Over the past decade, a variety of economic concerns has been added to national security considerations in assessing U.S. dependence on foreign minerals. The adequacy of new investment in developing additional mines and processing capacity has been questioned. The prospect of cartels has stirred further fears. The growth of state trading in minerals and Third World hostility to the traditional multinational mining companies has combined with the ostensible success of OPEC to suggest that governments in other developing countries might organize cartels and multiply the prices of their mineral exports. Although such attempts have had little success to date, an extended period of rapid economic growth and increased demand throughout the industrialized world could tax minerals production capacity and raise prices significantly, even in the absence of cartel actions.

## THE NATURE OF THE PROBLEM: DEPENDENCE VS. VULNERABILITY

A more precise statement of the minerals supply problem would focus not on dependence but on U.S. vulnerability to a curtailment of expected supplies of minerals from foreign sources. While dependence can be defined as the percentage of U.S. consumption provided by foreign suppliers, vulnerability involves a variety of factors, including the degree of monopoly in mineral supply, the availability of recyclable stocks, the criticality of the mineral's uses, and the availability of alternatives or conservation opportunities. The circumstances that could result in a curtailment or cessation of shipments to the United States and their likelihood must also be assessed to determine vulnerability.

While risks are certainly inherent in using imported minerals to satisfy domestic needs, the benefits of doing so are also undeniable. For a number of minerals--such as chromium, columbium, or mica--U.S. supplies are either so small as to make extraction costs prohibitive or so limited that they were exhausted long ago. The United States produces another group of minerals in quantities sufficient only to meet a small fraction of U.S. demand. For both of these groups, prohibiting imports to alleviate vulnerability would impose very high costs on U.S. industry. In order to replace imported minerals, it would be necessary to undertake one or more costly alternatives: exploit uneconomical deposits within the country, resort to less satisfactory substitutes, or launch an expensive research and development effort to develop adequate substitutes.

Another group of materials is imported in raw or processed form because they can be obtained from foreign sources at somewhat lower cost than from domestic sources. Such lower costs may be important in maintaining the competitiveness of U.S. production of the goods or equipment in which the imported metals are contained. For example, domestically produced copper could be substituted for aluminum in many uses, but only at higher cost. Similarly, production of domestic iron ore could be increased to replace imports, but the added expense would further disadvantage U.S. steel production, which is already hard pressed by foreign competition.

Thus, relying on imported supplies of materials poses both costs and benefits. The costs of such reliance consist of risks that shortages may occur as a result of military, political, or economic contingencies, or natural disasters in the country of origin. The benefits consist of lower costs for defense and industrial production, which, in turn, lower costs to U.S. consumers and make U.S. products more competitive in domestic and foreign markets. These costs and benefits can be analyzed and their magnitudes weighed. Policies to ameliorate the problems arising from dependence on foreign minerals suppliers must balance these costs and benefits.

## PLAN OF THIS PAPER

This paper analyzes the vulnerability risks posed by eight major strategic minerals. Chapter II presents an overview of minerals vulnerability and the development of the National Defense Stockpile. Chapter III examines the vulnerability issue in greater detail for four strategic minerals--chromium, cobalt, manganese and the platinoid group of metals--that would be essential in a national emergency, especially for defense production. In Chapter IV, similar assessments are made for four "bulk" minerals (that is, those with important and widespread uses in the U.S. economy)--copper, lead, zinc, and aluminum. Except for aluminum, the United States has substantial reserves of these minerals. Chapter V discusses policy options to enhance minerals security.

## CHAPTER II. BACKGROUND

This chapter presents an overview of U.S. dependence on foreign minerals and the nature of U.S. vulnerability to interruptions in their supply. It then discusses the evolution and the role of the National Defense Stockpile.

### U.S. IMPORTS OF METALS AND MINERALS

The Bureau of Mines of the U.S. Department of the Interior evaluates annually U.S. import reliance for 85 metals and minerals. The United States is a net exporter of 19 and imports are not recorded for two more. For 12 materials, data are withheld to maintain the confidentiality of the records of the limited number of producers or users. For seven others, the available data are not sufficient to calculate net import reliance. The Bureau then provides net import data for the remaining 45 materials. For both the 12 "withheld" and seven "not available" groups, however, there is evidence that the United States imports a significant proportion of its needs.

Thus, there are 64 minerals and metals for which the United States is a net importer. The United States has no current strategic stockpile goals for 35 of the items on this list, however. 1/ Among these are gold, silver, gem stones, and a number of building materials or agricultural products for which domestic production could be expanded at relatively low additional cost or which are largely imported from Canada (such as, potash and peat). Most of the rest have important uses but adequate alternatives can be substituted; such substitutes are either produced domestically or appear elsewhere in the stockpile goals.

The United States is, therefore, consistently a net importer of 29 strategic and critical minerals that are included in the National Defense Stockpile. 2/ Table 1 lists these minerals, together with percentages

---

1. The United States does have a very small stockpile goal (28 short tons) for steatite block and lump talc. It is a net exporter of talc, though dependent on foreign sources for the special form mandated by the Federal Emergency Management Agency for stockpiling.

2. The National Defense Stockpile includes 93 commodities that incorporate 34 different minerals. However, five of these minerals are not net imports, have a zero stockpile target, or are a synthetic product assembled in the United States from imported substances.

TABLE 1. U.S. NET IMPORT RELIANCE FOR STRATEGIC AND CRITICAL NONFUEL MINERALS, 1979 TO 1981 (In percents) a/

| Mineral | 1979 | 1980 | 1981 |
|---|---|---|---|
| Antimony | 53 | 48 | 51 |
| Asbestos | 83 | 78 | 80 |
| Bauxite and Alumina | 93 | 94 | 94 |
| Beryllium | -- b/ | -- b/ | -- b/ |
| Bismuth | -- b/ | -- b/ | -- b/ |
| Cadmium | 64 | 55 | 63 |
| Chromium | 90 | 91 | 90 |
| Cobalt | 94 | 93 | 91 |
| Columbium | 100 | 100 | 100 |
| Copper | 12 | 14 | 5 |
| Diamonds--Industrial | 100 | 100 | 100 |
| Fluorspar | 86 | 87 | 85 |
| Graphite | -- b/ | 100 | 100 |
| Iodine | -- b/ | -- b/ | -- b/ |
| Lead | 4 | -- c/ | 10 |
| Manganese | 98 | 98 | 98 |
| Mercury | 59 | 26 | 39 |
| Micasheet | 100 | 100 | 100 |
| Nickel | 69 | 73 | 72 |
| Platinum-Group | 89 | 88 | 85 |
| Quartz Crystals | -- d/ | -- d/ | -- d/ |
| Rutile (Titanium) | -- b/ | -- b/ | -- b/ |
| Silicon | 13 | 8 | 20 |
| Tantalum | 96 | 90 | 91 |
| Thorium | -- d/ | -- d/ | -- d/ |
| Tin | 80 | 79 | 80 |
| Tungsten | 58 | 53 | 52 |
| Vanadium | 28 | 17 | 42 |
| Zinc | 63 | 60 | 67 |

SOURCE: U.S. Interior Department, Bureau of Mines, Mineral Commodity Summaries, 1982, for 23 minerals and CBO rough estimates derived from the Bureau of Mines partial data for six.

a. Net import reliance is defined as net imports adjusted for changes in inventories as a percent of apparent consumption.

b. Data withheld to maintain confidentiality of limited producers or users.

c. Net export.

d. Not available.

showing the proportion of apparent U.S. consumption that was met by net imports in 1979, 1980, and 1981. The three years illustrate various levels of economic activity. On the whole, 1979 was a year of relatively high economic activity, while 1980 was a poor year for the U.S. economy, and 1981 was a year of global recession.

Of the 29 strategic and critical minerals, U.S. dependence on imports exceeds 90 percent for ten and is between 50 and 90 percent for 13. 3/ The six for which U.S. import reliance is less than 50 percent are beryllium, copper, lead, mercury, silicon, and vanadium. The data in Table 1 do not include the metal contained in U.S. foreign trade in finished products. Were it possible to calculate the metal content in these products, measured import reliance might be higher. Moreover, U.S. reliance on imported supplies of some minerals has grown over the past two decades as richer U.S. deposits have been depleted, environmental restrictions have been implemented, and industrial output has increased to meet growing demand. Most of the increase in reliance occurred in the 1960s; the percentages have not changed much since 1970. While the United States was a net exporter of copper, iron and steel, and vanadium in 1960, it is now a net importer. Dependence on imported bauxite and alumina increased from 74 percent in 1960 to 94 percent in 1981 and on imported cobalt from 66 percent to 91 percent, respectively. Dependence has also increased for zinc, cadmium, tungsten, and titanium. For most other minerals, the percentages have remained essentially stable over the two decades.

Obviously the U.S. economy, including defense and other industrial production, would be severely crippled if all imports of all these materials were cut off. But not only has such a contingency never occurred (even in wartime) but the probability of such an event in the future is extremely low. Minerals supplies would be only one of a host of problems faced by the United States if all foreign trade were brought to a sudden halt. The more probable contingency for which U.S. minerals policy should provide is a sharp reduction, if not a complete termination, of imports of one or more of these essential minerals.

## THE NATIONAL DEFENSE STOCKPILE

The National Defense Stockpile is the cornerstone of U.S. minerals policy. It contains 93 commodities, 80 are of mineral origin and the

---

3. Based on the import reliance percentages calculated by the Bureau of Mines for 23 minerals as shown on Table 1, plus CBO rough estimates for the remaining six minerals derived from partial data reported by the Bureau of Mines.

remainder are agricultural products, such as quinine and opium. Stockpile goals have been set for 64 of the 80 mineral commodities. These 64 commodities represent 34 different minerals, most of which are divided into different grades and stages of processing for which separate stockpile goals are established. One mineral may be stockpiled in the form of ore, processed metal, an alloy with other metals, or some combination of these. For example, both chromite ore and several grades of ferrochrome (chromium alloy) are stockpiled.

Of the 34 minerals included in the National Defense Stockpile, five--talc, silver, sapphire and ruby, molybdenum, and jewel bearings--are excluded from the import dependent listing in Table 1 for various reasons. For three of the mineral groups--silver, sapphire and ruby, and molybdenum--the stockpile goals have been reduced to zero. 4/ Of the remaining 31 minerals with goals above zero, the United States is a net importer of 30; it is a net exporter of talc. The fifth item excluded from the Table 1 listing--jewel bearings--is a synthetic product assembled in the United States from imported substances. The list of 31 stockpiled minerals is presented in the Appendix. For 14 out of the 31 minerals, strategic stockpile inventories at the end of the first quarter of 1982 were in excess of the established goals, although in several cases inventories were below goals for particular subcategories of the mineral.

## Evolution of the Stockpile

While the authority for the National Defense Stockpile is now found in the Strategic and Critical Materials Stockpiling Revision Act of 1979, its origins go back to before World War II. In 1939, the Strategic Materials Act authorized the government to determine the quality and quantities of strategic and critical materials that should be stockpiled. In 1946, the Strategic and Critical Materials Stockpiling Act confirmed the Congress' commitment to assured adequate supplies of materials in the event of a military emergency. The act was motivated, however, as much by concern for the drop in mineral prices that would occur if materials stocks held at the conclusion of the war were sold.

The Korean War led to another period of materials shortages and again focused attention on minerals vulnerability. The Defense Production Act of 1950 allowed the government to subsidize production of a number of minerals, such as cobalt. The materials stockpile was also augmented under the

4. Significant publicly owned inventories exist for silver and sapphire and ruby, despite the zero goal. No inventory exists for molybdenum.

act. In 1951, the President's Materials Policy Commission (known as the Paley Commission) endorsed a policy of supplying the economy with minerals bought "at the least cost possible for equivalent values," thus rejecting a policy of minerals self-sufficiency. While the commission recommended that a stockpile be maintained for strategic minerals to meet U.S. requirements during a military emergency, it sanctioned reliance on lower-cost foreign sources for economic purposes. Ever since, this principle has been the basis of U.S. minerals policy.

In 1979, the Congress passed the Strategic and Critical Materials Stockpiling Revisions Act. The major purpose of the legislation was to update and revise the defense stockpile program, particularly setting a three-year military contingency as the criterion for establishing stockpile goals. (Over the previous two decades, stockpile requirements had been successively reduced by the Executive Branch from five to three to one year's demand associated with a military contingency.) In addition, the act specified that the stockpile was to be managed for defense purposes and not to control or influence commodity prices. It also consolidated inventories collected under all previous legislation into one National Defense Stockpile. 5/

The National Materials and Minerals Policy, Research, and Development Act of 1980 mandated the development of a national minerals policy, and was largely concerned with improving materials information and analysis and policy coordination within the Executive Branch. Pursuant to this act, President Reagan sent the Congress his National Materials and Minerals Program Plan in April 1982. Apart from providing increased availability of public lands for research and development and placing greater emphasis on both government and private research and development, it contained no new policy directions.

## Current Stockpile Status

The value of materials now held in the defense stockpile is estimated at $11 billion at current market prices. Of this total, however, $4 billion represents the value of minerals held in excess of official stockpile goals. The value of the stockpile would be about $18 billion if all stockpile goals

---

5. Inventories had been built under the previous Strategic Materials Acts, the Commodity Credit Corporation Charter Act of 1949, and the Trade Development Assistance Act of 1954. This last act authorized either bartering of agricultural products for minerals or the use of revenues from surplus food sales for minerals purchases.

were met. Thus, if materials in excess of stockpile targets were sold at current market values, completing the stockpile would require $7 billion in new appropriations.

Recent Budgetary Treatment. The Congress authorizes both purchases for and sales from the stockpile, and appropriates funds for purchases as well. The General Services Administration, which conducts stockpile transactions on behalf of the Federal Emergency Management Agency (FEMA), is directed to carry out these transactions with minimal effect on minerals markets. Thus, purchases do not necessarily occur in the year their funds are appropriated, and revenues are often carried over. For example, the Congress appropriated $57.6 million in fiscal year 1982 for purchases, $120 million in fiscal year 1983, and $120 million has been requested for fiscal year 1984. Actual purchases of $44 million occurred in fiscal year 1982 and an estimated $156.2 million will occur in fiscal year 1983. 6/ Recent purchases have included cobalt, metallurgical bauxite, and small quantities of refractory bauxite and tantalum, among other materials.

Sales from the stockpile--predominantly of surplus tin, industrial diamonds, and tungsten--totaled $178 million in fiscal year 1982 and $197 million in fiscal year 1983. Requested fiscal year 1984 sales are estimated at $314 million, including the sale of $100 million worth of surplus silver. The sale of surplus silver had been planned earlier, but was suspended in the Department of Defense Appropriation Act of 1982 pending further study.

## Relation to a National Defense Emergency

The defense stockpile is intended by law to assure the availability of minerals needed for the national defense. Its stated purpose is to meet the military, industrial, and essential civilian needs of the United States during a national emergency. A national emergency is defined as mobilization for the national defense and use of the stockpile is now expressly forbidden for economic or budgetary purposes. Thus, the stockpile is designed to operate primarily during a period of international hostilities. The law further provides that the quantities in the stockpile should be sufficient for a period of not less than three years of mobilization needs.

---

6. Appropriated funds are placed in a special Stockpile Transaction Fund used to finance minerals purchases. Receipts from minerals sales are also placed in this fund, but must be reappropriated for new acquisitions.

The stockpile goals are established by the Federal Emergency Management Agency through an elaborate interagency process that involves simulation of wartime minerals requirements as well as domestic primary and secondary production under conditions of national mobilization. Emergency scenarios are postulated, but their character is obviously sensitive for both national security and foreign policy reasons and they are not publicly available. Nevertheless, the published strategic stockpile goals shed some light on the kinds of contingencies that must have been assumed.

A strategic stockpile of minerals and metals could hardly be relevant to a nuclear war involving an attack on the United States. A global conventional war must be postulated, during which the enemy would be capable of interdicting all foreign mineral supplies. Such interdiction could be the result of enemy occupation of the mineral producing areas, or an enemy alliance with the governments of those areas, or the capture of sea lanes to the United States.

Under these circumstances, U.S. vulnerability to the loss of Canadian and Mexican supplies would presumably rank rather low. Dependence on Canada and Mexico for selected minerals is shown in Table 2. While future governments of these countries might conceivably wish to distance themselves from a particular global conflict in which the United States was involved, neither could risk U.S. retaliation for wartime embargoes they might impose on exports of strategic and critical materials to the United States. Large stockpile goals have been established for copper and lead, though the United States is a net importer of less than 15 percent of its consumption of these basic metals and obtains a fourth to a third of its gross imports of copper and over two-thirds of its imports of lead from Canada and Mexico. The goals for tungsten, cadmium, fluorspar, nickel, and zinc also appear to be high relative to recent U.S. net imports and the high degree of reliance on Canadian and Mexican supplies. A modest stockpile goal has been set for asbestos, though Canada supplies virtually all of U.S. imports. Both Canada and Mexico have sufficient resources to increase production of the materials listed in Table 2 to meet U.S. needs during an emergency.

The stockpile goals for bauxite are equal to about three years of imports from Jamaica and Surinam, currently the source of half of U.S. bauxite imports. Storage problems deter the establishment of a goal for alumina, of which three-fourths of U.S. imports are derived from Australia and virtually all the rest from Jamaica and Surinam. Canada supplies three-fifths of U.S. gross imports of aluminum metal, using Caribbean bauxite as its raw material. The stockpile goal for aluminium metal is nearly equal to average annual gross imports, although the United States has been a net exporter of this metal over the past three years.

TABLE 2. SELECTED STRATEGIC STOCKPILE GOALS, NET U.S. IMPORTS, AND CANADIAN-MEXICAN SHARE OF U.S. IMPORTS (In short tons)

| Mineral | Stockpile Goals a/ | U.S. Net Imports, 1979-81 Average | Canadian-Mexican Share of U.S. Imports, 1981 (In percents) |
|---|---|---|---|
| Asbestos | 20,000 | 389,000 | 97 |
| Cadmium | 11,700,000 | 2,824 | 49 |
| Copper | 1,000,000 | 229,000 | 31 |
| Fluorspar | 3,100,010 | 1,122,000 | 62 |
| Graphite | 29,000 | 57,000 | 61 |
| Lead | 1,100,000 | -- b/ | 69 |
| Nickel | 200,000 | 161,987 | 56 c/ |
| Silicon | 29,000 | 81,000 | 28 |
| Tungsten | 50,666,000 | 5,094 | 30 |
| Zinc | 1,425,000 | 678,700 | 61 |

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1981.

a. Stockpile goals as of March 31, 1982.

b. Net exports.

c. Includes 10 percent of U. S. imports that comes from Norway, which manufactures nickel from matte imported from Canada.

Other stockpile goals concern a variety of minerals whose military and economic importance is substantial, but which are imported in relatively small tonnage from a variety of sources in Latin America and Asia. Except for tin and rutile (titanium), net imports in each case are less than 20 thousand tons a year from all sources, though the gross tonnage of imported ore may be larger in some cases. A 20-thousand-ton shipment would be half or less the capacity of a single bulk freighter, assuming that secure shipping was available. If the sources of supply were not under enemy control, U.S. needs under conditions of emergency might well be met by air transport.

The rest of the stockpile goals consist of metals of African origin--chromium, industrial diamonds, platinum-group metals, and manganese--imported primarily from the Union of South Africa, Zimbabwe, Zaire, and Gabon. Cobalt is imported from Zaire and Zambia. These sources pose greater vulnerability risks.

The strategic stockpile goals thus appear to provide generous insurance against national defense contingencies (such as a three-year cessation of minerals trade) whose probability of occurrence is low. On the other hand, a loss of supplies of these minerals under some circumstances would be extremely damaging. But many of these circumstances would not involve a defense emergency. Rather, they would reflect political or logistical conditions, such as those already experienced in oil and cobalt.

## Relation to Political and Economic Events

An interruption or curtailment of U.S. supplies of one or more critical materials arising from political or economic events is far more likely than a national defense emergency. The 1973 and 1979 oil shocks, the ongoing Iraq-Iran War, and the interruption of Zaire's cobalt supplies in 1978, all suggest that some interruption of mineral supplies may occur again. While such disruptions are unlikely to affect U.S. national security or economic well-being to the same extent as those arising out of a national defense emergency, they may be more likely and could cause significant economic damage for a limited period of time. For such contingencies, the U.S. government does very little to provide insurance. The defense stockpile is not intended for such emergencies, nor does the government make any other provisions.

The causes of such disruptions could be actions by foreign governments intended to disrupt U.S. supplies for political purposes or to raise prices, localized political or military actions that incidentally disrupt supplies, or abrupt demand surges in excess of existing worldwide production capacity. But users of imported materials generally regard such events as normal business risks, much as they would strikes or natural disasters affecting their domestic sources of supply. They try to keep well-informed about the likelihood of such events affecting a major foreign supplier. Many have sophisticated contingency plans for a supply interruption and most maintain inventories at a level intended to provide time to arrange for alternative supplies or substitute materials. In the case of cobalt, such private inventories proved quite adequate in 1978 when the importer (who had a near monopoly of U.S. supplies of the primary metal) put his customers on a 70 percent allocation. Free market prices rose, but only limited supplies were purchased at the higher prices. Thanks to private inventories, no production line dependent on cobalt was shut down, nor was production of military or industrial equipment incorporating cobalt curtailed.

Despite this salutary experience, a policy that depends on the private sector to provide for possible acts by foreign governments or political groups that could threaten U.S. industrial production and employment may be questioned. When interest rates are high, company profits are poor, and raw material prices are stable or declining, private companies are under considerable internal pressure to reduce inventories and accept greater risks of supply interruptions. Private company acceptance of greater risks under such circumstances may be less acceptable in terms of the national economic interest.

The minerals of concern to the U.S. economy are essentially the same as those for which strategic stockpile targets have been established. The peacetime problem is mitigated considerably by the possibility of turning to alternative sources of supply in the event of a political, economic, or military contingency affecting one supplier. The single exception would be formation of a cartel in which most of the major suppliers participated.

Persistent attempts to establish such cartels over the past decade have not been successful, however. Such a cartel would have both to control a large proportion of world production and to forgo the benefits accruing to noncartel suppliers who could expand their production and sales under cover of the cartel's restrictive umbrella. The cartel members would also have to accept the further invasion of their markets by new producers, recyclers, and producers of substitute materials. Still, two-thirds of every mineral (except tantalum) for which strategic stockpile goals have been established originate in only three or four foreign countries. Indeed, it is the absence of diversified sources of supply that is at the root of U.S. vulnerability to minerals supply shortages that could arise from political, economic, or localized military events.

The Committee on Natural Resources of the International Economic Policy Association is composed of representatives of major companies that are important users of imported minerals. It recently identified only nine nonfuel minerals as warranting major concern: chromium, cobalt, columbium, fluorspar, manganese, the platinum group, tantalum, titanium, and tungsten. 7/

As a part of a Nonfuel Minerals Policy Review ordered by the President in late 1977, Resources for the Future was commissioned to study seven of the major minerals identified as potential problems in the course of

---

7. T.W. Stanley, A National Risk Management Approach to American Raw Materials Vulnerabilities (Washington, D.C.: International Economic Policy Association, 1982).

the preliminary work of the cabinet-level committee charged with the review. The study foresaw long-term supply problems only for aluminum and lead, largely because of cutbacks in plans to expand capacity for bauxite, alumina, aluminum, and lead refining. 8/ As for short-term contingencies, it judged the probability of shortages up to 20 percent of usual consumption to be moderate to high for cobalt, chromite, ferrochromium, ferromanganese, alumina, aluminum, copper, and lead. The study reported that it was unlikely that either zinc or manganese ore would be in short supply for more than a few months because of any imaginable short-term contingency. Cobalt, chromium, and ferromanganese gave concern because of potential disruptions in southern Africa; aluminum because of possible disruption in Guinea and the Caribbean; and copper and lead because of possible surges in demand in the event of a simultaneous economic boom in the industrialized world.

U.S. vulnerability is, in one sense, greater in the case of political or economic contingencies than in the event of a global war. Peacetime disagreements with various mineral producer governments over political or economic interests could conceivably lead to a reduction in their shipments of raw materials to the United States. In wartime, however, the threat of vigorous U.S. retaliation would be much more credible, and damaging behavior on the part of foreign suppliers much less probable.

Reliance on southern African supplies remains a significant, if not primary, concern. The stability of the government of Zaire has been a continuing problem. Its copper-cobalt producing province has been subject to two invasions in recent years that met considerable local support. The ability of the South African government to maintain peaceful domestic conditions is questionable, and the antagonism of its neighbors to its apartheid policy has strengthened with the passage of time. The U.S. government may one day be compelled, for political reasons, to participate in an embargo on all imports from South Africa. Thus, a stockpile might eventually be useful as a buffer against an interruption of southern African supplies, but never be needed for use during a military mobilization in the United States. Unless the Congress were to pass new legislation, however, the current stockpile would be unavailable to ameliorate the loss of minerals supplies from the first type of disruption.

---

8. Resources for the Future, Major Mineral Supply Problems (Washington, D.C.: National Technical Information Service, 1979).

## CHAPTER III. ANALYSIS OF SELECTED STRATEGIC MATERIALS

A mineral is strategic and critical if it is both imported and essential to industrial production--especially defense production. But, high import dependence does not necessarily mean high risk; risk is a function of the relative stability of sources, the political orientation of these sources, and the nature of alternative sources that could be used during a supply disruption. Risk also depends on the criticality of the mineral's applications.

This chapter examines four strategic minerals that are most frequently listed as problem "minerals" from the foregoing perspectives. The four minerals chosen for review are cobalt, chromium, manganese, and the platinum group. Cobalt is not only an important ingredient of the "superalloys" necessary for jet engines, but is also essential for the manufacture of high-speed machine tool bits and permanent magnets used in precision electronics. Chromium is necessary for the manufacture of stainless steel. Manganese is essential in steelmaking. Platinum has important applications in the manufacture of automobile pollution-control devices and of electrical and electronic goods, as well as in petroleum refining and in petrochemicals.

Another characteristic that all four of these minerals share is that the bulk of their supply comes from sub-Saharan Africa. The United States produces few or no supplies. The principal African sources--Zaire and South Africa--are vulnerable at least to terrorism and at worst to takeover by unfriendly forces. Zaire's Shaba province, where most of the cobalt is mined, has been attacked twice in the past decade by rebels based in neighboring Angola--once with some interruption of the cobalt supply--and further incursions are threatened. The Transvaal district of South Africa, where most of the chromium, platinum, and manganese originates, is within striking range by African National Congress rebels operating out of Zimbabwe and other neighboring countries and enclaves, besides being subject to domestic racial strife. The principal alternative sources of chromium are Zimbabwe, whose reliability is far from assured, and the Soviet Union. The Soviet Union is the major alternative source for platinum. For manganese, the most important alternative U.S. supplier is Gabon.

All four minerals also share in the phenomenon that U.S. vulnerability is substantially mitigated by the availability of both supply and consumption alternatives. Both the nature of the risk and the character of the alternatives differ considerably in their details from commodity to commodity, however. Accordingly, individual consideration is essential.

## CHROMIUM

The United States used 504,000 tons of chromium in 1981. Around 90 percent of this consumption was met by imports, at a cost of $264 million. Chromium arrives in the United States in two important forms: as ore (chromite) and as processed (refined) ferroalloy (mostly ferrochromium). Imports have shifted to the latter form, as South African and Zimbabwean processing plants have progressively taken markets away from U.S. ferroalloy makers. For example, while in 1970 nearly 95 percent arrived as ore, in 1981 imports were equally divided between ore and ferroalloy.

Chromite is mined in three principal varieties. The first, with high aluminum content, is useful for making refractories (exceptionally heat-resistant furnaces). A second has high chromium content and is used to make low-carbon ferrochromium. The third has a relatively higher iron content and is useful both for chemical applications (including liquors for chromium plating) and to produce high-carbon ferrochromium. A decade ago this third variety was considered "low grade" and hardly qualified as metallurgical ore, but it is now the predominant--and cheapest--one used for ferrochromium manufacture. South Africa's growing predominance as both a chromite and a ferrochromium supplier is due primarily to concentrated reserves of this cheaper type of ore, along with transportation, energy, and labor economies.

Supplementary U.S. tariff protection had been in force since 1978 on low-cost, high-carbon ferrochromium, but was allowed to expire in November 1982, whereupon its price immediately fell, though not to pretariff levels. In permitting the expiration, the Administration rejected a petition of the Ferroalloy Producers Association for continued protection.

### Uses

About 45 percent of the chromium consumed in the United States is used to make stainless steel, typically from ferrochromium. Roughly another 15 percent goes into other alloy steels. Chromium enhances resistance to corrosion and oxidization, especially at high temperatures, and may also be used to increase hardness (important in some military applications, such as high-speed engines). Chromium's use in nonferrous alloys is only about 2 or 3 percent of total consumption, but it is critical since such alloys are mainly used to meet exacting requirements for jet engines and other high-temperature applications. Generally, the more critical the chromium application, the higher the total value of the final product and the lower the sensitivity of chromium demand to price, since chromium is only a small part of overall cost.

Chemical uses of chromium, which rely on direct utilization of chemical-grade ore, account for about 20 percent of total consumption. This classification includes one method to produce pure chromium metal, chromium plate, and chemicals for leather tanning, pigments, and many other uses. The balance of chromium demand results from the refractory use of chromite, which requires an ore that comes mostly from the Philippines rather than South Africa. This is a stagnant, if not diminishing, application since a large part is used in open-hearth steelmaking--an obsolescent method in a declining U.S. industry.

## Sources of Supply

Except for a small quantity of ore mined and exported in 1976, there has been no domestic mining of chromite since 1961, when the last Defense Production Act contract was phased out. About 10 percent of U.S. chromium supply is provided by recycling (essentially of chromium contained in stainless steel); the remaining 90 percent is obtained from imports. Imports increasingly are in the form of ferrochromium; this form now constitutes 40 to 50 percent of the overall import total and more than half of total chromium use in metallurgy.

Table 3 summarizes the sources of U.S. chromium supply in 1981. At present, all chromite is imported. The small amount of refractory-grade chromite not supplied by the Philippines originates in South Africa. South Africa supplies the major part of metallurgical-use chromite, but substantial quantities are also imported from the USSR, Finland, Madagascar, and Turkey. Zimbabwe (formerly Rhodesia) used to be an important ore supplier--surreptitiously, during the days of the UN trade embargo against Rhodesia. It has apparently ceased shipping ores directly, and now processes them into ferrochromium.

Between 1978 and 1981, South Africa was the source of about 70 percent of U.S. imports of ferrochromium. Zimbabwe and Brazil are growing in relative importance as suppliers, eclipsing formerly second-place Yugoslavia. Turkey is also a contributor, along with a new and possibly growing entrant, the People's Republic of China.

TABLE 3. SOURCES OF U.S. CHROMIUM IMPORTS FOR 1981 a/

| Country | Percent of Chromite Imports | Percent of Ferrochromium Imports |
|---|---|---|
| South Africa | 57.3 | 56.4 |
| Zimbabwe | -- | 16.7 |
| Philippines | 14.1 | 0.6 |
| Yugoslavia | -- | 12.4 |
| Brazil | -- | 4.5 |
| USSR | 13.0 | -- |
| Finland | 6.5 | -- |
| Turkey | 5.4 | 2.1 |
| Other | 3.7 | 7.3 |

SOURCE: U. S. Bureau of Mines, Minerals Yearbook, 1981.

a. Percents based on chromium content.

Nature of the Risks

While there is a wide spectrum of opinion regarding the risk of instability in South Africa because of its racial policies, the consensus seems to be that it is growing. As a consequence, isolated acts of violence and sabotage could interfere for limited periods with some of the export flow of both chromite and ferrochrome. At some later date, a protracted struggle could throttle more of the flow for longer periods. Under almost any plausible outcome, however, full flow of both ferroalloy and ore could be expected to resume once the conflict was settled. A United Nations-adopted embargo against South Africa is also possible, but at the moment it seems unlikely that the United States would cooperate in such an action.

In peacetime, a reasonable summary of the South African supply risk for the next decade includes an outside chance that nearly all of it could be interrupted for as much as a year or more. A more likely scenario is short-term interruption--a matter of months--of a minor portion of the supply as a result of strikes or sabotage against producing facilities, power supplies, or rail export connections. Another risk is the possible deliberate interruption by South Africa of the outward rail movement of Zimbabwean ferrochrome, which is now shipped either through South African or a Mozambican rail line whose interdiction could be engineered by South Africa. Within the present political context, however, an extended concurrent interruption of both the South African and the Zimbabwean chromium supplies seems remote.

The relatively minor flow of chromium from the Soviet Union is subject to obvious risk even short of a national emergency. Commercial rather than political reasons appear to explain fluctuations in U.S. imports from that source over the past two decades, however. The supply of Brazilian chromium could be preempted in the future by the needs of that country's own industry, but that eventuality would develop gradually. Finally, the potential for instability in the Philippines suggests a degree of insecurity about the U.S. supply of refractory grade chromite. This kind of chromite is becoming progressively less critical, however.

A major East-West conflict would entail the additional risks of military occupation of Southern Africa, political alienation of the United States from black African producers, or interruption of sea traffic. For the most part, the sea lanes in question would merit priority military protection for reasons going well beyond the need for chromium. The United States would also have more important reasons than chromium supply protection to resist any attempt at territorial takeover.

Apart from the risks of physical interruption, the very large share of ferrochromium supplied by South Africa to the free world suggests the future possibility of oligopolistic pricing actions. Only a strong and prolonged worldwide economic recovery, however, would make such price manipulation feasible.

## Supply Alternatives

A number of available supply alternatives could be called upon to counter almost any chromium supply contingency. It might not take much more than a year to replace all of the South African supply, if an interruption from that source were perceived to be long lasting.

The most immediate crunch would occur in the supply of ferrochromium. Existing inventories, both those in private hands and those in the national stockpile, contain much more chromite than ferrochromium. Private stocks of chromite have been running at eight to nine months of consumption. Ferrochromium stocks in the hands of both producers and consumers have been closer to three months of consumption. The real bottleneck, therefore, would be furnace capacity to convert ore into ferrochromium. Not only is there little available alternative U.S. furnace capacity suitable for rapid conversion to ferrochrome production, but the United States also lacks the capacity to manufacture new furnaces. These are imported from European sources. Once the rather substantial slack in existing Japanese and European capacity is taken up, Brazil would probably be the next most important alternative for ferrochrome furnace capacity.

Wartime vulnerability would be reduced through a program recently announced by the General Services Administration to upgrade part of the national strategic stock of chromite into ferrochromium. That program is also intended to replace the expired tariff protection by providing business for the U.S. ferrochromium industry.

A continuing major contingency in southern Africa could result in a shortage of chromite itself. To replace this shortfall, the flow of chromite from Brazil, Turkey, Finland, Madagascar, and a dozen other places could be expanded. Depending upon the circumstances and the price, additional supplies might also be forthcoming from the Soviet Union. The Philippines could be called upon for metallurgical as well as refractory ore.

At higher prices or with some subsidy, the Stillwater complex in Montana could be activated fairly quickly to produce domestic chromite, as could beach sand mining in Oregon. Research by the Bureau of Mines suggests, however, that the required break-even price for these operations is higher than probable market prices, even under circumstances of severe chromite shortfall. 1/

## Consumption Alternatives

Considerable scope exists for chromium conservation and substitution. Much of the demand for stainless steel can be satisfied with less chromium content. Equivalent anticorrosion qualities can be attained--though at higher cost--by increasing the content of nickel. Equivalent or near-equivalent heat-resistance qualities can be achieved--again usually at higher cost--by the use of such alternative alloying elements as nickel, cobalt, columbium, or molybdenum. Aluminum, copper, glass, titanium, and plastics can substitute for stainless steel in many applications. Finally, the total supply of chromium available for stainless steel production can be increased by more intensive recycling.

## Conclusions

The risks of a shortfall in chromium supply are significant. The most critical--though certainly not the most probable--would involve a denial of

---

1. U.S. Bureau of Mines, unpublished paper (November 1981).

southern African supplies during a major military conflict. If the current national stockpile were completely upgraded into ferrochromium, it would be equal to four to five years of normal peacetime consumption. This would seem more than ample to meet all critical needs. It would certainly be ample if its mandated stockpile goal was filled (again substituting ferrochromium for most of the ore).

Cost is a major drawback to upgrading. Fulfilling the chromite goal would only cost an additional $700,000 to $900,000. Upgrading just the present chemical and metallurgical chromite inventory, including below specification material, to ferrochromium would cost around $500 million.

Either in wartime or in a major peacetime contingency--especially one occuring during a time of general economic recovery--an interruption in chromium supply could simply result in substantial price rises. Price increases would probably accompany any other problems that might arise. The many opportunities for chromium conservation, substitution of alternative materials, and alternative chromite production would serve to place a ceiling on upward price pressures, however. Moreover, chromium prices per se would not contribute significantly to general price inflation. Expenditures on chromium account for only a small portion of the final cost of most metallurgical end products. For example, a recent study for the Bureau of Mines estimates that doubling the price of domestic ferrochrome would raise the price of stainless steel by only 6 percent. 2/

## COBALT 3/

The United States used some 13 million pounds of cobalt in 1981, of which 92 percent was imported, at a cost of $261 million. Of the four strategic metals examined in this chapter, cobalt is the only one within recent history to have been subjected to a significant supply disruption. After the second of two invasions of Zaire's Shaba (Katanga) province by Katangan dissidents operating out of Angola, the official (producer) price of cobalt rose from about $7 per pound in May 1978 to $25 per pound by February 1979. Spot prices went as high as $50. The price rise was exacerbated by an already tight market. In April 1978 (prior to the invasion) the Zairian distributor in the United States announced that it would limit its

---

2. F.E. Katak, T.B. King and J.P. Clark, "Domestic Production of Stainless Steel Mill Products: Cost and Supply Analysis," Materials and Society, vol. vi:2 (1982).

3. For additional information, see Congressional Budget Office, Cobalt: Policy Options for a Strategic Mineral (September 1982).

customers to only 70 percent of their preceding year's supplies. Retrospectively, it was learned that very little hiatus occurred in actual Zairian output. Though the rail link through Angola to the sea was effectively cut off, it was perfectly feasible to ship cobalt by air. By the end of 1981, the official price of cobalt had sunk back to $17, and by early 1982 to $12.50. On the spot market, the metal was selling at $4 per pound before the end of 1982.

Such price gyrations are a consequence of the high degree of concentration of the Western world's cobalt supply in Shaba province. Lack of confidence in the stability of the Zairian government is widespread and its ability to cope with revolutionary challenges is suspect. Foreign forces were called upon to help quell the May 1978 invasion. Price volatility was also a consequence of a worldwide economic boom in 1977-1978 and a subsequent recession.

## Uses

Significant changes took place in cobalt consumption as the result of the 1978-1979 price runup. Examples include substitution of ceramics and organic composites for cobalt as well as the use of cobalt-free alloys, even in such critical applications as engine blades and vanes. Use of cobalt for permanent magnets--such as those used in radios--has declined from about a third of total U.S. consumption to about one-sixth. The reasons are twofold. First, the source of U.S. electronics supplies has shifted substantially from the United States to Japan. Second, when cobalt prices zoomed, the electronics industry realized that consumer electronic goods could be adequately served by ceramic magnets.

Cobalt consumption has declined in a variety of uses. The use of cobalt in chemical form, as a drier and pigment in paints, is price sensitive. Most of the decline in this use occurred prior to the mid-1970s with the decreased use of oil-based paints. Technological change has been the principal factor behind declining cobalt use in glass and ceramics. In general, the nonmetallic (chemical-compound) uses of cobalt have dropped from about 30 percent of total consumption prior to the mid-1970s to about 20 percent in more recent years. This change has taken place despite a growing use of cobalt compounds as catalysts, especially in petroleum refining and petrochemical manufacture.

An important use of cobalt--as the "cement" in cemented carbide cutting tools--has declined quite abruptly in the last few years, from more than 15 percent to less than 10 percent of the total. The reason is essentially the economic recession and lower oil prices, with their effects on the machine-tool and mining and drilling industries. The 1978-1979 cobalt price rises also had lasting effects on cobalt conservation in such applications, as well as increasing routine recycling, although cutting tools still require some cobalt content.

Conservation has been least employed in the metal's use in high-temperature alloys, mostly for gas turbine engines, especially in jet airplanes. In 1982, this use accounted for some 37 percent of total consumption--well beyond both the proportion and the absolute amounts of the mid-1970s. Cobalt is important in imparting high-temperature strength and its cost is very low relative to the total cost of an engine.

## Sources of Supply

Sources of cobalt imports for 1981 are summarized in Table 4. It should be noted that Norway, Japan, and Belgium are exporters of refined metals rather than ore. Zaire's Shaba province supplies about 60 percent of the free world's cobalt, where it is produced as a by-product of copper mining and processing. Neighboring Zambia, whose cobalt capacity is increasing, is the next largest world supplier. Thus, two-thirds of the Western supply originates in central Africa. With or without the excuse of domestic instability, Zaire is in a position to lead or abet an upward price spiral whenever the industrial world is at a high level of economic activity. When world industrial activity is weak, cobalt supplies typically decline,

TABLE 4. SOURCES OF U.S. COBALT IMPORTS FOR 1981

| Country | Percent of Imports a/ |
|---|---|
| Zaire | 26.8 |
| Canada | 11.8 |
| Norway | 10.5 |
| Japan | 10.4 |
| Zambia | 9.7 |
| Finland | 7.7 |
| Belgium-Luxembourg | 6.0 |
| Other | 17.0 |

SOURCE: U. S. Bureau of Mines, Minerals Yearbook, 1981.

a. Percents based on cobalt content.



23-960 O - 83 - 6 : QL 3

since nearly all cobalt output is a by-product of copper or nickel, whose demands are procyclical. Demand for cobalt usually declines as well. But even during recessions, Zaire and Zambia may maintain high levels of copper and cobalt output in order to avoid increasing domestic unemployment and to maintain the flow of foreign exchange. Under these conditions, continued high production would depress prices for both minerals.

Most of the supply of cobalt follows a roundabout route from mines to industrial consumers. Historically, most of the refining or re-refining of Zaire's cobalt took place in Belgium. Only since 1975 have any U.S. facilities existed for refining primary cobalt. Plants for recovery of the nearly 10 percent of cobalt supply that comes from recycled scrap have been in existence longer. Traditionally, Zairian cobalt was marketed either through Belgian channels or with Belgian advice and assistance (Union Miniere or its affiliates). Increasingly, however, the Zairian government is taking marketing into its own hands.

Given the lack of U.S. refining facilities, the great bulk of U.S. imports of cobalt arrives already in metallic form (including scrap). The sole domestic primary refinery operates on nickel-cobalt or copper-cobalt matte--obtained from Botswana, South Africa, New Caledonia, and Australia. A recently established U.S. re-refiner imports metallic (cathode) cobalt from Zaire and processes it into extra-fine powder. It is owned by the Belgian Company Union Miniere affiliate and will replace Belgian production. In addition, plans have been announced for construction of a U.S. plant for recycling the now significant amount of cobalt used as catalysts in petroleum processing.

## Nature of the Risks

The high proportion of U.S. cobalt supply that comes directly or indirectly from a small area in central Africa suggests high vulnerability to supply disruption. The peacetime risk can easily be overestimated, however. One source of reassurance is the decline in the Zairian share of the U.S. market and the continuing growth of the Zambian portion. Peacetime contingencies that might concurrently interrupt production in both countries appear to be improbable, since sources of political tension are very different in each of these countries. Also, it is hard to conceive of a regime in either country that could long afford to forego copper exports to the West and with them the cobalt produced as a by-product. If land transportation facilities were shut down, cobalt metal could be shifted by air at a supportable cost. A more stringent contingency would involve interruption of power supplies to cobalt refineries in these countries.

A more realistic peacetime risk is rapid price escalation. Producers other than Zaire have been quite willing to go along with its price leadership when supplies are tight. In fact, other countries may have initiated some of the past increases. In the event of another artificial price boost, however, cobalt users might be less prone to make matters worse by rushing to expand stocks. While U.S. consumer stocks of cobalt are now quite low (about a month's normal consumption), dealer stocks in the United States bring the total up to about eight months.

## Supply Alternatives

In the event of a supply interruption, the most important immediate insurance would consist of stocks in the United States and Belgium, and at cobalt processing facilities in Finland, Norway, Canada, and Japan. Some contingencies might leave large stocks of the metal in Zaire itself.

Secondary fallbacks would be increased concentrate or matte production in Zambia (which already has plans for further expansion), Canada, Finland, Australia, the Philippines, and other sources. Zairian copper output would be interrupted by the same contingency that affected cobalt. Further, a cobalt contingency would increase the demand for nickel, since the latter is in some measure a substitute. This would lead to greater nickel production, in which cobalt is a frequent by-product.

Ore in the Blackbird mine in Idaho contains both cobalt and copper. It has already been partially developed and could be quickly brought into full production if cobalt prices rose above $25 per pound. Consideration has also been given to reopening the Madison mine in Missouri, where cobalt can be produced in conjunction with copper, nickel, and lead, as well as to a new mine in California (Gasquet Mountain), where the cobalt is associated with nickel and chromium. The Blackbird mine alone could reduce U.S. import dependence by some 10 or 15 percent. At the current price of $5 per pound the required subsidy would be on the order of $20 per pound, or some $30 million per year for the 1.5 million pounds of potential cobalt production. Potential output of cobalt at each of the other two mines is also in the 1.5 to 2.0 million pound range.

Existing processing capacity in the United States would be insufficient to handle the additional ore. On the other hand, excess processing capacity does exist in a number of other countries, including Canada. The current worldwide excess capacity is probably enough to make up for the loss of Zairian processing. Should a supply contingency occur during a period of international economic boom, however, the availability of processing facilities would be a problem, especially if the boom were strong enough to absorb surplus stocks. Barring adequate warning, shortages could last for a year or more, unless they were counteracted by substantial releases from the strategic stockpile.

A deliberate attempt on Zaire's part to escalate prices could probably be successful only with cooperation from Zambia and others at a time of high economic activity. It would undoubtedly be met by expansion of cobalt production elsewhere. Boom times would in any event bring additional cobalt on the market, since the production of both nickel and copper would expand. In Canada, INCO (formerly the International Nickel Company) has already taken steps to recover more cobalt from its ore, doubling its total output. Finnish refined cobalt capacity has recently been increased by half, presumably in response to the last price escalation. Japan has considerable refining capacity, operating on cobalt concentrates from Australia.

## Consumption Alternatives

The earlier a cobalt contingency occurred, the greater the room for maneuver. The reason, paradoxically, is that the 1978-1979 price escalation set in motion forces that soon will reduce the use of cobalt to essential levels, leaving only limited room for further adjustment. Only this past year, for example, Pratt & Whitney proved out cobalt-free alloys for critical engine parts. Though there has already been some application of ceramics and composites in high-temperature applications, worldwide burgeoning of high-temperature materials research promises many new developments for the years immediately ahead. Within the coming decade, large savings could be made in cobalt consumption simply by speeding up the pace of research, testing and certification of new materials, and further adopting metalworking methods that initially produce more nearly finished shapes, with less waste and scrap. As time goes on, the use of cobalt in structural materials will be reduced to the most essential uses, thus narrowing the scope for further saving. But with less use of cobalt, the existing national defense stockpile would, of course, stretch further.

Conservation of cobalt in cutting tools has already run much of its course. There is as yet no demonstrably practical alternative to the use of cobalt in cemented carbides, though alternatives to carbide tools exist and new tool materials may be developed. Substitution in an emergency might well mean higher material costs or reduce the efficiency of machining, mining, or drilling. Cobalt consumption for permanent magnets is sufficiently price sensitive to induce some retrogression to the use of alnico (aluminum-nickel-cobalt) magnets in goods for which they are less than essential. When more exacting requirements obtain, the use of cobalt can be reduced by combining it with samarium or other rare-earth metals.

Some room for cobalt conservation and substitution exists in both ceramics and paint production, although the quantities that can be saved are relatively minor because of the declining cobalt use in these applications. In most emergencies, conservation in the use of cobalt as a catalyst would be inhibited both by the need for more chemical and petroleum products and concurrent difficulties in obtaining other catalysts. Part of the catalytic use facilitates oil desulfurization, and would be hard to forgo unless the emergency was so acute as to cause general relaxation of air pollution standards. Omission of the catalysts would make some chemical processes impracticable and greatly increase the costs of others.

### Conclusions

It could be difficult to reduce cobalt use significantly if an emergency restricted supply, especially since a number of potential substitutes might themselves be in short supply. Research and development in progress is opening up more possibilities for substitution, however. But at the same time, process readjustments stimulated by the last price escalation have decreased the margin for further rapid adjustments.

The main safeguard against sudden, short-lived contingencies is the current high level of worldwide cobalt stocks. It could take a sustained period of high international economic growth to absorb excess inventories held by producers and dealers. For sustained emergencies, there are a number of substantial alternatives to central African sources of ore, although expanded use of these sources would require the installation of additional refining facilities. For meeting either an acute or a sustained military emergency, the national stockpile provides substantial insurance, even at its current roughly 50 percent fulfillment level. If the remaining 50 percent was purchased at current spot cobalt prices, it would cost about $210 million.

## MANGANESE

The United States consumed slightly more than a million tons of manganese in 1981, 98 percent of which was imported, at a cost of $270 million dollars. Manganese is essential to almost all steelmaking, and its resource base is more evenly distributed worldwide than other metals discussed in this chapter.

### Uses

Like chromium, manganese ore comes in metallurgical, refractory, and chemical (including battery-making) grades. Also like chromium, the great bulk of metallurgical use is as ferroalloy--both ferromanganese and silicomanganese--and metallurgical supply is the principal supply concern. Unlike chromium, the chemical grades of manganese ore are the most exacting, but the quantities required are not large and suitable substitutes can be synthesized.

About 85 percent of manganese is used in the steel industry. The principal purpose of manganese in steelmaking is to remove sulfur; most of the manganese does not remain in the steel but comes out in the slag. It also serves as a deoxidizer. Some amounts are retained in or added to steel as an alloying element, imparting hardness. The major advantage of using manganese is its low cost. 3/ To date, there has been little reason to develop substitutes, although some alternative materials (such as, aluminum for deoxidation) are used in special circumstances.

## Sources of Supply

Only a few countries have significant manganese reserves, with South Africa and the USSR holding more than four-fifths of the world total. This distribution is based on an evaluation of ore that contains enough manganese to make mining economic. The U.S. Bureau of Mines defines manganese ore as having a natural content of 35 percent or more manganese. Ores ranging down to a manganese content of 25 percent may be reported by various countries as manganese ore production, with much of this lower-grade material being upgraded by processing. Based on the official definition, the United States has no manganese production, but some manganese is in fact mined domestically as a constituent of iron-bearing ores. At somewhat higher prices, it would be profitable to mine substantially more lower-grade ore around the world, including within the United States.

South Africa accounts for about three-fourths of noncommunist world reserves, but for only about a third of noncommunist mine production. Over the three-year average of 1978-1981, the largest U.S. ore supplier was Gabon, with about 32 percent of total U.S. ore imports. South Africa, on the other hand, was the single largest U.S. supplier of ferromanganese, with 42 percent of the total. Combined with its 24 percent share of shipments of ore, South Africa supplied the United States with about 35 percent of its manganese overall. By contrast, Gabon supplied overall less than 10 percent. Sources of manganese ore and alloy for 1981 are summarized in Table 5. As with chromium, the percent imported as ferromanganese is

---

3. See, for example, National Materials Advisory Board, Manganese Reserves and Resources of the World and Their Industrial Implications (1981), p. 65.

TABLE 5. SOURCES OF U.S. MANGANESE IMPORTS FOR 1981 a/

| Country | Percent of Ore Imports | Percent of Ferromanganese Supply |
|---|---|---|
| South Africa | 32.4 | 40.6 |
| Gabon | 30.2 | -- |
| France | -- | 28.4 |
| Brazil | 12.9 | 1.8 |
| Australia | 11.4 | 1.0 |
| Mexico | 8.6 | 6.9 |
| Canada | -- | 9.3 |
| Morocco | 4.5 | -- |
| Portugal | -- | 4.9 |
| Other | -- | 7.1 |

SOURCE: U. S. Bureau of Mines, Minerals Yearbook, 1981.

a. Percents based on manganese content.

increasing. Over the 1978-1981 period, more than two-thirds of all manganese reached the United States in this form; a decade earlier the proportion had been only 20 percent.

Besides South Africa and Gabon, France (for ferromanganese only), Brazil and Australia figure as principal U.S. sources. The Bureau of Mines counts overall imports as 98 to 99 percent of U.S. total supply. This calculation apparently contains the small amounts produced by domestic mining, but ignores the important contribution made by slag recycling. Also, it attributes to imports the considerable releases in recent years of manganese ore from the strategic stockpile. The latter factor is now somewhat academic, however, since stockpile releases have been discontinued. Stockpile holdings of ore are currently under goal, principally because the goal has been quadrupled since 1975, although a limited amount of below-specification material remains to be disposed of.

## Nature of the Risks

The risks for U.S. manganese supply are somewhat similar to those for chromite, but far less critical. Sources of ore supplies (direct and indirect) are far less concentrated, and the Soviet Union is not currently among the suppliers. Sources have varied considerably over the years. For example, in the 1950s India was the principal source of ore and the world's leading exporter. In the 1960s Brazil and Gabon became increasingly important suppliers as India diverted exports to its domestic steel industry.

As with chromium, the principal risk of manganese supply disruptions lies in the heavy and increasing U.S. reliance on a single source--South Africa--for ferroalloy. Given the greater number of alternative Western suppliers, however, with access either to domestic ore or to sources outside South Africa, the price-escalation risk is far lower. Although the same risks of instability in South Africa apply for manganese supplies as for chromium, they would not affect as great a proportion of the supply.

More flexibility exists in the types of furnaces that can be converted to produce ferromanganese than ferrochrome, thus making alternative ore sources more usable. Active blast furnaces have already been changed from the production of pig iron to ferromanganese when additional supplies of the latter were needed. Even retired blast furnaces could be used for this purpose. There are two limitations on this flexibility, however. One is the likelihood that a South African contingency would jointly affect ferrochrome and ferromanganese, thus tying up some of the alternative furnaces. The other limitation would occur if a contingency coincided with a worldwide economic boom. Then available blast furnace capacity might be entirely occupied with producing pig iron, thus eliminating the alternative of furnace conversion.

Manganese supply risks in a military conflict are similarly somewhat less than those for chromium, despite the fact that the great bulk of U.S. manganese supply comes directly or indirectly from politically vulnerable areas in sub-Saharan Africa. France, the principal ferromanganese supplier after South Africa, also depends on Gabon for ore. The risk is diminished by the relatively growing role of Brazil as an ore producer, and its increasing capacity to convert that ore into ferroalloy. Although much of this increasing output is normally used in Brazil's own steel production, it remains a relatively accessible source in an emergency.

## Supply Alternatives

It would be relatively easy to increase the flow of manganese ore quickly. Deposits are widespread, and most of them can be easily mined using large-scale, open-pit methods. The United States itself has a large quantity of marginally subeconomic deposits, and there are similar additional deposits in Canada and Mexico. The U.S. processing industry tends to maintain ore stocks equivalent to about a year's consumption. The national stockpile contains two and one-half to three times the industry level, the exact multiple depending on whether below-grade material is counted.

In contrast, industry stocks of ferromanganese tend to run at only three to four months of normal consumption, and the stockpile level (and goal) is only moderately greater. Under present economic conditions, a large amount of excess blast furnace capacity exists, which could be used to produce ferromanganese from ore supplies. Excess capacity on a smaller scale may persist even into a period of economic boom, because the declining U.S. steel industry uses less of its furnace capacity. Depending on the timing of a supply contingency, this margin, plus old blast furnaces and stocks of ferroalloy, might serve to provide adequate supplies until additional furnaces could be installed. If not, the United States would have to call upon Brazil and probably India to bridge the gap. During an economic boom or military emergency, it is unlikely that Europe would have surplus ferromanganese and it, in any case, relies heavily on African sources for ore. Japanese production, while relying more importantly on Australian and Indian ores, would also tend to be fully committed under such economic or military conditions.

The huge amounts of manganese contained in old slag piles would, for all practical purposes, be unavailable as an emergency ferroalloy supplement. To the limited extent that the material could be used, it would have to be recirculated through ironmaking blast furnaces. Additional amounts of manganese could be recovered by recycling old steel scrap. This source also tends to be scarce during economic booms, however, and available amounts are constrained by the current use of scrap by the U.S. steel industry.

## Consumption Alternatives

The principal consumption alternative for manganese is conservation. Because manganese is cheap, it tends to be used profligately. In large measure, the amount of manganese used in steelmaking depends on the mix of various types of furnaces. In particular, electric furnace technology requires relatively less manganese per ton of steel, and the proportion of electric-furnace steel in the United States is increasing. Another route to manganese conservation, followed by Japan, is the greater use of silicomanganese in place of ferromanganese. This practice reduces the amount of manganese lost to slag, as does electric steelmaking. The National Materials Advisory Board has estimated that unit use of manganese in steelmaking might be reduced by as much as 20 to 30 percent, 4/ but conversion to this practice would take an extensive period of readjustment.

4. Ibid., p. 68.



23-960 O - 83 - 7 : QL 3

The prospects for reducing manganese consumption quickly are more limited.

## Conclusions

Potential risks of disruption in U.S. manganese supply are less critical than those for either cobalt or chromite. No monopoly exists, and alternative sources of supply are more numerous. As in the case of chromium, however, a potential bottleneck could arise in the supply of the ferroalloy, because of the substantial switch from domestic to foreign production. So long as the economy is slack, large furnace capacity is available to resume ferromagnese production. Moreover, more flexibility exists than in the case of chromium to shift capacity from other uses to such production. If a contingency should occur during boom times, however, industrial and government stocks might not be large enough to cope fully with demand, pending new furnace installations.

More of the national stockpile could be held as ferroalloy than is now done. Converting all of the metallurgical ore currently on hand to ferromanganese, including nonspecification material, would probably cost about $500 million. As with chromium, the President has ordered some upgrading of the stockpiled ore to increase mobilization readiness and to provide some relief to the domestic manganese refining industry.

## PLATINUM-GROUP METALS

Manganese and chromium are bought and sold by the ton. Cobalt, consumed in much smaller quantities, is bought and sold by the pound. The platinum-group (platinoid) metals, consumed in still smaller quantities, are measured by the troy ounce. In fact, their prices are high enough to qualify them as "precious" metals. Platinum itself is widely used in jewelry and is subject to speculative trading and hoarding, as an alternative to gold. As a group, the platinoid metals slightly outrank cobalt in total annual cost to the U.S. economy. Industrial use of these metals was approximately 1.9 million ounces in 1981, although total consumption (including stock-building) was about 0.5 million ounces greater. About 83 percent of these supplies were imported at a cost of $800 million.

## Uses

The platinum group consists of six metals, which are the most corrosion-resistant known. Use of platinum itself is some 1 million ounces per year, only slightly higher than palladium, but more than twice as high in cost. Rhodium and ruthenium rank far behind, at less than 100,000 ounces per year. Iridium has the next smallest usage, principally in electrical applications. For example, it is used jointly with platinum in high-voltage relays. Rhodium and iridium tend to be the most expensive of the six. Osmium is the rarest and is consumed only in small quantities, mostly as an alloy of the other platinoid metals to impart additional hardness.

Increasingly, the major U.S. use of platinum itself is for catalytic converters in automobile pollution-control devices. Even in 1982--a depressed year for automobile sales--close to two-thirds went into this application. A long-standing use has been in electrical and electronic goods, mostly to provide long-term reliability in electrical contacts. Another long-standing use, as a catalyst in petroleum refining and other chemical operations, appears to be in at least temporary decline, but this may be the result of increased recycling. In both automotive and industrial catalytic uses, one or more of the other platinoid metals is used in conjunction with platinum itself, for cost-savings or other reasons.

Palladium, the other major component of the group, has long been used principally for electrical goods, which now account for almost half the total. A large part provides reliable telephone relays. The use of palladium in automotive pollution-control catalysts has increased demand. Another important use has been in medicine and dentistry. Both medical/dental and electrical applications are fairly sensitive to the relative prices of platinum, palladium, and gold.

Of the lesser platinoid metals, rhodium has lately found its greatest use in catalytic converters, although it also continues to have considerable application in the chemical, electrical, and glass industries. One of its uses is in an alloy of platinum used in devices for glass extrusion, an application that may become increasingly important with increased use of optical fibers. Ruthenium finds its greatest use in the chemical and electrical industries and osmium in the chemical industry and in medicine and dentistry. Except for osmium, all the platinoids are used to some extent in jewelry.

Given a degree of interchangeability among the platinum-group metals, a continual shifting about in consumption mix occurs with changing relative prices, not only of the platinoid metals themselves, but of gold, silver, and other substitutes. Usage patterns also tend to change rapidly because of the association of these costly metals with high technology industries.

## Sources of Platinum

The platinum metals do not deteriorate. It is quite feasible to recover them for reuse unless they become a very small component of widely disseminated products, as is the case with much of the platinum used in electronic equipment. Much of this secondary recovery shows up neither in supply nor in consumption statistics. For example, more than a million ounces a year of the platinoid metals are refined in the United States on behalf of users without furnaces, especially for owners wishing to reclaim spent catalyst. If such amounts were added both to reported U.S. supply and consumption in 1982, the import reliance of the United States would be reduced from 85 percent to 60 percent.

Sources of U.S. platinum-group imports in 1981 are shown in Table 6. South Africa directly supplied the United States with about 80 percent of these imports, plus additional amounts refined in the United Kingdom. South Africa also supplied the United States with about 40 percent of its imports of palladium; the Soviet Union share used to be almost as high but lately has declined. South Africa supplied 70 to 80 percent of ruthenium imports, as well as principal shares of both iridium and rhodium, though the proportions are highly variable. Most of the osmium was refined in the United Kingdom from other countries' ores. Belgium and Luxembourg are also refiners.

A variety of other countries have figured as suppliers of refined platinum-group metals to the United States, but only a few are significant ore producers. Canada is most important among those who also mine these

TABLE 6. SOURCES OF U.S. PLATINOID IMPORTS FOR 1981

| Country | Percent of Imports a/ By Weight | By Value |
|---|---|---|
| South Africa | 56.9 | 67.4 |
| United Kingdom | 10.6 | 11.3 |
| USSR | 12.6 | 6.3 |
| Belgium-Luxembourg | 4.9 | 4.6 |
| Other | 15.0 | 10.4 |

SOURCE: U. S. Bureau of Mines, Minerals Yearbook, 1981.

a. Includes imports of refined scrap metals and semimanufactured metal.

metals (as by-products), but Colombia and Japan are also of some consequence.

## Nature of the Risks

A handful of mines and an even smaller number of refineries in a concentrated section of South Africa's Transvaal account for about 70 percent of U.S. primary platinoid supply. Much of the rest comes from the Soviet Union. Moreover, the supply of the most acceptable substitute, gold, tends to come principally from the same two countries. Thus, platinum-group metals pose a substantial supply risk.

Beyond the supply risk is the risk of deliberate price escalation. Moreover, both platinum and palladium, and to a lesser extent the other platinoid metals, are prime candidates for price runups through speculation and hoarding, and both respond to the price of gold. Add the substantial control over new supply exercised by South Africa and the Soviet Union, and the market appears to be unduly conducive to price ratchets.

The small number of mine and refinery locations in South Africa suggests an inordinate vulnerability to interdiction of supply by insurrection or sabotage. Concentration of the great bulk of production in the hands of only two companies also suggests a high vulnerability to strikes, as well as to market manipulation. The additional fact that the great bulk of South Africa's platinum is produced for its own sake and not as a by-product lessens any constraint on market manipulation. Gold, not platinum, is the principal source of South Africa's foreign exchange, and gold production adds only a minor amount of platinum coproduct.

A perceived risk from the Soviet Union is that its offerings may be subordinated to political objectives. While evidence to support such a view is scanty, the reason for supply concern is real. The Soviet Union does not always have acute foreign exchange problems, and its sales of palladium are rarely critical to its balance of trade. As a state trader, the Soviet Union can and usually does try to manage the timing and mode of its offerings to maximize long-run commercial advantage. Conceivably, greater domestic need may also contribute to a gradual decline in Soviet offerings. If this happens, the West could adapt relatively easily to such a change.

Since so much of U.S. domestic consumption is now tied to air pollution control, the central risk is that supply curtailment would entail lower air quality standards for some period of time. In addition to the use of platinum in automobile catalytic converters, the platinoids are also used as catalysts to increase refinery yields of high-octane gasoline. In an emergency, more of this could be done with lead. Another catalytic use is to remove sulfur.

In electrical and electronic applications, the platinoids have critical uses. If they were unavailable, the lifetime costs of electrical and electronic goods would increase significantly. Such uses are only a small part of total platinoid consumption, however, and they can easily be satisfied by diversion from other uses. While many applications are in military hardware and a lack of platinoid metals would be a serious impediment to defense production, the amount required is quite small. In general, the overall cost of these military and civilian devices and systems are so high that the value of any contained platinoids, even at a multiple of present prices, would be negligible.

## Supply Alternatives

The single most important supply alternative for the platinoids is the stock of metal already in use. This includes the world's stock of jewelry, much of which might become more valuable to its owners as scrap than as heirlooms or objets d'art if platinum prices were to soar. In an all-out emergency, the stock of platinum, palladium, and rhodium in the automotive fleet's catalytic converters should be included. Converters in scrapped cars have begun to accumulate, and before long will be routinely processed. Inventories of the platinoid metal held in the form of industrial catalysts are already routinely recycled. They would become an important source if, in an emergency, it were decided to forgo some of the functions they now perform.

Large inventories of palladium, in particular, are carried in the strategic stockpile (holdings are about 40 percent of goal). The amount on hand is close to a year and a half of normal consumption--a large supply for essential use. Government holdings of platinum are equal to less than a half-year of normal consumption, but known commercial stocks add another half-year. Known commercial stocks of palladium equate to about four months of normal consumption. Stocks of rhodium and ruthenium would meet normal consumption for the better part of a year. Stocks of iridium are well in excess of recent annual rates of consumption, although consumption is highly volatile. Stocks of osmium fluctuate considerably, but at recent levels exceed a year's consumption.

Finally, increased primary production is possible in a number of areas outside South Africa, and this would automatically be called forth by rising prices. Rising prices would also stimulate increased sales from the Soviet Union, unless the cause of the South African interruption were an East-West military confrontation.

The United States is one possible source of additional mine production. The Stillwater complex in Montana contains deposits of platinum and palladium, as well as of chromite. Platinoids are already recovered as a by-product of copper production elsewhere in the United States. They have been produced in the past from deposits in Alaska, and these could be reactivated. They might also be extracted from beach sands in Oregon.

Canada has platinoid metals, particularly in association with Sudbury nickel; production would be increased if nickel prices were higher. Canada also has other platinoids associated with nickel and copper production, as well as a near-economic deposit in which the platinoid metals are themselves of primary interest. Other probably expandable sources include Colombia, where platinoid metals are produced as a coproduct with gold, and the nickel mines of Australia, where the platinoid metals are produced as a by-product.

## Consumption Alternatives

The principal consumption alternative is conservation, particularly in jewelry. Jewelry probably accounts for nearly half the total use of platinum in market-economy countries worldwide, thus providing large leeway for diversion to more critical applications in a supply emergency. Alternatives for the platinoid metals are restricted because the principal substitute is gold, which would probably also be in short supply during a platinum-group contingency, given their common producers and applications. The flow of gold, however (especially from hoarded supplies), would be stimulated by the upward pressure of platinoid shortages on gold prices.

Apart from gold, silver and tungsten are substitutes for the platinoids in electrical uses. Ceramics may be substituted in dental restitutions, and plastics in this and other kinds of prothesis. Rare-earth metals, nickel, vanadium, and titanium are possible substitutes in catalytic uses. Over a long period of readjustment, engineering improvements and cleaner fuels (both, of course, at a price) could diminish the need for the platinum-group metals in automotive emission control.

## Conclusions

The extremely high concentration of platinoid supply in South Africa and the Soviet Union renders this group of metals one of the most critical of all potential mineral contingency problems, both in terms of supply interruption and deliberate price escalation. Price rises would provide much of the solution to any crisis, leading to the selling of hoarded items (especially of jewelry), large-scale diversion of platinoid consumption from less essential uses, and expansion of alternative production. Furthermore, the most essential uses tend to be those that can most readily bear heightened platinoid costs, because the platinoids are only a small part of overall costs.

Critical applications of the platinoids in ensuring lasting high performance of essential civilian and military systems require only a relatively small proportion of the total supply. A further broad area of consumption needs can be satisfied by available substitute materials, and a still broader area of consumption can be curtailed, if necessary by law.

Given such options, the stockpiled quantities of platinum, palladium, and iridium seem more than adequate to provide for necessary transitions during a military conflict, even at current small percentage-of-goal levels. Bringing the stockpile up to goal would cost more than $550 million--about $350 million for platinum, $200 million for palladium, and a small additional amount for iridium.

# CHAPTER IV. ANALYSIS OF SELECTED BULK MINERALS

The metals discussed in the preceding chapter were selected for their critical industrial and defense uses and the near total U.S. dependence on imported supply. The ones discussed in this chapter were selected because of the volume of their use in the U.S. economy and international competition for their supplies. They are the four major nonferrous metals that enter ubiquitously into the country's durable goods and structures. Recent consumption of aluminum has been at the rate of 5 to 6 million tons a year and is certain to go higher. Copper, which used to be the highest volume nonferrous metal, is now consumed at about 2 million tons a year. Lead and zinc are each in the million-ton-per-year range, about the same as manganese.

The problems posed by copper, lead, and zinc depend less on security of supply than on international competitiveness. A large number of Americans depend for their livelihoods on their mining, smelting, and refining. Among the minerals discussed in the preceding chapter, by contrast, direct employment is small and security of supply is the overriding factor.

All four of these metals are now traded on international commodity exchanges (copper, lead, and zinc for many years; aluminum only recently). Prices fluctuate widely, mostly with the state of the world industrial economy, whose condition has depressed the nonferrous metals industry for several years. In addition, the domestic smelting and refining industry has had to contend with aging plants and—especially onerous for lead and zinc—the need to comply with new pollution-control standards. Foreign competitors, to a large degree, have newer processing plants, a lesser concern with pollution, and, in the case of producers in the less developed countries (LDCs), an overriding interest in maintaining employment and the flow of foreign exchange even if it means continuing to produce at an economic loss.

## ALUMINUM

The United States consumed 5.1 million tons of aluminum in 1981. Net imports of the metal were essentially nil, but 97 percent of the necessary bauxite and alumina were imported at a cost of about $1 billion. The price of aluminum decreased gradually during the post World War II period and aluminum took over a good part of the markets formerly served by steel, copper, lumber, and zinc (galvanized iron).

The advent of OPEC changed public concerns remarkably. With an average of around eight kilowatt hours of electricity incorporated into the manufacture of every pound of primary (virgin) aluminum, rocketing fuel costs began to make a big difference in smelter competitiveness, depending upon the type and source of power supply. The other effect of OPEC was to generate a general concern about cartelization. Formation of the International Bauxite Association and the imposition by Jamaica, and then others, of heavy levies on their exports of bauxite heightened the concern. It was feared that aluminum supply and price would be at the mercy of outside suppliers, threatening the U.S. economy and possibly interrupting material supplies for the aerospace industry and other critical users. These concerns have now subsided, but not entirely died out.

## Role in the U.S. Economy

Prior to the severe drop in nearly all materials consumption in 1982, occasioned by the worldwide recession, primary aluminum was roughly a $7.5 billion industry. The recovery of secondary aluminum from scrap and the conversion of aluminum into sheets, wire, castings, and other intermediate forms more than doubles that value. 1/ In early 1981, before the recent recession, some 37,000 workers were employed in primary aluminum refining, 35,000 in aluminum rolling mills, and 53,000 in aluminum foundries. 2/ Additional numbers were engaged in the manufacture of aluminum extrusions and aluminum wire, for a total of about 147,000. 3/ This makes aluminum about one-fifth the size of the iron and steel industry and two-thirds as large as all other nonferrous metal production combined.

Little bauxite is mined in the United States. Domestic production of bauxite employed fewer than 500 workers and generated gross revenues of only about $50 million in 1977. 4/ Roughly 97 percent of the feedstock for U.S. aluminum smelters is imported, either as bauxite or as alumina.

---

1. See U.S. Department of Commerce, Bureau of Industrial Economics, U.S. Industrial Outlook, 1982, p. 165.

2. Commerce Department, Bureau of Labor Statistics, Employment and Earnings (May 1982).

3. Commerce Department, U.S. Industrial Outlook, 1982, p. 165.

4. U.S. Bureau of the Census, Census of Mineral Industries (1977).

As of the mid-1970s, the United States consumed about 3.5 tons of aluminum per million dollars of gross national product (GNP), and the ratio is still growing. 5/ In terms of weight, this was only about 3 or 4 percent of the amount of steel consumed, but in terms of volume it was around 10 percent and in terms of monetary value, about 15 percent. Moreover, steel's "intensity of use," (the amount of steel needed to make a given amount of real output) has been declining, while that of aluminum has been increasing. Yet it takes less than half a cent's worth of finished aluminum to produce a dollar of GNP. 6/

## Uses and Substitutes

Aluminum is employed in such diverse uses as construction, transportation equipment, and containers and packaging. Of the roughly 4.7 million tons of "new" aluminum consumed in 1982, down from a peak of 6.0 million in 1978, approximately 39 percent went into cans and packaging materials, 20 percent into transportation equipment, and 14 percent into construction. 7/ In addition, some 600,000 tons of aluminum contained in bauxite and alumina was diverted into the making of chemicals, refractories, and abrasives or into alumina exports. Although aluminum is also important for the production of military hardware, such as aircraft and missiles, peacetime requirements are only a small part of normal civilian consumption.

Soft-drink and beer cans consume most of the aluminum used in the packaging market. Aluminum now accounts for some 85 percent of the beverage can market, which is still growing. Construction applications include siding, door and window frames, mobile homes, bridge and guard rails, ducting, and many other uses in which aluminum has displaced wood, copper, or steel. Although this use of aluminum was low in relative share as well as absolute volume in 1982 because of the concentrated impact of the recession on the construction industry, its long-term trend is growing.

---

5. L.L. Fischman, et al., World Mineral Trends and U.S. Supply Problems, pp. 88, 173.

6. Derived from U.S. Department of Commerce, The Detailed Input-Output Structure of the U.S. Economy: 1972, vol. II (1979).

7. "New" aluminum refers to primary aluminum production plus recovery from scrap. Circulating industrial scrap is omitted.

Aluminum's increasing use in transportation equipment has been spurred by the need for lighter vehicles. It has as yet made only moderate competitive inroads into the passenger-car market. In 1981, automobiles accounted for about half the total amount of aluminum use in the transportation equipment sector, while trucks, buses, and trailers accounted for another one-fourth, and aircraft, vessels, and rail cars for the balance.

Electrical applications have been one of aluminum's fastest growing markets, induced particularly by the use of aluminum in high-voltage transmission lines. This market is relatively saturated. Aluminum will continue to displace steel in transmission towers and copper in other types of wiring, but its prospects in the sizable house-wiring market have been dimmed by alleged safety considerations. Though these have been overcome technically, receptivity to the use of aluminum in this application has yet to be widely revived.

Aluminum's lighter weight no longer gives it clear price advantage over copper on a weight basis. The weight saving is frequently offset by such technical problems as difficulty in soldering. Aluminum still retains some price advantage, however, in that it takes fewer pounds of aluminum to perform any given function. In relation to steel, aluminum's advantage in terms of the costs of material required to perform equivalent functions is mixed, since per pound, steel is usually much cheaper. Moreover, the steel industry is countering aluminum competition with advances such as thinner tinplate. The development of high-strength, low-alloy steel has so far forestalled significant aluminum inroads into the manufacture of automobile bodies. In the future, aluminum will also have to face increasing competition from high-strength (composite) plastics. In general, however, future trend growth in aluminum is likely to continue to be faster than that of steel or of the other three nonferrous metals that this chapter considers.

## Sources of Supply

The United States imports nearly 100 percent of its supplies of bauxite and alumina--the feedstocks for smelters that produce unfabricated aluminum metal. Domestic bauxite accounts for only about 5 percent of the metallic aluminum supply. Over the period 1978-1981, 40 percent of the imported bauxite arrived from Jamaica and 28 percent from Guinea, while 76 percent of the alumina originated in Australia. The sources of these imports for 1981 are given in Table 7. Most of the imports still arrive as bauxite and are "refined" into alumina in this country, but the proportion arriving as alumina is increasing. Apart from the desire of most bauxite-producing countries to increase their processing revenues, shipment as alumina eliminates about 60 percent of the original bulk of bauxite ore.

TABLE 7. SOURCES OF U.S. BAUXITE AND ALUMINA IMPORTS FOR 1981

| Country | Percent of Bauxite Imports | Percent of Alumina Imports | Approximate Percent of Combined Equivalent |
|---|---|---|---|
| Australia | 0.1 | 74.3 | 53.1 |
| Jamaica | 40.8 | 13.1 | 21.0 |
| Surinam | 8.5 | 11.3 | 10.5 |
| Guinea | 27.0 | -- | 7.7 |
| Brazil | 9.6 | -- | 2.7 |
| Canada | -- | 0.9 | 0.7 |
| Other | 14.0 | 0.4 | 4.3 |

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1981.

Sources of supply for bauxite are not wholly interchangeable, since refineries must be adapted to the ore composition. In particular, Jamaican bauxite (a mixed variety) is not readily interchangeable with the African and South American varieties (gibbsite).

## Nature of the Risks

Because so much of the bauxite and alumina feedstock for the U.S. aluminum industry comes from Third World countries that are members of the International Bauxite Association, there has been concern about both possible cartelization and security of supply. The fragility of some of the sources is illustrated by difficulties experienced by the Alcoa bauxite subsidiary in Surinam in dealing with the leftist-leaning military regime that recently took over that country.

The U.S. aluminum industry has, however, shown great adaptability in developing alternative sources. Roughly a dozen different countries contribute to U.S. bauxite supply, and there are as many or more untapped bauxite producers. More than ample capacity currently exists around the world to convert bauxite into alumina. Only the sustained resumption of rapid growth in world consumption would begin to produce refinery bottlenecks.

Energy and labor costs and pollution abatement represent the major problems facing the U.S. aluminum industry. The three problems are interrelated inasmuch as rising energy costs have squeezed the margins available for liberal labor settlements and for dealing with pollution. Even the most efficient smelters require 6 kilowatt hours of electricity for each pound of aluminum, and additional energy is required for baking the carbon electrodes. The method of power production and price setting are the two most important determinants of which aluminum smelting capacity will remain competitive and where new capacity will be installed. The rapid increase in natural gas prices in the Southwest has already caused the closing of part of the aluminum smelting industry in that area and will result in further permanent closures. In the Northwest, where most of the electricity is generated by water power, future competitiveness will depend in part on the outcome of a controversy over whether the aluminum companies, which had been accustomed to low-cost, interruptible power, will in the future be charged the same rates as other industrial consumers. In general, however, capacity shutdowns in that area have been mostly a consequence of the recession and obsolescence. With renewed economic growth, the level of operating capacity both in the Northwest and in some other parts of the country is likely to be restored and perhaps expanded.

Future capacity growth in the United States will not be nearly as rapid, however, as either trend growth in U.S. consumption or the growth of smelting capacity elsewhere in the world. Canada is one of the places with a competitive power advantage, and will remain the principal U.S. source of imported aluminum metal. Normally some 15 to 20 percent of the gross supply of the metal form is imported, mostly from Canada. Other countries with competitive advantage include Brazil, Venezuela, Australia, and a number of those in central Africa—one of which, Ghana, is already a significant U.S. supplier.

Depending on the pace of world economic recovery, there is the potential for future sharp rises in the price of aluminum. While trend growth in aluminum consumption will remain strong, the prolonged recession has resulted in delays and cancellations of many previous plans for capacity expansion. Both at the refinery and smelter levels, this could cause future bottlenecks. Given the current outlook for a drawn-out recovery, however, there should be ample time to reactivate expansion plans. Moreover, aluminum price increases should be restricted by competition with alternative materials.

## Conclusions

There is little reason for governmental concern with U.S. aluminum supply or the health of the U.S. aluminum industry. The industry has shown considerable resilience even during prolonged recession, discounted prices, and operations averaging only 60 percent of capacity. Current industry stocks of aluminum now stand at about seven to eight months of normal consumption. These levels are considered high and probably will be reduced before much production expansion occurs. The existing capacity margin provides insurance against sharp price rises for some time to come, however.

Despite the importance of aluminum in the production of aircraft, missiles, and other military hardware, peacetime military requirements are low in relation to normal civilian consumption. Mobilization needs are higher, but could readily be satisfied by diversion from less essential uses. Of the stockpile goal of 700,000 tons of aluminum metal, the inventory currently contains only 2,000 tons, and no apparent priority has been given to making up the difference. The goal of about 27 million long tons of metallurgical grade bauxite is about half filled. Since bauxite prices are highly negotiable and barter could be used to acquire part of the ore, it is difficult to estimate costs of filling the inventory goal. About $400 million, including transportation, is a rough estimate. There is no stockpile goal for alumina, presumably because of its poor storage qualities.

## COPPER

Copper is the oldest metal used by man and is now second only to aluminum as the most commonly used nonferrous metal. A large part of copper consumption occurs in association with zinc (as in brass) and with tin or lead (as in bronze).

### Role in the U.S. Economy

In 1981, before the recession, some 36,000 persons were employed in copper mining and milling, a level that had been maintained for several years. 8/ The smelting and refining phases of the copper industry employed about 12,000 persons. Sustained output of refined copper (primary and secondary) is roughly 2 million tons. 9/ Gross receipts in 1977 were close to $2 billion in the mining phase of the copper industry, 10/ and around

8. Bureau of Labor Statistics, Employment and Earnings (May 1982).

9. U.S. Department of Commerce, U.S. Industrial Outlook, 1982, p. 157.

10. U.S. Bureau of the Census, Census of Mineral Industries (1977).

$4 billion in the smelting and refining phase. 11/ Shipments of refined metal peaked at $5.7 billion in 1979 and have since declined. 12/

In 1982, U.S. copper mining and refining were the sole source of primary domestic arsenic, selenium, tellurium, platinum, and palladium--all of which have critical uses. The industry also yielded about 20 percent of U.S. primary gold output, 27 percent of the silver, and nearly 40 percent of the molybdenum. 13/

As of the mid-1970s, the United States consumed around 1.2 tons of copper per million dollars of GNP, or less than 2 cents worth per dollar. Because of generally declining intensity of materials use in the U.S. economy and losses to competing materials, the ratio of copper use to GNP continues to decline, but the rate of decline is probably decelerating. 14/ Most of the losses to aluminum have already occurred, as have the gains of copper use over steel (galvanized iron) in plumbing. Copper faces additional competitive losses to glass fibers in telephones and other telecommunications, but because of copper's price advantage, the rate of substitution is likely to be slow.

## Uses and Substitutes

About 80 percent of net new copper supply (primary metal plus copper recovered from old scrap) entered U.S. consumption in 1982 as refined metal. Three-quarters of this went into wire products and the rest into other shapes and forms. The Bureau of Mines estimates that 54 percent of the copper ended up in electrical applications, 20 percent in construction, 13

---

11. U.S. Department of Commerce, Census of Manufactures (1977).

12. U.S. Deparment of Commerce, U.S. Industrial Outlook, 1982, p. 159.

13. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983.

14. L.L. Fischman, et al., World Mineral Trends, pp. 106, 186-7. Also S.V. Radcliffe, et al., Materials Requirements and Economic Growth: A Comparison of Consumption Patterns in Industrialized Countries, U.S. Bureau of Mines (December 1981), pp. 72, 256.

percent in industrial machinery, and 8 percent in transportation equipment. 15/

The most critical uses occur in power generation and distribution, communications, and electronics. Copper will retain importance in power generation for some time to come, but if necessary, substitution of aluminum could be accelerated in the distribution phase, including building wiring. The use of optical fibers could be accelerated in communications, and the communications burden could be shifted in greater degree to radio, laser links, and satellites. In construction, aluminum, galvanized iron, and plastics could serve, in part, as alternatives to copper. In the most critical electronic applications, copper content has now become almost incidental relative to total value. This use can, therefore, readily absorb any cost increases necessary to divert copper from other applications.

## Sources of Supply

The United States has been the world's leading copper producer almost every year since 1883 and until recent decades was a net exporter. A significant portion of past imports was used not for domestic consumption, but was smelted and refined in coastal processing plants for reexport. Even today, copper is one of the few metals in which the United States is nearly self-sufficient. Net imports have fluctuated from year to year, in the range of zero to 20 percent of net copper consumption. Table 8 presents sources of gross copper imports in 1981.

In general—the recent recession was an exception--the proportion of imports arriving as refined metal has been increasing. Over the years 1978-1981, Chile was on average responsible for 32 percent of copper imports, Canada for 22 percent, Peru for 14 percent, and Zambia for 11 percent. 16/ Chile has regained the relative dominance in U.S. import supply which it enjoyed prior to the nationalization of U.S.-owned mines in 1971. Canada, Zambia, and the Philippines are all growing producers. Thus, including U.S., Mexican, and Panamanian production, the overwhelming bulk of U.S. copper supply will continue to originate in the Western Hemisphere.

Self-sufficiency in copper could be re-achieved in a relatively short time, if necessary. Substantial price increases would be required, however,

---

15. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983.

16. Ibid.

TABLE 8. SOURCES OF U.S. COPPER IMPORTS FOR 1981

| Country | Percent of Imports a/ |
|---|---|
| Chile | 32.1 |
| Canada | 25.3 |
| Peru | 12.1 |
| Zambia | 10.3 |
| Zaire | 5.7 |
| Mexico | 5.5 |
| Philippines | 4.7 |
| Other | 4.3 |

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1981.

a. Based on copper content of gross imports of ore and concentrates, matte, blister, refined copper, and scrap. Refined copper accounted for 77 percent of the total.

because of the comparatively high production costs and the financial incentives needed to induce major domestic investment in a highly volatile, and thus rather risky, industry.

## Nature of the Risks

The principal problem plaguing the U.S. copper industry has been the recent recession and accompanying low prices. Current copper prices of about 75 cents per pound are down 60 cents from their early 1980 peak and not much above their mid-1970s average. Meanwhile, operating costs have increased, substantial investments have had to be made in pollution control and new smelting processes, and debt-to-equity ratios have risen to historically high levels. Some major mines and smelters have been closed, inventories have continued to build up, and the industry is operating well under capacity—about two-thirds of capacity in the mining sector. The copper industry's problems are exacerbated by the industry's geographical concentration in the Southwest, which localizes the effects of industry downturns in one region. Arizona alone produces 65 percent of both mine and refinery output. Thirteen out of the country's fifteen primary smelters are located in Arizona, Utah, New Mexico, and Montana. 17/

Most of the industry's problems would be rapidly solved by renewed economic growth and consequent rising prices. Even at their current high levels, industry inventories are only about three months of normal consumption, and less than half the amount is in the hands of producers. 18/ A number of the closed mines will not be reopened because they are essentially depleted, and some smelting capacity will not be reactivated because it is obsolescent and too difficult to retrofit to meet new pollution standards. At the same time, new smelting capacity, utilizing more economical, less polluting, modern technology has been added. The industry has also been moving in part toward "electrowinning" technology that bypasses the smelting stage altogether and may be combined with leaching mining methods and the reworking of old ores.

The copper stockpile goal is equivalent to about five months of normal consumption. Even counting some copper in brass or below specifications, it is only about 3 percent filled.

## Conclusions

There is very little security risk attendant upon U.S. copper supply. The largest interruptions in the past have come from labor strikes, both in the United States and abroad, and these will probably continue to be the principal problem. The overwhelming bulk of copper supply is domestic, and most of the rest originates in the Western Hemisphere, much of it in Canada. Domestic capacity is substantial at all stages of production, from mining through refining and fabricating. There is a large secondary copper industry which usually generates a surplus of scrap copper for export and could supply additional copper in an emergency.

The largest single risk is that of sharp price runups in time of general economic boom. Because of the great volatility of copper prices, recessions cause major financial losses and stifle the capital investment needed to maintain a steady pace of modernization, expansion, and fulfillment of pollution-abatement requirements. This problem has been partially

---

17. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983; Commerce Department, U.S. Industrial Outlook, 1982.

18. Ibid; and U.S. Bureau of Mines release, "1982 Raw Nonfuel Mineral Production" (January 19, 1983), p. 3.

alleviated by the larger reservoir of funds available to the many firms after their aquisition by oil firms.

Despite the adherence of major LDC copper producers to the Intergovernmental Council of Copper Exporting Countries (CIPEC), a copper exporting organization antedating the International Bauxite Association, there is scant risk of effective cartel action except in times when demand-supply pressures would run up prices anyway. Control over supply is precluded by the dominant position of the United States as a producer, the large number of other producers, and the need for most of them to maintain the employment and flow of foreign exchange associated with copper production.

Fulfilling the stockpile goal, at present depressed prices, would cost about $1.4 billion.

## LEAD

Lead is another metal of ancient use. The Romans fashioned it into pipes for water supply, and contributed its Latin name (plumbum) to what is now called plumbing. Today, it is suspected that the Romans who used this piped water were slowly poisoned, much as are poor children who ingest lead-based paint in old buildings. Discoveries like this have rapidly changed the character of lead's applications. The 20th century saw a shift from lead to galvanized iron and then to copper for piping. Lead has been eliminated from most paints and has been phased out of much gasoline. Health concerns have also resulted in the imposition of pollution-control standards that have become a heavy burden on the lead smelting industry.

A distinctive characteristic of the lead industry is the very large role played by secondary recovery. This is because of the heavy proportion of total consumption that goes into automotive batteries, the relatively short life of such batteries, and the well-established system for recycling batteries for lead recovery and re-use. Lead in batteries could be counted as an inventory of metal in circulation, rather than metal that was being consumed. In any case, the development of long-life and maintenance-free batteries is beginning to modify the established cycle. Longer-life batteries are increasing the amount of recyclable lead in current use. Maintenance-free batteries have increased the requirement for pure lead in contrast to the predominantly antimonial lead that battery recyclers have been equipped to recover. Recovery of pure lead is a more difficult process, requiring smelting.

## Role in the U.S. Economy

Because nearly all lead is recovered from ores that also contain zinc, economic data on the mining phase of these two metals are generally combined. According to the 1977 Minerals Census, gross receipts for lead-zinc mining were $1.85 billion, slightly more than receipts for copper mining. Somewhat over half these revenues may be ascribed to lead. The number of lead and zinc mines (130) and total employment (32,000) were each about 50 percent higher than the corresponding figures for copper. Domestic lead mining is overwhelmingly concentrated in one state--Missouri--and the bulk of lead smelting and refining is also centered there. 19/

At their peak in 1979, receipts of primary lead smelters-refineries reached $1.4 billion, but they declined by around 40 percent before beginning to recover in 1982. 20/ Although smelting and refining are distinct processing operations, they are mostly integrated within the same companies, if not the same plants. Data on secondary lead production are not readily available, but the quantities of such lead exceed those of primary lead. 21/ Since secondary lead is produced mostly as antimonial lead, and antimony is more expensive, the difference in value of output between primary and secondary is even greater. Employment in lead scrap collection and secondary lead recovery probably far exceeds the 3,000 persons engaged in the primary smelting and refining industry. 22/

As of the mid-1970s, the United States consumed around a ton of lead per million dollars of GNP. This is only about four cents worth per dollar of GNP, including both primary and secondary lead, and the cost is declining. 23/

---

19. U.S. Bureau of Mines, Mineral Facts and Problems, 1980 ed., preprint, p. 2.

20. U.S. Department of Commerce, U.S. Industrial Outlook, 1982, p. 160; U.S. Bureau of Mines, Mineral Commodity Summaries, 1983.

21. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983.

22. Primary employment from U.S. Industrial Outlook, 1982, p. 160.

23. L.L. Fischman, et al., World Mineral Trends and U.S. Supply Problems, pp. 119, 197-8.

## Uses and Substitutes

About 60 percent of total lead use (primary and secondary combined) is in one application--storage batteries. The great bulk of these are used in automotive transportation. With about 10 to 15 percent of lead consumption used in anti-knock additives and additional amounts in such applications as bearings and radiator solder, nearly three-quarters of all lead use is bound up with transportation. 24/

Residual use of lead in paints and pigments, primarily for lead oxide in rustproofing, accounts for less than 8 percent of lead consumption in recent years, and other uses are still smaller. Lead is still used in construction for caulking, some piping, and soundproofing, and in construction and equipment for radiation shielding. Its use in cable covering is being replaced by plastics. While its military use for ammunition is important, this application consumes a very small part of total supply. The once critical need for lead in aviation gasoline has been significantly reduced by the advent of jet engines.

Given the continuing elimination of lead from gasoline and as a solder in high-technology electronics and its replaceability in most forms of caulking and sheathing, the remaining critical use will be in batteries. Though there are substitutes for lead-acid batteries, there are none of comparable cheapness. As discussed above, maintenance-free batteries require pure lead, which now has to be supplied mainly from primary lead. The secondary recovery industry is, however, adapting to the production of pure instead of antimonial lead, so this supply problem will eventually be eliminated. Another current difficulty is the scarcity of battery scrap, occasioned by the longer-lived maintenance-free batteries and the slowing in growth of numbers of automobiles, but this is a passing phenomenon.

## Sources of Supply

Despite the current zero or even negative net U.S. reliance on lead imports, gross imports are still about 10 percent of consumption. Refined metal constitutes about 80 percent of the total import dependence. The rest consists of ore, concentrates, and semi-processed lead. Over the period 1978-1981, Canada and Mexico accounted for 39 percent and 37 percent of finished imports, respectively, while Peru and Honduras accounted for 32

---

24. U.S. Bureau of Mines, Mineral Commodity Summaries, 1981-1983; Mineral Facts and Problems, 1980; U.S. Department of Commerce, U.S. Industrial Outlook, 1982.

percent and 27 percent, respectively, of ore and intermediate forms.25/ Sources of U.S. lead imports for 1981 are summarized in Table 9.

TABLE 9. SOURCES OF U.S. LEAD IMPORTS FOR 1981

| Country | Percent of Imports a/ |
|---|---|
| Canada | 41.9 |
| Mexico | 27.0 |
| Honduras | 8.9 |
| Australia | 7.4 |
| Peru | 7.0 |
| Other | 7.8 |

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1981.

a. Based on lead content of gross imports of ores, flue dust, and residues; base bullion; pigs and bars; sheet, pipe, and shot; and reclaimed scrap. Pigs and bars (refined lead) accounted for 76 percent of total imports.

## Nature of the Risks

As with the other nonferrous metal industries, the principal problems facing the lead industry are low prices and the costly need to meet environmental standards. In addition, since lead poses high risks to human health, the industry has been required to give special attention to minimizing exposure hazards in the workplace.

There is no resource problem in lead. Large new discoveries have recently been made in Missouri and the resulting new capacity will well outweigh losses from the closing of older, less economic mining operations. In total, the United States has the largest lead resources of any country in the world and is at least comparable with the USSR in resources that could be produced at current prices.

The stockpile goal for lead, which had once been reduced to zero, is now set at 1.1 million tons. It is 55 percent filled, and there are no evident

25. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983 and earlier years.

plans for near-term additional procurement. Completion of the goal would cost about $200 million at current prices.

The lead industry is unusually depressed, because it is tied to automobile output through its major use in automotive batteries. Lead prices have been very low, even in comparison with the other nonferrous metals; at the end of 1982 at a little over 20 cents per pound, they were less than half of their 1979 average and the lowest since 1976. In early 1983, however, lead prices showed signs of an upturn. Even if U.S. automobile production does not regain earlier levels, it should improve enough to give a decided upward boost to primary lead sales. The attendant increased scrappage of old automobiles will provide increased scrap for the secondary lead industry. Stocks of lead have remained low and are now down to about a month and a half of normal consumption, about evenly divided between primary smelters, and secondary smelters and consumers in the form of batteries. The secondary industry ran at only about 50 percent of capacity in 1982, but the primary industry exceeded 80 percent.

## Conclusions

The future health of the lead industry is not a serious problem, except for continuing cyclical instability. Its recovery is tied to the U.S. automobile industry. Lead demand should increase despite the progressive loss of one of lead's principal markets, gasoline additives. New U.S. lead mines are quite competitive. The primary smelting industry has by now made most of the required adaptation to pollution abatement and workplace health safeguards. The secondary industry may experience some further shakeout, but appears able to adapt both to pollution abatement requirements and to changing battery specifications.

There is no security problem with regard to lead supply. The United States is essentially self-sufficient and could at most times either readily replace the limited flows of lead concentrates and metal from foreign countries or, if necessary, eliminate outward flows, especially of lead scrap. The great bulk of imports is from adjacent countries, and most of the balance from elsewhere in the Western Hemisphere. The most serious risk seems to be the possibility of prolonged labor strikes. These have caused supply slowdowns in the past (for example, in 1981), but could be controlled in a mobilization emergency.

## ZINC

The United States consumed 1.2 million tons of zinc in 1981. About 64 percent was imported, at a cost of $680 million. Zinc's principal distinction among the nonferrous metals is the relatively small and unusual role of "old" scrap in the total supply. Only about 20 percent of all processed zinc-containing scrap is old scrap--that is, obtained from finished goods. Of this amount, nearly half is the zinc content in brass and bronze. Nearly all the latter goes right back into brass and bronze, which is the single form into which well over half of all scrap zinc, old and new combined, is recycled. 26/

Two-thirds of zinc scrap is so-called "new" scrap--that is, industrial process scrap, recovered from the tanks and furnaces of galvanizers, die casters, chemical plants, and other users. The largest portion of this becomes a direct input into chemical products, which are also produced directly from ore as well as from slab zinc. A smaller portion ends up as zinc dust, incorporated into paints, especially for the automotive industry. A generally declining portion is redistilled into slab zinc. 27/

About two-thirds of U.S. mine production of zinc is from primarily zinc ores; more than half originates in Tennessee. Roughly 25 percent is extracted from zinc ores in the Middle Atlantic states of New York, New Jersey, and Pennsylvania. Another 20 percent is derived in combination with lead mining, overwhelmingly from the ores in Missouri. 28/

### Role in the U.S. Economy

As noted earlier, lead and zinc mining in combination earned about $1.85 billion in 1977; zinc receipts accounted for somewhat less than half of this. Judging by the relative volume of ore processed, it probably also accounted for less than half the combined 32,000 employees. Primary slab zinc output was valued at roughly $500 million in 1981, down modestly from a 1979 peak of over $570 million. 29/ It then dropped sharply to $255 million in 1982. 30/ As of the mid-1970s, the United States consumed only

---

26. U.S. Bureau of Mines, Minerals Yearbook, 1980, vol. I.

27. Ibid.

28. Ibid.

29. Department of Commerce, U.S. Industrial Outlook, 1982.

30. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983.

about three-quarters of a ton of zinc per million dollars of GNP. This ratio had been declining and may be expected to decline further. Because of the use of zinc in galvanized steel, automobile hardware, and various machinery parts, there is a close correlation between zinc consumption and that of steel. The ratios have been fairly steady at 9 to 10 kilograms of zinc per metric ton of steel (0.9 to 1.0 percent). At recent prices, the amounts of zinc consumed in the United States amount to about 6 cents per dollar of GNP, slightly higher than the corresponding value for lead.

## Uses and Substitutes

About 70 percent of total zinc consumption is as slab zinc, nine-tenths of which is produced from virgin origin. Slab zinc is used in making alloys for automobile parts. While a small amount of zinc enters into chemicals directly from ore, the bulk comes from secondary zinc recycled from brass and other alloys. 31/ Apart from the recirculating alloy stock and some secondary zinc used in chemicals and paints, almost half of all zinc goes into galvanizing, close to 30 percent into zinc-base alloys, and 10 to 15 percent into brass and bronze production. Of these processed forms of zinc, about 40 percent is used in construction, 20 percent in transportation equipment (principally automobiles), and 20 percent or more in other machinery and equipment, both electrical and nonelectrical. 32/

The principal use of zinc in the United States is as an anticorrosive coating for steel, as is found in galvanized sheet and strip steel for automobile bodies. Because of its special applications in one-sided galvanizing and improvements in steel production, zinc holds a strongly competitive position against displacement by either aluminum or plastic. In another major automotive use--die-cast trim, parts, and hardware--zinc has already been substantially displaced by aluminum, magnesium, and plastics. But the development of economical, thin-walled castings seems to have arrested the decline in consumption in this area.

Another large share of galvanized sheet goes into construction--for roofing, siding, guttering, and conduits. Here, aluminum and copper, among other materials, are important substitutes and competitors. Copper has taken over part of the piping function from galvanized iron, and both metals are giving way to some extent to plastic piping. Galvanized nails, wire, and

---

31. U.S. Bureau of Mines, Minerals Yearbook, 1980, pp. 899-900.

32. Ibid.; and Mineral Commodity Summaries, 1981-1983.

fencing remain important and resilient markets for zinc, as do galvanized structural shapes.

Zinc, in the form of brass, is used in automobile radiators, where it remains resistant, though not impervious, to replacement by aluminum. Other brass applications, such as those for electrical devices, seem to be diminishing; this is probably due more to declining metal content of the devices than to replacement of brass by other metals. The principal substitute for brass or bronze screws is zinc-plated screws, but screws in general may be yielding ground to other modes of joining and fastening.

One of the more minor forms of zinc—rolled zinc—heretofore used largely in dry-cell batteries, had a boost in use starting in 1982, when the government substituted zinc for most of the copper in pennies. The new penny is 98 percent zinc with a 2 percent copper coating; the old one was 95 percent copper and 5 percent zinc. This use could eventually consume as much zinc each year as now goes into galvanized piping.

## Sources of Supply

Overall import dependence for zinc shows a decline from a peak of 66 percent in 1978 to an estimated 53 percent in 1982. 33/ The shift occurred in 1982, when the cumulation of permanent and temporary zinc smelter closings, along with a sharp drop in total consumption, converted the United States from a heavy net importer of zinc ore and concentrates to a net exporter.

Some 70 to 90 percent of U.S. zinc imports in recent years have been in the form of slab zinc, with the remaining 10 to 30 percent arriving as ore or concentrates. Over the 1978-1981 period, Canada was responsible for 59 percent of the crude mineral imports and Peru for 17 percent. Canada was also the source of more than half the slab zinc. 34/ Table 10 summarizes the source of gross imports of unmanufactured zinc in 1981.

## Nature of the Risks

The closing of the Bunker Hill smelter at the end of 1981 was the latest in a series of closures dating from 1972 in response to low real prices

---

33. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983.

34. Ibid.

TABLE 10. SOURCES OF U.S. ZINC IMPORTS FOR 1981

| Country | Percent of Imports a/ |
|---|---|
| Canada | 56.9 |
| Peru | 8.4 |
| Mexico | 4.2 |
| Germany | 3.7 |
| Finland | 3.4 |
| Zaire | 3.3 |
| Spain | 3.3 |
| Australia | 3.2 |
| Other | 13.6 |

SOURCE: U.S. Bureau of Mines, Minerals Yearbook, 1981.

a. Based on zinc content of ores and concentrates, blocks, pigs and slabs. Slab zinc (refined zinc) accounted for 71 percent of the total.

and the difficulties of complying with environmental standards. In 1970, the United States had been essentially self-sufficient in slab zinc, with a smelter capacity of 1.38 million tons and slightly lower consumption. By 1978, active capacity had fallen to about 850,000 tons and since then it has dropped to about 400,000 tons. Late 1982 production rates were little more than half of that capacity. 35/ Major smelter closings occurred in 1979, 1980, and 1981. 36/ Not all of these closings are permanent, however, and one completely new smelter was opened in 1978 as a joint venture of New Jersey Zinc and Belgium's Union Miniere.

Mine closings have more or less kept pace with smelter closings. Despite these closings, there was a surplus in zinc concentrates in 1982. These resulted from the decreased demand during the recession and the near absence of the labor strikes that had lowered production in earlier years. 37/

---

35. U.S. Bureau of Mines release, "Zinc Industry in November and Smelter Production in December 1982" (February 8, 1983).

36. U.S. Department of Commerce, U.S. Industrial Outlook, 1982.

37. U.S. Bureau of Mines release, "1982 Raw Nonfuel Mineral Production."

Stocks of slab zinc are not high either by past standards or in relation to normal consumption. Producer and consumer stocks combined would suffice for only about a month's consumption, and merchant stocks add less than a month more. The national stockpile contains enough zinc for about four months of normal consumption, even though its goal is only about one-fourth met.

As with lead, zinc consumption prospects should improve considerably with the revival of the domestic automobile industry. It will also get a boost from a resurgence in construction. Over the long run, there is the possibility that zinc, rather than lead, will reap the benefit of electric automobiles or use of storage batteries for electric-utility load leveling, given its potential superior capacity-weight relationships.

## Conclusions

The U.S. zinc industry has recently undergone a cyclical decline. Economic recovery should reabsorb excess smelter capacity and cause some mines to be reopened. Over the longer run, it is likely that smelter capacity will be expanded somewhat, but not at the same rate as trend increases in zinc consumption. Thus, import reliance is likely to revert to, then increase beyond, previous levels. Vulnerability will not materially increase, however. Canada has the largest economic or near-economic zinc reserves in the world, and Canada and the United States jointly have two-thirds the world total. 38/ Thus, 80 to 90 percent of U.S. supply will continue to originate either in Canada or the United States. Much of the remainder will come from Peru and Mexico. Judging by the record, the greatest supply risk is from labor strikes. Under the circumstances, there seems little justification for fulfilling the stockpile goal. To do so at present producer prices would cost some $800 million.

---

38. U.S. Bureau of Mines, Mineral Commodity Summaries, 1983.

# CHAPTER V. POLICY OPTIONS

The United States has a considerable range of policy options to reduce its dependence on imported nonfuel minerals and limit the impact of any shortages that might result from such dependence. From a budgetary perspective, the least costly option would rely completely on the private sector to purchase the most economical supplies and to maintain appropriate inventory levels, irrespective of whether the source was domestic or foreign. But that option could impose a high cost on the economy if a serious shortage were to occur, either as a result of a national defense emergency or other events affecting access to foreign sources of supply.

As the preceding chapters have illustrated, the conditions surrounding the supplies of individual minerals vary widely. Significant differences exist concerning the nature and extent of risk involved in relying on imported supplies, the potential damage that might result from a contingency, and the ease with which the private market might adjust by resorting to consumption or supply alternatives. Five of these eight minerals--aluminum, chromium, cobalt, manganese, and the platinum group--share some risk of supply disruption from political instability, logistical difficulties, or attempts at price manipulation. The risk is particularly significant for those minerals produced principally in South Africa and the Soviet Union. While a variety of limiting circumstances would make disruption of these supplies less devastating than the oil shortages of the 1970s, any such disruption could exact real economic costs through losses of output and employment in industries that depend on foreign minerals.

This chapter examines the following options to mitigate such costs:

- Increase the National Defense Stockpile;
- Build economic stockpiles;
- Subsidize domestic production;
- Diversify sources of supply;
- Encourage exploration and development on public lands;
- Intensify metals and materials research and development; and
- Utilize foreign policy initiatives.

Since many of these policy options have, in fact, been employed in the past, previous experience provides some guide to their effectiveness and cost. The following discussion of each option evaluates the factors likely to determine cost and effectiveness, as well as some difficulties of implementation and management.

## STOCKPILES

Stockpiles are named for their purposes. A defense stockpile is one intended for use only during time of war. An economic stockpile is a buffer stock, intended to smooth out shortages and sudden price runups arising from localized interruptions of individual minerals. For example, the Strategic Petroleum Reserve would presumably be made available at public auction under circumstances well short of warfare and thus could be considered an economic stockpile. Under current policy, the United States has a National Defense Stockpile of minerals and materials, intended to support defense production and essential civilian needs in time of national emergency. It does not have an economic stockpile that would bridge market shortages during other disruptions, such as the interruption of mineral production in one nation or region.

### The National Defense Stockpile

The National Defense Stockpile is both the first and the most widely and repeatedly endorsed measure to minimize vulnerability to a wartime shortage of imported raw materials. The stockpile was initiated under the 1939 Strategic Minerals Act. Endorsed as the most cost-effective option by the Materials Policy (Paley) Commission and subseqent panels, it has been virtually immune from criticism in principle. Many claim, however, that it has not been managed well or used properly.

In principle, a stockpile could be built up during periods of low economic activity and accompanying low raw materials prices. Stockpiled materials would be released only during a national emergency, presumably when market demand and prices would be much higher. Depending on the time interval, profits from sales would offset part or all of the costs of management and storage as well as interest on government borrowing to finance purchases. The very existence of the stockpile should discourage potential aggressors who might hope to defeat the United States in a conventional war by cutting off its supplies of vital raw materials and thus its defense production capabilities. But, in practice, several issues have been raised regarding the defense stockpile.

Should Stockpile Goals Be Filled? As discussed in Chapter II, the minerals stockpile targets are developed by the Federal Emergency Management Agency. In an elaborate interagency process, the stockpile goals are determined based on assumptions about mineral demands during a three-year mobilization for war. This paper does not attempt to critique the 140 or so policy assumptions used to calculate the goals. The validity of the goals depends on the validity of these assumptions, however. Among the critical ones are the needs of the U.S. economy--both civilian and military--under mobilization conditions; probable increases in production in the United States, Canada, Mexico, and other secure sources; and levels of minerals consumption in other industrial nations.

About $11 billion in new appropriations would be required to meet all current goals at early 1982 prices, of which about $4 billion could be obtained by selling excess inventories. But the $11 billion figure includes purchases of minerals whose security risk is low. At current cash market prices, about $1.4 billion would be needed to meet the goal for copper, $600 million for nickel, $800 million for zinc, and $200 million for lead. The vulnerability of the United States to serious shortages of these metals, even in the event of a national emergency, can be questioned, given the extent to which U.S. needs are met from North American supply sources and the possibility for expanding North American production rapidly. The extent of vulnerability in a national emergency for these and other minerals obtained from nearby sources of supply is a matter of judgment, as is the decision to pay fairly high insurance premiums for protection against low probability risks.

In addition, the stockpile targets are premised on requirements for a three-year mobilization. The probability of a military contingency requiring such an extended effort may be low. If the one-year goal set by President Nixon in 1973 were reinstituted, the sale of excess inventories could be sufficient to finance stockpile goals for all materials on the list. Alternatively, stockpile procurement could be accelerated for those specific minerals for which substitutes would be difficult to find in an emergency and which are imported from relatively insecure sources--specifically, South Africa, Zaire, and the Soviet Union.

Whatever goals may be deemed essential, any procurement would be most advantageous before economic recovery drives up raw material prices. Given the volatility of raw materials prices and the traditional movement of minerals prices over the business cycle, the cost of meeting defense stockpile goals could well increase by 50 percent or more if procurement is delayed until the international economy has reached its next cyclical peak.

Should Stockpile Levels Over Goals Be Sold? The only stockpiled materials that have been used for military purposes since the Korean War are nickel, copper, and quinine, released during the Vietnam War. About 35 percent or more of the inventory has, for 20 years or more, consisted of materials in excess of stockpile goals. The authorization of sales of excess inventories, however, has been hampered by fears and charges of market disruption made by domestic and foreign producers. Nevertheless, substantial sales were made out of the stockpile inventory during the 1960s and early 1970s. These sales yielded some $6.8 billion by disposing of materials whose acquisition cost was only $4 billion. Assuming that the sold materials remained in the stockpile for 15 years on average, the profits yielded an average annual return of 3.6 percent, less than interest, storage, and management costs.

Assuming that existing excess inventories could be sold at current market prices, they would yield $4 billion. The threat of such stockpile releases was used in the 1960s and again in the early 1970s to discourage domestic metal producers from raising their prices. Some consider that inventories were determined to be excessive in order to help balance budget deficits. Stockpile disposal legislation sent to the Congress in April 1973 was accompanied by a Presidential message that pointed out its potential value in the current fight against rising prices. 1/ The message went on to state that the nation had greater capability to find substitutes than it had at the time the three-year goal was set and concluded that "twelve months would give us sufficient time to mobilize so that we could sustain our defense effort as long as necessary."

Silver inventories in particular have long been considered excessive. However, the large quantities sold between 1967 and 1970 at $1.29 per ounce continue to be noted by opponents of legislation to authorize additional disposals. (Prices have centered between $10 to $12 per ounce since mid-1981.) Stockpile disposals of silver were not authorized in 1980 when the price of silver exceeded $40 per ounce. This price, however, resulted from massive speculative demand and alleged improper conduct by selected silver traders. Thus, it is unlikely that silver prices will return to these abnormally high levels. Surplus silver sales could raise about $1 billion at current prices. These revenues could be used to purchase minerals whose contribution to national security would be far greater than that of silver.

The demand for other minerals is more procyclical, and current markets are depressed and prices abnormally low. For these, it might be desirable to delay sales until substantial world-wide economic recovery has occurred and raw materials prices have recovered. At that time, sales could yield perhaps 50 percent more to the U.S. Treasury and also exert a dampening effect on inflationary pressures.

---

1. Presidential Documents: Richard Nixon, 1973, vol. 9, no. 6.

Are The Right Quality Materials Stored? The stockpile has also been criticized because existing inventories purchased in the 1950s no longer meet current physical or chemical requirements. For example, the platinum-group inventory consists of bars, plate, and sheet while current specifications call for sponge. The Inspector General of the General Services Administration (GSA) has audited the stockpile six times over the past decade and has issued critical reports on each occasion. He has charged that materials have been stolen or otherwise disappeared and has claimed to have found major billing errors. The GSA Office of Property Management is responsible for the storage, inspection, maintenance, and security of the stockpiled materials. It lacks funds to undertake a detailed inventory of more than a very few materials each year. Whatever the validity of or explanation for each of the foregoing pieces of evidence, it seems clear that government purchase, storage, and sale of stockpiled raw materials operate under severe institutional handicaps. Appropriating funds for a comprehensive audit of the stockpile would allow GSA to perform its functions with improved efficiency.

## Economic Stockpiles

While the strategic stockpile for national defense emergencies has long been an instrument of U.S. government policy, the events of the 1970s evoked concerns about contingencies with other origins--local wars or disturbances in major foreign supply areas, embargoes, cartels, or insufficient investment in foreign production capacity to accommodate demand surges. In 1976, the National Commission on Supplies and Shortages suggested formation of an economic stockpile to cope with such contingencies. Part of the strategic stockpile might be set aside for that pupose, or a separate stockpile could be created. In either event, the economic stockpile would be used only to meet severe supply disruptions, not to influence market prices in the absence of a clearly defined disruption.

The history of the strategic stockpile in the 1960s and the 1970s produced strong opposition to a new policy instrument that might be used by the federal government to influence the market. Metals users prefer that the government not engage in purchases that would tend to raise their costs at a time when the markets for their products are likely to be weak. Mining and metal producing companies, on the whole, expect their prices and their profits to be cyclical and volatile. They are not eager to have the government engage in sales that would shave off the peak prices that provide a substantial part of their profits over a period of years. Both groups tend to prefer to take their chances on the market rather than be subject to government intervention. Thus, very little support for a government economic stockpile exists within the mining and metal producing community, whether foreign or domestic.

Several foreign countries do have economic stockpiles. In Sweden, peacetime stockpiles of chromium, manganese, cobalt, and vanadium are maintained in addition to a wartime stockpile. The peacetime stockpile is for use in the event that supply lines are disrupted in a circumstance short of war. Switzerland offers minerals importers low interest rates and tax rebates to maintain stocks corresponding to about a normal 12-month supply. Japan provides interest rate subsidies and loan guarantees to three private metal stockpiling associations. Stockpiles of nine critical nonferrous metals are maintained to stabilize the supply of key minerals, contribute to national security, and, incidentally, to assist those developing countries that depend on earnings from exporting such materials to Japan.

Some of the problems encountered with the management of the National Defense Stockpile might be overcome by creating an independent, publicly owned corporation that would operate with its own capital, either borrowed directly from the U.S. Treasury or from the private market with government guarantees. 2/ The potential advantage of such a corporation is that it could be charged with purchasing minerals on a more selective basis than that of the National Defense Stockpile. On the other hand, such a corporation might not be more efficient than its existing counterpart.

Under another alternative, the federal government would provide financial incentives to encourage private companies to hold larger inventories of specified materials than is their "normal" commercial practice. 3/ Normal could be defined in terms of ratios of inventories to consumption. Among the incentives that have been suggested are: a tax credit for materials inventories held in excess of normal levels; interest and carrying cost rebates paid directly by the federal government for a percentage of the costs of above-normal inventories; purchase cost rebate contracts; and tax-free interest on bonds floated by user industries to finance inventories in excess of normal levels.

The advantage of private stockpiling is that user companies would tailor their inventories to their evolving requirements. Fresh inventories would be maintained through frequent turnover and the government would

---

2. Former Senator Harrison H. Schmitt suggested the establishment of a Strategic Stockpile Commission that would function as an independent federal agency to manage the National Defense Stockpile, using the Stockpile Transaction Fund.

3. See J.H. Holt and T.W. Stanley, Alternative Nonmineral Stockpiling Policies: Private Stockpiling (International Economic Studies Institute, forthcoming).

benefit from the application of the same management practices to above-normal inventories that are usually employed by private companies for normal inventories. Moreover, the private firms would share the cost of the extra inventories, and government incentives would be kept at a level well below the total cost.

The disadvantages include the administrative complexities of maintaining central information and control by the federal government, the difficulties of policing, the potential for abuse by participating companies, and the cost of the program to the federal government. In addition, such a policy could encourage private users to reduce their nonsubsidized normal inventories and rely instead on subsidized inventories. To illustrate the federal cost of a private stockpile program, the Holt and Stanley study estimates that the government would have to provide $50 million to $60 million in incentives to yield a 4 million pound addition to normal cobalt inventories for a ten-year period. 4/ A 4 million pound addition would more than double average private inventories held between 1977 and 1981 and would be equal to about an average of three months' U.S. imports. At current market prices, this quantity of cobalt could be purchased for about $20 million. The Holt-Stanley study assumes higher prices for cobalt than those that now prevail.

If the policy goal was to prepare for minerals disruptions that would compromise the national defense effort, then selected incentives could be created to induce defense contractors to hold larger inventories. Defense procurement contracts could include subsidization of mineral inventories or, alternatively, specified inventory levels could be made a condition of receiving such a contract.

## SUBSIDIZATION OF DOMESTIC PRODUCTION

Title III of the Defense Production Act (DPA) of 1950 authorized the President to guarantee loans and to take other financial steps to expand productive capacity and supply in the interest of national defense. Under this legislation, a $2 billion authorization was enacted to meet shortages during the Korean War. Over the ensuing decade, this funding generated about $8.4 billion in additional production. Aluminum production in the United States doubled, tungsten mining quadrupled, copper mining capacity increased by a fourth, domestic nickel and titanium production was developed, and foreign columbium-tantalum mining and processing facilities were greatly expanded. Over $1 billion worth of materials acquired under this

4. Ibid.

authority was sold to private users during the 1950s, at prices that recovered about 93 percent of the government's purchase cost. 5/

But, in general, the results achieved through the use of Title III authority were expensive. In addition to long-term purchase contracts at guaranteed prices, producers received direct subsidies (subsidized exploration costs and subsidized power for an aluminum producer, as well as direct payments for the production of columbium-tantalum, copper, and graphite), government guaranteed loans, loans at subsidized interest rates for new or expanded facilities, and very rapid depreciation schedules for tax purposes. By mid-1959, stockpile inventories had been acquired by the government under the purchase contracts at the cost of about $1.4 billion but had an estimated market value of only $843 million. The inventories eventually became part of the strategic stockpile.

In the case of cobalt, domestic producers were paid $2.38 per pound, while foreign producers received the existing world market price of $1.29 per pound. 6/ The domestic producers ceased production when their government purchase contracts expired. Excess government cobalt inventories were sold between 1966-1969 at prices ranging from $1.53 to $1.72 per pound.

While U.S. production of tungsten quadrupled between 1950 and 1955, it dropped by 50 percent in 1957, the first year after government purchases were terminated. 7/ By 1960, production of domestic tungsten concentrate was only two-thirds larger than in 1950 and supplied slightly more than half of U.S. consumption. The domestic price of tungsten stayed at the government guaranteed price of $3.97 per pound until the termination of contracts in 1957, when it dropped to $1.18 per pound.

Titanium, columbium-tantalum, and manganese offer further instances in which the market value of DPA inventories in 1959 were 50 percent or less of acquisition costs. In the case of manganese, low-grade domestic deposits were mined at prices 70 to 130 percent above the 1959 market levels. Once the government purchase contracts were terminated, U.S. production of these materials ceased completely and have not been resumed.

---

5. See Joint Congressional Committee on Defense Production, Ninth Annual Report on the Defense Production Act (1959).

6. See Charles River Associates, Economic Analysis of the Cobalt Industry (Cambridge, Mass., 1969).

7. See Charles River Associates, Economic Analysis of the Tungsten Industry (Cambridge, Mass., 1969).

Chromite production in the United States also ended with the cessation of DPA contracts.

For a quarter of a century, Title III of the DPA has not been used to support domestic production of nonfuel minerals, with the single exception of an $83 million loan in 1967 to help develop a new copper mine. In 1982, however, the House Committee on Banking, Finance and Urban Affairs reported a bill (H.R. 5540, 97th Congress) amending the Defense Production Act of 1950 to authorize the appropriation of $5 billion over a five-year period for loans, loan guarantees, purchase agreements, and price guarantees intended to assist the modernization of industries in the United States that are necessary to the manufacture or supply of national defense materials. Assistance would be provided to firms engaged in expansion of the domestic capability to produce or process critical strategic metals, minerals, and materials. An additional $1.75 billion would be authorized for a five-year program for skills training and for modernizing the equipment of schools of higher education engaged in such skills training.

The proposal risks repetition of the 1950s experience--temporary expansion of uneconomic domestic mining and minerals processing at very high cost. In the early 1950s, shortages and rapidly escalating prices in foreign markets jeopardized a needed rapid increase in defense production. The current defense buildup faces no such threat. The minerals industry--at home and abroad--is experiencing a sharp decline in production and employment, mine shutdowns, and considerable excess capacity. 8/

For example, it is estimated that a floor price in the $25 per pound range, guaranteed for ten years, would have to be set to induce domestic production of cobalt. 9/ By late 1982, cobalt was selling on the spot market at $4 per pound and stockpile purchases were made in 1981 at $12.50 to $15 per pound. While a pound of annual domestic productive capacity is equal to the three pounds of stockpiled material necessary to meet the three-year mobilization goal (presuming the capacity exists in time), subsidizing domestic production would risk paying twice or more the world price for a ten-year period. Nor is it likely that productive capacity would remain in place after government purchases were suspended unless it could operate at competitive prices.

---

8. See U.S. Bureau of Mines release, 1982 Raw Non-Fuel Mineral Production (January 19, 1983).

9. Congressional Budget Office, Cobalt: Policy Options for a Strategic Mineral (September 1982).

Nevertheless, there might be cases when competitive production capacity could be created with the help of some initial public financing. If the required federal subsidy was a low percentage of the market price, it might be preferable to bear this cost than to incur the expense of a three-year stockpile. But, this case would most often apply in metal industries that already have substantial domestic excess capacity and that pose the smallest security risks.

A corollary benefit of providing subsidies for expanding domestic production would be expanded capacity to meet peacetime contingencies. The likelihood of deliberate action by foreign governments to restrict the flow of raw materials to the United States would be reduced if U.S. mines and processing facilities had excess capacity or readily expandable capacity in place. If any contingency did arise, the impact on U.S. production and prices would be lessened to the extent that U.S. needs could be met more fully from domestic sources.

Another corollary benefit would be assistance to the depressed U.S. mining and processing industry, its work force, and its communities. The very real problems of employees and communities could be addressed by other means, however, notably through retraining and assistance in developing other community-based enterprises. It is difficult to justify production subsidy programs unless most of the cost is warranted as an efficient method of insuring the country against the risks of supply shortages.

## OTHER OPTIONS

The most immediate and direct way to reduce U.S. vulnerability to disruptions in the flow of foreign minerals is through stockpiling and subsidization of domestic production, although the efficiency with which these options reduce vulnerability differs. In the long term, however, a variety of options are available to insure against the risk of minerals disruptions or to reduce the magnitude of the risk itself. These include the diversification of mineral sources, greater access to mineral deposits on public lands, research and development, and greater emphasis on minerals policy in formulating foreign policy.

### Diversification of Sources of Supply

Diversifying sources of supply would offer both U.S. metal-using industries and the country greater assurance that damage from supply contingencies would be contained. For defense emergencies, of course, diversifying away from North American sources would make little sense.

Since sea lanes within the Western Hemisphere are more likely to be safe, expanding Eastern Hemisphere sources could be less desirable. More numerous sources of supply--wherever they may be--also lessen the potential for development of cartels. On the other hand, diversification to countries controlled by potentially hostile regimes carries other risks and unstable regimes offer little promise as reliable long-term suppliers.

For two decades after World War II, investments in foreign mines and foreign processing facilities were substantial, but most of the product was exported to Japan and European industrialized countries. The rest of the industrialized world expanded its metal-using industries at a much faster pace than did the United States during this period. U.S. supplies of almost every imported material continued to come largely from a very few sources, as U.S. importers sought supplies at the lowest costs and were little concerned about reliability. Canadian mineral production expanded rapidly during this period, as did the variety of minerals produced there. Its exports were largely directed to the United States.

Events in the 1960s and 1970s focused attention on the relative reliability of suppliers, particularly in the Third World. As Japan's balance of payments improved, its early foreign investments were concentrated on acquiring new foreign materials supplies and diversifying its sources as much as possible. The U.S. minerals industry encountered more competition in its efforts to develop foreign production and more difficulty in finding a hospitable reception in the Third World. Australia and South and West Africa became centers for new minerals investment, attracted by an apparently more hospitable environment than existed in other areas with resource export potential.

Nevertheless, a relatively few foreign supply sources still predominate for almost every mineral. The U.S. government has very few means for inducing users of foreign materials to diversify their sources. The Western Hemisphere Trading Act did provide tax incentives for private investment in the Western Hemisphere, but that legislation has expired. U.S. foreign investment incentives, including investment insurance, do not discriminate in favor of those areas that would represent additional diversification.

Multilateral and bilateral aid programs and investment guarantees could reduce U.S. supply vulnerabilities by expanding and diversifying foreign production of critical and strategic materials. The aid programs would not need to finance minerals or metals processing investments directly. They could contribute to creating a climate in which private-sector investments would be attractive or they could finance infrastructure construction that would both promote private mineral investment and enhance other development. Such aid programs would increase budgetary expenditures only if aggregate aid levels increased. The investment insurance programs have been self-financing to date.

## Access to Public Lands

About one-third of the land area of the United States (some 734 million acres) consists of public lands, much of it designated as public parks, wilderness, and wilderness study areas. The President has stated that 40 to 68 percent of federal land is now estimated to be closed to minerals exploration and development. Controversy has long persisted about whether these lands should be preserved for recreational and aesthetic uses or opened for minerals exploration and development. Preservationists oppose exploration even by the government, lest development follow. Mining interests are reluctant to finance exploration unless mineral finds can be developed. As a result, the United States has hardly begun assessing the minerals potential of most public lands.

Knowledge that useful domestic resources exist could lead to their development during a contingency, though a high priority given to preservation could limit such use to situations of extreme severity and duration. Such knowledge could be obtained through more intensive exploratory surveys by the U.S. Geological Survey. Such surveys could lead to substantial mineral finds that might reduce the need to resort to much more expensive alternative provisions against contingencies. 10/

## Research and Development

Research and development (R&D) has and could reduce U.S. vulnerability to shortages of imported minerals and metals through contributions to improving every step of the extraction and industrial production process. In mining, it could enable the economic exploitation of lower quality ores, deeper mining, and the exploitation of smaller veins. It could facilitate more efficient processing and recycling, conservation of scarce minerals, and the substitution of more available materials for those in scarce supply. Some resulting technologies might become economical even under normal supply conditions. Others could be held in reserve until supply shortages and the ensuing price increases made it feasible to incur the additional cost, as was the case for cobalt in 1978. Analyses of individual minerals in the preceding two chapters present numerous examples of new technologies that

---

10. The details of such a survey can be found in Congressional Research Service, Assessing the Mineral Potential of the Public Lands, Report no. 82-XXX 5 (May 1983).

have already become economical and are in use or that would become so if shortages led to significant price increases.

The federal government now accounts for about one-half of U.S. expenditures on R&D for minerals. Four percent of its R&D budget is devoted to funding 20 percent of the country's $5.4 billion expenditure on R&D in this area. 11/ These federal R&D expenditures, however, have been mainly for fuels and renewable resources rather than for nonfuel minerals. And most of the nonfuel mineral expenditures have been used for materials utilization, evaluation of materials properties, and the development of special materials substances derived from nonfuel minerals. 12/ Basic resource development and processing have been relatively neglected. The Administration's proposed increase in fiscal year 1984 funding for the National Science Foundation, which promotes basic research, might reverse this trend. If not, the Congress might wish to consider legislation to promote R&D for nonfuel minerals and metallurgical science.

The 80 percent of minerals R&D funded by private firms is designed to develop new products and/or increase their competitiveness. However, government funds are essential to help extend the base of scientific knowledge for substitution, conservation, and new materials applications. Private firms do underwrite some basic research, even though its results benefit competitors as well as themselves. That fact limits the funds that private firms can be expected to devote to this use, however.

Compared to the cost of acquiring and maintaining inventories or subsidizing production, research and development might prove inexpensive. If directed particularly toward those materials for which U.S. reliance on foreign sources entails some vulnerability, it could reduce risks considerably, as it has already.

### Foreign Policy and Diplomatic Initiatives

If wars represent the failure of diplomacy, the same may be said of contingencies that might create serious shortages of critical or strategic nonfuel minerals. Foreign policy requires setting priorities among competing national interests that constantly arise in dealing with foreign governments. U.S. interests in reducing vulnerabilities to raw materials shortages

---

11. U.S. Department of Commerce, Critical Materials Requirements, 1981.

12. Batelle-Columbus Laboratory, Assessing the Adequacy of R&D (Columbus, Ohio, February 1979).

have often fallen by the wayside, sometimes because the issue has not been adequately focused on and understood in the policymaking process. Nevertheless, if diplomacy was effective in reducing such vulnerabilities, the economic cost could be very low.

As noted in a recent study, foreign policy could be addressed to any or all of the following: facilitating new exploration and mining; protecting existing mining investment; encouraging political stability and unhampered flow of supplies to foreign markets; encouraging new governments to maintain and expand minerals production and export; discouraging foreign government support of private cartels or participation in restrictive intergovernmental agreements; diversifying sources of supply; encouraging foreign governments to be dependable and reliable suppliers. 13/

Multilateral investment insurance is a promising instrument for encouraging more minerals exploration and development in the Third World. The idea was revived by the current president of the World Bank and endorsed by the U.S. government. The reluctance of many developing countries to participate in such programs has not received much priority in U.S. diplomatic relations with those governments. A higher priority for expanding minerals and metals productive capacity has only recently received much attention in the World Bank's lending program. An opportunity remains for stimulative efforts in U.S. policy toward the World Bank and other multilateral lending agencies.

From a materials vulnerability standpoint, the most important problems for U.S. foreign policy are those in central and southern Africa--South Africa, Zimbabwe, Gabon, Zaire, Zambia, Angola, and Mozambique. The achievement of independence in Zimbabwe has eased the problems of U.S. vulnerability to the interruption of chromium supplies from South Africa, but the reliability of its supplies would be much enhanced if they could be transported effectively and securely through Mozambique rather than South Africa.

Minority rule in South Africa remains a problem in U.S. relations with other African countries and is a source of continuing concern over the reliability of South African supplies, particularly for chromium, platinum, manganese, and industrial diamonds. The present South African government is a reliable supplier and has every reason to remain so in the foreseeable future. Its prospects for retaining control indefinitely are much less promising. If a successor regime took power under conditions that

---

13. Resources for the Future, Major Mineral Supply Problems, Chapter 17, "Foreign Policy Implications."

heightened resentment toward the United States for supporting the present regime, the country could become a much less reliable supplier. Its need for foreign exchange should be a mitigating factor, however, under most circumstances. A friendly successor regime could offer more durable protection for U.S. vulnerabilities.

The risk of peacetime supply interruptions might be more responsive to U.S. diplomatic efforts. A careful foreign policy review, focused on the sources of U.S. concern about materials vulnerability and the possible means of mitigating the likelihood of an interruption or limiting its consequences, could suggest diplomatic efforts that might yield substantial benefits without significant cost to other U.S. interests. The financial cost of such a review and of the measures that it might suggest is unlikely to be large.

# APPENDIX

TABLE A-1. STATUS OF THE NATIONAL DEFENSE STOCKPILE FOR STRATEGIC MINERALS (As of March 31, 1982)

| Mineral | Stockpile Goal (In thousands) a/ | Existing Stockpile (In thousands) | Percent Complete |
|---|---|---|---|
| Aluminum Metal Group | 7,150 | 3,444 | 48 |
| Aluminum | 700 | 2 | 2 |
| Bauxite, metal grade, Jamaica type | 21,000 LDT | 8,859 | 42 |
| Bauxite, metal grade, Surinan type | 6,100 LDT | 5,300 | 86 |
| Aluminum Oxide | 638 | 259 | 41 |
| Abrasive grain | 0 | 51 | Excess |
| Fused crude | 0 | 250 | Excess |
| Bauxite, abrasive grade | 1,000 LCT | 0 | 0 |
| Antimony | 36 | 41 | Excess |
| Asbestos, Amosite | 17 | 43 | Excess |
| Asbestos, Chrysotile | 3 | 10 | Excess |
| Bauxite, Refractory | 1,400 LCT | 175 | 12 |
| Beryllium Metal Group | 1.2 | 1.1 | 87 |
| Ore | 18 | 18 | 100 |
| Beryllium copper metal alloy | 8 | 7 | 94 |
| Beryllium metal | 0.4 | 0.2 | 57 |
| Bismuth | 2,200 LB | 2,081 | 95 |
| Cadmium | 11,700 LB | 6,329 | 54 |
| Chromium, Chemical and Metallurgical Group | 1,353 | 1,325 | 98 |
| Chromite, chemical grade ore | 675 SDT | 242 | 36 |

(Continued)

TABLE A-1. (Continued)

| Mineral | Stockpile Goal (In thousands) a/ | | Existing Stockpile (In thousands) | Percent Complete |
|---|---|---|---|---|
| Chromium, Chemical and Metallurgical Group (Continued) | | | | |
| Chromite, metallurgical grade ore | 3,200 | SDT | 2,488 | 78 |
| Chromium, ferro, high carbon | 185 | | 403 | Excess |
| Chromium, ferro, low carbon | 75 | | 319 | Excess |
| Chromium, ferro, silicon | 90 | | 58 | 65 |
| Chromium, metal | 20 | | 4 | 19 |
| Chromite, Refractory Grade Ore | 850 | | 391 | 46 |
| Cobalt | 85,400 | LB | 40,802 | 48 |
| Columbium Group | 4,850 | LB | 2,511 | 52 |
| Columbium carbide powder | 100 | LB | 21 | 21 |
| Columbium concentrates | 5,600 | LB | 1,780 | 32 |
| Columbium, ferro | 0 | | 931 | Excess |
| Columbium metal | 0 | | 45 | Excess |
| Copper | 1,000 | | 29 | 3 |
| Diamond, Industrial Group | 29,700 | KT | 40,952 | Excess |
| Diamond die, small | 60 | PC | 25 | 42 |
| Diamond, industrial, crushing bort | 22,000 | KT | 23,693 | Excess |
| Diamond, industrial, stones | 7,700 | KT | 17,246 | Excess |
| Fluorspar, Acid Grades | 1,400 | SDT | 896 | 64 |

(Continued)

TABLE A-1. (Continued)

| Mineral | Stockpile Goal (In thousands) a/ | Existing Stockpile (In thousands) | Percent Complete |
|---|---|---|---|
| Fluorspar, Metallurgical Grade | 1,700 SDT | 412 | 24 |
| Graphite, Natural | | | |
| Ceylon, amorphous lump | 6.3 | 5.5 | 8.7 |
| Malagasy, crystalline | 20 | 18 | 90 |
| Other | 2.8 | 2.8 | 100 |
| Iodine | 5,800 LB | 7,756 | Excess |
| Jewel Bearings | 120,000 PC | 70,424 | 59 |
| Lead | 1,100 | 601 | 55 |
| Manganese Dioxide, Battery Grade Group | 87 SDT | 222 | Excess |
| Natural ore | 62 SDT | 219 | Excess |
| Synthetic dioxide | 25 SDT | 3 | 12 |
| Manganese, Chemical, and Metallurgical Group | 1,500 | 1,971 | Excess |
| Ore, chemical grade | 170 SDT | 221 | Excess |
| Ore, metallurgical group | 2,700 SDT | 3,370 | Excess |
| Ferro, high carbon | 439 | 600 | Excess |
| Ferro, medium carbon | 0 | 29 | Excess |
| Ferro, silicon | 0 | 24 | Excess |
| Metal, electrolytic | 0 | 14 | Excess |
| Mercury | 10.5 FL | 189 | Excess |
| Mica, Muscovite, Black, Stained, and Better | 6,200 LB | 5,212 | 84 |
| Mica, Muscovite Film, First and Second Qualities | 90 LB | 1,274 | Excess |

(Continued)

TABLE A-1. (Continued)

| Mineral | Stockpile Goal (In thousands) a/ | Existing Stockpile (In thousands) | Percent Complete |
|---|---|---|---|
| Mica, Muscovite Splittings | 12,630 LB | 18,707 | Excess |
| Mica, Phlogopite Block | 210 LB | 131 | 62 |
| Mica, Phlogopite Splittings | 930 LB | 1,681 | Excess |
| Nickel | 200 | 32 | 16 |
| Platinum Group Metals | | | |
| Iridium | 98 TROZ | 17 | 17 |
| Palladium | 3,000 TROZ | 1,255 | 42 |
| Platinum | 1,310 TROZ | 453 | 35 |
| Quartz Crystals | 600 LB | 2,066 | Excess |
| Rutile | 106 SDT | 39 | 37 |
| Sapphire and Ruby | 0 KT | 16,306 | Excess |
| Silicon Carbide, Crude | 29 | 81 | Excess |
| Silver (Fine) | 0 TROZ | 137,506 | Excess |
| Talc, Steatite Block and Lump | .028 | 1.1 | Excess |
| Tantalum Group | 7,160 LB metal | 2,392 | 33 |
| Tantalum carbide powder | 0 LB | 29 | Excess |
| Tantalum metal | 0 LB | 201 | Excess |
| Tantalum minerals | 8,400 LB | 2,551 | 30 |
| Thorium Nitrate | 600 LB | 7,132 | Excess |

(Continued)

TABLE A-1. (Continued)

| Mineral | Stockpile Goal (In thousands) a/ | Existing Stockpile (In thousands) | Percent Complete |
|---|---|---|---|
| Tin | 42.7 MT | 194.6 | Excess |
| Titanium Sponge | 195 | 32,3 | 17 |
| Tungsten Group | 50,666 LB metal | 79,875 | Excess |
| Carbide powder | 2,000 LB | 2,033 | Excess |
| Ferro | 0 LB | 2,025 | Excess |
| Metal powder | 1,600 LB | 1,899 | Excess |
| Ores and concentrates | 55,450 LB | 86,860 | Excess |
| Vanadium Group | 8.7 | 0.5 | 6 |
| Ferro | 1.0 | 0 | 0 |
| Pentoxide | 7.7 | 0.5 | 7 |
| Zinc | 1,425 | 378 | 27 |

a. Short tons unless otherwise indicated, as below:

| | |
|---|---|
| FL = flask | LT = long ton |
| KT = karat | MT = metric ton |
| LB = pounds | PC = piece |
| LCT = long calcined ton | SDT = short dry ton |
| LDT = long dry ton | TROZ = troy ounce |