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STRATEGIC RESOURCES AND NATIONAL SECURITY
AN INITIAL ASSESSMENT

STANFORD RESEARCH INSTITUTE

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STRATEGIC RESOURCES AND NATIONAL SECURITY: AN INITIAL ASSESSMENT

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Data on 74 nonenergy mineral resources are compiled in a standardized format to facilitate a survey of the use of materials by the U.S. Department of Defense (DOD) from the perspective of resource availability. U.S. Bureau of Mines data on the supply and demand for materials within the U.S. economy are combined with DOD spending data from the U.S. General Services Administration in a calculation of the total use of materials by DOD for the years 1963 through 1972. An input-output matrix of the U.S. economy specifying 399 economic sectors is employed to

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) obtain the estimates to total (i.e., direct plus indirect) use of 65 of the materials by DOD. The data summarized in the report form the basis for an analysis of the likelihood of future materials' supply shortages and the sensitivity of national security to critical shortages of materials.

STRATEGIC RESOURCES AND NATIONAL SECURITY:
AN INITIAL ASSESSMENT

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This report has been prepared by members of the Operations Evaluation Department of the Engineering Systems Division of SRI. Supervision was exercised by Robert M. Rodden, Director of the Department. The project leader was Evan E. Hughes. The major task of calculating estimates of the levels of use of materials for defense purposes was carried out by Sanford Baum. Mark D. Levine contributed to all phases of the work and had special responsibility for the application of the economic input-output model used for the estimates of defense use. Steve W. Woodcock was responsible for obtaining and analyzing data on reserves, resources, imports, and stockpiles.

Richard A. Schmidt, now of Electric Power Research Institute, conceived and planned the project at SRI and led it in the early phases. Evan Just, a consultant to SRI on mining engineering, made substantial contributions to both the data gathering and the analysis aspects of the project. His advice and experience were a valuable asset throughout. William Lawrence, a former director of the Stockpile Division of the Office of Emergency Preparedness, served as a consultant to the SRI project team.

The extensive tasks of data collection, calculation, and presentation of the results were carried out by Patricia Lynch, Lyle Schump, Sally Sherman and L. H. Wu.

Significant contributions to the project have been made by people and organizations outside of SRI. The authors are especially grateful to K. L. Wang of the U.S. Bureau of Mines and to Kiet Ang, Everard Lofting, and Carl Quong of the Mathematics and Computing Group at Lawrence Berkeley Laboratory of the University of California for providing the economic input-output matrix and for carrying out some of the computations at Berkeley.

Discussions with Philip Ritz, Judith Sever, Michael Porter, C. C. Mow, Bernard Springer, and Richard Oliver provided useful information about the uses of input-output analysis and other work in government concerning resource problems. Additionally, we are grateful to Mr. Ritz for providing the military final demand vector for 1967 prior to formal publication of the I/O matrix.

Flow diagrams from annual Commodity Statements were provided by James W. Pennington of the U.S. Bureau of Mines and were extremely useful sources of information. Other U.S. government officials who provided insight and data for the study include: Ray Davis of the Office of the Assistant Secretary of Defense (Installations and Logistics); Alfred Bergmann of Army Materiel Command; Paul Butler and Arnold Marvin of the Department of Commerce; Robert Frandsen, Albert Schulman, and Edward Terrar of the Office of Preparedness of the General Services Administration; and John Morgan of the U.S. Bureau of Mines. We are especially grateful to Mr. Schulman for providing us with the 170 component DOD final demand vector for the years 1963 to 1972. Without this information, the present analysis would have been considerably less complete.

The ARPA technical monitor, Rudy Black, played an important role throughout the project by maintaining regular contact with the SRI team and providing essential advice and criticism.

I SUMMARY AND CONCLUSIONS

This report discusses the use of materials for national defense purposes from the perspective of the availability of the mineral resources. The report covers 74 different materials. Excluded from consideration are energy materials (fuels) and gases (helium, and others). The work reported here constitutes one of the initial phases in a program sponsored by Defense Advanced Research Projects Agency (ARPA) for the purpose of identifying potential shortages of raw materials and actions that could alleviate such problems. The major role of the report in the ARPA program is to provide a data base. The report also presents the first stage of analysis based on the data collected by specifying which of the materials studied appear to be most critical from the perspective of resource availability and national security.

Nearly all the data collected and used in this report are the product of one of four U.S. government agencies. These agencies and the data obtained from them are as follows:

- U.S Bureau of Mines (Department of the Interior) for data on production, consumption, prices, imports, stockpile releases, reserves, and uses of materials.
- U.S. Geological Survey (Department of the Interior) for data on mineral reserves and resources both within the United States and abroad.
- Bureau of Economic Analysis (Department of Commerce) for the input-output matrix of the U.S. economy, 367 sectors (frequently called a 363 sector description), based on 1963 data
- Office of Preparedness (General Services Administration) for tables giving Department of Defense expenditures categorized by sectors of the economy.

Data developed by U.S. Bureau of Mines and used by Lawrence Berkeley Laboratory to set up a 399 sector input-output matrix provided an important element of the analysis.

The results presented here were obtained by compiling data on reserves, resources, supply, and demand for each of the materials into a common framework for display and analysis, and by calculating the defense use of materials from the available economic and mineral data. The results obtained for each material are displayed on data summary sheets presented in Section V. These summary sheets contain (1) line graphs of the trends over the past 5 to 20 years in U.S. consumption, production, prices, net imports, stockpile releases, and defense use; (2) bar graphs showing reserves and resources of the United States and the world; and (3) tables giving the economic sectors for the defense use and the countries of origin of the U.S. imports.

To determine the levels of defense use of materials the 399 sector input-output matrix was used to convert the direct defense procurement from the various sectors of the economy into the total output, direct plus indirect, from each sector for defense. For purposes of this report, "defense-use" means use by the Department of Defense (DOD), because the defense spending data used in the calculations are for DOD procurements. This differs from other analyses that include the Atomic Energy Commission (AEC) procurements as part of national defense. The role of the matrix calculation is to derive from the procurement data--which gives the dollars spent by DOD directly in each sector--the extent to which DOD is also purchasing goods and services from other sectors because of their roles in supporting the sector of the direct DOD purchase. Details of the method are presented in Section IV and Appendix B.

The data summarized in this report can be made the basis for various analyses designed to identify the most critical materials problems and possible approaches to their solution. The sponsor and the authors intend that those interested in strategic resources and national security will find here a useful base for their own analyses of the problem. One possible analysis of the data is presented in Section VI of the report. This section concludes with a summary of the results of that analysis.

The conclusions of this report are summarized in Table 4 in Section VI, where the 74 materials studied are ranked in order from the most critical to the least critical in terms of the likelihood of a shortage having a serious effect on national security. The ranking was obtained by taking the geometric mean of five numerical indicators of criticality, each indicator having a potential range from 1 (not critical) to 10 (very critical). While the precise ordering of the materials should not be considered significant, the materials appearing toward the top of the list can be taken as prime candidates for potential supply problems and, hence, as having the highest priority for further study of strategic resources and national security. The 15 materials of highest priority in this ranking scheme are:

1. Mica--sheet
2. Manganese
3. Platinum group
4. Mercury
5. Tungsten
6. Chromium
7. Antimony
8. Tantalum
9. Fluorine
10. Graphite
11. Cobalt
12. Aluminum
13. Tin
14. Silver
15. Nickel

The criteria included in the particular ranking scheme used to produce this list of materials and priorities are:

- Fraction of U.S. consumption used for defense
- Adequacy of U.S. reserves
- Fraction of U.S. consumption supplied by imports
- Vulnerability of sources of supply
- Difficulty of substitution.

Also presented in Section VI is an alternative ranking (Table 5) that includes two additional criteria. The additional criteria concern the economic and industrial importance of the materials.

II RECOMMENDATIONS

The ARPA program on strategic resources and national security should continue research along three or four lines suggested by this and other preliminary investigations. The possibility of the Department of Defense taking a more active role in the formulation and implementation of policies designed to assure national security in the face of potential shortages of materials should be seriously considered, but not until the options for such a role have been more clearly identified and evaluated.

The major lines for further investigation by ARPA are the following:

(1) Improvement of the present data base. The estimates of defense use of materials obtained for this report are based on the best available method for determining the total dependence, direct plus indirect, of DOD on the numerous sectors of the economy. In the process of gathering the data and carrying out the calculations, SRI has become aware of assumptions and choices that must be made as to sources of information and computational procedures. The adequacy and usefulness of the present results can be improved by some additional sensitivity analysis and comparisons with other results. Gaps in the data summary pages of Section V can be filled by further work.

(2) Projections of future supply and demand situations for various materials. While this report is useful as an indicator of future supply problems and, in fact, expresses the quantities of each material's production, consumption, reserves, and resources in terms of a unit thought to be representative of U.S. annual demand about 1985, both the analysis and the fact-gathering aspects of studies of strategic resources would benefit from a greater emphasis on circumstances likely to occur in the future. Changes in technology and economics could be considered explicitly and made the basis for a revised ranking of the critical materials.

(3) Identification and evaluation of policies and actions to alleviate potential shortages of materials. The present study has served to identify materials most likely to be involved in critical shortages. The data presented here on secondary production (recycling) and stockpiling of materials provide the starting point for an assessment of options available for dealing with problems of supply. These and other options should be systematically identified and evaluated. The most productive evaluation is likely to result from a study of what could be done to alleviate supply problems for the specific materials given a high priority on the basis of the data or analysis in this report.

(4) Implications for foreign policy and international relations. The listing of foreign sources of raw materials given on the data summary pages of this report (Section V) provides a starting point for an evaluation of the vulnerability of the U.S. supply of various materials. A preliminary evaluation along this line is among the ranking criteria used in the analysis of Section VI. Considerably more effort should be expended on identifying the explicit nature and implications of U.S. imports of strategic materials. Comparisons should be made with regard to trade and resource constraints of other countries. Possible responses to international cartels of raw material suppliers should be identified and evaluated.

III INTRODUCTION

A. Historical Aspects and General Remarks

The growth and diversity of demands for mineral raw materials in this century has been phenomenal, particularly in the United States. In the first 35 years of the century, more minerals were used than in all prior history, and that quantity was doubled in the next 35 years. Although some minerals--such as gold, platinum, diamond, and mercury--have always been relatively scarce, within established price ranges none have been scarce enough to discourage their use. Thus, served by such great abundance of minerals, industry has been free to grow and diversify with little constraint. In general, minerals have been cheap to the point of encouraging considerable waste. They have moved freely in world trade, and the United States, with a sixteenth of the world population, has become accustomed to using a third of the world's mineral supplies. (Historical trends in U.S. consumption and production of some mineral materials are shown in the graphs in Appendix A.)

The mineral self-sufficiency of the United States has been gradually declining for many years. Nevertheless, domestic sources still account for about 85 percent of our total requirements in dollar values.

Although the United States has the world's greatest mineral industry--being the leader in such important commodities as oil, natural gas, copper, cement, sand and gravel, stone, lead and molybdenum, and among the top three in coal and iron ore--the value of its mineral production is about three percent of the gross national product, and fuels account for two-thirds of this amount. These are astonishing figures, considering the importance of minerals in the national economy and the fact that civilized living as we know it, or even a populous world under any kind of living, is absolutely dependent on a mineral supply base.

If one scrutinizes the rates of increase of mineral consumption and population growth in this century, it is difficult to believe that trends can continue in the same fashion for more than a decade or two longer. It seems certain that either population growth must be halted or per capita consumption of many minerals must decline because of the inroads of depletion.

Although historically prices of minerals in constant dollars have remained level or declined somewhat in spite of depletion, it seems likely that the immense demands and wastefulness of our times are finally having their effect and that minerals will gradually account for a greater fraction of the gross national product. Moreover, mineral-exporting nations are rapidly becoming more possessive about their mineral reserves and, recognizing that minerals sell cheaply but are essential, they are beginning to charge what the traffic will bear for their mineral exports and forming coalitions to force prices higher. Embargoes or quotas to conserve these depletable assets for their own future use may not be far behind. Thus, the United States and other industrial nations apparently will not only be paying more for their mineral imports, but also will probably be faced with limitations on volume. In addition to fuel shortages, there will probably be raw material shortages in several commodities. Our standard of living will be affected; we shall be moved toward unaccustomed measures of conservation, reclamation, and substitution; and probably there will be constraints on the freedom of equipment designers to choose whatever materials they may wish. Such constraints are likely to have a retardant effect on performance unless the handicaps can be overtaken by improved designs and workmanship.

The current trend toward greater reliance on imports of raw materials is caused in part by the substantial depletion of our domestic mineral resource base. This country began with a fine mineral endowment, and this was still true in the 1920s. Since that time, we have conducted an unparalleled depletion of our resource base; we are in a somewhat better position today than the European countries with regard to mineral resources simply because we started with a larger inheritance.

1. Past Mineral Emergencies

Mineral emergencies or near-emergencies are not new in our national experience. In the First World War, the United States suffered shortages of several minerals, particularly in the ferro-alloy category, which came close to cramping the war effort. Some rationing was done of these short materials to favor military needs. This experience made a sufficient impression on a small group of informed mineral specialists to cause a dedicated effort to forestall subsequent shortages under similar circumstances. The result was the Stockpile Act of 1938.

However, the Second World War followed so closely behind the enactment of this legislation that there was no time to acquire an important mineral inventory; thus, the United States became embroiled in that conflict without such protection. As a result, we were forced to undertake a complicated, troublesome rationing program that, after several collapses and agency shakeups, became part of the Controlled Materials Plan of the War Production Board. Because price controls threatened to impair productivity of lead, zinc, and copper mines, they were subsidized under a program called the Premium Price Plan. The mines, except for gold mines, were favored under the military draft, and soldiers were sent to work in the copper mines. In the foreign field, a large mineral purchase program was conducted by the Board of Economic Warfare. Domestic and foreign purchases were made by Metals Reserve Company. New mineral development was encouraged by floor-price contracts and loans provided by Reconstruction Finance Corporation. Because of all these activities, serious mineral shortages were prevented.

The German submarines developed a means of identifying bauxite ships in convoys coming up from South America, and came very close to cramping our aluminum production, sinking some 96 bauxite vessels. However, the Navy countered the submarine menace before the problem became too serious.

Thus, in regard to mineral supplies, we survived two world wars by only a small margin, with the benefit of much good luck and in spite of a lack of advance preparation. Congress was sufficiently impressed by the experience to strengthen the Stockpile Act and to give strong moral and financial support to the stockpiling program, which proceeded apace during the fifties in spite of high prices. For example, Congress wrote into the Marshall Plan, administered by Economic Cooperation Administration, provisions that a portion of the foreign-aid funds should be used to acquire surplus materials from the participating countries, and to generate new sources of production, taking repayment in kind. Under this program, large inventories of rubber, diamonds, sisal, and strategic mica were acquired, and production of Jamaican bauxite, Algerian lead-zinc, Madagascar graphite, Congolese manganese, and Ubangi diamonds was stimulated.

During the Korean War, no serious shortages of minerals were encountered, as special steps were taken to prevent them. The Defense Minerals Procurement Agency made purchases, extended floor-price contracts, and arranged government loans to new operations. A program of five-year guaranteed prices was set up to encourage domestic production of strategic minerals, and the Defense Minerals Exploration Agency--still functioning as the Office of Minerals Exploration--was organized to subsidize domestic exploration and development of strategic and critical minerals.

2. The Outlook

Despite the assaults that population growth and continued increases of per capita demands are making on national and world mineral resources, and the resultant implications of growing scarcities, it appears that for the rest of this century foresighted measures can prevent mineral shortages from jeopardizing national security. Technological progress has greatly facilitated mineral exploration and extended mineral reserves by making lower and lower grade resources usable. Further progress in these areas may be anticipated. Also, there is a large potential for better reclamation (secondary production). Higher prices can effect a profound influence in furthering discoveries, increasing utilization of lower grade resources, and promoting reclamation. Considering the small fraction of the national effort that mineral supplies now require, our ability to pay much higher prices can hardly be questioned. Moreover, for defense requirements, the continued maintenance of an adequate stockpile is a practicable and even profitable safeguard.

B. Background of This Report

Planning for a study of strategic resources and national security began at ARPA and at SRI during the first half of 1973. As originally conceived, the study was to focus on materials that are obtained largely through imports and to examine the facts and possible solutions relating to potential shortages of these materials. As the plans for an ARPA program in this area were made more specific, the need for a broad data base consistent with the special concerns of national defense became apparent. Therefore, the initial contribution by SRI to the ARPA program took the form of the present study. This study can be characterized as a survey of supply-demand relationships for a wide spectrum of materials combined with a determination of the level of defense use of the materials.

The method of approach and the sources of data for this report are described in Section IV, which follows immediately. In summary, this report combines data on materials and resources from the Department of the Interior with economic analysis based in part on information from the Department of Commerce and the General Services Administration to reveal the defense use of materials in the context of availability of the raw materials.

The exclusion of the energy minerals--e.g., coal, natural gas, oil, and uranium--from this study is explained by the fact that ARPA has previously sponsored similar research focused on such resources and their use for national defense.[1]*

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*Numerical superscripts refer to the references listed at the end of the report.

IV METHOD OF APPROACH

The objectives of this study are the formulation of a data base for the ARPA program on strategic resources and the use of that data base in a preliminary analysis of potential resource problems. The data base is presented in the form of the data summary pages for 76 materials that constitute the bulk of the following section (Section V). This section describes the procedures and sources used in the production of those data summary pages. The last section of the report (Section VI) describes the procedure used in the preliminary analysis of the data and presents the results of that analysis.

The organization of this section is keyed to the presentation used for the data summary pages. Thus, the following subsections describe the derivation of the data presented in each part of the data summaries.

A. Specification of a Unit for Each Material

To reconcile the vast range in the quantities of different materials used in the United States with the desire to display the trends in U.S. consumption and production in a linear graph common to all the materials, a unit of quantity was adopted individually for each material. The intended use of the data base in the ARPA strategic resources program suggested the choice of a unit that reflects the level of use of each material in the future period for which planning is intended. Therefore, a procedure was adopted to systematically derive a unit for each material that is characteristic of U.S. annual demand for that material anticipated within a few years before or after 1985.

The basis for the quantity used as the unit is a projection of cumulative consumption of each material in the United States made by the Bureau of Mines. These projections are presented in a set of summary tables prepared by BuMines in 1974 and based on 1972 data.[2] The values given in this source are the cumulative primary demand for the period 1972 to 2000, expressed as the quantity of the elemental material (e.g., as quantity of aluminum rather than bauxite or any other form in which aluminum may be traded or used). These cumulative demand values were divided by 28 to obtain an average annual consumption characteristic of the period of projection. Because the BuMines projected only primary demand (that derived from mines) while the report includes secondary (reclaimed, recycled, scrap, and the like) material as a factor in both consumption and production, the unit had to be adjusted to account for secondary material in about a dozen cases where such sources are an important part of annual supply. The adjustment was made using a factor that would approximately scale 1968 and 1972 primary demand up to total demand for those years. The factors were calculated from data given in the flow diagrams from the Commodity Statements for the years 1968 and 1972,[3] copies of which were provided to SRI by the Bureau of Mines. The unit sizes so calculated were expressed to two-figure accuracy and rounded to the nearest 5 to obtain the units adopted for the individual materials.

B. Consumption and Production

The data on U.S. consumption and production of the materials are taken almost exclusively from Bureau of Mines publications. The Minerals Yearbooks[4] for 1971, 1966, 1961, 1956, and 1951 were used for much of this information. (Five year trends are usually given in each yearbook; hence, the particular volumes indicated.) Late in the project flow diagrams[3] were obtained for 1968 to 1972, and these were used to correct production and consumption trends for some materials. The flow diagrams were especially useful because the quantities shown in them are expressed in terms of the elemental material and, therefore, made it possible to avoid the frequently complicated conversions of Minerals Yearbook data to the elemental form. The flow diagrams were taken as the standard, and whenever possible, the figures chosen from Minerals Yearbook were those that were consistent with the flow diagrams. (The only flow diagrams generally published are those used throughout Minerals Facts and Problems 1970[5] to show the supply-demand relationships for materials in 1968.)

The flow diagrams were also used to obtain the 1972 world production of each material.

C. Prices

Price trends for the period 1950 to 1971 have been compiled for over a third of the materials studied. The prices have been converted to a price index reflecting the price in constant (i.e., deflated) dollars on a basis defined to set the 1971 price at index value 100. The formula used to compute the price index for each year is

$$\text{Price Index} = 100 \times \frac{\text{Price for year}}{\text{Price for 1971}} \times \frac{\text{Wholesale Price Index for 1971}}{\text{Wholesale Price Index for year}}$$

In the charts, the Price Index is called "Price Relative to Constant Dollars".

The annual values of the Wholesale Price Index (WPI) are taken from Statistical Abstract of the United States, 1974.[6] The overall WPI is used rather than the WPI for the mineral industries because the intent is to display mineral prices relative to the rest of the economy. The prices used are those whose trends are indicated in the Minerals Yearbooks.[4] In some cases, trends of prices were taken from data compiled by SRI and published for private circulation, such as the Chemical

Economics Handbook.[7] In these cases, the prices chosen to indicate the trend are those that appear consistent with the Minerals Yearbooks.

D. Imports

The data summary pages of Section V display information concerning imports in two forms. One is a graph showing the trends of net imports, defined as imports minus exports, expressed as a percent of the annual consumption. The other is a table concerning import sources that shows the countries from which U.S. imports of each material were obtained in 1972.

Because the form and detail of information on imports and exports varies considerably from one material to another in the Minerals Yearbook, it has not been possible to show consistent trends of net imports from 1950 to 1972 for all materials. The flow diagrams[3] have been most useful in interpreting the Minerals Yearbook[4] data for nearly all materials. For a number of materials only the 1968- to 1972 net import trends could be included in the data summaries. In these cases the net imports were derived from the flow diagrams[3] for those years.

The tables displaying 1972 import sources were derived from the U.S. Bureau of Mines' flow diagrams.[3] The diagrams represent the most recent year for which data are available and are based on preliminary calculations by the Bureau.

The list under Import Sources omits countries that are significant producers if they did not supply any of the U.S. demand for that particular material in 1972. It includes countries that supplied a portion of their primary production to the United States either directly or through other countries. It also includes some countries that had no primary production of their own but supplied a portion of their production from imported ores to the United States. In some cases, such an intermediate producer may be supplied by only one primary producer; therefore, the amount sent to the

United States by the country that processes the ore is credited to the primary producer, with the intermediate omitted from the table. In other cases, an intermediate producer may have its own primary production, or may receive material from several primary producers. An exact, quantitative account of materials flow from primary producers through intermediates and thence to the United States cannot always be determined from available data. The quantity of material derived from such poorly defined sources is included in the table but without reference to specific primary sources.

These tables of import sources provide, insofar as is possible, an indication of the ultimate commerce from import countries to the United States, for the year 1972. For each material, they show how much was produced by each import source relative to the world total, what proportion of this production was sent to the United States, and how much of the total U.S. demand this import segment represents. As demonstrated by the tables, countries with no primary production may nonetheless supply a substantial portion of U.S. demand. Countries with a large proportion of the world's production may send little to the United States, and there are a number of variations in between. Some materials may be considered domestically sufficient for 1972, as noted on the data summary pages, when U.S. production exceeds or equals demand. Some of these domestically sufficient materials may also be imported, primarily for the purpose of reexport, but this is not shown in the tables. A few materials were supplied entirely from industry stocks accumulated from earlier imports or domestic production, and a few materials were imported in excess of demand, for reexport or industry stocks.

E. Government Stockpiles

It was originally intended to display data on stockpile acquisitions and releases over the last two decades, but the limitations on obtaining such data make this task unfeasible within the deadline of this report. The General Services Administration, through the Office of Preparedness, administers the stockpiling programs of the U.S. government. GSA supplied information on stockpile acquisition and releases: semi-annual reports listing inventory levels from 1967 to 1973,[9] and a discontinuous listing of inventory levels at irregular intervals over the past 25 years.[10] This information did not meet the immediate needs of this study, which would have required a continuous annual monitoring of inventory levels over the past quarter century and a convenient conversion to the elemental forms of the materials. GSA indicated that such information is on tape, but is accessible only through an effort beyond the limits of this report. Whether alternate sources can be found remains to be seen. Without a continuous record of stockpile acquisitions and releases, the interrelationships between stockpiling activities and other avenues of materials supply and demand cannot be clarified for most of the period between 1950 and 1972.

However, for the five years from 1968 to 1972, the flow diagrams[3] give the quantities of material released from or acquired by the government stockpiles. These figures are presented on the data summary paper as annual stockpile releases expressed as percent of the annual U.S. consumption.

F. Resources and Reserves

Resources and reserves are distinguished, respectively, by geologic criteria and economic considerations applied to such geologic criteria. A resource is the ultimately available quantity that is concentrated in accessible places. A reserve is the portion thereof that is currently known and obtainable at current prices and costs and technology. Accessible places are usually confined to the minable depth of the continental crust, although for specific materials, such as manganese or magnesium, the sea floor or even the sea itself may be included. A concentration is a condition where the material is found in greater proportion than its average crustal abundance. Thus, implicit in the concept of resources are broad economic and technological assumptions. Specific economic and technological parameters are used to delineate the extent of reserves.

Reserves are more reliably estimated than resources, since they are the basis of the current minerals industry. Nevertheless, discoveries from increased exploration, variations in cost of extraction, fluctuations in demand, or improvements in technology can all radically affect the reserve quantity. Resource figures are presumed to be more stable, but increased knowledge of geology can affect these estimates as well. For both resources and reserves, amounts in other countries are usually harder to judge than amounts in the United States. Consequently, these figures are an indication of how much the experts know and are willing to guess, and are not statements of absolute fact. The margin for error is at least ±50 percent.

Reserves and resources are charted on a logarithmic scale in the data summary pages and measured in the same units used to express production and consumption data on those pages. All figures were converted to conform with the standard units of measure. When data sources gave amounts in terms of oxides, the conversion to metal was computed by proportion of atomic weight. When amounts were given in terms of ore, an average or prevailing grade of ore was determined and applied. When estimates were made as probable multiples of quantitative figures given elsewhere, such computations were followed. In some cases, data were not available, but a description estimation was given by a reference. Accordingly, the term "insignificant" generally indicates a quantity less than ten units, and the term "large" generally indicates a quantity greater than 1000 units.

The primary source for U.S. and world reserve figures was Table 14A from the Bureau of Mines Commodity Statement Summary Tables.[2] Most modifications of these figures were based on the Bureau of Mines Commodity Data Summaries, 1974,[8] which gives a more detailed treatment of each material. A few reserve estimates came from U.S. Geological Survey Professional Paper 820, 1973,[11] when Bureau of Mines estimates seemed too modest by comparison, or were lacking. The primary source for resource figures was USGS Professional Paper 820, United States Mineral Resources.[11] Some figures were taken from the Commodity Data Summaries,[8] which themselves rely upon PP820. A few numbers were used from the Bureau of Mines Mineral Facts and Problems, 1970.[5]

G. Defense Use of Materials

This report addresses the problem of estimating DOD use of materials to provide baseline information for DOD planning and to better assess potential problems in supply that may result from a large dependence on specific materials. The most straightforward solution to the problem of estimating DOD materials' consumption is the evaluation of detailed records of DOD procurement for the years of interest. Such a direct estimation of DOD consumption would not provide adequate results for several reasons. The data sources for this information, known as bills of materials, are not available in a unified or consistent form, nor do they adequately describe the material content of items that the DOD purchases. Even if it were possible to estimate direct materials' consumption by DOD, the failure to include indirect usage of materials (i.e., the material used in the production or delivery of the item purchased by DOD) would introduce a significant error into the estimates.

Because of limitations in the data and the inadequacies of estimating DOD consumption by direct methods, we have chosen an indirect procedure, which employs input/output analysis, to address the problem. This method entails:

- Use of a 399 sector I/O table and defense procurements for 399 sectors (for the years 1963 to 1972) to estimate both direct and indirect DOD purchases in dollars from the industrial sectors.

- Conversion of the direct and indirect DOD dollar purchases from the sectors of the economy into quantities of materials used by DOD.

This approach allows us to take the amount of material provided as input to various producing sectors and to determine the amount of that material that is delivered, or otherwise used, directly or indirectly, by the DOD. The first part of the approach represents a straightforward application of I/O techniques. The second part requires a blending of minerals data, namely, the Bureau of Mines descriptions of end-use of materials,[5] with economic data.

The value of output used by the military directly or indirectly was generated by the use of standardized I/O techniques that will be detailed below and in Appendix B. In effect, these techniques relate the sales made to final demand (e.g., households, or in the present case, the DOD) to the intermediate output from various economic sectors. The technique takes into account the fact that the product delivered to final demand by a given producing sector includes inputs from other sectors, and that part of the output from the given sector will be utilized as an input by other sectors. The computational procedure includes the multiplication of a matrix that contains information about dollar flows among industrial sectors in the economy (termed intermediate demands) by a vector of military final demands. The resulting product is a vector of total outputs that DOD derives directly and indirectly from the various producing sectors to meet the military final demand.

The I/O matrix used in this work is a variant of the standard "Input-Output Structure of the U.S. Economy for 1963," published by the Department of Commerce.[12] The variant was developed by the Bureau of Mines; it was tested and used for applications by the Sanitary Engineering Research Laboratory (SERL) of the University of California. The matrix differs from those in standard I/O tables in that the I/O sectors responsible for the introduction of material inputs into the U.S. economy (e.g., ferrous minerals or coal) are expanded to a greater level of detail. This has the effect of expanding the number of sectors from 363 to 399. The resulting matrix treats the minerals-producing sectors in greater detail than any other I/O matrix that has been developed, and this feature is expected to be useful in further analysis of materials use. The data and system of programs is described in a SERL report entitled "Computational Aspects of Input-Output Analysis Applied to Resources Management.[13]

The military final demand vectors, to which the SERL matrix was applied, are based on data from work by Mr. Albert Schulman,[14] Office of Preparedness, General Service Administration. The data contain Mr. Schulman's determinations of DOD final demand for the years 1963 through 1972. Each vector consists of 170 components. Some of the components represent an aggregation of sectors in the 363 component (final demand vector developed for the years 1963 and 1967 by the Bureau of Labor Statistics) others, notably in the construction area, represent expansions. Schulman's methods and some of his results are described in References 15 and 16.

To apply the SERL matrix, it was necessary to perform data aggregations and disaggregations that would convert the 170 component vectors into a form consistent with the 399 component vectors. This was achieved by first converting the 170 component vectors into the standard, i.e., 363, component vectors. The aggregations were straightforward, since the component descriptors provided by Mr. Schulman made clear the components that had to be summed to convert the vector into the standard industrial code format consistent with the I/O matrix. The disaggregation of the 170 component vector was equally straightforward. It was accomplished by using the standard 363 component vector for 1963, compiled by the Bureau of Labor Statistics, as a model for the disaggregation: The DOD final demands in any given year were made consistent with the distribution of DOD final demands among sectors in 1963.* Values for the components of 1963 military final demand are given in the standard tables for that year.† Expansion from the 363 component vector to the 399 component vector was achieved by essentially the same procedure. In this case, the basis for the disaggregation was a 399 component vector[17] expanded from the 1963 standard vector on the basis of the principles used to expand the 399 sector SERL matrix.

Application of the SERL matrix to the 399 component vector of military final demand results in a vector of total military purchases (direct and indirect) required to meet the final DOD demand. Each component of the vector produced by this process represents the total sales, from a producing sector, that are required to support the military requirements for the corresponding year.

Data from the Bureau of Mines were used to relate the quantity of a given material consumed by the military to the vectors of total military purchases. The data from the Bureau of Mines specified the quantity of a given material used as inputs by various producing sectors, or, more frequently, by various groups of sectors. The amount of a given material consumed per dollar of total sales is derived by dividing the amount of material in a specified input sector(s) by the total sales to the entire U.S. economy from the specified sector or by the summed total sales from the specified group of sectors. Multiplication of this quantity by the total military sales for the sector(s) results in an estimate of the amount of the material required from the sector of the military. By repeating this process to obtain the flow of materials to DOD from each

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*The most recent final demand vector compiled by the Bureau of Labor Statistics is that for 1967. This vector was not used as the basis for the disaggregation because it has not yet been fully authenticated.

†See column 97.10, Volume I of Reference 12.

sector and then summing the results, an estimate of the total amount of the various materials required for the satisfaction of military demands is generated.

This estimate of military demand for a material is divided by the total amount of a material supplied to the U.S. economy to obtain an estimate of the fraction of the total material input consumed by the military.

The data on minerals use required for conversion of the dollar demands into material demands were taken from the 1970 edition of Minerals Facts and Problems.[5] The information is given there in the flow diagrams showing the supply-demand relationships for the individual materials for the year 1968. These give the U.S. consumption (called "demand" on the diagrams) of material in that year. The consumption or demand data for other years were taken from other Bureau of Mines sources: The information for the years 1969 through 1972 was obtained from unpublished flow diagrams for supply-demand relationships,[3] courtesy of J. W. Pennington. Commodity Data Summaries[18] were used for the U.S. consumption in the years 1963 to 1967. Since these latter consumption data do not always include consumption of secondary (recycled) material, they can be different from the true U.S. demand for materials. To avoid gross discrepancies, comparisons between the independent estimates of consumption and demand were made, and, if differences greater than 10 percent were observed, no attempt was made to calculate defense use for the years prior to 1968.

The data on the (sector) total sales to the entire economy were obtained by expanding recently available 1967 I/O data from a 363 sector format to a 399 sector format, again according to the principles used to create the SERL matrix.[17] These total sales data were converted to 1968 dollars by applying a factor of 1.08, the ratio of 1968 GNP and 1967 GNP in current dollars.[19] All entries in the I/O matrix and the DoD final demand vectors for all years were expressed in 1963 dollars. The output vector produced by the matrix multiplication was converted from 1963 dollars to 1968 dollars. The conversion factor was 1.08, as determined from the Wholesale Price Index for all commodities.[6]

Several points should be made concerning the concepts that formed the foundation of the input/output approach used here. The basic assumption implicit in the approach is that intermediate flows through the economy to final military demand have the same relative composition as intermediate flows that contribute to the final demand of the entire economy. Obviously, this approach is more appropriate to some producing sectors than it is to others, but no alternative assumption appeared possible at this time. Future work may be needed to evaluate and improve upon this assumption.

A second assumption was that the quantity of a material derived from a given sector is proportional to the demand from the sector in dollars. For DOD, this is equivalent to assuming that DOD final demand from a given sector corresponds to the average output of the sector. Thus, a customer that generates twice the sales volume of a sector is expected to use, directly or indirectly, twice the amount of material from the sector, regardless of his specific purchases from the sector. As in the case of the first concept, this assumption is obviously more appropriate to some sectors than it is to others--but no alternative assumption appears possible at this time.

V PRESENTATION OF THE DATA

The data compiled in the course of this study are displayed on the data summary pages that constitute most of this section. The information concerning each material has been put into a standard format of graphs and tables on a data summary page. An additional page of notes about each material accompanies the appropriate data summary page. This complete section of the report consists of an explanation of the standard format for data summary, the data and notes on each material, and details concerning the important case of iron.

A. Description of the Data Summary Pages

Section IV described the methodology and sources used to compile each of the categories of information displayed in the data summaries. Therefore, the presentation here is limited to a listing of the headings found on the data summary pages and a description of the kind of information displayed under each heading.

- Data Summary: The materials are ordered alphabetically and named according to the elemental content (e.g., "aluminum" rather than "bauxite," "fluorine" rather than "fluorspar," and so forth). The unit used to express absolute quantities of the material is specified under the name. The 1972 world primary production of the material is given next in terms of the unit just defined.
- U.S. Consumption and Production: This graph shows total consumption (C) of material in the United States in the form specified by the name (e.g., chromium not chromite or Cr_2O_3), with the quantity expressed in the unit defined at the top of the page. Both total consumption (C) and production (P) include primary and secondary material (i.e., material derived from mine production and reclaimed from scrap, respectively). In those cases where secondary production (SP) is

a substantial contributor to total production (P) in the United States, it is shown as a separate curve. Production (both P and SP) is that from domestic ores and scrap, and excludes material that may be refined in the United States from imported raw materials.

The curve or line projecting consumption (C) to the end of the century has been composed by SRI specifically for this report, but is based on a Bureau of Mines projection of cumulative U.S. demand to the end of the century.[3] The projection has been drawn to make the cumulative demand from 1972 to 2000 equal about 28 units, as is consistent with the derivation of the unit size described in Section IV-A. The projections so drawn tend to fall in the middle of the range of projections shown in Minerals Facts and Problems, 1970.[4]

- Price Relative to Constant Dollars: The derivation of the price index shown in this graph on a logarithmic scale has been described in Section IV-C. The annual average Wholesale Price Index has been used to convert the annual average price for some form of the material into constant dollars. The notes on each material specify the form to which the price applies.

- Net Imports and Stockpile Releases: The net import (NI) graph expresses the excess of imports over exports as a percent of total U.S. consumption (C) for each year. The elemental content of imports and exports of the material in any form (ore, concentrate, ingot, or other) other than finished or mill products is taken into account.

  As explained in Section IV-E, the lack of data in a convenient form has prevented the presentation of a complete trend graph for stockpile releases (SR) on an annual basis. Suitable data were available for the period 1968 to 1972 and are shown here as a percent of U.S. consumption (C) for each of these years. Note that the term "stockpile" means U.S. government stockpiles and not industry stocks.

  Negative values of net imports (NI) indicate a net export. Similarly, negative values of stockpile releases (SR) indicate an acquisition by the government for the stockpile.

- Reserves and Resources: These bar graphs express reserves and resources on a logarithmic scale in terms of the unit defined at the top of the page. Because this unit approximates the U.S. consumption expected in some future year (circa 1985), the numerical values for U.S. reserves and resources approximate the years of supply at some possible future consumption level. To interpret the world figures in a similar way, the fact that the unit is tied to U.S. consumption, which is but a fraction (often about one-third) of world consumption, must be taken into account. The definitions of reserves and resources given in Section IV-F make clear the economic considerations that dominate reserve estimates and the uncertainties in both reserve and resource estimates. These factors should serve as precautions against taking the bars shown too literally as years of supply.

- Defense Use: This graph shows the trend of defense use of the material, expressed as the percent of total U.S. consumption of the material in each of the years 1963 through 1972. The derivation of the values shown is described in detail in Section IV-G and Appendix B. As described in those sections, the basis for these defense use estimates is expenditures by the Department of Defense (DOD) and does not include expenditures by the Atomic Energy Commission (AEC). A comparison of DOD and AEC expenditures relative to each other and to the United States GNP for the years 1963 to 1972 is given in Table 6 in Section VI.

- Defense Use by Sector: This graph shows the fractions of the total defense use accounted for by procurements, directly and indirectly, from various sectors of the economy. The numbers labeling the curves refer to the sectors named in the table immediately below the graph. The fractions shown on the charts are on a cumulative basis and total to 100 percent.

- Identification of Sectors: This table presents the legend explaining the numerical labels in the graph above it and also gives the percentage in 1972 of total defense use of the material accounted for by procurements, directly and indirectly, from the economic sectors associated with the major defense uses.

- Sources of Imports 1972: This table lists the countries from which the United States obtained significant fractions of the material in 1972. It also shows what fraction of the world primary production was accounted for by each country in 1972 and the fraction of each country's production sent to the United States. The final column shows the fraction of U.S. consumption in 1972 accounted for by imports from each country. The total of the last column may not agree with the percent net imports shown for 1972 in the graph New Imports and Stockpile Releases because the graph includes the effect of exports. Further comments on this table are contained in Section IV-D.

B. Data Summary Pages

The following pages present the data on each of the materials included in this study. Facing each data summary page is a page of notes on the particular material. The materials included are:

Aluminum	Mica, Sheet
Antimony	Molybdenum
Arsenic	Nickel
Asbestos	Niobium (see Columbium)
Barium	Nitrogen
Beryllium	Palladium
Bismuth	Perlite
Boron	Phosphorus
Bromine	Platinum
Cadmium	Platinum Group
Calcium	Potassium
Cesium	Pumice
Chlorine	Rare Earths
Chromium	Rhenium
Clays	Rhodium
Cobalt	Rubidium
Columbium	Sand and Gravel
Copper	Selenium
Corundum	Silicon
Diatomite	Silver
Feldspar	Sodium
Fluorine	Stone (crushed)
Gallium	Stone (dimension)
Garnet	Strontium
Germanium	Sulfur
Gold	Talc
Graphite	Tantalum
Gypsum	Tellurium
Hafnium	Thallium
Indium	Thorium
Iodine	Tin
Iron	Titanium
Kyanite	Tungsten
Lead	Vanadium
Lithium	Vermiculite
Magnesium	Yttrium
Manganese	Zinc
Mercury	Zirconium
Mica, Scrap and flake	

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NOTES ON ALUMINUM

Uses: Auto pistons, blocks, transmissions, trim, body, brakes, steering, paint, accessories, trucks, buses, trailers, semis. Aircraft, marine, rail applications. Cargo containers. Residential siding, doors, windows, roofing, awnings, heating and ventilation, curtain walls, screen frames and screening, railing, prefabrications. Bridge, street and highway applications. Cable for high voltage transmission lines, towers, conduit, telephone cable, machinery, lighting fixtures, capacitors. Large and small appliances, furniture, utensils. Foil, caps, cans, other containers. Machinery, handling equipment, irrigation pipe. Superpurity for octane catalyst, jewelry.

Consumption and Production: Both primary and secondary production and consumption are included. The drop in secondary production and total production indicated for 1972 can be attributed to a change in the presentation of statistics by Bureau of Mines, namely, the dropping of "new scrap" as a source of secondary production.

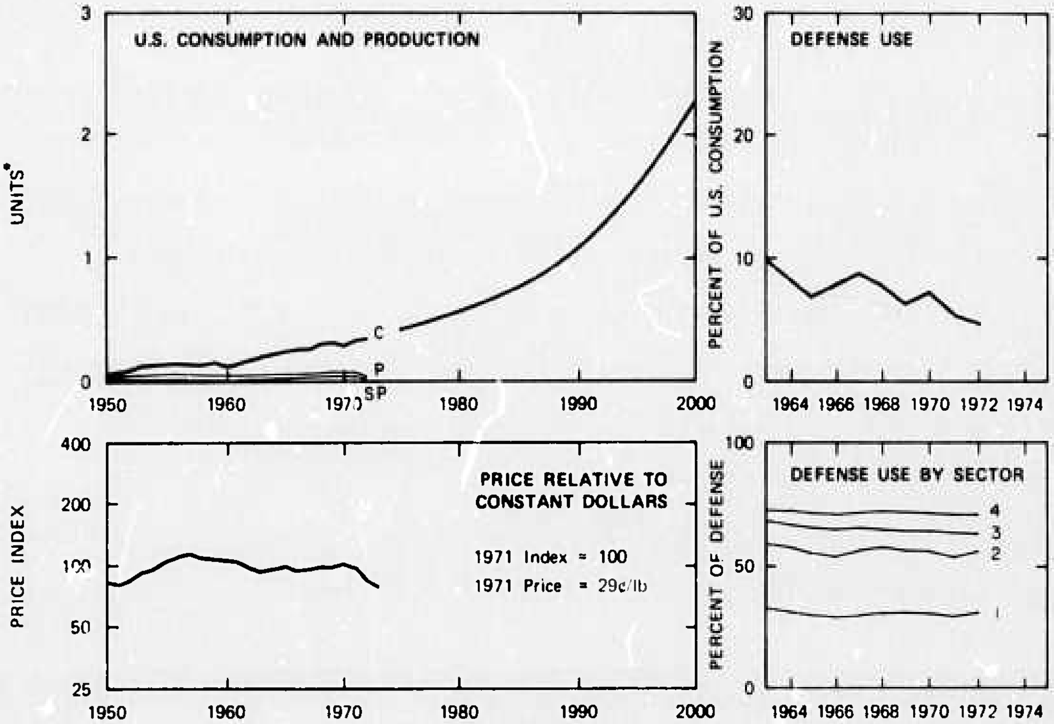
Price: The price given is the average for aluminum ingot.

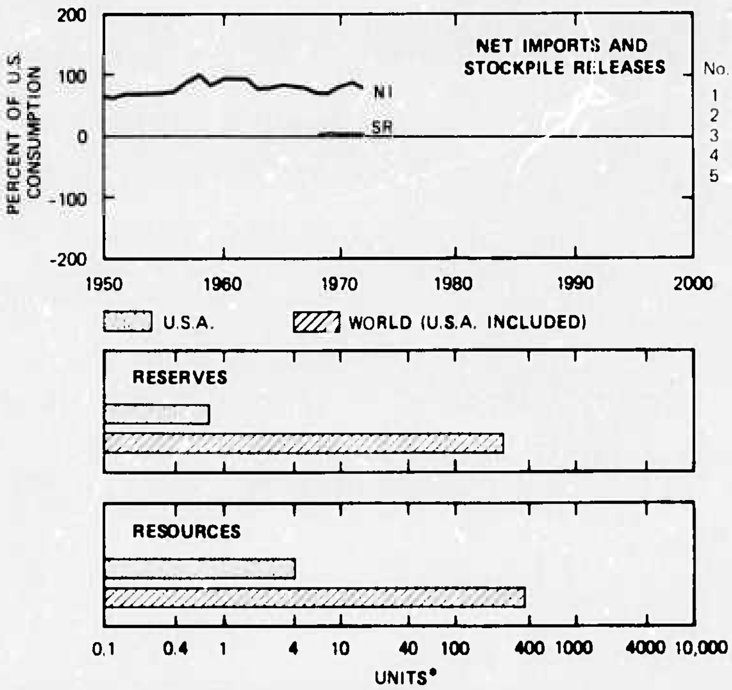
Imports: The percentages given are based on the combined elemental content of bauxite, alumina, and metal.

Stockpile: Aluminum is included on the list of Basic Stockpile Materials, 1972, in the following forms: Metal: abrasive grain oxide; crude fused oxide, Jamaican metal grade bauxite; Surinam metal grade bauxite; refractory bauxite. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance 1972 = 5,319,000 short tons of aluminum.

Reserves and Resources: The figures shown are for bauxite deposits only. Other domestic sources are vast but require new technology or higher prices to be brought into production.

DATA SUMMARY: ALUMINUM
One Unit = 15,000,000 Short Tons
1972 World Production = 1.0 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Electrical Equip., Supplies	32
2	Aircraft and Parts	24
3	General Building Contractors	9
4	Motor Vehicles	8
5	Other (Estimated)	27
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	21	21	13
Jamaica	18	70	37
Surinam	12	55	19
Guyana	7	21	4
France	5	6	<1
Dom. Rep.	2	70	4
Haiti	1	63	2
Canada	0	–	11
Norway	0	–	1
Japan	0	–	1
Other	15	9	4
			96

*Unit defined at top of page

NOTES ON ANTIMONY

Uses: Alloy with lead, other metals for battery grids, chemical pumps and pipes, tank linings, roofing sheets, cable sheaths, antifriction bearings, decorative castings, small arms bullets. Antimony oxides, sulfides, in metalware, ceramic enamels, special glass, pigments, infrared reflecting camouflage paints, vulcanizing agent, UV absorber for textiles, fire-resistant military fabrics, tracer bullets, smoke markers, percussion-type ammunition. High-purity metal for semiconductors, thermoelectric devices.

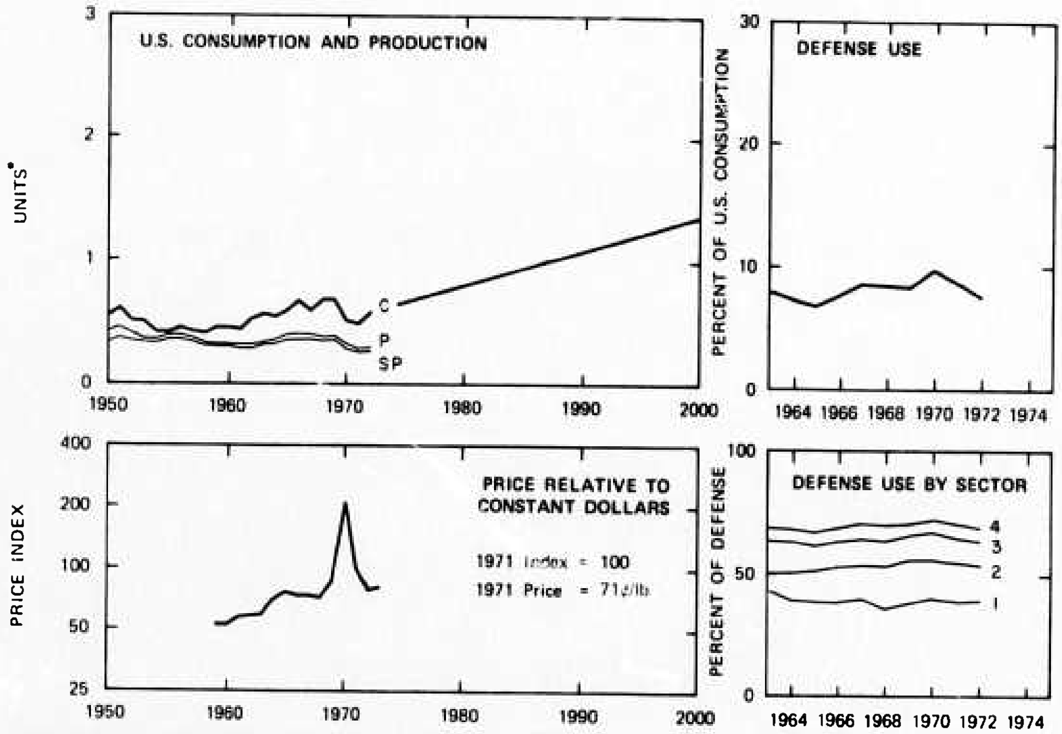
Price: The price given is the average in New York.

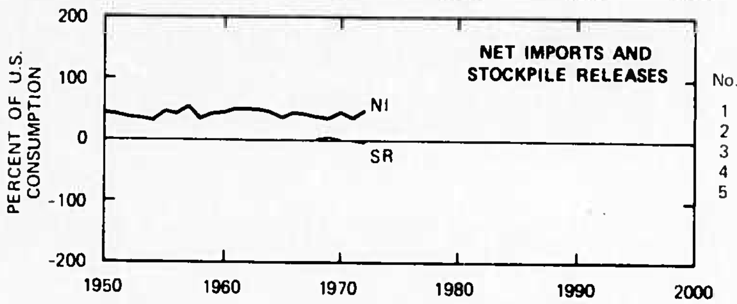
Imports: The percentages given are based on the combined elemental content of metal and oxide.

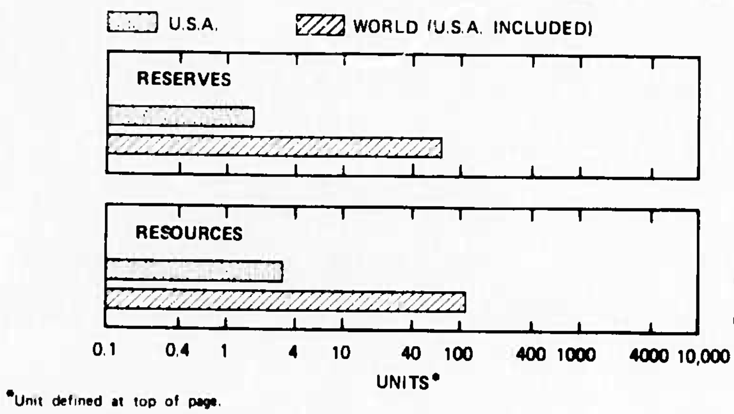
Stockpile: Antimony is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. The government stockpile balance for 1973 is 46,676 short tons.

Resources and Reserves: Economic estimates are based on by-product and co-product association with multiple element ores.

DATA SUMMARY: ANTIMONY
One Unit = 65,000 Short Tons
1972 World Production = 1.2 units







*Unit defined at top of page.

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Storage Batteries	40
2	Fire Retardant Chemicals	14
3	Communication Equipment	10
4	Industrial Chemicals, Pigments	6
5	Other (Estimated)	30
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported of U.S.	Percent of U.S. Demand Supplied
South Africa	21	58	24
Bolivia	19	13	5
China	17	13	4
Thailand	7	NA	NA
Mexico	6	42	5
Yugoslavia	4	8	<1
Australia	2	2	<1
Morocco	1	NA	NA
Peru	1	3	<1
Chile	NA	NA	3
France	NA	NA	3
Other	5	35	4
			48

NOTES ON ARSENIC

Uses: Insecticides, herbicides, fungicides, algaecides, tapeworm eradicants, livestock dips, wood preservatives, dyestuffs, cotton leaf desicants. Decolorizer, opal glass. Enamels. Flotation reagent. Lead hardener for auto engines. Copper alloy for radiators, other soldered components. Skin disorder and animal therapy.

Consumption and Production: Arsenic trioxide (white arsenic) is produced by one company as a by-product of base metal ores and production figures are not published.

Price: The price quoted is that of refined white arsenic, 99.5 percent, at New York docks, in barrels, small lots.

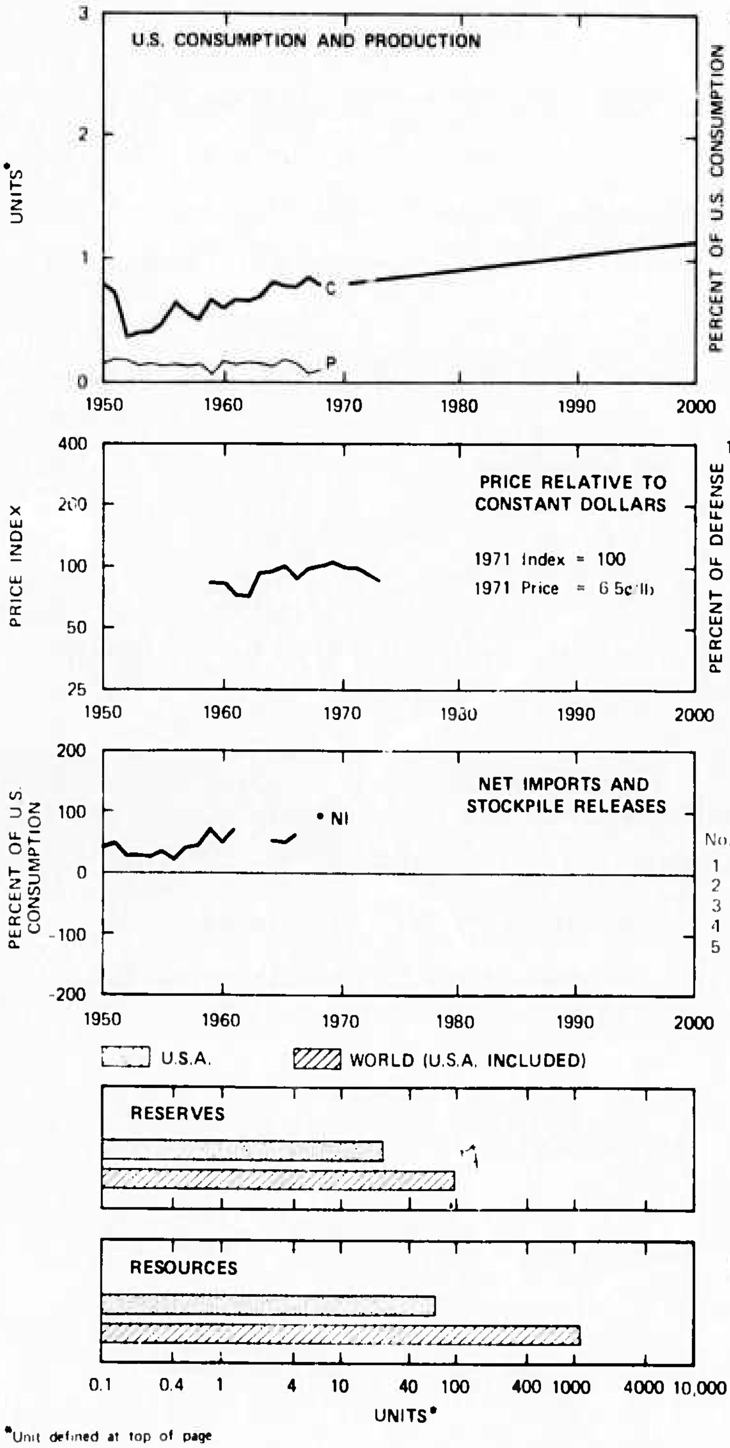
Imports: Percentages are based on the combined elemental content of compounds and metal.

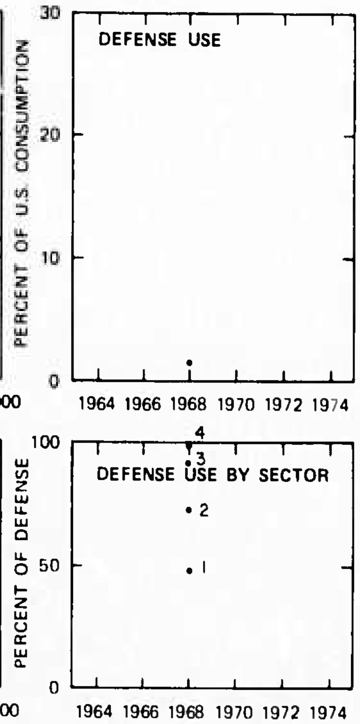
Stockpile: Arsenic is not on the list of Basic Stockpile Materials, 1972.

Resources and Reserves: Economic estimates are based on by-product and co-product association with complex base metal ores.

Defense Use: U.S. demand data acceptable for the defense use estimate was available only for 1968.

DATA SUMMARY: ARSENIC
One Unit = 30,000 Short Tons
1972 World Production = 1.6 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Agricultural Chem. (Pesticide)	48
2	Nonferr. Alloys (Copper Lead)	24
3	Industrial Inorg. Chem. (C.R)	19
4	Glass and Glassware	8
5	Other (Estimated)	1
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Sweden	28	51	NA
France	17	14	NA
Philippines	12	100	NA
Mexico	10	55	NA
S.W. Africa	7	6	NA
Peru	6	72	NA
Canada	<1	88	NA
Other	NA	NA	NA

NOTES ON ASBESTOS

Uses: Fireproof textiles, packings, woven brake linings, clutch facings, electrical insulation, high pressure and marine insulation, pipe for transporting water, pipe insulation and wrappings, vinyl sheet backings, millboard, filler in vinyl and asphalt floor tile, joint and insulation cements, roof coatings, plastics, caulking compounds, blanket insulation for marine turbines and jet engines, marine partition board, filters, welding rod coating.

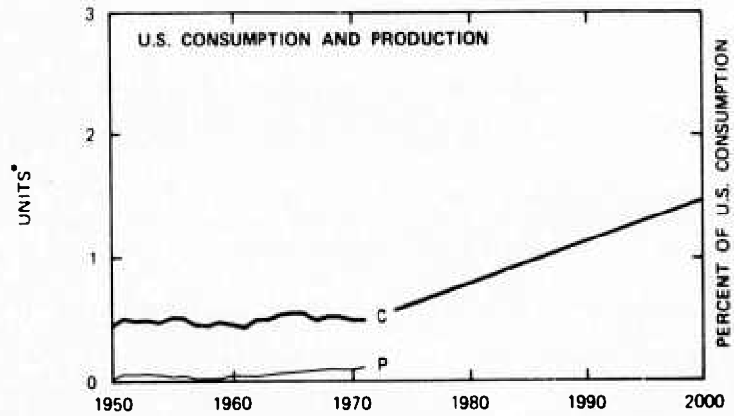
Price: The price quoted is an average, f.o.b. mine.

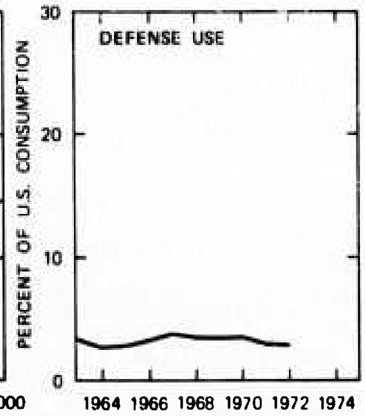
Imports: Percentages are based on combined figures for chrysotile, crocidolite, and amosite.

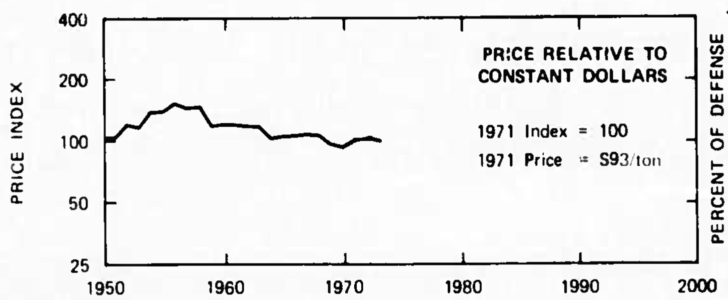
Stockpile: Asbestos is included on the list of Basic Stockpile Materials, 1972, in the following forms: amosite; chrysotile; crocidolite. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 96,000 short tons of asbestos.

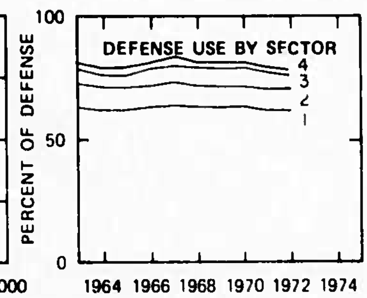
Reserves and Resources: Includes chrysotile, crocidolite, and amosite.

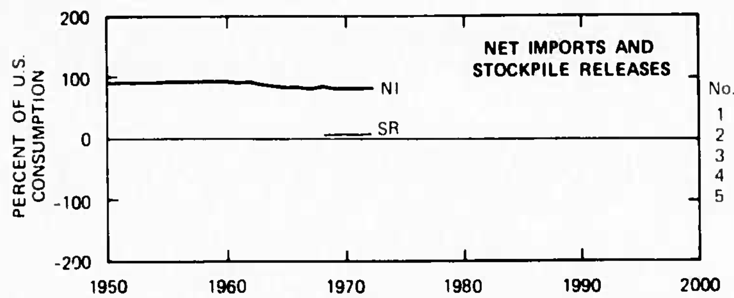
DATA SUMMARY: ASBESTOS
One Unit = 1,500,000 Short Tons
1972 World Production = 2.8 units





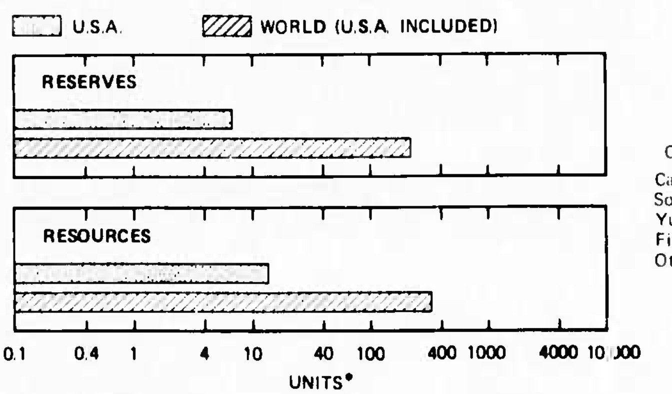






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Construction Cement Products	62
2	Floor Tile	9
3	Paper Products	6
4	Transport., Brk. Linings, Etc.	3
5	Other (Estimated)	20
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	40	43	88
South Africa	B	4	2
Yugoslavia	<1	2	<1
Finland	<1	3	<1
Other	2	3	<1
			90

*Unit defined at top of page

NOTES ON BARIUM

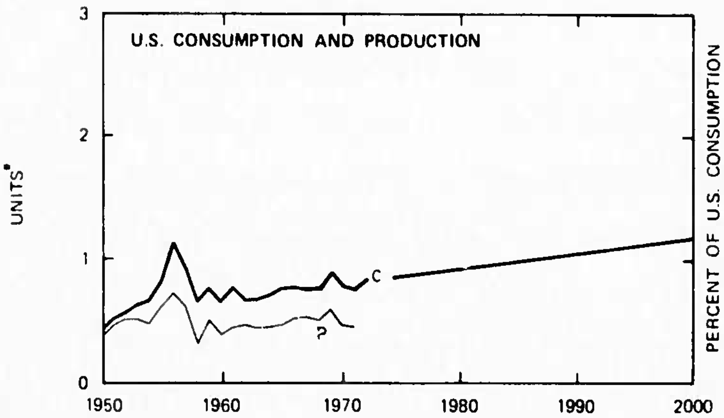
Uses: Weighting agent in well drilling muds. Additive to glass melt. Filler in paints, ink and rubber. Barium salts. Barium carbonate for ceramic flux, fine glassware, optical glass, TV picture tubes, case hardening baths, brick industry. Barium chloride for blanc fixe, barium colors, case hardening and heat treating baths, magnesium metal manufacture, laboratory reagent. Barium nitrate in green signal flares, tracer bullets, primers and detonators, enamels. Barium oxide for glass and plastics, acid furnace linings, arc moderator, sulfur reduction in iron. Barium hydroxide as additive to oil and greases, scum preventative in ceramics, beet sugar refining. Barium titanate in electronics.

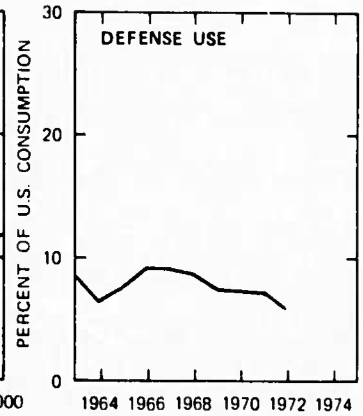
Price: Price per short ton average for primary barite f.o.b. mine.

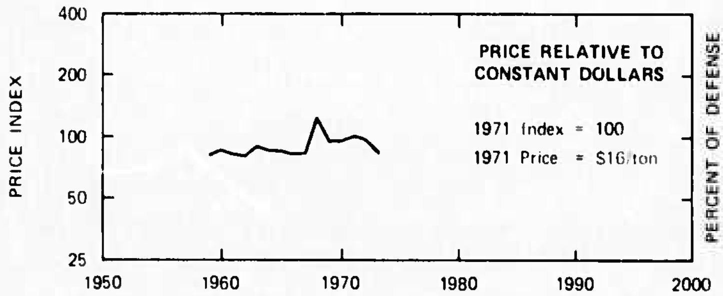
Imports: Percentages are based on 56% equivalent barium in barite.

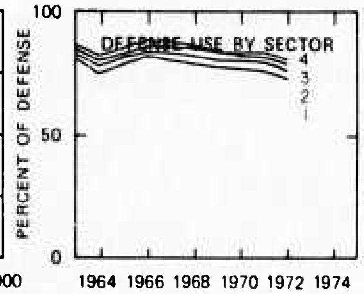
Stockpile: Barium is not on the list of Basic Stockpile Materials, 1972.

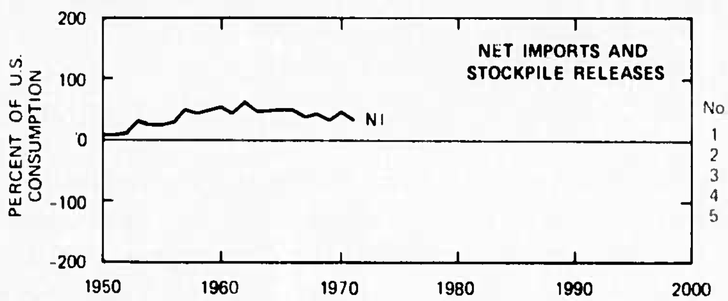
DATA SUMMARY: BARIUM
One Unit = 1,000,000 Short Tons
1972 World Production = 2.4 units





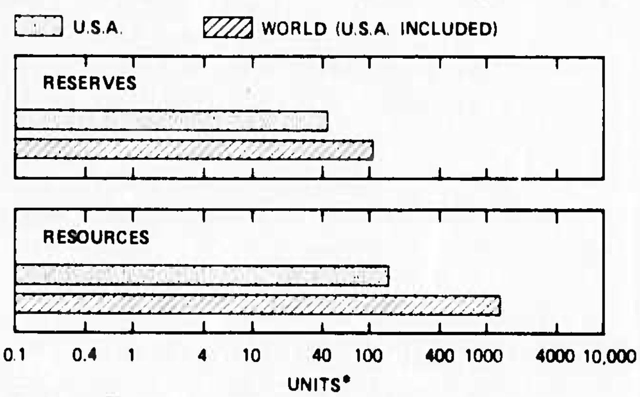






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Oil and Gas Drill Muds	74
2	Paints	3
3	Rubber	2
4	Glass	2
5	Other (Estimated)	19
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Mexico	7	48	9
Peru	6	77	14
Ireland	5	70	10
Morocco	2	40	3
Greece	2	72	5
Canada	2	27	1
			42

*Unit defined at top of page

NOTES ON BERYLLIUM

Uses: Copper alloy for springs, bellows, diaphragms, electrical contacts, aircraft engine parts, molds for plastic, marine propellers, gears, bearings and retainer rings, shims, precision castings, rollers, miniature electrical components, ball point pens, space vehicle antennas, hydrophones, diamond wire for saws. Nickel alloys for glass dies. Metal for structural components, aircraft brakes, rudders, jet engine parts, rocket fuel additives, missile parts. Nuclear weapons, noncommercial reactors. Inertial guidance systems. Beryl for reactors, ceramic electronics, spark plugs.

Production: The U.S. has become a major producer of beryllium since 1969, when a process to beneficiate low grade bertrandite ores was implemented. Because the Bureau of Mines keeps single company data confidential, the U.S. production from this new source is not shown.

Price: The price given is for imported ore in dollars per short ton unit (20 pounds) of BeO.

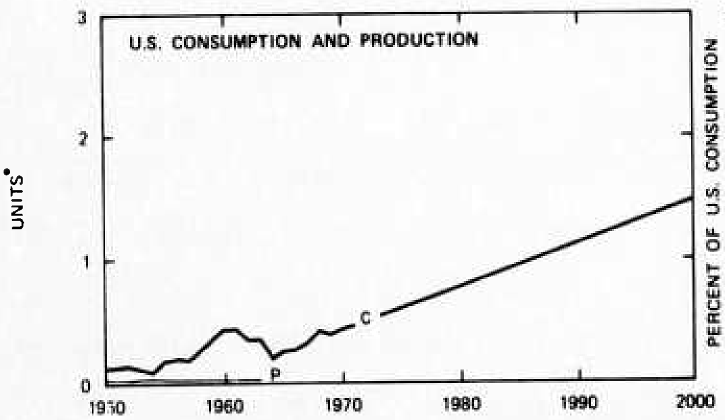
Stockpile: Beryllium is included on the list of Basic Stockpile Materials, 1972, in the following forms: Beryl ore; Beryllium Copper Master Alloy; Metal. Any releases are shown on the graph of Imports and Sotckpiles. The government stockpile balance for 1972 is 1,244 short tons.

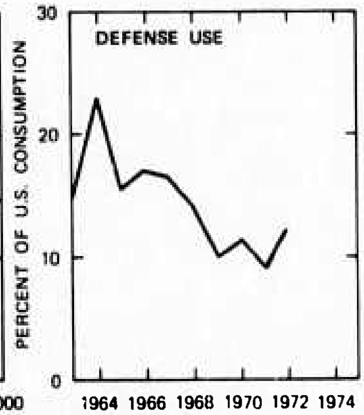
Imports: The United States is the major producer but the 1972 domestic figures are confidential. Flow diagrams suggest imports are about a third of U.S. consumption.

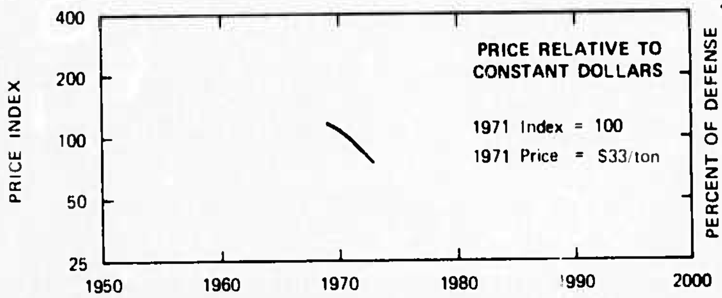
Resources and Reserves: Economic estimates are based on by-product and co-product association with other minerals.

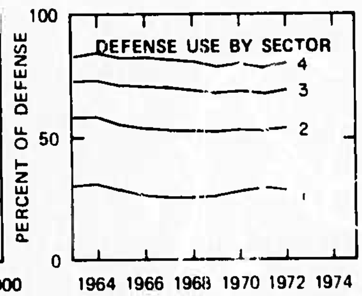
Defense Use: Year to year fluctuations of percent defense use are more reflective of fluctuations in the values given for U.S. consumption than of changes in defense procurements.

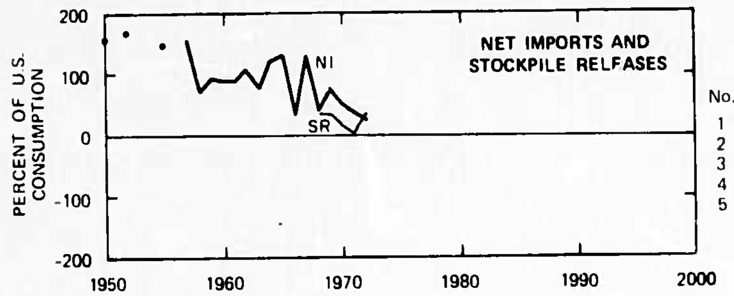
DATA SUMMARY: BERYLLIUM
One Unit = 850 Short Tons
1972 World Production = 2.7 units (estimate)

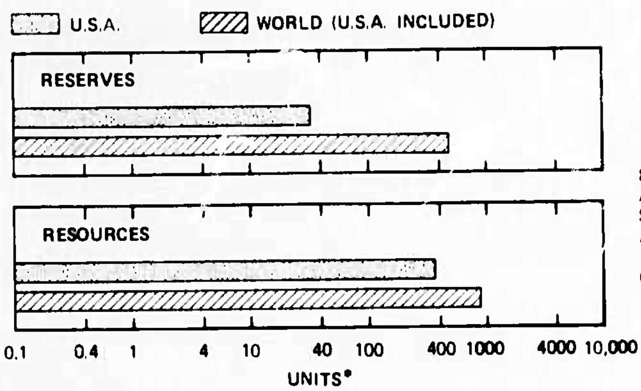












*Unit defined at top of page.

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Guided Mis., Space Vehicles	30
2	Radio, Television Equip.	26
3	Electrical Measuring Instrum.	15
4	Switchgear	11
5	Other (Estimated)	18
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Brazil	NA	88	23
Argentina	NA	83	3
South Africa	NA	300	11
Australia	NA	50	1
Rwanda	NA	67	1
Other	NA	118	4
			43

NOTES ON BISMUTH

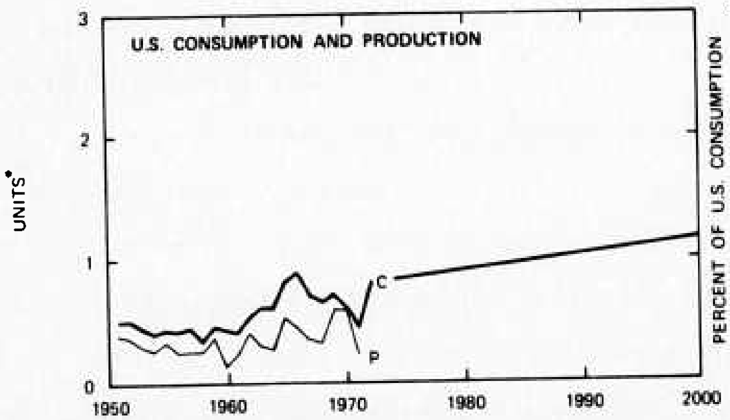
Uses: Ingestion remedies, antacids, burn and wound dressings, anti-syphilitics, X-ray examination. Lipstick, body powders, eye shadow, nail polish. Alloys for motor vehicle parts, aircraft and jet engine parts, streetcar wheels. Fusible alloys for dies, jigs, fixtures for metalworking, and firefighting, sprinkler systems. Automatic temperature controls for washing machines, dryers, refrigerators, air conditioners, computers. Oxidation catalyst for acryonitrile for acrylics. Dental work. Tool tempering baths, fabric dyeing baths, pattern making and tool anchoring devices, ovens for drying solid fuel for rockets.

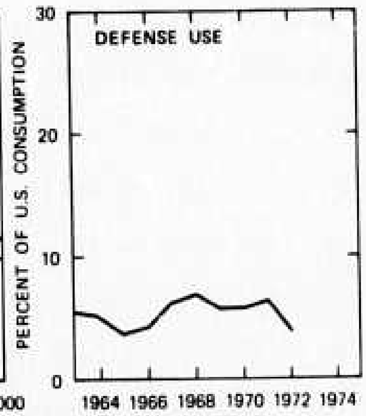
Price: The price given is the average per pound of metal.

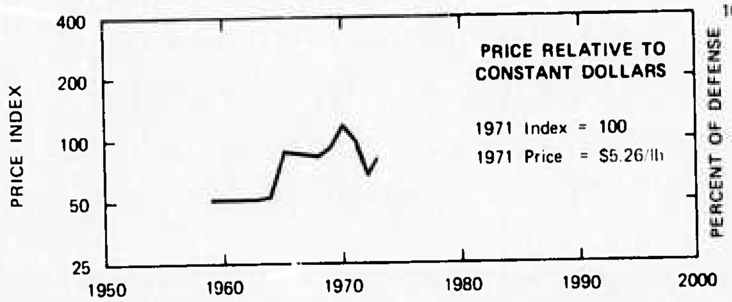
Stockpile: Bismuth is included on the list of Basic Stockpile Materials, 1972. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. The government stockpile balance for 1972 was 2,205,000 pounds of bismuth.

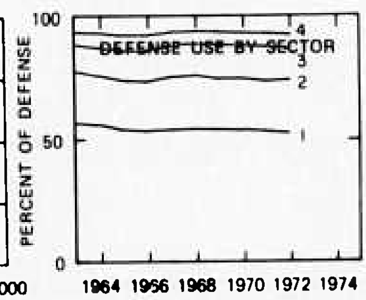
Resources and Reserves: Economic estimates are based on by-product and co-product association with complex base metal ores.

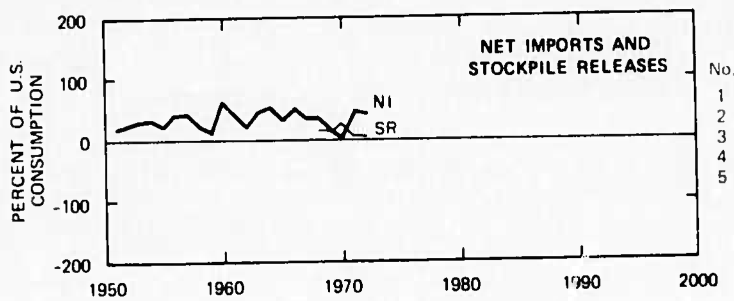
DATA SUMMARY: BISMUTH
One Unit = 3,500,000 Pounds
1972 World Production = 2.9 units (estimate)

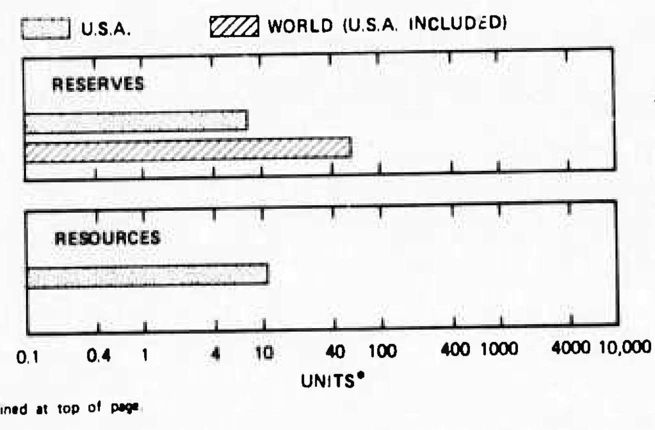












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation	52
2	Machinery and Electrical	22
3	Industrial Inorganic Chemicals	13
4	Automatic Temperature Controls	6
5	Other (Estimated)	7
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Japan	19	10	7
Peru	16	30	16
Mexico	14	17	8
Bolivia	10	<1	<1
Canada	4	12	2
Korea	2	53	4
Yugoslavia	2	<1	<1
France	2	4	<1
U.K.	0	—	13
Bel. Lux.	0	—	<1
Other	3	34	3
			54

NOTES ON BORON

Uses: Heat resistant glass, glassware, fiberglass. Vitrous enamel for sinks, stoves, appliances, etc. Soaps, cleansers, detergents, toothpaste, mouthwash, eyewash. Fertilizers, herbicides. Metallurgy fluxes and alloys. Delayed action fuses. Radio tube igniter. Solar battery coating. Spray nozzles. Bearing liners. Furnace parts. Reactor control elements and radiation shields. Ultrasonic grinding and drilling. Mold lubricant in glass manufacture. Silicone catalyst. Magnesium fire extinguisher. Organic reaction catalyst. Dehydrating agents. Special solvents. Plasticizers. Adhesive additives for latex paint. Fire retardants in plastics and protective coatings. Motor fuel additive to suppress preignition firing. Potential rocket fuel.

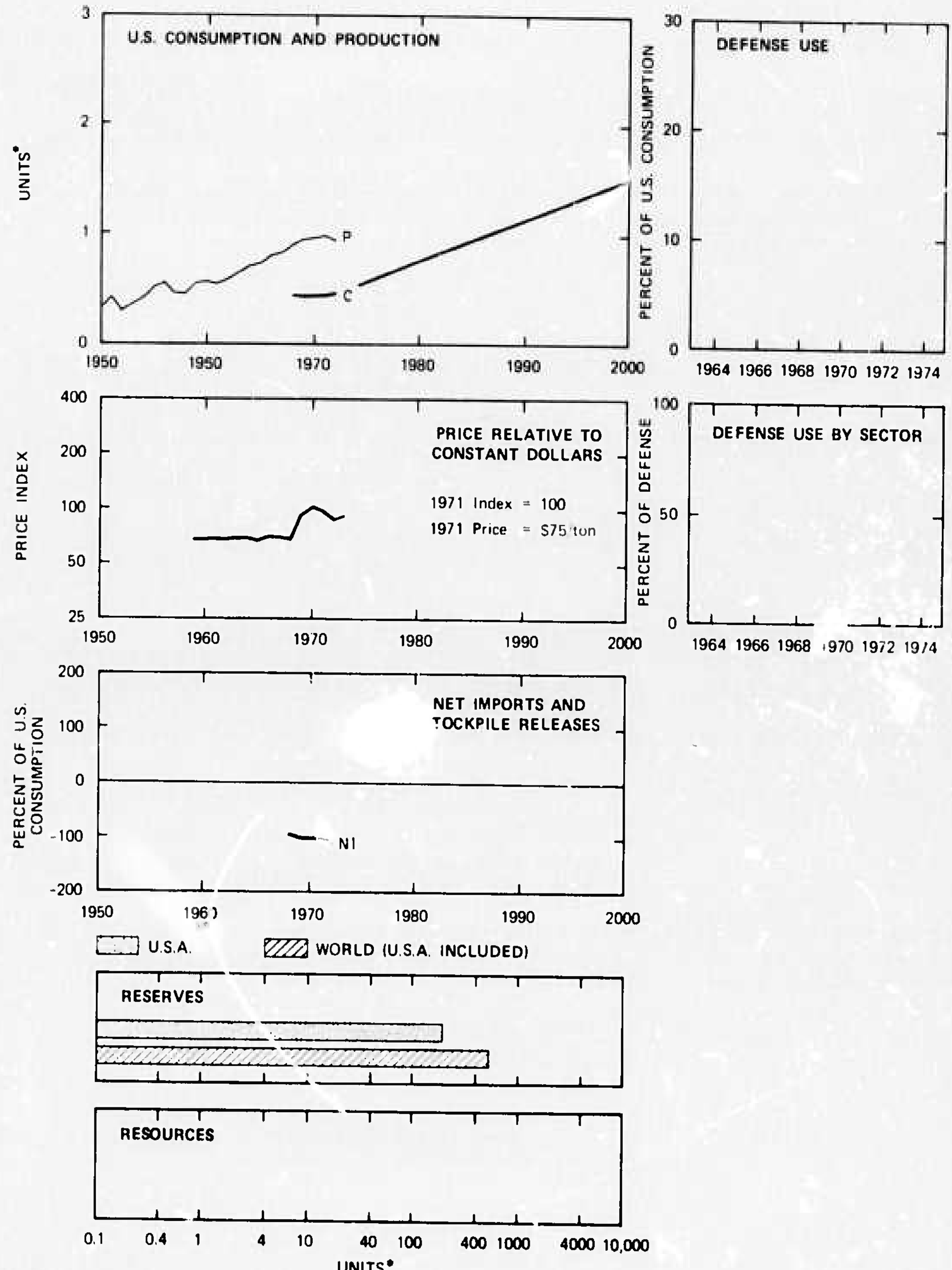
Price: The 1971 price was $75.25 per ton of granulated pentahydrate borax in bulk, f.o.b. mine.

Imports: The United States was self-sufficient in boron minerals in 1972.

Stockpile: Boron is not on the list of Basic Stockpile Materials, 1972.

Defense Use: Anomalies in the description of uses by economic sectors prevented estimates of DOD use. However, it appears that defense uses, with the possible exception of AEC, would not consume a disproportionately large amount of this material.

DATA SUMMARY: BORON
One Unit = 200,000 Short Tons
1972 World Production = 1.5 units



*Unit defined at top of page.

NOTES ON BROMINE

Uses: Gasoline additive to remove lead deposits. Disinfecting agents, fumigants, bleaching agents. Fire extinguishers. Photographic film, plates. Dyes. Inks. Sedatives, anaesthetics, antispasmodic agents. Hydrolic fluids. Refrigerating and dehumidifying agents. Hair waving preparations. Laboratory reagents.

Price: The price given is for bulk purified Bromine.

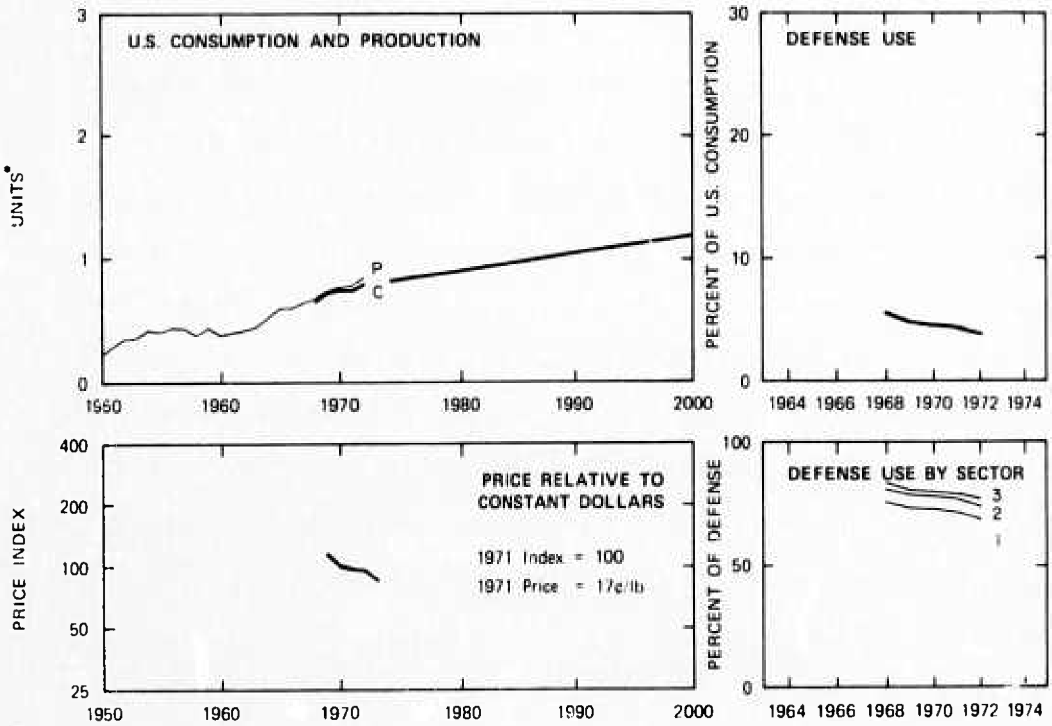
Imports: The United States was self-sufficient in Bromine in 1972.

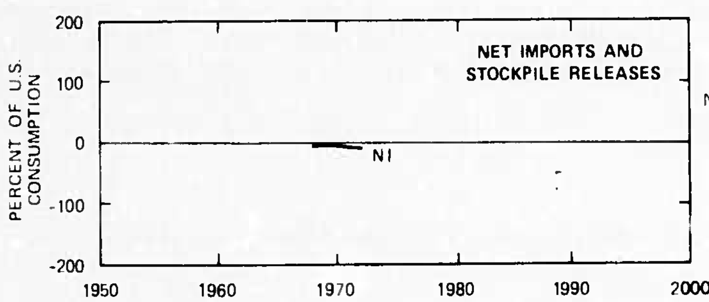
Stockpile: Bromine is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: Not including vast potential of sea water production. Both world and U.S. resources are "virtually unlimited" when brines and sea water are included. (Commodity Data Summaries, 1974)

Defense Use: Estimates for the years prior to 1968 were not made because the available data on U.S. consumption appeared inconsistent with the series used for 1968-1972.

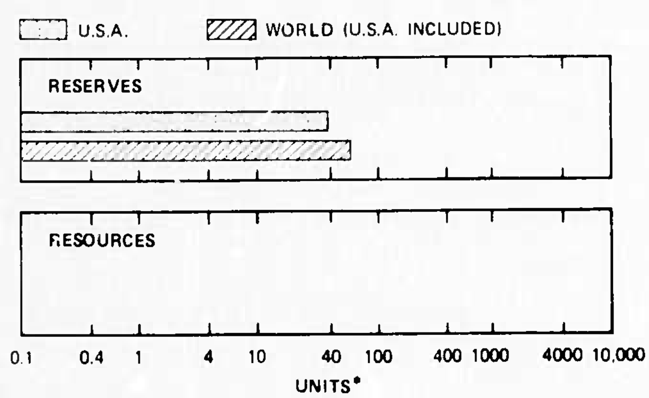
DATA SUMMARY: BROMINE
One Unit = 450,000,000 Pounds
1972 World Production = 1.8 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Petroleum Refining	69
2	Sanitation Preparations	5
3	Fire Extinguisher Charges	2
4	Other (Estimated)	24
		100



*Unit defined at top of page.

NOTES ON CADMIUM

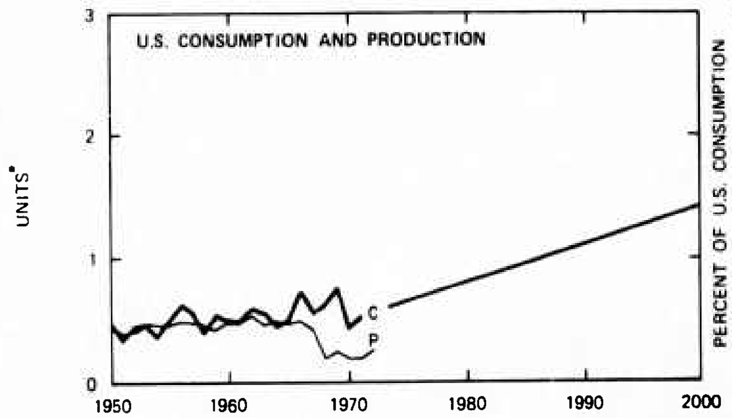
Uses: Electroplating nuts, bolts, screws, springs, fasteners, washers, rivets, carburetor and magneto parts for vehicles and aircraft; also electroplating marine equipment, hardware, household appliance parts, industrial machinery parts. Nickel-cadmium batteries for radios, portable telephones, starting motors, convenience appliances, airplanes, helicopters, standby power and lighting. Yellow, orange, red pigments for plastics, paints, enamels, lacquers, and printing inks. Polyvinylchloride stabilizer, other thermoplastics. Phosphors for black and white TV tubes, blue and green for color tubes, fluorescent tubes. Semiconductors and photoactive devices. Switches, relays, circuit breakers.

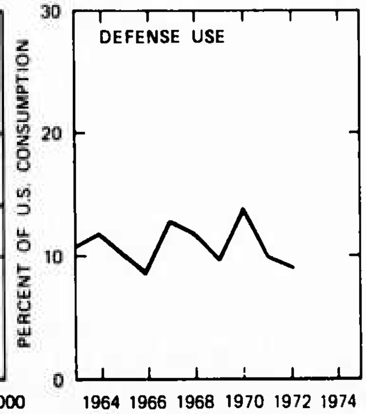
Price: The average quoted price for cadmium sticks and balls in lots of 1 to 5 tons.

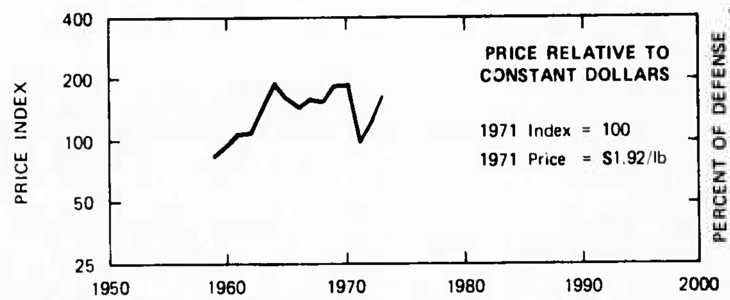
Stockpile: Cadmium is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 9,278,000 pounds of cadmium.

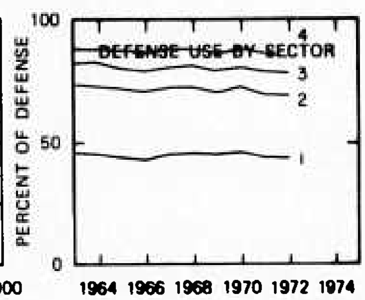
Resources and Reserves: Economic estimates are based on by-product association with zinc smelting.

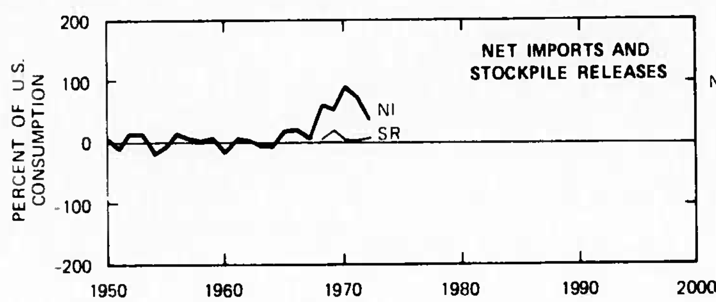
DATA SUMMARY: CADMIUM
One Unit = 20,000,000 Pounds
1972 World Production = 1.8 units

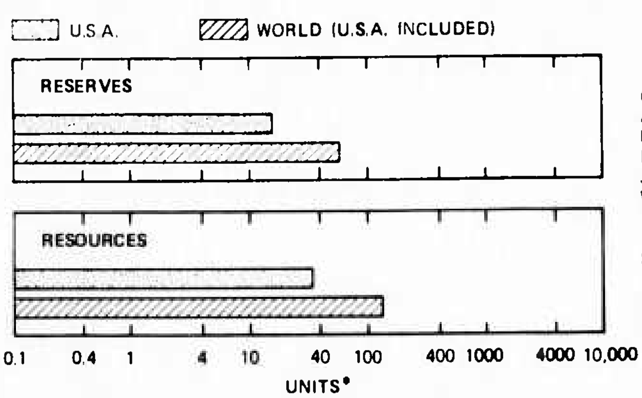












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Electroplating (Other)	45
2	Aircraft, Boats (Electroplat)	25
3	Plastic Materials	9
4	Pigments, Inorganic	7
5	Other (Estimated)	14
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	23	28	19
Australia	9	14	4
Peru	6	18	3
Mexico	5	84	12
Japan	5	2	1
W. Germany	2	10	<1
Ireland	2	9	<1
Hon./Nic.	2	84	4
South Africa	1	17	<1
Argentina	<1	4	<1
France	<1	17	<1
Other	4	16	2
			46

NOTES ON CALCIUM

Uses: Cement. Blast furnaces and steel works. Agricultural nutrient. Nonferrous metallurgy. Water treatment. Papermaking. Sugar refining. Sanitation. Petroleum refining. Lubricants. Corrosion inhibitors. Detergents. Highway deicing. Freeze-proofing concrete. Refrigeration. Tire weighting.

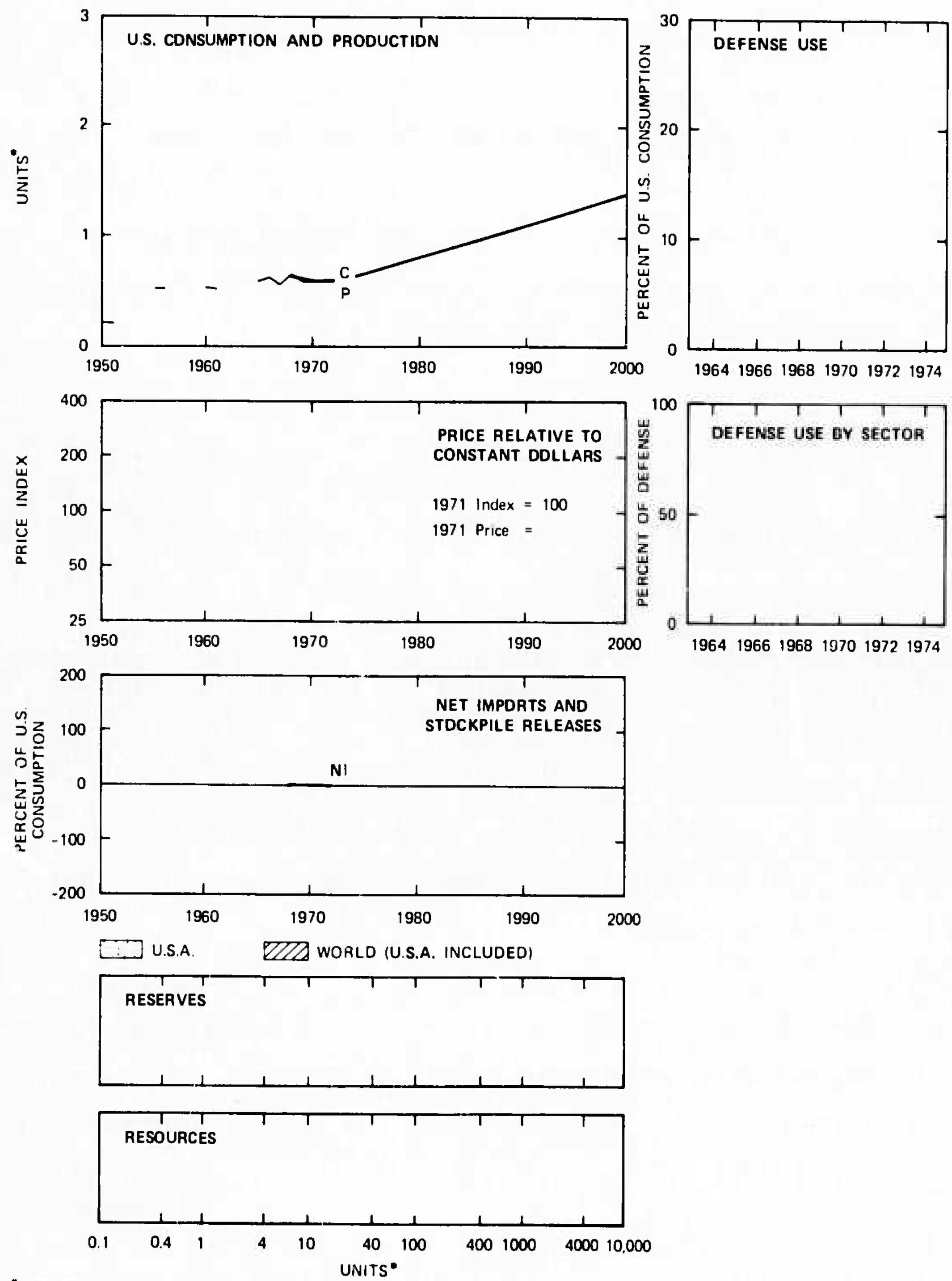
Imports: The United States was self-sufficient in calcium for 1972, but imported some quantities for re-export.

Stockpile: Calcium is not on the list of Basic Stockpile Materials, 1972.

Resources and Reserves: Large.

Defense Use: Anomalies in the description of uses by economic sector prevented estimates of DOD use. However, it appears that defense uses would not consume a disproportionately large amount of this material.

DATA SUMMARY: CALCIUM
One Unit = 150,000,000 Short Tons
1972 World Production = 3.2 units



*Unit defined at top of page

NOTES ON CESIUM

Uses: R & D of ionic propellant and thermionic power. Fluorination catalyst. Optical crystals. Storage battery electrolyte. Oil desulfurization. Microwave reflectors. Magnetohydrodynamics. Phosphors. Ultracentrifuge medium. Photomultiplier tubes, infrared lamps, scintillations counters, spectrophotometers. Scavenger in chemistry and metallurgy. Carbon dioxide purification. Catalyst for hydrogenation and polymerization processes.

Price: The price given is for pollucite.

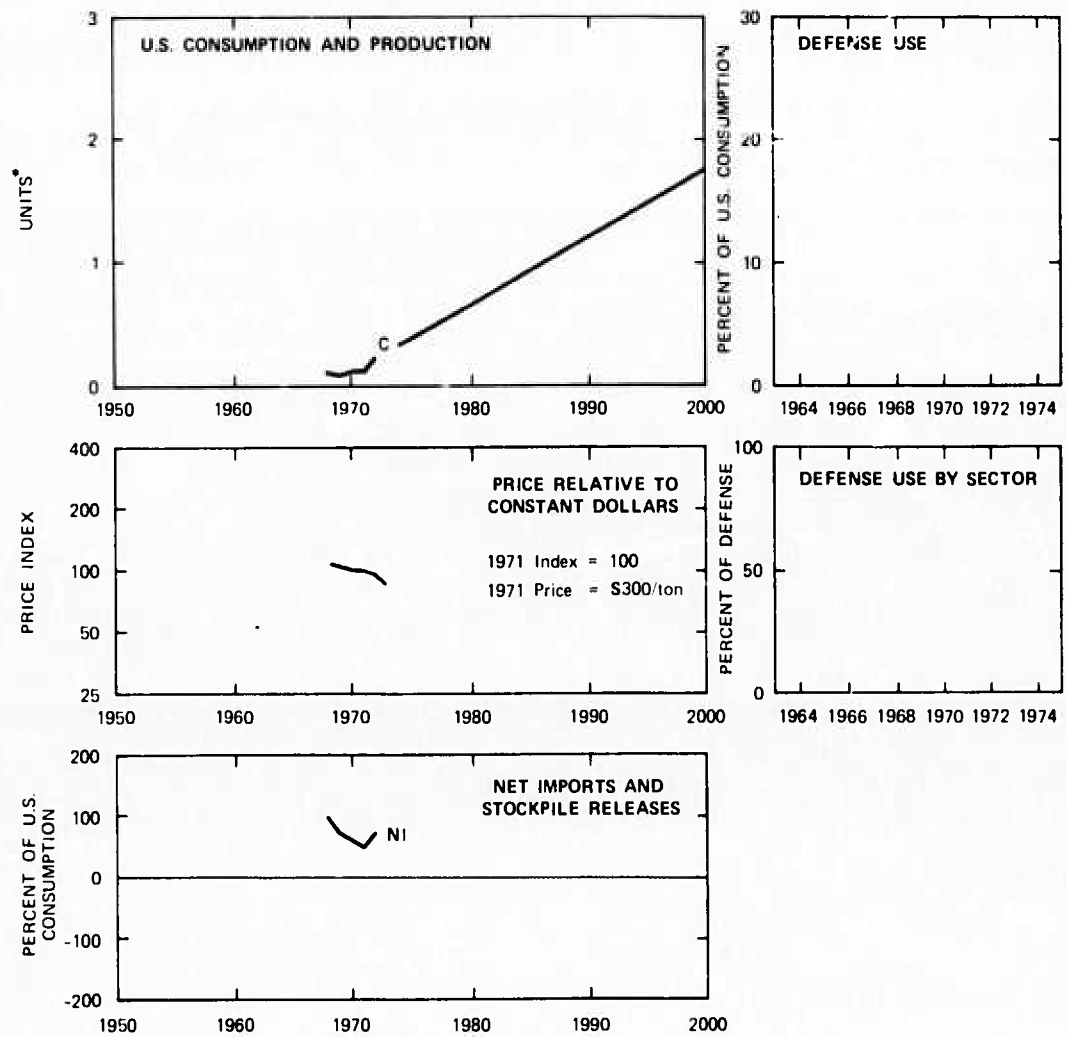
Imports: Prime sources for cesium processors not fully known.

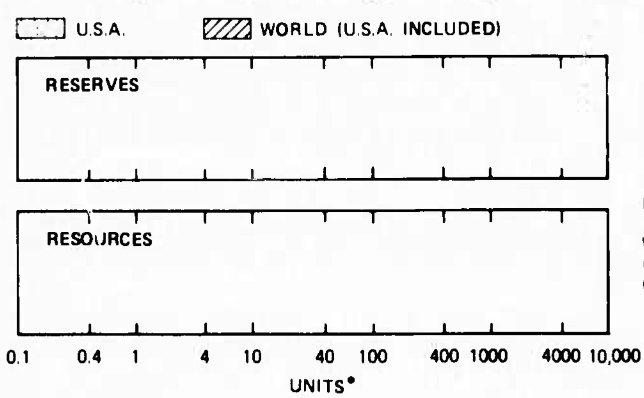
Stockpile: Cesium is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: Economic estimates are based on co-product association with lithium and beryl. No reserve figures for the United States because there has not been enough incentive to explore. World reserves and resources are "large".

Defense Use: Primary use of this material is for research and development. This category cannot be adequately treated with the 1963 input-output structure, which does not have category for this economic activity.

DATA SUMMARY: CESIUM
One Unit = 60,000 Pounds
1972 World Production = 0.4 units





*Unit defined at top of page

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Mozambique	85	50	NA
Rhodesia	15		NA
W. Germany	0	from above	55
Canada	0		12
Other	0		11
			78

NOTES ON CHLORINE

Uses: Bleaching pulp and paper. Manufacture of plastics such as teflon, other resins, used in upholstery, floor coverings, food packaging films, bottles, utensils, hose and tubing, electrical insulation, etc. Chlorinated solvents for dry cleaning, paint thinners, metal degreasing and machinery cleaning. Intermediate for auto antifreeze and antiknock additives. Pesticides. Sanitation. Textile and household bleaches. Refrigerants. Pharmaceuticals. Cosmetics. Beneficiating ores, metal extraction.

Price: The price given is for liquid chlorine in tanks, single units, freight equalized.

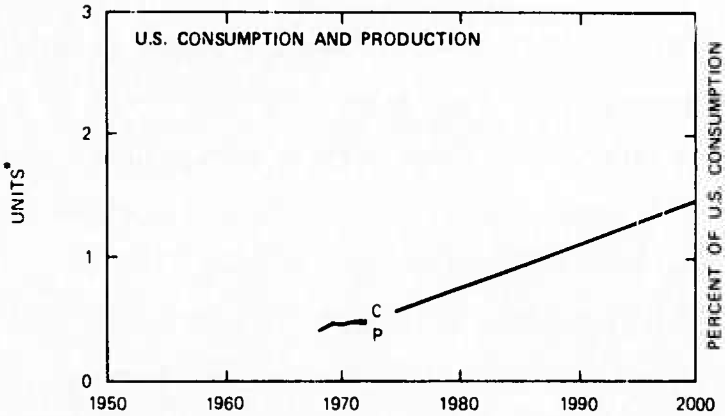
Imports: The United States was self-sufficient in chlorine in 1972.

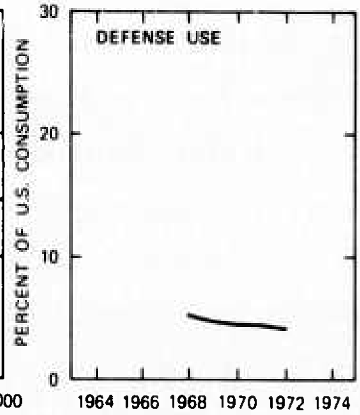
Stockpiles: Chlorine is not on the list of Basic Stockpile Materials, 1972.

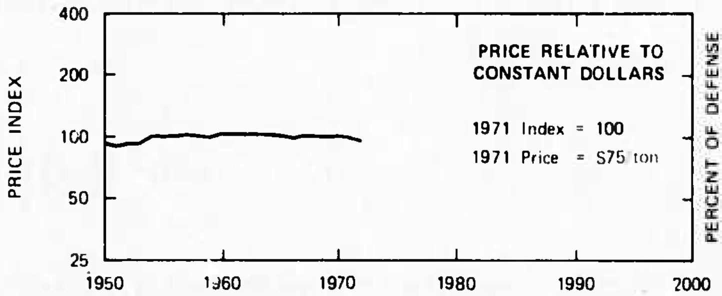
Reserves and Resources: "Large".

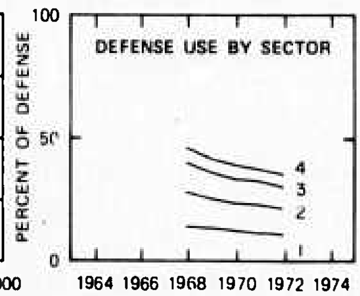
Defense Use: Estimates for the years prior to 1968 were not made because the available data on U.S. consumption appeared inconsistent with the series used for 1968-1972.

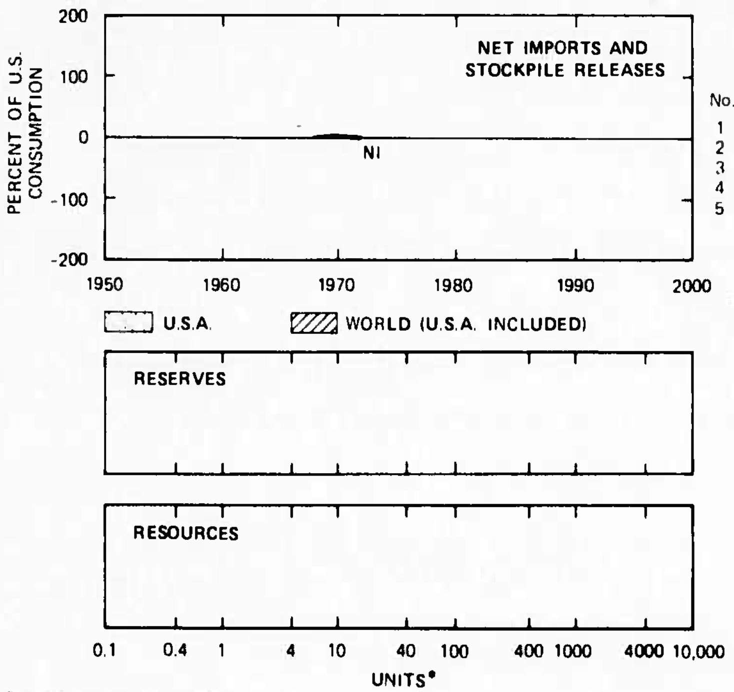
DATA SUMMARY: CHLORINE
One Unit = 20,000,000 Short Tons
1972 World Production = 1.3 units











*Unit defined at top of page.

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Automotive Fluids	11
2	Plastics, Resins	11
3	Pulp and Paper Ind.	9
4	Solvents	5
5	Other (Estimated)	64
		100

NOTES ON CHROMIUM

Uses: Steels for motor vehicles, railroads, ships, jet engine parts. Stainless steel trim, hardware, fixtures. Structural steel, as beams, decking, fencing, reinforcing. Pumps, tanks, pipe, tubes. Refinery, mining chemical plant equipment. Tools. Domestic stainless steel products, chromium plated appliances. Furnace linings, refractories. Plating. Yellow traffic paints, metal coatings. Treatment of hides, tanning operations. Textile dyes. Corrosion inhibitors. Catalysts, drilling and compounds. Surgical metal. Mold and core making.

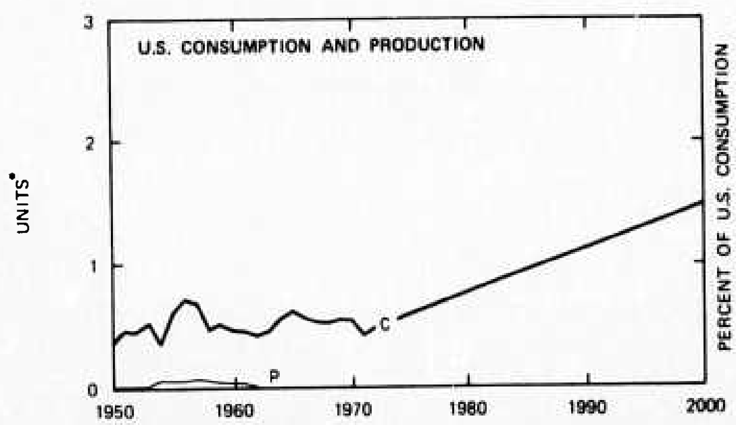
Price: The price given is for South African chromite, chemical grade.

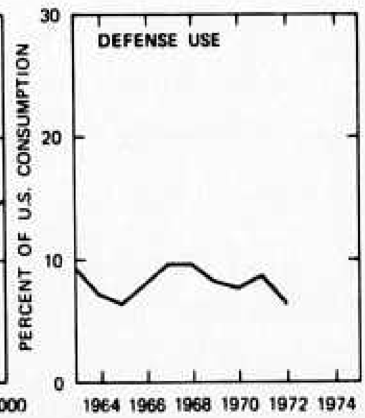
Imports: Percentages based on combined elemental content of ore, alloys, and chemicals.

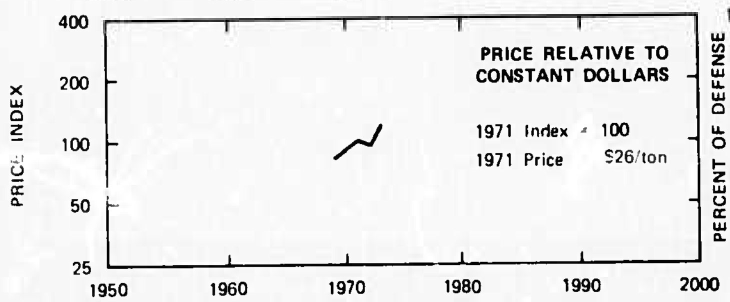
Stockpile: Chromium is included in the list of Basic Stockpile Materials, 1972, in the following forms: Chemical grade chromite; Metallurgical grade chromite; High-carbon ferrochromium; Low-carbon ferrochromium; Silicon ferrochromium; Metal; Refractory chromite. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 2,239,000 short tons of chromium.

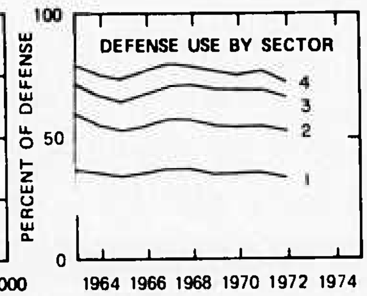
Reserves and Resources: United States reserves are insignificant.

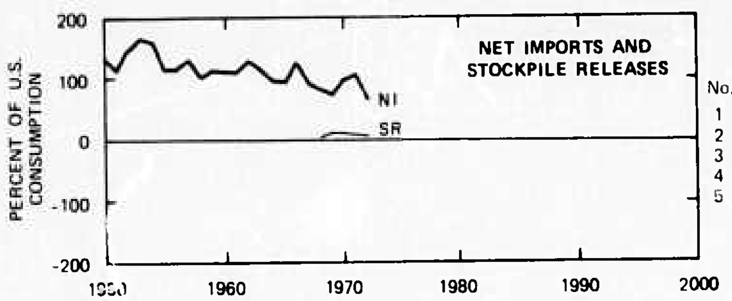
DATA SUMMARY: CHROMIUM
One Unit = 850,000 Short Tons
1972 World Production = 2.6 units

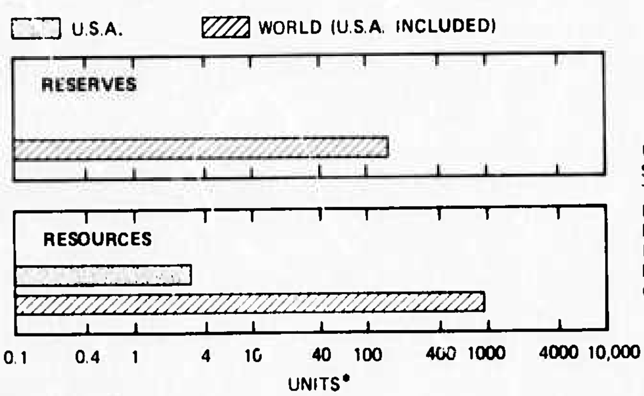












*Unit defined at top of page.

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation	33
2	Machinery and Equipment	19
3	Refractory Products	14
4	Construction Products	7
5	Other (Estimated)	27
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
USSR	33	19	25
South Africa	23	20	18
Turkey	10	17	6
Rhodesia	6	28	7
Philippines	4	32	5
Iran	3	6	<1
Pakistan	<1	73	1
Other	11	19	8
			70

NOTES ON CLAYS

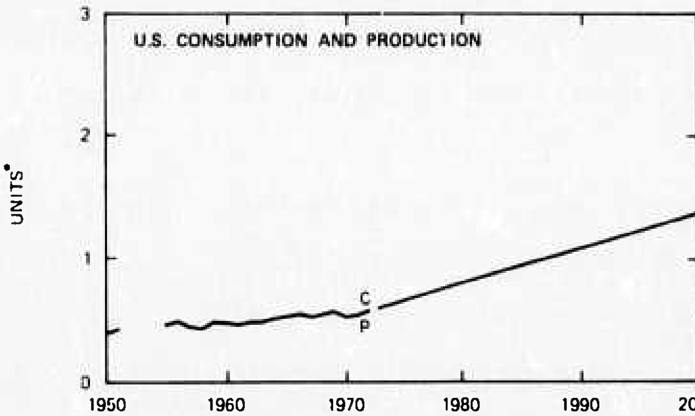
Uses: Construction products. Cement. Lightweight aggregates. Paper. High-grade ceramics. Binder for iron ore pellets. Absorbents. Drilling fluids.

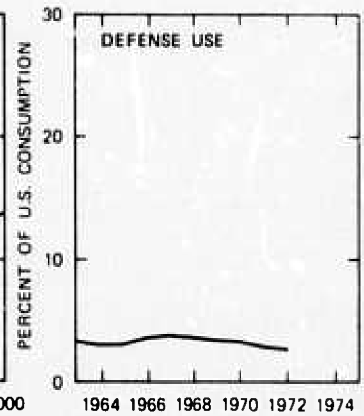
Imports: The United States was self-sufficient in clays for 1972.

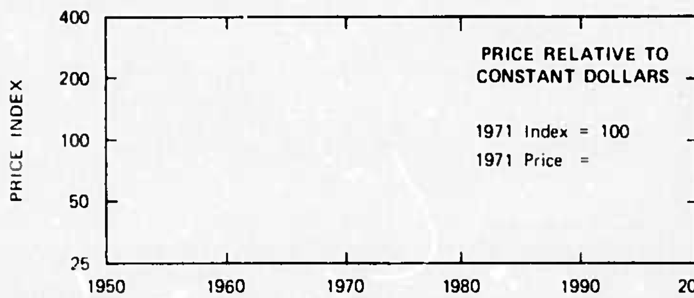
Stockpile: The clays group is not on the list of Basic Stockpile Materials, 1972.

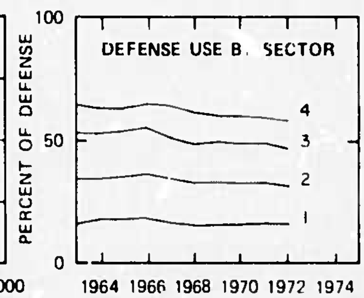
Reserves and Resources: Includes kaolin, ball clay, fire clay, bentonite, fuller's earth, and other clays. Reserves and resources are "large".

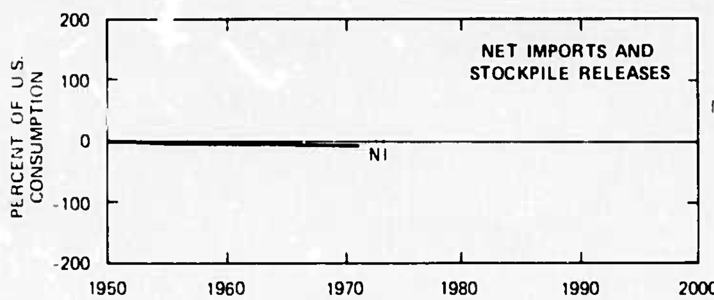
DATA SUMMARY: CLAYS
One Unit = 100,000,000 Short Tons
1972 World Production = 5.1 units





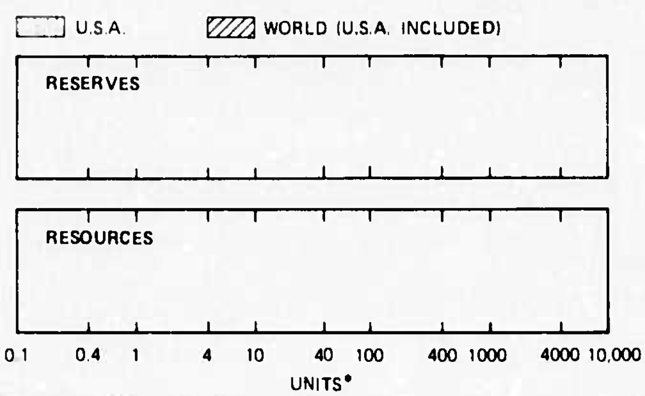






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Strultural Clay Products	16
2	Expanded Shale and Clay	16
3	Hydraulic Cement	15
4	Paper Mills	11
5	Other (Estimated)	42
		100



*Unit defined at top of page

NOTES ON COBALT

Uses: Jet engine components and aircraft frames. Alnico, cobalt-alloy permanent magnets. Glass to metal seals, low expansion steels, both for electronic equipment. Metal matrix for cutting tools, drawing dies, masonry saw teeth. High speed machining steels. Matrix in drill bits. Power shovel dipper teeth, plowshares. Pigments, driers, dyes, decolorizers, oxidizers. Catalyst for hydrogenation, hydration, desulfurication, oxidation, reduction. Ceramic pigment. Soil additive for animal nutrition. Gamma radiation for medical treatment and research.

Production: U.S. production is small and the data are confidential.

Price: The price given is for metal, f.o.b. New York or Chicago.

Imports: Complex intermediate trade is not included.

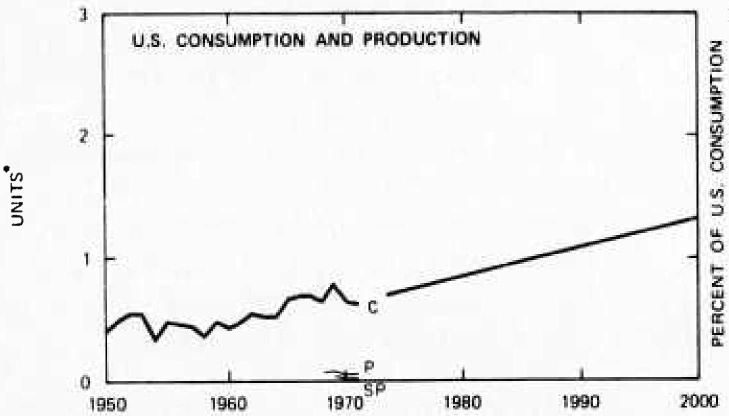
Stockpile: Cobalt is included on the list of Basic Stockpile Materials, 1972, in the elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 71,499,000 pounds cobalt.

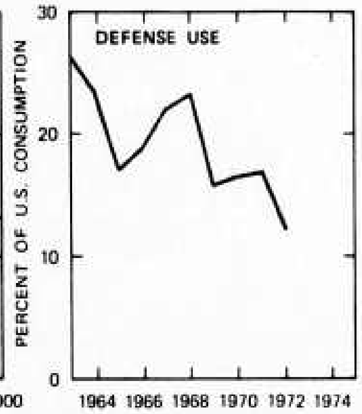
Reserves and Resources: Economic estimates are based on by-product association with copper, nickel, silver, iron, and zinc refining.

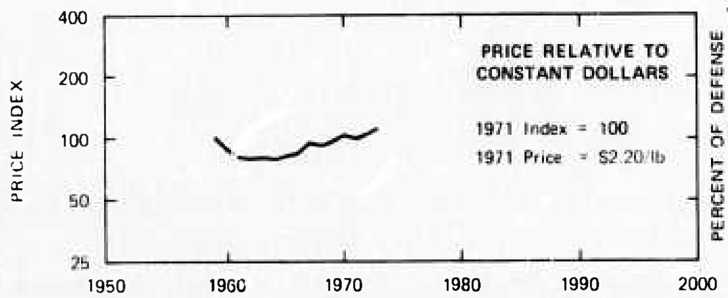
Defense Use: The percent used for defense was calculated despite some inconsistencies noticed in data on U.S. consumption.

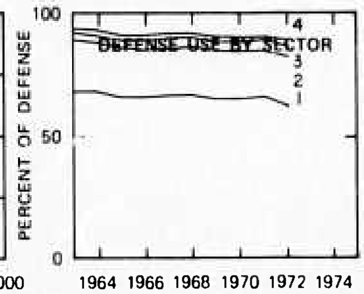
Year to year fluctuations in percent defense use can be attributed largely to fluctuations in the values used for U.S. consumption, rather than to changes in defense procurements.

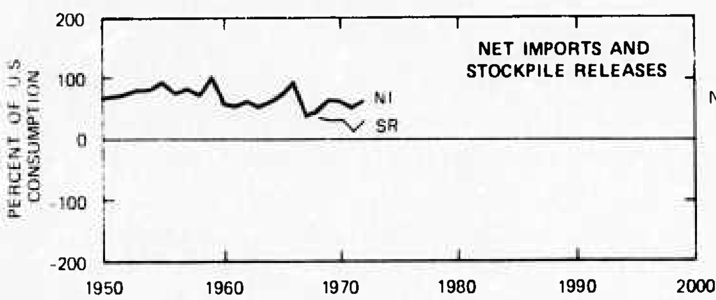
DATA SUMMARY: COBALT
One Unit = 20,000,000 Pounds
1972 World Production = 2.6 units





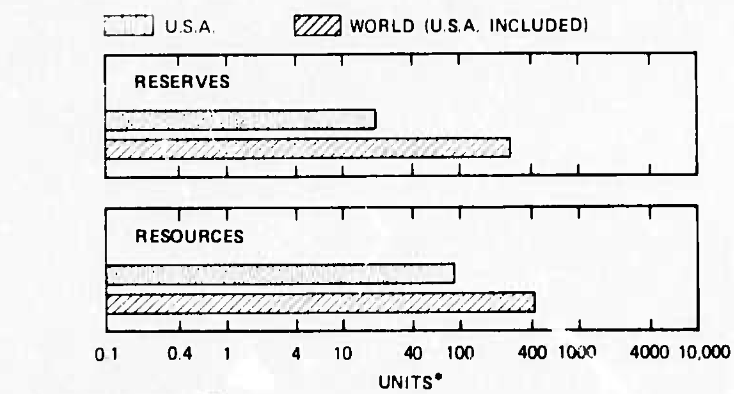






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Aircrft (Spacecrft) Engine, Pt	62
2	Electrical Equip., Supplies	21
3	Misc. Chemical Products	3
4	Paint, Allied Products	2
5	Other (Estimated)	12
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Zaire	56	32	47
Zambia	9	28	6
Canada	8	41	9
Finland	5	47	7
Morocco	5	20	3
Australia	3	3	<1
			72

*Unit defined at top of page.

NOTES ON COLUMBIUM (NIOBIUM)

Uses: Alloy steel in heavey equipment and machinery, oil and gas pipelines, structural members of buildings and bridges, architectural trim, rotary rock bit cutters, large antifriction bearings, auto power trains, trim, ships and railroad equipment. Superalloys in gas and steam turbines, rocket nozzles, jet turbine blades, high temperature aircraft applications. Food processing and kitchen equipment, oil, paper and chemical processing machinery, furnace parts, heat exchangers. Nuclear reactor construction. Metal shaping and forming equipment. Permanent magnets. Electronic components, resistance alloys. Coatings, glass to metal seals. Potential superconductor applications.

Price: The price given is an average for columbite ore, c.i.f. United States parts, in units of dollars per pound of contained pentoxide.

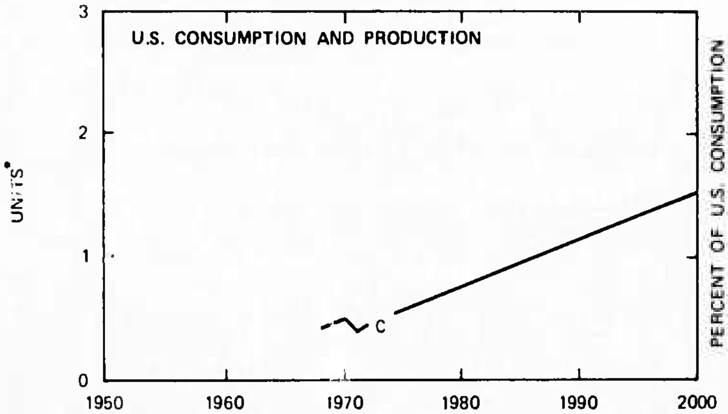
Imports: Percentages are based on combined elemental content of concentrate, ferrocolumbium, tinslag and others.

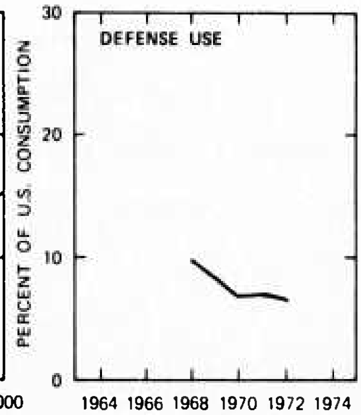
Stockpile: Columbium is included on the list of Basic Stockpile Materials, 1972, in the following forms: Columbium concentrates; Carbide powder; Ferrocolumbium; Metal. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 8,424,000 pounds columbium.

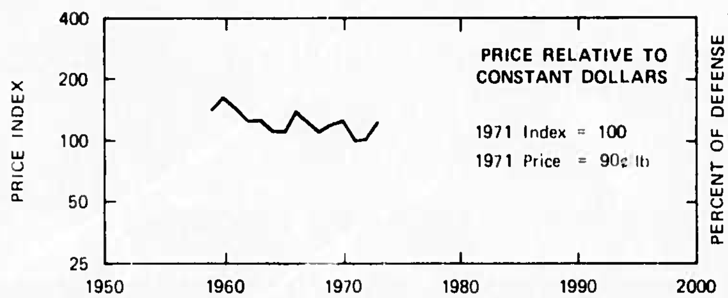
Reserves and Resources: Economic estimates are based on co-product association with tin mining, along with tantalum. No estimate for world resources. See tantalum.

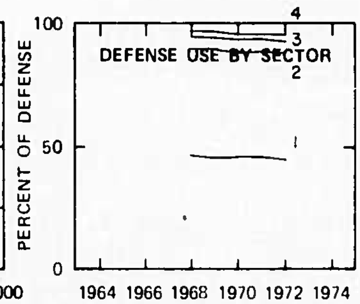
Defense Use: Because demand (consumption) data were combined with tantalum until 1968, no estimates of percent DOD were made for 1963-1967.

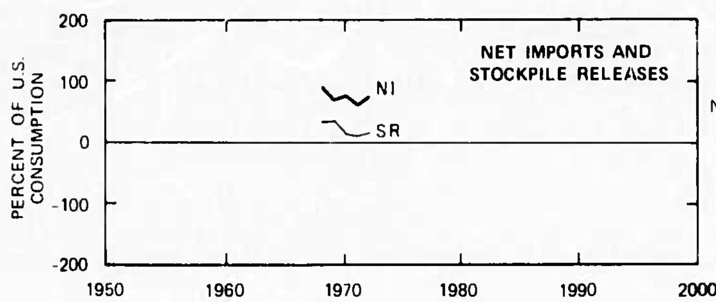
DATA SUMMARY: COLUMBIUM (NIOBIUM)
One Unit = 10,000,000 Pounds
1972 World Production = 1.5 units





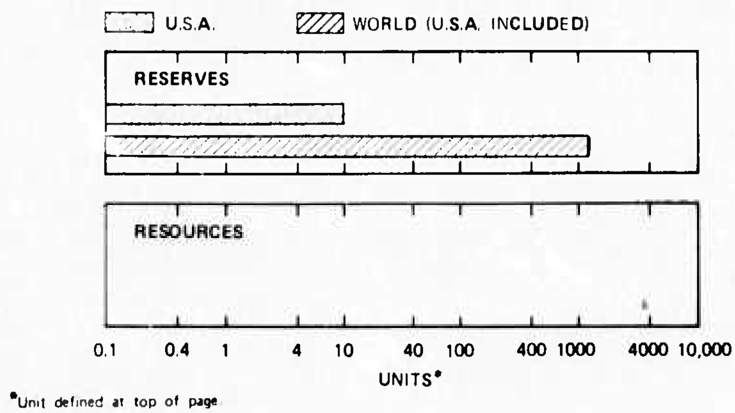






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation Equipment	45
2	Basic Steel Products	44
3	Metalworking Machinery	5
4	Special Industry Equipment	2
5	Other (Estimated)	4
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Brazil	53	26	48
Canada	20	<1	<1
Nigeria	10	33	12
Thailand	5	45	8
Malaysia	<1	13	<1
Zaire	<1	18	<1
U.K.	0	–	1
Other	<1	83	3
			74

*Unit defined at top of page

NOTES ON COPPER

Uses: All things electrical. Building construction for roofing, plumbing, hardware. Machinery for tubing, heat exchangers, turbines, oil baffles, check valves, plates, sheets, bars. Ordnance. Chemical compounds. Inorganic pigment. Jewelry. Instruments. Coinage.

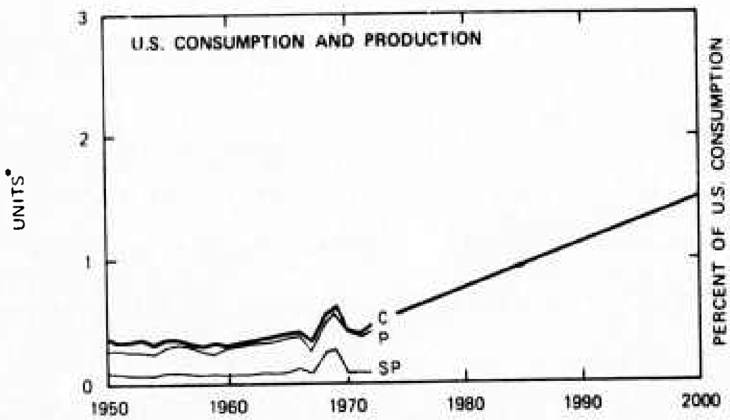
Price: The price quoted is the weighted average, cents per pound.

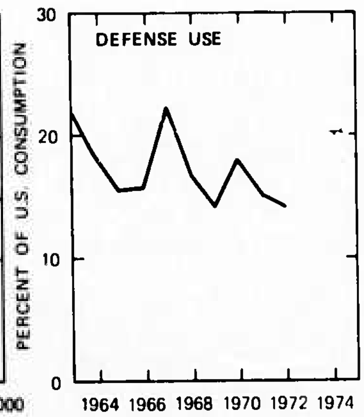
Imports: Most imports come as ore through United States refineries, some already refined.

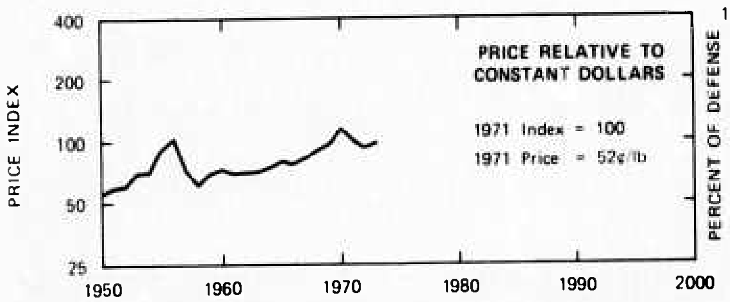
Stockpile: Copper is included on the list of Basic Stockpile Materials, 1972, in the following forms: High conductivity oxygen free copper; other forms. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 259,000 short tons of copper.

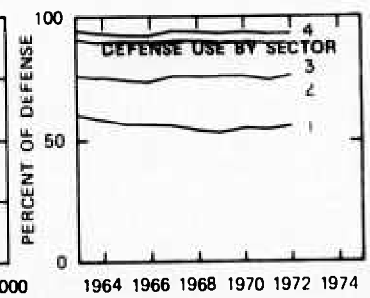
Defense Use: The percent used for defense was calculated despite some inconsistencies noticed in data on U.S. consumption.

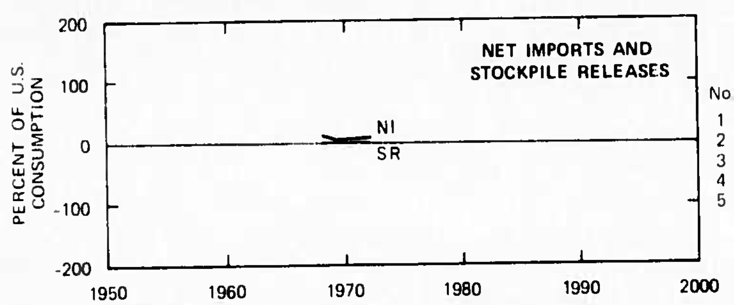
DATA SUMMARY: COPPER
One Unit = 5,000,000 Short Tons
1972 World Production = 1.5 units





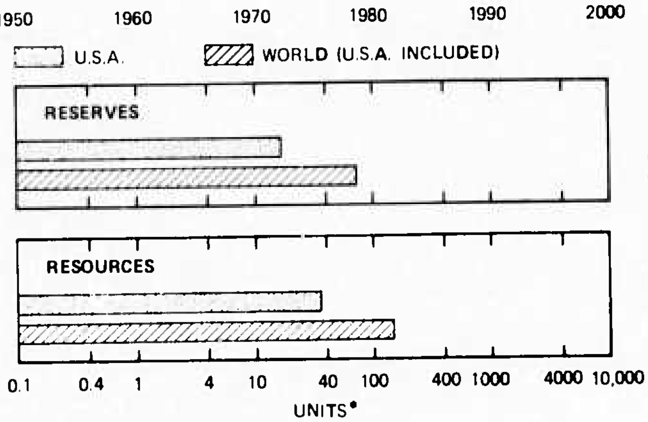






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Electrical Equip and Supplies	55
2	Ordnance	20
3	Transportation	14
4	Industrial Mach. Exc. Elect.	4
5	Other (Estimated)	7
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	11	18	6
Chile	11	7	2
Peru	4	34	4
Philippines	3	12	1
Australia	3	1	<1
South Africa	2	12	1
Japan	2	<1	<1
Yugoslavia	2	23	1
Mexico	1	20	<1
Other	8	1	<1
			16

*Unit defined at top of page

NOTES ON CORUNDUM

Uses: Optical grinding. Metal burnishing and finishing.

Price: The price given is the average value of imports. An embargo on imports from Rhodesia went into effect in 1969. The prices used for the graph after 1968 are "estimated declared value if not embargoed." (Commodity Data Summaries, 1974)

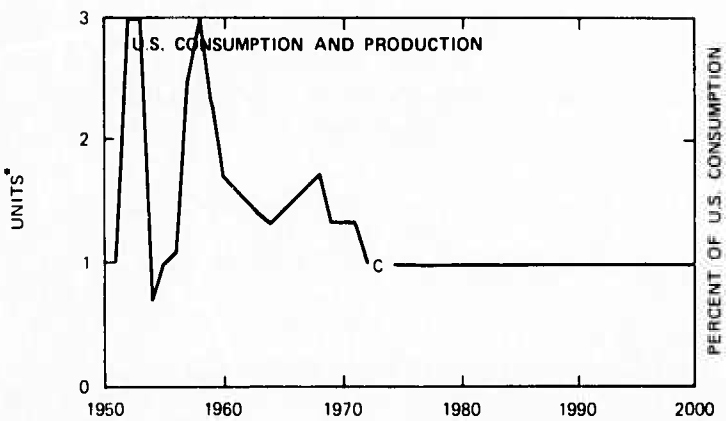
Imports: Domestic demand for 1972 was met entirely from industry stocks accumulated from earlier imports. U.S.S.R. and Rhodesia are main producers.

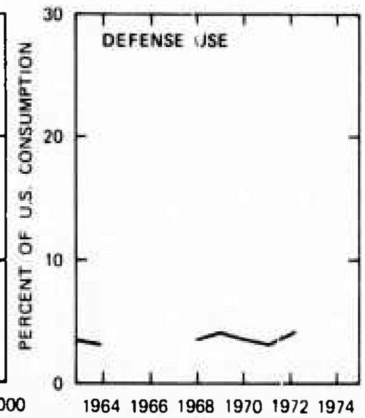
Stockpile: Corundum is not on the list of Basic Stockpile Materials, 1972.

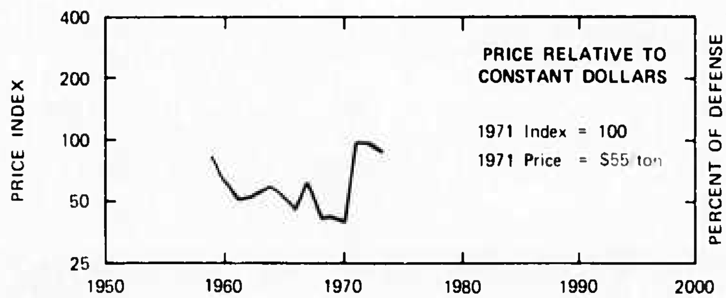
Reserves and Resources: United States reserves were "insignificant" Resources, no data.

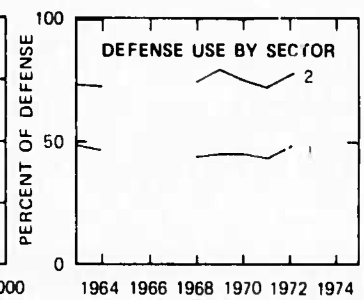
Defense Use: The U.S. consumption series did not contain values for 1965-1967, hence no percent DOD use is shown in graph.

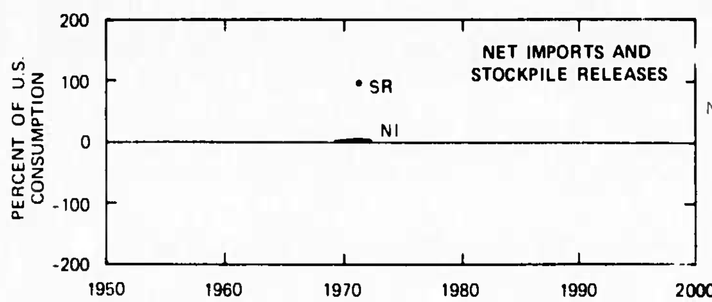
DATA SUMMARY: CORUNDUM
One Unit = 1,500 Short Tons
1972 World Production = 7.7 units





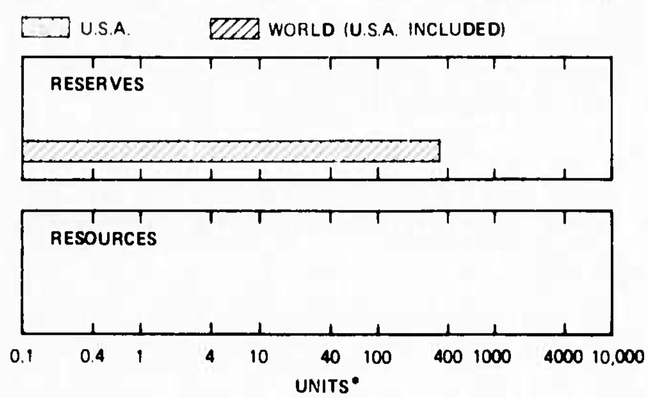






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Fabric. Leather Prod.	47
2	Opt. Instr. and Lens	30
3	Other (Estimated)	23
		100



*Unit defined at top of page

NOTES ON DIATOMITE

Uses: Filter for raw sugar liquors, organic oils, margarine, shortening, casein, fruit juices, acids, antibiotics, beer, chemicals, metallurgical solutions, solvents, waxes, wine and whiskey, water filtration, dry cleaning fluids. Filler in paint, asphalt products, paper, plastics, etc. Thermal insulation in boilers, stills, heat treating furnaces, kilns, etc. Catalyst carriers in petroleum refining, hydrogenation, acid manufacture. Thermal concrete. Carrier for insecticides. Anticaking agents for fertilizers and explosives. Mild abrasives. Scurce of highly reactive silica.

Price: The price given is an average per short ton, f.o.b., mine.

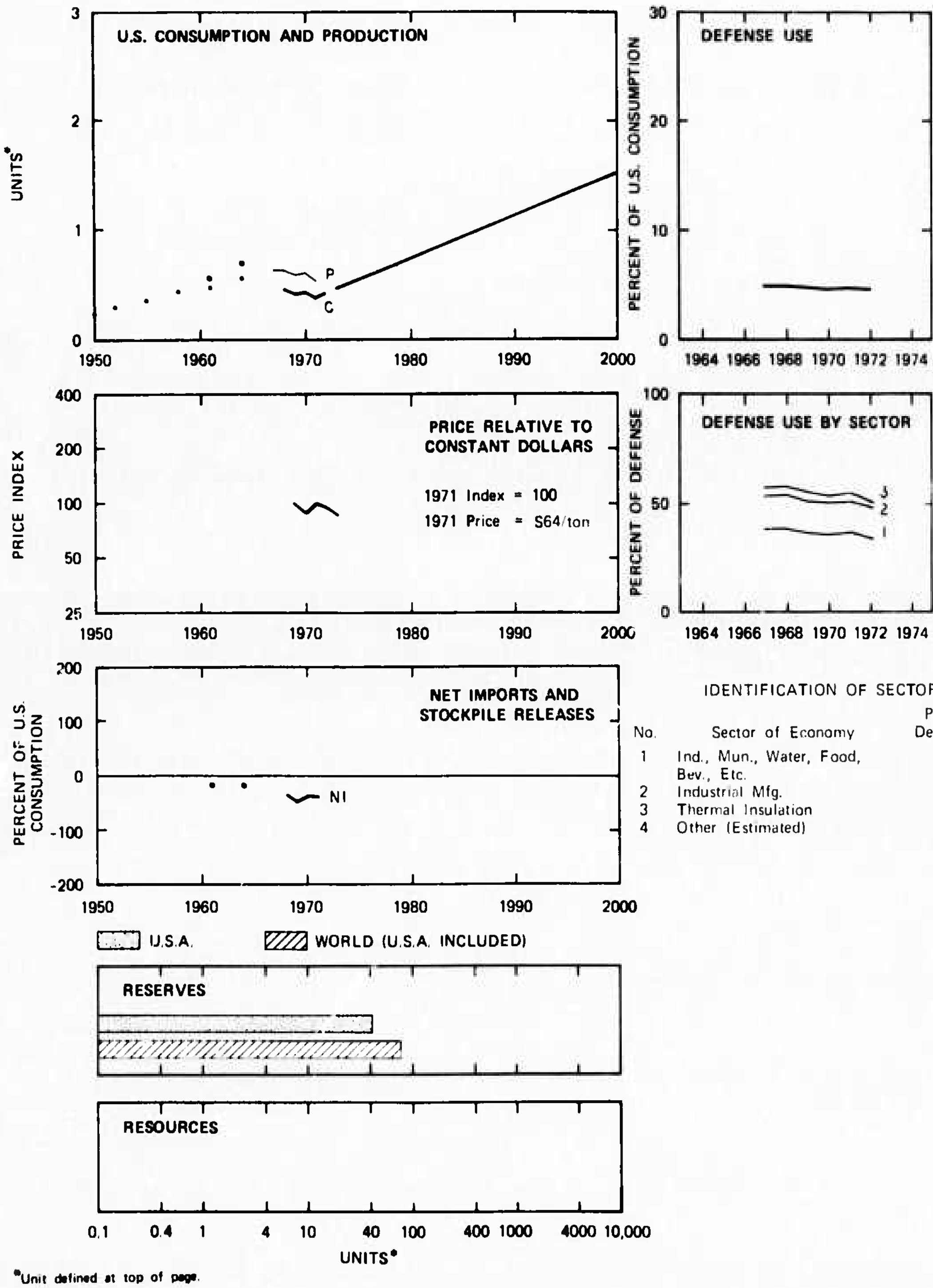
Imports: The United States was self-sufficient in diatomite for 1972.

Stockpile: Diatomite is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: Resources are "large".

Defense Use: Estimates for the years prior to 1968 were not made because the data on U.S. consumption appeared inconsistent with the series used for 1968-1972.

DATA SUMMARY: DIATOMITE
One Unit = 1,000,000 Short Tons
1972 World Production = 1.6 units



IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Ind., Mun., Water, Food, Bev., Etc.	34
2	Industrial Mfg.	14
3	Thermal Insulation	3
4	Other (Estimated)	49
		100

*Unit defined at top of page.

NOTES ON FELDSPAR

Uses: Glass making stabilizer. Ceramic flux, binder. Abrasives and scouring soaps. Special ceramics, such as those used on radar domes.

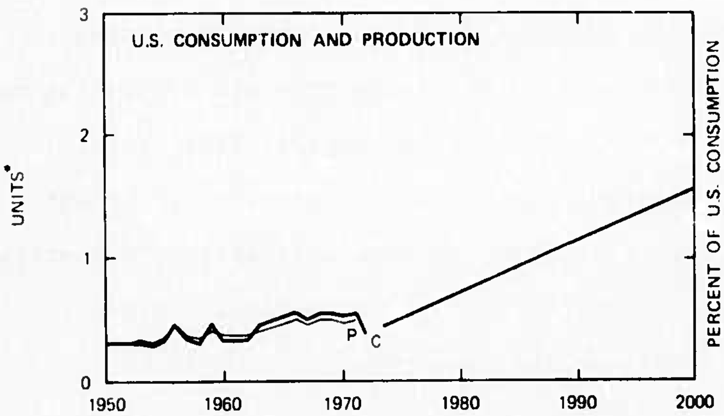
Price: The price given is an average.

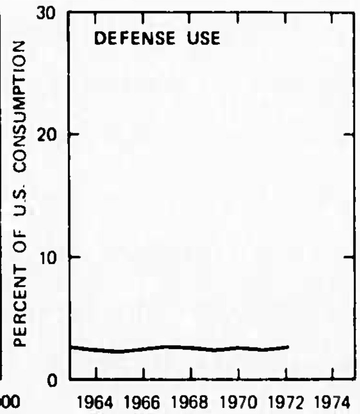
Imports: The United States was self-sufficient in feldspar in 1972.

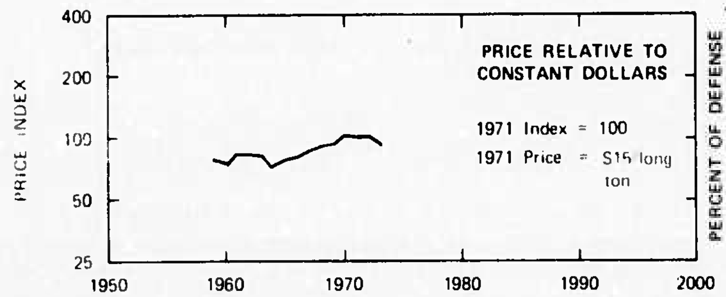
Stockpile: Feldspar is not on the list of Basic Stockpile Materials, 1972.

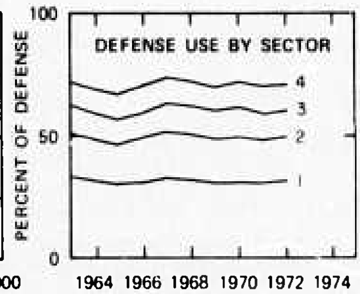
Reserves and Resources: Resources are "large".

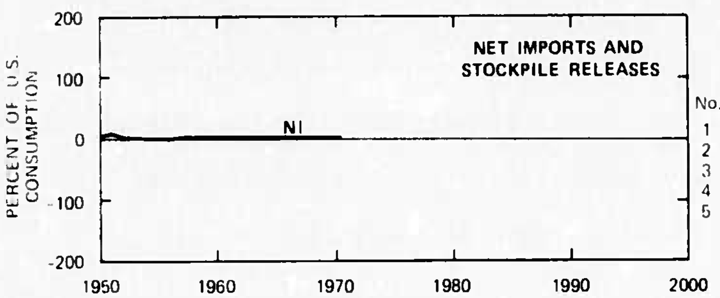
DATA SUMMARY: FELDSPAR
One Unit = 1,500,000 Short Tons
1972 World Production = 1.8 units





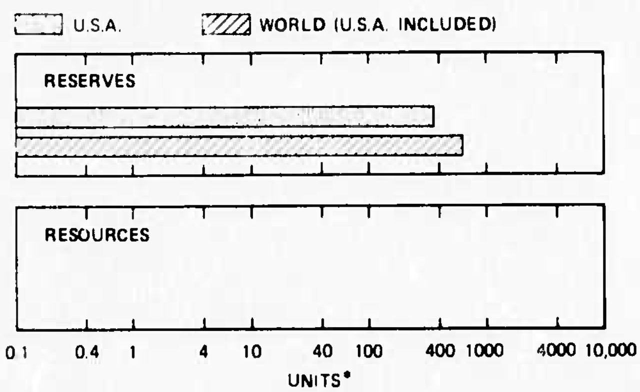






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Pottery	32
2	Flat Glass	18
3	Enameling	11
4	Container Glass	10
5	Other (Estimated)	29
		100



*Unit defined at top of page.

NOTES ON FLUORINE

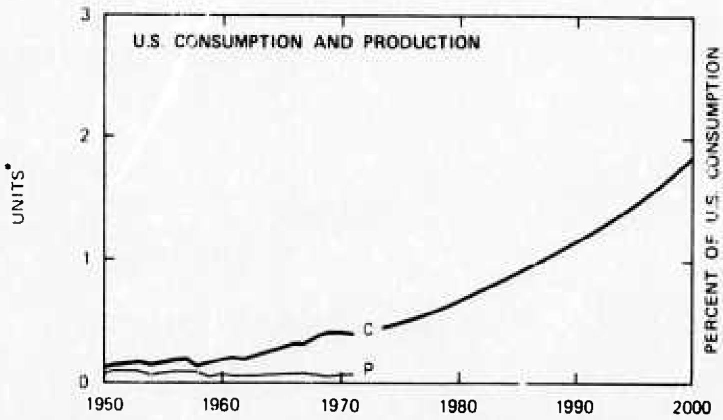
Uses: Refrigerants, aerosols, solvents, plastics, pesticides, dyes, medicinals, lubricants, hydrolic liquids, dielectric and antiradiation fluids, rubber additives, surfactants. Metallurgical flux, steel and aluminum. Electrometallurgy, glass, iron, ferroalloys. Cement, Water fluorination. Uranium processing. Octane catalyst. Polymerization, esterification, alkylation, nitration, sulfonation. Glass etching. Electroplating. Oil well stimulation.

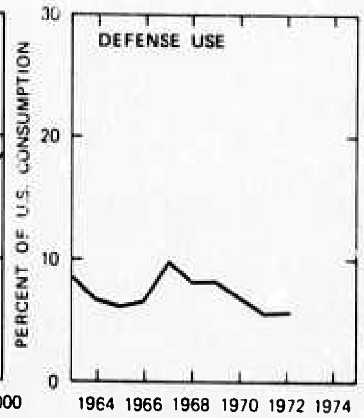
Price: The price quoted is for fluorspar and is the average mine value per ton.

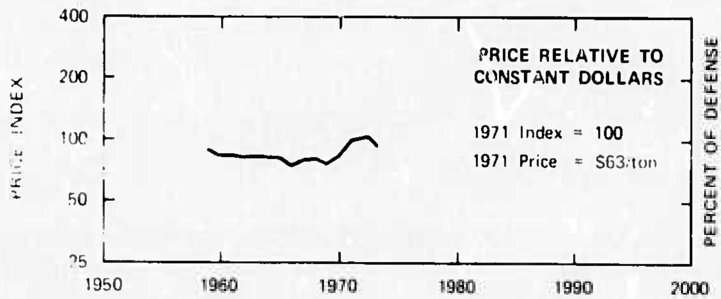
Imports: Percentages are based on elemental content of fluorspar.

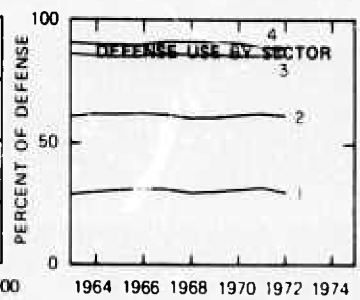
Stockpile: Fluorine is included on the list of Basic Stockpile Materials, 1972, in the following forms: Acid grade fluorspar; Metallurgical grade fluorspar. Any releases for 1968 - 1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 569,000 short tons of fluorine.

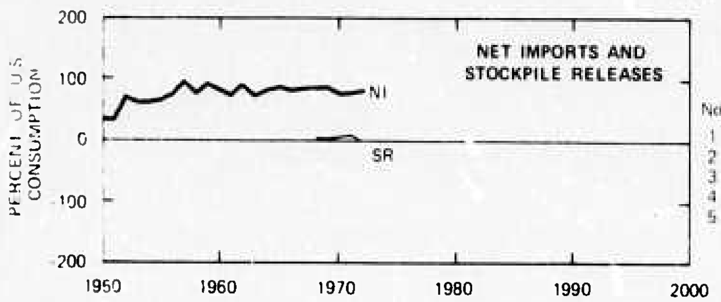
DATA SUMMARY: FLUORINE
One Unit = 1,500,000 Short Tons
1972 World Production = 1.6 units





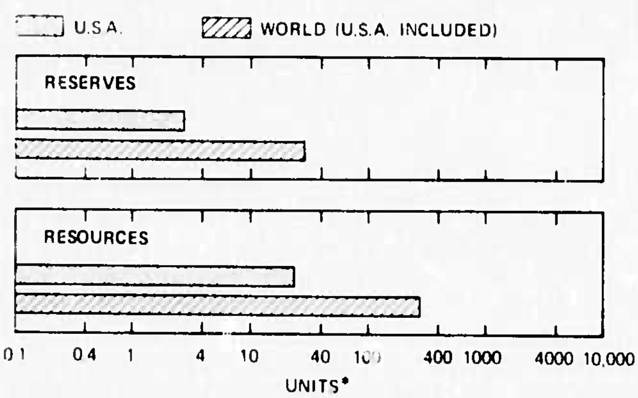






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Refrig., Aeros., Solvs., Pla	31
2	Steel Fluxing	30
3	Aluminum	24
4	Electrometallurgy	4
5	Other (Estimated)	11
		100



*Unit defined at top of page

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Mexico	22	80	65
Spain	10	25	10
Italy	6	25	5
South Africa	4	12	2
W. Germany	2	5	<1
Other	6	5	1

NOTES ON GALLIUM

Uses: Semiconductors. Light Emitting Diodes, as instrument indicator lights.

Price: The price given is in dollars per kilogram.

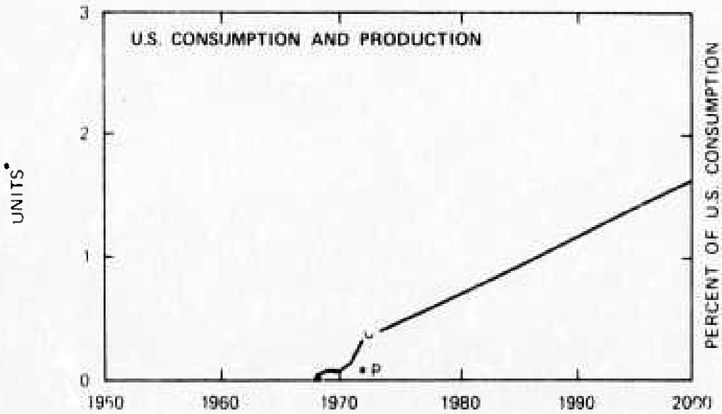
Stockpile: Gallium is not on the list of Basic Stockpile Materials, 1972.

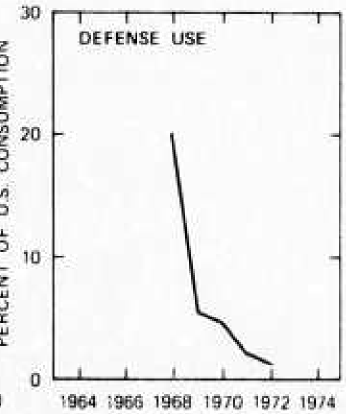
Reserves and Resources: Economic estimates are based on by-product association with aluminum and zinc production. Reserves and resources estimates are "large".

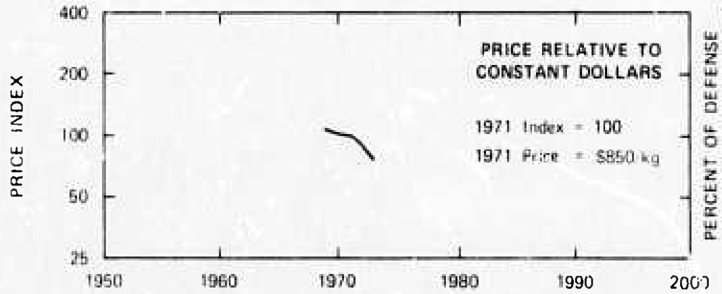
Defense Use: Consumption by sectors was specified in terms of ranges. Estimates given here are based on mid-range values.

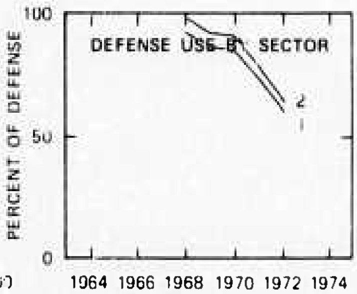
The high percent defense use in 1968 is due primarily to the low U.S. consumption that year compared to later years.

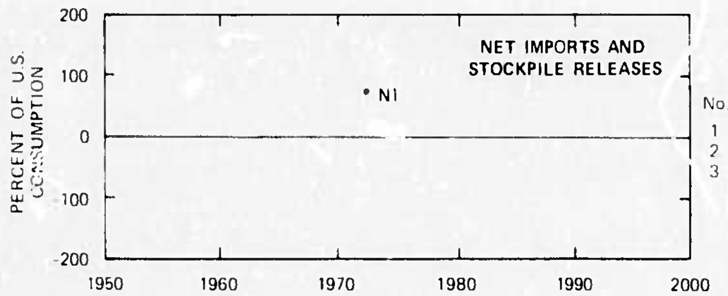
DATA SUMMARY: GALLIUM
One Unit = 15,000 kg
1972 World Production = 7 units





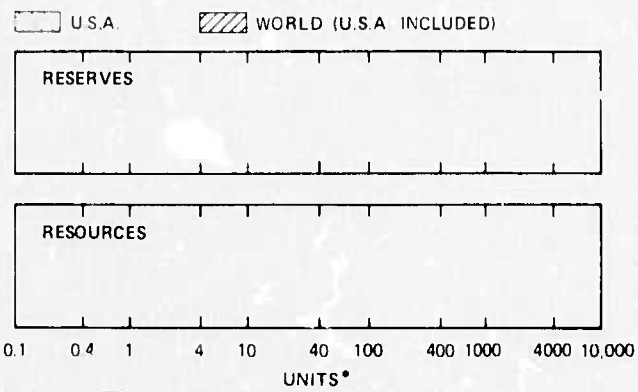






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Semiconductors	59
2	Mechanical Measuring Devices	4
3	Other (Estimated)	37
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	25	NA	NA
France	20	NA	NA
Canada	15	93	28
Switzerland	0	-	81
W. Germany	0	-	2
Other	NA	NA	8
			119

*Unit defined at top of page

NOTES ON GARNET

Uses: Optical lens and plate glass grinding, lapping of semiconductors and metals. Non-skid floor paint. Abrasive papers and cloths. Sandblasting aluminum, other materials.

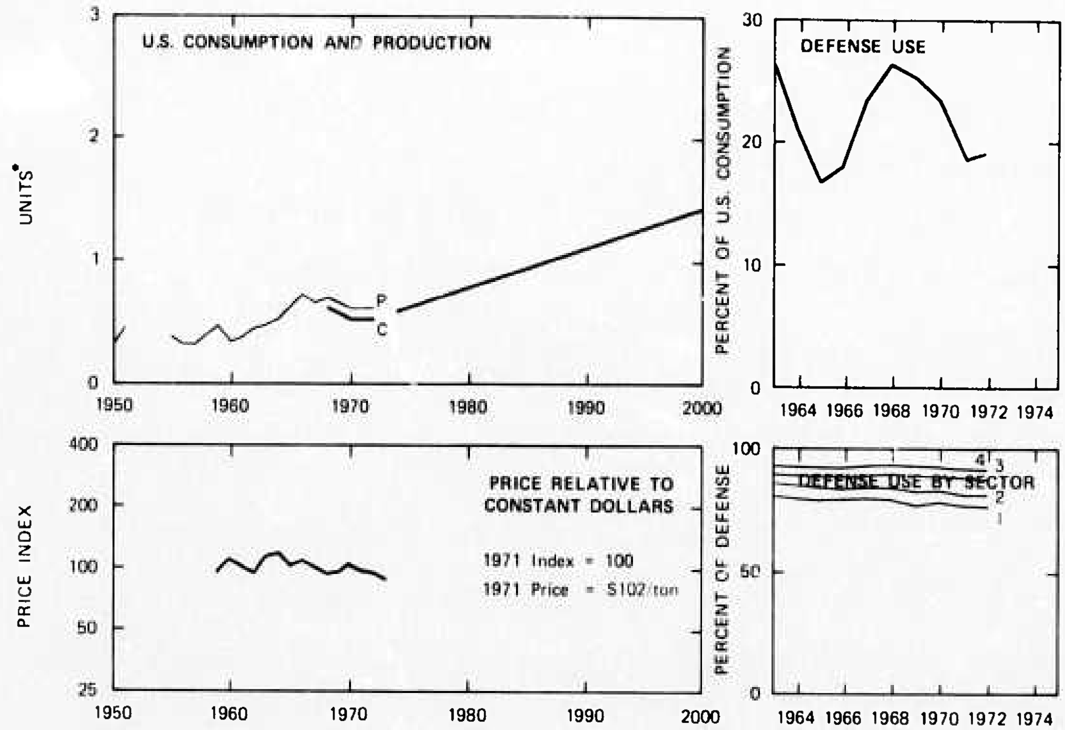
Price: The price given is the average value per ton.

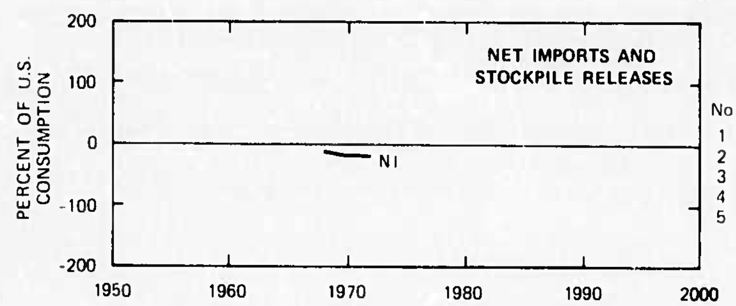
Imports: The United States was self-sufficient in garnet for 1972.

Stockpile: Garnet is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: Quantitative data on reserves and resources are not available, but both are "large", in the U.S. and abroad.

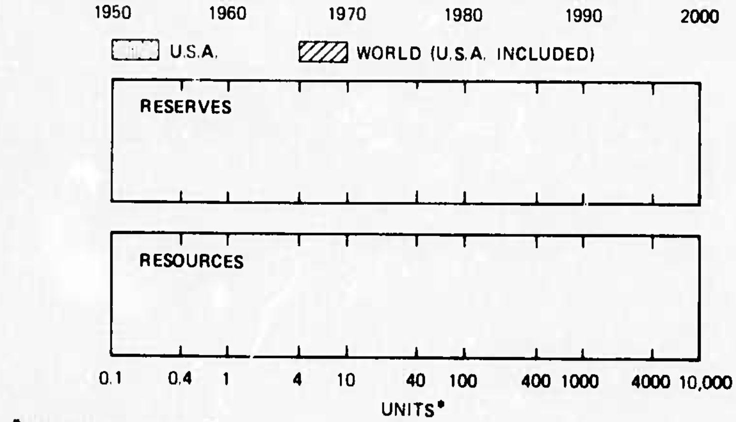
DATA SUMMARY: GARNET
One Unit = 30,000 Short Tons
1972 World Production = 0.8 units





IDENTIFICATION OF SECTORS

No	Sector of Economy	Percent of Defense 1972
1	Aircraft	76
2	Optical Instruments, Lenses	6
3	Semiconductors	6
4	Flat Glass	4
5	Other (Estimated)	8
		100



*Unit defined at top of page

NOTES ON GERMANIUM

Uses: Semiconductors for consumer electronics and co' munication, computing and data processing, nuclear measuring instruments. Optical glass. Infrared equipment. Alloying agent in copper, aluminum and magnesium. Gold solder. Phosphorous.

Price: The price given is an average domestic price per gram, in 1000 gram lots, first reduction quality.

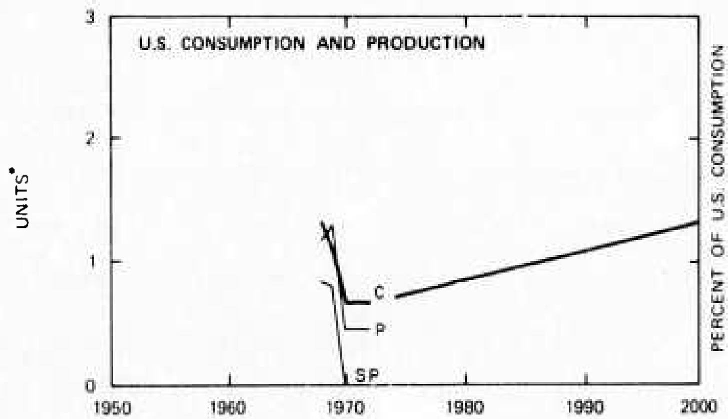
Imports: Partly through United States refineries, partly as metal.

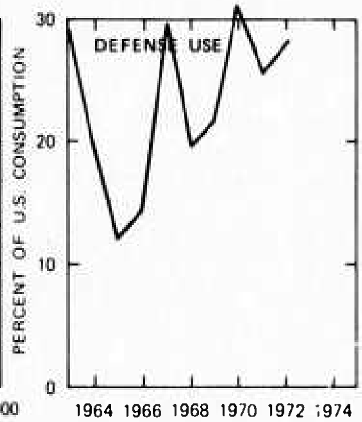
Stockpile: Germanium is not on the list of Basic Stockpile Materials, 1972.

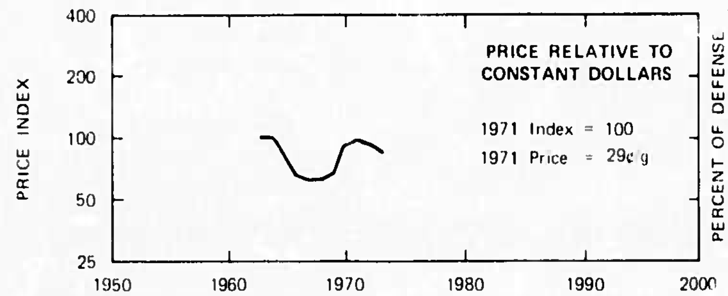
Reserves and Resources: Economic estimates are based on co-product association with zinc and copper process g. Not recovered from coal ashes and flue dust in the United States as it is in the United Kingdom.

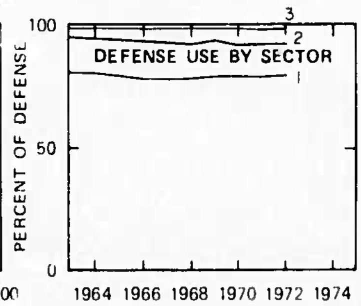
Defense Use: Large year to year fluctuations in percent defense use can be attributed largely to fluctuations in the values used for U.S. consumption rather than to changes in defense procurements.

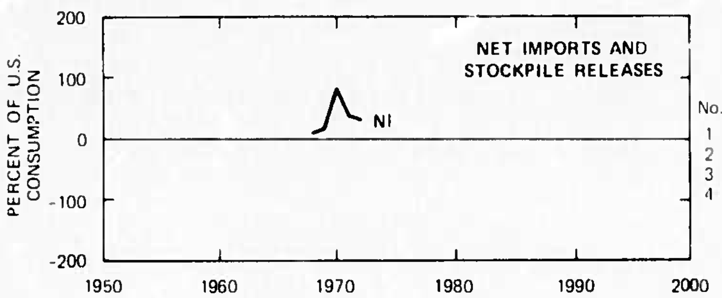
DATA SUMMARY: GERMANIUM
One Unit = 60,000 Pounds
1972 World Production = 2.7 units





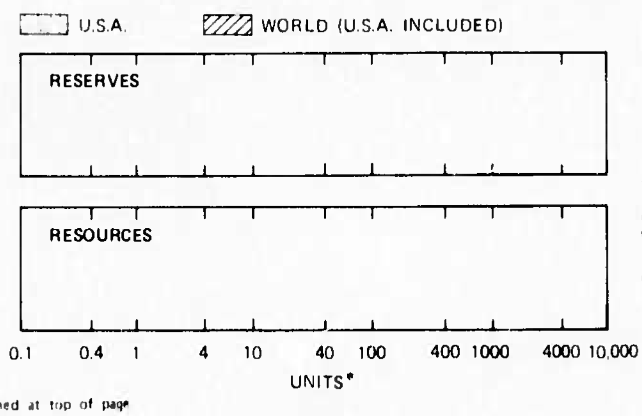






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Consumer Electron Con Eqp	80
2	Electron Computing Equip	13
3	Electronic Detctn Equip	5
4	Pressed + Blwn Glas Optcl	2
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Zaire	31	2	2
USSR	9	20	8
Canada	6	40	10
W. Germany	3	20	2.5
Czechoslovakia	1	50	2.5
Other	<1	100	2.5
			17

*Unit defined at top of page

NOTES ON GOLD

Uses: Monetary. Jewelry. Electric circuits, contacts, microwave tubes. Dental. Liquid bright coatings on glass, porcelain, fiberglass, plastic, metal. Infrared reflective coatings on missile heat shields, helmet visors. Glassware. Treatment of arthritis, cancer.

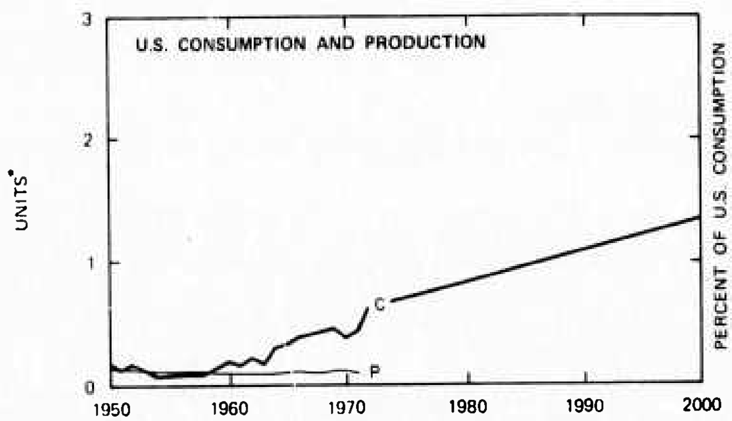
Price: The price quoted is an average, dollars per troy ounce.

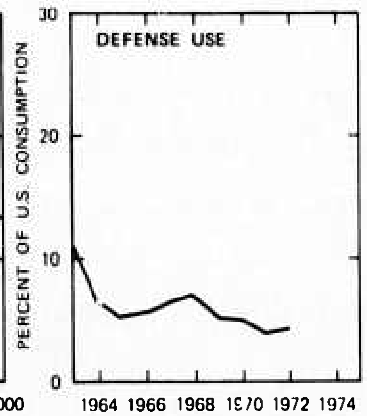
Imports: Some through United States refineries, most as refined metal.

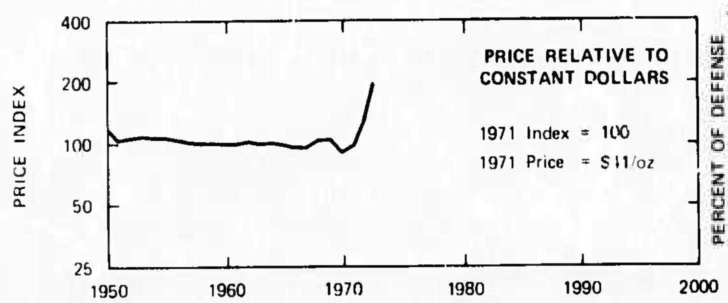
Stockpile: Gold is not on the list of Basic Stockpile Materials, 1972.

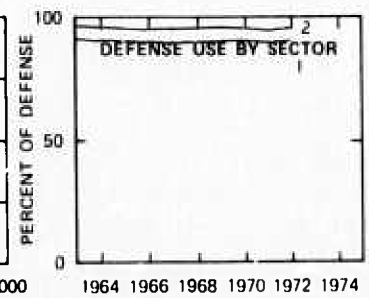
Resources and Reserves: Economic estimates are partly based on by-product and co-product association with other minerals.

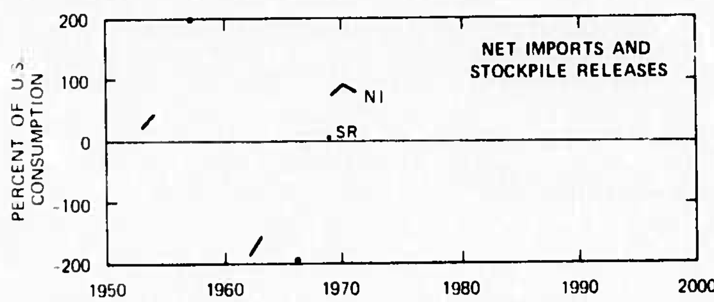
DATA SUMMARY: GOLD
One Unit = 15 Million Troy Ounces
1972 World Production = 3.0 units

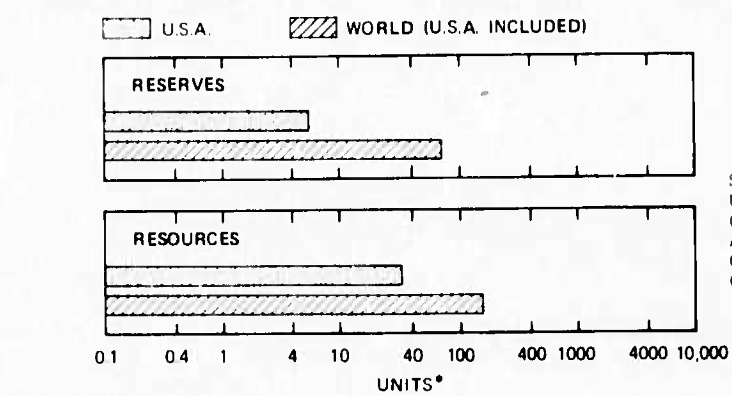












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Electronic Components	91
2	Jewelry, Prec. Mets.	5
3	Dental Equip. & Supplies	4
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
South Africa	65	7	24
USSR	15	8	6
Canada	5	146	32
Australia	2	5	<1
Ghana	2	NA	NA
Other	8	13	5
			68

NOTES ON GRAPHITE

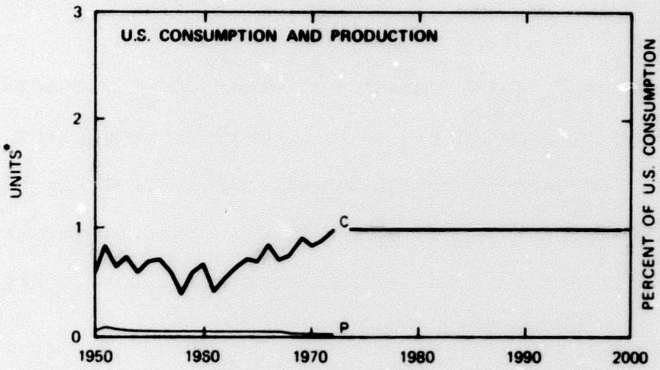
Uses: Foundry facings, brick mortar and patching, crucibles, nozzles, stopper heads, retorts, other refractory products. Carbon raiser in steel making. Lubricant, special packings. Lead pencils. Dry batteries. Brake linings. Electric motor brushes. Paints. Polish. Rubber. Explosives. Powder metallurgy.

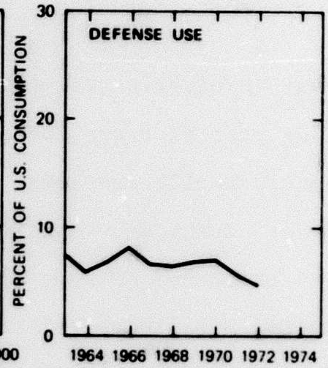
Price: The price given is an average import price for flake graphite at foreign ports.

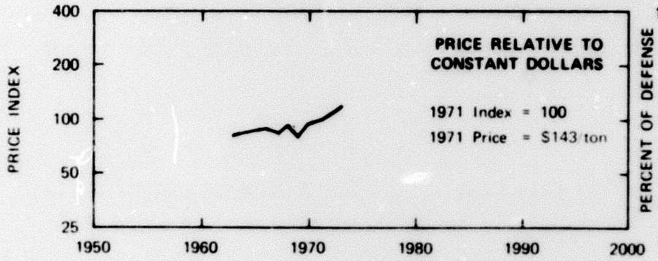
Stockpile: Graphite is included on the list of Basic Stockpile Materials, 1972, in the following forms: Natural Ceylon graphite; Natural Malagasy graphite; crystalline graphite other than Ceylon or Malagasy. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 36,000 short tons of natural graphite.

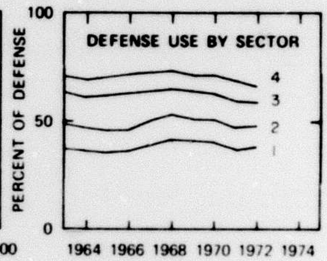
Reserves and Resources: United States reserves are "insignificant".

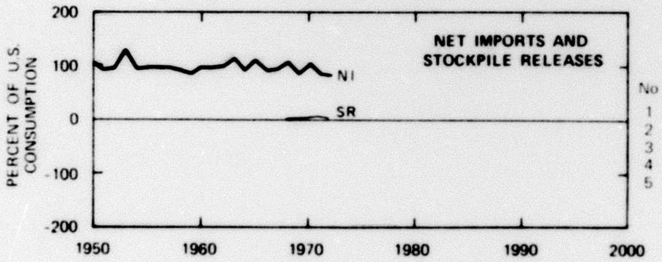
DATA SUMMARY: GRAPHITE
One Unit = 70,000 Short Tons
1972 World Production = 5.7 units

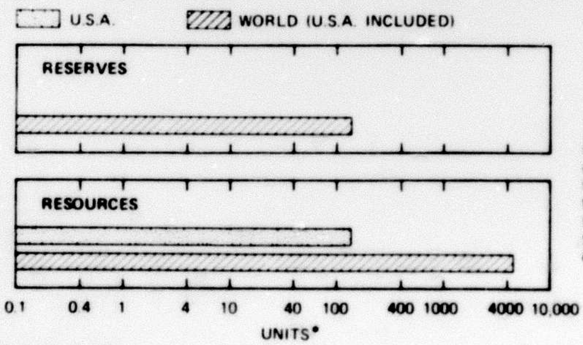












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No	Sector of Economy	Percent of Defense 1972
1	Foundries (Facings)	39
2	Steelmaking	11
3	Refractories (Noncrucible)	10
4	Lubricants + Packings	8
5	Other (Estimated)	32
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Mexico	15	77	67
China	8	3	1
Malagasy R.	5	30	9
W. Germany	4	14	3
Norway	2	44	6
SRI Lanka	2	38	4
Other	NA	NA	1
			91

NOTES ON GYPSUM

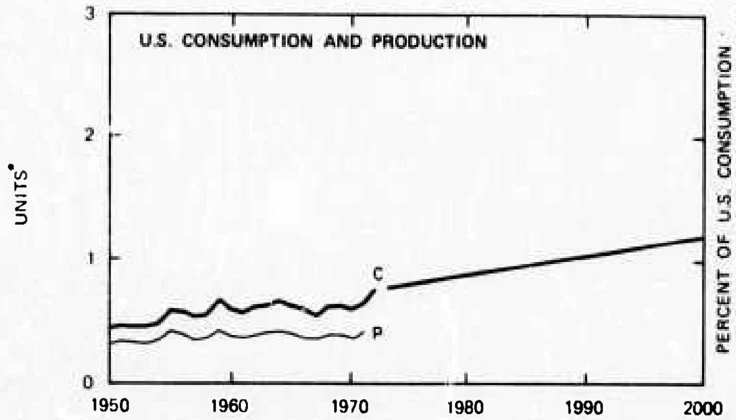
Uses: Prefabricated wallboard, lath, sheathing, other board products. Industrial plasters for models, patterns, casting molds, dehydrating agents, coal briquetting, orthopedic casts, dental casts, chalk crayon binder, machinery mounts. Cement. Soil conditioner. Yeast fermentation promoter. Glass. Fillers in wood, paint, textiles, paper. Production of calcium sulfide and ammonium sulfate.

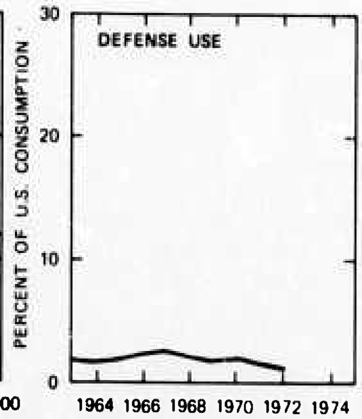
Price: The price quoted is an average, f.o.b. the mine, for crude gypsum.

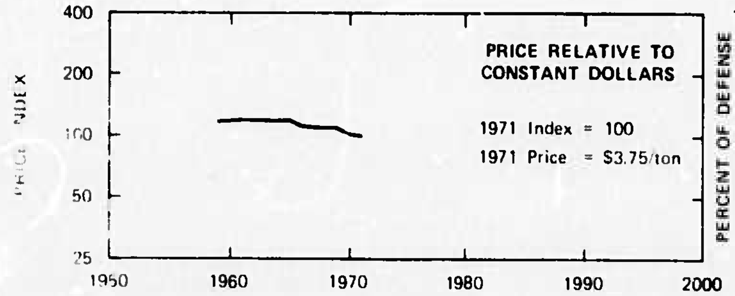
Stockpile: Gypsum is not on the list of Basic Stockpile Materials, 1972.

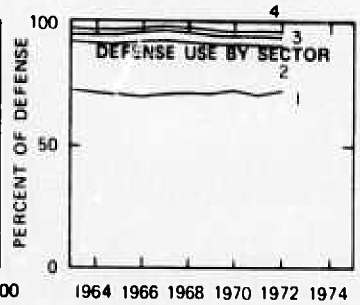
Reserves and Resources: World resources are "large".

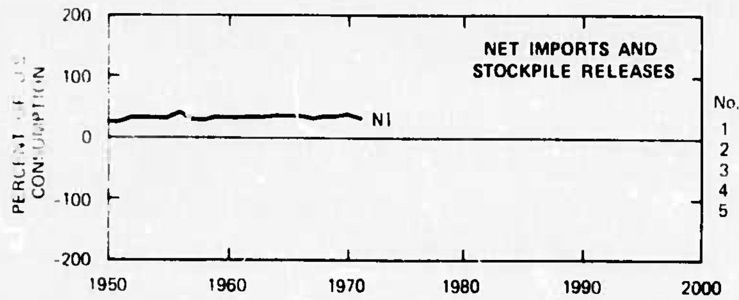
DATA SUMMARY: GYPSUM
One Unit = 25,000,000 Short Tons
1972 World Production = 2.5 units





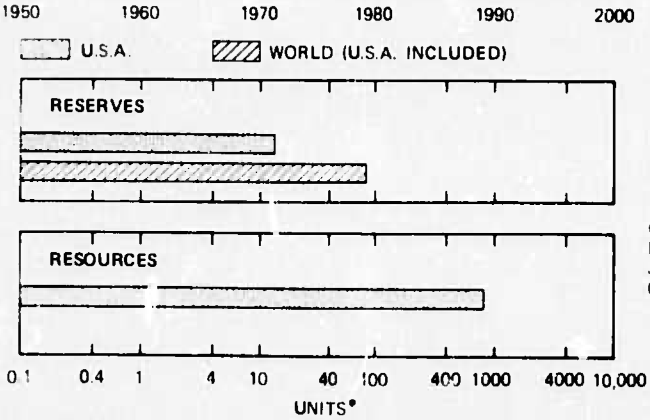






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Plasters, Buldg Prefab Pro	72
2	Cement Retarder	18
3	Agricultural	4
4	Plasters, Industrial	2
5	Other (Estimated)	4
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	12	74	30
Mexico	3	75	6
Jamaica	<1	100	2
Other	66	<1	<1
			40

*Unit defined at top of page

NOTES ON HAFNIUM

Uses: Reactor control rods. Alloy additive for jet aircraft and space power systems. Enamels. Insulator. Cutting tools. Bulb filaments. Vacuum tube getters. Flash bulbs. Composite fibers. Detonating caps and ammunition. Optical glasses.

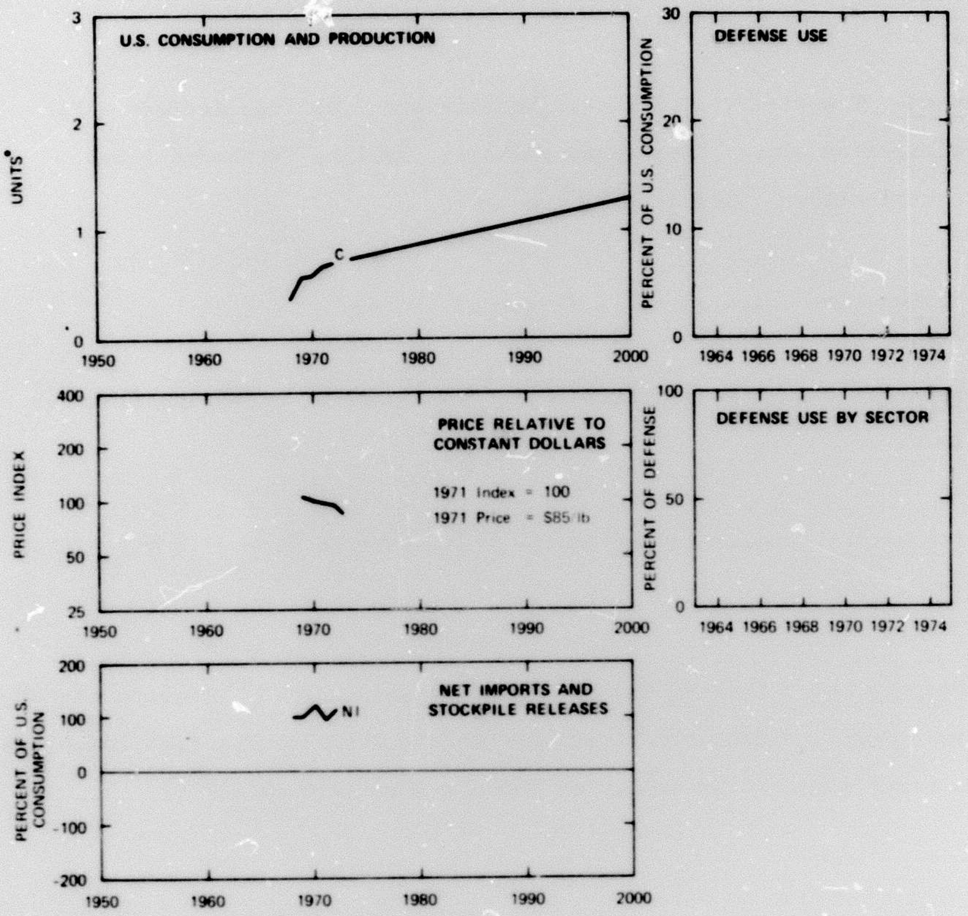
Price: The price given is for domestic hafnium.

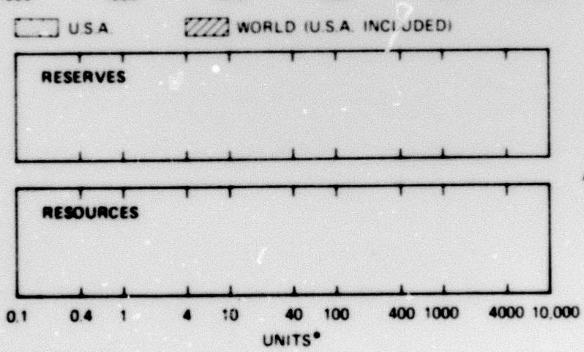
Stockpile: Hafnium is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: United States supply recovered as by-product in production of nuclear grade zirconium, in turn a by-product of titanium mineral production. Reserves and resources estimates are "large".

Defense Use: Anomalies in the description of uses by economic sectors prevented estimates of DOD uses. However, hafnium is of major importance to DOD since its principal use in 1968 (85% of material) was for nuclear reactor control rods, with the remainder for research and development.

DATA SUMMARY: HAFNIUM
One Unit = 50 Short Tons
1972 World Production = 1.7 units





*Unit defined at top of page

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	71	67	114

NOTES ON INDIUM

Uses: Transistors. Solder. Thermistors. Optical devices. Fire protection plugs. Aerospace gaskets. Sealing TV camera tubes. Dental alloys. Jewelry. Silverware.

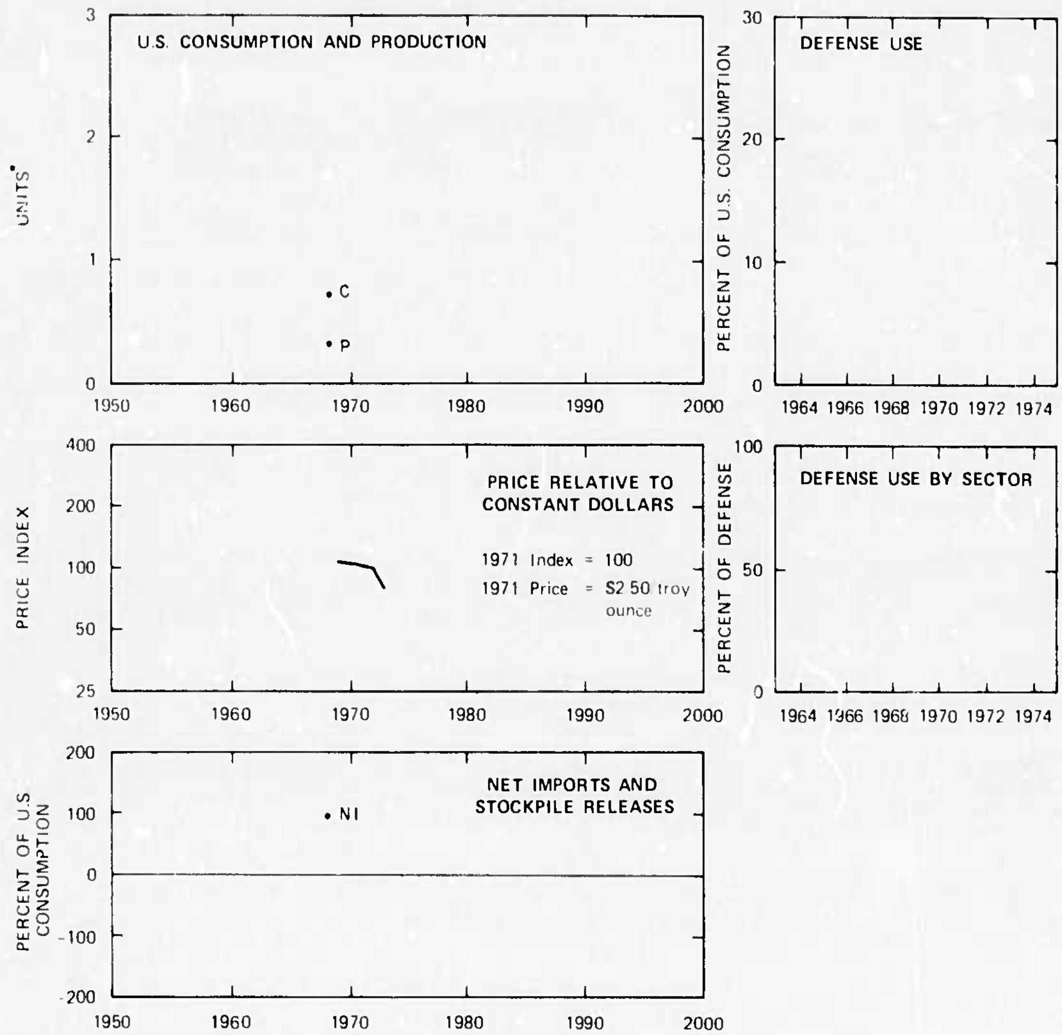
Price: The price given is an annual average.

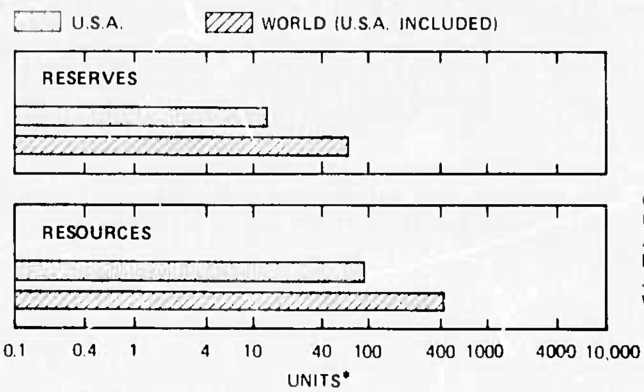
Imports: The United States demand information is confidential for 1972.

Stockpile: Indium is not on the list of Basic Stockpile Materials, 1972.

Defense Use: Because the flow diagram data showed "research and development", a sector not included in the 1963 input-output table, as a major user, no estimates of DOD use were attempted.

DATA SUMMARY: INDIUM
One Unit = 750,000 Troy Ounces
1972 World Production = 2.9 units





SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	23	42	NA
USSR	14	57	NA
Australia	9	46	NA
Peru	6	60	NA
Japan	5	15	NA
W. Germany	3	64	NA

*Unit defined at top of page

NOTES ON IODINE

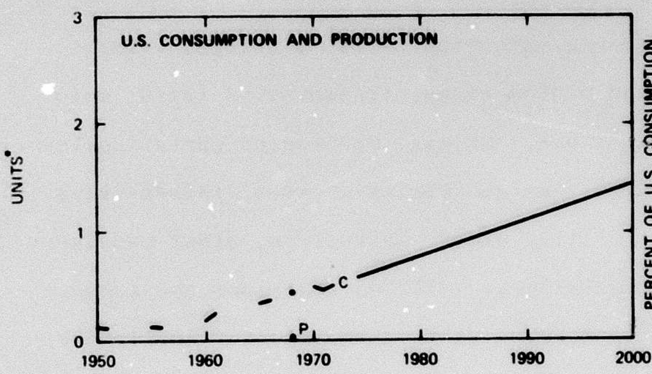
Uses: Disinfectants for detergents, surfactants, swimming pools, drinking water, industrial coolants and oils. Ionized salt. Animal and fowl feed. Photographic and photolithographic supplies. Dyes and certified food colorings. Catalysts for polybutadiene rubber, stabilized rosin, talloil products, semiconductor modification of selenium. Titanium, zirconium, boron, hafnium, other high purity metal manufacture. Octane catalyst. Separating olefin from paraffin hydrocarbons. Smog inhibitors. Cloud seeders. Additives in rechargeable dry cells and electric generator and motor brushes. Complexed with aromatic hydrocarbons as lubricants for titanium and stainless steel. Pharmaceutical, thyroid treatment.

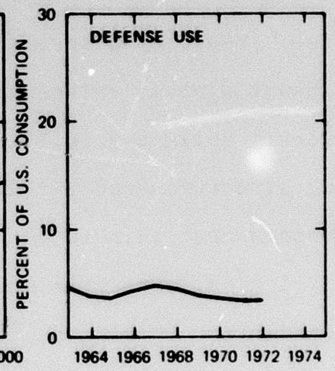
Price: The price given is the midpoint of a range for crude iodine.

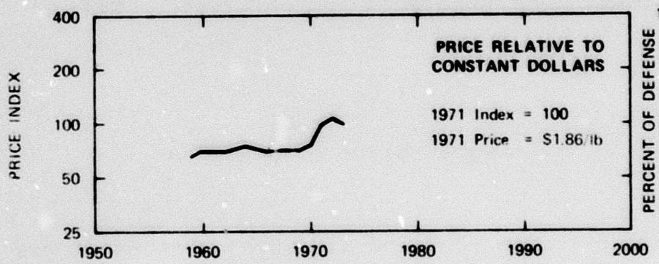
Stockpile: Iodine is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 8,012,000 pounds of iodine.

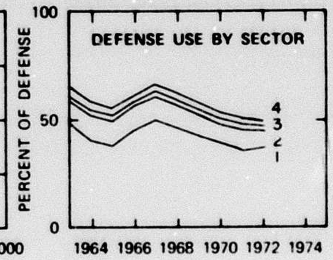
Reserves and Resources: Economic estimates are based on by-product association with natural gas production in Japan, nitrate mining in Chile and brine minerals in the United States.

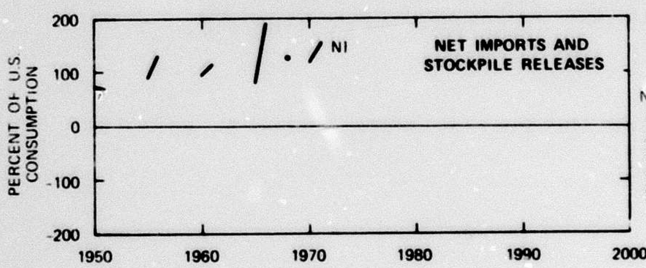
DATA SUMMARY: IODINE
One Unit = 10,000,000 Pounds
1972 World Production =





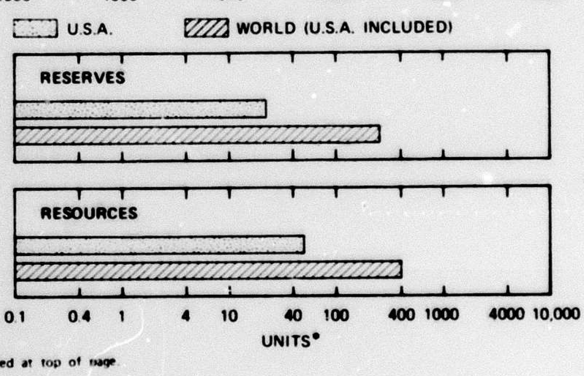






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Photographic Chemicals	38
2	Disinfectnt, Hosld + Indus	8
3	Pharmaceutical Preparatn	2
4	Animal + Fowl Feed	2
5	Other (Estimated)	50
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Japan	NA	38	118

*Unit defined at top of page.

NOTES ON IRON

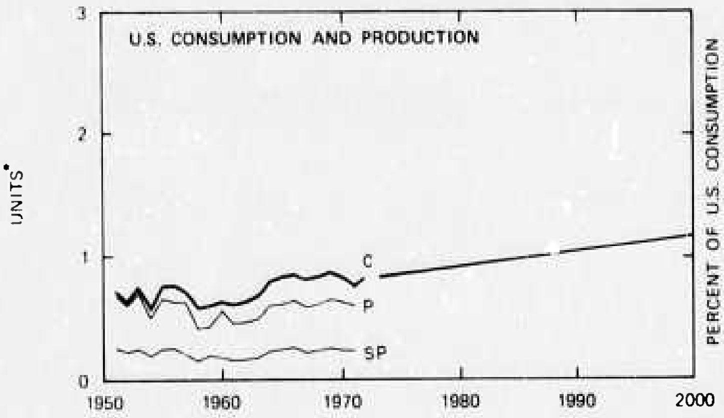
Uses: Vehicle bodies, frames, steering parts, bearings, trim, exhaust system, valves and piston rings, transmission train, motor block. Rails and rolling stock. Ships. Jet engine parts. Building structures and fixtures. Metal forming presses, lathes, saws, compressors, autoclaves, drills, plows, harvesters, other machinery. Metal cans, pressurized containers. Oil and gas pipes and tubes, refineries, holding tanks, service station equipment. Appliances, stainless steel ware. Ordnance. Chemicals and catalysts. Office supplies and furniture.

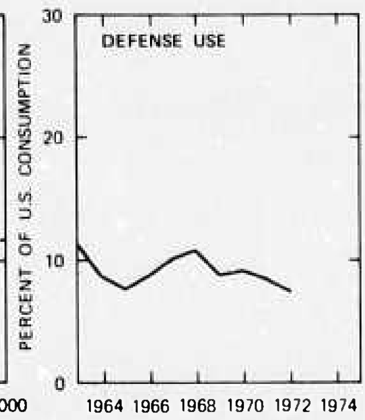
Price: The price quoted is the average price of pig iron.

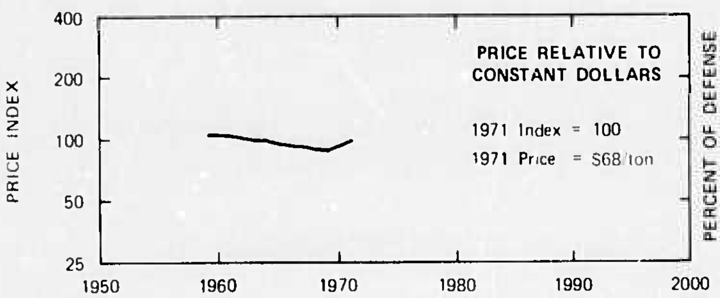
Imports: Percentages are based on combined elemental content of ore and pig iron. See additional discussion in Section V-C.

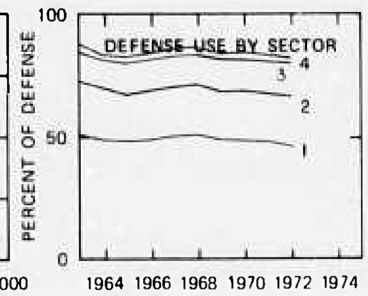
Stockpile: Iron is not on the list of Basic Stockpile Materials, 1972.

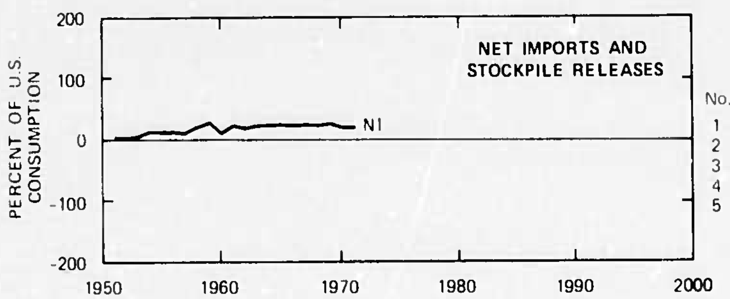
DATA SUMMARY: IRON
One Unit = 150,000,000 Short Tons
1972 World Production = 3.2 units





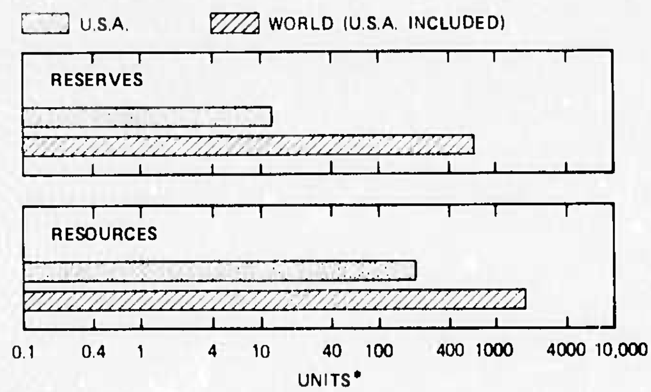






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation	46
2	Machinery + Equip (Ind + Agr)	20
3	Construction Products	13
4	Pipe, Tubes + Equip Oil + G	3
5	Other (Estimated)	18
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	9	1	<1
Brazil	6	3	1
Canada	6	45	10
Liberia	3	12	2
Venezuela	3	62	6
Peru	1	14	<1
Chile	1	3	<1
Other	5	1	<1
			20

*Unit defined at top of page

NOTES ON KYANITE

Uses: Blast furnace stoves, stacks, reheat furnaces, steel degassing chambers and soaking pits, pouring and handling equipment, kiln furniture. Blown aluminum silicate high temperature insulation, brake linings, foundry mold facings, glass batch addition for alumina content, ceramic tile body components, pyrometer tubes, electrical porcelain, spark plug insulators, spinnable fibers, ceramic honeycomb mortars, grinding media, extrusion dies, welding rod coating. Thin films, starting material for crystalline zeolites, metal fiber reinforced ceramic parts for leading wings of supersonic aircraft and spacecraft, skid resistant flooring. Aluminum silicon master alloys.

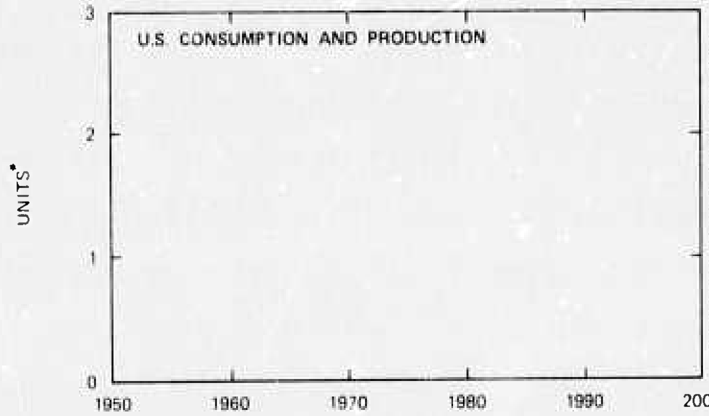
Imports: Figures are confidential.

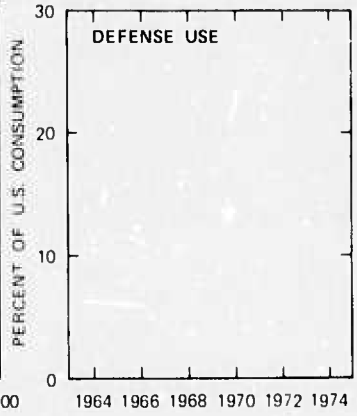
Stockpile: Kyanite was not on the list of Basic Stockpile Materials, 1972.

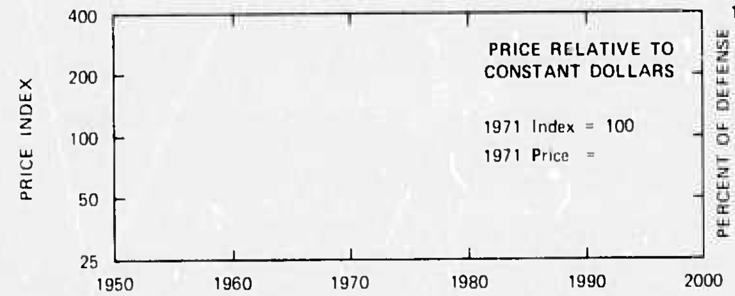
Reserves and Resources: These include kyanite, sellmanite, avalusite, synthetic mullite. World resources are "large".

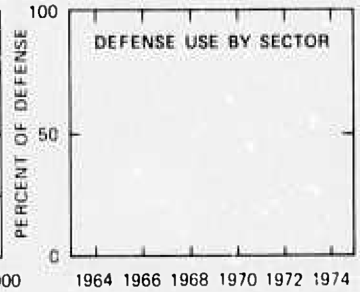
Defense Use: Anomalies in the description of uses by economic sectors prevented estimates of defense use.

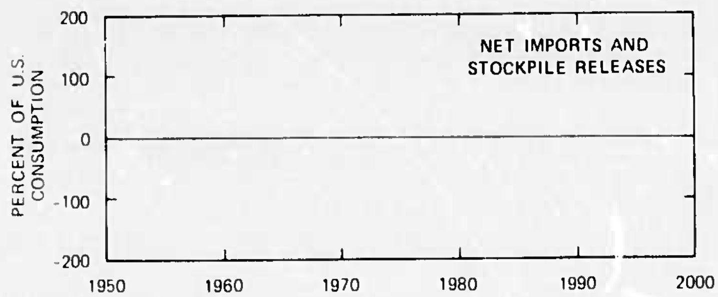
DATA SUMMARY: KYANITE
One Unit = 300,000 Short Tons
1972 World Production =

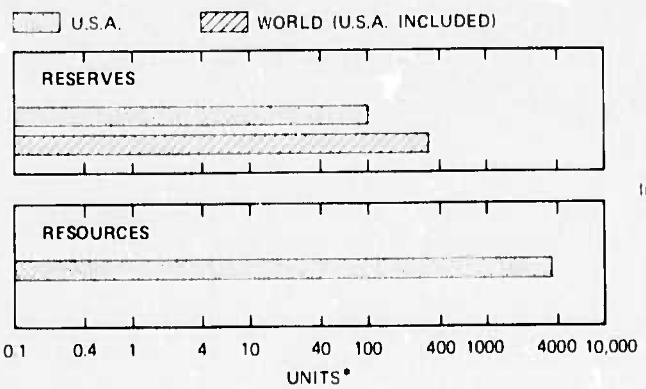












*Unit defined at top of page

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
India	NA	NA	NA

NOTES ON LEAD

Uses: Storage batteries. Octane additive. Bearings. Solder. Alloys. Greases. Paints. Counterweights. Waste piping. Radiation shielding, packaging. Vibration dampener, sound barrier in buildings. Cable sheathing. Ammunition. Paste and paint tubes. Printing type. Annealing bath. Oxidizing agent for dyes, matches, rubber substitutes, glass, pottery enamels, glazes, oil refining, adhesives, artist's pigments, paints. Insecticide. Vinyl plastics stabilizers. Sinkers and ballast. Lead-tin solder for tin coated cans.

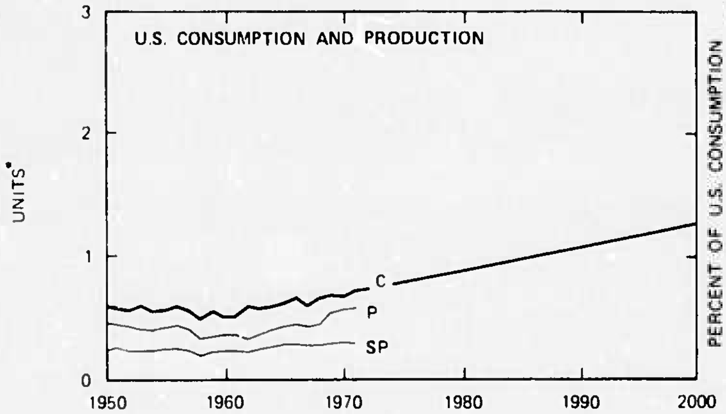
Price: The price quoted is for common lead, average New York price.

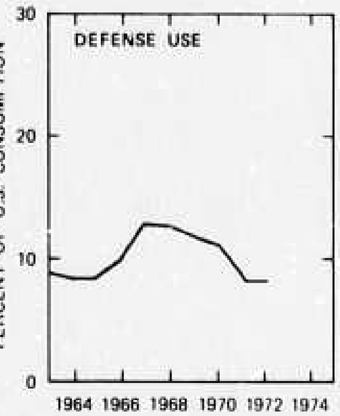
Imports: Some through United States refineries, most as metal.

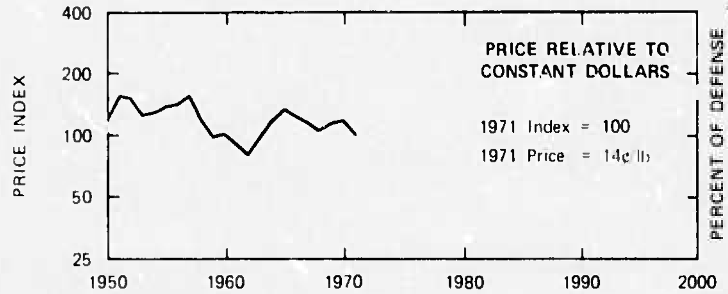
Stockpile: Lead is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968 - 1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 1,086,000 short tons of lead.

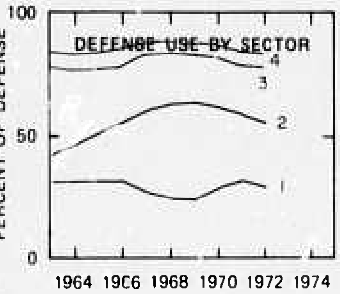
Reserves and Resources: Economic estimates are partly based on co-product and by-product association with other heavy metals. Resource estimates are "large".

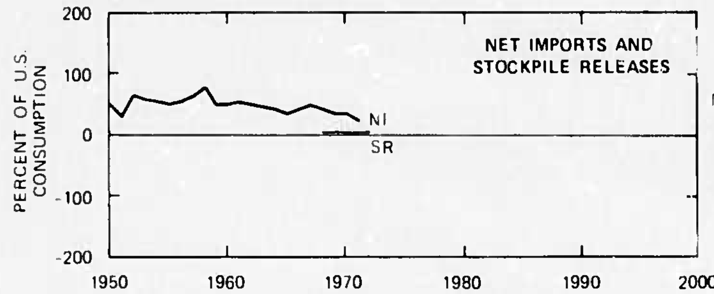
DATA SUMMARY: LEAD
One Unit = 2,000,000 Short Tons
1972 World Production = 1.9 units

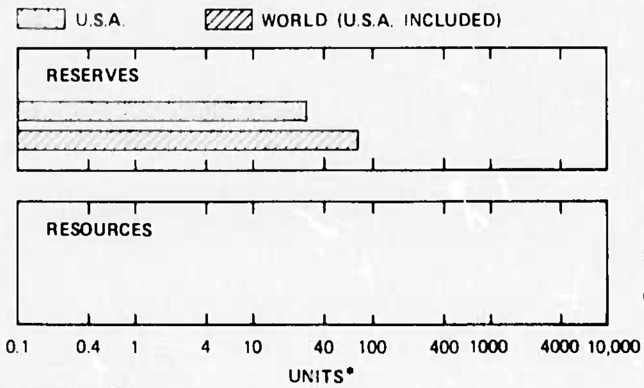












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation	28
2	Small Arms Ammunition	27
3	Communication Equip.	23
4	Gen. Bldg. Construction	5
5	Other (Estimated)	17
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	12	15	4
Canada	11	27	8
Peru	5	35	5
Yugoslavia	5	1	<1
Mexico	5	24	3
S.W. Africa	2	15	<1
Honduras	<1	74	1
Other	14	5	2
			24

NOTES ON LITHIUM

Uses: Ceramics. Glass. Greases. Humidity stabilizer in air conditioners. Oxygen regeneration in space capsules and submarines. Processing synthetic rubber, paint, pharmaceuticals. Steel and copper metallurgy. Organic synthesis. Vitamin A production. Welding and brazing. Laundry bleaches. Production of hydrogen. Aluminum processing. Magnesium alloys, for aerospace and industrial uses. Reactor cooling. Heat transfer fluid. Rocket fuel.

Price: The price given is for imported ore in dollars per ton of contained lithium.

Imports: United States demand and world production information is confidential.

Stockpile: Lithium is not on the list of Basic Stockpile Materials, 1972.

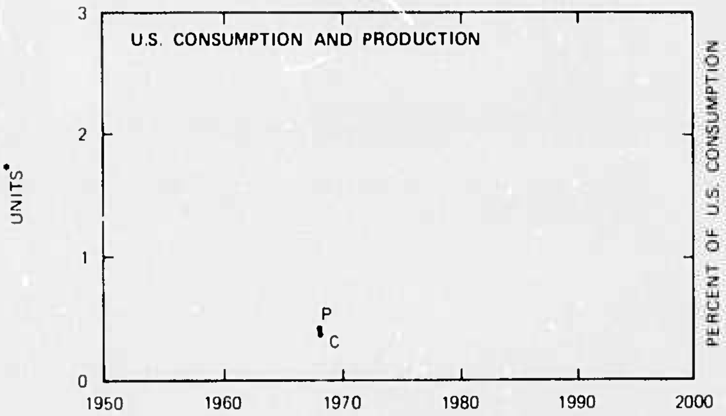
Reserves and Resources: Economic estimates are partly based on co-product and by-product association with many other minerals.

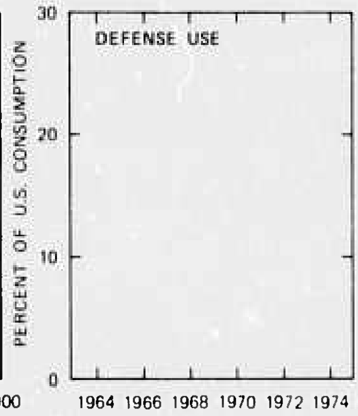
Defense Use: Because data on U.S. consumption were not available for years other than 1968, defense use was estimated for that year only.

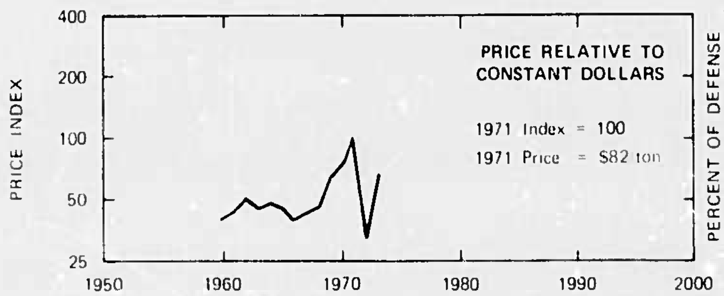
DATA SUMMARY: LITHIUM

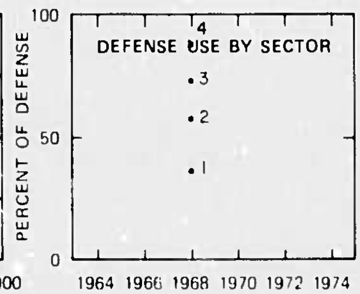
One Unit = 7,000 Short Tons

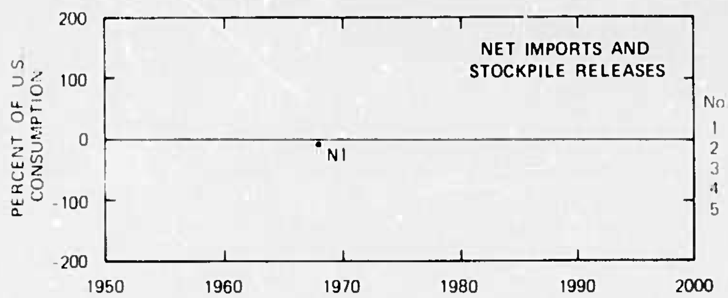
1972 World Production =





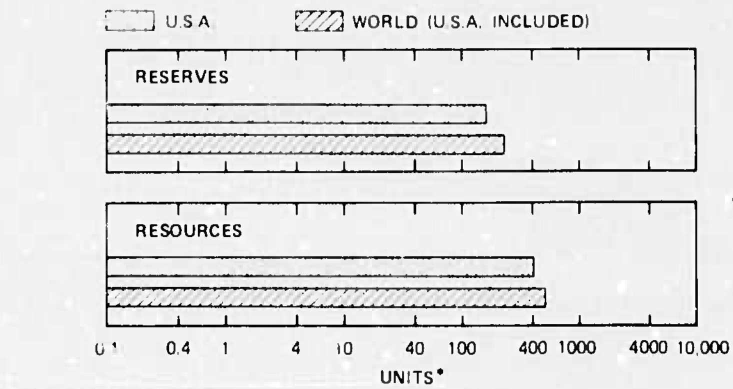






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Fluxes, Welding, Brazing	37
2	Greases	21
3	Ceramic and Glass	16
4	Metallurgy	15
5	Other (Estimated)	11
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	NA	63	NA

*Unit defined at top of page

NOTES ON MAGNESIUM

General: The data summary is based on total magnesium supply and demand, combining the data on magnesium compounds with those on magnesium metal. In 1972, the U.S. demand for the metal was about one tenth of the total demand for magnesium.

Uses: Metallurgical refractories. Vulcanizing agent in rubber, other chemical applications. Uranium recovery from ores. Thermal insulator. Table salt additive. Pharmaceuticals and cosmetics. Industrial chemicals. Flooring cement. Dyes. Sizing. Paper. Fertilizers. Explosives. Matches. Aircraft and missiles. Machinery. Tools. Electrical devices. Ductile iron. Auto and transportation equipment. Reducing agent for titanium, zirconium, hafnium, uranium, beryllium, scavenger and deoxidizer. Cathodic protection in underground pipe, water tanks and water heaters. Batteries. Photoengraving plates.

Price: The price given is an average for the metal.

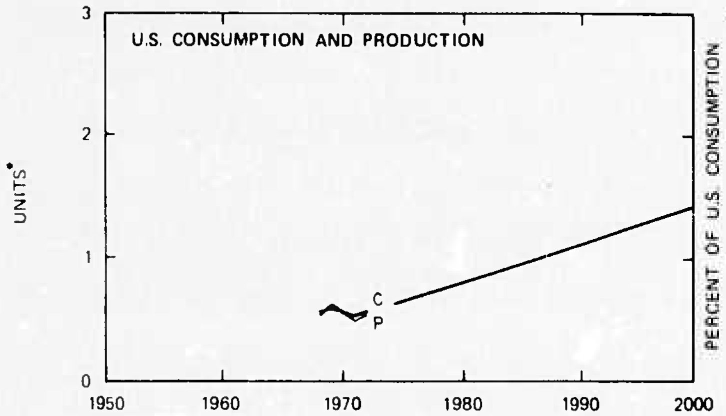
Imports: Percentage is based on combined elemental content of metal and magnesite. World production does not include dolomite, sea water, and well brine.

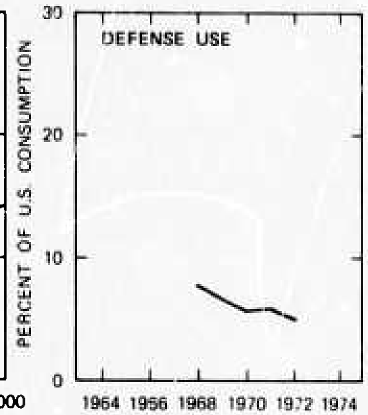
Stockpile: Magnesium is not on the list of Basic Stockpile Materials, 1972.

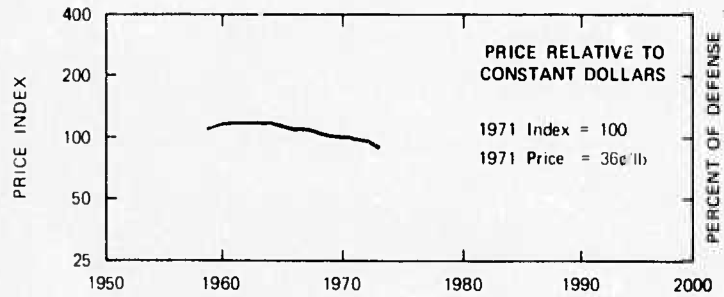
Reserves and Resources: "Large."

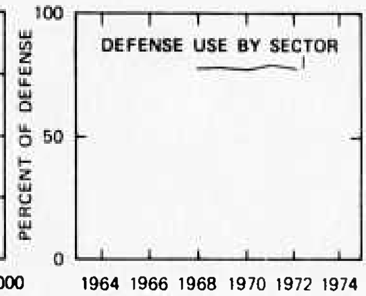
Defense Use: Estimates for the years prior to 1968 were not made because the available data on U.S. consumption did not appear consistent with the series used for 1968-1972.

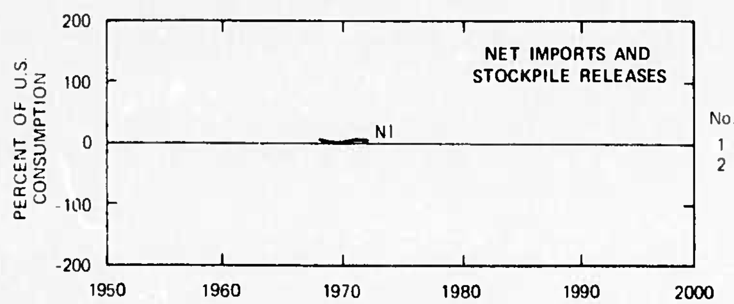
DATA SUMMARY: MAGNESIUM
One Unit = 2,000,000 Short Tons
1972 World Production = 2.7 units

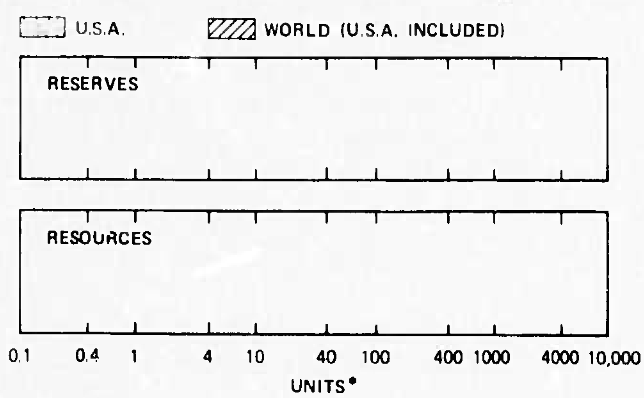












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Nonclay Refractories	78
2	Miscellaneous Chem Prod	22
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Austria	15	2	<1
China	10	1	<1
Greece	9	16	5
Turkey	3	1	<1
India	3	5	<1
Norway	1	7	<1
Canada	<1	33	<1
Other	7	11	2
			8

NOTES ON MANGANESE

Uses: Desulfurizing agent for processing of iron and steels used in industrial plants, commercial, residential and public buildings, bridges, dams, highways, other structures, plumbing, heating, air conditioning equipment, other fixtures, containers, appliances, furniture, pipes, tubing, equipment made from carbon steels. Alloy element for steels used in transportation, agricultural, mining, electrical, industrial machines and tools. Dry cell batteries. Photographic developer. Dye intermediate. Paint and varnish stabilizer. Disinfectants, deodorizers, bleaches, dyes. Catalyst for chlorination and paint and pharmaceutical preparation. Fertilizer. Brick manufacture. Ordnance. Bolts, nuts, rivets, screws, forgings.

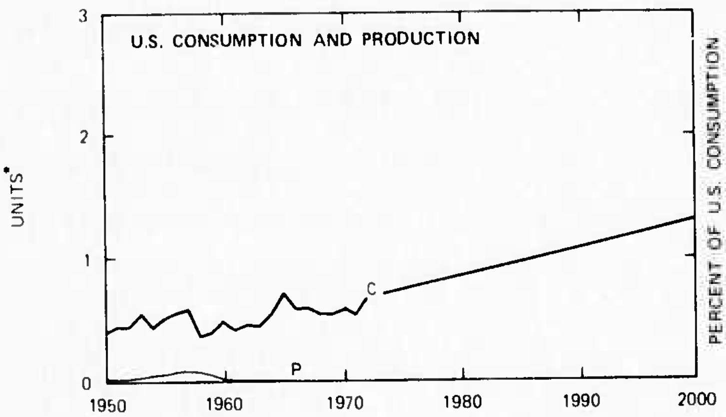
Price: The price index is derived from an average in dollars per long ton unit of contained manganese for 46-48% manganese metallurgical ore, c.i.f. U.S. ports, duty extra.

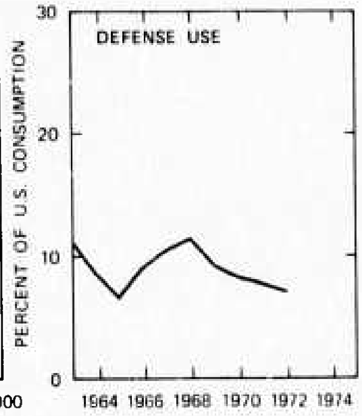
Imports: Percentage is based on combined elemental content of all forms of manganese.

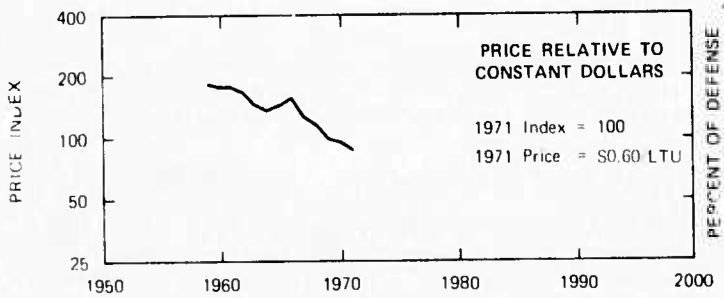
Stockpile: Manganese is included on the list of Basic Stockpile Materials, 1972, in the following forms: Battery grade natural ore; Battery grade synthetic dioxide; Type A chemical grade ore; Type B chemical grade ore; Metallurgical ore; High carbon ferromanganese; Low carbon ferromanganese; Medium carbon ferromanganese; Silicon manganese; Electrolytic manganese metal. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 4,929,000 short tons of manganese.

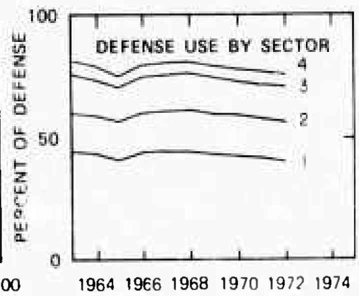
Reserves and Resources: U.S. reserves are insignificant, even at substantially higher prices. World land based resources are large and, in addition, there are very extensive deep sea deposits of manganese oxide.

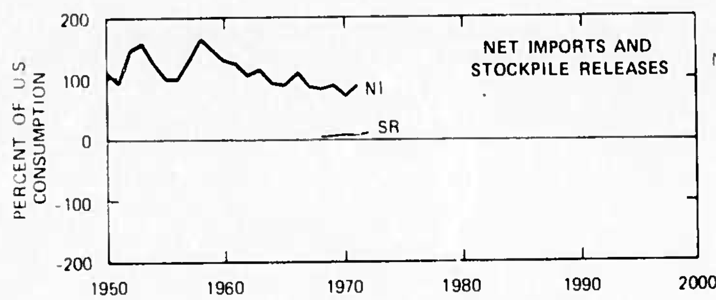
DATA SUMMARY: MANGANESE
One Unit = 2,000,000 Short Tons
1972 World Production = 5.0 units

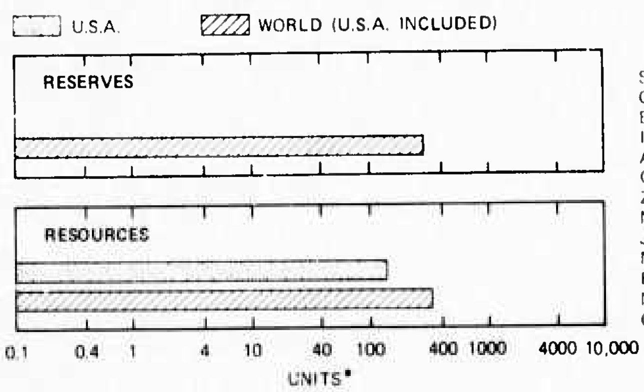












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No	Sector of Economy	Percent of Defense 1972
1	Transportation	40
2	Construction Products	16
3	Machinery and Equipment	15
4	Appliances and Equipment	5
5	Other (Estimated)	24
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
South Africa	15	12	13
Gabon	10	34	24
Brazil	10	20	14
India	6	4	2
Australia	6	6	3
Ghana	3	8	3
Zaire	2	38	6
Mexico	1	31	3
Japan	<1	34	2
Morocco	<1	25	1
France	0	–	6
Norway	0	–	3
Other	1	20	2
			82

NOTES ON MERCURY

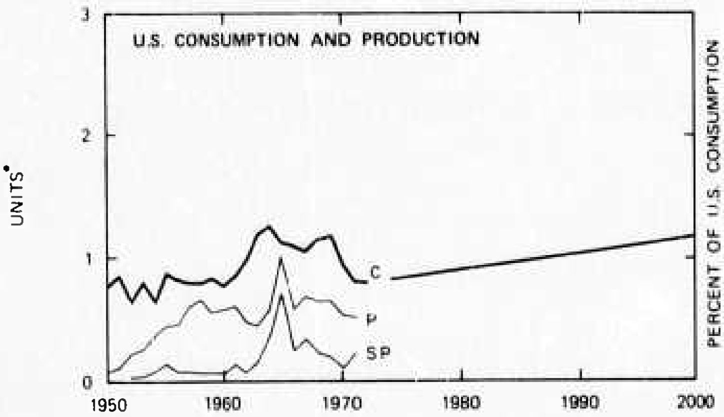
Uses: Manufacture of alkalines, chlorine. Batteries, electrical apparatus, lamps, current-carrying wire devices. Paints. Mechanical measuring devices. Pharmaceuticals. Agricultural chemicals. Dental supplies.

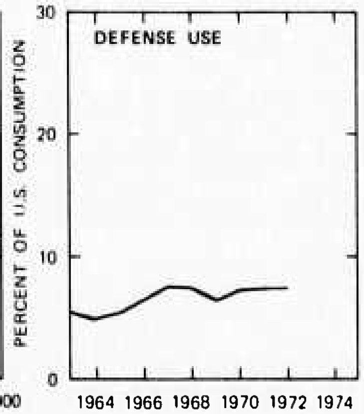
Price: The price quoted is per flask, average New York, duty paid.

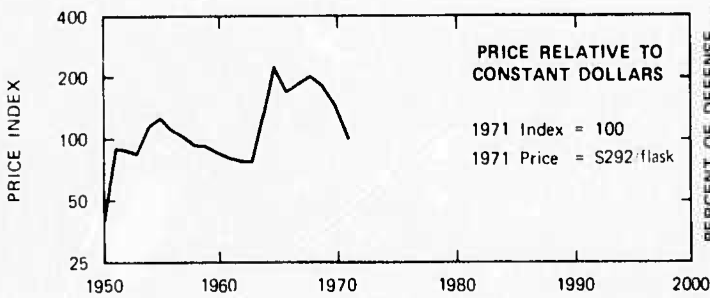
Stockpile: Mercury is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 200,105 flasks of mercury.

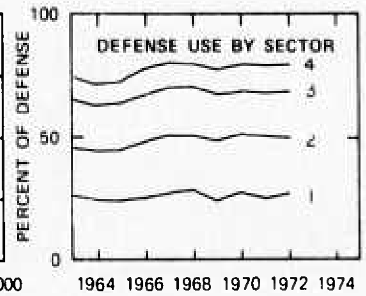
Reserves and Resources: Resources are estimated at $1000/flask.

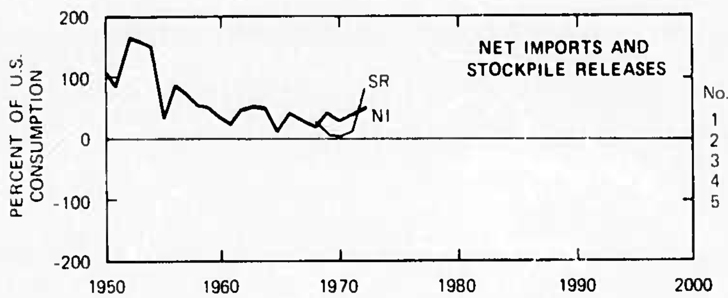
DATA SUMMARY: MERCURY
One Unit = 65,000 Flasks (76 Pound Flasks)
1972 World Production = 4.3 units

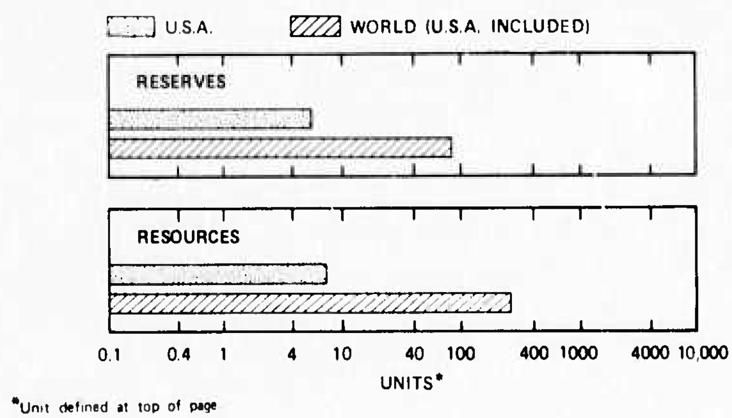












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Electrical (Batt. Appar. Lamps)	28
2	Alkalies, Chlorine	24
3	Mechanical Measuring Devices	19
4	Paints, Allied Products	10
5	Other (Estimated)	19
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Spain	22	2	2
Mexico	8	24	10
Yugoslavia	6	8	3
Canada	5	94	26
Turkey	4	4	<1
Algeria	3	33	6
Japan	2	<1	<1
Philippines	1	3	<1
Peru	1	73	4
Other	1	60	3
			55

NOTES ON MICA, SCRAP AND FLAKE

Uses: Paper for electrical insulation. Wallboard joint cement. Rolled roofing. Asphalt shingles. Paint pigment extender. Rubber filler and mold lubricant. Welding rod coating. Coating for wallpaper, concrete, stucco, tile, metal casting cores and molds. Special greases. Absorbant. Well drilling muds.

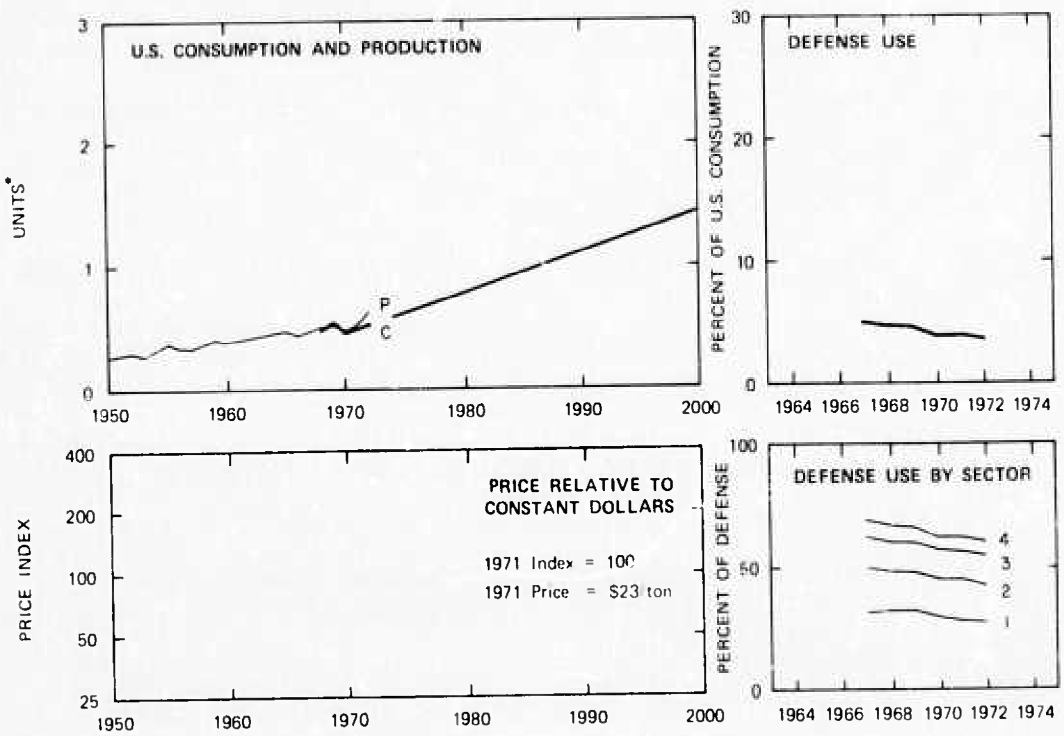
Price: The price given is an average for scrap and flake.

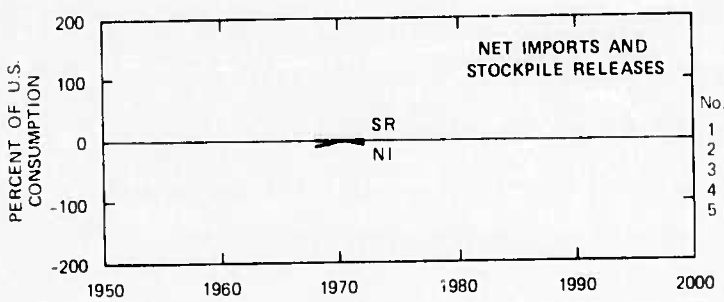
Stockpile: Mica, scrap and flake, was not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: "Large".

Defense Use: Estimates for the years prior to 1967 were not made because the available data on U.S. consumption appeared inconsistent with the series used for 1968-1972.

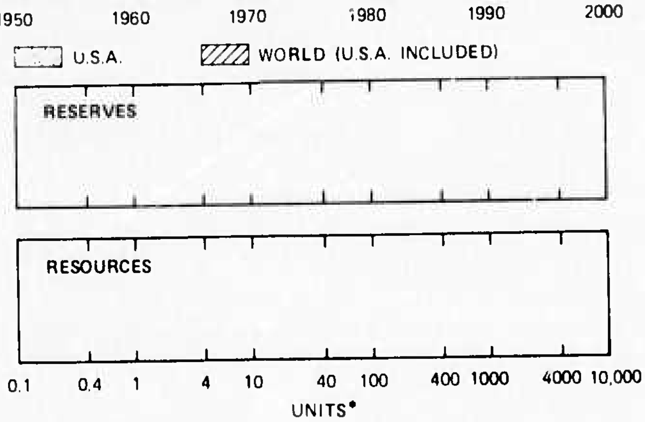
DATA SUMMARY: MICA, SCRAP, AND FLAKE
One Unit = 250,000 Short Tons
1972 World Production = 0.8 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Paint Pigment Extender	26
2	Roofing	16
3	Gypsum Plasterbd. Cement	12
4	Electron. Elec. Ind. Mica Paper	6
5	Other (Estimated)	40
		100



*Unit defined at top of page

NCTES ON MICA, SHEET

Uses: Electrical insulation in appliances from heating elements to large motors. Vacuum tube spacers. Dielectric material in capacitors. Fuse windows. Liners for steam equipment. Diaphragms.

Consumption: The anticipated decline in consumption is based on expectations of effective substitutions and continued technological changes.

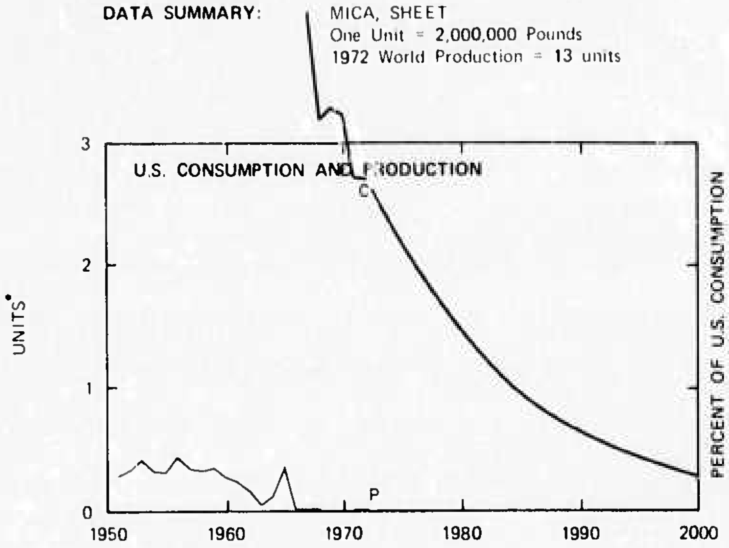
Price: The price given is for block and film.

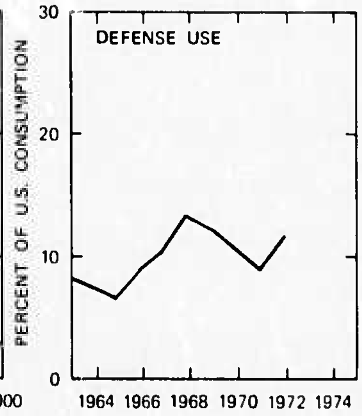
Imports: Percentages are based on combined figures for block and film, and splittings. In 1972 the stockpile release was so large that the U.S. was a net exporter despite the usual imports shown in the table.

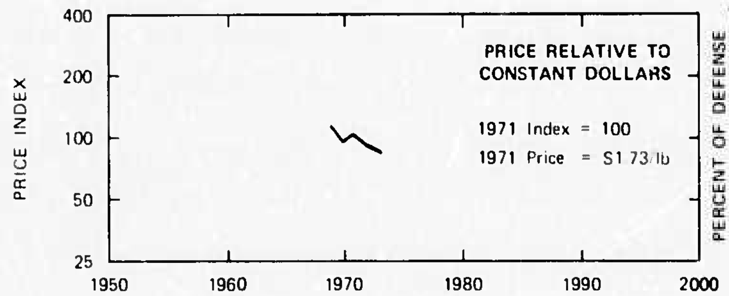
Stockpile: Mica sheet is included on the list of Basic Stockpile Materials, 1972, in the following forms: Stained and better Muscovite block; First and Second qualities Muscovite Film; Muscovite Splittings; Phlogopite block; Phlogopite splittings. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 60,749,000 pounds of mica.

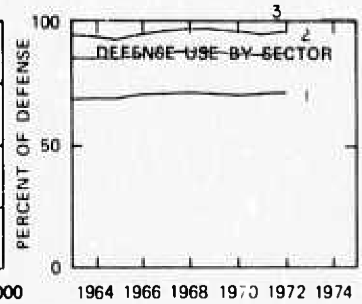
Reserves and Resources: Reserves and resources in the United States are "insignificant". World resources are "large".

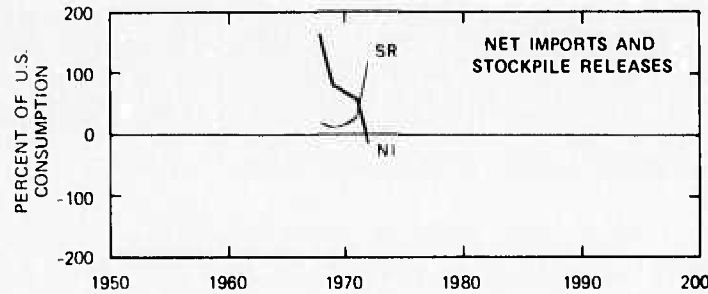
DATA SUMMARY: MICA, SHEET
One Unit = 2,000,000 Pounds
1972 World Production = 13 units





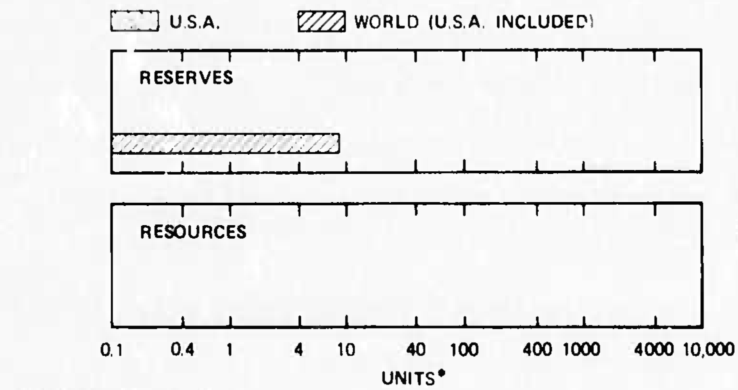






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Electrical Appliance Mfg.	72
2	Elect., Elect. Ind. Vac. Tubes	15
3	Electron. Elect. Ind. Capac.	9
4	Other (Estimated)	4
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
India	74	26	89
Brazil	15	21	14
Malagasy R.	4	45	7
Other	7	12	4
			114

*Unit defined at top of page.

NOTES ON MOLYBDENUM

Uses: Alloys for auto, railroad, aircraft, space systems, from auto camshafts to rocket engines. Alloys for tool steel, agricultural, mining, electrical, industrial machinery. Pipes and tubing for petroleum and chemical process boilers, superheaters, heat exchangers, condensers, and distillation and refining equipment; also for hydraulic system lines, aircraft landing gear, control systems, food processing, electrical power generating. Primers, cracking catalysts, reagents, lubricant ceramics, catalysts for alcohols, formaldehyde, other chemical applications. Electric furnace heating elements, contacts, electrodes, anodes, power transistors, rectifiers, other semiconductors. Permanent magnets. Metal-to-glass seals. Dies. Fertilizers. Hard facing rods. Cutting and wear resistant materials.

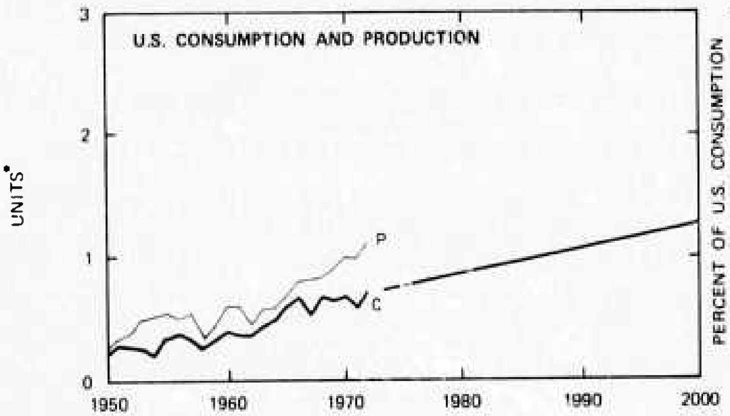
Price: The price quoted is for concentrate at Climax, Colorado.

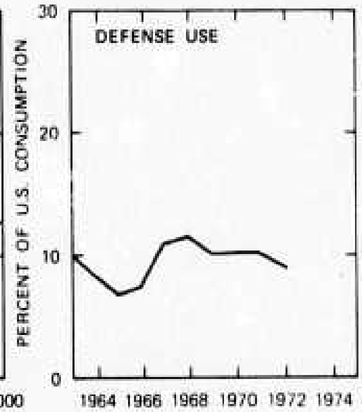
Imports: None. The United States is a heavy exporter.

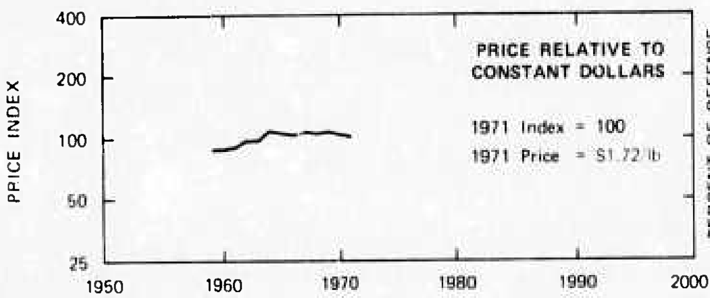
Stockpile: Included on the list of Basic Stockpile Materials, 1972, in the following forms: Disulphide molybdenum; ferromolybdenum; molybdenum oxide. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance for 1972 was 46,805,000 pounds of molybdenum.

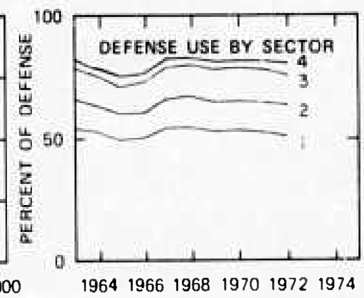
Reserves and Resources: Economic estimates are partly based on rich associations with copper, tungsten, uranium, and others.

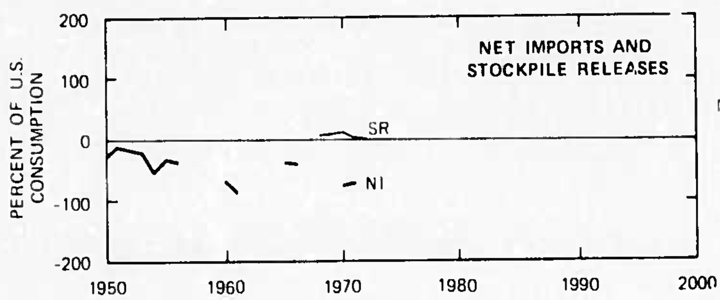
DATA SUMMARY: MOLYBDENUM
One Unit = 100,000,000 Pounds
1972 World Production = 1.8 units





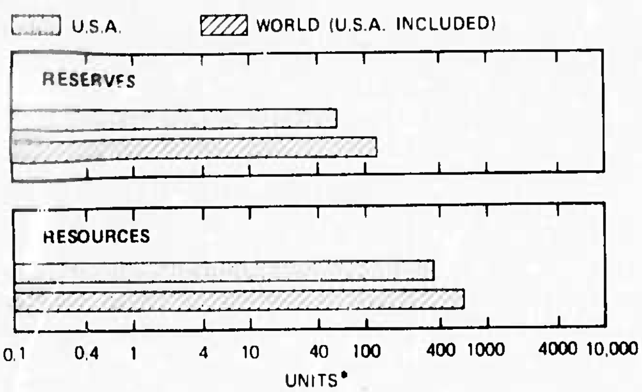






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation Equip	51
2	Industrial Mach., Mach. Tools	13
3	Pipe, Tubing, Tubular Products	12
4	Chemical Catalyst, Pigmt, Lub	4
5	Other (Estimated)	20
		100



*Unit defined at top of page

NOTES ON NICKEL

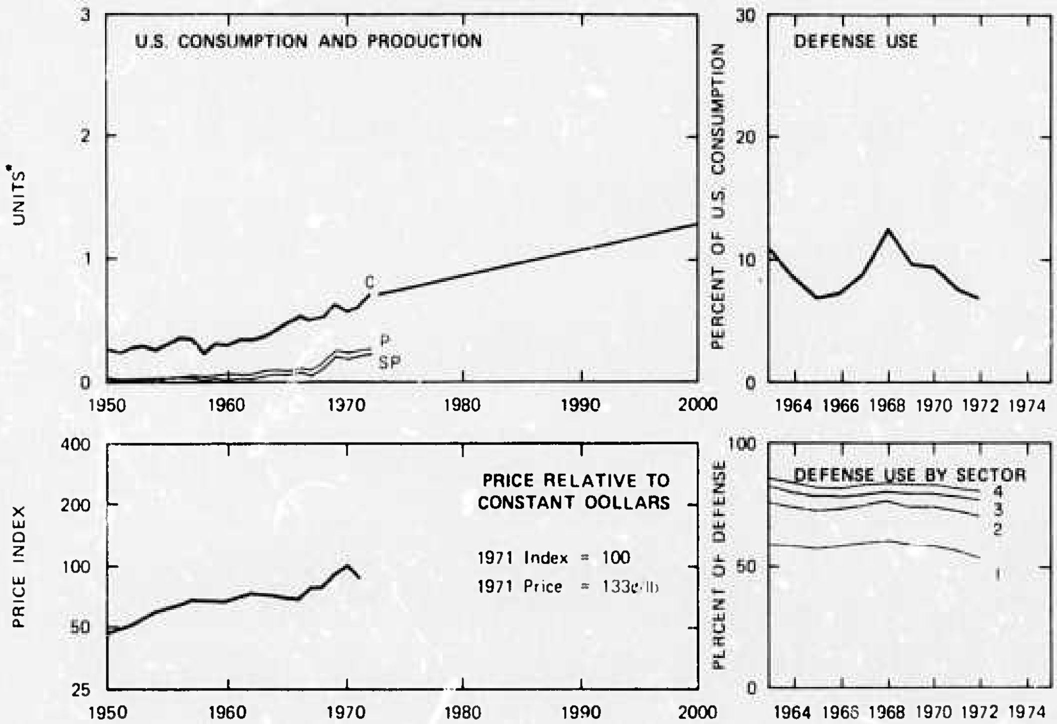
Uses: Corrosive chemical processing equipment. Boilers, kettles, ducts. Cutlery, handtools, hardware. Alloys in gas turbines, superchargers, jet engines, airframes, electroplated aircraft parts. Electroplated auto trim. Stainless steel bus, van, tank truck bodies. Resistance alloys, glass-to-metal seals, transistors. Appliances. Food processing equipment. Industrial machinery. Decorative and structural building elements. Salt water exposures in ships and boats. Catalysts in hydrogenation of fats and oils. Batteries and fuel cells. Carbides and hard facing. Enamel-iron bond in ceramics.

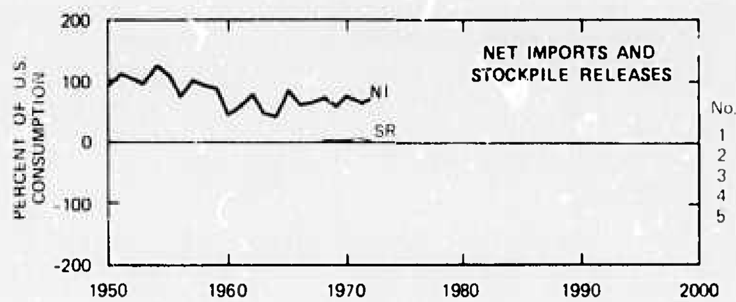
Price: The price quoted is an average, cents per pound.

Stockpile: Nickel is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance for 1972 was 47,700 short tons of nickel.

Reserves and Resources: United States reserves are "insignificant".

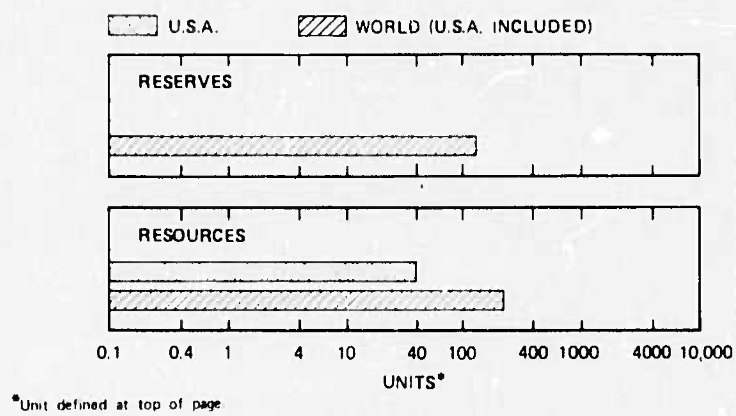
DATA SUMMARY: NICKEL
One Unit = 350,000 Short Tons
1972 World Production = 2.0 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Aircraft and Parts	54
2	Elect. Mach. Equip., and Supp	17
3	Ship, Boat Bldg. and Repairs	7
4	Motor Vehicles and Equip.	4
5	Other (Estimated)	18
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	37	56	58
USSR	20	<1	<1
N. Caledonia	16	10	4
Dom. Rep.	3	13	1
Rhodesia	2	14	<1
South Africa	2	23	1
Greece	2	7	<1
U.K.	0	—	3
Other	1	28	1
			70

*Unit defined at top of page

NOTES ON NIOBIUM

General: The element niobium is known as "columbium" in the minerals community. See COLIMBIUM.

DATA SUMMARY: NIOBIUM

see COLUMBIUM

NOTES ON NITROGEN

Uses: Gas blanketing to prevent fires and explosions, oxidation, in various processes, including petroleum refining, manufacture of paint, synthetic diester lubricants used in military aircraft, paraffin wax, regeneration of reforming catalysts, steel making, metal welding, degasifying molten aluminum, float glass with molten tin. Inert blanket for storage of gasoline, butadience, phosphorus, other chemicals. Liquid nitrogen for metal shrinking, metal powder manufacture, precipitation hardening of steel, aluminum stress relief, coolant for masers and lasers, infrared detectors, biological preservation, low temperature skin treatment, cryosurgery, freezing foods, other cryogenic applications. Pressure sealing of insulated electric and telephone cables. Hypersonic wind tunnels. Propellant transfer to missiles and space vehicles. Electron tube manufacture. Pressurized yield booster for oil wells. Fertilizer, explosives for ammonia. Urea for resin plastics, animal feed supplement, de-icer, paper and textiles. Also numerous other uses in chemical manufacturing.

Price: Average price of natural nitrates (Sodium nitrate bulk) in dollars per short ton.

Imports: The United States was self-sufficient in nitrogen for 1972, but there were minor imports for re-export.

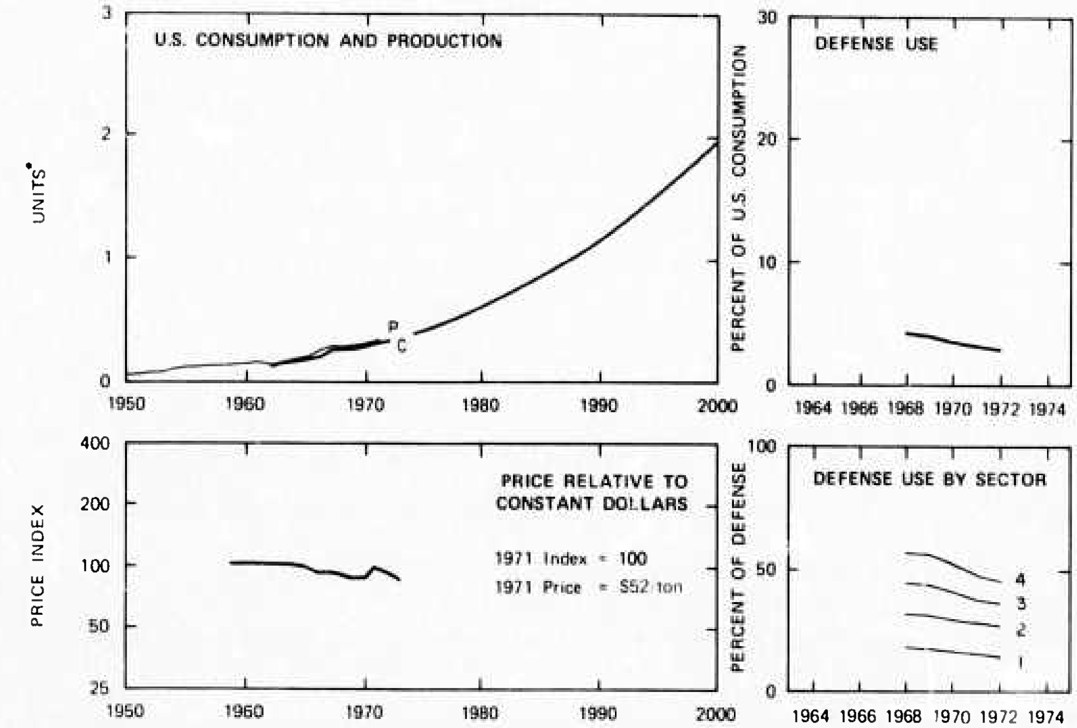
Stockpile: Nitrogen is not on the list of Basic Stockpile Materials, 1972.

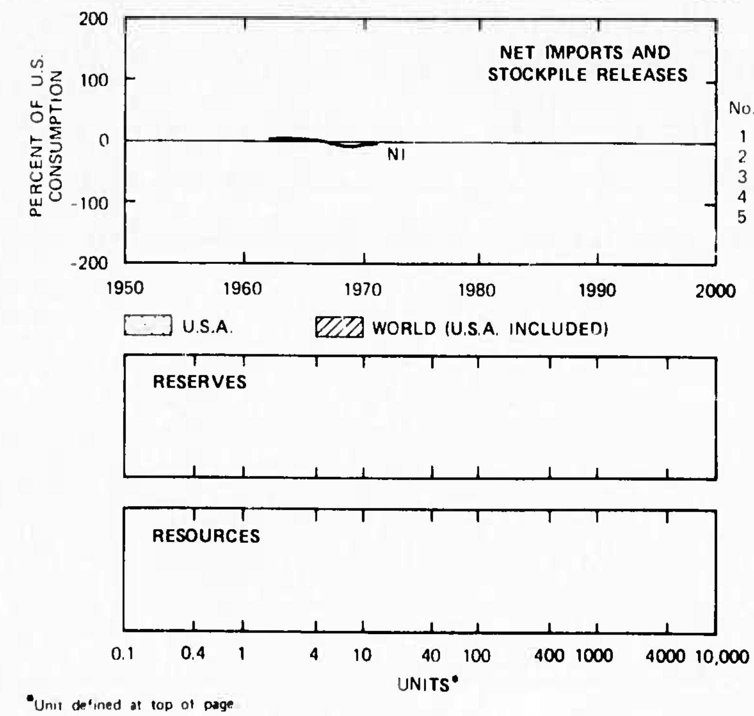
Reserves and Resources: "Large." Limited only by the energy needed to produce from the atmosphere.

Comment: End use description includes a category titled "aerospace" for which there is no entry in the input-output tables. Thus a significant portion is included under the "Other" label. In addition, lack of demand data restricted defense use estimates to 1968 through 1972.

Nitrogen is produced and consumed in both elemental form as liquid nitrogen and fixed form as ammonia. The data summary page is not completely consistent as consumption and production are for fixed nitrogen only, while defense use includes the elemental form as well.

DATA SUMMARY: NITROGEN
One Unit = 35,000,000 Short Tons
1972 World Production = 2.0 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Chemical Processing	15
2	Fertilizers	12
3	Electronics	10
4	Explosives	9
5	Other (Estimated)	54
		100

*Unit defined at top of page

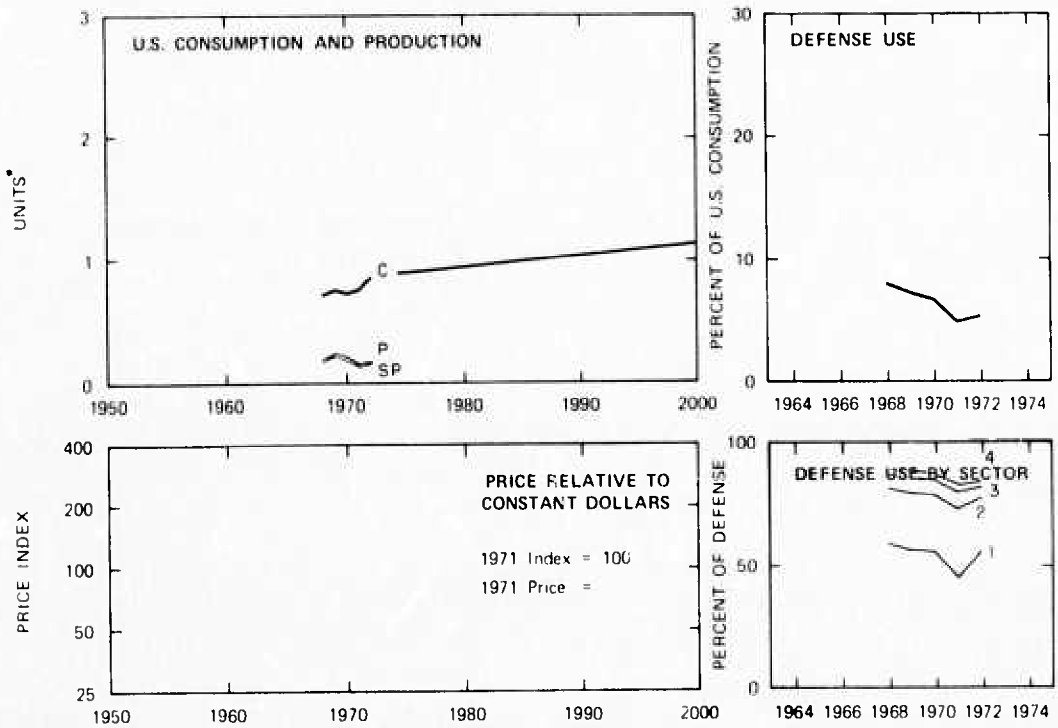
NOTES ON PALLADIUM

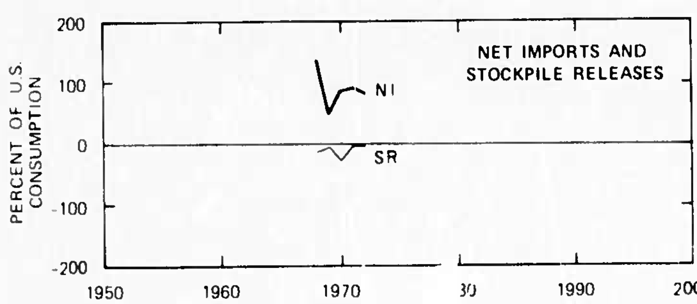
General: Palladium is one of the platinum group of metals. The flow diagrams present some data on palladium apart from the rest of the group, and these provide the 1968-1972 figures shown on the data summary page. See PLATINUM GROUP for some of the information not given here.

Price: A price trend for platinum metal is shown on the platinum group page. Since 1971, the price of palladium has approximately doubled, reaching about 170 on the price index scale, while that of platinum has increased only as the general inflation.

Stockpile: Palladium is one of the platinum group metals held in U.S. government stockpiles. As of 31 December 1973 the stockpile objective for palladium was nearly 330,000 troy ounces, and the total inventory of palladium was about 1,250,000 troy ounces ("Stockpile Report to Congress, July-December 1973", Office of Preparedness, U.S. General Services Administration). Some accessions to the government stockpile during the 1968-1972 period are indicated on the graph.

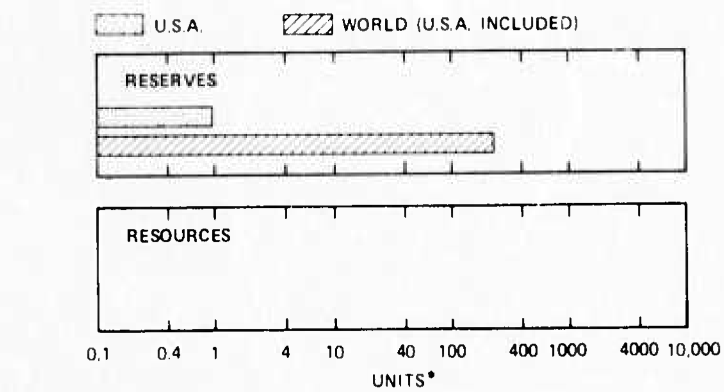
DATA SUMMARY: PALLADIUM
One Unit = 1,000,000 Troy Ounces
1972 World Production = 2.1 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Telephone Industrial Controls	56
2	Industrial Organic Chem. N.E.C.	21
3	Industrial Inorg. Chem. N.E.C.	5
4	Petroleum Refining	2
5	Other (Estimated)	16
		100



*Unit defined at top of page

NOTES ON PERLITE

Uses: Similar to vermiculite for plaster, concrete, insulation, agricultural, filler applications. Also filter aid in sugar refining, fruit juice extraction, pharmaceutical processing, water purification, removal of impurities from industrial process fluids.

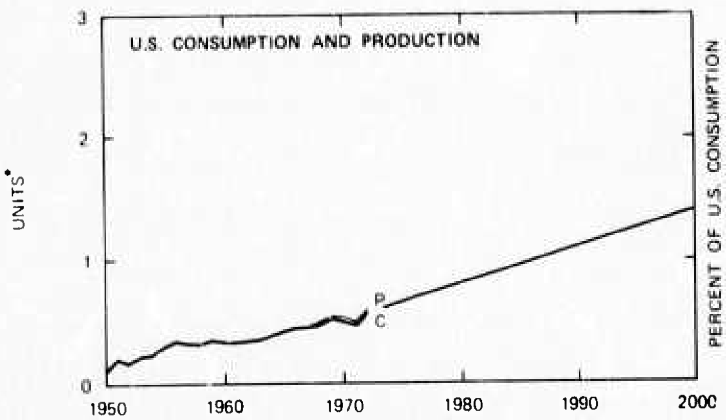
Price: The price given is for crude perlite, f.o.b. mine, as sold to expanders.

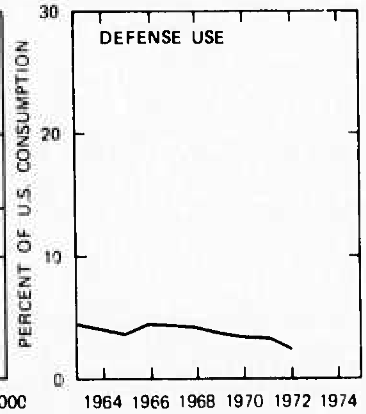
Imports: The United States was self-sufficient in perlite in 1972.

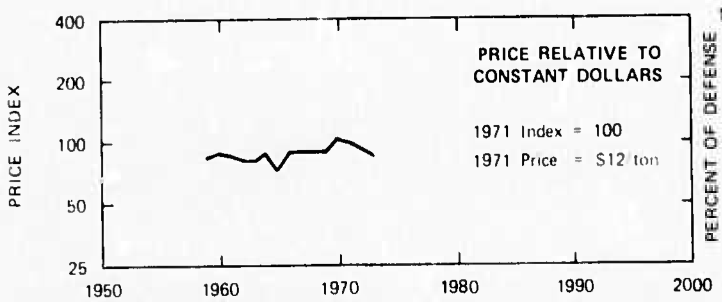
Stockpile: Perlite is not on the list of Basic Stockpile Materials, 1972.

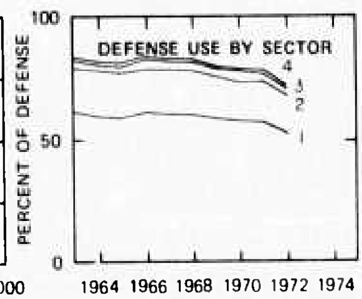
Reserves and Resources: World resources are "large".

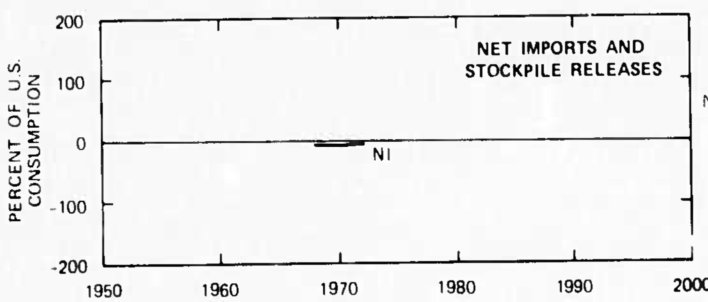
DATA SUMMARY: PERLITE
One Unit = 900,000 Short Tons
1972 World Production = 2.0 units





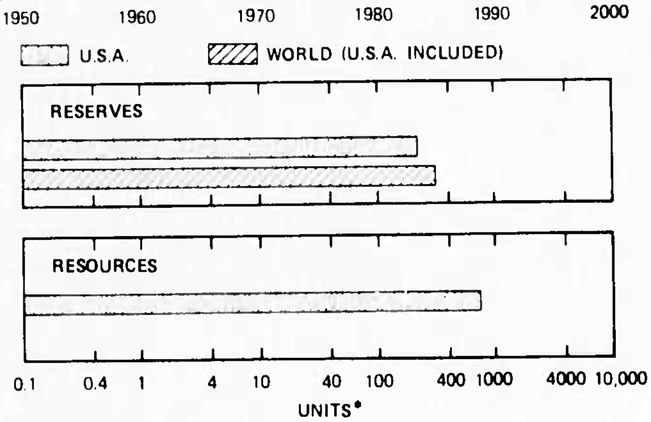






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Aggregates	53
2	Indstr Water Food, Bevrage	15
3	Thermal Insulation	3
4	Agricultural	1
5	Other (Estimated)	28
		100



*Unit defined at top of page

NOTES ON PHOSPHORUS

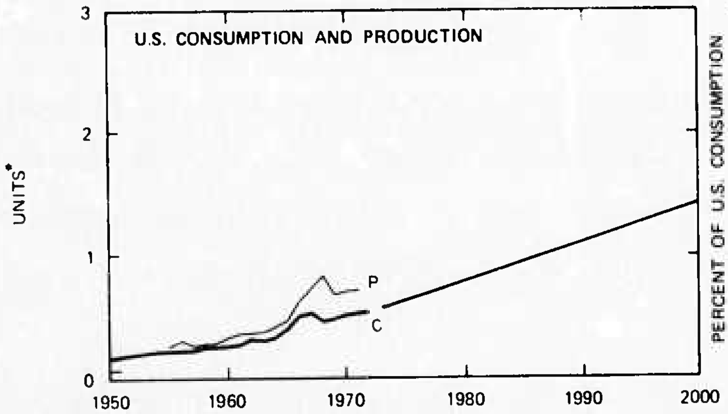
Uses: Fertilizers. Cleaning compounds. Surface treatment of metals. Animal and fowl feed. Rat poisons. Soft drinks. Matches. Fire retardants. Toothpaste. Dental cement. Plastics. Shaving cream. Gasoline additive. Baking powder. Bone china. Water softeners. Dyes for textiles. Photographic film and chemicals. Glass. Insecticides. Sugar processing. Pharmaceuticals. Oil refining. Silk fabrics. Military uses.

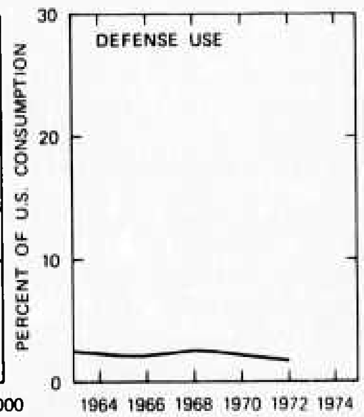
Price: January price quotation for phosphate rock in dollars per short ton, f.o.b. plant. (Actual selling prices can be over 50% higher.)

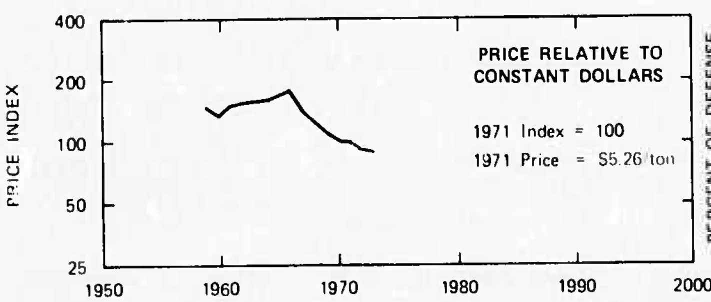
Imports: The United States was self-sufficient in phosphorus for 1972, but there were minor imports for re-export.

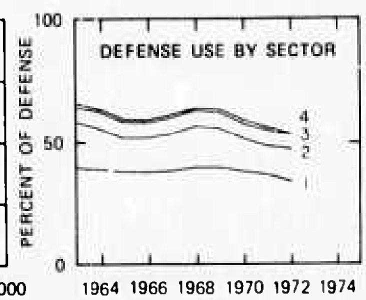
Stockpile: Phosphorus is not on the list of Basic Stockpile Materials, 1972.

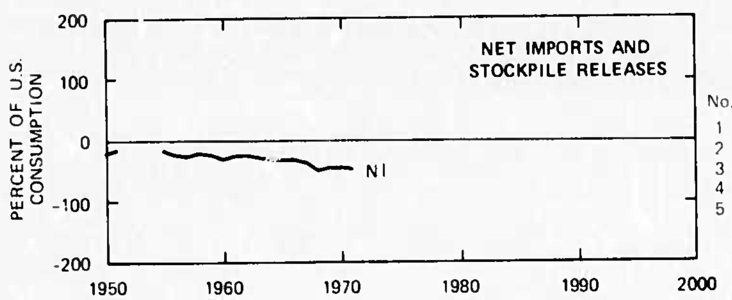
DATA SUMMARY: PHOSPHORUS
One Unit = 7,500,000 Short Tons
1972 World Production = 1.9 units





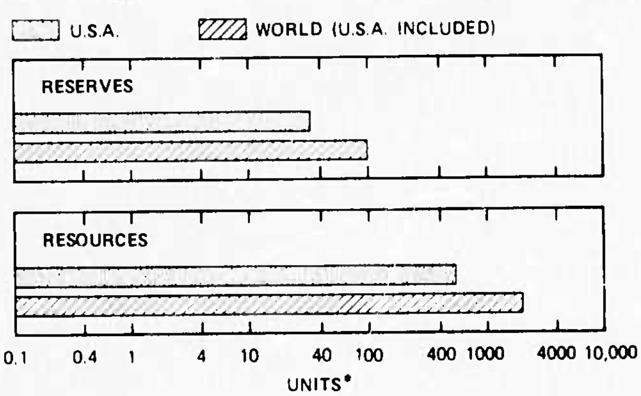






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Fertilizers	34
2	Plating and Polishing	13
3	Soaps and Detergents	6
4	Feed for Animals and Fowl	1
5	Other (Estimated)	46
		100



*Unit defined at top of page

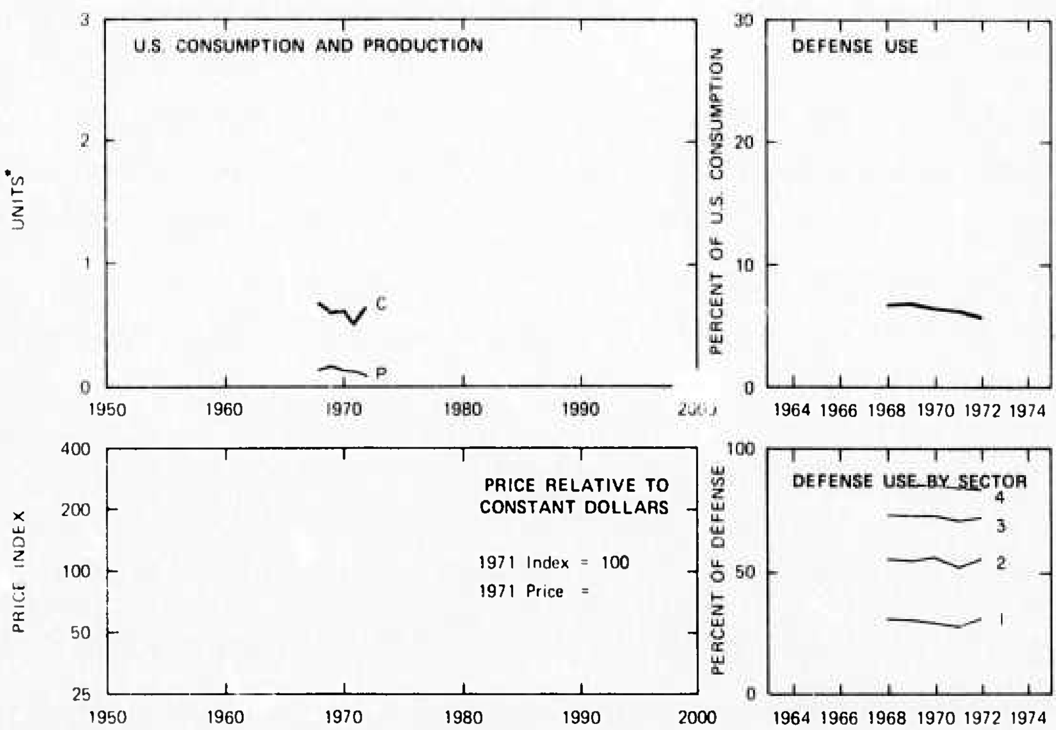
NOTES ON PLATINUM

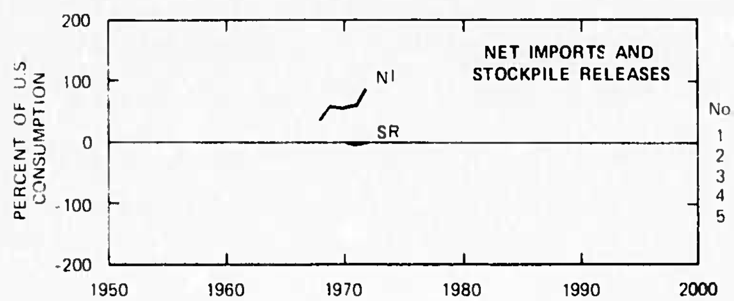
General: Platinum is only one element of the platinum group of metals. The flow diagrams present some data on platinum apart from the rest of the group, and these provide the 1968-1972 figures shown on the data summary page. See PLATINUM GROUP for some of the information not given here.

Price: See platinum group, where the price given is that for platinum.

Stockpile: Platinum is one of the platinum group metals held in U.S. government stockpiles. As of 31 December 1973 the stockpile objective for platinum was 187,500 troy ounces, and the inventory of platinum was nearly 453,000 troy ounces ("Stockpile Report to the Congress, July-December 1973," Office of Preparedness, U.S. General Services Administration). No significant accessions to or releases from the platinum stockpile occurred in the 1968-1972 period.

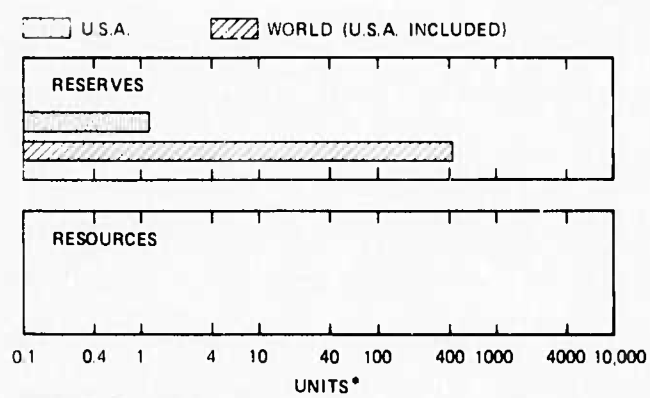
DATA SUMMARY: PLATINUM
One Unit = 850,000 Troy Ounces
1972 World Production = 2.6 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Telephone, Industrial Controls	31
2	Petroleum Refining	25
3	Industrial Inorg. Chem.	17
4	Industrial Org. Chem.	11
5	Other (Estimated)	16
		100



*Unit defined at top of page

NOTES ON PLATINUM GROUP

General: The elements in the platinum group are: platinum, palladium, iridium, osmium, rhodium, and ruthenium. See also: Palladium, Platinum, and Rhodium.

Uses: Catalyst for nitric acid used in fertilizers and explosives, refining hydrogen, high octane gasoline, reactions for pharmaceuticals, vitamins, antibiotics. Spinnerets for glass fibers, synthetic fibers. Telephone contacts. Magnets for wave tubes. Electrical instrument circuits. Jewelry. Orthodontic devices. Laboratory ware. Cathodic protection. Furnace windings. Brazing alloys.

Price: The price quoted is an average for platinum metal. It is the producers allocated price in dollars per ounce. Since 1971, this index has not changed much, but that for palladium nearby doubled in 1973.

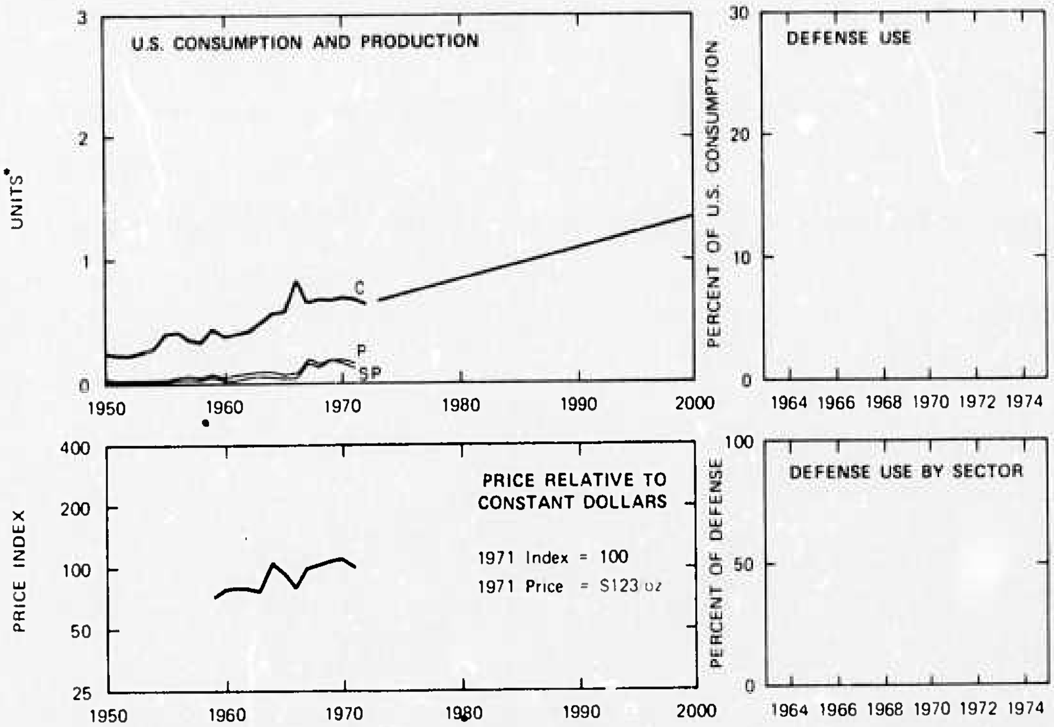
Imports: Percentages are based on combined figures for palladium, platinum and rhodium.

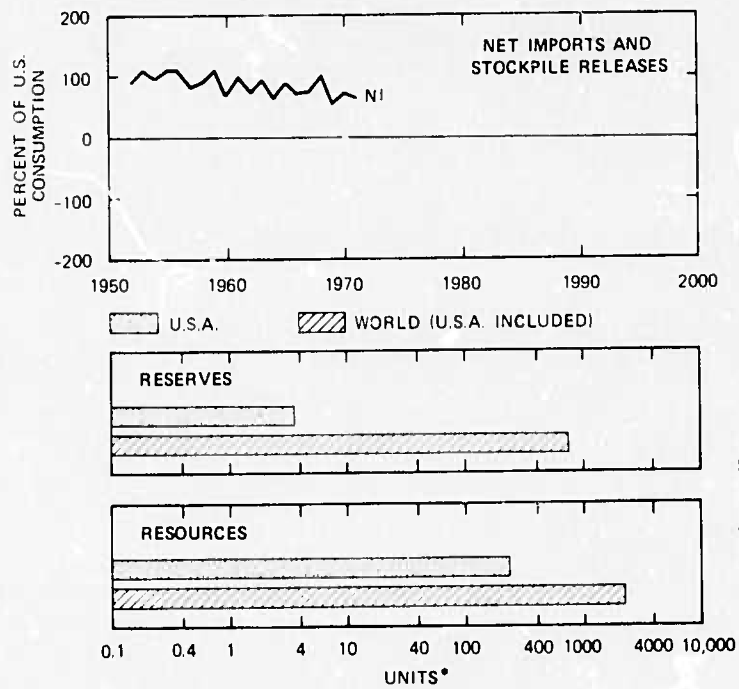
Stockpile: The platinum group is included on the list of Basic Stockpile Materials, 1972, in the following forms: Iridium; palladium; platinum. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 1,708,000 troy ounces platinum metals.

Reserves and Resources: Economic estimates are based on co-product association with nickel-copper minerals. The group includes palladium, platinum, and rhodium.

Defense Use: No estimates are given here because no data on uses by economic sectors were available for the platinum group as a whole. However, individual defense use estimates were obtained for palladium and platinum, and are shown on the respective data summary pages.

DATA SUMMARY: PLATINUM GROUP
One Unit = 2,000,000 Troy Ounces
1972 World Production = 2.5 units (estimate)





SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
USSR	50	36	52
South Africa	41	13	16
Canada	8	18	4
Colombia	<1	100	2
Japan	<1	11	7
U.K.	0	—	31
Other	<1	425	1
			113

*Unit defined at top of page

NOTES ON POTASSIUM

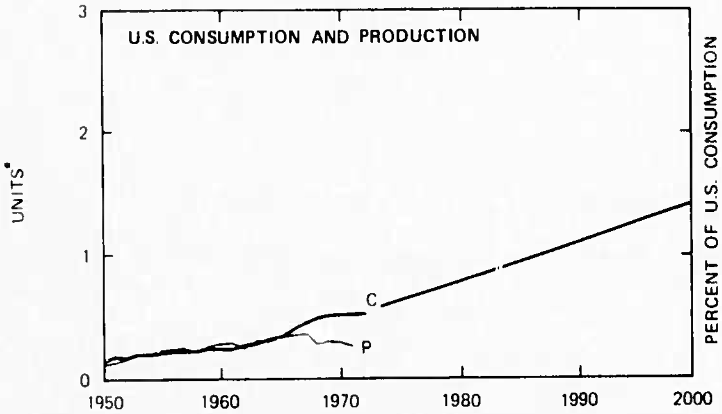
Uses: Fertilizer blends. Chemical industry. Flux in metal industry.

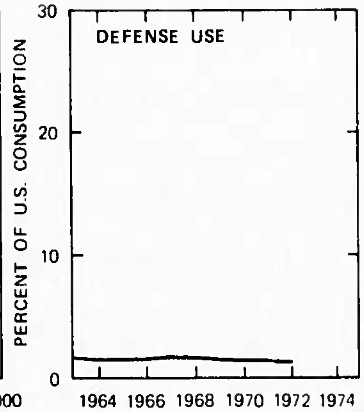
Price: The price given is the average quoted for potash in cents per short ton unit (20 lbs.) of the oxide, K_2O, standard 60% muriate f.o.b. Carlsbad.

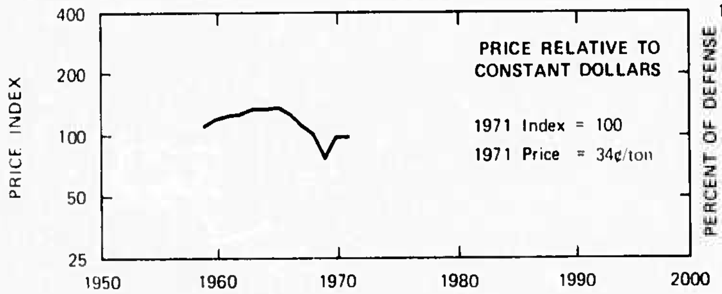
Stockpile: Potassium is not on the list of Basic Stockpile Materials, 1972.

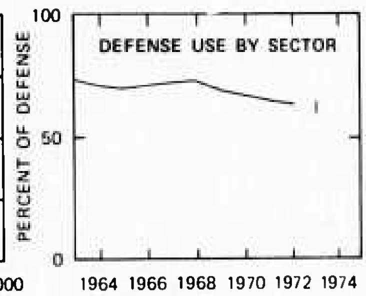
Reserves and Resources: World resources of potassium compounds are "enormous."

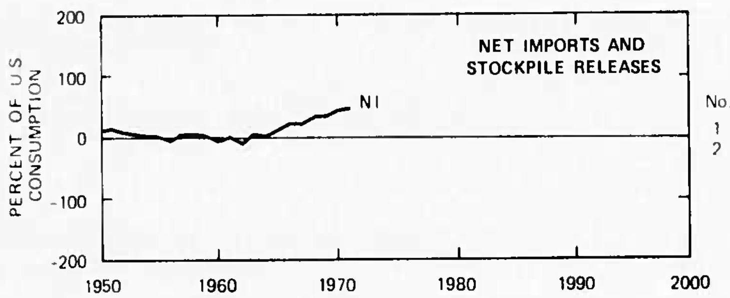
DATA SUMMARY: POTASSIUM
One Unit = 7,500,000 Short Tons
1972 World Production = 2.5 units





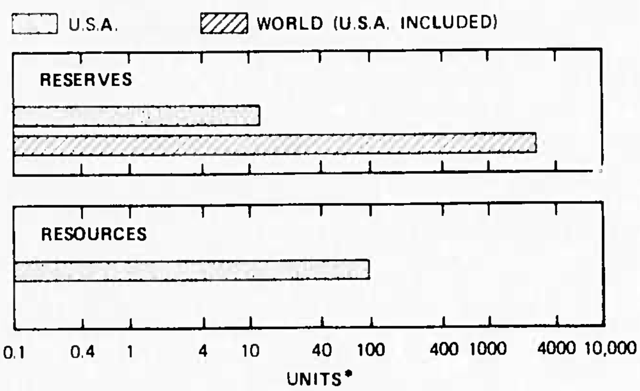






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Fertilizer	64
2	Other (Estimated)	36
		100



*Unit defined at top of page

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	18	67	58
W. Germany	14	<1	<1
France	9	<1	<1
Israel	3	18	2
Congo (Braz.)	1	7	<1
Chile	<1	27	<1
			62

NOTES ON PUMICE

Uses: Road surfacing. Railroad ballast. Pozzolan cement. Structural aggregates. Abrasive for glass, metal, leather, stone, wood polishing, also soaps and cleansing compounds. Absorbents, carriers for insecticides, filter mediums. Soil conditioners. Fillers for numerous products.

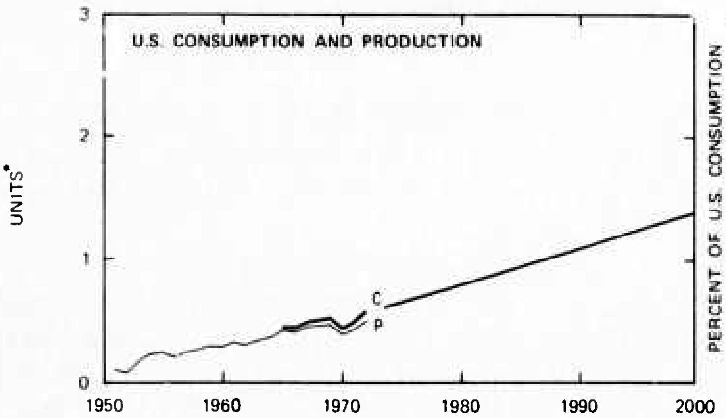
Price: The price given is the average for pumice and volcanic cinder f.o.b. mine or mill.

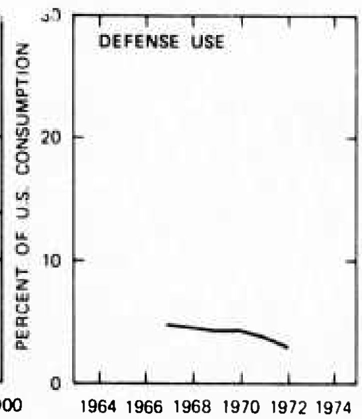
Stockpile: Pumice is not on the list of Basic Stockpile Materials, 1972.

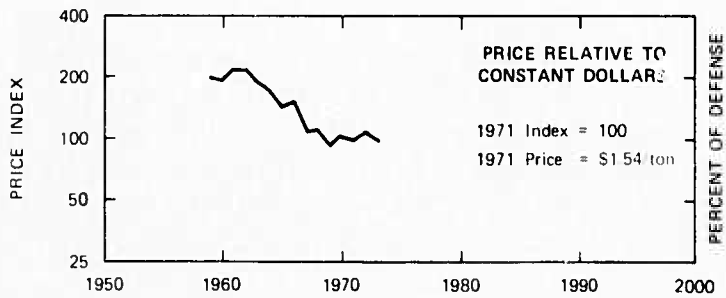
Reserves and Resources: World resources are "large".

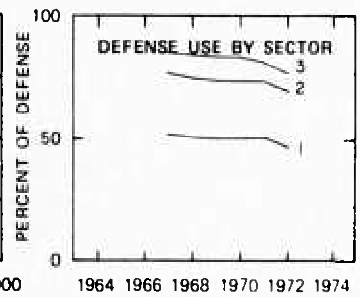
Defense Use: Estimates for the years prior to 1967 were not made because the available data on U.S. consumption appeared inconsistent with the series used for 1968-1972.

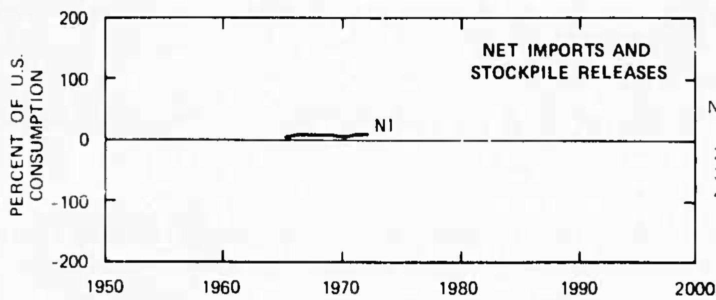
DATA SUMMARY: PUMICE
One Unit = 7,500,000 Short Tons
1972 World Production = 2.4 units





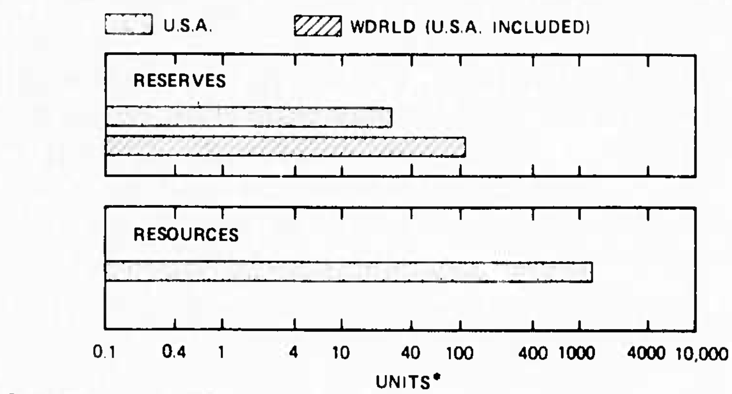






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Road Construction	46
2	Aggregate Concrete	22
3	Railroad Ballast	9
4	Other (Estimated)	23
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Italy	34	6	8
Greece	7	23	6
			14

*Unit defined at top of page

NOTES ON RARE EARTHS

General: Data on quantities of rare-earth metals are expressed as weights of rare-earth oxide (REO), in keeping with standard practice, but contrary to the "elemental content" rule applied to all other elements in this report.

Uses: Catalysts for petroleum refining, chlorine recovery, hydrocarbon oxygenation. Polishing eyeglasses, camera and instrument lenses, mirrors, plate glass. Glass decolorizer, colorizer UV absorber in welder's goggles, special sunglasses, optical filters, food containers. TV tube glass, nuclear reactor windows. Camera lenses. Yellow ceramic tile stain. Glass ceramics. Porcelain enamel opacifier. Microwave control, capacitors. Permanent magnets. Lighter flints. Alloying agents. Carbon arc electrodes in searchlights, motion picture lighting and projection. Fluorescent lamp coating, vapor lamp additive, color TV tube phosphors. Lasers and masers. Reactor absorption and shielding, atomic fire extinguishers.

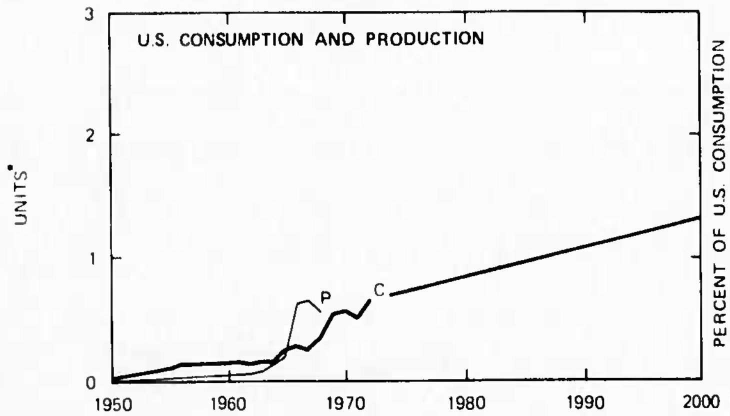
Imports: Percentages are based on an equivalent measure of "Rare Earth Oxides" for all rare earths.

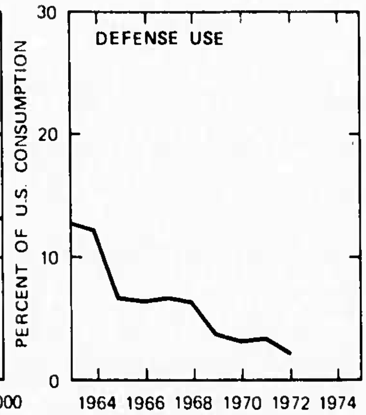
Stockpile: The rare-earth metals are not on the list of Basic Stockpile Materials, 1972.

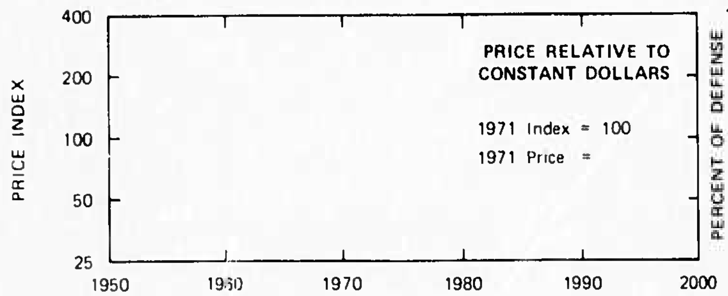
Reserves and Resources: Economic estimates are based on by-product association with titanium minerals, zircon production, and other minerals. Resources are presumed large, no data.

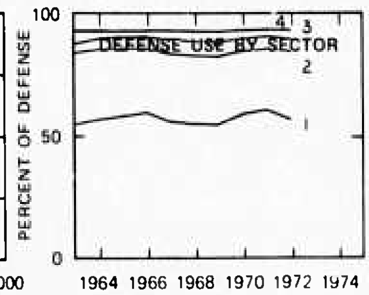
Defense Use: The pronounced decline shown for percent defense use is due primarily to the great increase in the U.S. consumption quantity to which defense use is compared. Taking into account the probable increase in use factor (tons per dollar output) of the relevant economic sectors since 1968 would lead to high values of the defense fraction of total U.S. consumption.

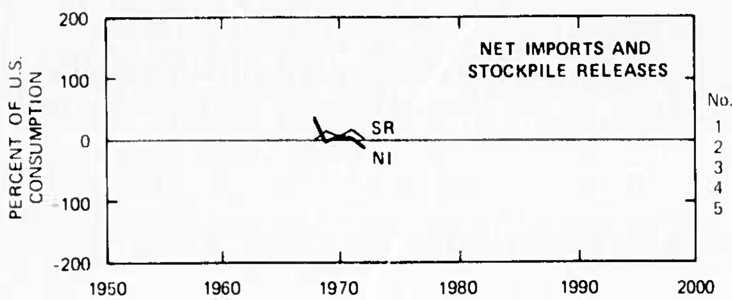
DATA SUMMARY: RARE EARTHS
One Unit = 20,000 Short Tons
1972 World Production = 1.2 units





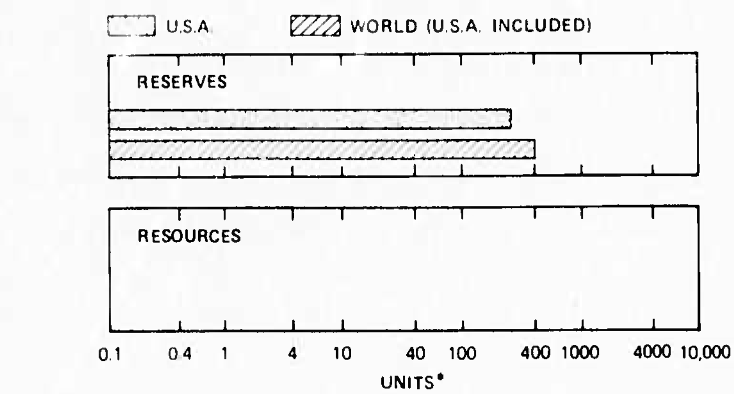






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Petroleum Refining	58
2	Nodular Iron, Carbon Grap	28
3	Optical Instrmts + Lenses	5
4	Electrical Components	4
5	Other (Estimated)	5
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Malaysia	5	46	4

*Unit defined at top of page

NOTES ON RHENIUM

Uses: Research. Thermocouples and high temperature electrical control systems. Structural alloys with tungsten. With silver coating pivot pins in variable wing aircraft. Igniter for flash bulbs. Electric furnace heaters. High current contacts. Vacuum tube filaments. Cathodes, cathode supporters, heaters. Catalyst in hydrogenation reactions. Electro- and vapor plating. Lamp filaments. Radiation and heat shields. Superrefractory alloys.

Price: The price given is the average for metal powder 99.99 percent pure.

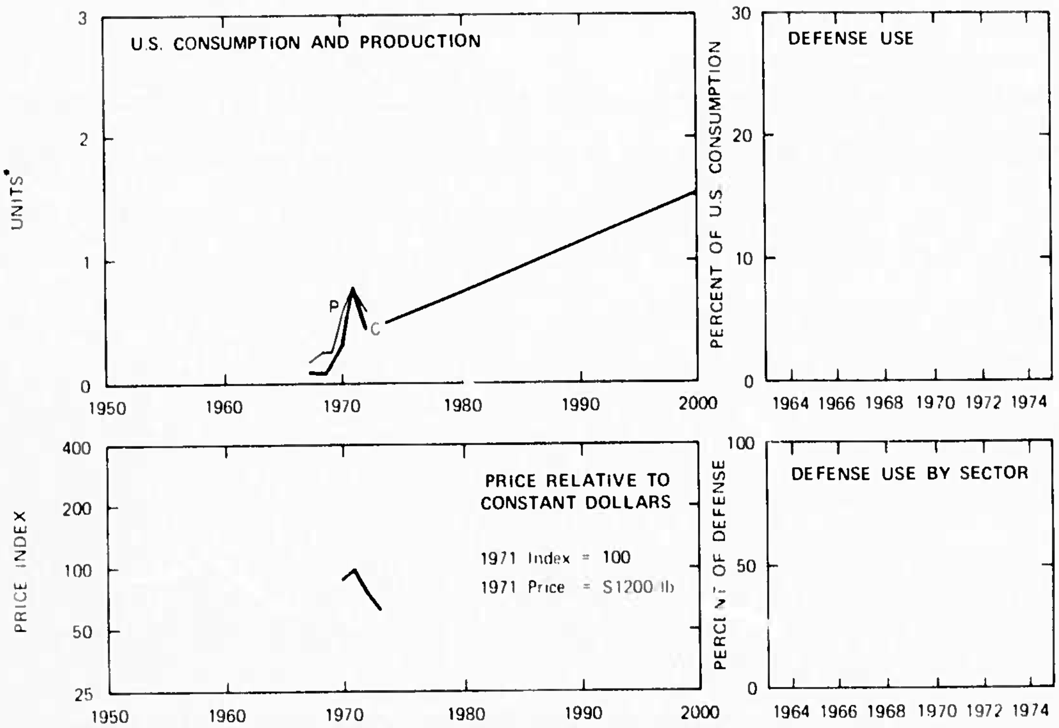
Imports: Processed by intermediates, not imported directly.

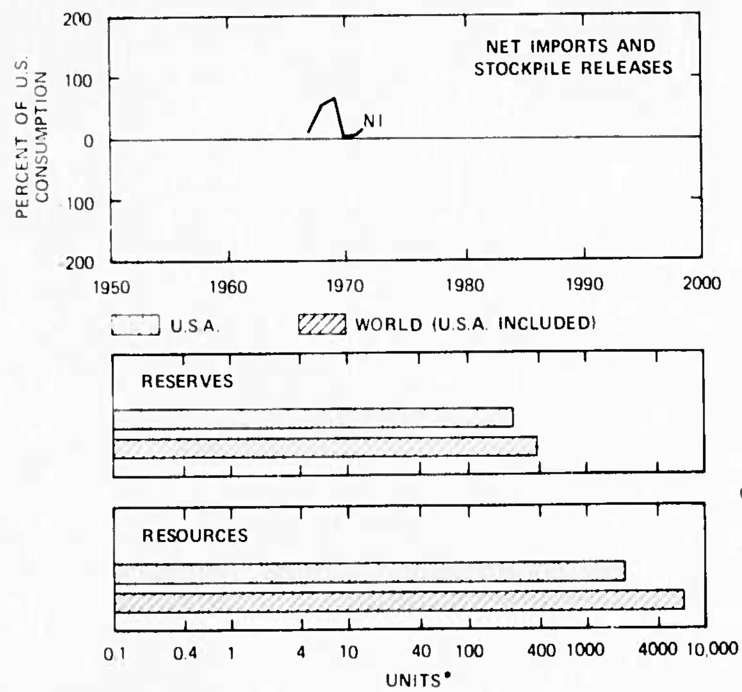
Stockpile: Rhenium is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: Economic estimates are based on by-product association with copper-molybdenum production.

Defense Use: Because "research and development", a category not treated as a separate industry in the 1963 input-output table, is given a major consuming sector in the flow diagram, no defense use estimates were made.

DATA SUMMARY: RHENIUM
One Unit = 10,000 Pounds
1972 World Production = 1.0 units





SOURCES OF IMPORTS 1972

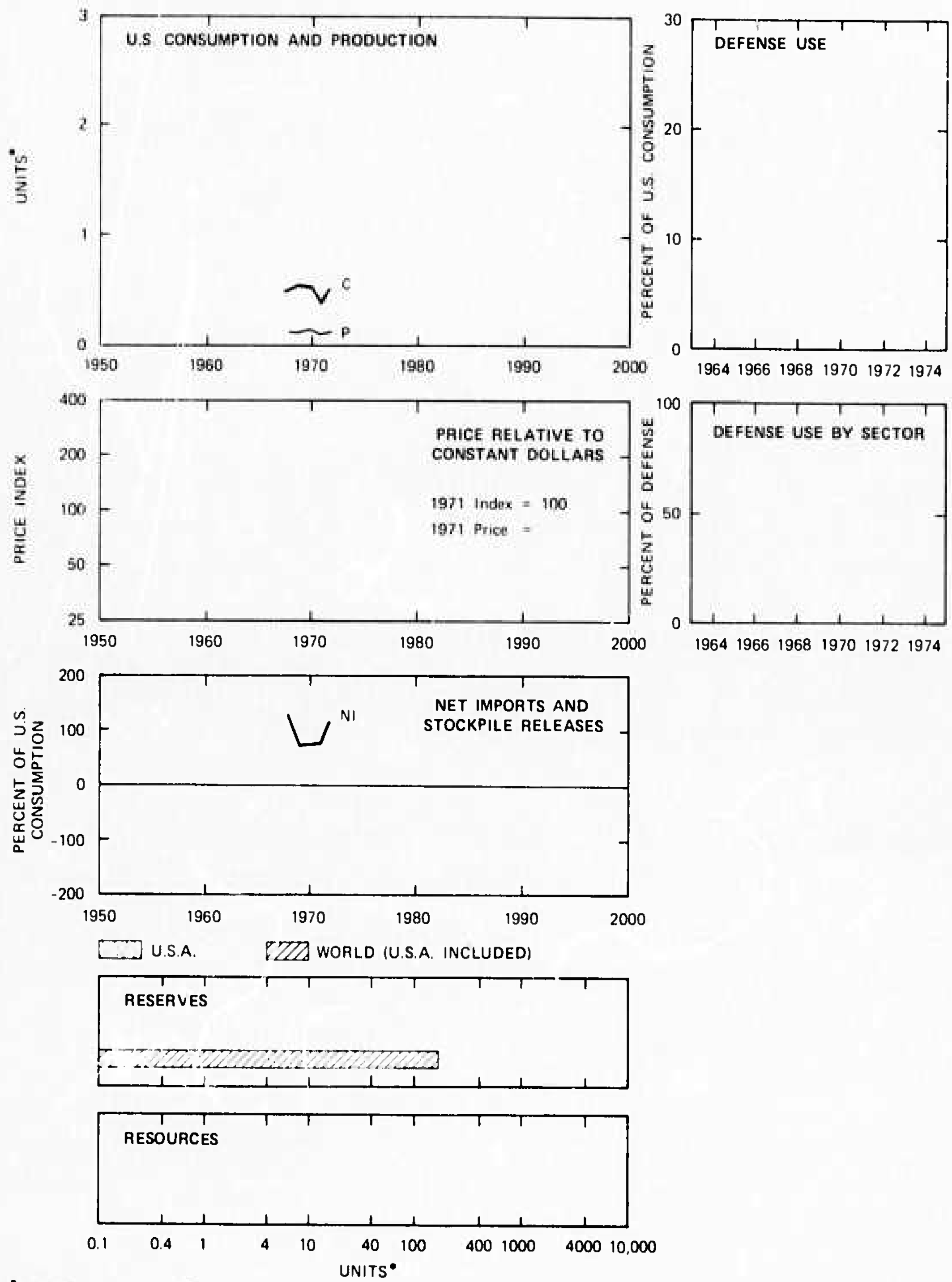
Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Chile	19	68	46

*Unit defined at top of page

NOTES ON RHODIUM

General: Rhodium is one of the platinum group of metals. The flow diagrams present some data on rhodium apart from the rest of the group, and these provide the 1968-1972 figures shown on the data summary page. See PLATINUM GROUP for some information not given here.

DATA SUMMARY: RHODIUM
One Unit = 90,000 Troy Ounces
1972 World Production = 1.1 units



*Unit defined at top of page

NOTES ON RUBIDIUM

Uses: Radio vacuum tubes. Photocells. Medical trace element. Ultracentrafuge medium for DNA, viruses, other large molecule separation. Portable magnetometer used in archeology. Organic catalyzers.

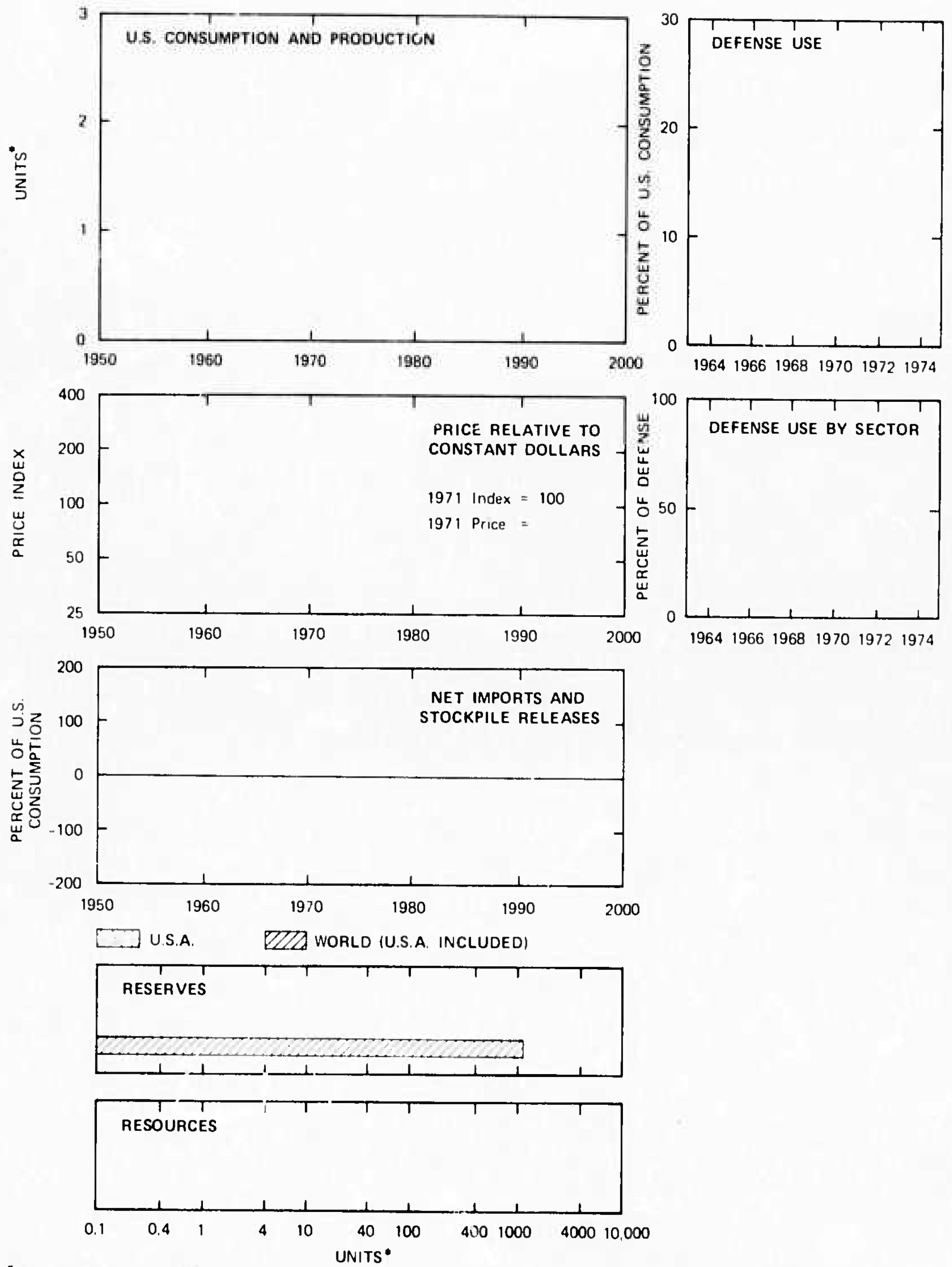
Imports: United States demand figure is confidential. World production is unknown.

Stockpile: Rubidium is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: Economic estimates are based on by-product association with lithium and beryl production. No data for resources. United States reserves are "insignificant".

Defense Use: Because "research and development", a category not treated as a separate industry in the 1963 input-output table, is given as a major consuming sector in the flow diagram, no defense use estimates were made.

DATA SUMMARY: RUBIDIUM
One Unit = 2,000 Pounds
1972 World Production = (unknown)



*Unit defined at top of page

NOTES ON SAND AND GRAVEL

Uses: Roadbuilding, Concrete. Fill, Foundry and glass sand. Abrasive, sandblasting. Filtering sands. Railroad ballast. Hydrofracturing oil and gas wells.

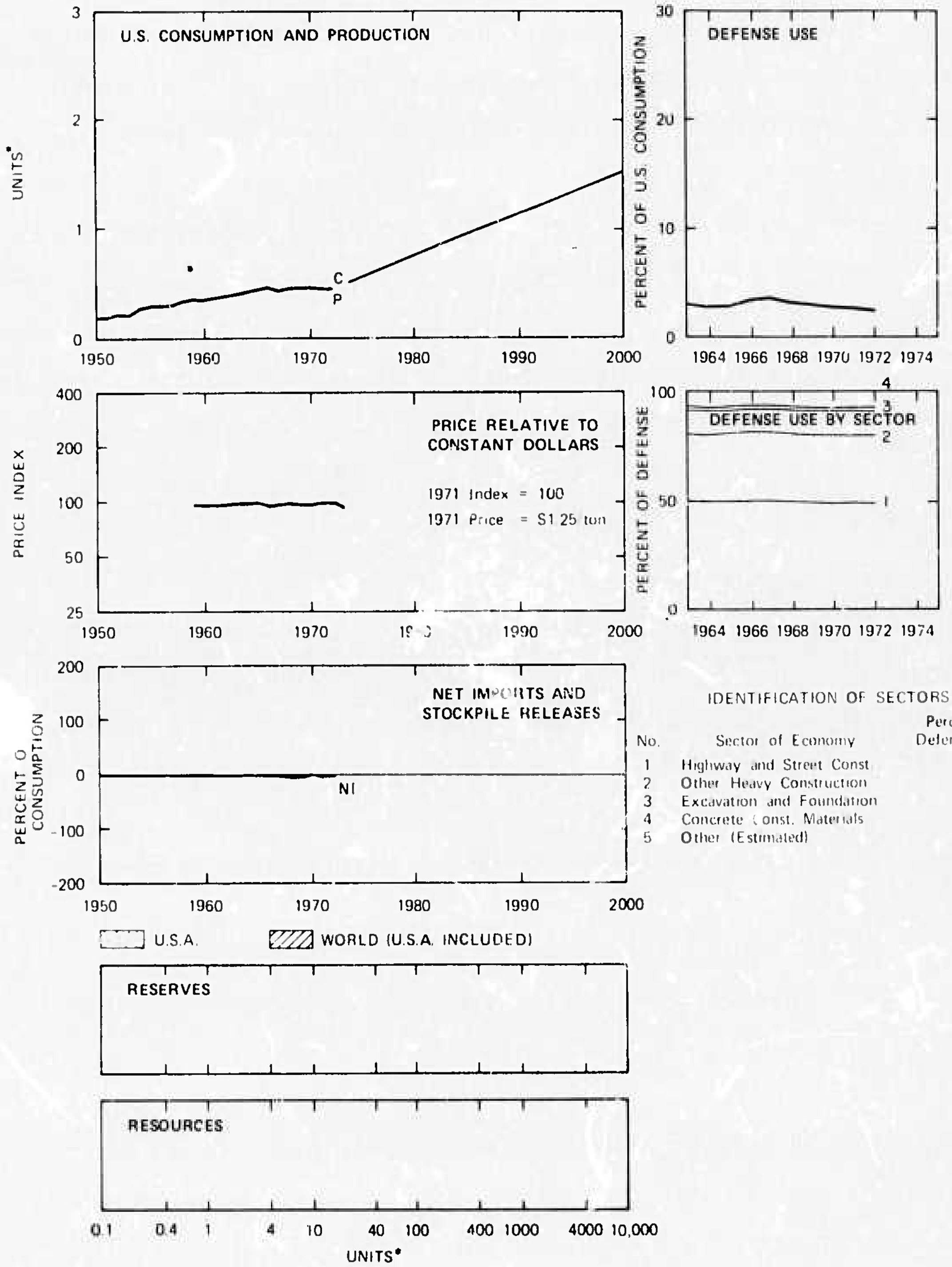
Price: The price given is in dollars per ton.

Imports: The United States was self-sufficient in sand and gravel for 1972. Most imports occur when nearest source is across an international boundary.

Stockpile: Sand and gravel is not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: "Large".

DATA SUMMARY: SAND AND GRAVEL
One Unit = 2,000,000,000 Short Tons
1972 World Production = 3.5 units



IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Highway and Street Const.	49
2	Other Heavy Construction	31
3	Excavation and Foundation	10
4	Concrete Const. Materials	2
5	Other (Estimated)	8
		100

*Unit defined at top of page

NOTES ON SELENIUM

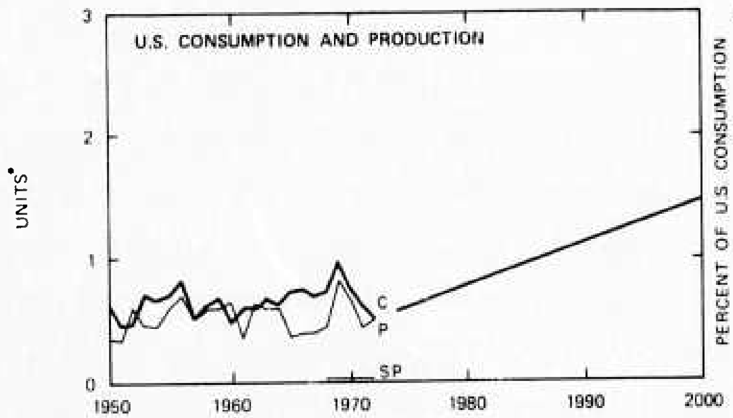
Uses: Flat-glass and pressed or blown glass and glassware; ruby-red glass for tableware, vehicular taillights, traffic and other signal lenses, light filters, infra-red equipment, tinted glass for office building windows. Rectifiers for electroplating, welding, dc motors, battery chargers, magnetic coils, arc lamps, induction braking, voltage regulators. Semiconductors. Photocells. Xerography cylinders. Orange-red pigments for plastics, paints, enamels, inks, and rubber. Stainless steel additive. Pharmaceuticals such as niacin, cortisone, dandruff and dermatitis controls, deodorants. Rubber vulcanizing. Hydrogenation, harden fats in soaps, waxes, edible fats, plastics. Antioxidation, printing inks, mineral, transformer, vegetable, linseed, oiticica, tung oils. Solvent for paint and varnish, rubber resins, glue. Lubricants. Insecticides, parasiticides, bactericides, herbicides. Photographic photosensitizers and toners. Mercury vapor detectors. Fire preofing agents. Insect repellants. Phosphorescents, luminescents. Delay action blasting caps. Chromium electroplating.

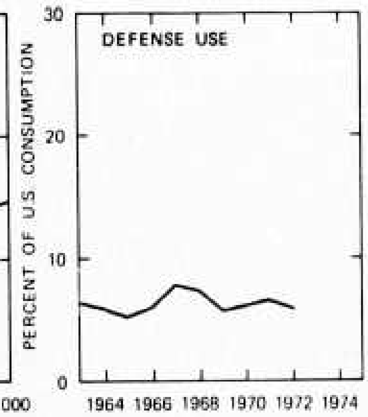
Price: The price given is an average for commercial grade metal in 100 pound lots.

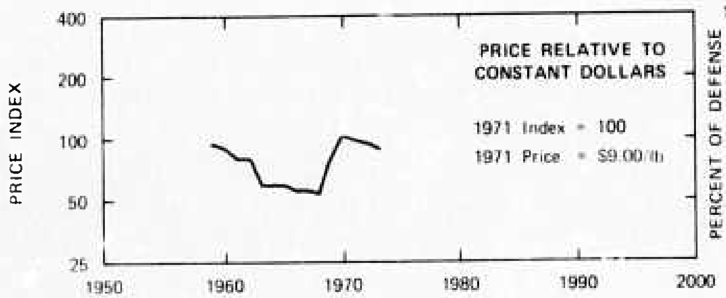
Stockpile: Selenium is not on the list of Basic Stockpile Materials, 1972.

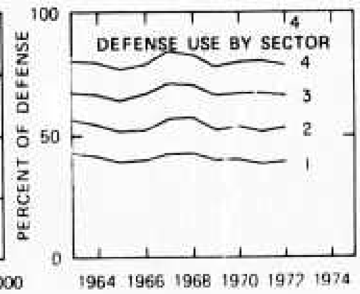
Reserves and Resources: Economic estimates are based on by-product association with electrolytic copper refining, lead and sulfuric acid manufacture. World resources are large.

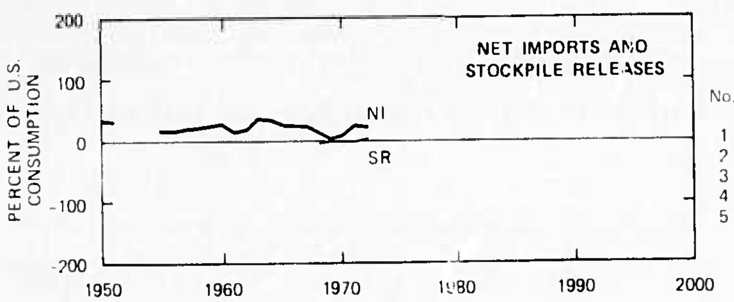
DATA SUMMARY: SELENIUM
One Unit = 1,500,000 Pounds
1972 World Production = 2.1 units

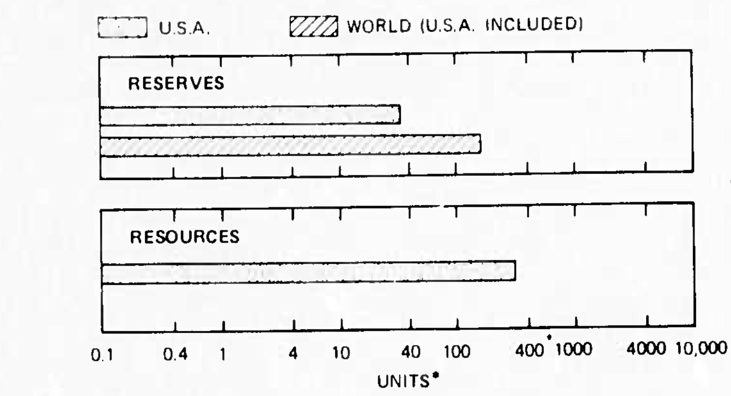












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transform., Semicond., Rel. Dev.	41
2	Duplicating Machines	14
3	Inorganic Pigments	13
4	Flat Glass, Glass, Glassware	13
5	Other (Estimated)	19
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Japan	24	4	3
Canada	21	55	36
Sweden	4	6	<1
Mexico	3	29	3
Yugoslavia	2	7	<1
Peru	<1	6	<1
Australia	<1	29	<1
			42

NOTES ON SILICON

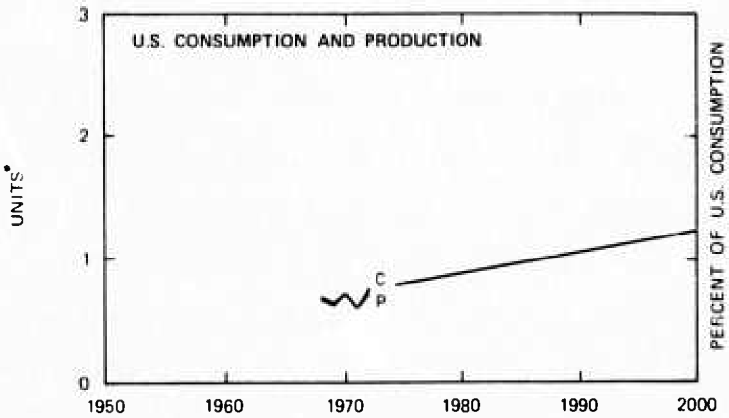
Uses: Essentially all iron and steel requires silicon in the primary production step. Aluminum alloys containing silicon for cast motor blocks, brake and transmission parts, trailer parts, castings for railroad, ship and aircraft use. Special purpose electrical steel with silicon for motors, transformers, generators; silicon steel and aluminum alloys for electrical components, light fixtures, bases, frames, transmission towers. Silicon-base chemical compounds. Rectifiers and semiconductors. Optical goods. Foundry products. Heavy media in ore preparation, coal cleaning, mold coatings, magnesium production.

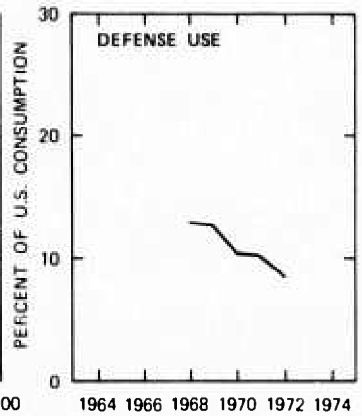
Price: The price given is an average f.o.b. plant in carload lots for metallurgical grade silicon.

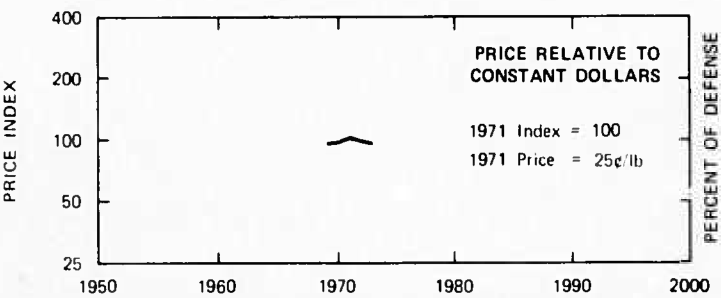
Imports: The United States was virtually self-sufficient in silicon for 1972, except for minor economic imports from various countries.

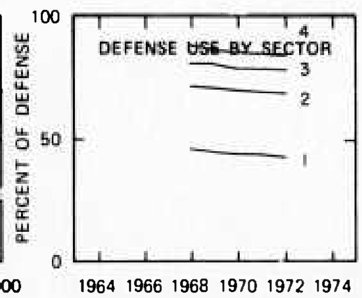
Reserves and Resources: "Reserves in major producing countries are large in relation to demand. Quantitative estimates are not available. ... Identified resources of silica sand are virtually inexhaustible. Known deposits can satisfy world demand at reasonable cost for centuries." (Commodity Data Summaries, 1974)

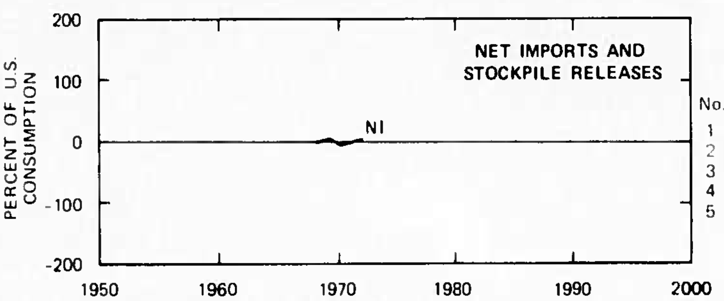
DATA SUMMARY: SILICON
One Unit = 750,000 Short Tons
1972 World Production = 2.5 units





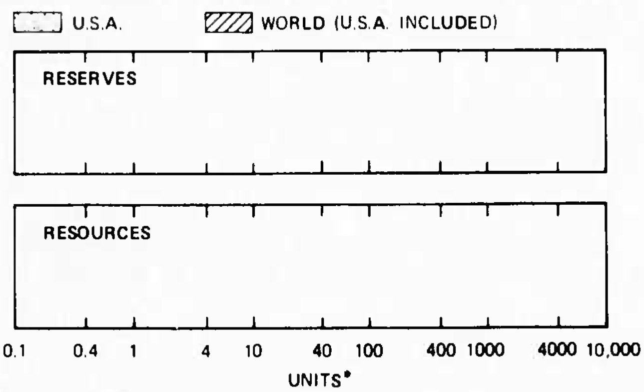






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation	42
2	Machinery Equip.	27
3	Construction Products	9
4	Electric Trans. Equip.	6
5	Other (Estimated)	16
		100



*Unit defined at top of page

NOTES ON SILVER

Uses: Sterling silverware. Electroplate. Coinage. Photographic materials. Electrical contacts in telephone relays, aviation equipment, fluorescent lamp controls, electromagnetic counters and in protective devices for motors and thermostats, switchgear, switchboard apparatus, other electronic components. Solders and brazing alloys in air conditioners, refrigeration, refrigeration, aircraft manufacture. Batteries for space and defense applications. Jewelry. Chemicals. Medicines. Dental amalgams. Mirrors. Catalysts. Nuclear reactor control rods. Bearings. Fuel cells. Epoxy.

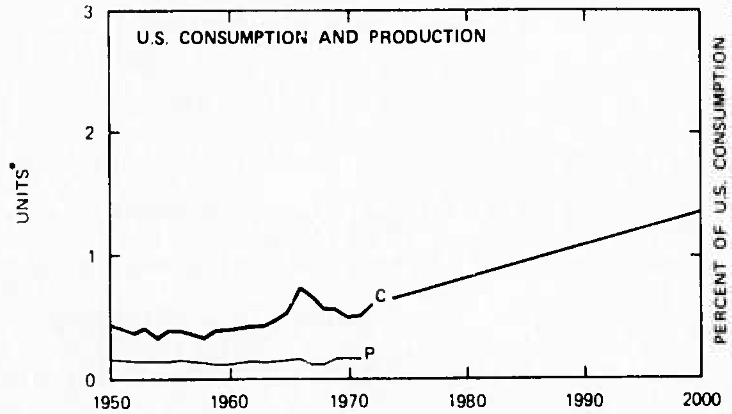
Price: 1950-1959 prices quoted are an average, limited State Treasury purchase price for newly mined silver. 1960-1971 is an average, New York price. By 1973 the price index for silver had risen to about 140.

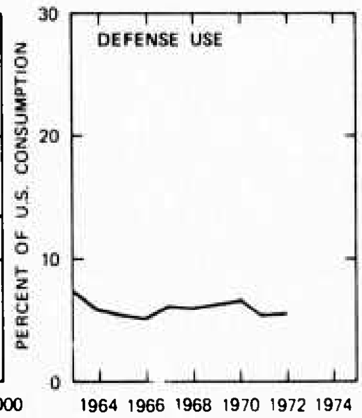
Imports: Some through United States refineries, some as refined metal.

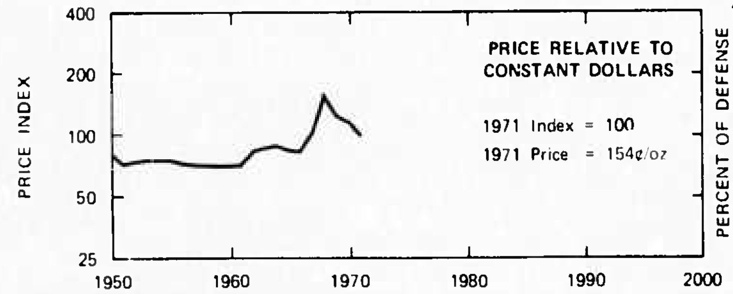
Stockpile: Silver is included on the list of Basic Stockpile Materials, 1972, in elemental form. Government strategic stockpile balance in 1972 was 139,500,000 troy ounces of silver. The releases shown for 1968-1972 are from the U.S. Treasury.

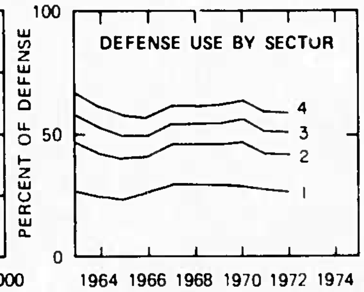
Reserves and Resources: Economic benefits are based on associations with other heavy metals.

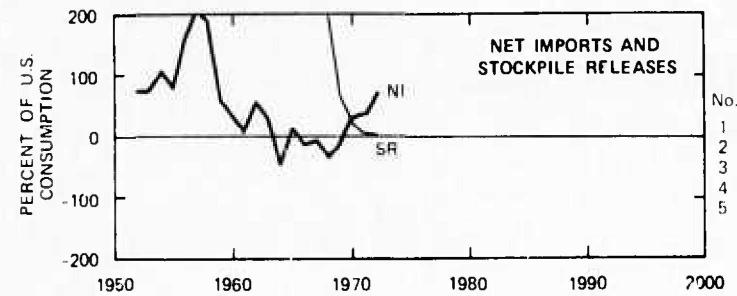
DATA SUMMARY: SILVER
One Unit = 250,000,000 Troy Ounces
1972 World Production = 1.2 units





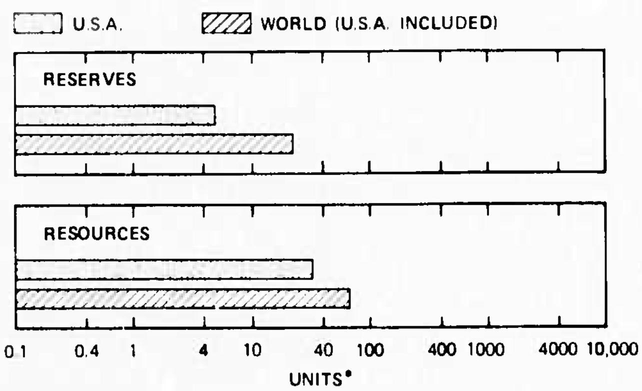






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Photographic Equip. Supplies	26
2	Electronic Components	16
3	Switchgear, Switchbrd Appar.	9
4	Primary Batteries, Dry, Wet	8
5	Other (Estimated)	41
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	16	74	23
Peru	14	43	11
Mexico	13	22	5
Australia	8	12	2
South Africa	1	17	<1
Honduras	1	90	2
Other	19	5	2
			40

*Unit defined at top of page

NOTES ON SODIUM

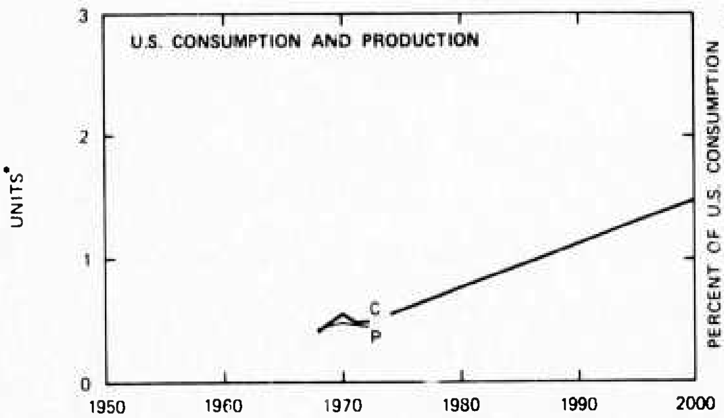
Uses: Processing pulpwood to produce paper, paperboard, and allied products. Rock salt for ice and snow melting, soil stabilization for roads. Manufacturing phenol for resin production. Intermediates for chemical compounds. Soaps, detergents, bleaches. Stone and clay products, glass. Rayon. Food products. Water softeners. Aluminum processing. Cattle feed and medicinals. Petroleum refining. Neutralizing acid spills. Producing gasoline additives.

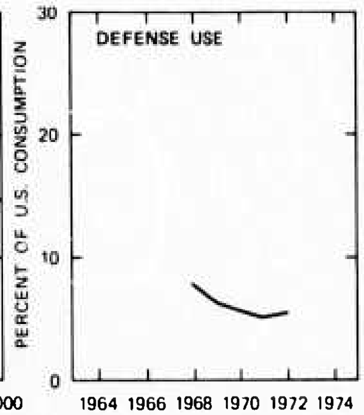
Stockpile: Sodium is not on the list of Basic Stockpile Materials, 1972.

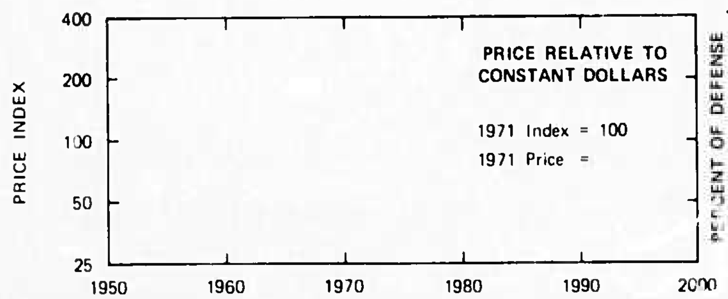
Reserves and Resources: "Large".

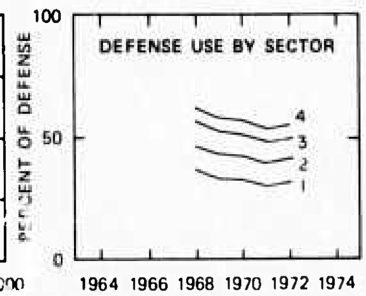
Defense Use: Lack of suitable U.S. consumption data prior to 1968 prevented defense use estimates for those earlier years.

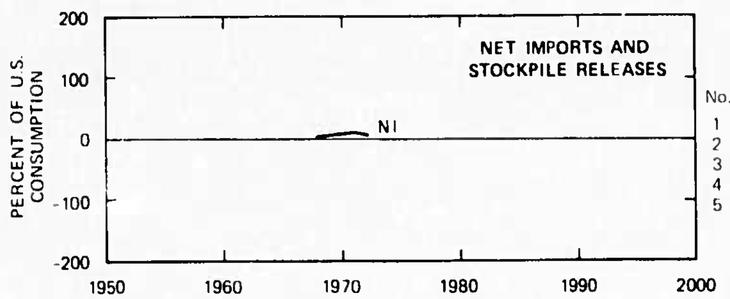
DATA SUMMARY: SODIUM
One Unit = 40,000,000 Short Tons
1972 World Production = 1.6 units





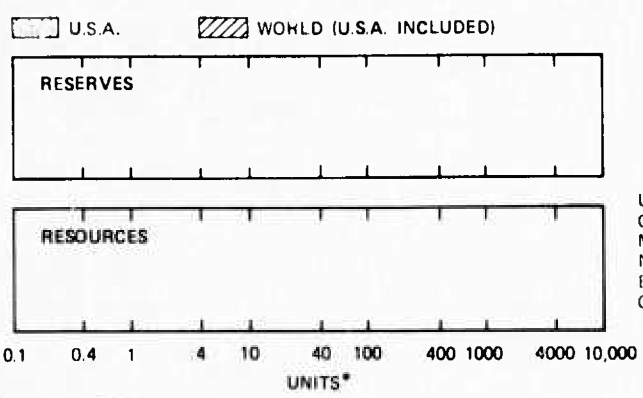






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation	32
2	Phenol	9
3	Industrial, Inorganic Chem	9
4	Soap Detergents, Bleaches	6
5	Other (Estimated)	44
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
U.K.	6	<1	<1
Canada	4	19	2
Mexico	3	26	2
Netherlands	2	<1	<1
Bahamas	<1	98	2
Other	13	2	<1
			7

*Unit defined at top of page

NOTES ON STONE

(Crushed and Dimension)

Uses: Exterior and interior facing panels for buildings, curbing, flagging, slate roofing. Monumental works, gravestones, markers. Slate electrical panels, blackboards, billiard tabletops, decorative stone panels for furniture. Cement. Fluxing stone for iron and steel. Agricultural stone.

Price: The price given is an average in dollars per ton.

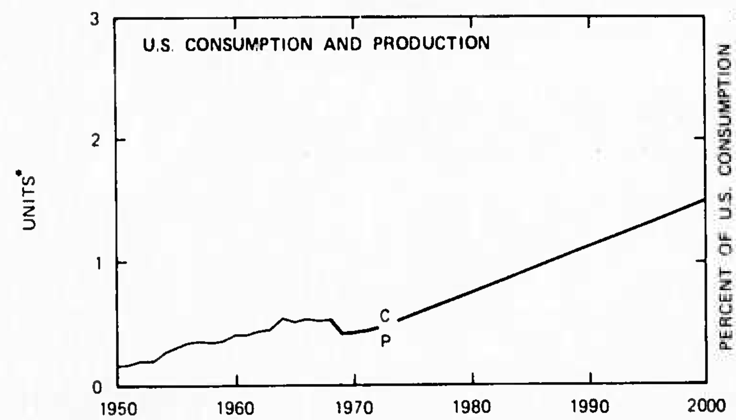
Imports: The United States was self-sufficient in crushed and dimension stone in 1972. However, nearly one-sixth of the demand for dimension stone was imported for unique decorative purposes.

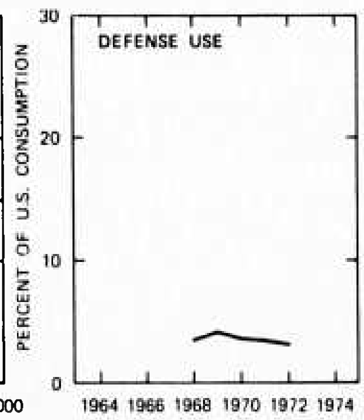
Stockpile: Stone is not on the list of Basic Stockpile Materials, 1972.

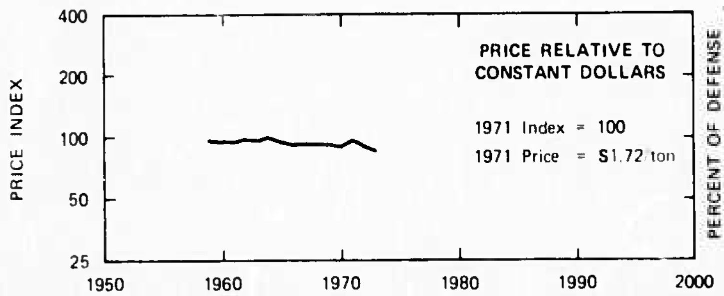
Reserves and Resources: "Large".

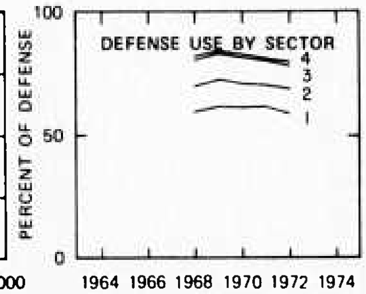
Defense Use: Lack of adequate data on U.S. consumption prior to 1968 prevented defense use estimates for the earlier years.

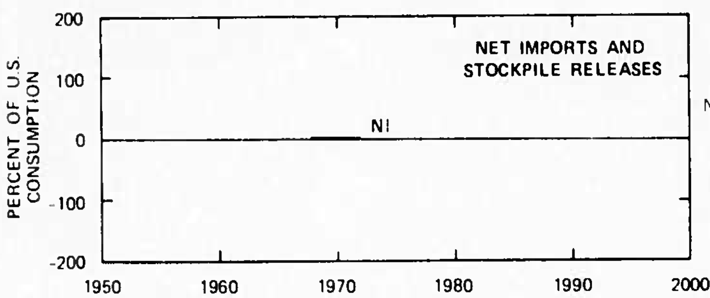
DATA SUMMARY: STONE (CRUSHED)
One Unit = 1,500,000,000 Short Tons
1972 World Production = 3.1 units





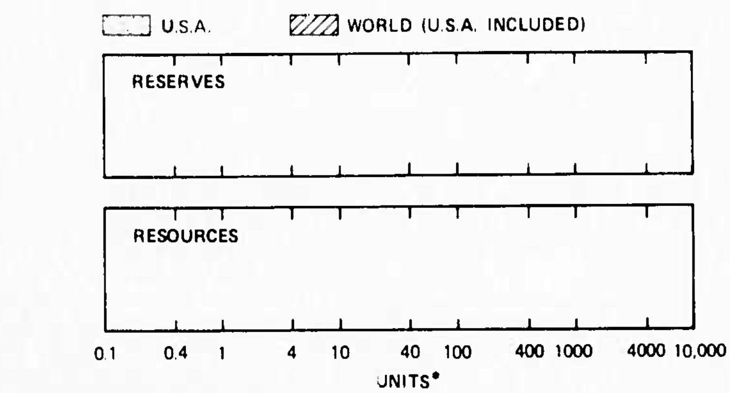






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Construct. Concrete, Roadstone	59
2	Primary Metals (Flux)	10
3	Cement	10
4	Agriculture, Animal Feed	1
5	Other (Estimated)	20
		100

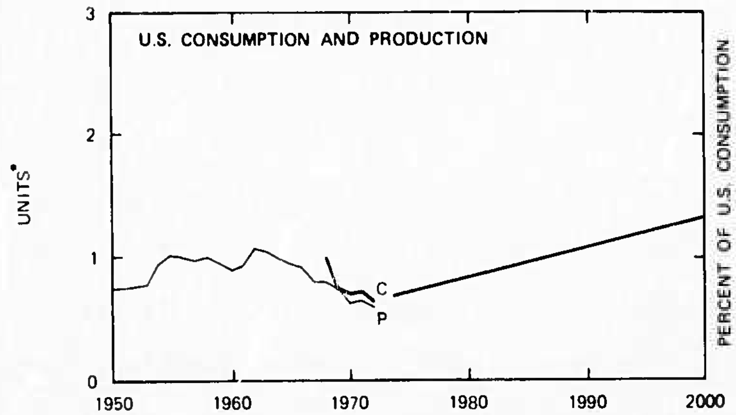


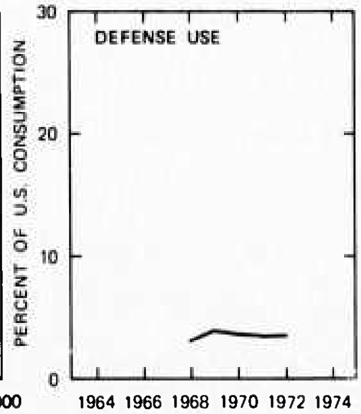
*Unit defined at top of page

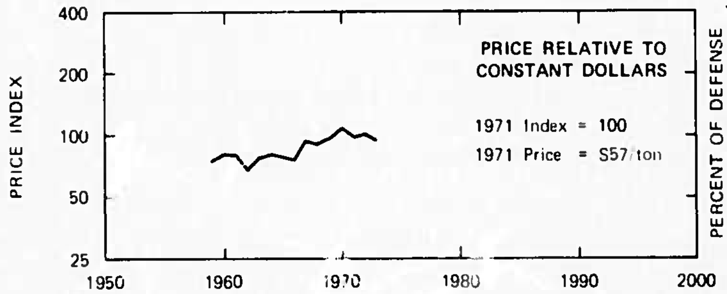
NOTES ON STONE (DIMENSION)

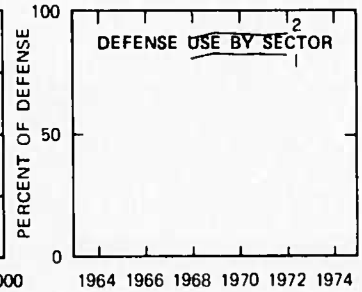
See notes opposite preceeding page on STONE (CRUSHED)

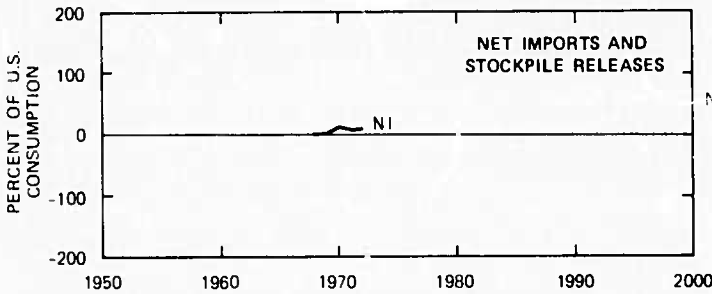
DATA SUMMARY: STONE (DIMENSION)
One Unit = 2,500,000 Short Tons
1972 World Production = 22 units





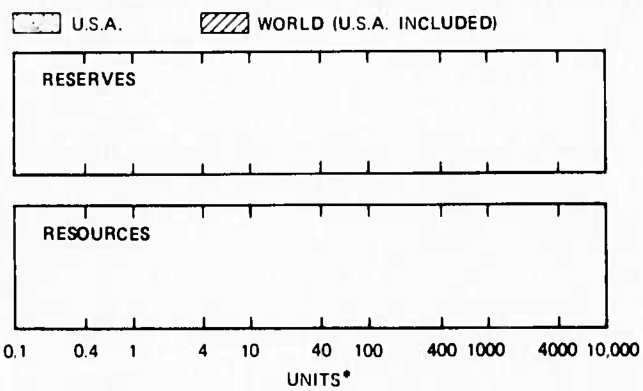






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Construction	83
2	Monumental	8
3	Other (Estimated)	9
		100



*Unit defined at top of page.

NOTES ON STRONTIUM

Uses: Brilliant crimson color for tactical and distress and illumination flares, tracer ammunition. Safety fusees. Fireworks. Lead removal from electrolytic zinc. Bearing lubricants for dry ovens and aircraft engines. Ceramics. Paint filler. Welding rod coating. Medicines. Depilatories. Case hardening baths. Optics. Rubber filler. Rayon manufacture. Alloys. Magnets. Color TV glass, electronic tubes.

Price: The price quoted is an average value at the port of exportation, per ton of ore.

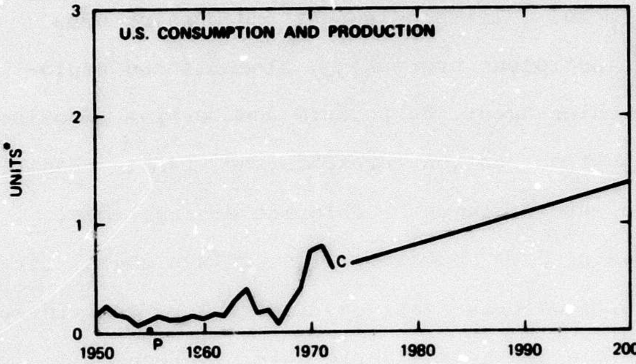
Imports: Spain has also been a source, about 7 percent of imports in the 1969-1972 period.

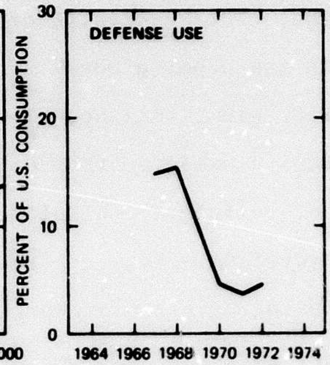
Stockpile: Strontium is not on the list of Basic Stockpile Materials, 1972. Celestite was previously on the stockpile list and releases of this are reflected in the SR graph for 1968-1972.

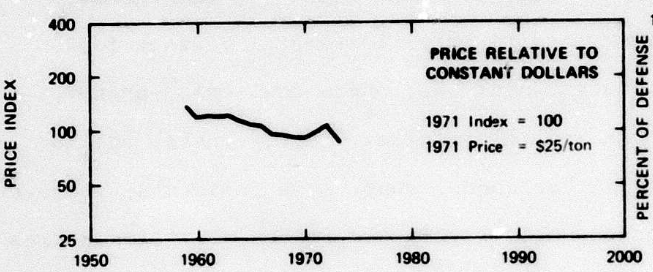
Reserves and Resources: The U.S. has substantial resources, but the grade is too low to constitute a reserve. World reserves and resources are large but unevaluated.

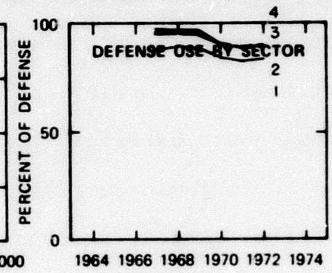
Defense Use: Lack of adequate data on U.S. consumption prior to 1967 prevented defense use estimates for the earlier years.

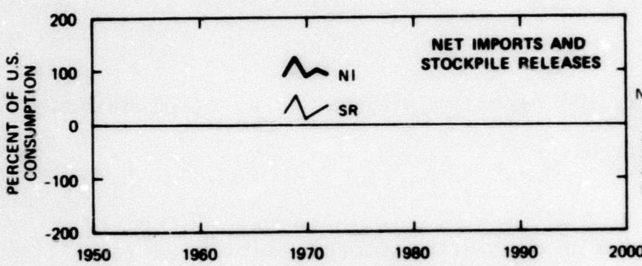
DATA SUMMARY: STRONTIUM
One Unit = 25,000 Short Tons
1972 World Production = 1.7 units





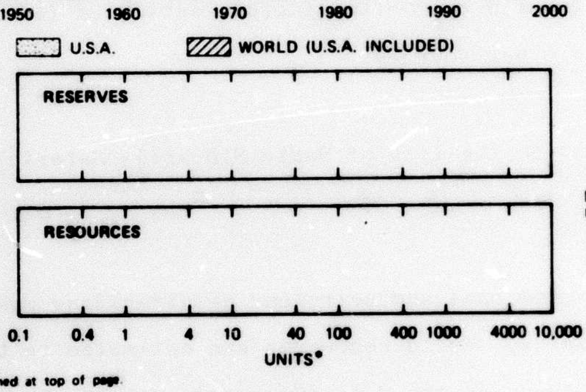






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Pyrotechnics, Signals	84
2	Zinc Refining	6
3	Grease (Additive)	1
4	Paints	1
5	Other (Estimated)	8
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Mexico	29	100	83
U.K.	10	32	9
			92

*Unit defined at top of page.

NOTES ON SULFUR

Uses: Intermediate in production of fertilizers, titanium dioxide, rayon, electrorefining of metals, leaching copper and uranium ores, pulp and paper processing, petroleum processing, alcohols and explosives, alum, analine, bleaching agent, boric acid and borates, bromine, carbon dioxide, carbon disulfide, carbon tetrachloride, casein, caustic soda, celluloid, cellulose esters, cements, chlorine drying, coke, dehydrating agent, detergents, dyes, ebonite, fire extinguishers, fireproofing agents, fireworks, food preservatives, fumigants, fungicides, glue, glycerin, hydrochloric acid, hydrofluoric acid, impregnant, inorganic or organic acids, insecticides, leather, livestock food, lubricants, magnesium, matches, medicine, pharmaceuticals, phenol, photographic material, plastics, plate glass, refrigerants, resins, road surfacing materials, rubber goods, soap, soda, solvents, storage batteries, sugar, sulphonated oils, synthetic rubber, textiles, tires and rubber, water purifications.

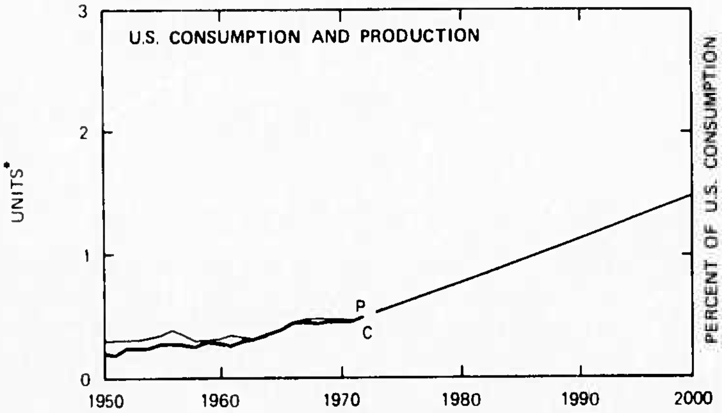
Price: The price given is the reported average value of elemental sulfur f.o.b. mine or plant.

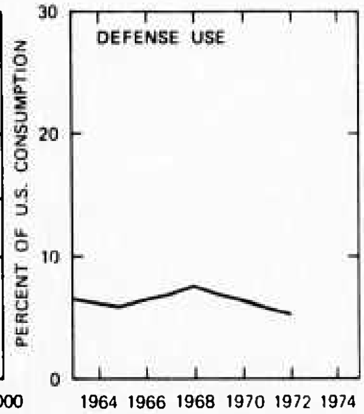
Imports: Percentages of world production include estimates from smeltergases, gypsum and other sources.

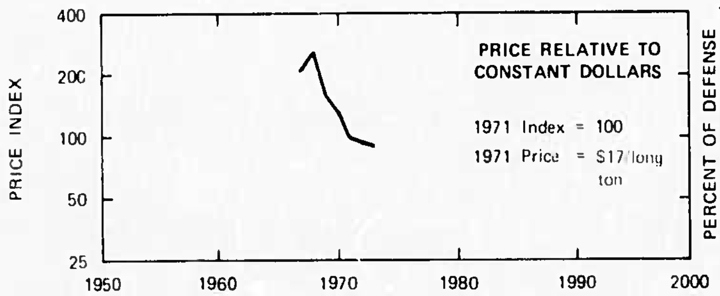
Stockpile: Sulfur is not on the list of Basic Stockpile Materials, 1972.

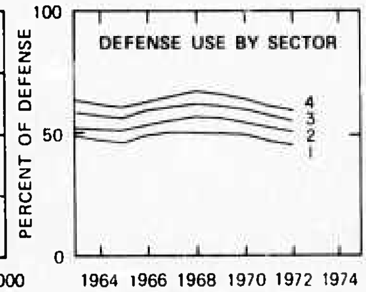
Reserves and Resources: New coal and petroleum desulfurizing could drastically affect estimates. World resources are estimated to be on the order of five times those of the U.S. (Commodity Data Summaries, 1974).

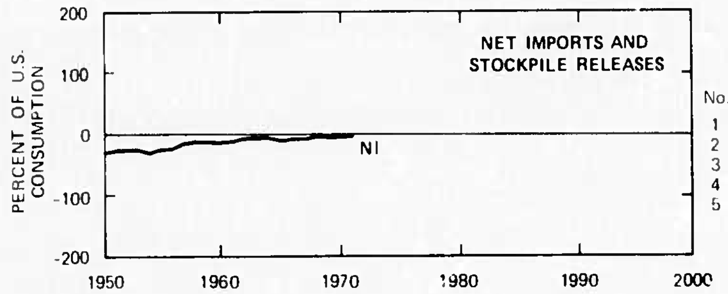
DATA SUMMARY: SULFUR
One Unit = 20,000,000 Long Tons
1972 World Production = 2.2 units





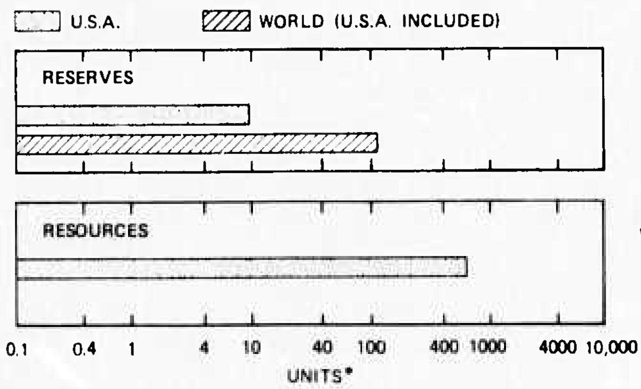






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Fertilizer	45
2	Explosives	5
3	Inorganic Pigments	5
4	Nonferr. Metals (Ore Leaching)	5
5	Other (Estimated)	40
		100



*Unit defined at top of page

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	17	12	9
Mexico	2	26	3
W. Germany	2	<1	<1
			12

NOTES ON TALC

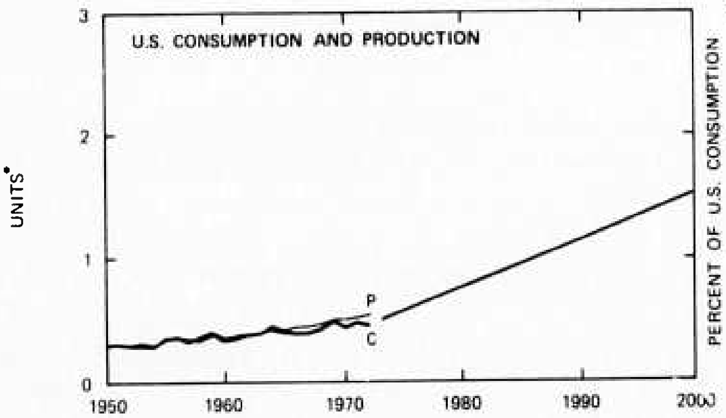
General: Includes talc, soapstone, and pyrophyllite.

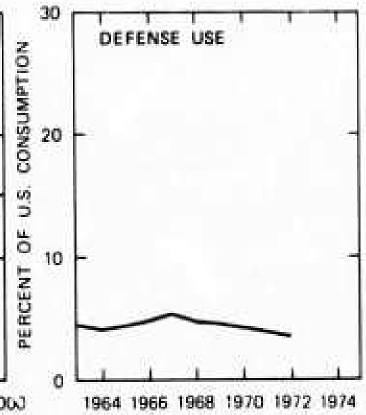
Uses: Ceramics. Paint. Roofing. Paper. Toilet preparations. Insecticides. Rubber. Textiles. Pigment in white shoe polishes, glove cleaners. Salami dusting powder. Mold anti-stick. Leather finishing. Plastic filler. Concretes. Polishing peanuts, gunpowder grains, turned wood articles, rice. Cup greases.

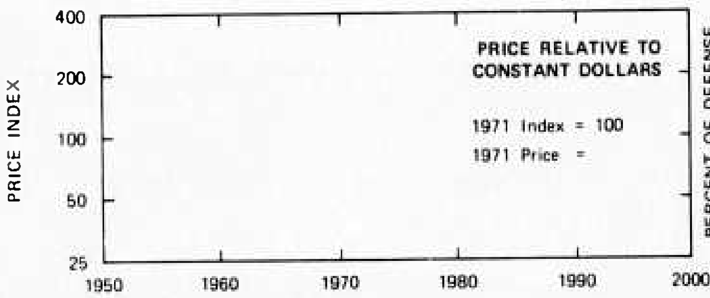
Imports: The United States was self-sufficient in talc for 1972.

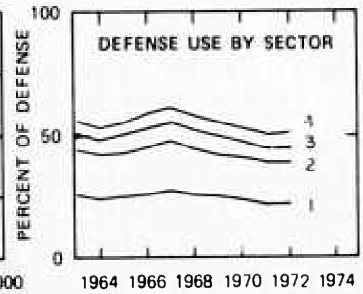
Stockpile: Talc is included on the list of Basic Stockpile Materials, 1972, in the form of steatite block and lump. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 5,000 short tons of talc.

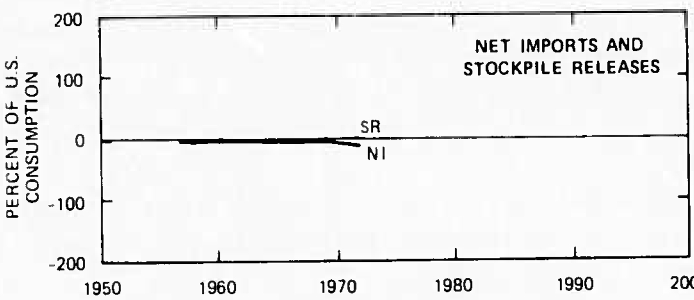
DATA SUMMARY: TALC
One Unit = 2,000,000 Short Tons
1972 World Production = 2.6 units





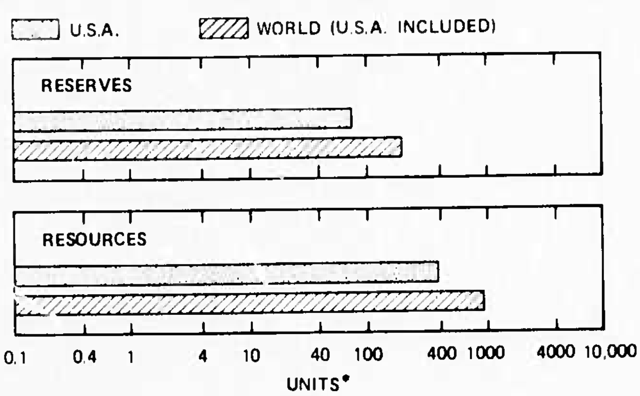






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Ceramics	24
2	Paint	17
3	Roofing	6
4	Rubber	5
5	Other (Estimated)	48
		100



*Unit defined at top of page

NOTES ON TANTALUM

Uses: Capacitors, gas absorber and electron emitter in tubes, transistors, miniature electronic valves, high-voltage surge arresters. Chemical and metallurgical processing equipment and heat exchangers, vacuum crucibles, tubing lining, vacuum and inert gas furnaces. Surgical mesh, plates, strips, screws, staplers, instruments. Synthetic fiber spinnerets. Laboratory ware. Electroplating anodes. Optical glass. Breeder reactor control rods, plutonium reactor structures. Refractory superalloys in aerospace structures, jet engines, space power systems. Metal cutting tools.

Price: The price given is for tantalite, an average price per pound of tantalum pentoxide on a 60% basis.

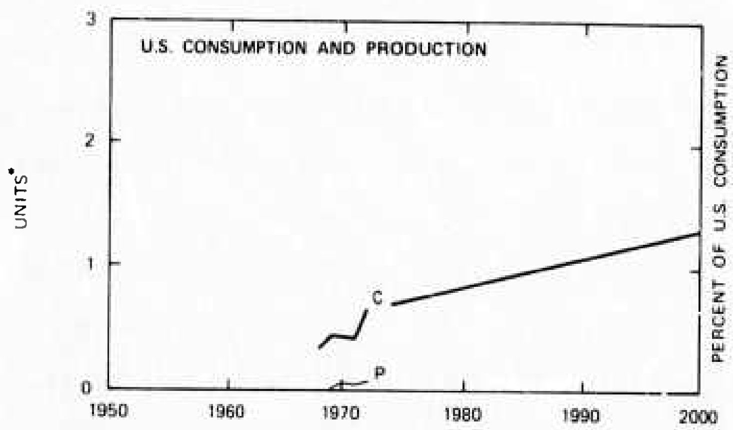
Imports: Percentages are based on combined elemental content of concentrate, tin slag and others.

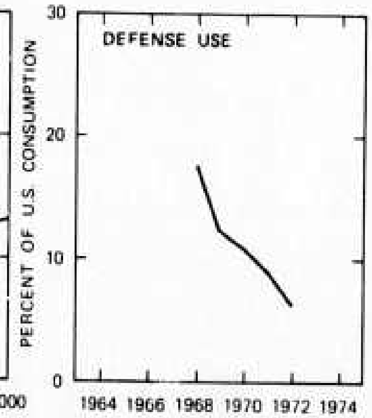
Stockpile: Tantalum is included on the list of Basic Stockpile Materials, 1972, in the following forms: Carbide powder; metal; minerals. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 4,054,000 pounds of tantalum.

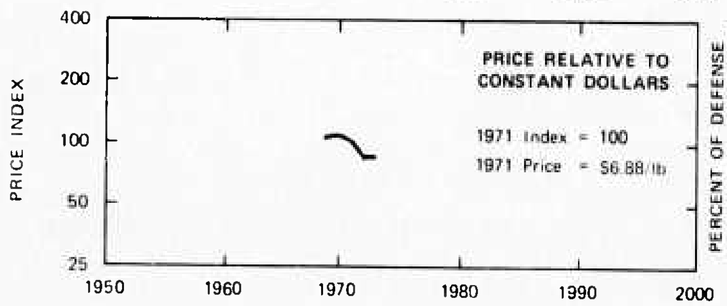
Reserves and Resources: Economic estimates are based on by-product association with tin mining, along with columbium. United States reserves and resources are "insignificant".

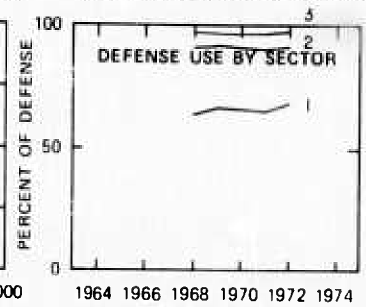
Defense Use: No estimates are given for years prior to 1968 because the available data on U.S. consumption combined tantalum with columbium (niobium).

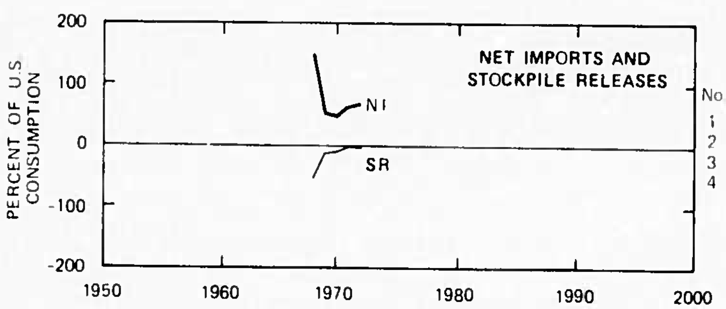
DATA SUMMARY: TANTALUM
One Unit = 3,000,000 Pounds
1972 World Production = 1.1 units

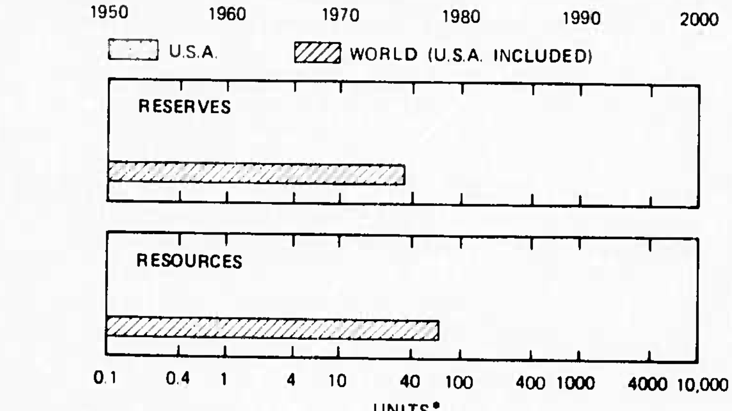












*Unit defined at top of page.

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Electronic Components	67
2	Nuclear Aerospace	23
3	Metalworking Machinery	7
4	Chem. Equip., Misc.	3
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Thailand	41	50	34
Nigeria	19	66	21
Brazil	7	46	6
Canada	8	20	2
Australia	4	96	7
Malaysia	4	27	2
Zaire	3	38	2
Mozambique	<1	44	<1
U.K.	0	—	2
Other	2	100	3
			80

NOTES ON TELLURIUM

Uses: Alloying element for steel, copper, iron, lead. Vulcanizing agents for natural and synthetic rubber and in plastic. Ultramarine, black, blue, red and brown color and for glass and ceramics. Insecticide, germicide, fungicide. Catalyst. Optical glasses and chalcogenide infrared transmitting glasses. Blasting caps. Photo print toners. Batteries, thermoelectric applications, solar cells, infrared windows, semiconductor dopants.

Price: The price given is an average per pound.

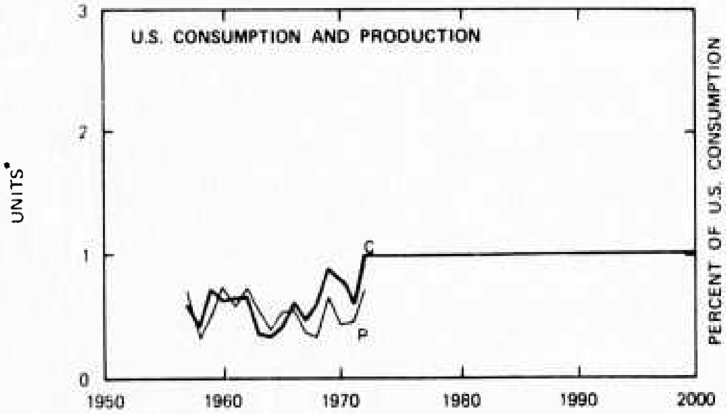
Imports: All imports are previously refined. The imports from Peru in 1972 were unusually large; more typical of previous years would be approximately equal amounts from Peru and Canada.

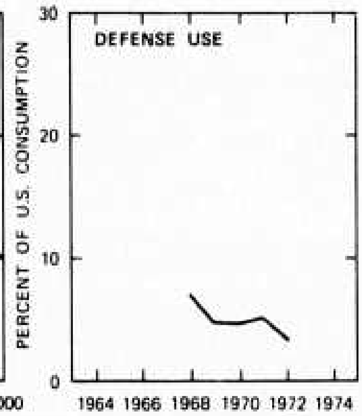
Stockpile: Tellurium is not on the list of Basic Stockpile Materials, 1972.

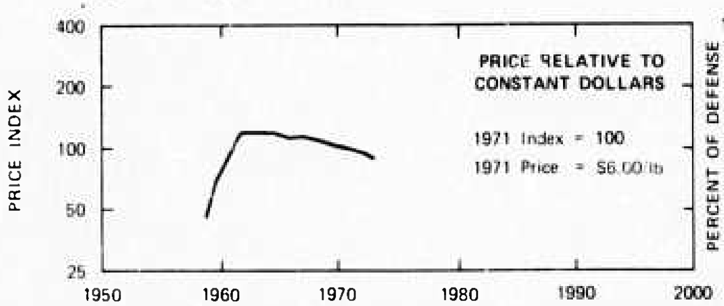
Reserves and Resources: Economic estimates are based on by-product association with electrolytic copper refining, lead production.

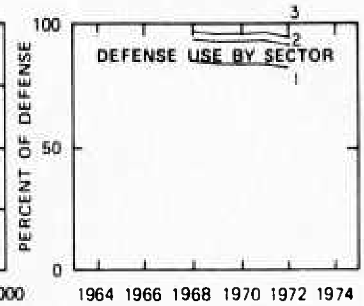
Defense Use: Lack of adequate data on U.S. consumption prior to 1968 prevented defense use estimates for the earlier years.

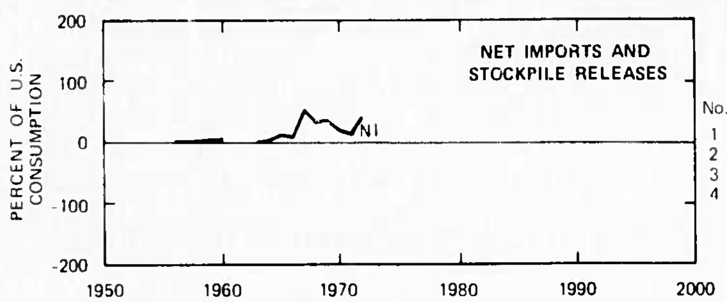
DATA SUMMARY: TELLURIUM
One Unit = 350,000 Pounds
1972 World Production = 1.6 units





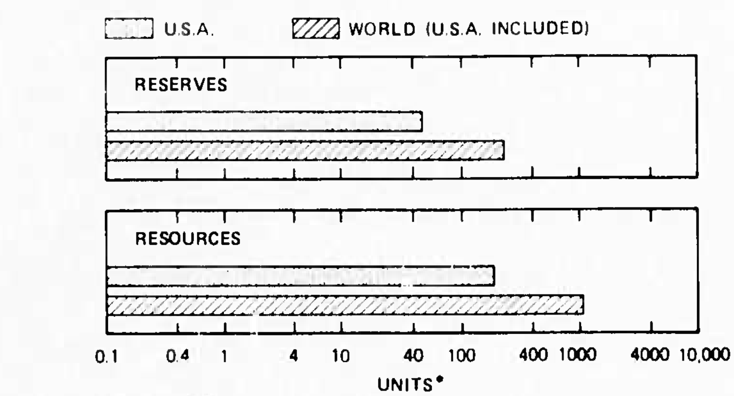






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Primary Metals Industries	83
2	Rubber, Misc. Plastic Prod.	9
3	Chemicals, Allied Products	3
4	Other (Estimated)	5
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	8	31	4
Peru	7	327	38
			42

*Unit defined at top of page

NOTES ON THALLIUM

Uses: Insecticide, rodenticide. Gamma radiation detectors. Infrared transmission and detection. Electronic coatings. Alloys for low temperature thermometers, bearings, electrical contacts, acid containers, solder, anodes for copper electrowinning, catalyst for sulfuric acid, telephones. Optical instrument glass, synthetic gems. Anti-knocking additive.

Price: The price given is in dollars per pound for the metal.

Imports: Some through United States refineries in zink concentrates, some as metal, some as compounds; percentages are based on combined elemental content.

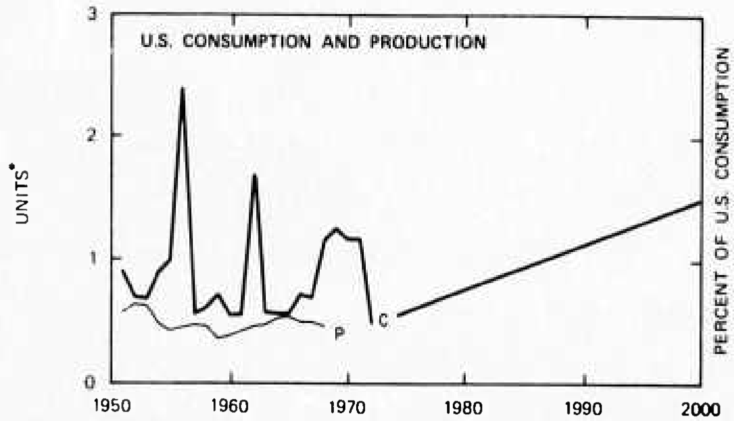
Stockpile: Thallium is not on the list of Basic Stockpile Material, 1972.

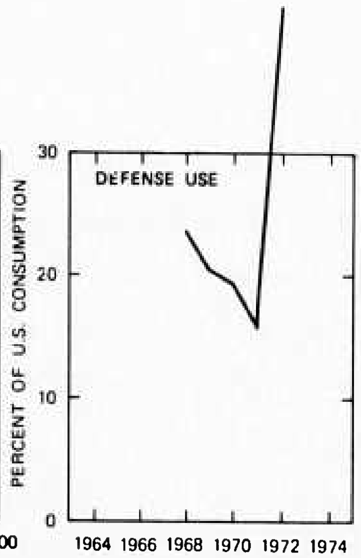
Reserves and Resources: Economic estimates are based on by-product association with base metal smelting, mostly zinc. Resources are "large".

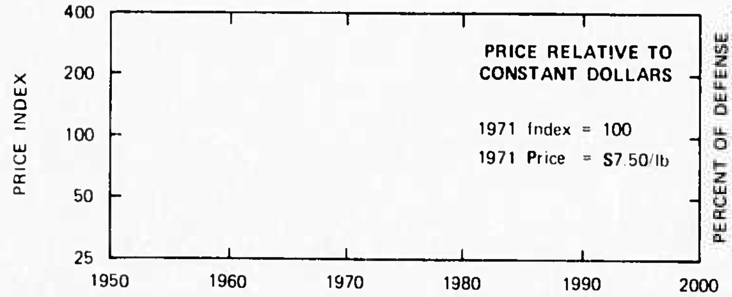
Defense Use: Lack of adequate data on U.S. consumption prior to 1968 prevented defense use estimates for the earlier years.

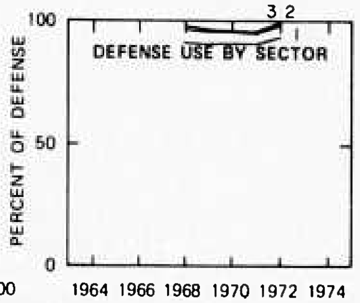
The huge increase shown for defense use as a fraction of U.S. consumption in 1972 reflects the factor of two decreases in total U.S. consumption rather than a marked change in defense procurements.

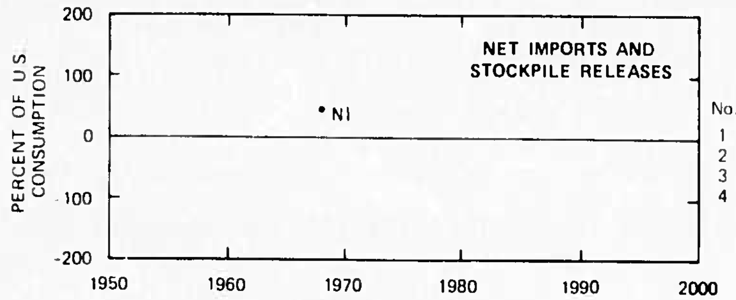
DATA SUMMARY: THALLIUM
One Unit = 5,500 Pounds
1972 World Production = 5.6 units





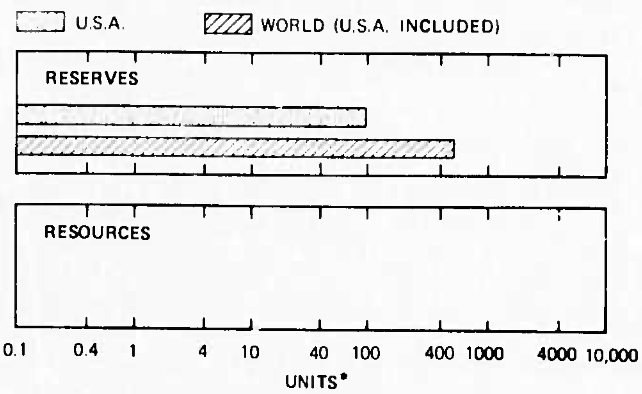






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Consumer Elec. Comm. Equip	93
2	Electronic Comp. Equip.	4
3	Agric. Pesticides	1
4	Other (Estimated)	2
		100



*Unit defined at top of page

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	23	10	25
USSR	12	12	17
Australia	9	4	4
Peru	6	4	3
Mexico	5	19	11
W. Germany	2	13	3
Ireland	2	6	1
Bel. Lux.	0	—	43
Other	NA	NA	6
			113

NOTES ON THORIUM

Uses: Welsbach-type incandescent gas mantles. Magnesium-base alloys. Dispersion hardening of stainless steel, nickel, tungsten. Specialized refractories. Catalysts for organic chemicals. Electron discharge tubes, radiation detectors, computer memory components, photo-conductive films, fuel cell elements. Structural alloys for aerospace and military projects. Thermal and breeder reactor fuel.

Consumption: The great increase projected is based on use of thorium as a fuel for nuclear reactors.

Price: The price given is for thorium nitrate, mantle grade.

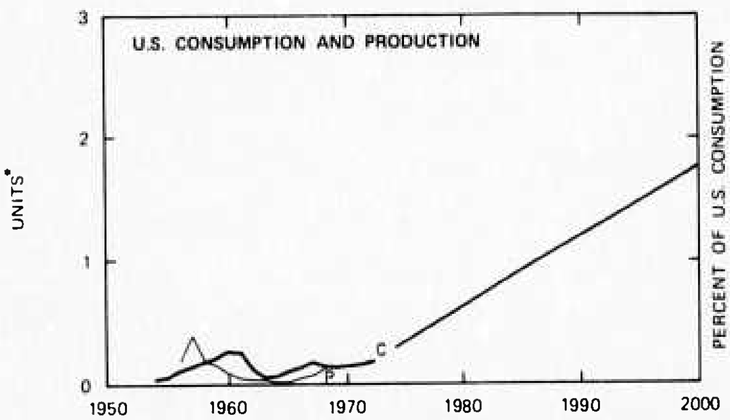
Imports: Percentages are based on combined elemental content of monazite and thorium compounds. United States demand includes energy uses.

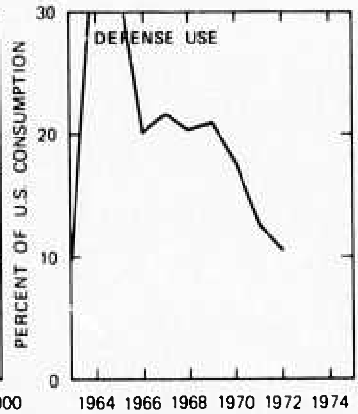
Stockpile: Thorium is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 3,170 short tons of thorium.

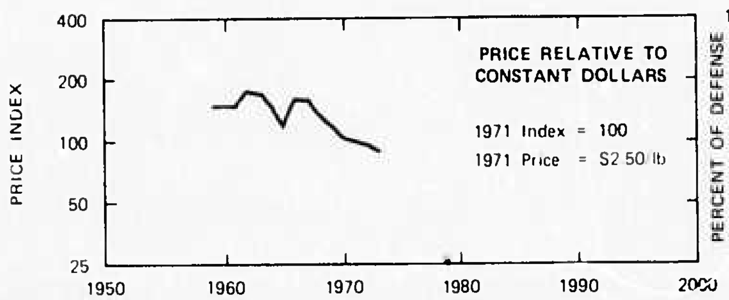
Reserves and Resources: Unit of measure considers great growth in energy applications, currently very small. Mostly a by-product of titanium and zircon.

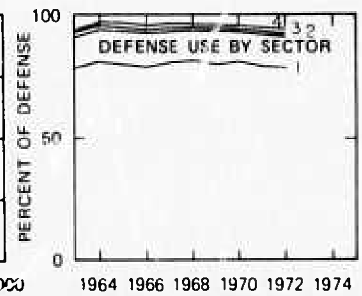
Defense Use: The peak shown in 1964-65 for defense use as a fraction of U.S. consumption is more reflective of a decrease in U.S. consumption than any change in defense procurement.

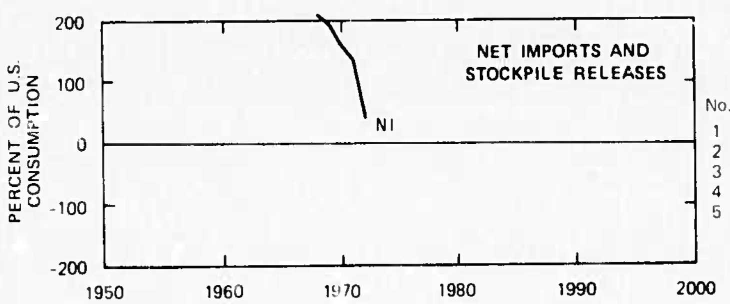
DATA SUMMARY: THORIUM
One Unit = 750 Short Tons
1972 World Production = 1.6 units

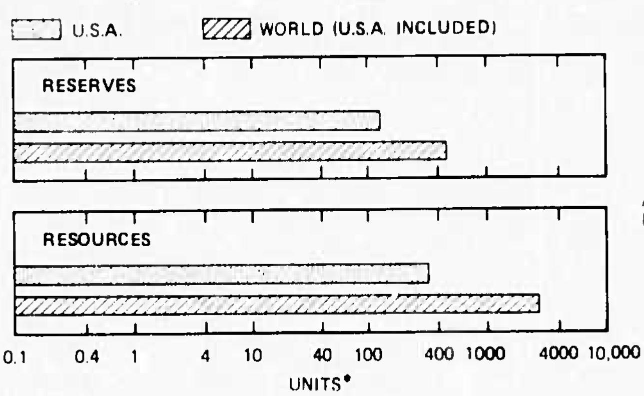












IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Aircraft Alloys	78
2	Gas Mantles	13
3	Dispersion Hardening Alloys	2
4	Catalysts	2
5	Other (Estimated)	5
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	29	1	3
Malaysia	12	47	41
			44

*Unit defined at top of page

NOTES ON TIN

Uses: Solder, brass and bronze, bearings, pipe and tubing for transportation, machinery, electrical equipment, plumbing and heating. Tin cans. Iron alloy. Plastic polyvinyl chloride additive. Marine and domestic paints. Bactericide and fungicide. Toothpaste. Molten glass forms.

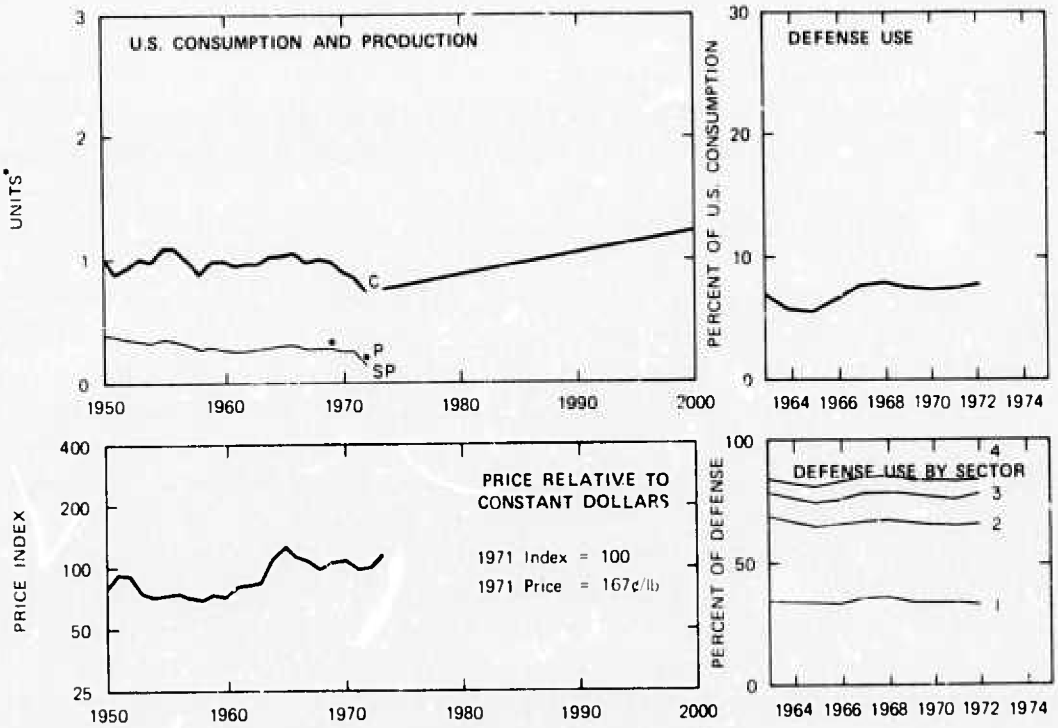
Price: The price quoted is an annual average in New York.

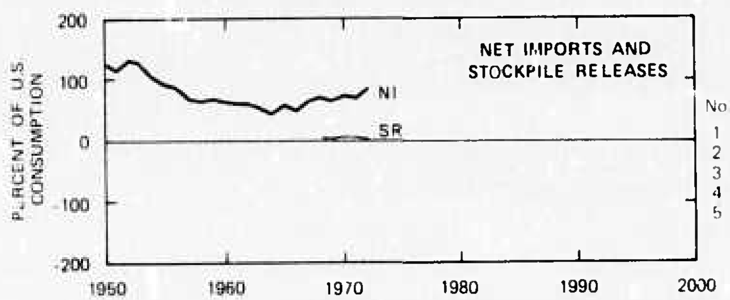
Imports: Bolivian tin through United States smelters, the rest is metal.

Stockpile: Tin is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 250,664 long tons of tin.

Reserves and Resources: U.S. reserves have been estimated at only 5,000 long tons (Commodity Data Summaries, 1974), less than a tenth of a unit.

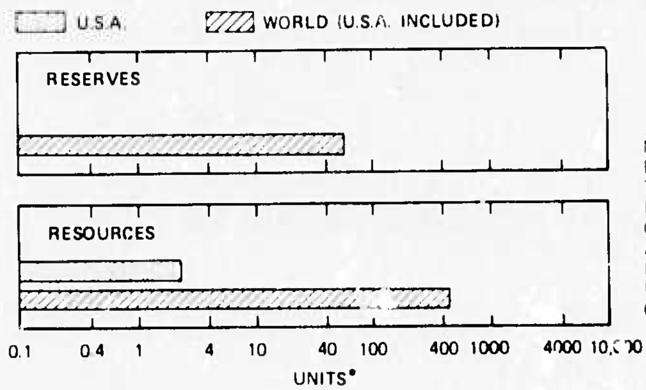
DATA SUMMARY: TIN
One Unit = 80,000 Long Tons
1972 World Production = 3.0 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation Equip.	34
2	Elect. Equip., Supplies	33
3	Machinery, Exc. Elect.	12
4	Metal Cans	7
5	Other (Estimated)	14
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Malaysia	32	43	55
Bolivia	13	17	8
Thailand	12	53	20
Indonesia	9	9	3
China	8	6	<1
Australia	5	19	4
Nigeria	3	3	<1
U.K.	1	14	<1
Other	6	14	3
			94

*Unit defined at top of page

NOTES ON TITANIUM

General: Throughout this analysis the metal, rutile ore, and ilmenite ore data have been totaled on the basis of titanium content. This causes the dependence on imports and the defense use to be smaller than is often shown on the basis of rutile (the ore used to make titanium metal) or titanium sponge metal.

Uses: Titanium dioxide pigment for paints, varnishes, and lacquers, printing paper, photographic papers, polyethylene, polyvinylchloride, polystyrene and polyolefin products, rubber tires, floor coverings, ink, porcelain enamels, wall coverings, upholstery materials, artificial leather, oil cloth, roof coatings, ceramic capacitors, electromechanical transducers, welding rod coatings, glass fibers. Titanium carbide for cutting tools. Organotitanium compounds for polymerization catalysts, water repellents, dyes. Metal for turbine engines, aircraft assemblies, missiles and space vehicles. Chemical process equipment. Armor, mortar tubes, tank hatches, missiles, other ordnance. Deep diving submersible vehicles, surface effect vehicles. Cryogenic magnets. Steel making, cast iron additive, electolytic plating holder.

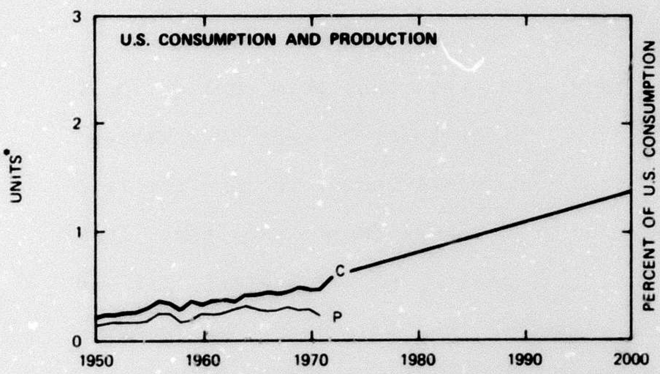
Price: The price quoted is that of sponge metal.

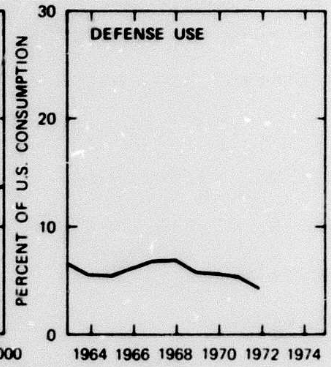
Imports: Percentages are based on combined elemental content of rutile and ilmenite, used for both metal and pigment purposes.

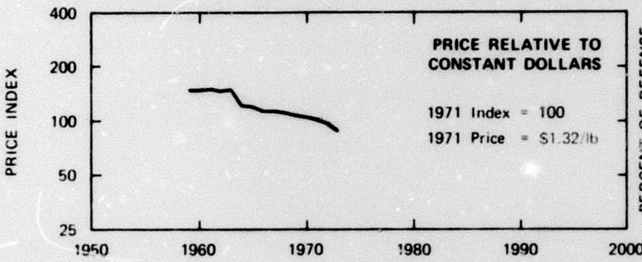
Stockpile: Titanium is included on the list of Basic Stockpile Materials, 1972, in the following forms: Titanium sponge; rutile. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 67,000 short tons of titanium.

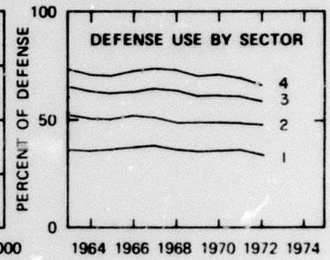
Reserves and Resources: Estimates include rutile and ilmenite, the two ores being added on the basis of titanium element content. U.S. reserves of rutile are small compared to consumption.

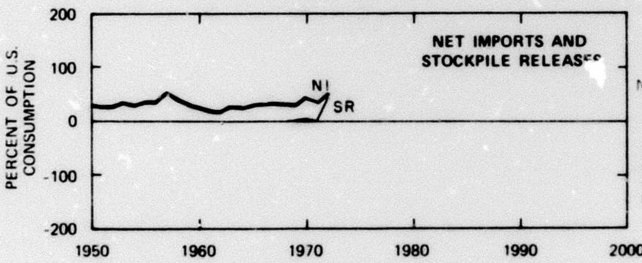
DATA SUMMARY: TITANIUM
One Unit = 1,000,000 Short Tons
1972 World Production = 1.6 units





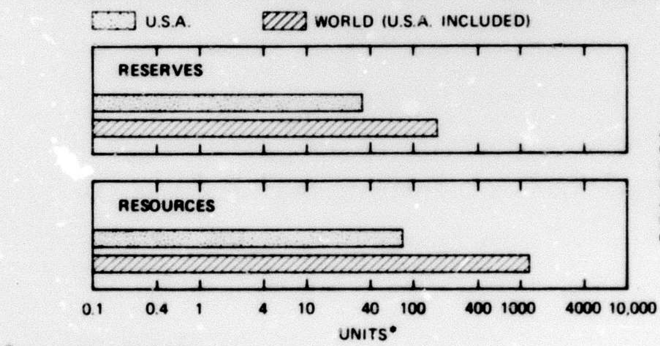






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Paints, Vars., Lacs., Enams., Etc.	35
2	Aircraft Engs., Parts, Etc.	13
3	Airframe Assemb. Incl. for GM	11
4	Paper Mills, Exc. Bldg. Paper M.	8
5	Other (Estimated)	23
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	28	26	19
Canada	24	47	22
Norway	13	9	3
Finland	3	10	<1
Japan	<1	350	1
France	0	–	1
Other	NA	NA	<1
			47

*Unit defined at top of page.

NOTES ON TUNGSTEN

<u>Uses</u>: Machine tools and dies. Rock bits, earth moving blades. Tire studs, gas turbines, rocket nozzles, aircraft stabilizer counterweights, high-strength auto, railroad, ship applications. Incandescent filament, fluorescent cathode, electric discharge cathode. Distributor points, electrical contact points for telephones, clocks, business machines, remote control devices. Inert arc welding. Textile dyes, ink, paints, enamels, glass, oil and water colors, luminescent pigments. X-ray screens, TV tubes, fluorescent lighting. Solid lubricants. Lasers. Catalysts. Ball point pen tips. Thermocouples. Armorpiercing projectiles. Heating elements. Flame spraying. Nuclear fuel crucibles. Chemical analyses. Textile fireproofing. Hard surfacing.

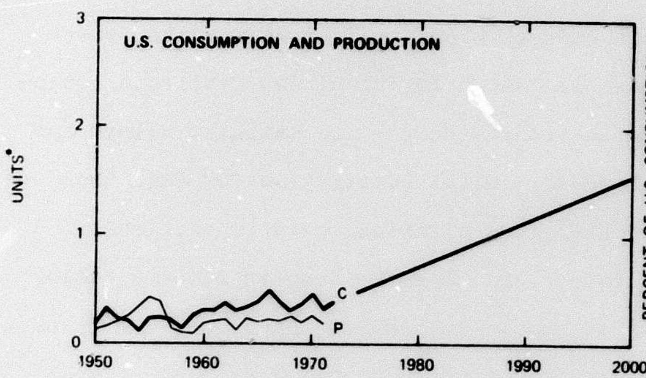
<u>Price</u>: The price used is per short ton unit (20 pounds) of tungsten trioxide (average c.i.f. U.S. ports, duty paid).

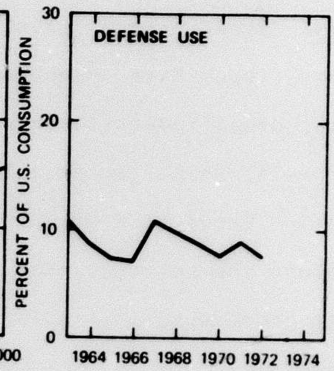
<u>Imports</u>: Percentages are based on combined elemental content of concentrate, ferrotungsten.

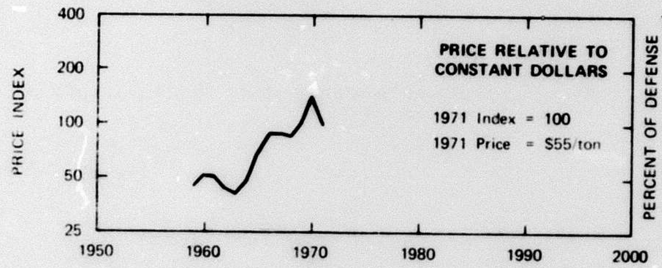
<u>Stockpile</u>: Tungsten is included on the list of Basic Stockpile Materials, 1972, in the following forms: Carbide powder; ferrotungsten; carbon reduced metal powder; hydrogen reduced metal powder; ores and concentrates. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 129,871,000 pounds of tungsten.

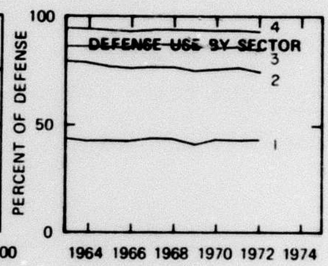
<u>Reserves and Resources</u>: Economic estimates in the United States are based on co-product association with molybdenum operations.

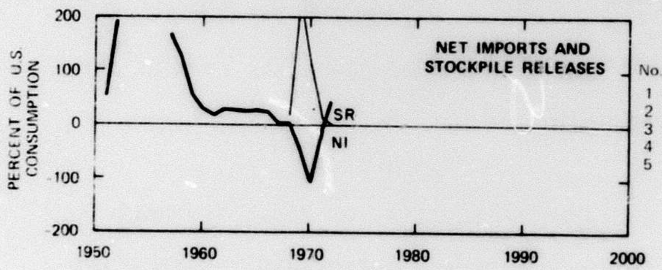
DATA SUMMARY: TUNGSTEN
One Unit = 35,000,000 Pounds
1972 World Production = 2.4 units





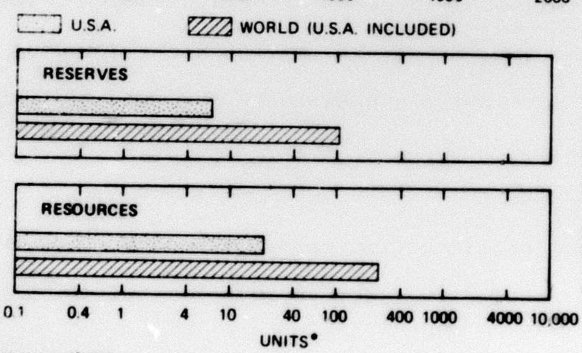






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Metalworking Machinery	43
2	Transportation Equip.	32
3	Const. Mine Mach., and Equip.	10
4	Electrical Equip., Supplies	8
5	Other (Estimated)	7
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
China	18	4	5
Thailand	9	12	6
Bolivia	6	16	6
Korea	5	8	3
Canada	5	46	13
Australia	4	12	3
Portugal	3	4	<1
Brazil	3	4	<1
Peru	2	43	6
France	1	<1	<1
Other	6	11	4
			47

*Unit defined at top of page.

NOTES ON VANADIUM

Uses: Steel alloys for structures, pipelines, storage tanks, power trains, rock bits, pump casings, earth moving blades, railroad equipment, other industrial applications. Ferro- and titanium alloys for aircraft, ships, autos, railroad. Metal cutting and forming, hand tools. Production of sulfuric acid, plastics, paints, varnishes, lusters for pottery, porcelains, and glass, synthetic rubbers, color film processing chemicals, glazes, dye, ink. Welding rods. Permanent magnets.

Price: The price given is the midpoint of a range for dealer exports of vanadium pentoxide.

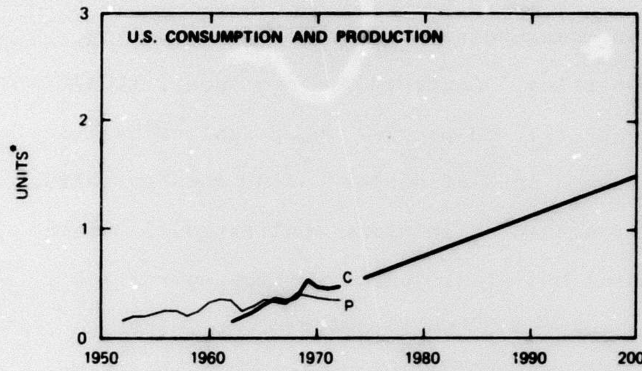
Price: The price quoted is vanadium pentoxide, dealer exports.

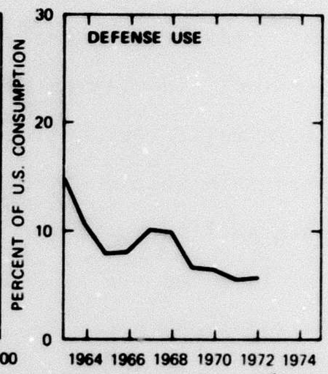
Imports: Percentages are based on combined elemental content of residues, slag, and ferrovanadium.

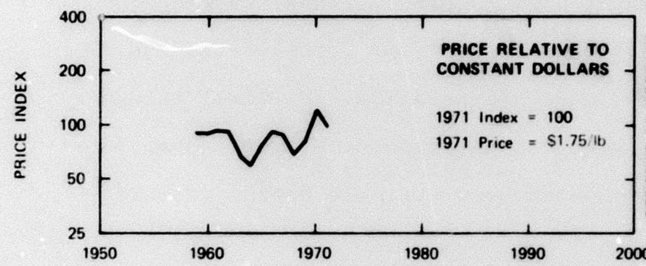
Stockpile: Vanadium is included on the list of Basic Stockpile Materials, 1972, in the following forms: Ferrovanadium; vanadium pentoxide. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 2,800 short tons of vanadium.

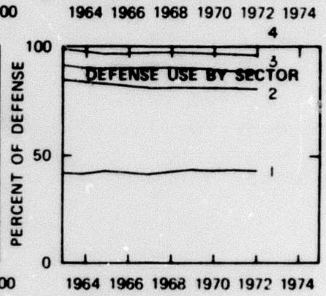
Reserves and Resources: Economic estimates are based on co-product association with uranium, phosphate rock, and other minerals. Resources are "large".

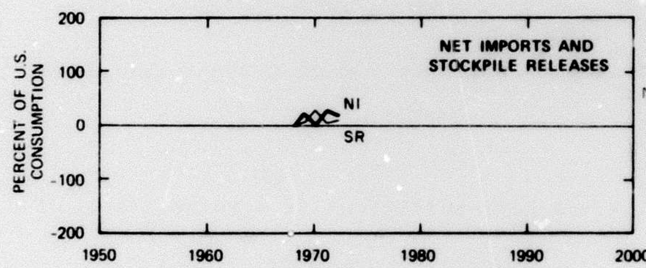
DATA SUMMARY: VANADIUM
One Unit = 15,000 Short Tons
1972 World Production = 1.7 units





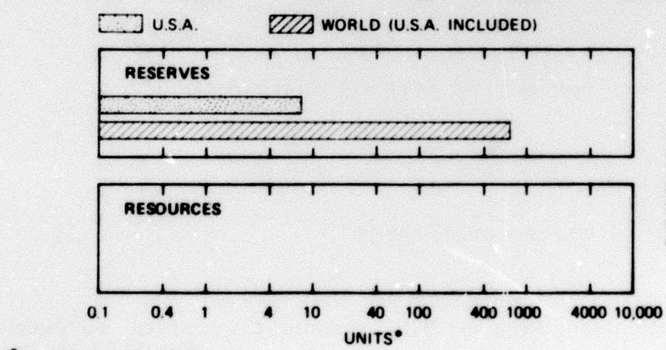






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Construction Products	43
2	Transportation Equip.	38
3	Construction Machinery, Equip.	9
4	Metal Working Mach. and Tools	7
5	Other (Estimated)	3
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
South Africa	32	7	8
USSR	30	NA	NA
Norway	5	1	<1
Finland	5	NA	NA
S.W. Africa	2	NA	NA
Europe	0	—	2
Other	5	73	13
			~23

*Unit defined at top of page

NOTES ON VERMICULITE

Uses: Plaster for steel or concrete structures for fireproofing, acoustical, insulation properties. Concrete for roof deck, floor fill in multistory buildings, tilt-up panels, spray applied backing for curtain wall construction. Insulation for hollow masonry walls, double shelled tanks for cryogenic engineering applications, molten metal ladle covers, inbedding hot steel ingots for transportation, covering steam pipes, refrigeration. Soil conditioning, plant growing medium, packing material for nursery stock, carrier for agricultural chemicals, anticaking agent for fertilizers, and absorbent for animal litter. Packaging acids. Fillers, extenders, pigments in rubber, paint, enamel, plastics, ink, wallpaper, lubricants. Additive to gypsum board, wood particle board, asphalt shingles for fire resistance.

Price: The price given is the average per ton of crude vermiculite f.o.b. mine.

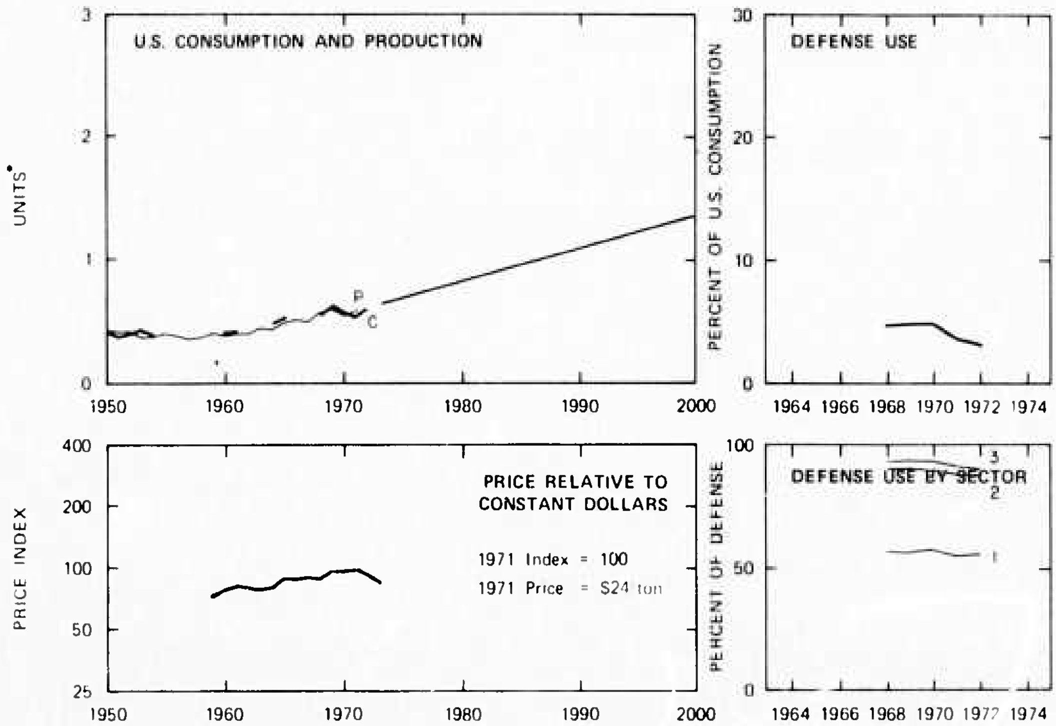
Imports: The United States was self-sufficient in vermiculite in 1972.

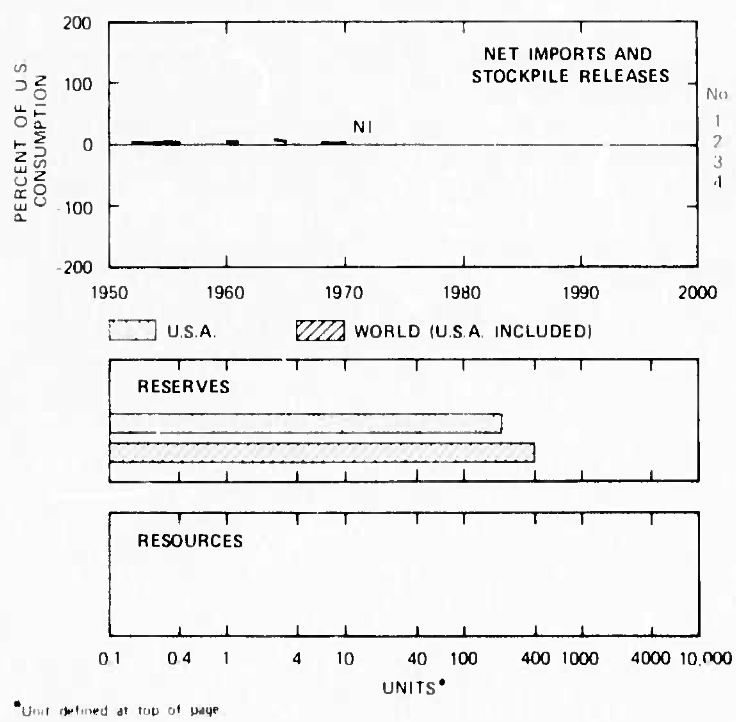
Stockpile: Vermiculite was not on the list of Basic Stockpile Materials, 1972.

Reserves and Resources: Resources are "large".

Defense Use: Lack of adequate data on U.S. consumption prior to 1968 prevented defense use estimates for the earlier years.

DATA SUMMARY: VERMICULITE
One Unit = 500,000 Short Tons
1972 World Production = 1.0 units





IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Thermal Insulation	56
2	Aggregates (Plaster, Concrete)	31
3	Agriculture	3
4	Other (Estimated)	10
		100

*Unit defined at top of page

NOTES ON YTTRIUM

Uses: Color TV phosphors. Microwave applications. Lasers. Fluorescent lamps. Alloying agent. Permanent magnets. Furnace windows, high-temperature microscope lenses, high-intensity incandescent and discharge lamps. Crucibles for uranium treatment. Zirconia refractory.

Imports: Canadian uranium residues produced prior to 1972.

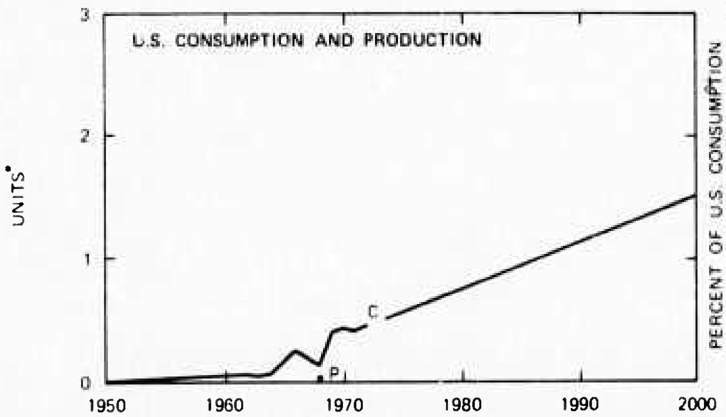
Stockpile: Yttrium is not on the list of Basic Stockpile Materials, 1972.

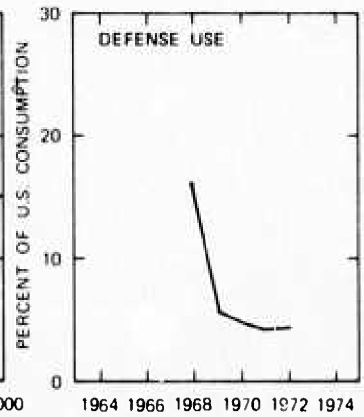
Reserves and Resources: Economic estimates are based on co-product association with uranium, titanium, and rare earths minerals. Resources are "large".

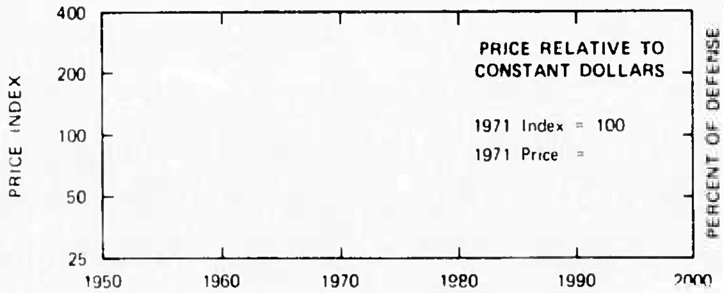
Defense Use: Lack of adequate U.S. consumption data prior to 1968 prevented defense use estimates for the earlier years.

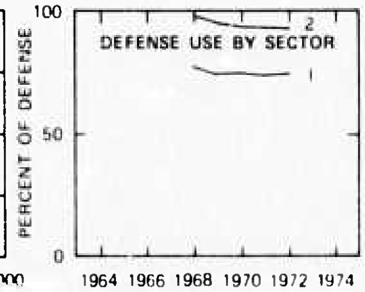
The much larger fraction devoted to defense use in 1968 is more reflective of the low value given for total U.S. consumption that year than of a fluctuation in defense procurements.

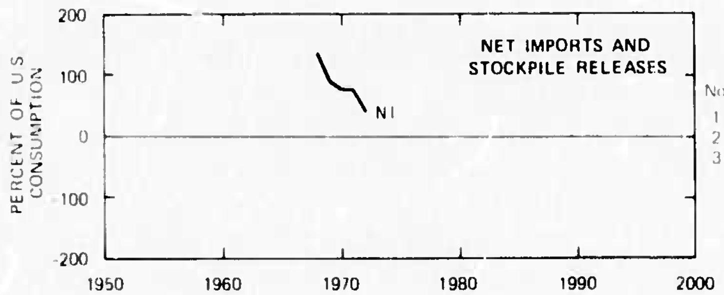
DATA SUMMARY: YTTRIUM
One Unit = 200 Short Tons
1972 World Production = 1.2 units





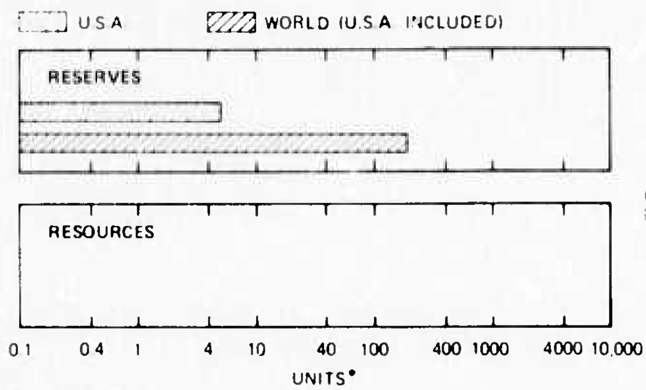






IDENTIFICATION OF SECTORS

No	Sector of Economy	Percent of Defense 1972
1	Cathode Ray Picture Tubes	75
2	Electronic Components N.E.C.	19
3	Other (Estimated)	6
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	0		29
Malaysia	0	48	12
			41

*Unit defined at top of page

NOTES ON ZINC

Uses: Galvanizing steel beams, fasteners, steel roofing and siding, guard rails, fencing. Brass hardware and decorative trim. Diecasting for carburetors, grilles, trim, other automotive hardware. Brass fittings and tubing for boats, autos, trucks. Galvanized electrical guy wires and appliances; diecasting pumps, mechanical transmissions, control rods, trim; brass in switches, timers, connectors, tubing. Galvanized pipe and fittings, brass pipe and fittings, heating equipment. Brass bearings, bushings, tubing, galvanized sheet, fittings, fasteners, diecast parts and fixtures for machinery. Zinc oxide pigments for rubber, paint and ceramic industries, textiles, floor coverings, lubricants. Zinc sulfate pigments. Trace element in animal and plant nutrition. Dry cell battery cases, mason jar covers, other chrome plated items. Photoengraving plate. Roofing. Cathodic protection. Costume jewelry, statuary, zippers, lawnmowers. Metallurgy of lead, cadmium, gold, silver, thallium, other rare metals.

Price: The price given is a weighted average for all grades of zinc metal.

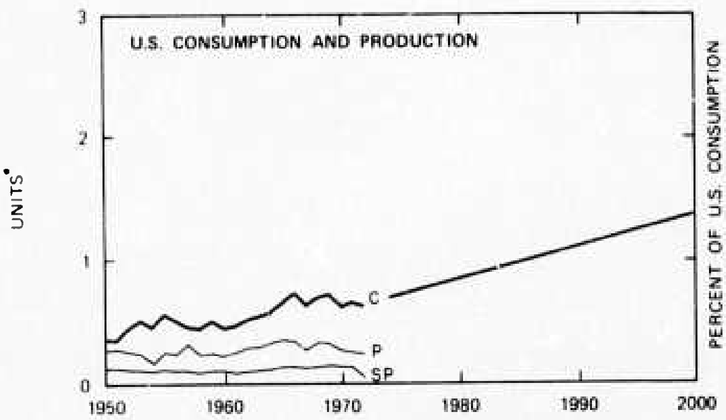
Imports: Some through United States refineries, most as processed metal and compounds. Percentages are based on combined elemental content.

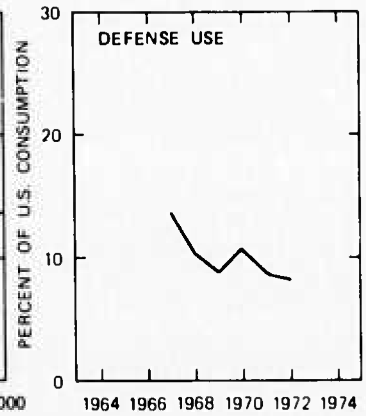
Stockpile: Zinc is included on the list of Basic Stockpile Materials, 1972, in elemental form. Any releases for 1968-1972 are shown on the graph of Imports and Stockpiles. Government stockpile balance in 1972 was 950,000 short tons of zinc.

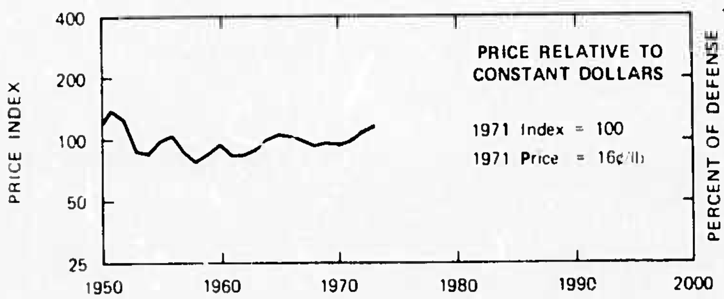
Reserves and Resources: Economic estimates are partly based on coproduct association with a wide variety of minerals.

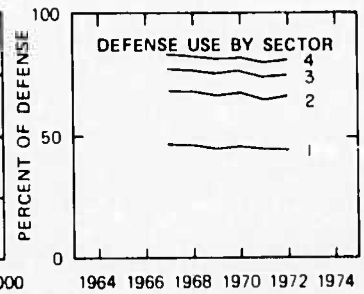
Defense Use: Estimates restricted by lack of adequate data on U.S. consumption prior to 1967.

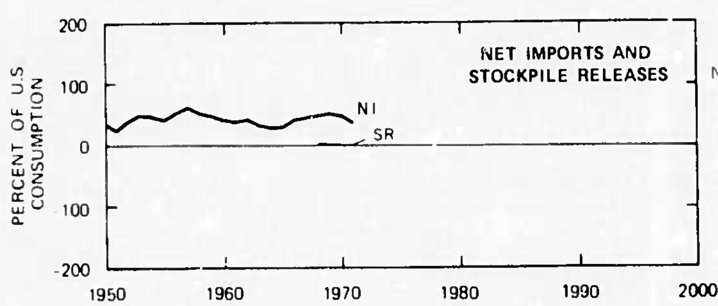
DATA SUMMARY: ZINC
One Unit = 2,500,000 Short Tons
1972 World Production = 2.6 units

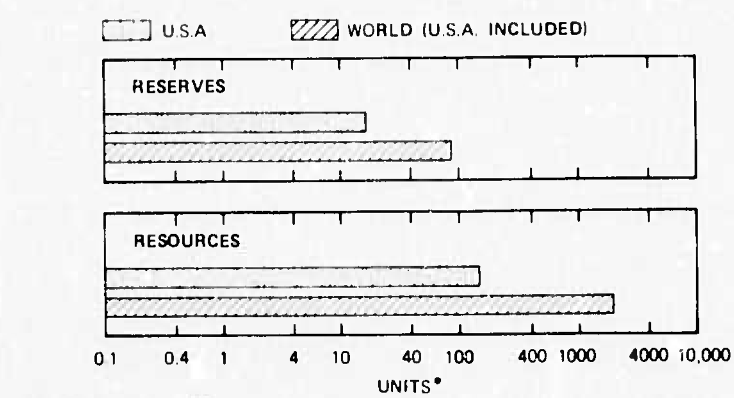












*Unit defined at top of page

IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1972
1	Transportation	43
2	Elect. Equip., Supplies	22
3	Pigments, Compounds	9
4	Industrial Mach., Exc. Elect	6
5	Other (Estimated)	20
		100

SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Canada	23	33	29
Australia	9	8	3
Peru	6	12	3
Japan	5	10	2
Mexico	5	27	5
Poland	4	2	<1
W. Germany	2	26	2
Zaire	2	18	1
Ireland	2	3	<1
Spain	2	1	<1
Finland	<1	9	<1
S.W. Africa	<1	42	1
Honduras	<1	23	<1
Other	7	17	5
			53

NOTES ON ZIRCONIUM

Uses: Refractories. Ceramic opacifier and pigment. Toothpastes. Polishing optical glass. Polymeric waxes. Leather tanning agents. Rust inhibiter in paints. Stainless steel film coating. Fixative in ink. Water repellents for leather and textiles. Nuclear reactor structures. Camera flashbulbs. Alloys for chemical industry in heat exchangers, acid concentrators, tank shafts, valves, pump housings, fan wheels, high-speed agitators, electrode assemblies, steam jet exhausts, tubing, pipes, spinnerets and crucibles. Magnesium alloys. Columbium alloys, superconducting magnets.

Price: The price given is the average quoted for domestic zircon concentrates.

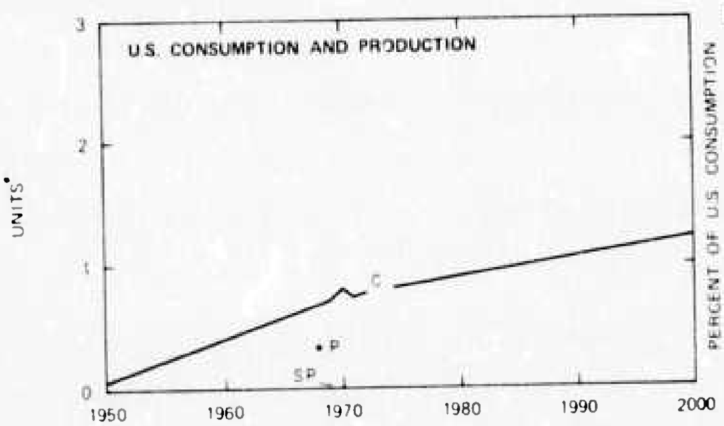
Imports: Percentages are based on combined elemental content of metal and non-metal. United States demand is confidential for 1972.

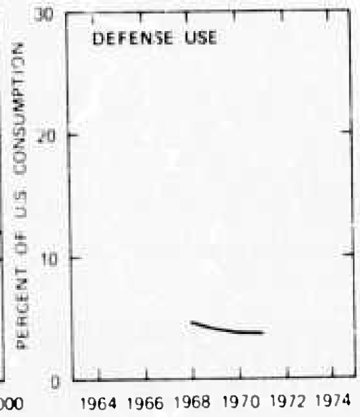
Stockpile: Zirconium is not on the list for Basic Stockpile Material, 1972.

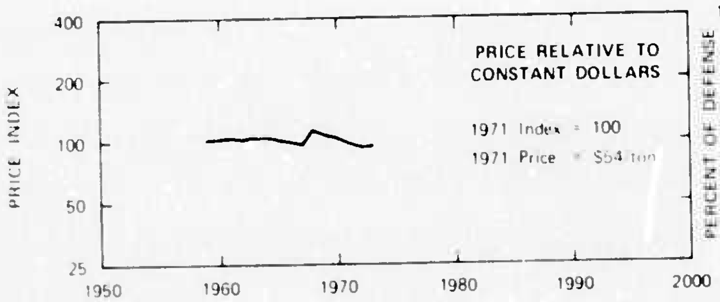
Reserves and Resources: Economic estimates are based on by-product association with titanium minerals.

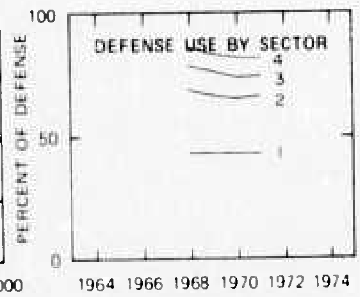
Defense Use: Lack of adequate data on U.S. consumption prior to 1968 and in 1972 restricted defense use estimates to the years shown.

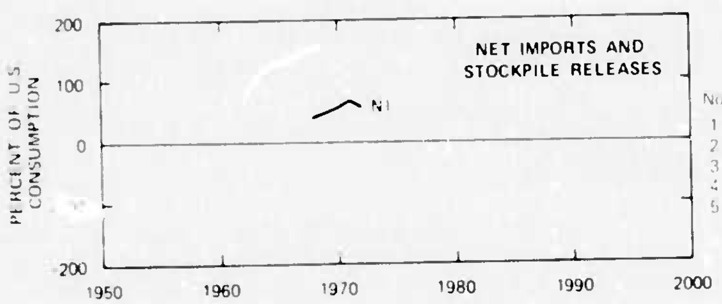
DATA SUMMARY: ZIRCONIUM
One Unit = 100,000 Short Tons
1972 World Production =





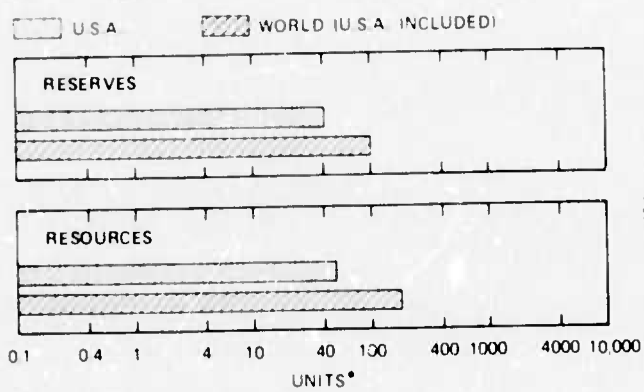






IDENTIFICATION OF SECTORS

No.	Sector of Economy	Percent of Defense 1971
1	Mins. Earth, Grnd. Fndry. Sand	43
2	Non-Clay Refractories	23
3	Misc. Chem. Products	9
4	Pottery Products, Ceramics	8
5	Other (Estimated)	17
		100



SOURCES OF IMPORTS 1972

Country	Percent of World Primary Production	Percent of Country's Production Exported to U.S.	Percent of U.S. Demand Supplied
Australia	NA	NA	NA
South Africa	NA	NA	NA

*Unit defined at top of page

C. Details on Iron Data

The Minerals Yearbooks[4] contain a vast amount of data concerning iron, and discuss iron in three separate chapters: Iron Ore, Iron and Steel, and Iron and Steel Scrap. We have made a special analysis of these data and compared the results for consumption, production, and net imports of elemental iron with those given in the flow diagrams[3] supplied by U.S. Bureau of Mines. Table 1 presents the results of our calculations from the Minerals Yearbooks data.

The estimates of iron consumption are misleading with regard to our national self-sufficiency because they ignore imports of steel in crude shapes. Nevertheless, we have used a similar system to conform with the flow diagrams of the Bureau of Mines' Mineral Facts and Problems. As can be seen from the last column of Table 2, the United States was a net exporter of steel until 1958. In 1959 it became a net importer, which it has remained since, on a generally increasing scale. However, except for 1952, we have been net importers of iron throughout the period 1951 to 1971, balancing iron in ore with steel.

Because the flow diagrams as presented in Mineral Facts and Problems are available for only a limited number of years, we have had to use the Bureau of Mines' Minerals Yearbooks as a basic source of data. However, in so doing we have had to make certain estimates to convert the data to the form used in this report. These estimates are explained below.

- U.S. Primary Productions is based on the totals of usable ore produced, multiplied by factors ranging from 51 percent in 1951 to 61 percent in 1971, increasing one-half percent per year, to reflect the average iron contents of ores, concentrates, and agglomerates.
- U.S. Secondary is taken from charts in the Iron and Steel Scrap chapter which indicate the net scrap receipts of steelmakers.

Table 1

IRON: U.S. CONSUMPTION, PRODUCTION, AND NET IMPORTS*, 1951-71
(Millions of Short Tons)

	Production			Apparent
	U.S. Primary	U.S. Secondary	Net Imports	Consumption
1951	67	37	4	108
1952	58	35	1	94
1953	69	36	7	112
1954	46	29	12	87
1955	61	37	16	114
1956	58	37	17	114
1957	64	31	13	108
1958	40	23	18	91
1959	37	28	25	87
1960	56	27	12	93
1961	44	25	21	92
1962	46	25	19	87
1963	47	27	24	94
1964	55	35	30	113
1965	56	36	31	121
1966	59	37	30	126
1967	55	33	31	122
1968	57	34	31	120
1969	59	3[illegible]	34	129
1970	61	34	28	126
1971	56	34	24	117

*Net steel imports not shown.

Source: SRI calculations based on data in Minerals Yearbooks of the U.S. Bureau of Mines

- Net Imports are computed by subtracting U.S. Primary as above from pig iron production, adding pig iron imports and estimated metal content of foreign ores charged into steel furnaces, and subtracting the estimated iron contents of ore exports.

- Apparent Consumption is computed by adding U.S. Primary, U.S. Secondary, and Net Imports, corrected by changes in home scrap produced as recorded in the charts from which U.S. Secondary data are taken.

Inasmuch as U.S. Demand as shown on the flow charts of Mineral Facts and Problems ignores steel exports and imports, it should be approximately equal to our Apparent Consumption, but the figures are not in exact agreement. Our estimates of U.S. Primary are in close agreement with these charts and the discrepancies appear to stem from scrap data. Both of these demand-consumption figures ought to agree with the tabulations of steel productions in Minerals Yearbooks but again conformity is lacking. Metallurgical losses are not considered in the flow diagrams but this ought to make these figures run higher than steel production, and the contrary is true. Because our estimates balance contributions from domestic and foreign ores in pig iron, metallurgical losses might affect the balance between these two types of ore, but they should not be reflected in the consumption estimates. However, the flow chart demand data are not consistently higher than our consumption estimates and for ten years the steel production figures are consistently higher than both of them. The discrepancies are indicated in Table 2.

Table 2

COMPARISON OF DIFFERENT SOURCES OF
DATA ON IRON CONSUMPTION IN U.S.
(Millions of Short Tons)

Year	Minerals Yearbook Steel Production	Minerals Facts and Problems Iron Demand	Iron Consumption Calculated by SRI	Minerals Yearbook Net Steel Imports (Exports)
1951	105		108	(3)
1952	93		94	(3)
1953	112		112	(3)
1954	88		87	(3)
1955	117		114	(4)
1956	115		114	(4)
1957	113		108	(5)
1958	79		91	(1)
1959	85		87	3
1960	99		93	1
1961	98		92	1
1962	98		87	2
1963	109		94	3
1964	127		113	3
1965	131		121	8
1966	134		126	9
1967	127		122	10
1968	131	120	120	15
1969	141	137	129	9
1970	132	117	126	6
1971	120	108	117	15

Sources: Mineral Yearbooks, Reference 4
Minerals Facts and Problems, the flow diagrams in References 3 and 5

VI ANALYSIS AND IMPLICATIONS

A. Priority Ranking of the Materials

As one basis for analyzing the resource data in a systematic way, we have rated the various commodities according to seven criteria, as follows:

(1) Percent of U.S. consumption used for defense purposes in 1972

(2) U.S. reserves, i.e., the quantity of material, in known deposits, economically recoverable under current (circa 1972) conditions

(3) Percent of U.S. consumption supplied by imports in 1972

(4) Vulnerability of sources of supply

(5) Difficulty of substitution

(6) Economic importance as measured by total value of the material consumed in the United States in 1972.

(7) Leverage in industry, i.e., importance to the economy beyond that reflected by the dollar value, due to the material's crucial role.

Each commodity has been rated on a 1 to 10 scale, with a higher value indicating a greater level of strategic importance. The procedures used to arrive at these values were:

(1) Defense use: The defense use calculated for 1972 as a percent of U.S. consumption was rounded to the nearest nonzero integer. Any defense use above 10 percent was taken as 10 on the scale.

(2) U.S. reserves: The quantity of reserves, expressed in units (as on the data summary pages), was divided by three and the quotient subtracted from 11 and rounded to the nearest nonzero integer. Any values in excess of 10 were assigned 10 on the scale. The result is the desired 1 to 10 scale with very low reserves giving a 10 and reserves above 30 units giving a 1.

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(3) Percent imports: The percent of consumption accounted for by imports in 1972 was divided by 10 and the result converted to the nearest integer from 1 to 10.

(4) Vulnerability of sources: Scale values were assigned on the basis of subjective judgment.

(5) Difficulty of substitution: Scale values were assigned on the basis of subjective judgment.

(6) Economic importance: The dollar value of the U.S. demand for material in 1972 was divided by $400 million and the result rounded to the nearest integer from 1 to 10. The dollar values were obtained from Table 1 of Reference 2.

(7) Leverage in industry: Scale values were assigned on the basis of subjective judgment as an attempt to take into account the fact that some materials having a relatively small dollar value in the economy are especially important due to their crucial role in a major industry. An example of this is manganese and its role in the production of steel.

The values established by these procedures are shown in columns 2 through 8 of Table 3, which is arranged alphabetically by material. Zero values indicate that data were not available for the material and criterion indicated.

To combine these values into single numbers indicative of priority for national security, two geometric means were computed for each material. One mean was based on consideration of all seven criteria (columns 2-8) while the other mean was based on a consideration of the first five criteria (columns 2-6). The numbers obtained in this way provide a crude indicator of which materials appear to be the most strategic in terms of national security. The difference between the next-to-last column and the last one is that the former uses all the ratings, whereas the latter omits the ratings for leverage in the industrial complex and for value of annual consumption. The last column identifies commodities that deserve attention because of scarcity, vulnerability, or usefulness for defense purposes even though

Table 3

PRIORITIES OF MATERIALS: ALPHABETICAL LISTING

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Impor-tance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
1. Aluminum	5	10	10	3	6	6	5	6.0	6.2
2. Antimony	8	10	5	6	7	1	3	4.7	7.0
3. Arsenic	1	3	0	6	4	0	2	2.7	2.9
4. Asbestos	3	9	9	5	5	1	2	3.8	5.7
5. Barium	6	1	4	3	4	1	3	2.6	3.1
6. Beryllium	10	1	4	6	6	1	3	3.3	4.3
7. Bismuth	4	8	5	3	7	1	3	3.7	5.1
8. Boron	0	1	1	6	7	1	3	2.2	2.5
9. Bromine	4	1	1	2	5	1	2	1.9	2.1
10. Cadmium	9	6	4	3	4	1	3	3.6	4.8
11. Calcium	0	1	1	1	7	1	9	2.0	1.6
12. Cesium	0	0	8	5	5	0	1	3.8	5.8
13. Chlorine	4	1	1	1	7	2	8	2.4	1.9
14. Chromium	7	10	7	7	5	1	5	5.1	7.0
15. Clays	3	1	1	2	7	1	4	2.1	2.1
16. Cobalt	10	4	7	6	7	1	4	4.7	6.5
17. Columbium	6	6	7	6	4	1	2	3.8	5.7
18. Copper	10	5	2	4	6	6	7	5.2	4.7
19. Corundum	4	10	0	0	2	1	1	2.4	4.3
20. Diatomite	4	1	1	3	3	1	2	1.8	2.0

Table 3 (continued)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Impor-tance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
21. Feldspar	3	1	1	2	5	1	2	1.8	4.0
22. Fluorine	6	10	8	5	6	1	3	4.6	6.8
23. Gallium	1	1	10	2	3	0	1	2.0	2.3
24. Garnet	10	3	1	2	2	1	1	2.0	2.6
25. Germanium	10	6	2	5	3	1	1	2.9	4.5
26. Gold	4	9	7	2	5	1	1	3.1	4.8
27. Graphite	5	10	9	6	5	0	2	5.5	6.7
28. Gypsum	1	6	4	2	3	1	3	2.4	2.7
29. Hafnium	0	1	10	3	5	0	1	2.7	3.5
30. Indium	0	7	0	4	5	0	1	3.4	5.2
31. Iodine	3	4	10	1	3	1	1	2.3	3.2
32. Iron	8	7	2	3	8	10	9	5.9	4.9
33. Kyanite	0	1	0	3	3	0	1	1.7	2.1
34. Lead	8	2	2	4	5	1	4	3.1	3.6
35. Lithium	7	5	0	3	6	0	2	4.2	5.0
36. Magnesium	5	1	1	2	4	1	3	2.0	2.1
37. Manganese	7	10	8	6	7	1	8	5.7	7.5
38. Mercury	7	9	6	7	7	1	2	4.5	7.1
39. Mica-Scrap	4	1	1	2	3	1	2	1.7	1.9
40. Mica-Sheet	10	10	10	7	4	1	2	4.8	7.8
41. Molybdenum	9	1	1	3	3	1	3	2.2	2.4
42. Nickel	7	10	7	4	4	2	4	4.8	6.0
43. Nitrogen	3	1	1	1	8	2	6	2.2	1.9
44. Perlite	3	1	1	2	2	1	1	1.4	1.6
45. Phosphorus	-	1	1	2	8	1	6	2.1	2.0

Table 3 (continued)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Importance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
46. Platinum-Group	5	10	10	6	8	1	3	4.9	7.5
47. Potassium	1	7	6	4	8	1	6	3.6	4.2
48. Pumice	3	2	1	2	3	1	1	1.7	2.0
49. Rare Earths	2	1	1	8	7	1	1	2.0	2.6
50. Rhenium	0	1	5	4	6	1	1	2.2	3.3
51. Rubidium	0	10	1	5	5	1	1	2.5	4.0
52. Sand and Gravel	2	1	1	2	6	3	7	2.4	1.9
53. Scandium	0	1	0	0	0	1	0	1.0	1.0
54. Selenium	6	1	4	3	7	1	2	2.7	3.5
55. Silicon	9	1	1	1	6	1	3	2.1	2.2
56. Silver	5	9	4	6	8	1	4	4.5	6.1
57. Sodium	5	1	1	1	6	1	5	2.0	2.0
58. Stone-Crush	3	1	1	1	6	3	7	2.3	1.8
59. Stone-Dimen	4	1	1	1	3	1	3	1.7	1.6
60. Strontium	5	1	9	4	4	1	1	2.6	3.7
61. Sulfur	5	8	1	1	7	1	5	2.8	3.1
62. Talc	4	1	1	3	5	1	2	2.0	2.3
63. Tantalum	6	10	8	6	6	1	2	4.5	7.0
64. Tellurium	3	1	4	4	6	1	1	2.2	3.1
65. Thallium	10	1	10	0	5	0	1	3.5	4.7
66. Thorium	10	1	4	7	4	0	1	3.2	4.1
67. Tin	8	10	9	4	3	1	3	4.3	6.1
68. Titanium	4	1	5	3	4	1	2	2.4	3.0
69. Tungsten	8	9	5	7	7	1	4	4.9	7.1
70. Vanadium	5	9	2	3	4	1	2	3.0	4.0

Table 3 (concluded)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Importance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
71. Vermiculite	3	1	1	2	3	1	1	1.5	1.8
72. Yttrium	4	9	4	0	0	0	0	5.2	5.2
73. Zinc	8	6	5	3	2	1	4	3.4	4.3
74. Zirconium	5	1	0	3	6	0	1	2.5	3.1

they may be small items in the national economy. The next-to-last column takes into account that the economy and national security are likely to be sensitive concerning material consumed in quantity by industrial activities. Tables 4 and 5 show how the materials are related when ranked according to one or the other of their mean values.

It is emphasized that this is but one of the ways in which the data might be analyzed. The purpose of the present work was to arrive at an initial assessment of strategic resources and national security and, in the process, arrive at an understanding of the available data and methods that are required for the assessment. We believe that the ranking system developed and applied helps provide such an assessment. One important limitation of the results of the ranking procedure is that most of the initial assessment is based on 1972 input data. Except for the effect of projected demand on the selection of the unit for measuring reserves, past trends and future projections have not been incorporated into this ranking system.

In summary, these tables present numbers that can serve as indicators of the likelihood of a critical shortage of a material. They suggest priorities for choosing materials for further analysis. The 15 materials of highest priority on natural security grounds are:

Aluminim	Mica--sheet
Antimony	Nickel
Chromium	Platinum group
Cobalt	Silver
Fluorine	Tantalum
Graphite	Tin
Manganese	Tungsten
Mercury	

Table 4

PRIORITIES OF MATERIALS: RANKING ON NATIONAL SECURITY CRITERIA

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Importance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
1. Mica-Sheet	10	10	10	7	4	1	2	4.8	7.8
2. Manganese	7	10	8	6	7	1	8	5.7	7.5
3. Platinum-Group	5	10	10	6	8	1	3	4.9	7.5
4. Mercury	7	9	6	7	7	1	2	4.5	7.1
5. Tungsten	8	9	5	7	7	1	4	4.9	7.1
6. Chromium	7	10	7	7	5	1	5	5.1	7.0
7. Antimony	8	10	5	6	7	1	3	4.7	7.0
8. Tantalum	6	10	8	6	6	1	2	4.5	7.0
9. Fluorine	6	10	8	5	6	1	3	4.6	6.8
10. Graphite	5	10	9	6	5	0	2	5.5	6.7
11. Cobalt	10	4	7	6	7	1	4	4.7	6.5
12. Aluminum	5	10	10	3	6	6	5	6.0	6.2
13. Tin	8	10	9	4	3	1	3	4.3	6.1
14. Silver	5	9	4	6	8	1	4	4.5	6.1
15. Nickel	7	10	7	4	4	2	4	4.8	6.0
16. Cesium	0	0	8	5	5	0	[illegible]	3.8	5.8
17. Asbestos	3	9	9	5	5	1	2	3.8	5.7
18. Columbium	6	6	7	6	4	1	2	3.8	5.7
19. Indium	0	7	0	4	5	0	1	3.4	5.2
20. Yttrium	4	9	4	0	0	0	0	5.2	5.2

Table 4 (continued)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Importance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
21. Bismuth	4	8	5	3	7	1	3	3.7	5.1
22. Lithium	7	5	0	3	6	0	2	4.2	5.0
23. Iron	8	7	2	3	8	10	9	5.9	4.9
24. Cadmium	9	6	4	3	4	1	3	3.6	4.8
25. Gold	4	9	7	2	5	1	1	3.1	4.8
26. Thallium	10	1	10	0	5	0	1	3.5	4.7
27. Copper	10	5	2	4	6	6	7	5.2	4.7
28. Germanium	10	6	2	5	3	1	1	2.9	4.5
29. Corundum	4	10	0	0	2	1	1	2.4	4.3
30. Zinc	8	6	5	3	2	1	4	3.4	4.3
31. Beryllium	10	1	4	6	6	1	3	3.3	4.3
32. Potassium	1	7	6	4	8	1	6	3.6	4.2
33. Thorium	10	1	4	7	4	0	1	3.2	4.1
34. Vanadium	5	9	2	3	4	1	2	3.0	4.0
35. Rubidium	0	10	1	5	5	1	1	2.5	4.0
36. Strontium	5	1	9	4	4	1	1	2.6	3.7
37. Lead	8	2	2	4	5	1	4	3.1	3.6
38. Selenium	6	1	4	3	7	1	2	2.7	3.5
39. Hafnium	0	1	10	3	5	0	1	2.7	3.5
40. Rhenium	0	1	5	4	6	1	1	2.2	3.3
41. Iodine	3	4	10	1	3	1	1	2.3	3.2
42. Tellurium	3	1	4	4	6	1	1	2.2	3.1
43. Zirconium	5	1	0	3	6	0	1	2.5	3.1
44. Sulfur	5	8	1	1	7	1	5	2.8	3.1
45. Barium	6	1	4	3	4	1	3	2.6	3.1

Table 4 (continued)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Impor-tance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
46. Titanium	4	1	5	3	4	1	2	2.4	3.0
47. Arsenic	1	3	0	6	4	0	2	2.7	2.9
48. Gypsum	1	6	4	2	3	1	3	2.4	2.7
49. Garnet	10	3	1	2	2	1	1	2.0	2.6
50. Rare Earths	2	1	1	8	7	1	1	2.0	2.6
51. Boron	0	1	1	6	7	1	3	2.2	2.5
52. Molybdenum	9	1	1	3	3	1	3	2.2	2.4
53. Talc	4	1	1	3	5	1	2	2.0	2.3
54. Gallium	1	1	10	2	3	0	1	2.0	2.3
55. Silicon	9	1	1	1	6	1	3	2.1	2.3
56. Clays	3	1	1	2	7	1	4	2.1	2.1
57. Kyanite	0	1	0	3	3	0	1	1.7	2.1
58. Magnesium	5	1	1	2	4	1	3	2.0	2.1
59, Bromine	4	1	1	2	5	1	2	1.9	2.1
60. Phosphorus	2	1	1	2	8	1	6	2.1	2.0
61. Diatomite	4	1	1	3	3	1	2	1.8	2.0
62. Feldspar	3	1	1	2	5	1	2	1.8	2.0
63. Pumice	3	2	1	2	3	1	1	1.7	2.0
64. Sodium	5	1	1	1	6	1	5	2.0	2.0
65. Chlorine	4	1	1	1	7	2	8	2.4	1.9
66. Mica-Scrap	4	1	1	2	3	1	2	1.7	1.9
67. Nitrogen	3	1	1	1	8	2	6	2.2	1.9
68. Sand and Gravel	2	1	1	2	6	3	7	2.4	1.9
69. Vermiculite	3	1	1	2	3	1	1	1.5	1.8
70. Stone-Crush	3	1	1	1	6	3	7	2.3	1.8

Table 4 (concluded)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Impor-tance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
71. Calcium	0	1	1	1	7	1	9	2.0	1.6
72. Perlite	3	1	1	2	2	1	1	1.4	1.6
73. Stone-Dimen	4	1	1	1	3	1	3	1.7	1.6
74. Scandium	0	1	0	0	0	1	0	1.0	1.0

Table 5

PRIORITIES OF MATERIALS: RANKING ON NATIONAL SECURITY AND ECONOMIC CRITERIA

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Impor-tance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
1. Aluminum	5	10	10	3	6	6	5	6.0	6.2
2. Iron	8	7	2	3	8	10	9	5.9	4.9
3. Manganese	7	10	8	6	7	1	8	5.7	7.5
4. Graphite	5	10	9	6	5	0	2	5.5	6.7
5. Copper	10	5	2	4	6	6	7	5.2	4.7
6. Yttrium	4	9	4	0	0	0	0	5.2	5.2
7. Chromium	7	10	7	7	5	1	5	5.1	7.0
8. Platinum-Group	5	10	10	6	8	1	3	4.9	7.5
9. Tungsten	8	9	5	7	7	1	4	4.9	7.1
10. Mica-Sheet	10	10	10	7	1	1	2	4.8	7.8
11. Nickel	7	10	7	4	1	2	4	4.8	6.0
12. Antimony	8	10	5	6	7	1	3	4.7	7.0
13. Cobalt	10	4	7	6	7	1	4	4.7	6.5
14. Fluorine	6	10	8	5	6	1	3	4.6	6.8
15. Mercury	7	9	6	7	7	1	2	4.5	7.1
16. Silver	5	9	4	6	8	1	4	4.5	6.1
17. Tantalum	6	10	8	6	6	1	2	4.5	7.0
18. Tin	8	10	9	4	3	1	3	4.3	6.1
19. Lithium	7	5	0	3	6	0	2	4.2	5.0
20. Asbestos	3	9	9	5	5	1	2	3.8	5.7

Table 5 (continued)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Impor-tance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
21. Columbium	5	6	7	6	4	1	2	3.8	5.7
22. Cesium	0	0	8	5	5	0	1	3.8	5.8
23. Bismuth	4	8	5	3	7	1	3	3.7	5.1
24. Potassium	1	7	6	4	8	1	6	3.6	4.2
25. Cadmium	9	6	4	3	4	1	3	3.6	4.8
26. Thallium	10	1	10	0	5	0	1	3.5	4.7
27. Indium	0	7	0	4	5	0	1	3.4	5.2
28. Zinc	8	6	5	3	2	1	4	3.4	4.3
29. Beryllium	10	1	4	6	6	1	3	3.3	4.3
30. Thorium	10	1	4	7	4	0	1	3.2	4.1
31. Gold	4	9	7	2	5	1	1	3.1	4.8
32. Lead	8	2	2	4	5	1	4	3.1	3.6
33. Vanadium	5	9	2	3	4	1	2	3.0	4.0
34. Germanium	10	6	2	5	3	1	1	2.9	4.5
35. Sulfur	5	8	1	1	7	1	5	2.8	3.1
36. Selenium	6	1	4	3	7	1	2	2.7	3.5
37. Arsenic	1	3	0	6	4	0	2	2.7	2.9
38. Hafnium	0	1	10	3	5	0	1	2.7	3.5
39. Strontium	5	1	9	4	4	1	1	2.6	3.7
40. Barium	6	1	4	3	4	1	3	2.6	3.1
41. Rubidium	0	10	1	5	5	1	1	2.5	4.0
42. Zirconium	5	1	0	3	6	0	1	2.5	3.1
43. Corundum	4	10	0	0	2	1	1	2.4	4.3
44. Gypsum	1	6	4	2	3	1	3	2.4	2.7
45. Titanium	4	1	5	3	4	1	2	2.4	3.0

Table 5 (continued)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Impor- tance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
46. Chlorine	4	1	1	4	7	2	8	2.4	1.9
47. Sand and Gravel	2	1	1	2	6	3	7	2.4	1.9
48. Iodine	3	4	10	1	3	1	1	2.3	3.2
49. Stone-Crush	3	1	1	1	6	3	7	2.3	1.8
50. Tellurium	3	1	4	4	6	1	1	2.2	3.1
51. Rhenium	0	1	5	4	6	1	1	2.2	3.3
52. Boron	0	1	1	6	7	1	3	2.2	2.5
53. Molybdenum	9	1	1	3	3	1	3	2.2	2.4
54. Nitrogen	3	1	1	1	8	2	6	2.2	1.9
55. Phosphorus	2	1	1	2	8	1	6	2.1	2.0
56. Clays	3	1	1	2	7	1	4	2.1	2.1
57. Silicon	9	1	1	1	6	1	3	2.1	2.2
58. Garnet	10	3	1	2	2	1	1	2.0	2.6
59. Rare Earths	2	1	1	8	7	1	1	2.0	2.6
60. Talc	4	1	1	3	5	1	2	2.0	2.3
61. Gallium	1	1	10	2	3	0	1	2.0	2.3
62. Magnesium	5	1	1	2	4	1	3	2.0	2.1
63. Sodium	5	1	1	1	6	1	5	2.0	2.0
64. Calcium	0	1	1	1	7	1	9	2.0	1.6
65. Bromine	4	1	1	2	5	1	2	1.9	2.1
66. Diatomite	4	1	1	3	3	1	2	1.8	2.0
67. Feldspar	3	1	1	2	5	1	2	1.8	2.0
68. Kyanite	0	1	0	3	3	0	1	1.7	2.1
69. Mica-Scrap	4	1	1	2	3	1	2	1.7	1.9
70. Pumice	3	2	1	2	3	1	1	1.7	2.0

Table 5 (concluded)

Name of Material	DoD Use	U.S. Reserves	Imports	Vulnerability of Sources	Difficulty of Substitution	Economic Importance	Industrial Leverage	Geometric Mean Columns 2-8	Geometric Mean Columns 2-6
71. Stone-Dimen	4	1	1	1	3	1	3	1.7	1.6
72. Vermiculite	3	1	1	2	3	1	1	1.5	1.8
73. Perlite	3	1	1	2	2	1	1	1.4	1.6
74. Scandium	0	1	0	0	0	1	0	1.0	1.0

B. Defense Expenditure as a Fraction of the U.S. Economy

Inspection of the graphs showing DOD use of materials will show that the percent use of many materials has decreased over the last five years. Some perspective on this effect can be obtained from Table 6, which contains a breakdown of annual defense expenditures, as defined in the Statistical Abstract of the United States.[19] The first row shows DOD expenditures as a percent of GNP for the years 1963 through 1972. Defense spending data are shown in current dollars in the other four rows of Table 6. These data show that the total national defense budget includes the Atomic Energy Commission and military assistance as well as DOD. The analysis in this project has been based on the DOD component of the total national defense budget.

Inspection of the first row of Table 6 will show that DOD expenditures relative to the GNP reached a peak in 1968 and then dropped to three quarters of that value by 1972. When this fact is considered together with the increased fraction of the DOD budget going for salaries of military personnel, it is not surprising that the DOD use of materials shows a downward trend after 1968.

C. Defense Use: Trends and Ranking

A final summary of the levels of defense use of materials estimated in this study is presented in Table 7. The percent of U.S. consumption going directly or indirectly to support DOD activities is tabulated for each material for each year for which an estimate could be made. The percentages given are those displayed graphically as "Defense Use" on the data summary pages of Section V.

In addition to presenting defense use trends for all the materials on a single page, Table 7 presents some new information and a new ranking (ordering) of the materials. The new information is the percent defense use averaged over the available annual estimates. The new ranking is the

Table 6

U.S. DEFENSE EXPENDITURES
(In Billions of Current Dollars)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
DoD as a percent of GNP	8.4%	8.1%	7.0%	7.5%	8.8%	9.3%	8.6%	8.0%	7.4%	6.9%
Military assistance	$ 1.4	$ 1.2	$ 1.1	$ 1.0	$ 0.9	$ 0.6	$ 0.8	$ 0.7	$ 1.0	$ 0.8
AEC	2.8	2.8	2.6	2.4	2.3	2.5	2.5	2.5	2.3	2.4
DoD	48.1	49.6	46.0	54.2	67.5	77.4	77.9	77.2	74.5	75.2
Total	$52.3	$53.6	$49.6	$56.8	$70.1	$80.5	$81.2	$80.3	$77.7	$78.3

*Statistical Abstract of the United States, 1971, 1972, and 1973 editions, Bureau of the Census, U.S. Department of Commerce.

Table 7

TRENDS IN DEFENSE USE OF MATERIALS

No.	Material	Ave.	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	Thallium	24.2						24	20	19	16	42
2	Germanium	23.3	29	20	12	14	30	20	22	31	26	28
3	Garnet	22.0	27	21	17	18	24	26	25	24	19	19
4	Thorium	20.4	10	35	33	20	22	21	21	18	13	11
5	Cobalt	19.4	27	24	17	19	22	23	16	17	17	12
6	Copper	17.6	23	19	16	16	23	17	14	19	15	14
7	Beryllium	14.3	15	22	15	17	16	14	10	11	9	12
8	Cadmium	11.2	11	12	10	9	13	12	10	14	10	9
9	Silicon	11.1						13	13	10	10	9
10	Tantalum	10.8						17	12	10	8	6
11	Zinc	10.1					14	10	9	11	9	8
12	Lead	10.1	9	8	8	10	13	13	12	11	9	8
13	Mica, Sheet	9.8	8	7	7	9	10	13	12	11	9	11
14	Molybdenum	9.5	10	8	7	7	11	11	10	10	10	9
15	Iron	9.1	11	9	8	9	10	11	9	9	8	8
16	Manganese	8.9	11	9	7	9	10	11	9	8	8	7
17	Tungsten	8.8	11	9	7	7	11	10	9	8	9	8
18	Strontium	8.8					15	15	10	4	4	5

Table 7 (continued)

No.	Material	Ave.	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
19	Vanadium	8.4	15	10	8	8	10	10	6	6	6	5
20	Chromium	8.2	10	7	6	8	10	10	8	8	9	7
21	Antimony	8.1	8	7	7	7	9	8	8	10	9	8
22	Nickel	7.9	11	8	7	7	9	12	10	9	7	7
23	Barium	7.8	9	6	8	9	9	9	7	7	7	6
24	Gallium	7.7						23	6	5	2	1
25	Columbium (Niobium)	7.7						10	8	7	7	6
26	Fluorine	7.3	9	7	6	7	10	8	8	7	6	6
27	Lithium	7.3						7				
28	Aluminum	7.3	10	8	7	8	9	8	6	7	5	5
29	Tin	7.2	7	6	6	7	8	8	8	7	7	8
30	Graphite (Natural)	6.9	8	6	7	8	8	7	7	7	6	5
31	Yttrium	6.8						16	5	5	4	4
32	Mercury	6.5	5	5	5	6	7	7	6	7	7	7
33	Palladium	6.4						8	7	7	5	5
34	Sulfur	6.4	7	6	6	6	7	7	7	6	6	5
35	Rare Earths	6.4	13	12	7	6	7	6	4	3	3	2
36	Platinum	6.4						7	7	7	6	5
37	Selenium	6.1	6	6	5	6	8	7	5	6	6	6

Table 7 (continued)

No.	Material	Ave.	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
38	Magnesium	6.1						8	7	6	6	5
39	Sodium	6.0						8	6	6	5	5
40	Gold	6.0	11	6	5	5	6	7	5	5	4	4
41	Silver	6.0	7	6	5	5	6	6	6	7	6	5
42	Titanium	5.8	7	6	5	6	7	7	6	6	5	4
43	Bismuth	5.3	6	5	4	4	6	7	6	6	6	4
44	Tellurium	5.0						7	5	5	5	3
45	Diatomite	4.7					5	5	5	5	5	4
46	Chlorine	4.6						5	5	5	4	4
47	Bromine	4.5						5	5	4	4	4
48	Talc, Soapstone, Pyrophyllite	4.4	4	4	4	5	5	5	4	4	4	4
49	Mica, Scrap and Flake	4.3					5	5	5	4	4	4
50	Vermiculite	4.2						5	5	5	4	3
51	Pumice	4.0					5	4	4	4	4	3
52	Iodine	4.0	5	4	4	4	5	4	4	4	3	3
53	Perlite	3.8	4	4	4	4	4	4	4	3	3	3
54	Nitrogen	3.8						4	4	4	3	3
55	Corundum	3.7	4	3				4	4	4	3	4

Table 7 (concluded)

No.	Material	Ave.	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
56	Stone, Crushed	3.5						3	4	4	3	3
57	Stone, Dimension	3.5						3	4	4	3	4
58	Asbestos	3.3	3	3	3	3	4	4	4	4	3	3
59	Clays	3.2	3	3	3	4	4	4	3	3	3	3
60	Sand and Gravel	2.9	3	3	3	3	3	3	3	3	3	2
61	Feldspar	2.7	3	3	2	3	3	3	3	3	3	3
62	Phosphorus	2.1	2	2	2	2	2	2	2	2	2	2
63	Gypsum	1.9	2	2	2	2	2	2	2	2	2	1
64	Potassium	1.5	2	2	2	2	2	2	1	1	1	1
65	Arsenic	1.5						1				

ordering of 65 materials according to this average defense use. Thus, another basis for assigning priorities is presented in Table 7; the materials toward the top of the list are distinguished by the fact that they are used for military purposes to a considerably larger extent than they are used in the U.S. economy at large.

For some materials the percent of U.S. consumption attributed to support of DOD activities shows substantial year to year fluctuations, in addition to the general downward trend after 1968. A review of intermediate stages in the calculations of these percentage figures shows that the large year to year fluctuations indicated in the data summary graphs and in Table 7 are due to large fluctuations in the figures given by the Bureau of Mines for the total U.S demand or consumption of these materials. The absolute quantities (as opposed to the percentages of the indicated U.S. consumption) used for defense tend to remain more constant. The note pages accompanying the data summary pages of this report point out this effect when it is most pronounced. Among the materials singled out in this way are: beryllium, cobalt, gallium, germanium, rare earths, thallium, and yttrium.

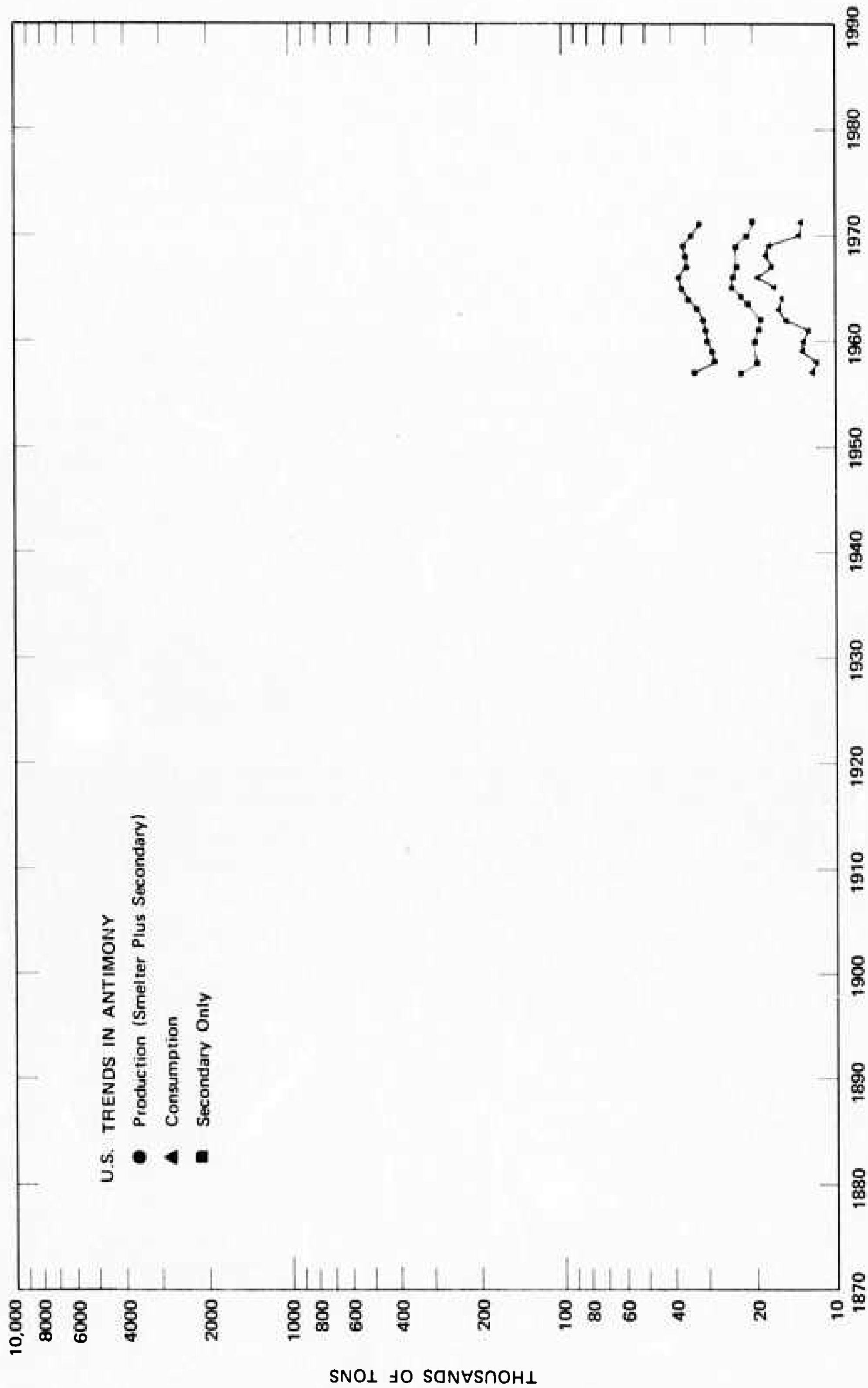
A comparison of the percent defense use values given in Table 7 with the figures in Table 6 giving the DOD expenditures as a percent of the U.S. gross national product suggests that defense use of most materials is somewhat less than the total defense share of the GNP. Again, it should be pointed out that the DOD expenditures used for Table 6 include the rapidly increasing fraction of the DOD budget that goes for compensation of military personnel rather than the purchase of goods and services from the industrial sectors.

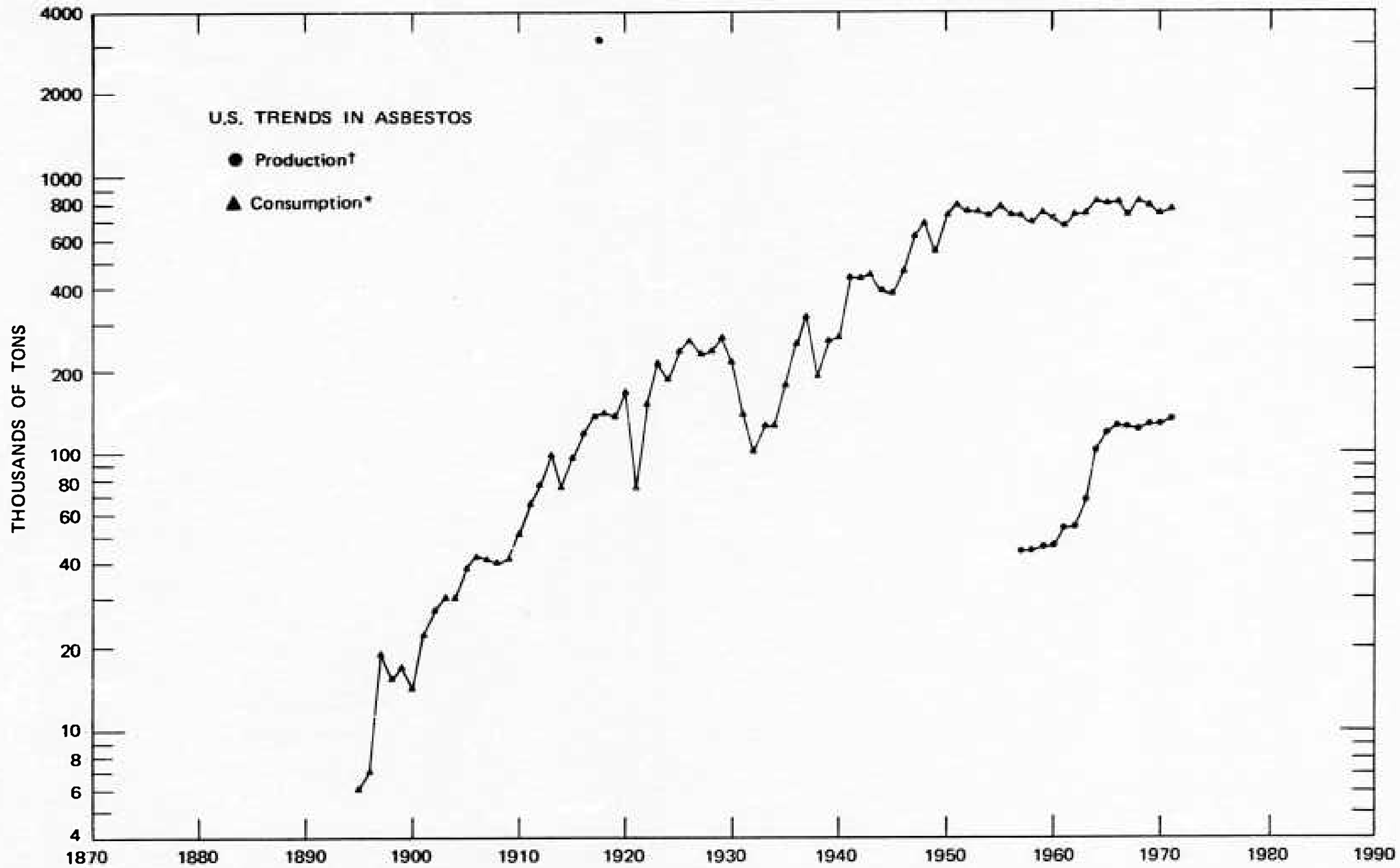
APPENDICES

Appendix A

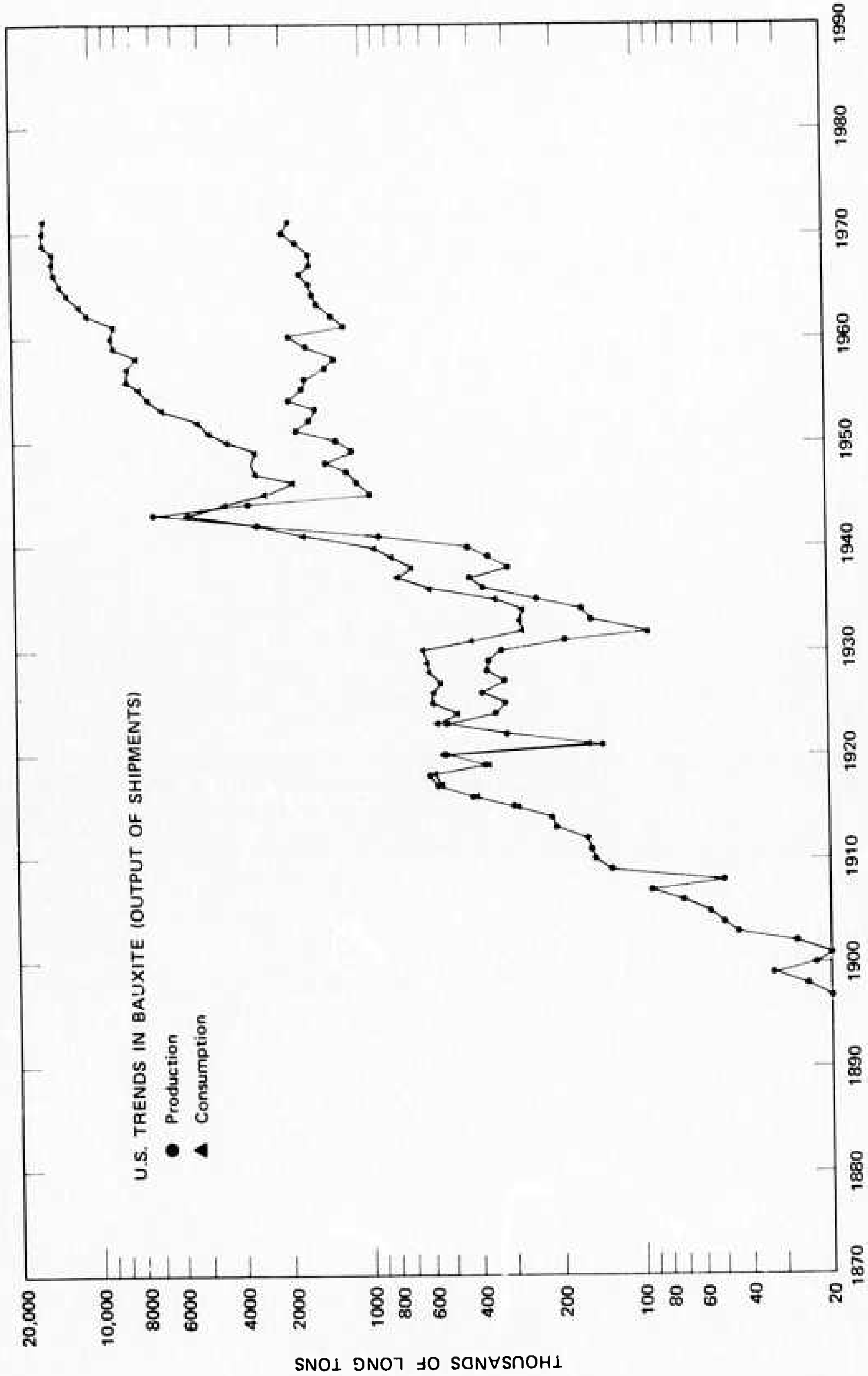
HISTORICAL TRENDS IN U.S. PRODUCTION AND CONSUMPTION OF MATERIALS

Using primarily data compiled and analyzed by Resources for the Future,[20] with some additional data obtained from the SRI Chemical Economics Handbook program,[7] graphs showing long-term trends in U.S. production and consumption have been produced for inclusion in this report. Those available are displayed on the following pages.


U.S. TRENDS IN ANTIMONY
Production (Smelter Plus Secondary)
Consumption
Secondary Only
THOUSANDS OF TONS
10,000
8000
6000
4000
2000
1000
800
600
400
200
100
80
60
40
20
10
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990



SOURCES: *Minerals Yearbooks 1961, 1966, 1971.
†Resources for Future, "Trends in Natural Resource Commodities".


U.S. TRENDS IN BAUXITE (OUTPUT OF SHIPMENTS)
Production
Consumption
THOUSANDS OF LONG TONS
20,000
10,000
8000
6000
4000
2000
1000
800
600
400
200
100
80
60
40
20
1870
1880
1890
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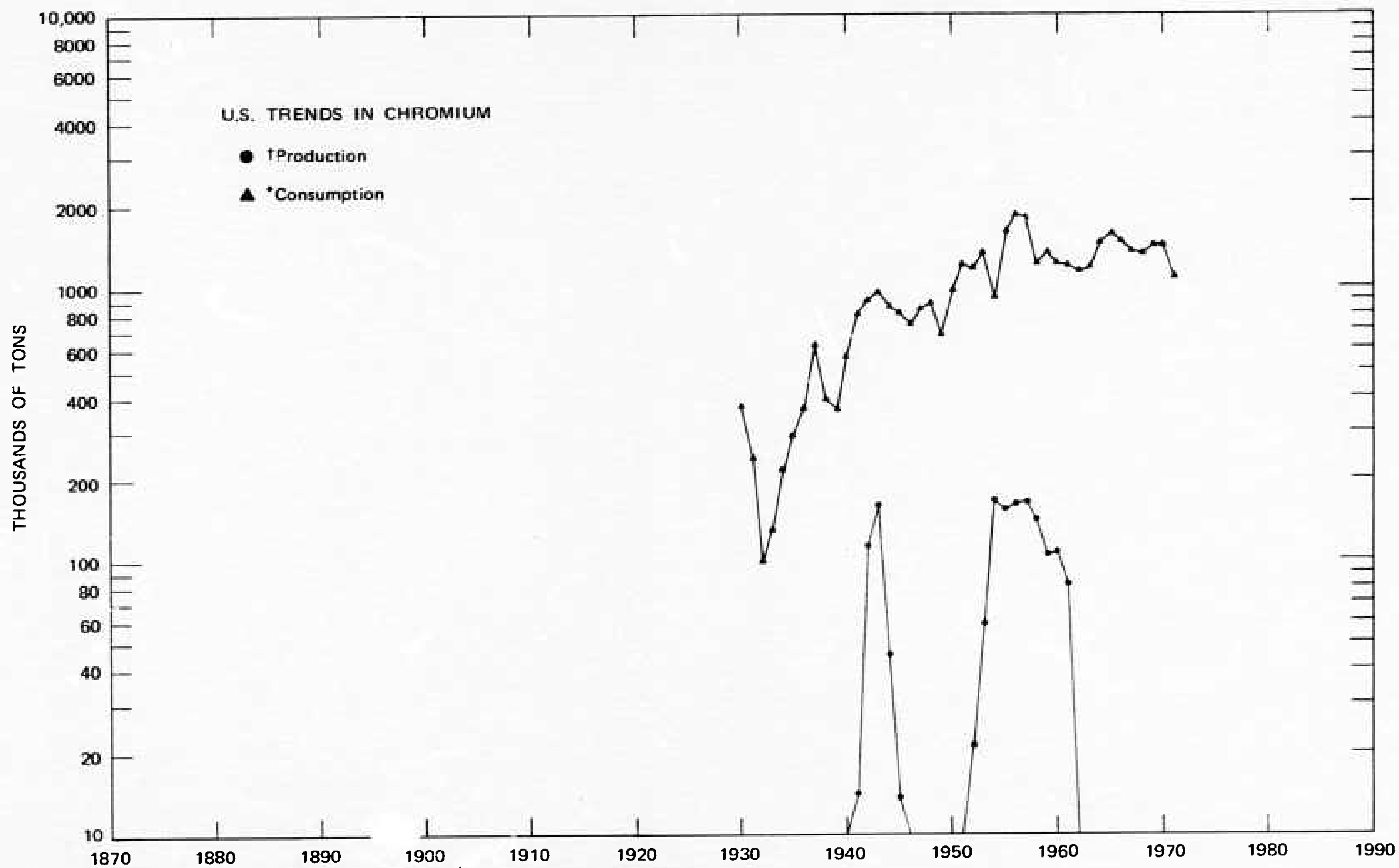
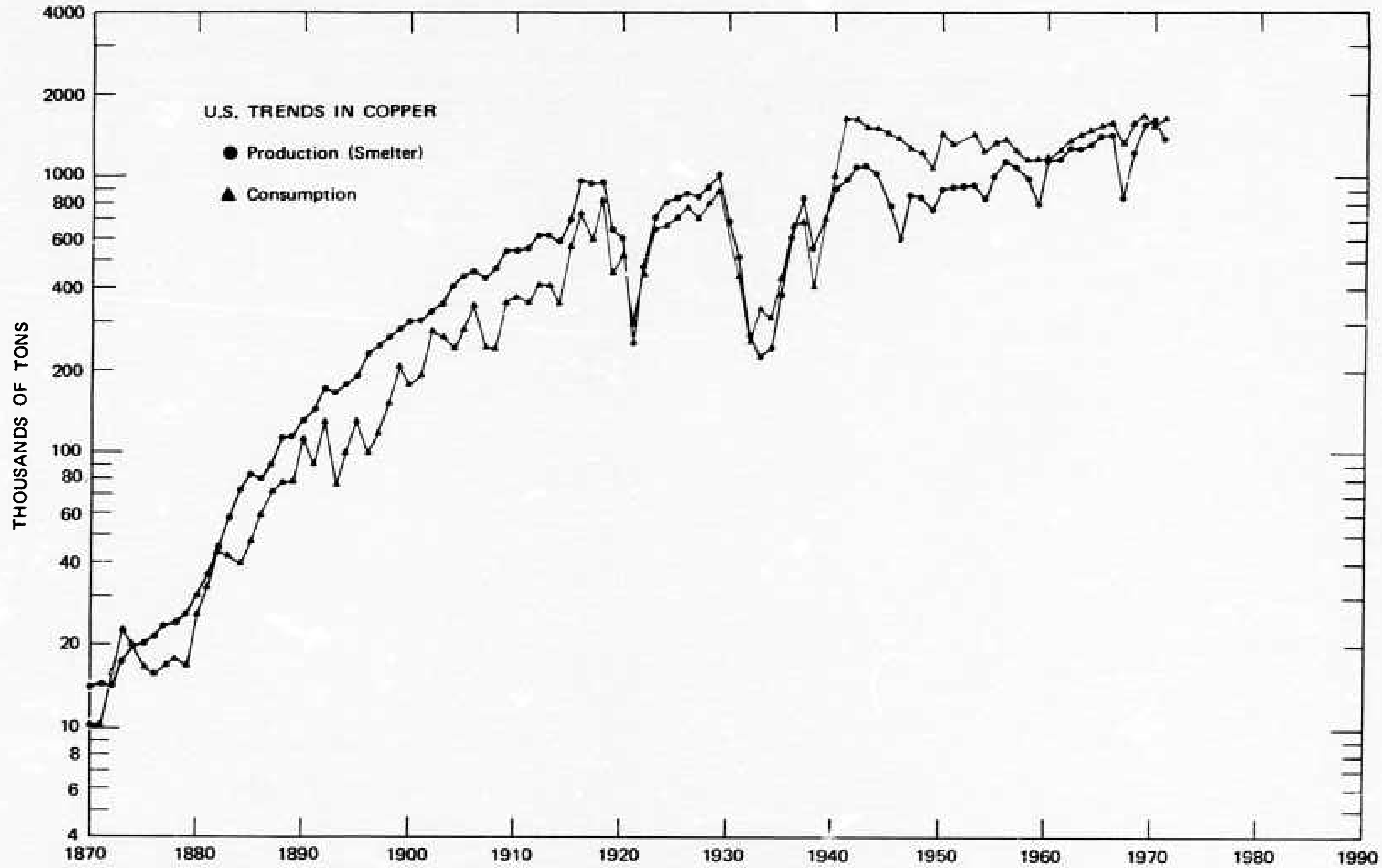
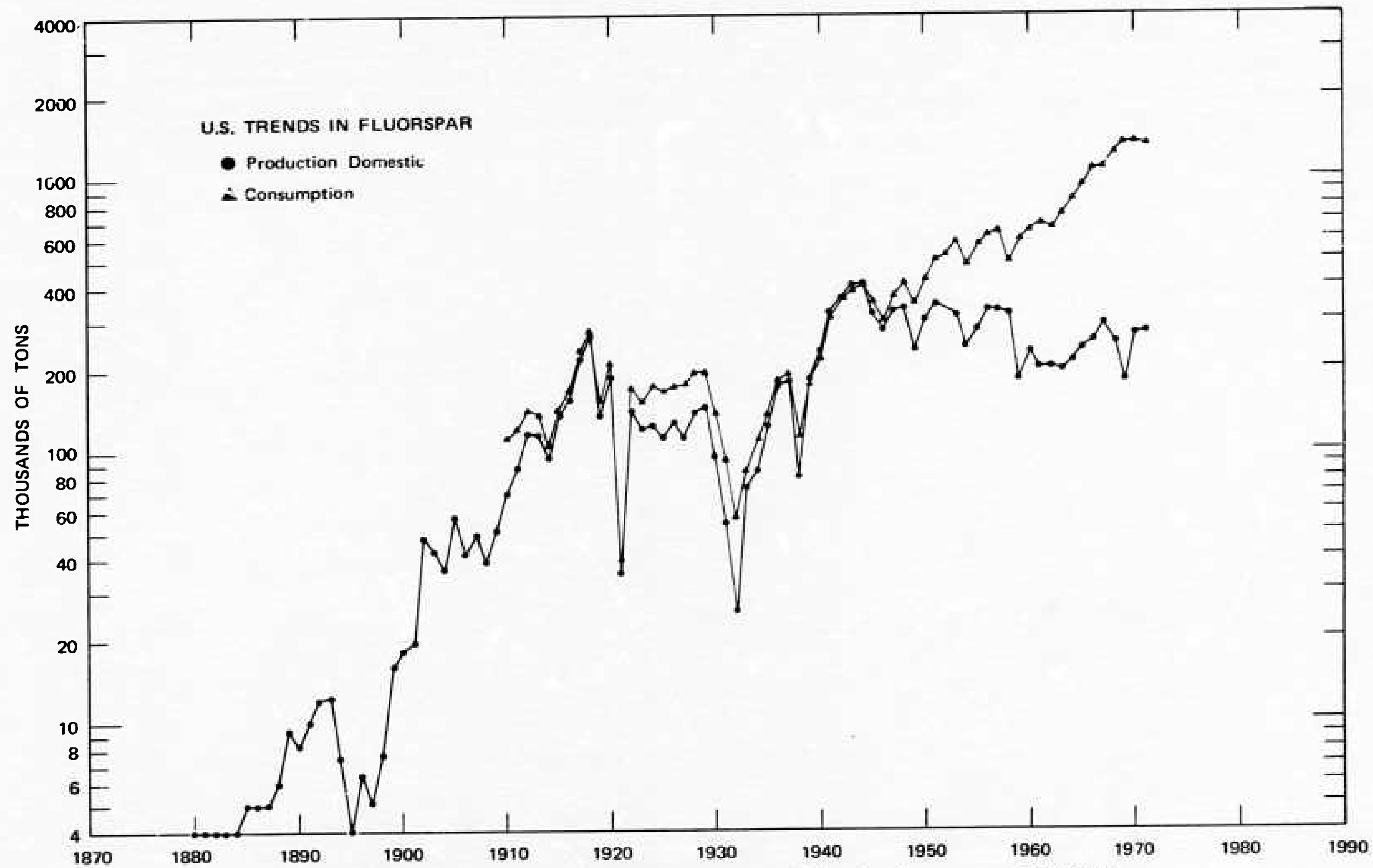
1930
1940
1950
1960
1970
1980
1990



SOURCES: *Data from Chemical Economics Handbook (overlap), 1930–1970.
Data from Minerals Yearbook, 1946–1971.
†Data from Chemical Economics Handbook (overlap), 1940–1962.
Data from Minerals Yearbook, 1946–1971.



SOURCES: Data from Minerals Yearbooks 1961, 1966, 1971. Smelter data used, also withdrawal, primary copper. 1957-1971
Data from Resources for Future, "Trends in Natural Resource Commodities". 1870-1957



SOURCES: Data from Minerals Yearbooks 1961, 1966, 1971. Smelter data used, also withdrawal, primary copper, 1957–1971
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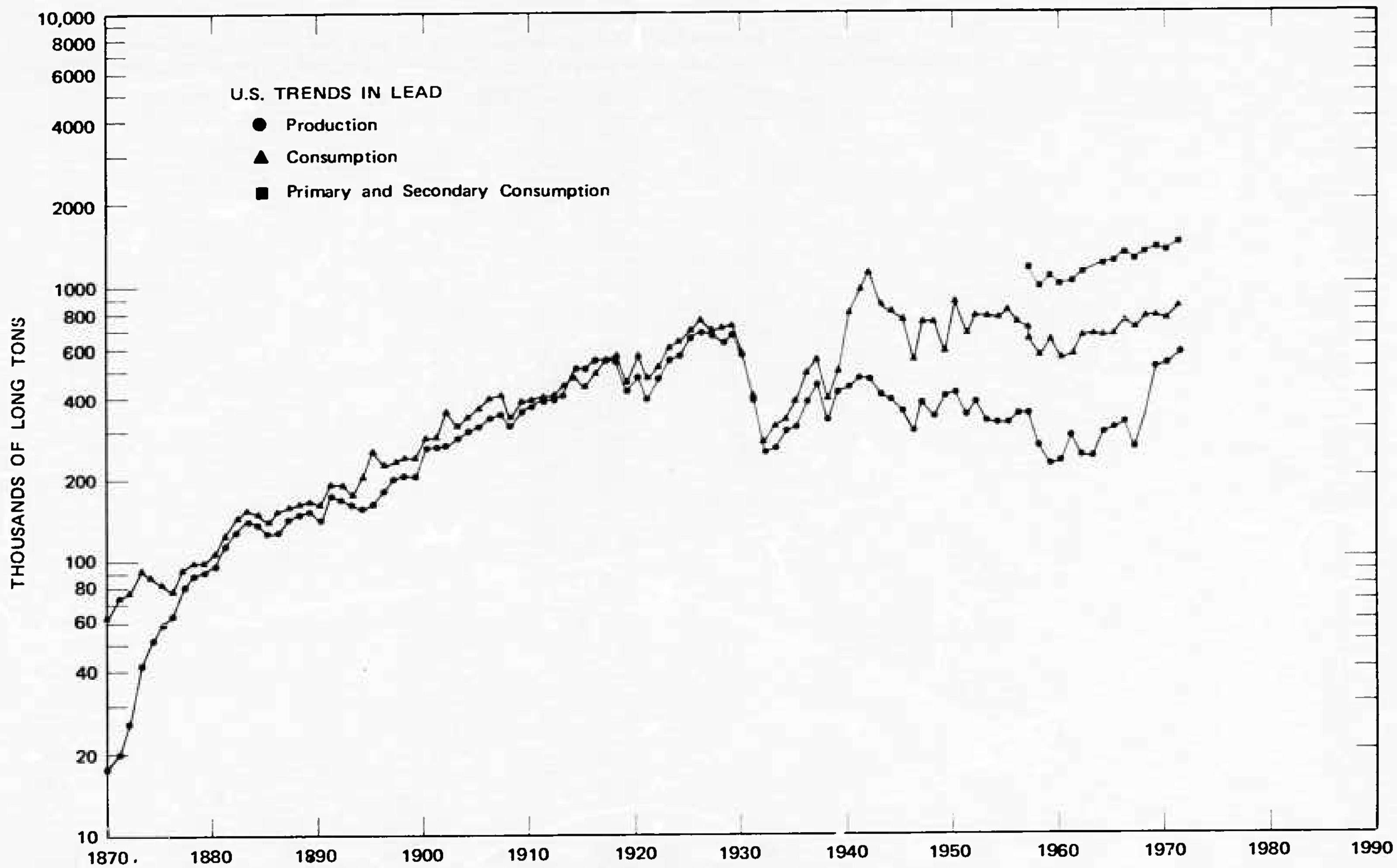
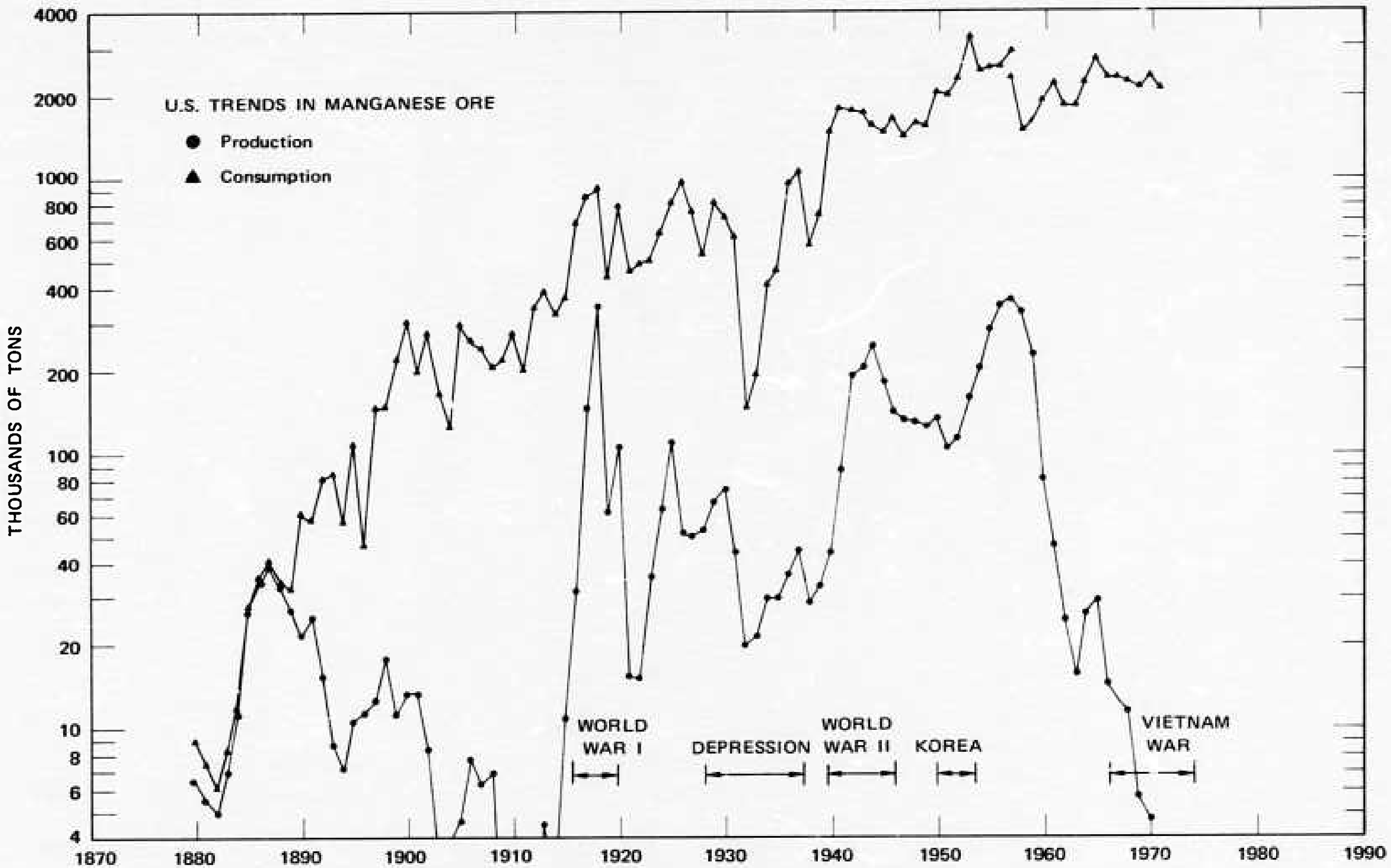
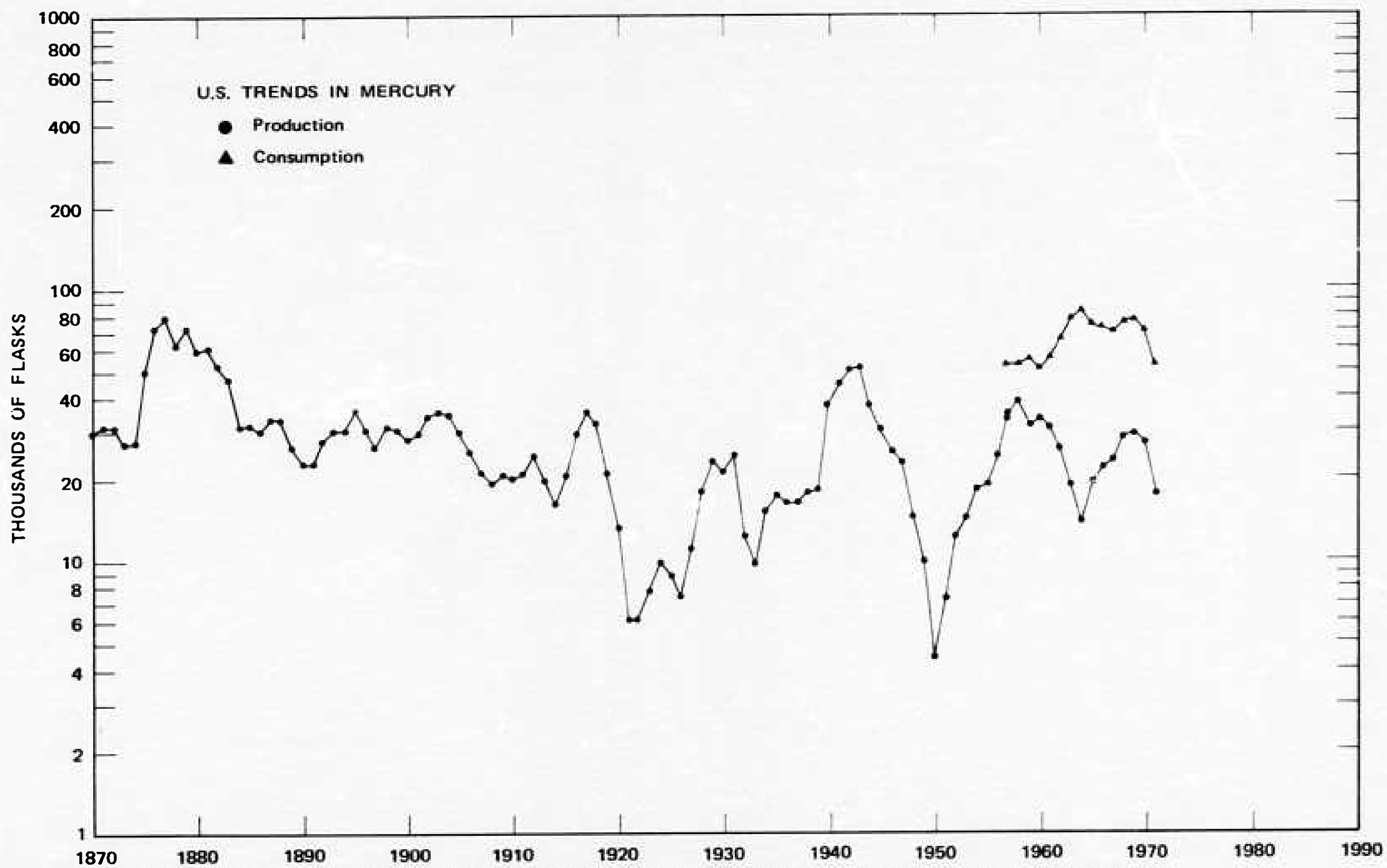


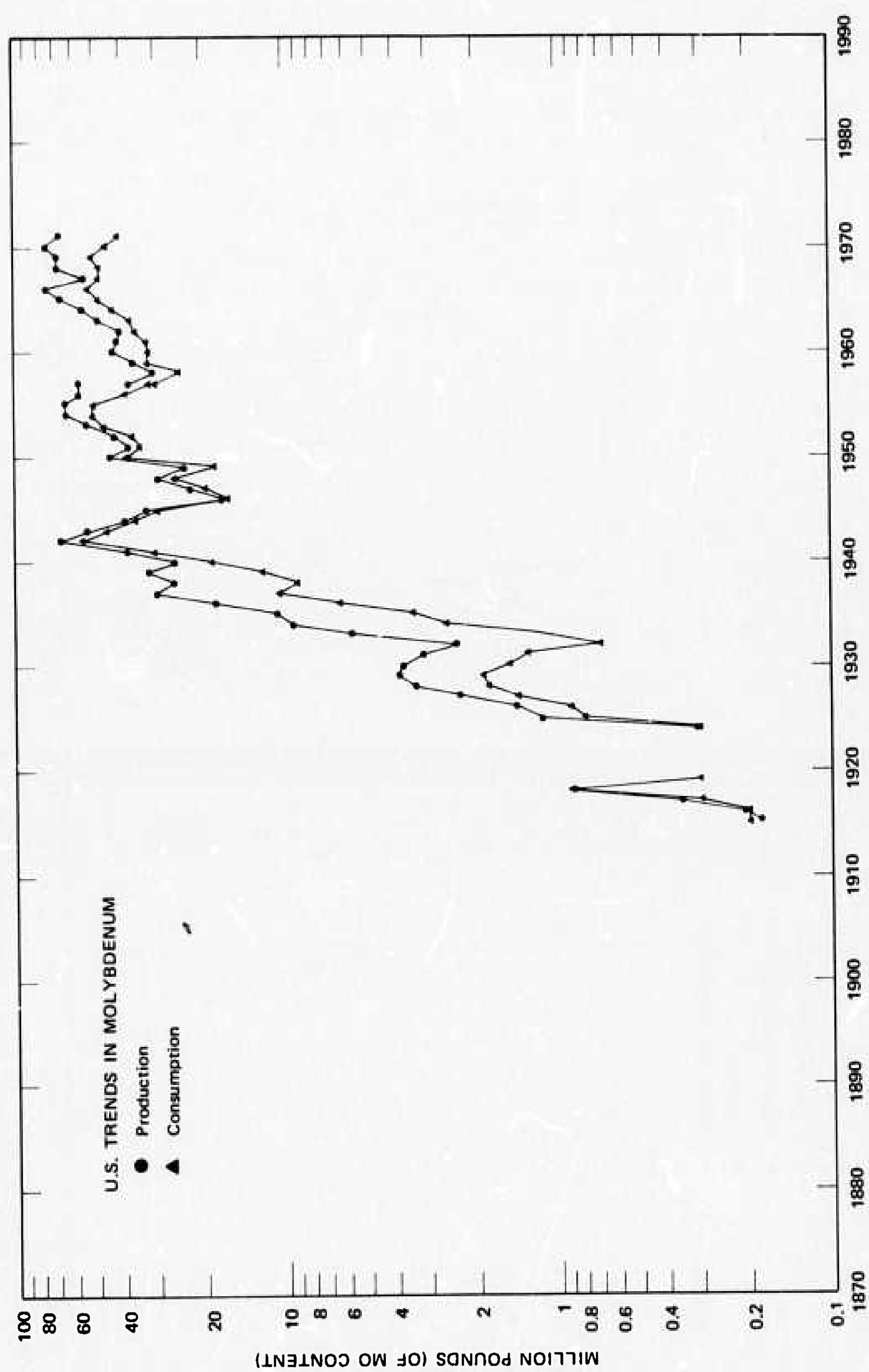
SOURCES: Consumption Figures in Minerals Yearbook Combine Primary and Secondary-Secondary Production was Subtracted to Approximate Primary Consumption for 1957-1971.



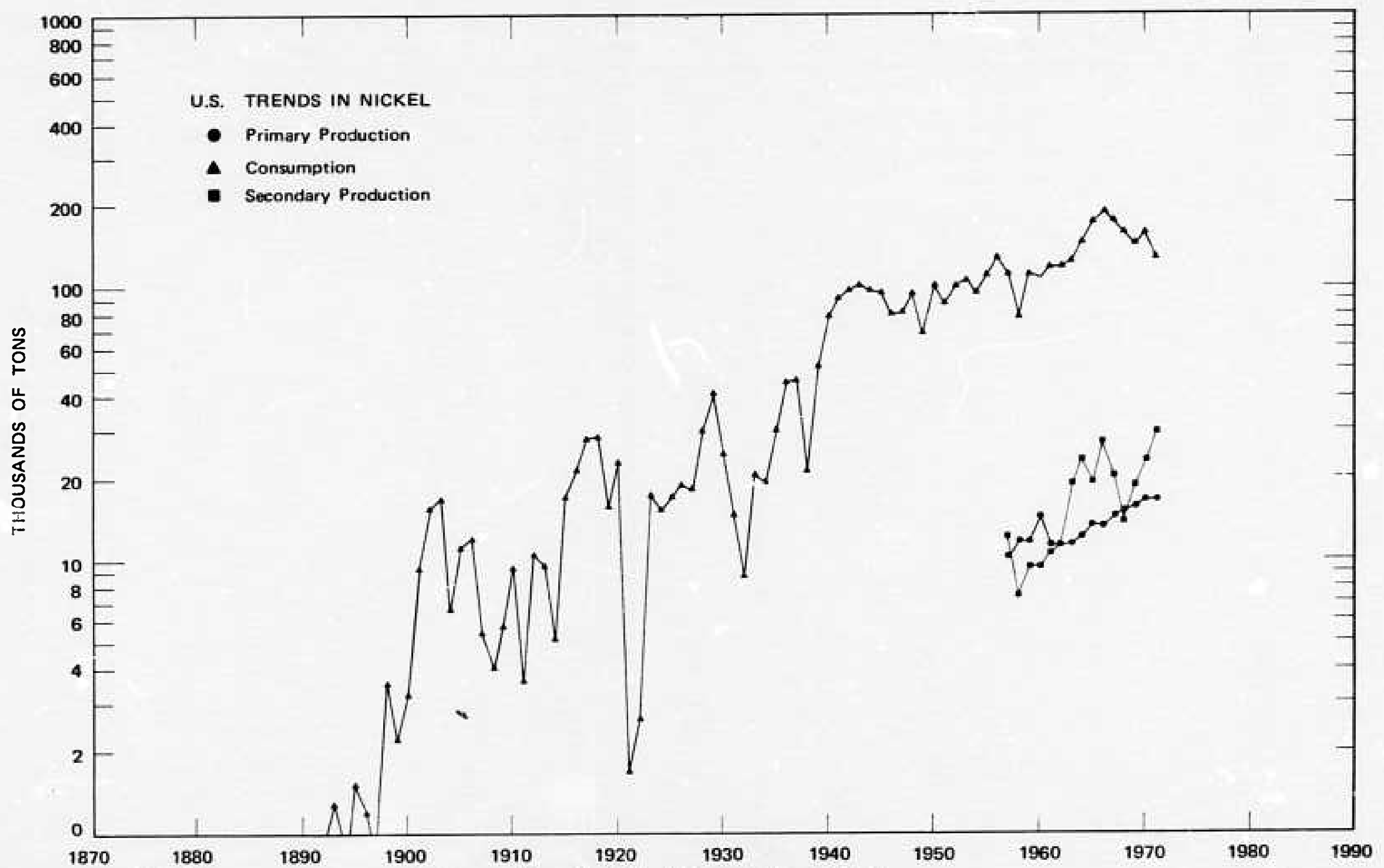
SOURCES: 1880-1957 Data from Resources for Future "Trends in Natural Resources Commodities".
1957-1971 Data from 1961, 1966, 1971 Minerals Yearbooks.



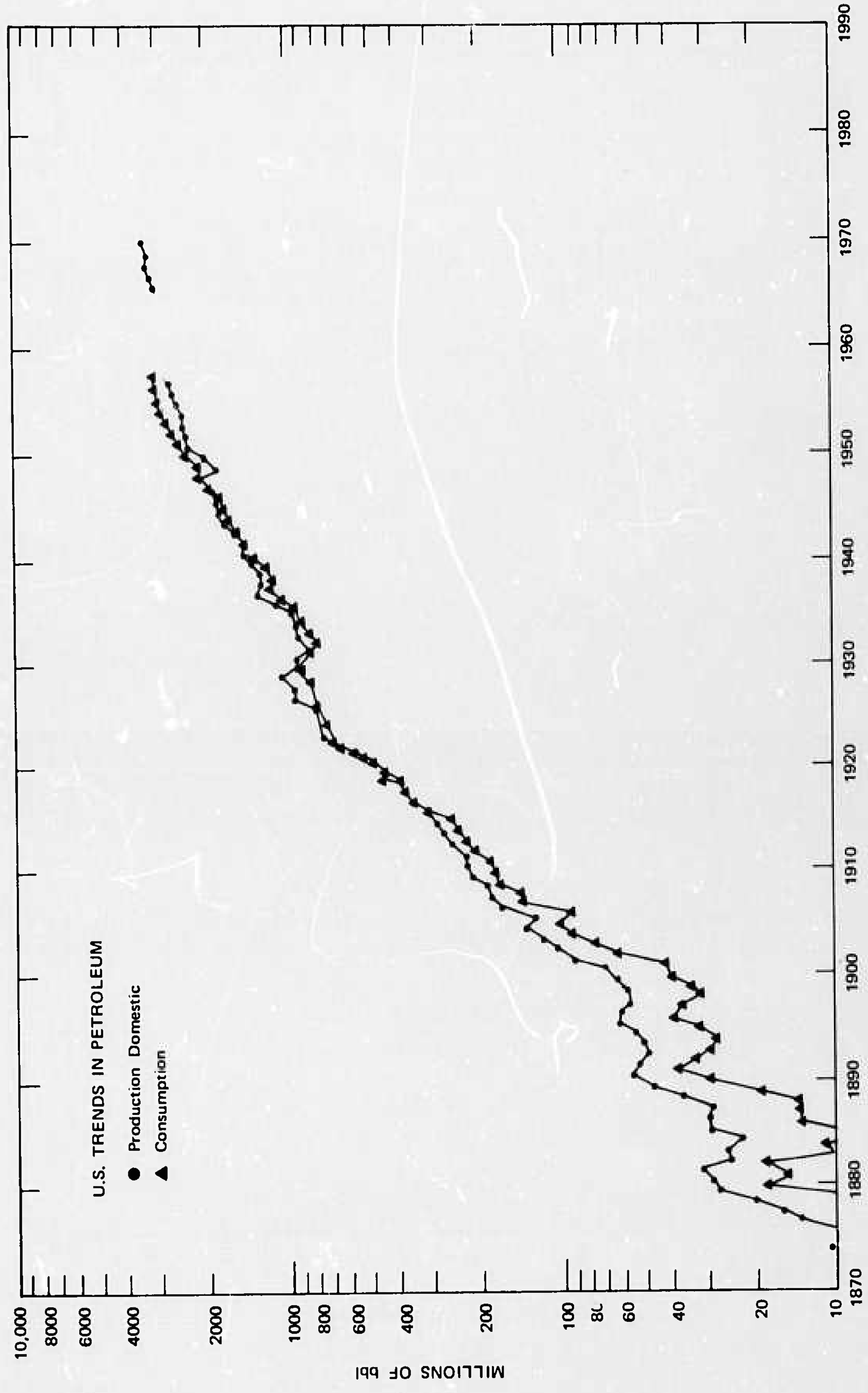
SOURCES: Resources for Future "Trends in Natural Resource Commodities", 1870-1957 Data; Minerals Yearbooks, 1957-1971 Data. Minerals Yearbooks.



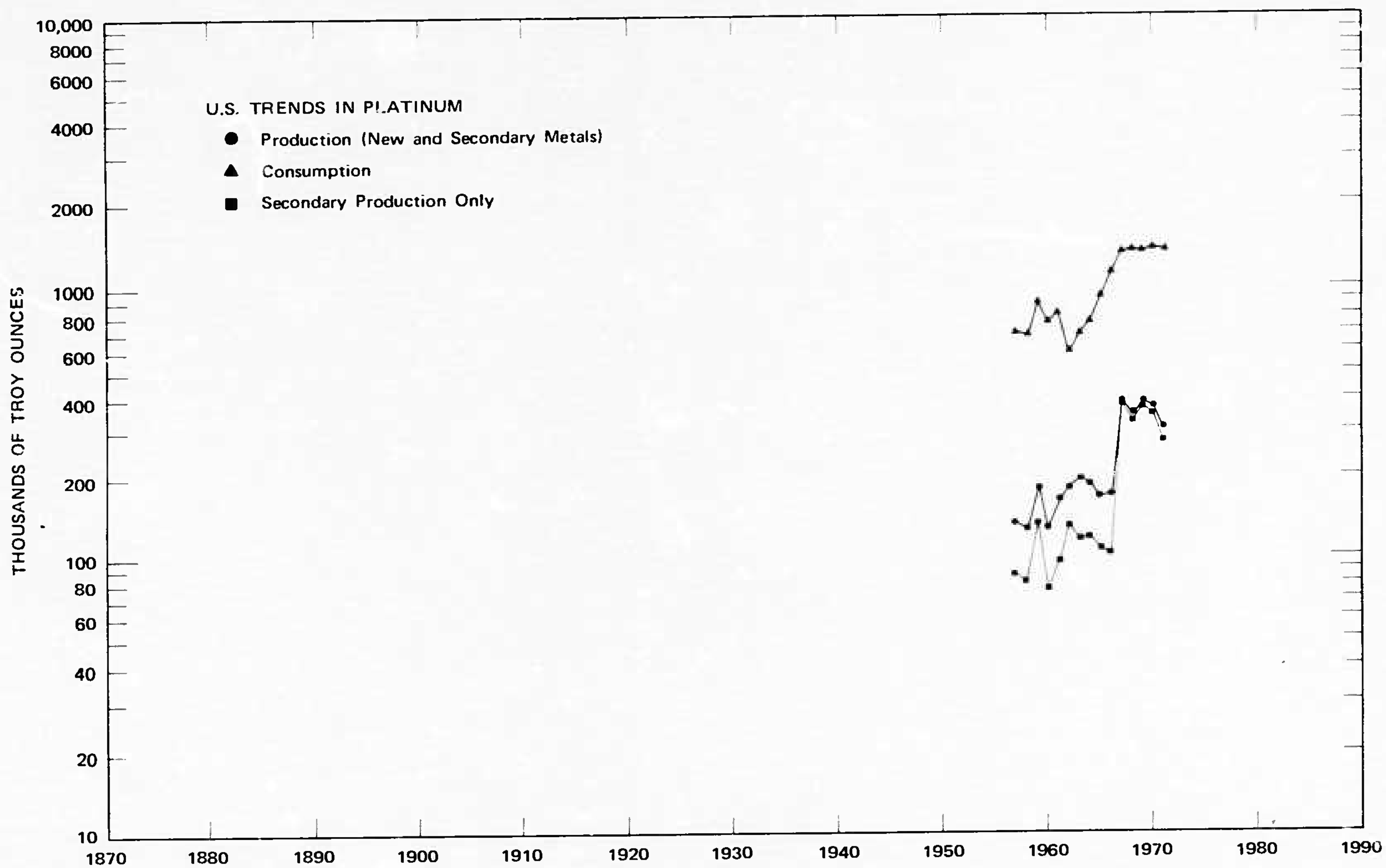
SOURCES: 1957-1971 Data from Minerals Yearbook
1915-1957 Data from Resources for Future, "Trends in Natural Resource Commodities".



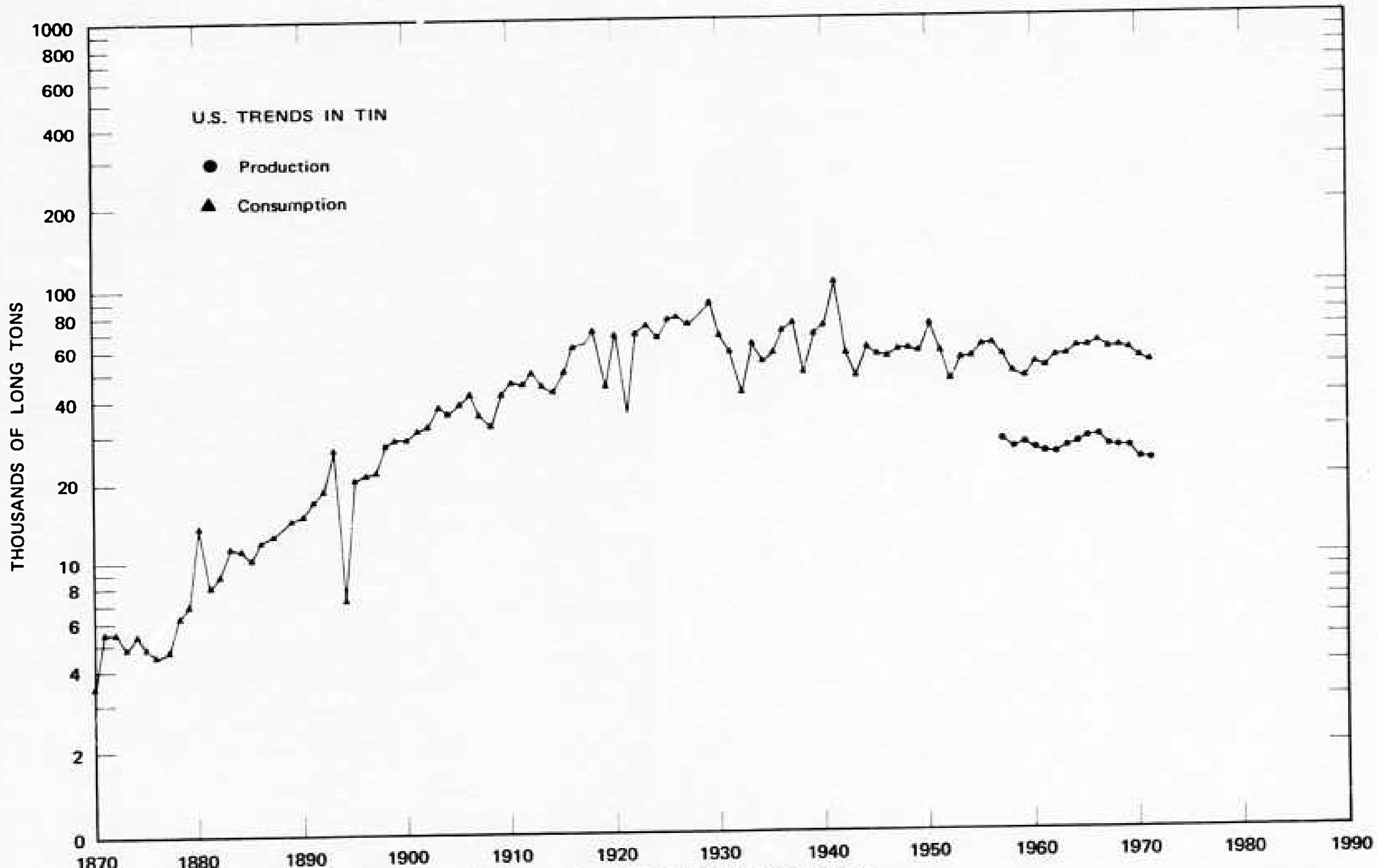
SOURCES: 1893–1957 Data from Resources for Future, "Trends in Natural Resource Commodities"
1958–1971 Data from Minerals Yearbooks, 1961, 1966, 1971.



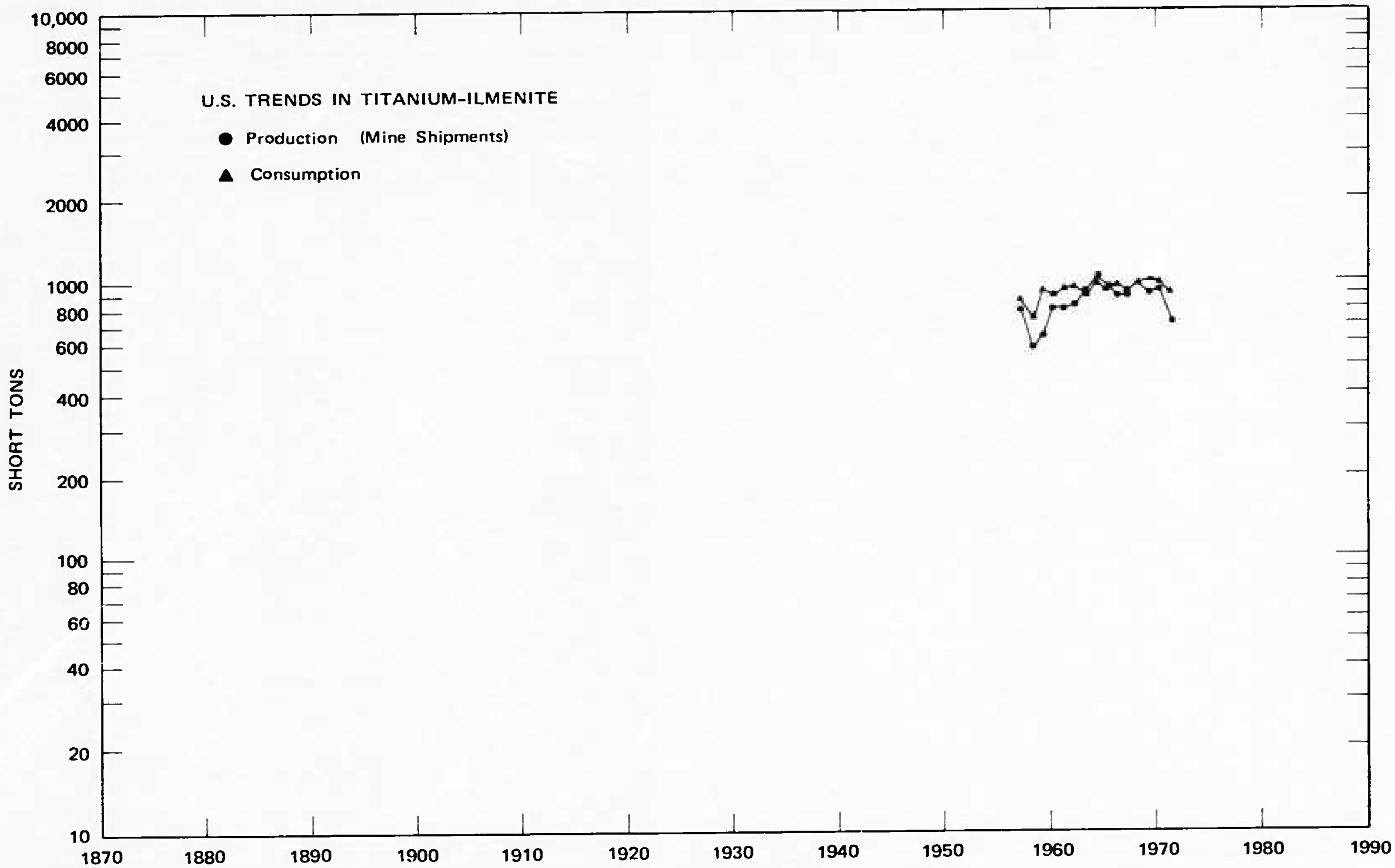
U.S. TRENDS IN PETROLEUM
Production Domestic
Consumption
MILLIONS OF bbl
10,000
8000
6000
4000
2000
1000
800
600
400
200
100
80
60
40
20
10
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990



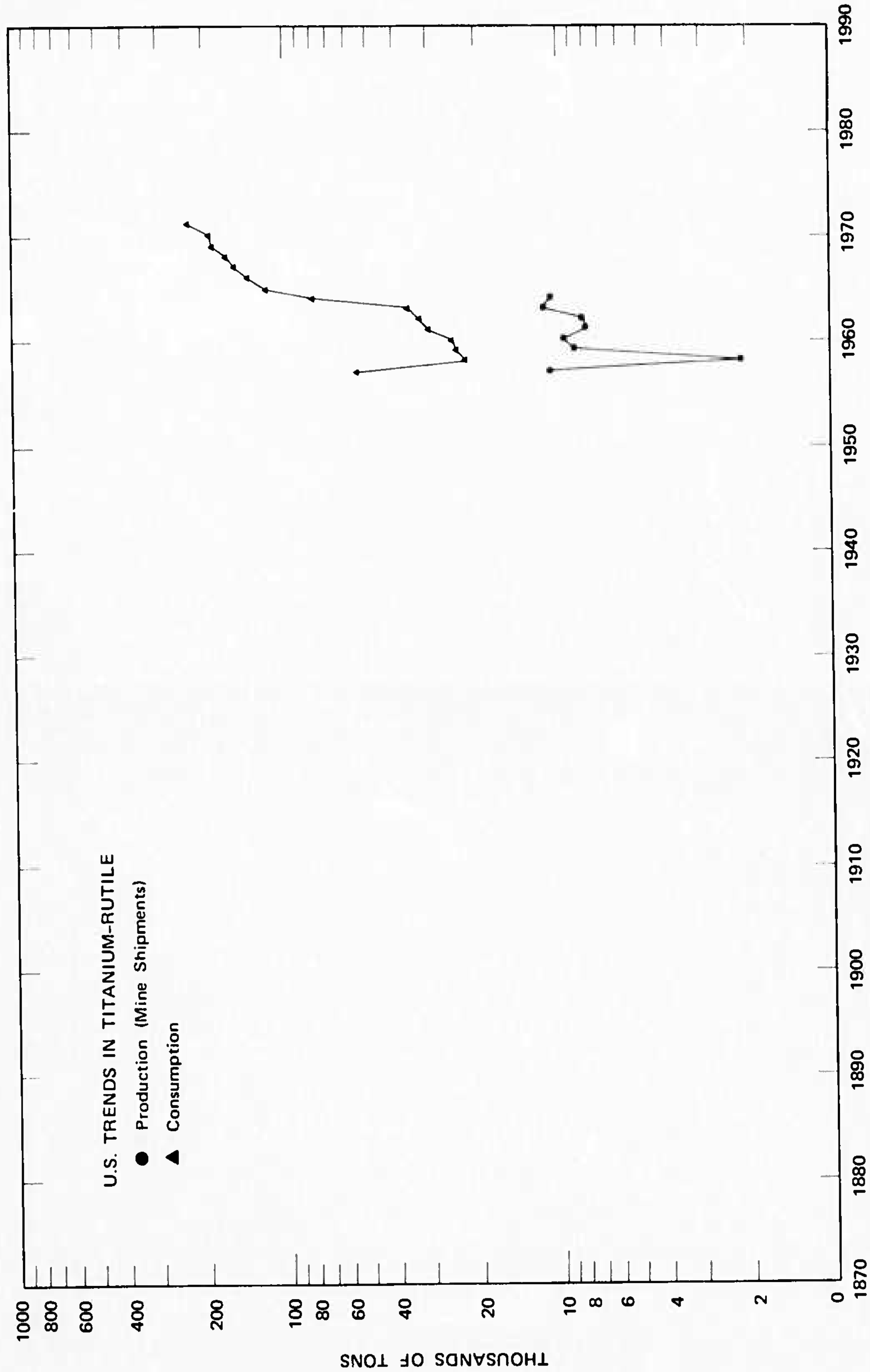
SOURCE: Minerals Yearbooks



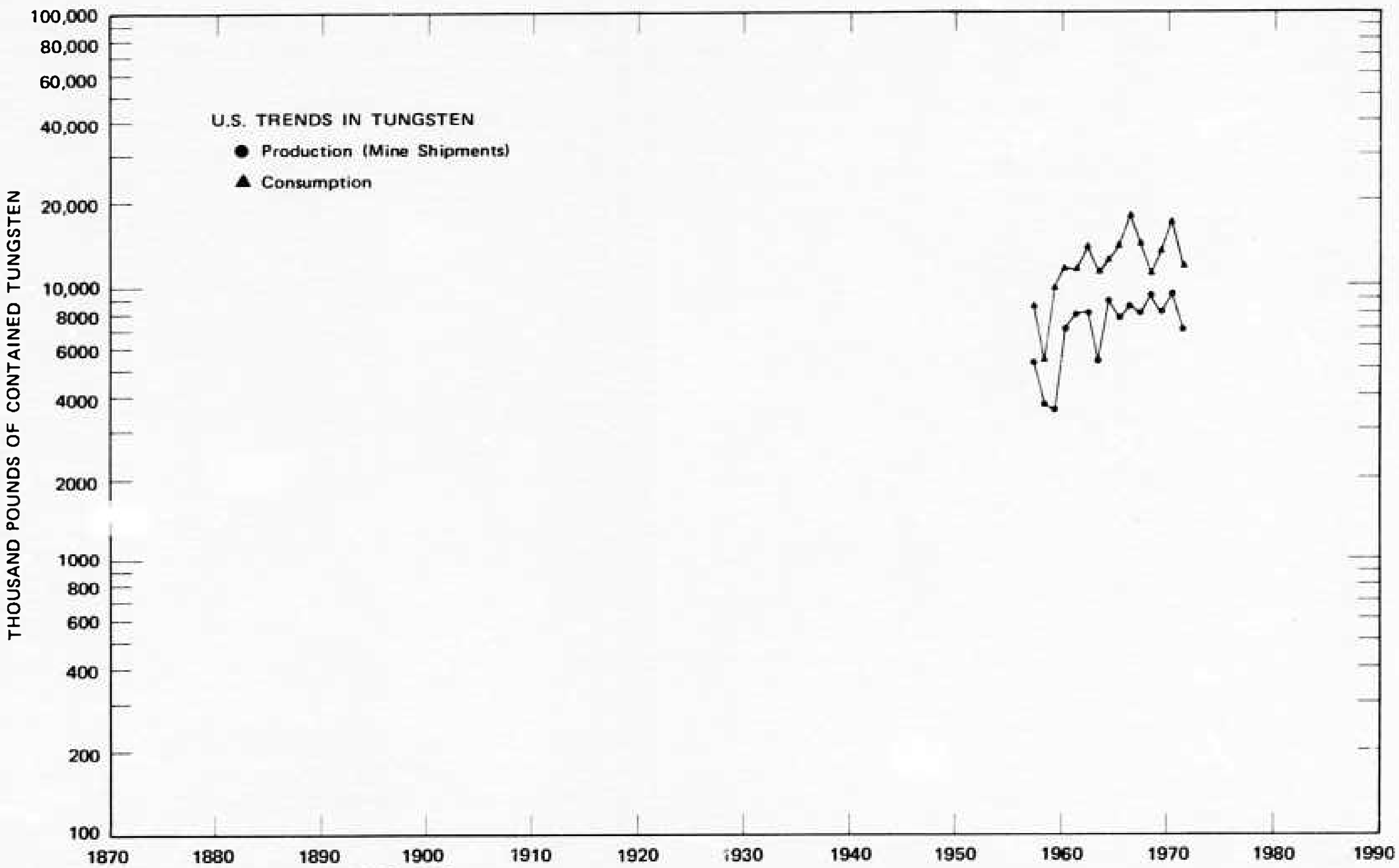
SOURCES: 1957-1971 Data from Minerals Yearbook-Consumption Data is Primary Consumption
1870-1957 Data from Resources for Future, "Trends in Natural Resource Commodities".



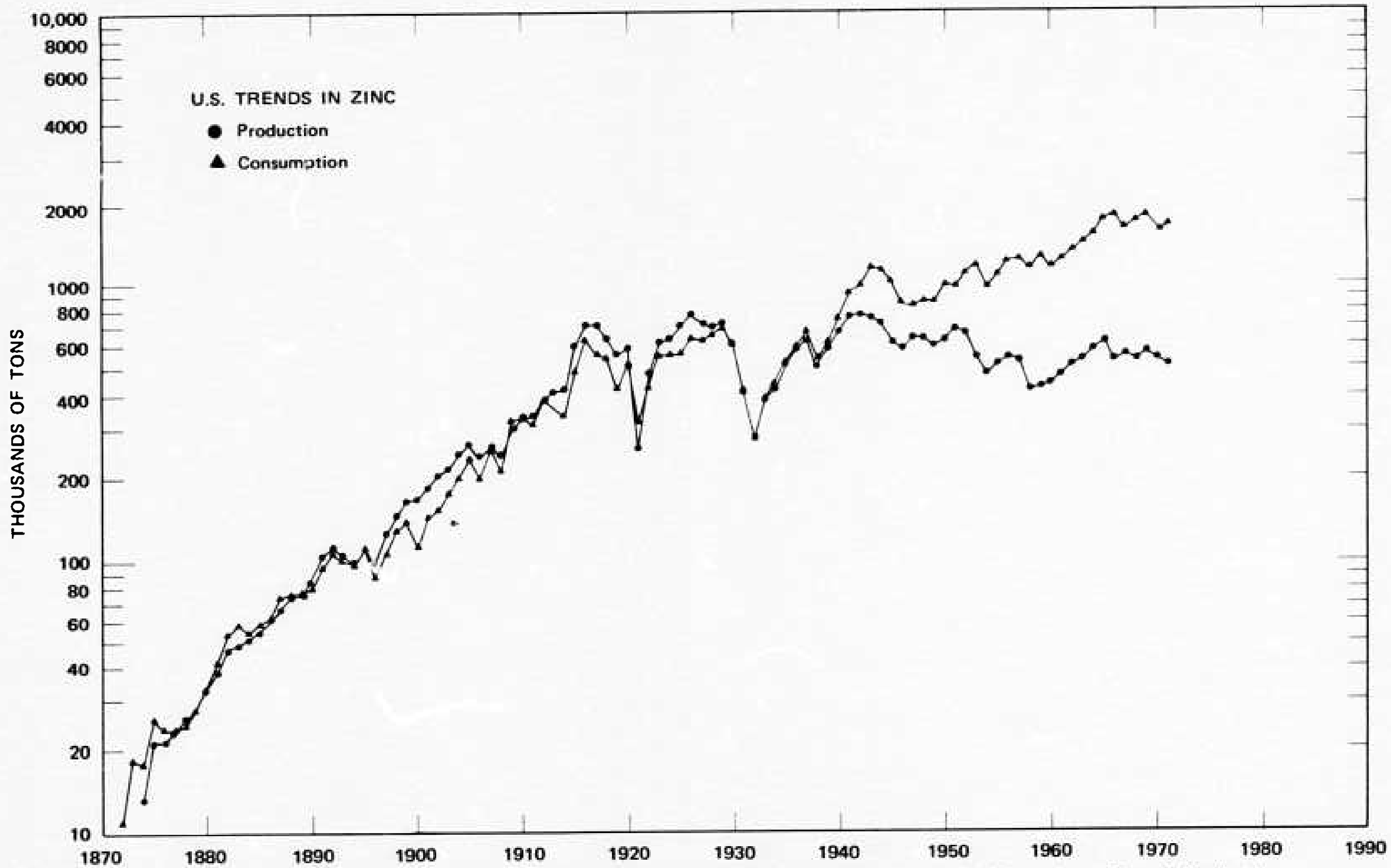
SOURCE: Minerals Yearbooks, 1961, 1966, 1971.



SOURCE: 1965-1971 Mine Shipment Data Withheld-Disclosure Purposes



SOURCE: Minerals Yearbooks, 1961, 1966, 1971.



SOURCES: 1874–1957 Data from Resources for Future, "Trends in Natural Resource Commodities". 1957–1971 Data from Minerals Yearbook.
1872–1957 Data from Resources for Future, "Trends in Natural Resource Commodities". 1957–1971 Data from Minerals Yearbook.

Appendix B

COMPUTATION OF ESTIMATES OF DEFENSE USE OF MATERIALS

As noted in the main body of this paper, DOD use of materials is estimated by (1) determining direct and indirect total military sales from producing sectors that are generated by military final demand and (2) applying a value for the (average) amount of a material per dollar of sale from some sector or group of sectors (use factors) to the military sales. In this appendix, we derive the method for determination of the total military sales and for subsequent application of this data with the appropriate use factors.

We will begin by describing some standard results from I/O theory. Let S_i (i = 1, ..., 399) be the total sales from the ith economic sector, where the sectors are defined as in the SERL matrix (Reference 13). Let z_{ij} be the sales from the ith sector to the jth sector. I/O theory assumes that the quantity of sales from the ith to the jth sector are a linear function of the total sales, i.e., output, of the jth sector. Thus, we can write

$$z_{ij} = a_{ij} S_j \tag{1}$$

where a_{ij} is a known quantity assumed to be constant over a suitable range of S_j values. The total sales from the ith sector are then given by

$$S_i = \sum_{j=1}^{399} z_{ij} + F_i \tag{2}$$

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where F_i are the sales from sector i to all portions of final demand. Combining (1) and (2), we have

$$S_i = \sum_{j=1}^{399} a_{ij} S_j + F_i \tag{3}$$

We can write such an equation for each of the 399 sectors and represent the entire set by a matrix relation of the following form

$$S = AS + F \tag{4}$$

where A is a (399 × 399) matrix, whose elements are the a_{ij}, and where S and F are (399 component) vectors of total sales and final demand, respectively, whose elements correspond to the various sectors. Equation (4) can be rewritten as

$$F = S - AS \tag{5}$$

and hence, as

$$F = (I - A)S \tag{6}$$

where I is the appropriate identity matrix. Since A is known to be nonsingular, we can take the inverse of (I - A) to obtain

$$S = (I - A)^{-1}F \tag{7}$$

This last result states that the vector of total sales generated by all forms of final demand can be determined by applying the (I - A) inverse to the vector of final demand. Under the assumption that the portion of final demand going to the military, F', has the same composition as the final demand delivered to the entire economy, it follows that the sales generated by the military, S', are given by

$$S' = (I - A)^{-1} F' \qquad (8)$$

Thus, with military final demand vectors, such as those obtained from the inputs provided by Schulman[14], it is possible to obtain estimates of total military sales.

The inputs provided by Schulman were all stated in terms of 1963 dollars. Since the Bureau of Mines descriptions of the partition of materials among producing sectors are for the year 1968, it was necessary to convert the total sales data to 1968 prices. In the present case, this was done by the application of the same factor, k', to each component of the total military sales vector.*

Many of the Bureau of Mines descriptions of the partition of a given material specified some fixed amount of the material as going to a group of sectors. For example, one specification states that 470 of the 4705 thousands of short tons of aluminum going to U.S. demand in 1968 were delivered to the group of producing sectors described under the heading of producers of "fabricated metal products consumer durables." In treating the sales data for such a group, it is necessary to sum over the relevant sectors so as to utilize the appropriate sales data.

Now consider the kth material of interest, which the Bureau of Mines description breaks out into L different, and usually unequal, parts. Let M_k be the total amount of this material (i.e., total U.S. demand for the year) and $m_{k,\ell}$ be the amount of material in the ℓth portion. Let

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*Note that if more than one conversion factor had been used, it would have been necessary to apply them to F' before applying Equation (8).

$G(k,\ell)$ be the set* of economic sectors that received the ℓth portion. Then, the total military sales of the industries receiving the ℓth portion of material k, s' is given by

$$s'_{k,\ell} = \sum_{i \epsilon G(k,\ell)} S'_i \tag{9}$$

where S'_i is the ith component of S'. Similarly, the total sales associated with this set of sectors is given by

$$s_{k,\ell} = \sum_{i \epsilon G(k,\ell)} S_i$$

The values of the components of S were given in 1967 dollars. They are converted to total sales in 1968 dollars by a factor, k_g, based on the ratio of 1968 GNP to 1967 GNP, when both GNP values are described in current dollars.

The use factor for the ℓth apportionment from the kth material, $U_{k\ell}$, is given by

$$U_{k\ell} = m_{k\ell}/(k_g s_{k\ell}) \tag{10}$$

and the amount of the ℓth apportionment used, directly or indirectly by the military, $m'_{k\ell}$ is

$$m'_{k\ell} = U_{k\ell} k' s'_{k\ell} \tag{11}$$

---

*More explicitly, the set of indices of the economic sectors that receive the ℓth portion of material, k.

The total amount of the material utilized in satisfying military demand, M'_k is then obtained by

$$M'_k = \sum_{\ell=1}^{L} m'_{k\ell} \tag{12}$$

To express this result as a percentage of U.S. demand, P, we divide by the value of M_k for that year, i.e.,

$$P = 100\ M'_k/M_k \tag{13}$$

where the value of M_k is for the same year as the S' value, i.e., for the year corresponding to the selected Schulman vector. To express the result in terms of a fraction of average annual consumption, between the year 1972 and the year 2000, f, we divide by N(k), the unit for the kth material developed in the treatment of consumption patterns, i.e.,

$$f = \frac{M'_k}{N(k)} \tag{14}$$

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