U.S. Department of the Interior
U.S. Geological Survey

MINERAL COMMODITY SUMMARIES 2002

USGS
science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
CHARLES G. GROAT, Director

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 2002

Published in the Eastern Region, Reston, Va.
Manuscript approved for publication January 25, 2002.

For sale by U.S. Government Printing Office
Washington, DC 20402

CONTENTS

General:

Commodities:

INSTANT INFORMATION

Information about the U.S. Geological Survey, its programs, staff, and products, is available from the Internet at URL <http://www.usgs.gov> or by contacting the Earth Science Information Center at 1-888-ASK-USGS.

This publication has been prepared by the Minerals Information Team. Information about the team and its products is available from the Internet at URL <http://minerals.usgs.gov/minerals> or by writing to Chief Scientist, Minerals Information Team, 988 National Center, Reston, VA 20192.

KEY PUBLICATIONS

Minerals Yearbook—These annual publications review the mineral industries of the United States and foreign countries. They contain statistical data on minerals and materials and include information on economic and technical trends and developments. The Yearbook is published in three volumes—Volume I, Metals and Minerals; Volume II, Area Reports, Domestic; and Volume III, Area Reports, International.

Mineral Commodity Summaries—Published on an annual basis, this report is the earliest Government publication to furnish estimates covering nonfuel mineral industry data. Data sheets contain information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for more than 90 individual minerals and materials.

Mineral Industry Surveys—These periodic statistical and economic reports are designed to provide timely statistical data on production, distribution, stocks, and consumption of significant mineral commodities. The surveys are issued monthly, quarterly, or at other regular intervals.

Metal Industry Indicators—This monthly publication provides economic indicators of selected metal industries.

Stone, Clay, Glass, and Concrete Products Industry Indexes—This monthly publication provides economic indicators of selected industrial minerals processing activities.

Materials Flow Studies—These publications describe the flow of materials from source to ultimate disposition to help better understand the economy, manage the use of natural resources, and protect the environment.

Metal Prices in the United States Through 1998—This publication provides an extended price history for a wide range of metals.

Minerals and Materials Information CD-ROM—Published three times a year, the CD features the Minerals Yearbook chapters published since 1994, the Minerals Commodity Summaries published since 1996, and recently released Mineral Industry Surveys in a completely searchable format.

WHERE TO OBTAIN PUBLICATIONS

- *Metal Prices in the United States Through 1998*, *Mineral Commodity Summaries*, *Minerals and Materials Information CD-ROM*, and the *Minerals Yearbook* are sold by the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954. To order by telephone, call (202) 512-1800.

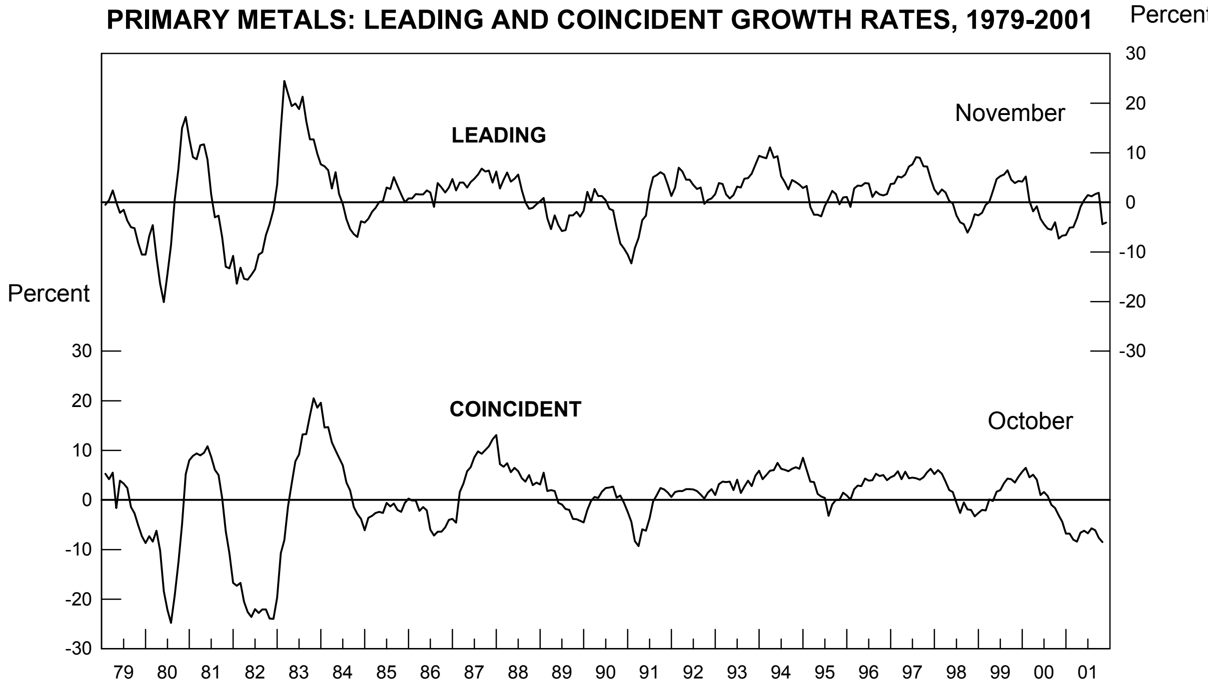
- *Mineral Industry Surveys* and *Metal Industry Indicators* can be obtained free of charge by calling (412) 386-6156 or by writing to NIOSH Printing Office, Pittsburgh Research Laboratory, P.O. Box 18070, Pittsburgh, PA 15236-0070.

- *Stone, Clay, Glass, and Concrete Products Industry Indexes* and materials flow studies are available in PDF format at URL <http://minerals.usgs.gov/minerals>.

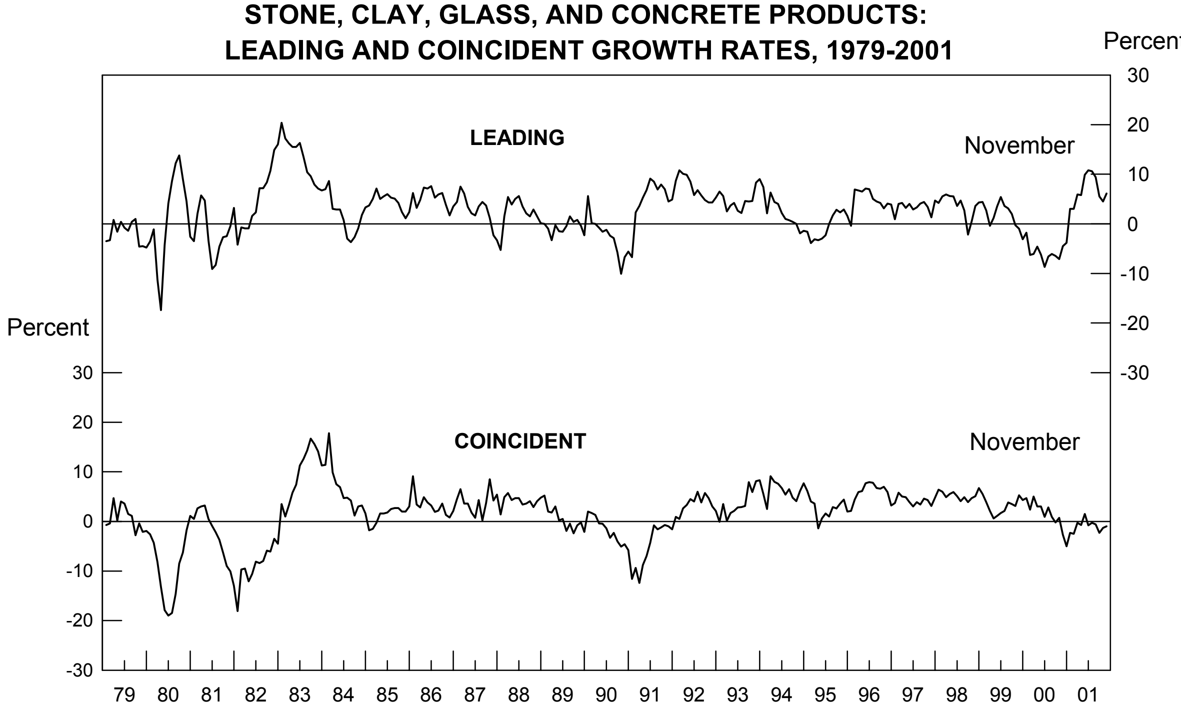
- All current publications are available in PDF format at URL <http://minerals.usgs.gov/minerals>.

GROWTH RATES OF LEADING AND COINCIDENT INDEXES FOR MINERAL PRODUCTS

PRIMARY METALS: LEADING AND COINCIDENT GROWTH RATES, 1979-2001



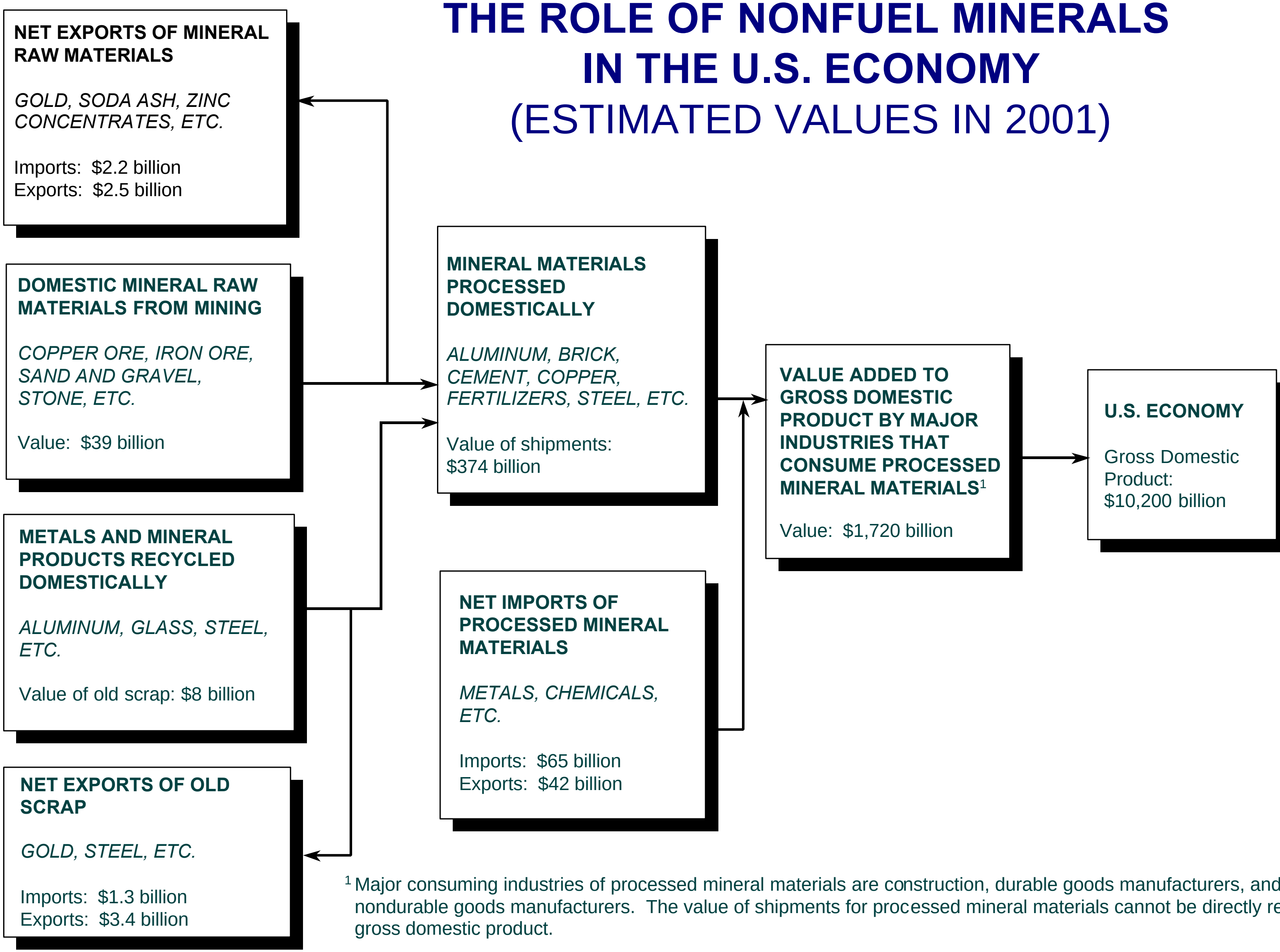
STONE, CLAY, GLASS, AND CONCRETE PRODUCTS: LEADING AND COINCIDENT GROWTH RATES, 1979-2001



The leading indexes historically give signals several months in advance of major changes in the corresponding coincident index, which measures current industry activity. The growth rates, which can be viewed as trends, are expressed as compound annual rates based on the ratio of the current month's index to its average level during the preceding 12 months.

Sources: U.S. Geological Survey, *Metal Industry Indicators* and *Stone, Clay, Glass, and Concrete Products Industry Indexes.*

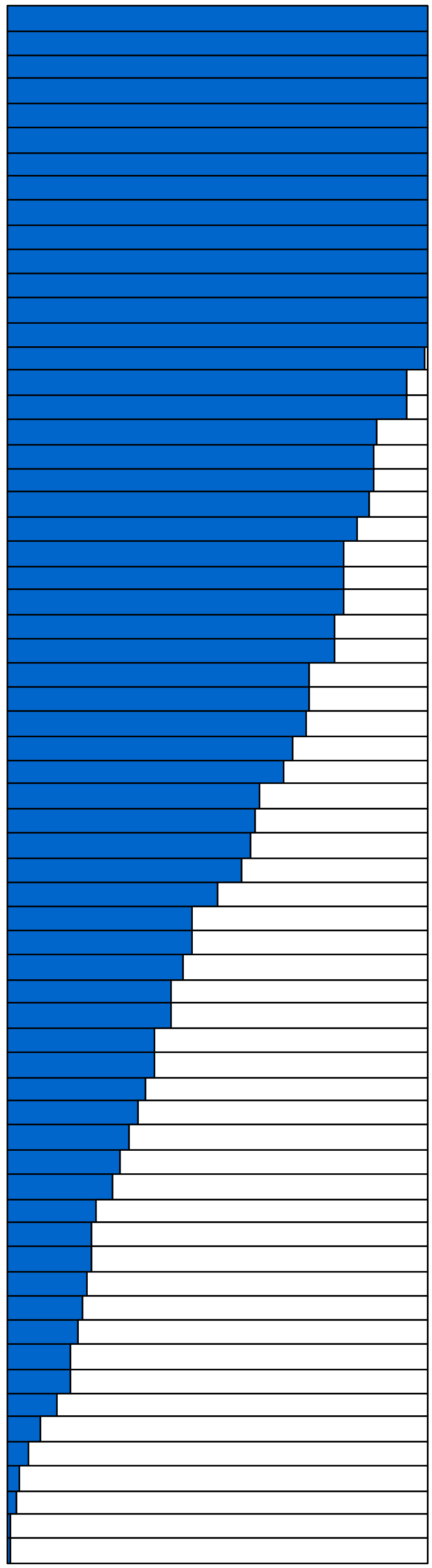
THE ROLE OF NONFUEL MINERALS IN THE U.S. ECONOMY
(ESTIMATED VALUES IN 2001)



[1] Major consuming industries of processed mineral materials are construction, durable goods manufacturers, and some nondurable goods manufacturers. The value of shipments for processed mineral materials cannot be directly related to gross domestic product.

Sources: U.S. Geological Survey and U.S. Department of Commerce.

2001 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS



Commodity	Percent	Major Import Sources (1997-2000)[1]
ARSENIC (trioxide)	100	China, Chile, Mexico
ASBESTOS	100	Canada
BAUXITE and ALUMINA	100	Australia, Guinea, Jamaica, Brazil
COLUMBIUM (NIOBIUM)	100	Brazil, Canada, Germany, Russia
FLUORSPAR	100	China, South Africa, Mexico
GRAPHITE (natural)	100	China, Mexico, Canada, Brazil
MANGANESE	100	South Africa, Gabon, Australia, Mexico
MICA, sheet (natural)	100	India, Belgium, Germany, China
QUARTZ CRYSTAL (industrial)	100	Brazil, Germany, Madagascar
STRONTIUM	100	Mexico, Germany
THALLIUM	100	Belgium, Canada, Germany, United Kingdom, France
THORIUM	100	France, Canada, Japan, Singapore
VANADIUM	100	Canada, South Africa, China, Austria
YTTRIUM	100	China, Japan, United Kingdom, Germany
GEMSTONES	99	Israel, India, Belgium
BISMUTH	95	Belgium, Mexico, United Kingdom, China
INDIUM	95	Canada, China, Russia, France
TIN	88	China, Peru, Indonesia, Brazil, Bolivia
BARITE	87	China, India, Canada, Mexico
PALLADIUM	87	Russia, South Africa, Belgium, United Kingdom
ANTIMONY	86	China, Mexico, South Africa, Belgium, Bolivia
DIAMOND (natural)	83	United Kingdom, Switzerland, Ireland, Belgium
POTASH	80	Canada, Russia, Belarus
STONE (dimension)	80	Italy, Brazil, Canada, India
TANTALUM	80	Australia, China, Thailand, Japan
CHROMIUM	78	South Africa, Kazakhstan, Russia, Turkey, Zimbabwe
COBALT	78	Finland, Norway, Canada, Russia
IODINE	72	Chile, Japan, Russia
TITANIUM MINERAL CONCENTRATES	72	South Africa, Australia, Canada, Ukraine
RHENIUM	71	Chile, Kazakhstan, Germany, Russia
RARE EARTHS	68	China, France, Japan, United Kingdom
PLATINUM	66	South Africa, United Kingdom, Germany, Russia
ZINC	60	Canada, Mexico, Peru
TUNGSTEN	59	China, Russia, Germany, Portugal
TITANIUM (sponge)	58	Russia, Japan, Kazakhstan
NICKEL	56	Canada, Norway, Russia, Australia
PEAT	50	Canada
MAGNESIUM METAL	44	Canada, China, Russia, Israel
SILVER	44	Mexico, Canada, Peru, United Kingdom
SILICON	42	Norway, South Africa, Russia, Canada
BERYLLIUM	39	Russia, Canada, Germany, Kazakhstan
MAGNESIUM COMPOUNDS	39	China, Canada, Australia, Austria
ALUMINUM	35	Canada, Russia, Venezuela, Mexico
PUMICE	35	Greece, Italy, Turkey
DIAMOND (dust, grit, and powder)	33	Ireland, China, Russia
COPPER	31	Canada, Chile, Peru, Mexico
NITROGEN (fixed), AMMONIA	29	Trinidad and Tobago, Canada, Mexico
VERMICULITE	27	South Africa, China
GYPSUM	25	Canada, Mexico, Spain
CEMENT	21	Canada, Thailand, China, Venezuela, Greece
GARNET (industrial)	20	Australia, India, China
LEAD	20	Canada, Mexico, Australia, Peru
MICA, scrap and flake (natural)	19	Canada, India, Finland, China
PERLITE	18	Greece
SALT	17	Canada, Chile, Mexico, The Bahamas
IRON and STEEL	15	European Union, Canada, Japan, Mexico
IRON ORE	15	Canada, Brazil, Venezuela, Australia
SULFUR	12	Canada, Mexico, Venezuela
IRON and STEEL SLAG	8	Canada, Italy, Brazil, France
BROMINE	5	Israel, United Kingdom, Belgium, Netherlands
CADMIUM	3	Canada, Australia, Belgium, Germany
PHOSPHATE ROCK	2	Morocco
STONE (crushed)	1	Canada, Mexico, The Bahamas
TALC	1	China, Canada, France, Japan

[1]In descending order of import share

SIGNIFICANT EVENTS, TRENDS, AND ISSUES

The Mineral Sector of the U.S. Economy[1]

In March 2001, shrinking global markets, reduced consumer spending, and declines in domestic manufacturing and industrial output ended the longest economic expansion in U.S. history and pushed the Nation's economy into its first recession in more than a decade (Berry and Pearlstein, 2001; U.S. Geological Survey, 2001a, b). Exacerbated by the terrorist attacks of September 11, the recession led to large reductions in the domestic production of processed mineral materials. Some of the most significant production declines in the U.S. metals industry were registered by aluminum, copper, and steel producers who faced strong foreign competition, higher energy costs, and lower prices for their products. Nevertheless, homebuilding and other domestic construction sectors—major consumers of nonmetallic mineral products such as cement, brick, glass, and stone— remained strong enough to help raise the total output of industrial mineral materials slightly above previous year levels (table 1). A strong U.S. dollar relative to other national currencies continued to weaken the competitive stance of U.S. metal and nonmetal mineral materials companies alike against foreign producers in markets at home and abroad.

Overall Performance

The estimated value of all mineral-based products manufactured in the United States during 2001 fell by about 8% to $374 billion (page 4). The estimated total value of U.S. raw nonfuel minerals production alone was $39 billion, a slight decrease compared with that of 2000. Within the raw nonfuel minerals category, however, there was a significant difference between its metal and nonmetal components: The value of metals output dropped by more than 10% to $9.1 billion; the estimated production value of industrial minerals increased by 2% to $29.9 billion.

Net imports of raw minerals and processed mineral materials during 2001 reflected the effect of the recession and a continuing reliance on other countries for mineral products (page 5). Imports of raw and processed mineral materials fell by 9% from previous year levels to a value of $67 billion; aluminum, copper, and steel were among the largest imports. Exports of raw and processed mineral materials during 2001 dropped slightly to a value of $45 billion. Total imports and exports of metal ores/concentrates and raw industrial minerals were less than $5 billion.

Two major sectors of the U.S. economy, motor vehicle manufacturing and the construction industry, exerted considerable influence on domestic demand for mineral-based materials in 2001. In a largely successful effort to combat the recession, domestic motor vehicle manufacturers boosted their sales by offering no interest loans to purchasers of new vehicles late in the year. Consequently, yearend domestic market sales of U.S.-produced motor vehicles—incorporating large quantities of steel and other metals as well as significant amounts of glass and plastics—were revived and helped mineral materials suppliers to avoid even greater losses (Freeman and Lundegaard, 2001). The construction industry— accounting for most of the consumption of clay, cement, glass, sand and gravel, and stone—benefited from declining mortgage rates available to purchasers of residential housing units. In addition, Federal expenditures for building highways and mass transit systems helped buoy demand for cement, sand and gravel, steel, and stone in some areas (table 2).

In 2001, 14 States produced nonfuel mineral commodities with individual total production values of greater than $1 billion. These States were, in descending order, California, Nevada, Texas, Arizona, Florida, Michigan, Georgia, Minnesota, Missouri, Utah, Pennsylvania, Ohio, Alaska, and New York; they composed 63% of the U.S. total output value (table 3).

U.S. production of mineral fertilizer nutrients declined during 2001, primarily in response to decreased domestic and foreign demand caused by several factors, including low grain prices and high fertilizer inventories. Domestic demand for phosphate rock reached its lowest point since 1986. Total domestic output of sulfur decreased significantly in 2001 because the final U.S. Frasch sulfur mine closed during the year. U.S. potash consumption declined slightly. Lower demand, larger inventories, and high prices for natural gas used by ammonia producers forced them to operate well below rated plant capacity.

In fiscal year 2001, the Defense Logistics Agency (DLA) sold $583 million of excess mineral materials from the National Defense Stockpile (NDS). (See the "Government Stockpile" sections in the mineral commodity reports that follow.) Under authority of The Defense Production Act of 1950, the U.S. Geological Survey advises the DLA on acquisitions and disposals of NDS mineral materials. At the end of the fiscal year, mineral materials valued at more than $2.5 billion remained in the stockpile.

Outlook

At yearend 2001, economists were divided about the depth that the recession would reach and when economic recovery would begin. Those who expected the recovery to arrive in early 2002 focused on encouraging economic signs such as falling petroleum prices, a decline in rates of applications for unemployment insurance, stronger than expected holiday consumer spending, a rising stock market, record new home sales, and low supplier inventories (Economist, 2001; Irwin, 2001; Liu and Sanchanta, 2001). Forecasters of a longer recession, however, pointed to surveys showing lower confidence levels among manufacturers, declining business investment, falling producer prices, high unemployment, declining corporate profits, and conflicting indices of consumer confidence (Bureau of Labor Statistics, 2001).

[1]Staff, U.S. Geological Survey.

TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

	1997	1998	1999	2000	2001[e]
Total mine production:[1]					
Metals	13,100	11,400	9,800	10,100	9,050
Industrial minerals	27,400	28,200	29,300	29,200	29,900
Coal	19,800	19,700	18,300	18,000	19,000
Employment:[2]					
Coal mining	79	75	70	63	65
Metal mining	41	38	34	31	27
Industrial minerals, except fuels	82	83	86	87	86
Chemicals and allied products	573	587	583	577	566
Stone, clay, and glass products	431	439	443	456	447
Primary metal industries	555	560	547	456	507
Average weekly earnings of production workers:[3]					
Coal mining	863	857	856	850	888
Metal mining	791	812	813	809	824
Industrial minerals, except fuels	671	681	689	707	735
Chemicals and allied products	716	738	749	771	785
Stone, clay, and glass products	569	591	606	626	655
Primary metal industries	683	684	703	737	736

[e]Estimated.
[1]Million dollars.
[2]Thousands of production workers.
[3]Dollars.

Sources: U.S. Geological Survey, U.S. Department of Energy, U.S. Department of Labor.

The speed and strength of recovery in the domestic mineral materials industry will depend to a great extent on how long consumers will maintain the pace of new motor vehicle sales and new home purchases that were underway in late 2001. At that time, home mortgage rates already had reached a 30-year low, and motor vehicle manufacturers announced that future no interest loans would be limited (Berry, 2001b; Fleishman, 2001). If further reductions in the prime lending rate are continued by the Federal Reserve Board in 2002, however, the low financing rates offered to home and motor vehicle buyers may be extended. In December, the Federal Reserve made its 11th cut in lending rates during 2001 and was expected by some economists to make further reductions early in 2002 (Berry, 2001a).

Significant International Events[2]

The third millennium dawned inauspiciously for the leading countries in the world economy, although worse was yet to come. The largest national economy, the United States, experienced a buying frenzy in the so-called high-tech stocks that collapsed after the first quarter and pulled the equities markets down. The large Japanese economy continued to experience declining consumer prices in the midst of classic deflation and virtually zero interest rates. Meanwhile, the economy of the European Union (EU) experienced slow growth due to low productivity and consumer confidence. High interest rates did nothing to stimulate domestic demand, exports, or the value of the euro, which recovered somewhat from its lows in currency markets, but did not approach its original issue value of about US$1.18. Withal, it was a weak economic stage that was set for the startling terrorist tragedies of September 2001, bringing further weaknesses to bear as events unfolded.

The financial shocks that began in Asia in 1997 involved weak banking practices, over-optimistic entrepreneurial activity, and a loss of confidence that resulted in major financial contractions in several countries that had been characterized as Asian “tigers.” A recovery that began in east Asia and Southeast Asia stalled in 2000, not only in Asia but also in Europe, where the EU’s monetary, financial, and mercantile requirements did not fit each country well in all cases, adding a degree of uncertainty to what was widely heralded as a broad economic achievement. Meanwhile, the United States generated the major part of the demand growth in the world economy, providing time for other countries to restructure their fiscal systems, reduce interest rates, and readjust their trade arrangements to participate in the global expansion. The U.S. economy, however, was based at least partly on growing equity values as well as a high ratio of private-sector debt to gross domestic product. Although monetary inflation was held in check by the actions of the Federal Reserve Board, the bursting of the technology-equities bubble in 2001 involved a loss of confidence that spread quickly to all equities markets, many commodity prices, and real estate. Private-sector debt collateralized by equities swelled and threatened both commercial and personal financial positions. In addition, early in the year a shortage of electrical power in California, largely the result of a partial deregulation of the electric power industry (Jenkins, 2001; Harris, 2001),

[2]David B. Doan and staff.

TABLE 2.—U.S. MINERAL-RELATED ECONOMIC TRENDS

	1997	1998	1999	2000	2001[e]
Gross domestic product (billion dollars)	8,318	8,782	9,269	9,873	10,200
Industrial production (1992=100):					
Total index	128	134	139	146	141
Manufacturing	131	139	145	152	145
Stone, clay, and glass products	121	127	131	134	132
Primary metals	125	128	129	132	119
Iron and steel	124	124	124	127	115
Nonferrous metals	127	132	136	138	123
Chemicals and chemical products	115	118	119	122	121
Mining	105	103	98	100	102
Metals	109	108	100	97	90
Coal	108	110	108	107	113
Oil and gas extraction	103	99	92	96	96
Stone and earth minerals	120	123	128	130	134
Capacity utilization (percent):					
Total industry	83	82	81	82	77
Mining	90	88	85	89	91
Metals	89	88	82	81	77
Stone and earth minerals	85	84	85	86	88
Housing starts (thousands)	1,470	1,620	1,650	1,580	1,609
Automobile sales (thousands)[1]	6,910	6,750	6,990	6,840	6,600
Highway construction, value, put in place (billion dollars)	43	45	52	53	57

[e]Estimated.

[1]Excludes imports.

Sources: U.S. Department of Commerce, Federal Reserve Board, Autodata Corp., and U.S. Department of Transportation.

spread to surrounding States that were facing tight electrical power markets of their own caused by low water levels at the reservoirs that supplied hydropower. The "energy crisis" threatened to bankrupt two of California's largest power companies and increased uncertainties in the California business community. It also disrupted metal production regionally. Aluminum companies in the Pacific Northwest and copper producers in the Southwest took plants off line as it became more profitable to sell power than to produce metal. The longer term impact of the crisis is still to be seen and will depend upon the ability of industrial users to obtain reliable sources of power at acceptable prices.

Amidst the contraction of markets in the United States, the remainder of the world fared no better. The Japanese problem involved a surfeit of bad debt still owed to its banks after a 10-year-old collapse in real estate values, and the banks' reluctance to write off nonperforming loans and cease supporting commercial loans to firms that would otherwise be bankrupt. A new Japanese administration hoped to force change but would probably have to break economic traditions in the country. Allowing the yen to move lower in value would stimulate exports but might well force other Asian currencies to follow suit, to no one's advantage (Pilling and Thornhill, 2002).

The European Central Bank coped with the slump of the U.S. economy at the same time that the EU was working on the consolidation of its constituent economies, rationalizing differences between governments of varying political orientation, no small task, and economic integration seemed to progress more rapidly than political integration. The confidence of EU investors dropped when the high-tech bubble burst in U.S. equity markets, and although the euro rallied somewhat in July, EU exports to the United States were down and interest rates were high enough to soften domestic demand. Overall, the trend of growth rates for the EU's three biggest economies, France, Germany, and the United Kingdom, slowed conspicuously in the first three quarters of 2001. The short leading index growth rate of the French economy was negative throughout the first 10 months of 2001 (Foundation for International Business and Economic Research, 2001a). The short leading index growth rates for the United Kingdom and Germany similarly fell throughout the first 10 months of 2001 (Foundation for International Business and Economic Research, 2001b, c). Thus, these three principal national economic engines languished through the spring, summer, and early fall.

The terrorist attacks of September 11, destroying symbols and some assets of world capitalism as well as damaging the headquarters of the U.S. military establishment, probably changed the world for the foreseeable future. But the destruction, as well as the loss of many lives, provided a clear rallying point and overwhelming justification for elimination of the terrorists. The comment has been heard that things will never be the same after this event, but similar comments were made in

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2001[p 1]

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$938,000	16	2.41	Cement (portland), stone (crushed), lime, sand and gravel (construction), cement (masonry).
Alaska	1,060,000	13	2.73	Zinc, gold, lead, sand and gravel (construction), silver.
Arizona	2,110,000	4	5.43	Copper, sand and gravel (construction), cement (portland), stone (crushed), lime.
Arkansas	491,000	30	1.26	Bromine, stone (crushed), cement (portland), sand and gravel (construction), gypsum (crude).
California	3,250,000	1	8.35	Sand and gravel (construction), cement (portland), boron minerals, stone (crushed), gold.
Colorado	676,000	22	1.74	Sand and gravel (construction), molybdenum concentrates, cement (portland), stone (crushed), gold.
Connecticut[2]	104,000	43	0.27	Stone (crushed), sand and gravel (construction), stone (dimension), clays (common), gemstones.
Delaware[2]	13,100	50	0.03	Sand and gravel (construction), magnesium compounds, gemstones.
Florida	1,750,000	5	4.50	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), cement (masonry).
Georgia	1,610,000	7	4.13	Clays (kaolin), stone (crushed), cement (portland), clays (fuller’s earth), sand and gravel (construction).
Hawaii	69,700	45	0.18	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), gemstones.
Idaho	344,000	35	0.88	Phosphate rock, silver, sand and gravel (construction), cement (portland), stone (crushed).
Illinois	911,000	17	2.34	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime.
Indiana	718,000	20	1.84	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Iowa	487,000	31	1.25	Stone (crushed), cement (portland), sand and gravel (construction), gypsum (crude), lime.
Kansas	640,000	23	1.64	Helium (Grade-A), cement (portland), salt, stone (crushed), helium (crude).
Kentucky	531,000	26	1.37	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (ball).
Louisiana	274,000	37	0.70	Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime.
Maine	91,000	44	0.23	Sand and gravel (construction), cement (portland), stone (crushed), cement (masonry), stone (dimension).
Maryland[2]	356,000	33	0.92	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts[2]	209,000	39	0.54	Stone (crushed), sand and gravel (construction), stone (dimension), lime, clays (common).
Michigan	1,620,000	6	4.17	Cement (portland), iron ore (usable), sand and gravel (construction), stone (crushed), magnesium compounds.
Minnesota	1,440,000	8	3.70	Iron ore (usable), sand and gravel (construction), stone (crushed), stone (dimension), sand and gravel (industrial).
Mississippi	177,000	41	0.45	Sand and gravel (construction), stone (crushed), cement (portland), clays (fuller’s earth), sand and gravel (industrial).
Missouri	1,340,000	9	3.45	Stone (crushed), cement (portland), lead, lime, zinc.
Montana	514,000	29	1.32	Palladium, gold, platinum, cement (portland), sand and gravel (construction).
Nebraska	163,000	42	0.42	Cement (portland), stone (crushed), sand and gravel (construction), lime, cement (masonry).
Nevada	2,930,000	2	7.53	Gold, sand and gravel (construction), silver, lime, cement (portland).
New Hampshire[2]	60,300	47	0.16	Sand and gravel (construction), stone (crushed), stone (dimension), gemstones.
New Jersey[2]	348,000	34	0.90	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2001^{p} [1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
New Mexico	$615,000	24	1.58	Copper, potash, sand and gravel (construction), cement (portland), stone (crushed).
New York	1,050,000	14	2.70	Stone (crushed), cement (portland), salt, sand and gravel (construction), wollastonite.
North Carolina	744,000	19	1.91	Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), feldspar.
North Dakota	39,300	48	0.10	Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial).
Ohio	1,070,000	12	2.74	Stone (crushed), sand and gravel (construction), salt, lime, cement (portland).
Oklahoma	530,000	28	1.36	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), gypsum (crude).
Oregon	326,000	36	0.84	Sand and gravel (construction), stone (crushed), cement (portland), diatomite, lime.
Pennsylvania[2]	1,270,000	11	3.27	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Rhode Island[2]	28,300	49	0.07	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), gemstones.
South Carolina	531,000	27	1.36	Cement (portland), stone (crushed), cement (masonry), sand and gravel (construction), clays (kaolin).
South Dakota	255,000	38	0.66	Gold, cement (portland), sand and gravel (construction), stone (crushed), stone (dimension).
Tennessee	708,000	21	1.82	Stone (crushed), cement (portland), zinc, sand and gravel (construction), clays (ball).
Texas	2,210,000	3	5.68	Cement (portland), stone (crushed), sand and gravel (construction), salt, lime.
Utah	1,310,000	10	3.36	Copper, gold, cement (portland), sand and gravel (construction), salt.
Vermont[2]	68,900	46	0.18	Stone (dimension), stone (crushed), sand and gravel (construction), talc (crude), gemstones.
Virginia	751,000	18	1.93	Stone (crushed), cement (portland), sand and gravel (construction), lime, clays (fuller's earth).
Washington	545,000	25	1.40	Sand and gravel (construction), stone (crushed), cement (portland), magnesium metal, gold.
West Virginia	185,000	40	0.48	Stone (crushed), cement (portland), sand and gravel (industrial), lime, salt.
Wisconsin[2]	368,000	32	0.95	Sand and gravel (construction), stone (crushed), lime, sand and gravel (industrial), stone (dimension).
Wyoming	986,000	15	2.53	Soda ash, clays (bentonite), cement (portland), helium (Grade-A), sand and gravel (construction).
Undistributed	85,300	XX	0.22	XX.
Total	38,900,000	XX	100.00	XX.

^{p}Preliminary. XX Not applicable.

[1]Data are rounded to three significant digits; may not add to totals shown.

[2]Partial total; excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed."

the midst of fear and even panic after the attack on Pearl Harbor in 1941. The equities market declined immediately, demonstrated conspicuous volatility for a few months, recovered fully in about 10 months, and climbed higher for several years. The commitment of U.S. troops to Korea in 1950, the Cuban missile crisis, and U.S. operations to restore the sovereignty of Kuwait all demonstrated the same pattern of stock market fluctuations. In each case, investor confidence was damaged, then uncertainty ruled in the equity markets, and finally investor confidence was restored.

During 2001, investor confidence had been progressively impaired, with more and more capital moving to the sidelines as investors preferred liquidity rather than commitment; then confidence was virtually shattered with the destruction of the World Trade Center. Infusions of capital by the central bank maintained liquidity in the United States and other countries, and monetary loosening by the Federal Reserve Board had been applied incrementally throughout 2001. The European Central Bank, however, has been hesitant to lower interest rates for the stimulation of growth, to the detriment of its equities markets. Japan has continued in its slump, but the terrorist shock may provide reasons to make tough decisions regarding bad loans that would help the Japanese economy on its way to recovery.

In the fourth quarter of the year, much capital remained sequestered, including risk capital that would in other circumstances have gone to exploration and mining. Markets for mineral commodities have been showing the effects of worsened economies and deflation. In addition, softening demand for new commercial aircraft, which resulted from the events of September 11, will likely be felt in the titanium and aluminum industries in 2002 (Sacco and others, 2001). Paradoxically, if history is any guide, the terrorist actions could lead to the beginning of an era of business expansion, enhanced trade, the restoration of confidence in 2002, and new activity in which risk capital moves toward reconstruction, the firming of mineral demand (especially the metals), and new ventures in the location and extraction of the materials needed by a strengthened world economy.

By yearend, equity markets in the United States had accomplished at least a partial recovery from the effects of the terrorist attacks, but the country's great economic engine labors with lowered employment, layoffs, and conspicuously reduced business spending. According to the United Nations Conference on Trade and Development (UNCTAD), foreign direct investment, already headed sharply downward from $1.3 trillion in 2000 to $760 billion in 2001 before the terrorist attacks, will likely fall at least 50% by the end of 200l (Millman, 2001). UNCTAD's projections are the lowest in 30 years and are likely to lead to increased efforts to put U.S. trade authority on a fast track, in that trade creates wealth and U.S. prosperity depends greatly on trade. Before this happens, consumer spending by U.S. citizens may well be the savior of the national economy, which may in turn foster the restoration of international trade and investor and consumer confidence abroad.

The Latin American amalgam of diverse economies absorbed various setbacks, but could lose more than most other regions as the result of the terrorist strikes in the United States. Mexico's mercantile ties to its northern neighbor are strong and profitable but vulnerable to the U.S. slowdown and the economic shock of September. Much of Latin America, even with looser ties, is likewise affected. Colombia coped with a three-sided civil war, not just a war on drugs. In Peru, two events of note occurred in 2001. First was the election of a new government, which indicated that it would pursue policies to encourage mineral exploration. The second event was the startup of operations at the giant Antamina copper-zinc deposit. Brazil devalued its currency repeatedly during 1999, 2000, and 2001, causing repercussions with its Mercosur trading partners. The Government of Brazil introduced power rationing to deal with energy shortages that were caused by a prolonged drought. Hydroelectric power provides 90% of Brazil's electricity. The aluminum and steel industries faced significant reductions in electric power supplies (Mining Journal, 2001). Argentina endured a worsening recession and an inability to pay off debt unless supported by International Monetary Fund loans, which did not appear to be forthcoming. Venezuela has seen its currency soften as citizens sell their inflating bolivars to acquire dollars. In turn, Latin America's economic health affects Europe; more than a quarter of Spanish companies' revenues were derived from Latin America (Sesit, 2001).

Africa made headlines in the War on Terrorists on several fronts. Reports appeared that Al Qaeda had profited by purchasing diamonds in Sierra Leone and the eastern Congo (Kinshasa) and selling them in Europe and the Middle East (Farah, 2001a). This was in addition to the already chilling accounts of the role of so-called blood diamonds in financing civil wars in Africa (Duke, 2001; Farah, 2001b). Other reports linked the smuggling of the semiprecious gem tanzanite to supporters of Osama bin Laden (Block and Pearl, 2001). The United Nations (UN) panel investigating the exploitation of natural resources in the Democratic Republic of the Congo (Kinshasa) issued several reports on the exploitation of Congo's natural resources by countries aiding the combatants in the civil war. The panel recommended the UN impose a moratorium on the exportation of high-value commodities, including columbite-tantalite, cobalt, copper, and gold, and that a review be conducted of concessions and commercial agreements signed by the assassinated President Laurent Kabila (Metal Bulletin, 2001).

The countries of Southeast Asia suffered from a significant diminishing of import demand by the United States as well as increasing competition by China for market share. China at present receives about 80% of east Asia's foreign direct investment, while the Association of Southeast Asian Nations (Asean) members get about 20%, reversing the situation 10 years ago when Asean members were solidly on top. The 1997 financial crisis did not spur the reforms that many had hoped for, including the development of more transparent and accountable institutions. Much of Southeast Asia is seen as less stable than at any time since the 1970s (Pura and Borsuk, 2001).

Two countries of particular significance to the United States and its interests, especially in the pursuit and elimination of terrorists and terrorist organizations, are China and Russia, each of which, in somewhat different ways, is evolving toward a market economy. In the 1990s, Russia sustained a total collapse of the communist system of central planning, followed by upheaval and a certain degree of financial buccaneering, as assets were transferred to private hands. After the financial devaluation of 1998, Russia finally seemed to achieve a level of economic stability. Planners had evidently hoped that a weaker ruble would encourage domestic industry and enhance export competitiveness, however, the main source of stability was income from natural-resource exports of oil and metals. The increased exports of natural resources has driven the ruble's value upward, which could discourage exports of manufactured goods and create problems for agricultural entities. One result of high prices for platinum-group metals has been significantly increased earnings for Noril'sk Nickel RAO, which began the process of modernizing its smelters. Taxes on personal income and corporate profits have been lowered, and foreign currency reserves have risen sharply; some Western creditors say that Russia is now strong enough to settle its external debts in full (Chazan, 2001). A looming problem for Russia, whose oil production now puts it as number two in the ranks of the major producers of the world, is the possibility of a price war with members of the Organization of Petroleum Exporting Countries (OPEC).

China moved gradually from central planning to centrally guided privatization of state-owned production facilities. Banking likewise moved slowly from an abundance of distressed debt, the result of years of Government-mandated lending, to a program of restructuring centered around the offering for sale of billions of dollars of troublesome loans, the greatest proportion of them involving state-owned enterprises. China's entry into the World Trade Organization (WTO) could result in reforms in most of the provinces' old and traditional ways of operating and could lead to the nurturing of free markets and capital formation as understood by the West. The prices of commodities and manufactured goods, which have long been tied to China's state-enterprise earnings are increasingly vulnerable to change, as a result of China's membership in the WTO. Although China's entry into the WTO is expected to result in an increase in foreign direct investment of 16% a year between 2002 and 2006 (Financial Times, 2001), and a shrinking appetite in the United States for Chinese exports extended the effects of the U.S. slump and terrorist slowdown even to the Chinese economy. Deflation became a clear possibility in China.

The terrorist strikes were the most recent test of the importance of gold, the price of which briefly increased by about 9% after the attacks, but which has since subsided, although the purchase of gold coins by individuals has increased markedly. Gold mining companies continued hedging operations, equivalent to selling gold at a given price to lock in profits in the event that market prices fall. The considerable volume of such sales itself tends to push the price lower. Many gold mining companies have had to shut down operations because of market price doldrums, while others are thought to be subsisting solely on income from hedging. The effect of hedging is to put more gold on the market; produced uneconomically, it increases the supply and lowers the price. In the longer term, the behavior of gold prices may depend upon whether it continues to serve as a store of value.

Monetary policies have played an increasingly important role relative to fiscal actions in sustaining various countries' economies at optimum performance. Currency manipulations through buying and selling, interest-rate changes, and revaluations are a continuing feature of the various national components of the world economy. Monetary activities, which in the present era of fiat money are the management tools of central banking systems, have provided at least temporary advantage in some circumstances and mitigated crises in others. A strong argument is made from time to time that adherence to a gold standard would mean that the Federal Reserve Board could stop estimating how much liquidity is good for the economy and allow the market to make that decision instead (Kemp, 2001). At present, however, the U.S. dollar has become a de facto standard of value in many parts of the world and gold has tended to fade in importance. Advocates of a gold standard are concerned that sooner or later at some random moment not now predictable, a major decision will be forced upon some central bank in the form of a choice between paper and gold, the paper being quite possibly the U.S. dollar. They argue that gold is universally recognizable, attractive, portable, durable, and unattached to any particular Government, bank, or company and that it possesses an independently verifiable value. Paper, they say, is none of these, being subject to whimsy, manipulation, and disaster.

In a broader sense, whether transactions are conducted in paper or commodities, the physical world operates on energy, deliverable on demand as needed. Although the energy may be from coal, oil, natural gas, hydroelectric installations, wind power, or solar power, its use to provide light, heat, and fuel for engines involves markets that are increasingly integrated. Transactions in electric power markets may literally take place at the speed of light (Harris, 2001). It has been said that energy is the currency of technology, and it plays a role in world economics rivaling that of money. Lack of electrical energy threatened to bring down the economy of California faster than lack of money from equity markets.

Crude oil prices had dropped from a high of about $32 per barrel in January 2001, down to about $27 in September, reflecting softening of demand in the world economic slump. The terrorist strike then pushed the price down abruptly as airlines canceled flights in response to sharp decreases in business and recreational travel. In November, the price of oil fell below $20, widely considered to be a floor. OPEC debated production cutbacks, even before September 11, but was faced with a new problem when Mexico, Norway, and Russia evinced no inclination to cut their production. OPEC had to deal with the possibility that by cutting any of its roughly 40% share of world production, it might simply be yielding more market share to non-OPEC countries. Russia, owing its increasing financial stability to its oil and gas production, could enhance its income by achieving a larger market share, but any price war with OPEC could result in smaller profits but on greater sales.

Nationally and internationally, the mining industry is sensitive not only to market demand and price for its products but also to the availability of capital and energy. Demand and pricing may improve sometime in 2002, but capital and energy are now seen to be subject to an unanticipated influence: terrorist destructiveness.

References Cited

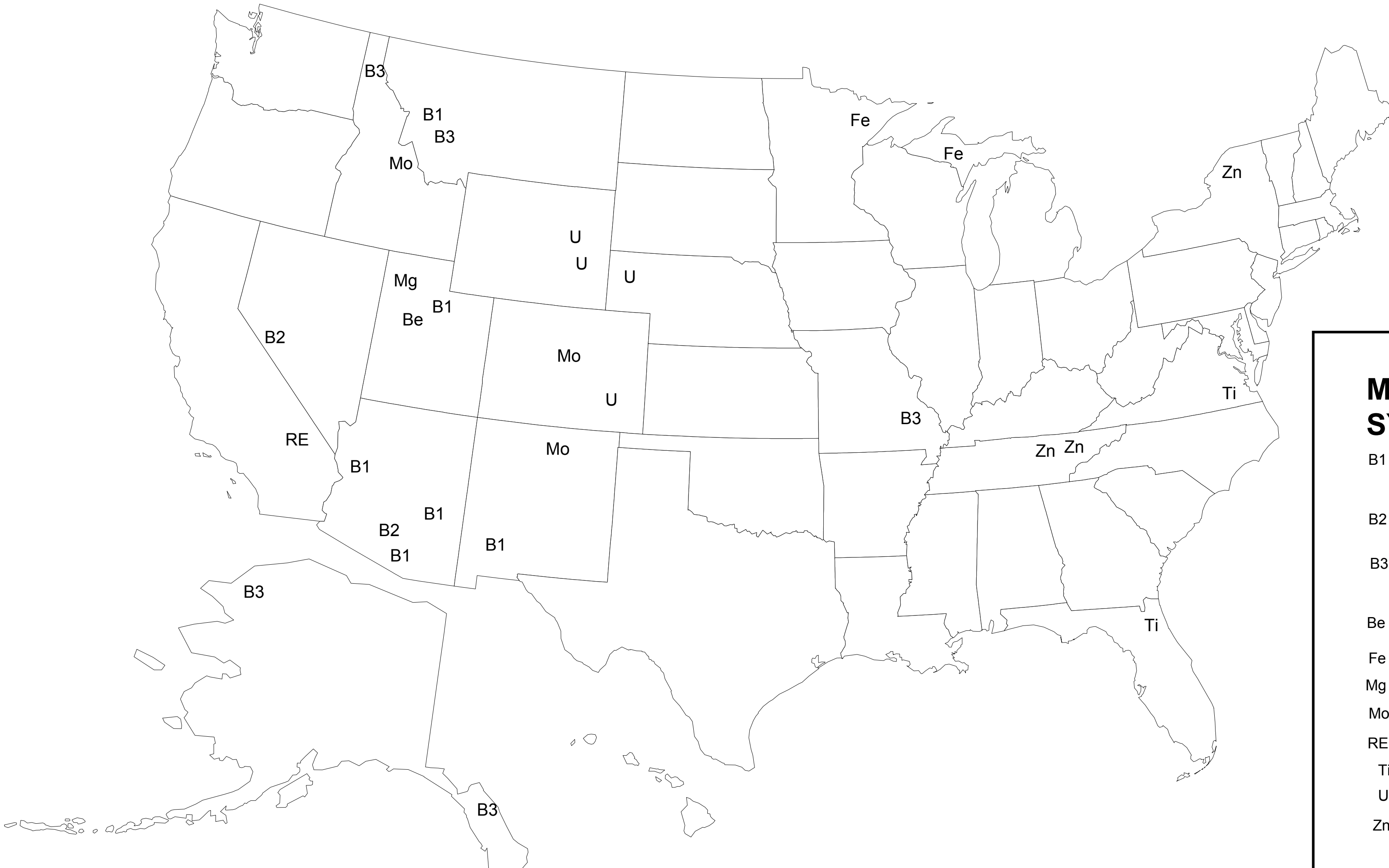
Berry, J.M., 2001a, Fed trims rates but cites gains: Washington Post, December 12, p. A1, A12.

———2001b, New sign of a sharp downturn: Washington Post, November 3, p. E1, E2.

Berry, J.M., and Pearlstein, Steven, 2001, Economy slipped into recession in March, panel says: Washington Post, November

27, p. A1, A8.
Block, Robert, and Pearl, Daniel, 2001, Much-smuggled gem called tanzanite helps bin Laden supporters: Wall Street Journal, November 16, p. A1, A8.
Bureau of Labor Statistics, 2001, Daily report: U.S. Department of Labor, November 23, 2 p.
Chazan, Guy, 2001, Russia may borrow $2 billion next year to cover its debts: Wall Street Journal, August 24, p. A6.
Duke, Lynne, 2001, Diamond trade's tragic flaw—Atrocities in African war zones threaten industry, some economies: Washington Post, April 29, p. H1, H4.
Economist, The, 2001, Message of hope?: The Economist (London), v. 361, no. 8249, November 24, p. 66-67.
Farah, Douglas, 2001a, Al Qaeda cash tied to diamond trade: Washington Post, November 2, p. A1, A22.
———2001b, Digging up Congo's dirty gems: Washington Post, December 30, p. A1.
Financial Times, 2001, China enters WTO dawn with mixed expectation: Financial Times, December 11, p. 6.
Fleishman, Sandra, 2001, When refinancing, it's hurry up and wait: Washington Post, November 10, p. H1, H13.
Foundation for International Business and Economic Research, 2001a, France—Continued sluggishness, no definitive sign of improvement: Foundation for International Business and Economic Research, November 5, p. 1.
———2001b, Germany—Slowdown continues, long-term prospects for recovery: Foundation for International Business and Economic Research, October 24, p. 1.
———2001c, United Kingdom—Slow growth continues: Foundation for International Business and Economic Research, November 7, p. 1.
Freeman, Sholnn, and Lundegaard, Karen, 2001, New-car deals shake up market for used vehicles: Wall Street Journal, November 11, p. B1, B3.
Harris, P.G., 2001, Where electricity deregulation works: Wall Street Journal, May 16, p. A22.
Irwin, Neil, 2001, Economy shrank in last quarter: Washington Post, December 10, p. E1, E8.
Jenkins, H.W., Jr., 2001, Maybe the utilities weren't so dumb after all: Wall Street Journal, May 16, p. A 23.
Kemp, Jack, 2001, Our economy needs a golden anchor: Wall Street Journal, June 28, p. A16.
Liu, Betty, and Sanchanta, Mariko, 2001, US retailers cheered by holiday sales: Financial Times (London), November 27, p. 21.
Metal Bulletin, 2001, UN report recommends Congo export ban: Metal Bulletin, no. 8628, November 26, p. 11.
Millman, Joel, 2001, International investment falls for 1st time since '91: Wall Street Journal, September 24, p. A8.
Mining Journal, 2001, Brazil rations power: Mining Journal: v. 336, no. 8637, June 8, p. 433, 437.
Pilling, David, and Thornhill, John, 2002, Japan's currency trap: Financial Times, January 16, p. 12.
Pura, Raphael, and Borsuk, Richard, 2001, Politics-as-usual hinders southeast Asia: Wall Street Journal, July 30, p. A15, A16.
Sacco, John, Haflich, Frank, and Lauchlan, Polina, 2001, Metals industry waits to feel effect of aerospace downturn: Metal Bulletin, no. 8611, September 27, p. 5.
Sesit, M.R., 2001, If Argentina's woes worsen, effects may spread through markets with links to Latin America: Wall Street Journal, October 29, p. A11.
U.S. Geological Survey, 2001a, Stone, clay, glass, and concrete products industry indexes, December 2001: U.S. Geological Survey, December, 5 p. (available only online at URL http://minerals.usgs.gov/minerals/pubs).
———2001b, Metal industry indicators, December 2001: U.S. Geological Survey, December, 12 p.

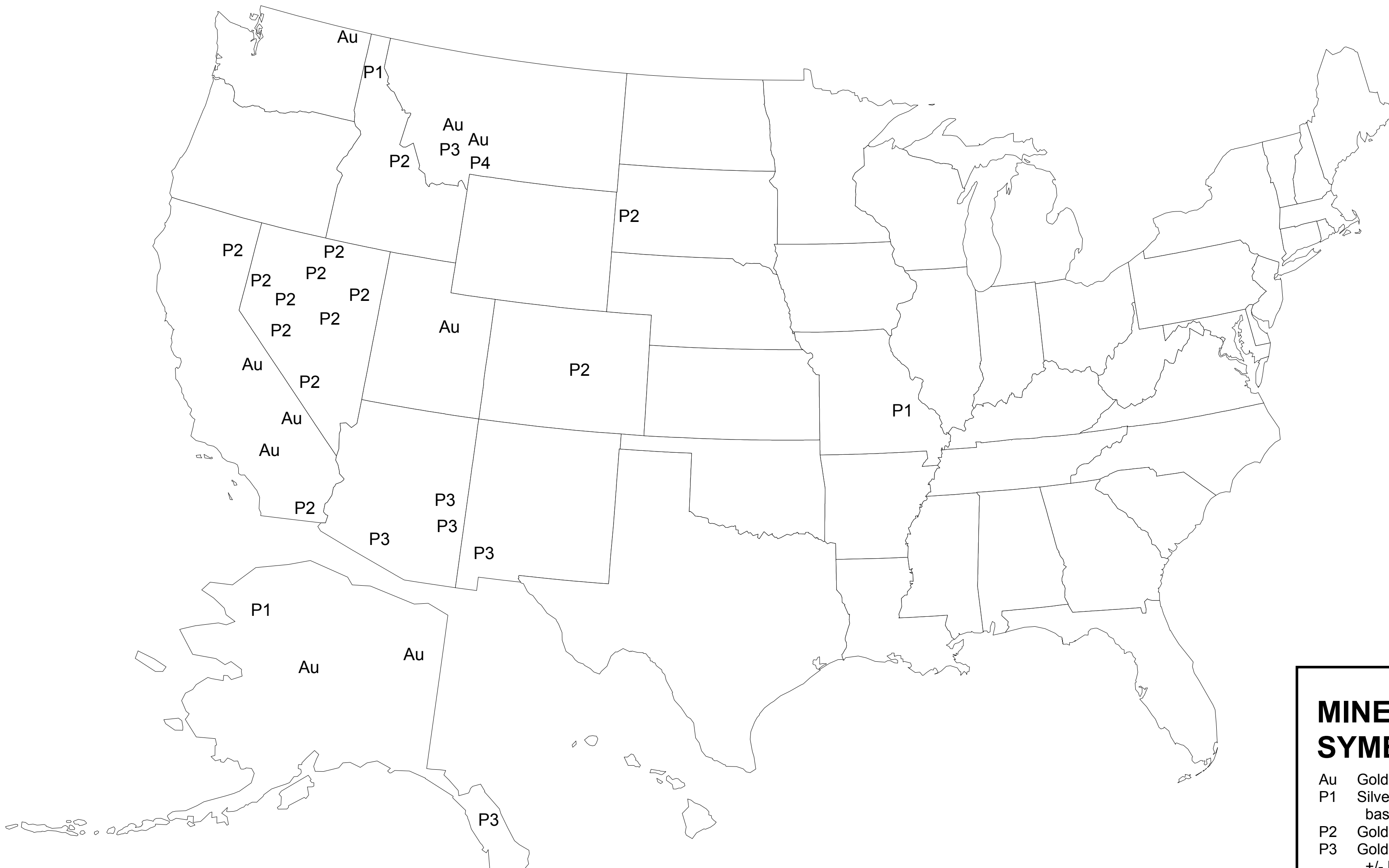
MAJOR BASE AND FERROUS METAL PRODUCING AREAS



MINERAL SYMBOLS

B1	Copper and molybdenum +/- gold, silver
B2	Copper +/- gold, silver
B3	Lead, zinc +/- copper +/- gold +/- silver
Be	Beryllium
Fe	Iron
Mg	Magnesium
Mo	Molybdenum
RE	Rare earths
Ti	Titanium minerals
U	Uranium
Zn	Zinc

MAJOR PRECIOUS METAL PRODUCING AREAS



MINERAL SYMBOLS

Au	Gold
P1	Silver +/- base metals
P2	Gold and silver
P3	Gold and silver +/- base metals
P4	Platinum and palladium

MAJOR INDUSTRIAL ROCK AND MINERAL PRODUCING AREAS - PART I

MAJOR INDUSTRIAL ROCK AND MINERAL PRODUCING AREAS - PART II

MINERAL SYMBOLS

BC	Ball clay
Bent	Bentonite
Clay	Common clay
DS	Dimension stone
FC	Fire clay
Fel	Feldspar
Ful	Fuller's earth
IS	Industrial sand
Ka	Kaolin
Li	Lithium carbonate
Per	Perlite
Pum	Pumice and pumicite

ABRASIVES (MANUFACTURED)

(Fused aluminum oxide and silicon carbide)
(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Fused aluminum oxide was produced by three companies at six plants in the United States and Canada. Production of regular-grade fused aluminum oxide was valued at about $18.1 million, and production of high-purity fused aluminum oxide was estimated at a value of more than $4.6 million. Silicon carbide was produced by three companies at three plants in the United States and Canada. Domestic and Canadian production of crude silicon carbide had an estimated value of more than $28.1 million. Bonded and coated abrasive products accounted for most abrasive uses of fused aluminum oxide and silicon carbide.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, United States and Canada (crude):					
Fused aluminum oxide, regular	93,500	99,600	[1]85,000	[1]90,000	[1]60,000
Fused aluminum oxide, high-purity	14,200	[1]15,000	[1]10,000	[1]10,000	[1]10,000
Silicon carbide	68,200	[1]70,000	[1]65,000	[1]45,000	[1]45,000
Imports for consumption (U.S.):					
Fused aluminum oxide	138,000	180,000	166,000	227,000	227,000
Silicon carbide	240,000	268,000	169,000	190,000	133,000
Exports (U.S.):					
Fused aluminum oxide	10,700	8,910	9,020	9,020	9,900
Silicon carbide	16,100	11,600	8,560	10,000	9,880
Consumption, apparent (U.S.):					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	NA	NA	NA	NA	NA
Price, range of value, dollars per ton, United States and Canada:					
Fused aluminum oxide, regular	370	361	351	331	302
Fused aluminum oxide, high-purity	570	550	425	566	511
Silicon carbide	490	610	600	585	624
Net import reliance[2] as a percentage of apparent consumption (U.S.)	NA	NA	NA	NA	NA

Recycling: Up to 30% of fused aluminum oxide may be recycled, and about 5% of silicon carbide is recycled.

Import Sources (1997-2000): Fused aluminum oxide, crude: Canada, 63%; China, 30%; and other, 7%. Fused aluminum oxide, grain: China, 42%; Canada, 23%; Austria, 11%; and other, 24%. Silicon carbide, crude: China, 82%; Canada, 13%; and other, 5%. Silicon carbide, grain: China, 57%; Brazil, 12%; Norway, 10%; Germany, 6%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Fused aluminum oxide, crude	2818.10.1000	Free.
Fused aluminum oxide, grain	2818.10.2000	1.3% ad val.
Silicon carbide, crude	2849.20.1000	Free.
Silicon carbide, grain	2849.20.2000	0.5% ad val.

Depletion Allowance: None.

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648- 7722]**

ABRASIVES (MANUFACTURED)

Government Stockpile: During the first three quarters of 2001, the Department of Defense sold 79.8 tons of fused aluminum oxide grain from the National Defense Stockpile (NDS) for $39,600. If current disposal rates and sale schedules continue, all fused aluminum oxide grain in the NDS will be sold by yearend 2003.

Stockpile Status—9-30-01[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Fused aluminum oxide, crude	—	5,956	—	—	—
Fused aluminum oxide, grain	16,287	20	16,287	5,443	167

Events, Trends, and Issues: Imports and higher operating costs continued to challenge producers in the United States and Canada. In June 2001, the last Canadian silicon carbide producer closed. Now there is only one silicon carbide producer left in North America. This means that the United States will now depend on imports to meet its needs for silicon carbide. Foreign competition, particularly from China, is expected to persist and further curtail production in North America.

World Production Capacity:

	Fused aluminum oxide capacity		Silicon carbide capacity	
	2000	2001[e]	2000	2001[e]
United States and Canada	160,000	160,000	85,000	70,000
Argentina	—	—	5,000	5,000
Australia	50,000	50,000	—	—
Austria	60,000	60,000	—	—
Brazil	50,000	50,000	43,000	43,000
China	460,000	460,000	455,000	455,000
France	40,000	40,000	16,000	16,000
Germany	80,000	80,000	36,000	36,000
India	40,000	40,000	5,000	5,000
Japan	50,000	50,000	60,000	60,000
Mexico	—	—	30,000	30,000
Norway	—	—	80,000	80,000
Venezuela	—	—	40,000	40,000
Other countries	80,000	80,000	190,000	190,000
World total (rounded)	1,070,000	1,070,000	1,050,000	1,030,000

World Resources: Although domestic resources of raw materials for the production of fused aluminum oxide are rather limited, adequate resources are available in the Western Hemisphere. Domestic resources are more than adequate for the production of silicon carbide.

Substitutes: Natural and manufactured abrasives, such as garnet or metallic abrasives, can be substituted for fused aluminum oxide and silicon carbide in various applications.

[e]Estimated. NA Not available. — Zero.
[1]Rounded to the nearest 5,000 tons to protect proprietary data.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B for definitions.

ALUMINUM[1]

(Data in thousand metric tons of metal, unless otherwise noted)

Domestic Production and Use: In 2001, 12 companies operated 23 primary aluminum reduction plants. The 11 smelters east of the Mississippi River accounted for 77% of the production; whereas the remaining 12 smelters, which included the 10 Pacific Northwest smelters, accounted for only 23%. Based upon published market prices, the value of primary metal production was $4 billion in 2001. Aluminum consumption, by an estimated 25,000 firms, was centered in the East Central United States. Transportation accounted for an estimated 35% of domestic consumption in 2001; packaging, 25%; building, 15%; consumer durables, 8%; electrical, 7%; and other, 10%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Primary	3,603	3,713	3,779	3,668	2,600
Secondary (from old scrap)	1,530	1,500	1,570	1,370	1,300
Imports for consumption	3,080	3,550	4,000	3,910	3,600
Exports	1,570	1,590	1,640	1,760	1,500
Shipments from Government stockpile excesses	57	([2])	—	—	—
Consumption, apparent[3]	6,720	7,090	7,770	7,530	6,000
Price, ingot, average U.S. market (spot), cents per pound	77.1	65.5	65.7	74.6	70.0
Stocks:					
Aluminum industry, yearend	1,860	1,930	1,870	1,550	1,500
LME, U.S. warehouses, yearend[4]	8	13	14	([2])	20
Employment, primary reduction, number	18,000	18,400	17,900	17,200	15,700
Net import reliance[5] as a percentage of apparent consumption	23	27	31	33	35

Recycling: In 2001, aluminum recovered from purchased scrap was about 3.2 million tons, of which about 60% came from new (manufacturing) scrap and 40% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 20% of apparent consumption.

Import Sources (1997-2000): Canada, 58%; Russia, 19%; Venezuela, 4%; Mexico, 3%; and other, 16%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Unwrought (in coils)	7601.10.3000	2.6% ad val.
Unwrought (other than aluminum alloys)	7601.10.6000	Free.
Waste and scrap	7602.00.0000	Free.

Depletion Allowance: Not applicable.[1]

Government Stockpile: None.

Prepared by **Patricia A. Plunkert [(703) 648-4979, pplunker@usgs.gov, fax: (703) 648-7757]**

ALUMINUM

Events, Trends, and Issues: Domestic primary aluminum production decreased significantly owing to smelter production cutbacks caused by increased energy costs and reduced energy supply in the Pacific Northwest. By mid-year, about 1.6 million tons per year of smelter capacity in Montana, Oregon, and Washington was closed. All but a token 25,000 tons per year of capacity at Goldendale, WA, had been closed in the region. Most of the smelters outside of this region were operated at or near their rated or engineered capacity.

Both U.S. imports for consumption and U.S. exports decreased in 2001. Canada continued to be the largest trading partner, accounting for about two-thirds of total aluminum imports and one-half of the exports. Imports from Russia, which had been on the increase over the last couple of years, decreased significantly in 2001.

Although the price of primary aluminum ingot fluctuated through August 2001, it generally trended downward. In January, the average monthly U.S. market price for primary ingot quoted by Platts Metals Week was 75.2 cents per pound; by August, the price was 66.1 cents per pound. Prices on the London Metal Exchange (LME) followed the trend of U.S. market prices. The monthly average LME cash price for August was 62.5 cents per pound. Prices in the aluminum scrap markets paralleled the general trend of primary ingot prices.

World production decreased slightly compared with that for 2000. At the end of June 2001, inventories of metal held by producers, as reported by the International Aluminium Institute, were at approximately the same level as those at the end of 2000; whereas LME inventories had doubled.

World Smelter Production and Capacity:

	Production		Yearend capacity	
	2000	2001[e]	2000	2001[e]
United States	3,668	2,600	4,270	4,280
Australia	1,770	1,800	1,770	1,770
Brazil	1,280	1,200	1,260	1,260
Canada	2,370	2,500	2,370	2,550
China	2,550	2,700	2,640	2,640
France	441	450	450	450
Norway	1,030	1,000	1,020	1,020
Russia	3,240	3,200	3,200	3,200
South Africa	671	680	676	676
Venezuela	570	570	640	640
Other countries	6,440	6,680	7,500	7,670
World total (rounded)	24,000	23,400	25,800	26,200

World Resources: Domestic aluminum requirements cannot be met by domestic bauxite resources. Potential domestic nonbauxitic aluminum resources are abundant and could meet domestic aluminum demand. However, no processes for using these resources have been proven economically competitive with those now used for bauxite. The world reserve base for bauxite is sufficient to meet world demand for metal well into the 21st century.

Substitutes: Copper can replace aluminum in electrical applications; magnesium, titanium, and steel can substitute for aluminum in structural and ground transportation uses. Composites, wood, and steel can substitute for aluminum in construction. Glass, plastics, paper, and steel can substitute for aluminum in packaging.

[e]Estimated. — Zero.
[1]See also Bauxite and Alumina.
[2]Less than ½ unit.
[3]Domestic primary metal production + recovery from old aluminum scrap + net import reliance.
[4]Includes aluminum alloy.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.

ANTIMONY

(Data in metric tons of antimony content, unless otherwise noted)

Domestic Production and Use: One silver mine in Idaho produced antimony as a byproduct for the first 2 months of 2001 before it shut down, and an additional very small amount of antimony was recovered as a byproduct of the smelting of lead and silver-copper ores. Primary antimony metal and oxide was produced by four companies at processing plants that used foreign feedstock and a small amount of domestic feed material. Single plants were in Idaho, Montana, New Jersey, and Texas. The estimated value of primary antimony metal and oxide produced in 2001 was $55 million. Secondary antimony was recovered, mostly in alloy form, at lead smelters; its value, based on the price of antimony metal, was about $3 million. The estimated distribution of antimony uses was as follows: flame retardants, 55%; transportation, including batteries, 18%; chemicals, 10%; ceramics and glass, 7%; and other, 10%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Mine (recoverable antimony)[1]	356	498	450	W	300
Smelter:					
Primary	26,400	24,000	23,800	20,900	18,000
Secondary	7,550	7,710	8,220	7,920	7,500
Imports for consumption	39,300	34,600	36,800	37,600	39,000
Exports of metal, alloys, oxide, and waste and scrap[2]	3,880	4,170	3,190	1,080	1,500
Shipments from Government stockpile	2,930	4,160	5,790	4,536	4,500
Consumption, apparent[3]	46,600	42,700	36,500	49,376	49,800
Price, metal, average, cents per pound[4]	98	72	63	66	65
Stocks, yearend	10,800	10,600	10,900	10,300	10,300
Employment, plant, number[e]	100	80	75	70	70
Net import reliance[5] as a percentage of apparent consumption	83	81	82	84	86

Recycling: Traditionally, the bulk of secondary antimony has been recovered as antimonial lead, most of which was generated and then also consumed by the battery industry. However, changing trends in this industry in recent years have caused lesser amounts of secondary antimony to be produced.

Import Sources (1997-2000): Metal: China, 87%; Mexico, 6%; Hong Kong, 4%; Kyrgyzstan, 2%; and other, 1%. Ore and concentrate: China, 32%; Australia, 29%; Mexico, 22%; Austria, 4%; Russia, 3%; and other, 10%. Oxide: China, 44%; Mexico, 15%; South Africa, 13%; Belgium, 11%; Bolivia, 9%; and other, 8%. Total: China, 32%; Mexico, 15%; South Africa, 13%; Belgium, 11%; Bolivia, 9%; and other, 20%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Ore and concentrates	2617.10.0000	Free.
Antimony and articles thereof, including waste and scrap	8110.00.0000	Free.
Antimony oxide	2825.80.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: Government stockpile sales of antimony continued for the ninth year, after being resumed in 1993 for the first time since 1988. Public Law 103-160 provided authorization for the sales. During the year, the Defense Logistics Agency (DLA) held monthly sales for antimony using a negotiated bid process. The DLA announced that its Annual Materials Plan for fiscal year 2002 permitted the disposal of up to 5,000 tons of antimony, the same amount allotted in 2001. Antimony was stockpiled in eight DLA depots, with the largest inventories stored in New Haven, IN, and Somerville, NJ.

Stockpile Status—9-30-01[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Antimony	4,716	2,691	4,716	4,536	4,622

Prepared by **James F. Carlin, Jr. [(703) 648-4985, jcarlin@usgs.gov, fax: (703) 648-7757]**

ANTIMONY

Events, Trends, and Issues: In 2001, antimony production from domestic source materials was derived mainly from the recycling of lead-acid batteries. Recycling plus U.S. mine output supplied only a minor portion of estimated domestic demand. The only domestic mine that produced antimony shut down in Idaho at the end of February.

The price of antimony metal continued to decline during the first half of 2001. Prices started the year at $0.68 to $0.73 per pound and ended the first half at $0.62 to $0.66 per pound. By the end of August, the price had slipped to $0.58 to $0.62 per pound. Industry observers attributed the price decline to a continued world oversupply situation, aggravated by growing exports from China.

Environmental and ecological problems associated with the treatment of antimony raw materials were minimal, because all domestic processors of raw materials now avoid sulfide-containing materials.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States	W	300	80,000	90,000
Bolivia	2,800	3,000	310,000	320,000
China	100,000	95,000	900,000	1,900,000
Kyrgyzstan	200	200	120,000	150,000
Russia	5,000	3,000	350,000	370,000
South Africa	5,000	5,000	240,000	250,000
Tajikistan	2,000	2,000	50,000	60,000
Other countries	[8]3,000	6,000	25,000	75,000
World total (may be rounded)	118,000	115,000	2,100,000	3,200,000

World Resources: U.S. resources are mainly in Alaska, Idaho, Montana, and Nevada. Principal identified world resources are in Bolivia, China, Mexico, Russia, and South Africa. Additional antimony resources may occur in Mississippi Valley-type lead deposits in the Eastern United States.

Substitutes: Compounds of chromium, tin, titanium, zinc, and zirconium substitute for antimony chemicals in paint, pigments, and enamels. Combinations of cadmium, calcium, copper, selenium, strontium, sulfur, and tin can be used as substitutes for hardening lead. Selected organic compounds and hydrated aluminum oxide are widely accepted substitutes as flame-retardants.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Data for 1997-2000 from the United States Securities and Exchange Commission 10-K report.
[2]Gross weight.
[3]Domestic mine production + secondary production from old scrap + net import reliance.
[4]New York dealer price for 99.5% to 99.6% metal, c.i.f. U.S. ports.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B for definitions.
[7]See Appendix C for definitions.
[8]Includes U.S. production.

ARSENIC

(Data in metric tons of arsenic content, unless otherwise noted)

Domestic Production and Use: Because arsenic is not recovered from domestic ores, all arsenic metal and compounds consumed in the United States are imported. More than 95% of the arsenic consumed was in compound form, principally arsenic trioxide, which was subsequently converted to arsenic acid. Production of chromated copper arsenate (CCA), a wood preservative, accounted for more than 90% of the domestic consumption of arsenic trioxide; CCA was manufactured primarily by three companies. Arsenic metal was consumed in the manufacture of nonferrous alloys, principally lead alloys for use in lead-acid batteries. About 30 tons per year of high-purity arsenic was estimated to have been used in the manufacture of semiconductor material. The value of arsenic metal and compounds consumed domestically in 2001 was estimated to be nearly $20 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	—	—	—	—	—
Imports for consumption:					
Metal	909	997	1,300	830	1,200
Compounds	22,800	29,300	22,100	23,600	24,000
Exports, metal	61	177	1,350	41	60
Estimated consumption[1]	23,700	30,100	22,000	24,000	25,000
Value, cents per pound, average:[2]					
Metal (China)	32	57	59	51	50
Trioxide (Mexico)	31	32	29	32	31
Net import reliance[3] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Arsenic was not recovered from consumer end-product scrap. However, process water and contaminated runoff collected at wood treatment plants were reused in pressure treatment, and gallium arsenide scrap from the manufacture of semiconductor devices was reprocessed for gallium and arsenic recovery. Domestically, no arsenic was recovered from arsenical residues and dusts at nonferrous smelters, although some of these materials are processed for recovery of other metals.

Import Sources (1997-2000): Metal: China, 87%; Japan, 6%; Hong Kong, 4%; and other, 3%. Trioxide: China, 52%; Chile, 29%; Mexico, 6%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Metal	2804.80.0000	Free.
Trioxide	2811.29.1000	Free.
Sulfide	2813.90.1000	Free.
Acid[4]	2811.19.1000	2.3% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert G. Reese, Jr. [(703) 648-4981, rreese@usgs.gov, fax: (703) 648-7757]**

ARSENIC

Events, Trends, and Issues: Wood preservatives are expected to remain the major domestic use for arsenic. As a result, the demand for arsenic in the United States probably will continue to correlate closely with demand for new housing and growth in the renovation or replacement of existing structures using pressure-treated lumber. In general, the demand for arsenic-based wood preservatives appears positive, barring greater acceptance of alternative preservatives or adverse regulatory activity.

Because of the toxicity of arsenic and its compounds, environmental regulation is expected to become increasingly stringent. This probably will adversely affect the demand for arsenic in the long term but will have only minor impacts in the near term. Mitigating the pollution effects and potential health hazards of naturally occurring and anthropogenic arsenic will continue as important research and regulatory areas. During 2001, the U.S. Environmental Protection Agency reviewed a proposed new standard for the amount of arsenic permissible in drinking water. If adopted, the new standard would reduce allowable arsenic in drinking water from the current standard of less than 50 micrograms per liter to perhaps as low as 10 micrograms per liter.

World Production, Reserves, and Reserve Base:

	Production (Arsenic trioxide)		Reserves and reserve base[5] (Arsenic content)
	2000	2001[e]	
Belgium	1,500	1,500	
Chile	8,200	8,000	World reserves and reserve base are thought to be about 20 and 30 times, respectively, annual world production. The reserve base for the United States is estimated to be 80,000 tons.
China	16,000	16,000	
France	1,000	1,000	
Kazakhstan	1,500	2,000	
Mexico	2,400	2,600	
Russia	1,500	1,500	
Other countries	1,800	2,000	
World total (may be rounded)	33,900	35,000	

World Resources: World resources of copper and lead contain about 11 million tons of arsenic. Substantial resources of arsenic occur in copper ores in northern Peru and the Philippines and in copper-gold ores in Chile. In addition, world gold resources, particularly in Canada, contain substantial resources of arsenic.

Substitutes: Substitutes for arsenic compounds exist in most of its major uses, although arsenic compounds may be preferred because of lower cost and superior performance. The wood preservatives pentachlorophenol and creosote may be substituted for CCA when odor and paintability are not problems and where permitted by local regulations. Ammoniacal copper quaternary, copper azole, copper citrate, and copper dimethyldithiocarbamate are some of the alternative wood preservatives available which use no arsenic. Nonwood alternatives, such as concrete, steel, or plastic lumber, may be substituted in some applications for treated wood.

[e]Estimated. — Zero.
[1]Estimated to be the same as net imports.
[2]Calculated from U.S. Census Bureau import data.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]Tariff is free for Canada, Israel, Caribbean Basin countries, and designated Beneficiary Andean and developing countries.
[5]See Appendix C for definitions.

ASBESTOS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: One firm in California accounted for 100% of domestic production. Asbestos was consumed in roofing products, 62%; gaskets, 22%; friction products, 12%; and other, 4%.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production (sales), mine	7	6	7	5	5
Imports for consumption	21	16	16	15	13
Exports[1]	20	18	22	19	16
Shipments from Government stockpile excesses	—	3	5	—	—
Consumption, estimated	21	16	16	15	13
Price, average value, dollars per ton[2]	210	210	210	210	206
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number	25	25	25	25	20
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: Insignificant.

Import Sources (1997-2000): Canada, 97%; and other, 3%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Asbestos	2524.00.0000	Free.

Depletion Allowance: 22% (Domestic), 10% (Foreign).

Government Stockpile: None

Prepared by **Robert L. Virta [(703) 648-7726, rvirta@usgs.gov, fax: (703) 648-7722]**

ASBESTOS

Events, Trends, and Issues: Domestic sales of asbestos remained unchanged from those of 2000. Imports and exports decreased by 13% and 16%, respectively, from those of 2000, according to the U.S. Census Bureau. Estimated consumption decreased by 13%. Some reported exports were likely to have been reexports, asbestos-containing products, or nonasbestos products. Exports of asbestos fiber were estimated to be approximately 5,000 tons. Essentially all the asbestos used in the United States was chrysotile. Canada remained the largest supplier of asbestos for domestic consumption.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	5	5	Moderate	Large
Brazil	170	210	Moderate	Moderate
Canada	340	340	Large	Large
China	260	250	Large	Large
Kazakhstan	125	230	Large	Large
Russia	750	750	Large	Large
South Africa	19	19	Moderate	Moderate
Zimbabwe	110	115	Moderate	Moderate
Other countries	121	92	Large	Large
World total	1,900	1,870	Large	Large

World Resources: The world has 200 million tons of identified resources and an additional 45 million tons classified as hypothetical resources. The U.S. resources are large, but are composed mostly of short fibers.

Substitutes: Numerous materials substitute for asbestos in products. The substitutes include calcium silicate; carbon fiber; cellulose fiber; ceramic fiber; glass fiber; steel fiber; wollastonite; and several organic fibers, such as aramid, polyethylene, polypropylene, and polytetrafluoroethylene. Several nonfibrous minerals were considered to be possible asbestos substitutes for products in which the reinforcement properties of fibers were not required. No single substitute was as versatile and as cost effective as asbestos.

[e]Estimated. NA Not available. — Zero.

[1]Probably includes nonasbestos materials and reexports.

[2]Average price for Group 7 Canadian chrysotile, ex-mine.

[3]Defined as imports - exports + adjustments for Government and industry stock changes. Most domestic production is exported; imports account f almost all domestic consumption.

[4]See Appendix C for definitions.

BARITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Barite sales by domestic producers increased slightly to 400,000 tons in 2001 and was valued at about $14 million. Sales were from three States, with the preponderance coming from Nevada, followed by Georgia and Tennessee. In 2001, an estimated 2.9 million tons of ground barite was sold from six States from domestic production and imports by domestic crushers and grinders. Nearly 95% of the barite sold in the United States was used as a weighting agent in gas- and oil-well-drilling fluids. Shipments went mostly to the gas drilling industry in the Gulf of Mexico and onshore in Louisiana and Texas, which had a little less than 70% of gas production in the conterminous United States. Smaller amounts were used in the Western United States, which had about 20% of gas production in the conterminous United States, in western Canada, and in Alaska. Industrial end uses for barite include an additive to cement, rubber, and urethane foam as a weighing material. Barite is also used in automobile paint primer for metal protection and gloss, "leaded" glass, and as the raw material for barium chemicals. In the metal casting industry, barite forms part of the mold-release compounds. Barite also has become part of friction products (brake and clutch pads) for transportation vehicles. Because barite blocks x rays and gamma rays, it is used in cement vessels that contain radioactive materials, gastrointestinal x-ray "milkshakes," and the faceplate and funnelglass of cathode-ray tubes used for television sets and computer monitors to protect against radiation.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Sold or used, mine	692	476	434	392	400
Imports for consumption:					
Crude barite	2,210	1,850	836	2,070	2,670
Ground barite	31	20	17	16	20
Other	12	13	18	15	10
Exports	22	15	22	36	40
Consumption, apparent[1] (crude barite)	2,920	2,340	1,280	2,460	2,960
Consumption[2] (ground and crushed)	2,180	1,890	1,370	2,100	2,600
Price, average value, dollars per ton, mine	22.45	22.70	25.60	25.10	25.00
Employment, mine and mill, number[e]	380	410	300	330	340
Net import reliance[3] as a percentage of apparent consumption	76	80	66	84	87

Recycling: None.

Import Sources (1997-2000): China, 88%; India, 9%; Canada, 1%; Mexico, 1%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Crude barite	2511.10.5000	$1.25/t.
Ground barite	2511.10.1000	Free.
Oxide, hydroxide, and peroxide	2816.30.0000	2% ad val.
Other chlorides	2827.38.0000	4.2% ad val.
Other sulfates	2833.27.0000	0.6% ad val.
Other nitrates	2834.29.5000	3.5% ad val.
Carbonate	2836.60.0000	2.3% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Imports for consumption of lower cost foreign barite increased by about 78% compared with 2000 levels and was about 770% of U.S. production. The major sources of imported barite have high-grade deposits with relatively low labor costs, and relatively low (per ton-mile) ocean transportation (compared to land transportation) cost to U.S. Gulf Coast grinding plants. The Nevada miners, crushers, and grinders were competitive in the California market, the Great Plains, and the Canadian markets and will probably continue to utilize local mines for several years. The barite mines in Nevada are nearing exhaustion and there has not been much discussion of replacement reserves. It may be that the producers eventually will choose to import rather than mine. This may be difficult for the California, Great Plains, and Canadian well drilling markets, in that they will have to pay more for the barite portion of their mud if barite production in that area disappears.

Prepared by **James P. Searls [(703) 648-7724, jsearls@usgs.gov, fax: (703) 648-7722]**

BARITE

Imports of barite totaled about 400,000 tons per 6 months for both halves of 1999, then rose to nearly 1 million tons in the first and second halves of 2000, and to about 1.2 million tons in the first half of 2001 and 1.4 million tons in the second half of the year.

Historically, oil drilling has long been a driving force in the demand for barite, but in recent years rising natural gas prices have become more influential. Natural gas prices rose from $1.79 per million Btu in March 1999 to a peak of about $8.20 per million Btu in mid-December 2000. Accordingly, the number of gas-directed rigs in the United States increased from about 360 rigs in March 1999 to about 800 rigs in September 2000, and peaked in the latter half of June 2001 at about 1,065 rigs. As domestic oil discoveries became profitable after 1999, both gas and oil well drill rig counts increased greatly, leading to increased barite consumption in 2000 and 2001. The ratio of gas-directed rigs to total U.S. rigs increased from about 60% in January 1998 (with about 640 gas-directed rigs) to 82% in June 2001, with about 1,035 rigs in a total of 1,270 rigs.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	392	400	6,000	60,000
Algeria	50	50	9,000	15,000
Bulgaria	120	120	10,000	20,000
China	3,500	3,800	30,000	150,000
France	75	75	2,000	2,500
Germany	120	120	1,000	1,500
India	550	650	53,000	80,000
Iran	185	190	NA	NA
Korea, North	70	70	NA	NA
Mexico	127	120	7,000	8,500
Morocco	350	320	10,000	11,000
Russia	60	60	2,000	3,000
Thailand	50	50	9,000	15,000
Turkey	130	120	4,000	20,000
United Kingdom	70	70	100	600
Other countries	350	250	12,000	160,000
World total (rounded)	6,200	6,600	160,000	550,000

World Resources: In the United States, identified resources of barite are estimated to be 150 million tons, and hypothetical resources include an additional 150 million tons. The world's barite resources in all categories are about 2 billion tons, but only about 550 million tons are identified.

Substitutes: In the drilling mud market, alternatives to barite include celestite, ilmenite, iron ore, and the synthetic hematite that is manufactured in Germany. None of these substitutes, however, has had a major impact on the barite drilling mud industry.

[e]Estimated. NA Not available.
[1]Sold or used by domestic mines - exports + imports.
[2]Domestic and imported crude barite sold or used by domestic grinding establishments.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.

BAUXITE AND ALUMINA[1]

(Data in thousand metric dry tons, unless otherwise noted)

Domestic Production and Use: Domestic ore, which for many years has accounted for less than 1% of the U.S. requirement for bauxite, was mined by one company from surface mines in Alabama and Georgia; virtually all of it was used in the production of nonmetallurgical products, such as abrasives, chemicals, and refractories. Thus, nearly all bauxite consumed in the United States was imported; of the total, about 95% was converted to alumina. Also, the United States imported more than one-half of the alumina it required. Of the total alumina used, about 90% went to primary aluminum smelters and the remainder went to nonmetallurgical uses. Annual alumina capacity was 6.35 million tons, with four Bayer refineries in operation at midyear.

Salient Statistics—United States:[2]	1997	1998	1999	2000	2001[e]
Production, bauxite, mine	NA	NA	NA	NA	NA
Imports of bauxite for consumption[3]	11,300	11,600	10,400	9,030	9,500
Imports of alumina[4]	3,830	4,050	3,810	3,820	3,000
Exports of bauxite[3]	97	108	168	147	100
Exports of alumina[4]	1,270	1,280	1,230	1,090	1,200
Shipments of bauxite from Government stockpile excesses[3]	1,430	3,300	4,180	1,100	200
Consumption, apparent, bauxite and alumina (in aluminum equivalents)[5]	4,210	5,000	4,870	3,870	3,200
Price, bauxite, average value U.S. imports (f.a.s.) dollars per ton	25	23	22	23	24
Stocks, bauxite, industry, yearend[3]	2,260	1,860	1,440	1,300	1,200
Net import reliance,[6] bauxite and alumina, as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1997-2000):[7] Bauxite: Guinea, 40%; Jamaica, 26%; Brazil, 16%; Guyana, 10%; and other, 8%. Alumina: Australia, 67%; Suriname, 12%; Jamaica, 8%; and other, 13%. Total: Australia, 31%; Guinea, 22%; Jamaica, 18%; Brazil, 10%; and other, 19%.

Tariff: Import duties on bauxite and alumina were abolished in 1971 by Public Law 92-151. Only imports from non-normal-trade-relations nations were dutiable. Countries that supplied commercial quantities of bauxite or alumina to the United States during the first 8 months of 2001 had normal-trade-relations status.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[8]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Bauxite, metal grade:					
Jamaica-type	5,390	2,790	5,390	2,030	1,190
Suriname-type	130	2,090	130	1,020	689
Bauxite, refractory-grade, calcined	43	7	2	5	—

Prepared by **Patricia A. Plunkert [(703) 648-4979, pplunker@usgs.gov, fax: (703) 648-7757]**

BAUXITE AND ALUMINA

Events, Trends, and Issues: World production of bauxite increased slightly from that of 2000. Based on production data from the International Aluminium Institute, world alumina production increased slightly during the first half of 2001 compared with that for the same period in 2000.

The 2002 fiscal year Annual Materials Plan submitted by the Defense National Stockpile Center proposed the sale of 2.03 million dry metric tons of metallurgical-grade, Jamaica-type bauxite and 5,080 calcined metric tons of refractory-grade bauxite from the National Defense Stockpile during the period October 1, 2001, to September 30, 2002.[9]

Spot prices for metallurgical-grade alumina, as published by Metal Bulletin, continued a decline that began in May 2000. The decline can be attributed to an oversupply of alumina in the world market; the result of weak metal demand and increased alumina production. The published price range began the year at $165 to $175 per ton. By the end of August, the price range had declined to $145 to $150 per ton, its lowest level since April 1999.

World Bauxite Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[10]	Reserve base[10]
	2000	2001[e]		
United States	NA	NA	20,000	40,000
Australia	53,800	53,500	3,800,000	7,400,000
Brazil	14,000	14,000	3,900,000	4,900,000
China	9,000	9,200	720,000	2,000,000
Guinea	15,000	15,000	7,400,000	8,600,000
Guyana	2,400	2,000	700,000	900,000
India	7,370	8,000	770,000	1,400,000
Jamaica	11,100	13,000	2,000,000	2,500,000
Russia	4,200	4,000	200,000	250,000
Suriname	3,610	4,000	580,000	600,000
Venezuela	4,200	4,400	320,000	350,000
Other countries	10,800	10,200	4,100,000	4,700,000
World total (rounded)	135,000	137,000	24,000,000	34,000,000

World Resources: Bauxite resources are estimated to be 55 to 75 billion tons, located in South America (33%), Africa (27%), Asia (17%), Oceania (13%), and elsewhere (10%). Domestic resources of bauxite are inadequate to meet long-term demand, but the United States and most other major aluminum-producing countries have essentially inexhaustible subeconomic resources of aluminum in materials other than bauxite.

Substitutes: Bauxite is the only raw material used in the production of alumina on a commercial scale in the United States. However, the vast U.S. resources of clay are technically feasible sources of alumina. Other domestic raw materials, such as anorthosite, alunite, coal wastes, and oil shales, offer additional potential alumina sources. Although it would require new plants using new technology, alumina from these nonbauxitic materials could satisfy the demand for primary metal, refractories, aluminum chemicals, and abrasives. Synthetic mullite, produced from kyanite and sillimanite, substitutes for bauxite-based refractories. Although more costly, silicon carbide and alumina-zirconia substitute for bauxite-based abrasives.

[e]Estimated. NA Not available. — Zero.

[1]See also Aluminum. As a general rule, 4 tons of dried bauxite is required to produce 2 tons of alumina, which, in turn, provides 1 ton of primary aluminum metal.

[2]Includes U.S. Virgin Islands.

[3]Includes all forms of bauxite, expressed as dry equivalent weights.

[4]Calcined equivalent weights.

[5]The sum of U.S. bauxite production and net import reliance.

[6]Defined as imports - exports + adjustments for Government and industry stock changes (all in aluminum equivalents). Treated as separate commodities, the net import reliance equaled 100% for bauxite and 31% for alumina in 2001. For the years 1997-2000, the net import reliance wa 100% for bauxite and ranged from 33% to 37% for alumina.

[7]Aluminum equivalents.

[8]See Appendix B for definitions.

[9]Defense Logistics Agency, 2001, FY 2002 Annual Materials Plan: Fort Belvoir, VA, Defense Logistics Agency news release, October 1, 2 p.

[10]See Appendix C for definitions.

BERYLLIUM

(Data in metric tons of beryllium content, unless otherwise noted)

Domestic Production and Use: A company in Utah mined bertrandite ore and recovered beryllium hydroxide from this ore and from imported beryl. The beryllium hydroxide was shipped to a plant in Ohio, where it was converted into beryllium metal, alloys, and oxide. Beryllium consumption of 295 tons was valued at about $104 million, based on the quoted producer price for beryllium-copper master alloy. The use of beryllium (as an alloy, metal, and oxide) in electronic and electrical components and aerospace and defense applications accounted for an estimated 80% of total consumption.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, mine shipments	231	243	200	180	180
Imports for consumption, ore and metal	20	50	20	20	50
Exports, metal	40	60	40	35	40
Government stockpile releases[e 1]	76	57	145	220	65
Consumption:					
Apparent	316	320	385	300	295
Reported, ore	259	270	260	240	240
Price, dollars (yearend):					
Domestic, metal, vacuum-cast ingot, per pound	327	327	327	421	338
Domestic, metal, powder blend, per pound	385	385	385	492	375
Domestic, beryllium-copper master alloy, per pound of contained beryllium	160	160	160	160	160
Domestic, beryllium oxide, powder, per pound	77	77	77	100	100
Stocks, consumer, yearend	110	80	20	115	75
Employment, number:					
Mine, full-time equivalent employees[e]	25	NA	NA	NA	NA
Primary refineries[e]	400	NA	NA	NA	NA
Net import reliance[2] as a percentage of apparent consumption	27	24	48	37	39

Recycling: Quantities of new scrap generated in the processing of beryllium-copper alloys and quantities of obsolete military equipment containing metallic beryllium were recycled. Data on beryllium recycled in this manner are not available.

Import Sources (1997-2000): Ore, metal, scrap, and master alloy: Russia, 21%; Canada, 18%; Germany, 12%; Kazakhstan, 12%; and other, 37%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Beryllium ores and concentrates	2617.90.0030	Free.
Beryllium oxide or hydroxide	2825.90.1000	3.7% ad val.
Beryllium-copper master alloy	7405.00.6030	Free.
Beryllium unwrought:		
Waste and scrap	8112.11.3000	Free.
Other	8112.11.6000	8.5% ad val.
Beryllium, wrought	8112.19.0000	5.5% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Beryl ore (11% BeO)	281	33	281	145	—
Beryllium-copper master alloy	41	16	41	80	51
Beryllium metal	298	34	252	36	23

Prepared by **Larry D. Cunningham [(703) 648-4977, lcunning@usgs.gov, fax: (703) 648-7757]**

BERYLLIUM

Events, Trends, and Issues: For the first one-half year, sales of alloy products (strip and bulk) were unchanged compared with those of the previous year. However, sales of strip products (the larger of the two lines) decreased in the second quarter, owing to a slow-down in the telecommunications and computer markets. Imports for consumption of beryllium ore, metal, and alloys increased; Brazil and Russia were the leading suppliers. Metal exports were up, with Canada, Chile, France, Japan, and the Netherlands the major recipients of the materials.

For fiscal year 2001, ending September 30, 2001, the Defense National Stockpile Center (DNSC) sold about 1,260 tons of beryllium-copper master alloy (BCMA) (about 51 tons of beryllium content) valued at about $7.62 million and about 23 tons of beryllium metal valued at about $3.62 million from the National Defense Stockpile. There were no sales of beryl ore in fiscal year 2001. The DNSC also proposed maximum disposal limits in fiscal year 2002 of about 3,630 tons of beryl ore (about 145 tons of beryllium content), about 2,000 tons of BCMA (about 80 tons of beryllium content), and about 36 tons of beryllium metal.

Because of the toxic nature of beryllium, the industry must maintain careful control over the quantity of beryllium dust and fumes in the workplace. The U.S. Environmental Protection Agency issues standards for certain hazardous air pollutants, including beryllium, under the Clean Air Act, and the Occupational Safety and Health Administration issues standards for airborne beryllium particles. To comply with these standards, plants are required to install and maintain pollution-control equipment. In beryllium-processing plants, harmful effects are prevented by maintaining clean workplaces; requiring the use of safety equipment, such as personal respirators; collecting dust, fumes, and mists at the source of deposition in dust collectors; establishing medical programs; and implementing other procedures to provide safe working conditions.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e] 2000	Mine production[e] 2001
United States	180	180
China	55	55
Kazakhstan	4	4
Russia	40	40
Other countries	2	2
World total (rounded)	280	280

Reserves and reserve base[4]

The United States has very little beryl that can be economically handsorted from pegmatite deposits. The Spor Mountain area, Utah, an epithermal deposit, contains a large reserve base of bertrandite, which was being mined. Proven bertrandite reserves in Utah total about 18,000 tons of beryllium. The world reserves and reserve base are not sufficiently well delineated to report consistent figures for all countries.

World Resources: World resources of beryllium have been estimated to be more than 80,000 tons (contained mostly in known nonpegmatite deposits). About 65% of the beryllium resources is concentrated in the United States; the Spor Mountain and Gold Hill areas in Utah and the Seward Peninsula area in Alaska account for most of the total.

Substitutes: Although the cost of beryllium is high compared with that of other materials, it is used in applications in which its properties are crucial. Graphite, steel, and titanium may be substituted for beryllium metal in some applications, and phosphor bronze may be substituted for beryllium-copper alloys, but these substitutions can result in substantial loss in performance. In some applications, aluminum nitride may be substituted for beryllium oxide.

[e]Estimated. NA Not available. — Zero.
[1]Net quantity (uncommitted inventory).
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B for definitions.
[4]See Appendix C for definitions.

BISMUTH

(Data in metric tons of bismuth content, unless otherwise noted)

Domestic Production and Use: There is no domestic refinery production of primary bismuth. One refinery in Nebraska formerly produced bismuth as a byproduct of lead refining, but bismuth operations there ceased on June 30, 1997. Bismuth is contained in some domestically mined lead ores, but no byproduct bismuth was produced. Forty-four companies, mostly in the eastern United States, accounted for an estimated three-fourths of the bismuth consumed in 2001. The value of bismuth consumed was estimated at more than $18 million. About 42% of the bismuth was used in fusible alloys, solders, and cartridges; 37% in pharmaceuticals and chemicals; 19% in metallurgical additives; and 2% in other uses.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, refinery	W	—	—	—	—
Imports for consumption, metal	2,170	2,720	2,110	2,410	2,500
Exports, metal, alloys, scrap	206	245	257	491	600
Shipments from Government stockpile excesses	229	—	—	—	—
Consumption, reported	1,530	1,990	2,050	2,130	2,200
Price, average, domestic dealer, dollars per pound	3.50	3.60	3.85	3.70	3.80
Stocks, yearend, consumer	213	175	121	118	115
Employment, refinery, number of workers[1]	[e]30	—	—	—	—
Net import reliance[2] as a percentage of apparent consumption	W	[e]95	[e]95	[e]95	95

Recycling: Bismuth was recovered from fusible alloy scrap, but contributes less than 5% of the U.S. supply.

Import Sources (1997-2000): Belgium, 32%; Mexico, 23%; United Kingdom, 18%; China, 16%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Articles thereof, including waste and scrap	8106.00.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: The final 85 tons of bismuth in the National Defense Stockpile was sold on November 4, 1997.

Prepared by **Robert D. Brown, Jr. [(703) 648-4984, rdbrown@usgs.gov, fax: (703) 648-7757]**

BISMUTH

Events, Trends, and Issues: Bismuth was used in several applications designed to provide nontoxic substitutes for lead. The Safe Drinking Water Act Amendment of 1996 required that all new and repaired fixtures and pipes for potable water be lead-free after August 1998. Bismuth use in water meters was one particular application that increased. Other major areas of development included bismuth shot for waterfowl hunting, bismuth-containing solders, and lubricating greases, especially extreme pressure lubricants. The use of new zinc-bismuth alloys in galvanizing to achieve better processing continued to grow. Bismuth was also used in ceramic glazes, crystal ware, and pigments. A bismuth-strontium-calcium-copper-oxide superconducting ceramic was installed as a major part of the electric power transmission infrastructure in Detroit. Denmark and Spain banned the use of lead in certain applications; bismuth could substitute in these cases.

World lead mine production and world primary lead refinery production has not increased significantly in recent years, limiting the amount of bismuth that can be produced as a lead byproduct. But bismuth was also recovered from some copper ores and from tungsten ores, especially in Asia. World mine production of bismuth was steady, and world refinery production increased in 2001. The domestic price decreased from $4.00 per pound to $3.85 per pound in January but increased to $4.15 per pound by the end of the first quarter. The price decreased to $3.75 per pound during the second quarter, and it stabilized at about $3.70 per pound for the remainder of the year. The average price for the year increased, but it did not reach the $4.00-per-pound level.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2000	2001[e]		
United States	—	—	9,000	14,000
Australia	—	—	18,000	27,000
Bolivia	740	750	10,000	20,000
Canada	202	225	5,000	30,000
China	2,500	2,450	200,000	470,000
Japan	155	155	9,000	18,000
Kazakhstan	130	130	5,000	10,000
Mexico	1,000	1,000	10,000	20,000
Peru	1,000	950	11,000	42,000
Other countries	150	150	15,000	35,000
World total (may be rounded)	5,880	5,810	290,000	690,000

World Resources: World reserves of bismuth are usually associated with lead deposits, except in China, North Korea, and Vietnam, where economically recoverable bismuth is found with tungsten ores and some copper ores, and in Australia, where it is found with copper-gold ores. Bismuth minerals rarely occur in sufficient quantities to be mined as principal products, except in Bolivia and China. Bismuth is potentially recoverable as a byproduct of the processing of molybdenum and non-Asian tungsten ores, although extraction of bismuth from these ores usually is not economic.

Substitutes: Antibiotics, magnesia, and alumina can replace bismuth in pharmaceutical applications. Titanium dioxide-coated mica flakes and fish scale extracts are substitutes in pigment uses. Indium can replace bismuth in low-temperature solders. Resins can replace bismuth alloy jigs used for holding metal shapes during machining. Glycerine-filled glass bulbs can replace bismuth alloys as a triggering device for fire sprinklers. Selenium, tellurium, and lead could replace bismuth in free-machining alloys.

[e]Estimated. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Data for first 6 months of 1997, until shutdown of only domestic refiner.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.

BORON

(Data in thousand metric tons of boric oxide (B_2O_3), unless otherwise noted)

Domestic Production and Use: The estimated value of boric oxide contained in minerals and compounds produced in 2001 was $557 million. Domestic production of boron minerals, primarily as sodium borates, by four companies was centered in southern California. The largest producer operated an open-pit tincal and kernite mine and associated compound plants. A second firm, using Searles Lake brines as raw material, accounted for the majority of the remaining output. A third company continued to process small amounts of calcium and calcium sodium borates. A fourth company used an in-situ process. Principal consuming firms were in the North Central United States and the Eastern United States. The reported distribution pattern for boron compounds consumed in the United States in 2000 was as follows: glass products, 75%; soaps and detergents, 7%; agriculture, 4%; fire retardants, 4%; and other, 10%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production[1]	604	587	618	546	650
Imports for consumption, gross weight:					
Borax	54	14	8	1	1
Boric acid	26	23	30	39	40
Colemanite	44	47	42	26	40
Ulexite	157	170	178	127	130
Exports, gross weight:					
Boric acid	92	106	107	119	100
Refined sodium borates	473	453	370	413	400
Consumption:					
Apparent	483	412	534	356	482
Reported	403	NA	416	360	NA
Price, dollars per ton, granulated pentahydrate borax in bulk, carload, works[2]	340	340	376	376	376
Stocks, yearend[3]	NA	NA	NA	NA	NA
Employment, number	900	900	900	1,300	1,300
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1997-2000): Boric acid: Chile, 37%; Turkey, 32%; Bolivia, 15%; Italy, 8%; Peru, 5%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Borates:		
Refined borax:		
Anhydrous	2840.11.0000	0.3% ad val.
Other	2840.19.0000	0.1% ad val.
Other	2840.20.0000	3.7% ad val.
Perborates:		
Sodium	2840.30.0010	3.7% ad val.
Other	2840.30.0050	3.7% ad val.
Boric acids	2810.00.0000	1.5% ad val.
Natural borates:		
Sodium	2528.10.0000	Free.
Other:		
Calcium	2528.90.0010	Free.
Other	2528.90.0050	Free.

Depletion Allowance: Borax, 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Phyllis A. Lyday [(703) 648-7713, plyday@usgs.gov, fax: (703) 649-7722]**

BORON

Events, Trends, and Issues: The United States was the world's largest producer of boron compounds during 2001 and exported about one-half of domestic production. All production was from California. Exported materials competed with borax, boric acid, colemanite, and ulexite primarily from Turkey, the largest producer of boron ore in the world.

The largest domestic producer continued mining and processing ore at its open pit mine. The production of boron, sodium bicarbonate, and sodium sulfate production from underground brines in California continued, but the company involved planned to sell its assets. The domestic underground and insitu operations also continued production during the year.

A Canadian company continued plans to develop a borate project in Yugoslavia. Material from the Piskanja property was being evaluated for grade, purity, and composition.

The Russian boric acid plant at Dalnegorsk was being transferred to a company that is 66% owned by the State. A $5.5 million line of credit was allocated until 2008 to pay off wage arrears and clear outstanding debts. In 2000, boric acid production decreased 25% to 70,000 tons per year because of downtime from September to December. Production returned to capacity at 17,000 tons for January and February 2001.

A subsidiary of Turkey's largest mining company was building a boric acid plant at Emet that will produce 100,000 tons per year by 2003. Production at the Bandirma plant was planned to be increased from 45,000 tons per year to 60,000 tons per year by 2002. Turkey is building a 274,000-ton-per-year pyrite-burning sulfuric acid plant at Bandirma to supply the acid for boric acid plants at Bandirma and Emet.

World Production, Reserves, and Reserve Base:[5]

	Production—all forms		Reserves[6]	Reserve base[6]
	2000	2001[e]		
United States	1,070	1,300	40,000	80,000
Argentina	360	360	2,000	9,000
Bolivia	35	35	4,000	19,000
Chile	340	340	8,000	41,000
China	105	110	27,000	36,000
Iran	4	4	1,000	1,000
Kazakhstan	30	30	14,000	15,000
Peru	30	9	4,000	22,000
Russia	1,000	1,000	40,000	100,000
Turkey	1,400	1,400	30,000	150,000
World total (rounded)	4,370	4,600	170,000	470,000

World Resources: Large domestic reserves of boron materials occur in California, chiefly in sediments and their contained brines. Extensive resources also occur in Turkey. Small deposits are being mined in South America. At current levels of consumption, world resources are adequate for the foreseeable future.

Substitutes: Substitution for boron materials is possible in such applications as soaps, detergents, enamel, and insulation. In soaps, sodium and potassium salts of fatty acids are the usual cleaning and emulsion agents. Borates in detergents can be replaced by chlorine bleach or enzymes. Some enamels use other glass-producing substances, such as phosphates. Insulation substitutes include cellulose, foams, and mineral wools.

[e]Estimated. E Net exporter. NA Not available.
[1]Minerals and compounds sold or used by producers; includes both actual mine production and marketable products.
[2]Chemical Market Reporter.
[3]Stocks data are not available and are assumed to be zero for net import reliance and apparent consumption calculations.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]Gross weight of ore in thousand metric tons.
[6]See Appendix C for definitions.

BROMINE

(Data in thousand metric tons of bromine content, unless otherwise noted)

Domestic Production and Use: The quantity of bromine sold or used in the United States from four companies operating in Arkansas and Michigan accounted for 100% of elemental bromine production, which was valued at an estimated $185 million. Arkansas, with six plants, continued to be the Nation's leading bromine producer, and bromine was the leading mineral commodity in terms of value produced in the State.

Three bromine companies accounted for 64% of world production. Two of these companies are located in the United States and accounted for about 94% of U.S. production.

The Surface Transportation Board proposed new merging and consolidation regulations for railroads, which are important carriers for bromine shippers. The chemical industry, which includes bromine, is the second largest customer of railroads. The industry had competitive, financial, and service concerns regarding the proposed regulations.

Bromine was used in fire retardants (40%), drilling fluids (24%), brominated pesticides (12%), water-treatment chemicals (7%), and other products, including photographic chemicals and rubber additives (17%). Other products included intermediate chemicals for the manufacture of products and bromide solutions used alone or in combination with other chemicals.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production[1]	247	230	239	228	204
Imports for consumption, elemental bromine and compounds[2]	11	10	10	20	20
Exports, elemental bromine and compounds	14	12	10	10	10
Consumption, apparent[3]	244	235	238	238	214
Price, cents per kilogram, bulk, purified bromine	80.2	70.0	87.0	90.0	67.0
Employment, number	1,700	1,700	1,700	1,700	1,700
Net import reliance[4] as a percentage of apparent consumption	E	—	E	4	5

Recycling: Approximately 35% of U.S. bromine production was converted to byproduct sodium bromide solutions, which were recycled to obtain elemental bromine. This recycled bromine is not included in the virgin bromine production reported by the companies.

Import Sources (1997-2000): Israel, 89%; United Kingdom, 6%; Belgium, 2%; Netherlands, 2%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Bromine	2801.30.2000	5.5% ad val.
Bromides and bromide oxides	2827.59.5000	3.6% ad val.
Bromochloromethane	2903.49.1000	Free.
Ammonium, calcium, or zinc bromide	2827.59.2500	Free.
Decabromodiphenyl and octabromodiphenyl oxide	2909.30.0700	9.8% ad val.
Ethylene dibromide	2903.30.0500	5.4% ad val.
Hydrobromic acid	2811.19.3000	Free.
Potassium bromate	2829.90.0500	Free.
Potassium or sodium bromide	2827.51.0000	Free.
Sodium bromate	2829.90.2500	Free.
Tetrabromobisphenol A	2908.10.2500	0.4¢/kg + 9.7% ad val.
Vinyl bromide, methylene dibromide	2903.30.1520	Free.

Depletion Allowance: Brine wells, 5% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Phyllis A. Lyday [(703) 648-7713, plyday@usgs.gov, fax: (703) 648-7722]**

BROMINE

Events, Trends, and Issues: A U.S. company's subsidiary signed a joint-venture agreement with a Jordanian company to build a bromine complex at Safi, Jordan. Construction, which began in 2000 and was expected to be completed by 2002, included a 50,000-ton-per-year bromine plant. Downturns in the economy, especially in electrical products such as computers and telecommunication equipment, led to a reduction in the demand for brominated fire retardants. Fire retardants accounted for approximately 40% of all plastic additives consumed in North America. Brominated fire retardants are competitive in terms of cost and performance in these electrical applications.

A French company began investing about $12.8 million in a speciality brominated derivatives plant in Port-de-Bouc, France. The bromine will be supplied from the company's Port-de-Bouc plant that produces 12,000 tons per year of elemental bromine. Production is destined for the pharmaceutical industry.

Israel was the second largest producer of bromine in the world and the largest producer of elemental bromine. Approximately 90% of production was for export, accounting for about 80% of international trade in bromine and bromine compounds to more than 100 countries. The purchase of the remaining public shareholding of three subsidiaries, including bromine operations, was completed by the major chemical company in Israel. Exports are used to produce bromine compounds at a plant in the Netherlands.

Under the Montreal Protocol, the global phase out of methyl bromide as a crop pesticide will occur during 2001-05 in the United States. Imports of crops grown and treated with methyl bromide in Mexico are expected to continue, however, because Mexico is not required to phase out methyl bromide until 2015.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2000	2001[e]		
United States[1]	228	204	11,000	11,000
Azerbaijan	2.0	2.0	300	300
China	45.0	45.0	NA	NA
France	2.0	2.0	1,600	1,600
India	1.5	1.5	([6])	([6])
Israel	185	200	([7])	([7])
Italy	0.3	0.3	([6])	([6])
Japan	20.0	20.0	([8])	([8])
Spain	0.1	0.1	1,400	1,400
Turkmenistan	0.15	0.15	700	700
Ukraine	3.0	3.0	400	400
United Kingdom	55.0	35.0	([6])	([6])
World total (rounded)	542	513	NA	NA

World Resources: Resources of bromine are virtually unlimited. The Dead Sea in the Middle East is estimated to contain 1 billion tons of bromine. Seawater contains about 65 parts per million of bromine or an estimated 100 trillion tons. The bromine content of underground water in Poland has been estimated at 36 million tons.

Substitutes: Chlorine and iodine may be substituted for bromine in a few chemical reactions and for sanitation purposes. Aniline and some of its derivatives, methanol, ethanol, and gasoline-grade tertiary butyl alcohol, are effective non lead substitutes for ethylene dibromide and lead in gasoline in some cars. There are no comparable substitutes for bromine in various oil and gas well completion and packer applications. Alumina, magnesium hydroxide, organic chlorine compounds, and phosphorous compounds can be substituted for bromine as fire retardants in some uses.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Sold or used by U.S. producers.
[2]Imports calculated from items shown in Tariff section.
[3]Includes recycled product.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.
[6]From waste bitterns associated with solar salt.
[7]From the Dead Sea. See World Resources section.
[8]From seawater. See World Resources section.

CADMIUM

(Data in metric tons of cadmium content, unless otherwise noted)

Domestic Production and Use: Primary cadmium metal in the United States is produced by two companies, one in Illinois and one in Tennessee, as a byproduct of smelting and refining zinc metal from sulfide ore concentrates. Secondary cadmium is recovered from spent nickel-cadmium (Ni-Cd) batteries by one Pennsylvania company. Based on the average New York dealer price, the combined output of primary and secondary metal was valued at about $249,000 in 2001. Consumption of cadmium during the past 3 years declined by about 50% in response to environmental concerns. About 75% of total apparent consumption was for batteries. The remaining 25% was distributed as follows: pigments, 12%; coatings and plating, 8%; stabilizers for plastics, 4%; and nonferrous alloys and other, 1%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, refinery[1]	2,060	1,240	1,190	1,890	1,400
Imports for consumption, metal	790	514	294	425	170
Exports of metal, alloys, and scrap	554	180	20	312	280
Shipments from Government stockpile excesses	161	190	550	319	250
Consumption, apparent	2,510	2,100	1,850	2,010	1,440
Price, metal, dollars per pound[2]	0.51	0.28	0.14	0.16	0.15
Stocks, yearend, producer and distributor	1,060	729	893	1,200	1,300
Employment, smelter and refinery	NA	NA	NA	NA	NA
Net import reliance[3] as a percentage of apparent consumption	19	38	9	6	3

Recycling: To date, cadmium recycling has been practical only for Ni-Cd batteries, some alloys, and dust from electric arc furnaces (EAF). The exact amount of recycled cadmium is unknown. In 2001, the U.S. steel industry generated more than 0.6 million tons of EAF dust, typically containing 0.003% to 0.07% cadmium. In 2001, 13 States had laws regulating battery labeling and removability, and 8 States had take-back requirements for Ni-Cd batteries.

Import Sources (1997-2000): Metal: Canada, 49%; Australia, 20%; Belgium, 16%; Germany, 6%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations[4] 12/31/01
Cadmium sulfide	2830.30.0000	3.1% ad val.
Pigments and preparations based on cadmium compounds	3206.30.0000	3.1% ad val.
Unwrought cadmium; waste and scrap; powders	8107.10.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Cadmium	800	—	800	544	115

Prepared by **Jozef Plachy [(703) 648-4982, jplachy@usgs.gov, fax: (703) 648-7757]**

CADMIUM

Events, Trends, and Issues: During the past decade, regulatory pressure to reduce or even eliminate the use of cadmium has gained momentum in many developed countries. In the United States, Federal and State agencies regulate cadmium content in the environment. To help unify different standards, the U.S. Environmental Protection Agency created a list of persistent and bioaccumulative toxic pollutants. Cadmium is one of eleven metals on the list, and it is targeted for a 50% reduction by 2005. The International Cadmium Association objected to the rating used for creating the list because no distinction was made between various cadmium compounds and cadmium metal. The European Commission issued a new proposal to ban all Ni-Cd batteries containing more than 0.002% cadmium beginning on January 1, 2008, and to increase the collection rate for all spent industrial and automotive batteries to 95% by weight by December 31, 2003.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[6]	Reserve base[6]
	2000	2001[e]		
United States	1,890	1,400	90,000	270,000
Australia	552	650	110,000	300,000
Belgium	1,400	1,400	—	—
Canada	1,390	1,150	55,000	150,000
China	2,200	2,200	13,000	35,000
Germany	1,000	800	6,000	8,000
Japan	2,472	2,500	10,000	15,000
Kazakhstan	1,060	1,100	25,000	40,000
Mexico	1,350	1,400	35,000	40,000
Russia	925	900	16,000	30,000
Other countries	5,460	5,200	240,000	310,000
World total (may be rounded)	19,700	18,700	600,000	1,200,000

World Resources: Estimated world resources of cadmium were about 6 million tons based on zinc resources containing about 0.3% cadmium. The zinc-bearing coals of the central United States, and Carboniferous-age coals of other countries, also contain large subeconomic resources of cadmium.

Substitutes: Ni-Cd batteries are being replaced in some applications with lithium-ion and nickel-metal hydride batteries. However, the higher cost of these substitutes restricts their use. Except where the surface characteristics of the coating are critical (e.g., fasteners for aircraft), coatings of zinc or vapor-deposited aluminum can substitute for cadmium in plating applications. Cerium sulfide is used as a replacement for cadmium pigments, mostly for plastics.

[e]Estimated. NA Not available. — Zero.

[1]Primary and secondary metal.

[2]Average New York dealer price for 99.95% purity in 5-short-ton lots. Source: Platts Metals Week.

[3]Defined as imports - exports + adjustments for Government and industry stock changes.

[4]No tariff for Canada and Mexico for items shown.

[5]See Appendix B for definitions.

[6]See Appendix C for definitions.

CEMENT

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 2001, about 85 million tons of portland cement and 4 million tons of masonry cement were produced at a total of 116 plants in 37 States, by 1 State agency and about 40 companies. There were also two plants in Puerto Rico. The ex-plant value of cement production, excluding Puerto Rico, was about $7.1 billion, and the value of total sales (including imported cement) was about $8.8 billion. Most of the cement was used to make concrete, worth at least $38 billion. Total cement consumption (sales) rose slightly to a new record level. Imported cement and clinker (to make cement) accounted for about 25% of the cement sold; total imports declined significantly, owing to higher domestic production capacity and a weakening construction market. Clinker, the main intermediate product in cement manufacture, was produced at 109 plants, with a combined apparent annual capacity of about 91 million tons. Including several facilities that merely ground clinker produced elsewhere, total finished cement (grinding) capacity was about 105 million tons. Texas, California, Pennsylvania, Michigan, Missouri, and Alabama, in descending order, were the six largest producing States and accounted for about one-half of U.S. production. About 74% of cement sales went to ready-mixed concrete producers, 13% to concrete product manufacturers, 7% to contractors (mainly for road paving), 4% to building materials dealers, and 2% to other users.

Salient Statistics—United States:[1]	**1997**	**1998**	**1999**	**2000**	**2001**[e]
Production, portland and masonry[2]	82,582	83,931	85,952	87,846	89,600
Production, clinker	72,686	74,523	76,003	78,138	78,900
Shipments to final customers, including exports	96,801	103,696	108,862	110,048	111,000
Imports of hydraulic cement for consumption	14,523	19,878	24,578	24,561	23,700
Imports of clinker for consumption	2,867	3,905	4,164	3,673	2,100
Exports of hydraulic cement and clinker	791	743	694	738	880
Consumption, apparent[3]	96,018	103,457	108,862	110,470	114,000
Price, average mill value, dollars per ton	73.49	76.46	78.27	78.56	79.00
Stocks, mill, yearend	5,784	5,393	6,367	7,566	6,000
Employment, mine and mill, number[e]	17,900	17,900	18,000	18,000	18,000
Net import reliance[4] as a percentage of apparent consumption	14	19	21	20	21

Recycling: Cement kiln dust is routinely recycled to the kilns, which can also burn a variety of waste fuels and recycled raw materials such as slags. Cement itself generally is not recycled, but there is a small amount of recycling of concrete for use as aggregate.

Import Sources (1997-2000):[5] Canada, 22%; Thailand, 12%; China, 11%; Venezuela, 8%; Greece, 8%; and other, 39%. Import sources were diversifying, with Asian sources (especially China, Korea, and Thailand) becoming major suppliers since 1998; Thailand became the single largest source of imported cement and clinker (combined) in 2000.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Cement clinker	2523.10.0000	Free.
White portland cement	2523.21.0000	Free.
Other portland cement	2523.29.0000	Free.
Aluminous cement	2523.30.0000	Free.
Other hydraulic cement	2523.90.0000	Free.

Depletion Allowance: Not applicable. Certain raw materials for cement production have depletion allowances.

Government Stockpile: None.

Events, Trends, and Issues: Continued very low interest rates, long project lead times, and strong public sector spending by the Federal Government allowed cement consumption levels to rise modestly in 2001 despite the generally much weaker general economy. Cement consumption in 2002 was expected to stagnate or decline somewhat, especially where projects relied on tenuous State funding. Cement company ownership continued to consolidate, notably with the largest U.S.-owned and overall second largest U.S. producer being purchased by a foreign company in 2000 and two of the major foreign-owned producers merging early in 2001.

Concern continued over the environmental impact of cement manufacture, particularly the emissions of carbon dioxide, handling of cement kiln dust (CKD), and emissions of nitrogen oxides. The cement industry is one of the largest sources of carbon dioxide emissions, and U.S. cement producers were voluntarily seeking to reduce emissions. Carbon dioxide reduction strategies by the cement industry were aimed at lower emissions per ton of cement, rather

Prepared by **Hendrik G. van Oss [(703) 648-7712, hvanoss@usgs.gov, fax: (703) 648-7722]**

CEMENT

than total emissions. Reduction strategies included installation of more fuel efficient kiln technologies, partial substitution of non-carbonate sources of calcium oxide in the kiln raw materials, and partial substitution of cementitious additives for portland cement in the finished cement products.

The rapid rise in fossil fuel costs in 2000 abated somewhat in 2001 but fuel costs remained of concern to the cement industry. Some cement companies burn solid or liquid waste materials in their kilns as a low-cost substitute for fossil fuels. Cement kilns can be an effective and benign way of destroying such wastes; the viability of the practice and the type of waste(s) burned hinge on current and future environmental regulations and their associated costs. The trend, tempered by administrative constraints, appears to be towards increased use of waste fuels. Environmental issues common to mining, such as restrictions on silica in dust, also affect cement raw materials quarries.

Although still relatively minor in the United States, there is growing use worldwide of natural and synthetic pozzolans as partial or complete replacements for portland cement. Pozzolans are materials that, in the presence of free lime, have hydraulic cementitious properties; examples include some volcanic ashes and industrial byproducts such as granulated blast furnace slag, fly ash, and silica fume. Pozzolanic cements, including blends with portland, can have performance advantages over some straight portland cements for certain applications. Because pozzolans do not require the energy-intensive clinker manufacturing (kiln) phase of production, their use reduces the unit monetary and environmental costs of cement manufacture. In the United States, most pozzolan consumption continued to be as sales directly to concrete manufacturers rather than within blended cements sold by cement plants.

World Production and Capacity:

	Cement production		Yearend clinker capacity[e]	
	2000	**2001[e]**	**2000**	**2001**
United States (includes Puerto Rico)	89,510	91,100	[6]91,228	93,000
Brazil	39,208	40,000	45,000	45,000
China	583,190	595,000	550,000	550,000
Egypt	24,143	22,000	24,000	30,000
France	20,000	21,000	24,000	24,000
Germany	38,000	40,000	43,000	43,000
India	95,000	100,000	110,000	115,000
Indonesia	27,789	28,000	45,000	45,000
Iran	20,000	23,000	26,000	27,000
Italy	36,000	36,000	46,000	46,000
Japan	81,300	82,000	96,000	96,000
Korea, Republic of	51,255	52,000	62,000	62,000
Mexico	31,677	30,000	40,000	40,000
Russia	32,400	35,000	65,000	65,000
Spain	30,000	30,000	40,000	40,000
Taiwan	18,500	18,500	24,000	26,000
Thailand	32,000	32,000	48,000	48,000
Turkey	35,825	36,000	33,000	33,000
Other countries (rounded)	330,000	340,000	350,000	350,000
World total (rounded)	1,600,000	1,650,000	1,700,000	1,800,000

World Resources: Although individual company reserves are subject to exhaustion, cement raw materials, especially limestone, are geologically widespread and abundant, and overall shortages are unlikely in the foreseeable future. Local shortages generally can be met through imports of cement and/or clinker.

Substitutes: Virtually all portland cement is utilized either in making concrete or mortars and, as such, competes in the construction sector with concrete substitutes such as clay brick, glass, aluminum, steel, fiberglass, wood, stone, and asphalt. Pozzolans and similar materials are being used as partial or complete substitutes for portland cement for some concrete applications.

[e]Estimated.

[1]Portland plus masonry cement, unless otherwise noted. Excludes Puerto Rico.

[2]Includes cement made from imported clinker.

[3]Production of cement (including from imported clinker) + imports (excluding clinker) - exports - changes in stocks.

[4]Defined as imports - exports + adjustments for Government and industry stock changes.

[5]Hydraulic cement and clinker.

[6]Reported.

CESIUM

(Data in kilograms of cesium content, unless otherwise noted)

Domestic Production and Use: Although cesium was not recovered from any domestically mined ores, it is thought that at least one domestic company manufactured cesium products from imported pollucite ore. Cesium, usually in the form of chemical compounds, was used in research and development and commercially in electronic, photoelectric, and medical applications.

Salient Statistics—United States: Salient statistics, such as production, consumption, imports, and exports, are not available. The cesium market is very small, with annual consumption probably amounting to only a few thousand kilograms. As a result, there is no active trading of the metal, and, therefore, no official market price. However, several companies publish prices for cesium and cesium compounds. These prices remain relatively stable for several years. The per-unit price for the metal or compounds purchased from these companies varies inversely with the quantity of material purchased. For example, in 2001, one company offered 1-gram ampoules of 99.98%-grade cesium metal at $50.00. The price for 100 grams of the same material from this company was $1,370.00, or $13.70 per gram.

Recycling: None.

Import Sources (1997-2000): The United States is 100% import reliant. Canada is the major source of cesium ores. Other possible sources of cesium-bearing material include Germany and the United Kingdom.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Alkali metals, other	2805.19.0000	5.5% ad val.
Chlorides, other	2827.39.5000	3.7% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert G. Reese, Jr. [(703) 648-4981, rreese@usgs.gov, fax: (703) 648-7757]**

CESIUM

Events, Trends, and Issues: U.S. demand for cesium remained essentially unchanged. The United States is likely to continue to be dependent upon foreign sources unless domestic deposits are discovered or technology is developed to use low-grade raw materials. The high cost and extreme reactivity of cesium limit its application at present. Because of the small scale of production of cesium products, no significant environmental problems have been encountered.

World Mine Production, Reserves, and Reserve Base: Data on mine production of cesium are not available, and data on resources are sketchy. The estimates of reserves and of the reserve base are based upon occurrences of the cesium aluminosilicate mineral pollucite, found in zoned pegmatites in association with the lithium minerals lepidolite and petalite. Pollucite is mined as a byproduct with other pegmatite minerals; commercial concentrates of pollucite contain about 20% cesium by weight.

	Reserves[1]	Reserve base[1]
Canada	70,000,000	73,000,000
Namibia	—	9,000,000
Zimbabwe	23,000,000	23,000,000
Other countries	NA	NA
World total (rounded)	100,000,000	110,000,000

World Resources: World resources of cesium have not been estimated.

Substitutes: The properties of rubidium and its compounds are quite similar to those of cesium and its compounds; thus, rubidium and cesium are used interchangeably in many applications.

NA Not available. — Zero.

[1]See Appendix C for definitions.

CHROMIUM

(Data in thousand metric tons, gross weight, unless otherwise noted)

Domestic Production and Use: In 2001, the United States consumed about 14% of world chromite ore production in various forms of imported materials, such as chromite ore, chromium chemicals, chromium ferroalloys, and chromium metal. Imported chromite was consumed by two chemical firms and two refractory firms to produce chromium chemicals and chromite-containing refractories, respectively. Consumption of chromium ferroalloys and metal was predominantly for the production of stainless and heat-resisting steel and superalloys, respectively. The value of chromium material consumption was about $327 million.

Salient Statistics—United States:[1]	1997	1998	1999	2000	2001[e]
Production, secondary	120	104	118	139	120
Imports for consumption	350	385	476	453	420
Exports	30	62	60	86	60
Government stockpile releases	47	93	19	85	60
Consumption:					
Reported[2] (excludes secondary)	333	277	298	206	280
Apparent[3] (includes secondary)	490	531	558	589	540
Price, chromite, yearend:					
South African, dollars per metric ton, South Africa	73	68	63	63	NA
Turkish, dollars per metric ton, Turkey	180	145	145	145	NA
Unit value, average annual import (dollars per metric ton):					
Chromite ore (gross weight)	74	74	62	64	65
Ferrochromium (chromium content)	1,212	1,027	732	797	800
Chromium metal (gross weight)	7,419	7,576	6,267	5,982	6,000
Stocks, industry, yearend	71	56	54	16	15
Net import reliance[4] as a percentage of apparent consumption	75	80	79	67	78

Recycling: In 2001, chromium contained in purchased stainless steel scrap accounted for 22% of apparent consumption.

Import Sources (1997-2000): Chromium contained in chromite ore and chromium ferroalloys and metal: South Africa, 48%; Kazakhstan, 16%; Russia, 9%; Turkey, 9%; Zimbabwe, 9%; and other, 9%.

Tariff:[5] Item	Number	Normal Trade Relations 12/31/01
Ore and concentrate	2610.00.0000	Free.
Ferrochromium, high-carbon	7202.41.0000	1.9% ad val.
Chromium metal	8112.20.6000	3% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: The Defense Logistics Agency, U.S. Department of Defense, submitted the Annual Materials Plan for 2002 in February 2001. In addition to the stockpile-grade uncommitted inventory listed below, the stockpile contained the following nonstockpile-grade uncommitted inventory, in thousand metric tons: metallurgical chromite ore, 33; high-carbon ferrochromium, 0.601; low-carbon ferrochromium, 6.89; and ferrochromium silicon, 7.28.

Stockpile Status—9-30-01[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001	Average chromium content
Chromite ore:						
Chemical-grade	192	6.16	192	90.7	—	28.6%
Metallurgical-grade	62.0	67.1	62.0	227	12.7	28.6%
Refractory-grade	202	16.9	202	90.7	12.8	[e]23.9%
Chromium ferroalloys:						
Ferrochromium:						
High-carbon	560	39.7	560	136	—	71.4%
Low-carbon	237	4.24	237	—	18.6	71.4%
Ferrochromium-silicon	9.37	3.33	9.37	—	2.47	42.9%
Chromium metal	7.28	0.021	4.10	0.454	0.124	[e]100%

Prepared by **John F. Papp [(703) 648-4963, jpapp@usgs.gov, fax: (703) 648-7757]**

CHROMIUM

Events, Trends, and Issues: Chromite ore is not produced in the United States, Canada, or Mexico. Chromite ore is produced in the Western Hemisphere only in Brazil and Cuba. Most of Brazilian production is consumed in Brazil; some is exported to Norway. Cuban production is small. The largest chromite-ore-producing countries (India, Kazakhstan, South Africa, and Turkey) accounted for about 80% of world production. South Africa alone accounts for more than 40% of world production and has been the major supplier of chromium in the form of chromite ore and ferrochromium to Western industrialized countries. Stainless steel, the major end use market for chromium, has shown long-term growth equivalent to about one or two new ferrochromium furnaces per year. To meet this demand, South African plants were built or expanded. Production capacity was then expanded through the addition of furnaces and plant enhancements that improved recovery and reduced cost, such as agglomeration, preheating of furnace feed, and recovery from slag. South African chromite ore and ferrochromium producers financed these process changes through joint ventures with stainless steel producers in Asia. By financing capacity growth and production efficiency, consumers have lowered their cost and secured their supply, and producers have secured market share and stabilized production rates. With existing South African plants efficiently meeting current (2001) demand, a new round of plant development and furnace additions is expected in Kazakhstan and South Africa to meet anticipated demand growth.

The U.S. Environmental Protection Agency regulates chromium releases into the environment. The U.S. Occupational Safety and Health Administration regulates workplace exposure.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001[e]	(shipping grade)[8]	
United States	—	—	—	10,000
India	1,500	1,500	26,000	57,000
Kazakhstan	2,610	2,300	320,000	320,000
South Africa	6,620	5,400	3,000,000	5,500,000
Turkey	1,000	500	8,000	20,000
Other countries	2,640	2,300	250,000	1,600,000
World total (rounded)	14,400	12,400	3,600,000	7,600,000

World Resources: World resources exceed 11 billion tons of shipping-grade chromite, sufficient to meet conceivable demand for centuries. About 95% of chromium resources is geographically concentrated in southern Africa. Reserves and reserve base are geographically concentrated in Kazakhstan and southern Africa. The largest U.S. chromium resource is in the Stillwater Complex in Montana.

Substitutes: Chromite ore has no substitute in the production of ferrochromium, chromium chemicals, or chromite refractories. Chromium has no substitute in stainless steel, the largest end use, or for chromium in superalloys, the major strategic end use. Chromium-containing scrap can substitute for ferrochromium in metallurgical uses. Substitutes for chromium-containing alloys, chromium chemicals, and chromite refractories generally increase cost or limit performance. In 1978, the National Academy of Sciences found that substituting chromium-free materials for chromium-containing products could save about 60% of chromium used in alloying metals, about 15% of chromium used in chemicals, and 90% of chromite used in refractories, given 5 to 10 years to develop technically acceptable substitutes and to accept increased cost.

[e]Estimated. NA Not available. — Zero.

[1]Data in thousand metric tons of contained chromium, unless noted otherwise.

[2]The years 1997 through 1998 include chromite ore; 1999 through 2001 exclude chromite ore.

[3]Calculated demand for chromium is production + imports - exports + stock adjustment.

[4]Defined as imports - exports + adjustments for Government and industry stock changes.

[5]In addition to the tariff items listed, certain imported chromium materials (see U.S. Code, chapter 26, sections 4661 and 4672) are subject to excis tax.

[6]See Appendix B for definitions.

[7]See Appendix C for definitions.

[8]Shipping-grade chromite ore is deposit quantity and grade normalized to 45% Cr_2O_3.

CLAYS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 2000, clay and shale production was reported in all States except Alaska, Delaware, Hawaii, Idaho, New Hampshire, Rhode Island, Vermont, and Wisconsin. About 230 companies operated approximately 650 clay pits or quarries. The leading 20 firms supplied about 50% of the tonnage and 77% of the value for all types of clay sold or used in the United States. U.S. production was estimated to be 40.6 million metric tons valued at $1.49 billion. Major domestic uses for specific clays were estimated to be as follows: ball clay—35% floor and wall tile, 22% sanitaryware, and 43% other uses; bentonite—26% pet waste absorbent, 25% foundry sand bond, 19% drilling mud, 15% iron ore pelletizing, and 15% other uses; common clay—56% brick, 20% cement, 16% lightweight aggregate, and 8% other uses; fire clay—73% refractories and 27% other uses; fuller's earth—75% absorbent uses and 25% other uses; and kaolin—55% paper, 7% refractories, and 38% other uses.

Salient Statistics—United States:[1]	1997	1998	1999	2000	2001[e]
Production, mine:					
Ball clay	1,060	1,130	1,200	1,140	1,170
Bentonite	4,020	3,820	4,070	3,760	3,820
Common clay	24,600	24,500	24,800	23,700	23,700
Fire clay[2]	415	410	402	476	391
Fuller's earth	2,370	2,350	2,560	2,910	2,400
Kaolin	9,280	9,450	9,160	8,800	9,030
Total[3]	41,800	41,600	42,200	40,800	40,600
Imports for consumption:					
Artificially activated clay and earth	19	19	17	18	14
Kaolin	30	53	57	63	49
Other	15	14	16	16	15
Total[3]	64	86	90	96	78
Exports:					
Ball clay	91	140	107	100	226
Bentonite	850	818	719	761	613
Fire clay[2]	222	168	189	216	217
Fuller's earth	144	121	152	136	151
Kaolin	3,380	3,550	3,310	3,690	3,560
Clays, not elsewhere classified	390	432	329	357	363
Total[3]	5,080	5,230	4,800	5,260	5,130
Consumption, apparent	36,800	36,500	37,500	35,600	35,500
Price, average, dollars per ton:					
Ball clay	47	45	40	42	42
Bentonite	42	46	43	41	42
Common clay	6	6	6	6	6
Fire clay	19	18	16	16	16
Fuller's earth	107	109	90	87	89
Kaolin	111	111	104	106	103
Stocks, yearend[4]	NA	NA	NA	NA	NA
Employment, number:[e]					
Mine	4,900	4,790	5,020	5,090	5,000
Mill	4,500	4,580	4,220	4,290	4,250
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1997-2000): Brazil, 43%; United Kingdom, 21%; Mexico, 17%; Canada, 7%; and other, 12%.

Prepared by **Robert L. Virta [(703) 648-7726, rvirta@usgs.gov, fax: (703) 648-7722]**

CLAYS

Tariff: Item	Number	Normal Trade Relations 12/31/01
Kaolin and other kaolinitic clays, whether or not calcined	2507.00.0000	Free.
Bentonite	2508.10.0000	Free.
Fuller's and decolorizing earths	2508.20.0000	Free.
Fire clay	2508.30.0000	Free.
Common blue and other ball clays	2508.40.0010	Free.
Other clays	2508.40.0050	Free.
Chamotte or dina's earth	2508.70.0000	Free.
Activated clays and earths	3802.90.2000	2.5% ad val.
Expanded clays and mixtures	6806.20.0000	Free.

Depletion Allowance: Ball clay, bentonite, fire clay, fuller's earth, and kaolin, 14% (Domestic and foreign); clay used in the manufacture of common brick, lightweight aggregate, and sewer pipe, 7.5% (Domestic and foreign); clays used in the manufacture of drain and roofing tile, flower pots, and kindred products, 5% (Domestic and foreign); clay used for alumina and aluminum compounds, 22% (Domestic).

Government Stockpile: None.

Events, Trends, and Issues: The amount of clay and shale sold or used by domestic producers decreased slightly in 2001. Small increases were reported for ball clay, bentonite, and kaolin. Fire clay and fuller's earth declined. Production of common clay and shale was unchanged. Imports for consumption decreased 19% to 78,000 tons in 2001. Brazil, Mexico, and the United Kingdom were the major sources for imported clays. Exports decreased 2% to 5.13 million tons in 2001. Canada, Finland, Japan, and the Netherlands were major markets for exported clays.

World Mine Production, Reserves, and Reserve Base: World production of bentonite was 9.9 million tons in 2001. The United States was the leading producing country with 3.82 million tons, followed by Greece with 950,000 tons, and the former Soviet Union countries with 750,000 tons combined. World production of fuller's earth was 3.8 million tons in 2001. The United States was the leading producing country with 2.4 million tons, followed by Germany with 500,000 tons. World production of kaolin was 41.2 million tons in 2001. The United States was the leading producer with 9 million tons (sales); followed by Uzbekistan with 5.5 million tons (crude); the Czech Republic, 6 million tons (crude); the United Kingdom, 2.4 million tons (processed); the Republic of Korea, 2.1 million tons (crude); Germany, 1.8 million tons (crude and sales); and Brazil, 1.7 million tons (beneficiated). Reserves and reserve base are large in major producing countries, but data are not available.

World Resources: Clays are divided for commercial purposes into ball clay, bentonite, common clay, fire clay, fuller's earth, and kaolin. Resources of these types of clay are extremely large except for lesser resources of high-grade ball clay and sodium-bentonite. Resources of kaolin in Georgia are estimated to be 1.4 billion tons.

Substitutes: Limited substitutes and alternatives, such as calcium carbonate and talc, are available for filler and extender applications.

[e]Estimated. E Net exporter. NA Not available.
[1]Excludes Puerto Rico.
[2]Refractory uses only.
[3]Data may not add to total shown because of independent rounding.
[4]Data on stocks are not available and are assumed to be zero for apparent consumption and net import reliance calculations.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.

COBALT

(Data in metric tons of cobalt content, unless otherwise noted)

Domestic Production and Use: The United States did not mine or refine cobalt in 2001; however, negligible amounts of byproduct cobalt were produced as intermediate products from some mining operations. U.S. supply comprised imports, stock releases, and secondary materials, such as superalloy scrap, cemented carbide scrap, and spent catalysts. There were two domestic producers of extra-fine cobalt powder: One produced powder from imported primary metal, and another produced powder from recycled materials. In addition to the powder producers, seven companies were known to be active in the production of cobalt compounds. Nearly 90 industrial consumers were surveyed on a monthly or annual basis. Data reported by these consumers indicate that approximately 44% of U.S. cobalt use was in superalloys, which are used primarily in aircraft gas turbine engines; 9% was in cemented carbides for cutting and wear-resistant applications; 20% was in various other metallic uses; and the remaining 27% was in a variety of chemical uses. The total estimated value of cobalt consumed in 2001 was $250 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Mine	—	—	—	—	—
Secondary	2,750	3,080	2,720	2,550	2,500
Imports for consumption	8,430	7,670	8,150	8,770	9,400
Exports	1,570	1,680	1,550	2,630	3,000
Shipments from Government stockpile excesses	1,620	2,310	1,530	2,960	2,300
Consumption:					
Reported (includes secondary)	8,910	9,130	8,410	8,700	8,500
Apparent (includes secondary)	11,200	11,500	10,700	11,700	11,200
Price, average annual spot for cathodes, dollars per pound	23.34	21.43	17.02	15.16	10.70
Stocks, industry, yearend	1,090	1,000	1,160	1,140	1,150
Net import reliance[1] as a percentage of apparent consumption	76	73	75	78	78

Recycling: About 2,500 tons of cobalt was recycled from purchased scrap in 2001. This represented about 29% of estimated reported consumption for the year.

Import Sources (1997-2000): Cobalt content of metal, oxide, and salts: Finland, 22%; Norway, 21%; Canada, 11%; Russia, 11%; and other, 35%.

Tariff: Item	Number	Normal Trade Relations[2] 12/31/01
Unwrought cobalt, alloys	8105.10.3000	4.4% ad val.
Unwrought cobalt, other	8105.10.6000	Free.
Cobalt matte, waste, and scrap	8105.10.9000	Free.
Wrought cobalt and cobalt articles	8105.90.0000	3.7% ad val.
Chemical compounds:		
Cobalt oxides and hydroxides	2822.00.0000	0.1% ad val.
Cobalt sulfates	2833.29.1000	1.4% ad val.
Cobalt chlorides	2827.34.0000	4.2% ad val.
Cobalt carbonates	2836.99.1000	4.2% ad val.
Cobalt acetates	2915.23.0000	4.2% ad val.
Cobalt ores and concentrates	2605.00.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: Sales of National Defense Stockpile cobalt began in March 1993. The Annual Materials Plan of the Defense Logistics Agency, U.S. Department of Defense, includes a cobalt disposal limit of 2,720 tons (6 million pounds) during fiscal year 2002.

Stockpile Status—9-30-01[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Cobalt	7,890	299	7,890	2,720	2,210

Prepared by **Kim B. Shedd [(703) 648-4974, kshedd@usgs.gov, fax: (703) 648-7757]**

COBALT

Events, Trends, and Issues: World production of refined cobalt has steadily increased since 1993. Some of the increase has been from new operations and some has been from a net increase in production by established producers. During this period, sales of cobalt from the National Defense Stockpile and cobalt in recycled scrap have also contributed to supply.

World demand for cobalt is strongly influenced by general economic conditions and by demand from industries that consume large quantities of cobalt, such as superalloy melters and manufacturers of rechargeable batteries. In 2001, several factors reduced overall demand for cobalt, including weak economic conditions in major consuming countries such as the United States and Japan, and a decrease in the production of rechargeable batteries so that battery inventories would be reduced. In September, terrorist attacks in the United States caused economic uncertainty, concern that renewed U.S. industrial activity would be delayed, and financial problems for the U.S. commercial airline industry, a major consumer of superalloys.

Since 1995, the general trend in cobalt prices has been downward. This trend is likely to continue if cobalt supply continues to increase at a faster rate than that of cobalt demand, or if cobalt demand decreases without a reduction in supply.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	—	—	NA	860,000
Australia	5,600	6,500	1,300,000	1,600,000
Canada	5,300	5,000	45,000	260,000
Congo (Kinshasa)	7,000	7,000	NA	2,500,000
Cuba	2,400	2,600	1,000,000	1,800,000
New Caledonia[5]	1,100	1,100	230,000	860,000
Philippines	NA	NA	NA	400,000
Russia	3,600	4,000	140,000	230,000
Zambia	4,600	7,000	360,000	540,000
Other countries	3,700	3,700	90,000	1,200,000
World total (may be rounded)	33,300	36,900	3,200,000	10,000,000

World Resources: The cobalt resources of the United States are estimated to be about 1.3 million tons. Most of these resources are in Minnesota, but other important occurrences are in Alaska, California, Idaho, Missouri, Montana, and Oregon. With the exception of resources in Idaho and Missouri, any cobalt production from these deposits would be as a byproduct of another metal. The identified world cobalt resources are about 11 million tons. The vast majority of these resources are in nickel-bearing laterite deposits, with most of the rest occurring in nickel-copper sulfide deposits hosted in mafic and ultramafic rocks in Australia, Canada, and Russia, and in the sedimentary copper deposits of Congo (Kinshasa) and Zambia. In addition, millions of tons of hypothetical and speculative cobalt resources exist in manganese nodules and crusts on the ocean floor.

Substitutes: Periods of high prices and concern about availability have resulted in various efforts to conserve, reduce, or substitute for cobalt. In many applications, further substitution of cobalt would result in a loss in product performance. Potential substitutes include barium or strontium ferrites, neodymium-iron-boron, or nickel-iron alloys in magnets; nickel, cermets, or ceramics in cutting and wear-resistant materials; nickel base alloys or ceramics in jet engines; nickel in petroleum catalysts; rhodium in hydroformylation catalysts; iron, manganese, or nickel in batteries; and manganese, iron, cerium, or zirconium in paints.

[e]Estimated. NA Not available. — Zero.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]No tariff for Canada or Mexico.
[3]See Appendix B for definitions.
[4]See Appendix C for definitions.
[5]Overseas territory of France.

COLUMBIUM (NIOBIUM)

(Data in metric tons of columbium content, unless otherwise noted)

Domestic Production and Use: There has been no significant domestic columbium mining since 1959. Domestic columbium resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Most metal, ferrocolumbium, other alloys, and compounds were produced by six companies. Feed for these plants included imported concentrates, columbium oxide, and ferrocolumbium. Consumption was mainly as ferrocolumbium by the steel industry and as columbium alloys and metal by the aerospace industry, with plants in the Eastern and Midwestern United States, California, and Washington. The estimated value of reported columbium consumption, in the form of ferrocolumbium and nickel columbium, in 2001 was about $85 million. Major end-use distribution of reported columbium consumption was as follows: carbon steels, 33%; superalloys, 23%; stainless and heat-resisting steels, 18%; high-strength low-alloy steels, 16%; alloy steels, 9%; and other, 1%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
Concentrates, tin slags, other[1]	NA	NA	NA	NA	NA
Ferrocolumbium[e]	4,260	4,900	4,450	4,400	4,100
Exports, concentrate, metal, alloys[e]	70	50	160	100	110
Government stockpile releases[e 2]	126	145	280	217	(14)
Consumption, reported, ferrocolumbium[e 3]	3,770	3,640	3,460	4,090	4,100
Consumption, apparent	4,030	4,150	4,100	4,300	4,300
Price:					
Columbite, dollars per pound[4]	3.00	3.00	3.00	6.25	NA
Pyrochlore, dollars per pound[5]	NA	NA	NA	NA	NA
Stocks, industry, processor and consumer, yearend	NA	NA	NA	NA	NA
Employment	NA	NA	NA	NA	NA
Net import reliance[6] as a percentage of apparent consumption	100	100	100	100	100

Recycling: While columbium is not recovered from scrap steel and superalloys containing it, recycling of these alloys is significant, and columbium content is reused. Data on the quantities of columbium recycled in this manner are not available.

Import Sources (1997-2000): Brazil, 75%; Canada, 9%; Germany, 4%; Russia, 2%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Columbium ores and concentrates	2615.90.6030	Free.
Columbium oxide	2825.90.1500	3.7% ad val.
Ferrocolumbium	7202.93.0000	5.0% ad val.
Columbium, unwrought:		
Waste and scrap	8112.91.0500	Free.
Alloys, metal, powders	8112.91.4000	4.9% ad val.
Columbium, wrought	8112.99.0000	4.0% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: For fiscal year 2001, ending September 30, 2001, the Defense National Stockpile Center (DNSC) sold about 48 tons of columbium contained in ferrocolumbium valued at about $1.29 million and about 9 tons of columbium metal ingots valued at about $323,000 from the National Defense Stockpile (NDS). The DNSC disposed of about 3 tons of columbium contained in tantalum minerals that were sold in fiscal year 2001; no value obtained as columbium was contained within the tantalum minerals. There were no sales of columbium carbide powder in fiscal year 2001. The DNSC also proposed maximum disposal limits in fiscal year 2002 of about 10 tons[7] of columbium contained in columbium carbide powder, about 254 tons of columbium contained in columbium concentrates, and about 9 tons of columbium metal ingots. The NDS uncommitted inventories shown below include about 244 tons of columbium contained in nonstockpile-grade concentrates.

Prepared by **Larry D. Cunningham [(703) 648-4977, lcunning@usgs.gov, fax: (703) 648-7757]**

COLUMBIUM (NIOBIUM)

Stockpile Status—9-30-01[8]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Columbium:					
Carbide powder	10	—	10	[7]10	—
Concentrates	594	—	594	254	[9]3
Ferrocolumbium	—	—	—	[7]68	48
Metal	46	—	46	9	9

Events, Trends, and Issues: For the first one-half year, domestic demand for columbium ferroalloys in steelmaking and demand for columbium in superalloys (mostly for aircraft engine components) increased slightly compared with the similar period of 2000. For the same period, overall columbium imports increased; Brazil accounted for more than 70% of quantity and about 65% of value. Exports increased, with Canada, Italy, Mexico, and the United Kingdom receiving most of the columbium materials. The published price for columbite ore was discontinued in October at a range of $5.50 to $7 per pound of pentoxide content. Unchanged since September 1997, the published price for steelmaking-grade ferrocolumbium was quoted at a range of $6.75 to $7 per pound of columbium content and high-purity ferrocolumbium was quoted at a range of $17.50 to $18 per pound of columbium content. Industry sources indicated in December 1999 that nickel columbium sold at about $18.50 per pound of columbium content, columbium metal products sold in the range of about $24 to $100 per pound in ingot and special shape forms, and columbium oxide for master alloy production sold for about $8.80 per pound. Public information on current prices for these products was not available. No domestic columbium mine production is expected in 2002, and it is estimated that U.S. apparent consumption will be about 4,400 tons. Most of total U.S. demand will be met by columbium imports in upgraded forms.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[10]	Reserve base[10]
	2000	2001[e]		
United States	—	—	—	Negligible
Australia	160	200	16,000	NA
Brazil	30,000	30,000	4,400,000	5,200,000
Canada	2,290	2,300	140,000	400,000
Ethiopia	7	5	NA	NA
Nigeria	35	30	60,000	90,000
Rwanda	28	25	NA	NA
Other countries[11]	—	—	NA	NA
World total (rounded)	32,600	32,600	4,600,000	5,700,000

World Resources: Most of the world's identified resources of columbium are outside the United States and occur mainly as pyrochlore in carbonatite deposits. On a worldwide basis, resources are more than adequate to supply projected needs. The United States has approximately 150,000 tons of columbium resources in identified deposits, all of which were considered uneconomic at 2001 prices for columbium.

Substitutes: The following materials can be substituted for columbium, but a performance or cost penalty may ensue: molybdenum and vanadium as alloying elements in high-strength low-alloy steels; tantalum and titanium as alloying elements in stainless and high-strength steels; and ceramics, molybdenum, tantalum, and tungsten in high-temperature applications.

[e]Estimated. NA Not available. — Zero.
[1]Metal, alloys, synthetic concentrates, and columbium oxide.
[2]Net quantity (uncommitted inventory). Parentheses indicate negative number (increase in inventory).
[3]Includes nickel columbium.
[4]Yearend average value, contained pentoxides for material having a Nb_2O_5 to Ta_2O_5 ratio of 10 to 1.
[5]Yearend average value, contained pentoxide.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]Actual quantity limited to remaining sales authority or inventory.
[8]See Appendix B for definitions.
[9]Columbium units contained in the disposal of tantalum minerals.
[10]See Appendix C for definitions.
[11]Bolivia, China, Congo (Kinshasa), Russia, and Zambia also produce (or are thought to produce) columbium, but available information is inadequa
make reliable estimates of output levels.

COPPER

(Data in thousand metric tons of copper content, unless otherwise noted)

Domestic Production and Use: Domestic mine production in 2001 declined to 1.34 million metric tons and was valued at about $2.2 billion. The principal mining States, in descending order, Arizona, Utah, and New Mexico, accounted for 99% of domestic production; copper was also recovered at mines in three other States. Although copper was recovered at about 25 mines operating in the United States, 15 mines accounted for about 99% of production. Four primary smelters and 1 secondary smelter, 4 electrolytic and 3 fire refineries, and 14 solvent extraction-electrowinning facilities operated during the year. Refined copper and direct melt scrap were consumed at about 35 brass mills; 13 rod mills; and 600 foundries, chemical plants, and miscellaneous consumers. Copper and copper alloy products consumed[1] in building construction totaled 39%; electric and electronic products, 28%; transportation equipment, 11%; industrial machinery and equipment, 11%; and consumer and general products, 11%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production: Mine	1,940	1,860	1,600	1,440	1,340
Refinery:					
Primary	2,070	2,140	1,890	1,590	1,600
Secondary	396	349	230	209	170
Copper from all old scrap	498	466	381	353	310
Imports for consumption:					
Ores and concentrates	44	217	143	([2])	20
Refined	632	683	837	1,060	1,200
Unmanufactured	999	1,190	1,280	1,350	1,550
Exports:					
Ores and concentrates	127	37	64	116	50
Refined	93	86	25	94	20
Unmanufactured	628	412	395	661	600
Consumption:					
Reported refined	2,790	2,890	2,980	3,030	2,710
Apparent unmanufactured[3]	2,940	3,030	3,130	3,100	2,770
Price, average, cents per pound:					
Domestic producer, cathode	107.0	78.6	75.9	88.2	76
London Metal Exchange, high-grade	103.2	75.0	71.3	82.2	72
Stocks, yearend, refined, held by U.S. producers, consumers, and metal exchanges	314	532	565	334	800
Employment, mine and mill, thousands	13.2	13.0	11.6	10.2	10
Net import reliance[4] as a percentage of apparent consumption	13	14	27	37	31

Recycling: Old scrap, converted to refined metal and alloys, provided 310,000 tons of copper, equivalent to 11% of apparent consumption. Purchased new scrap, derived from fabricating operations, yielded 910,000 tons of contained copper; about 90% of the copper contained in new scrap was consumed at brass or wire-rod mills. Of the total copper recovered from scrap (including aluminum- and nickel-base scrap), brass mills recovered 65%; copper smelters and refiners,13%; ingot makers, 11%; and miscellaneous manufacturers, foundries, and chemical plants, 11%. Copper in all old and new, refined or remelted scrap contributed 33% of the U.S. copper supply.

Import Sources (1997-2000): Unmanufactured: Canada, 34%; Chile, 24%; Peru, 16%; Mexico, 14%; and other, 12%. Refined copper accounted for 67% of imports of unwrought copper.

Tariff: Item	Number	Normal Trade Relations[5] 12/31/01
Unrefined copper; anodes	7402.00.0000	Free.
Refined and alloys; unwrought	7403.00.0000	1.0% ad val.
Copper powder	7406.10.0000	Free.
Copper wire (rod)	7408.11.6000	3.0% ad val.

Depletion Allowance: 15% (Domestic), 14% (Foreign).

Government Stockpile: The stockpile of about 20,000 tons of refined copper was liquidated in 1993. The stockpile of about 8,100 tons of brass was liquidated in 1994. For details on inventories of beryllium-copper master alloys (4% beryllium), see the section on beryllium.

Prepared by **Daniel L. Edelstein [(703) 648-4978, dedelste@usgs.gov, fax: (703) 648-7757]**

COPPER

Events, Trends, and Issues: World mine production of copper rose by about 300,000 tons (2%), despite a significant drop in U.S. production. World mine capacity rose by only about 100,000 tons (1%), representing a break from the rapid expansion in capacity over the preceding 5 years. Although, according to preliminary data compiled by the International Copper Study Group,[6] world refinery production increased by about 450,000 tons (5%) for the first 7 months of 2000, world copper use declined by 2.6% for the corresponding period. As a result, a calculated global production surplus of about 200,000 developed and reported stocks increased by more than 350,000 tons. This contrasts with an inventory draw-down for the first 7 months of 2000 of about 275,000 tons. Copper prices trended downward throughout the year with rising inventories, and by September the average monthly COMEX and U.S. producer price had fallen to $0.654 and $0.696 per pound, respectively.

U.S. production cutbacks continued into 2001. The Continental Mine in Montana, which had expected to reopen in late 2000, remained closed. Phelps Dodge Corp. completed conversion of its Morenci, AZ, mine to an all-leach operation by the end of the first quarter and curtailed concentrate production at Chino, NM. (For details, see USGS Mineral Industry Surveys, Copper in March 2001.) With falling copper prices, rising inventories, and a weak demand outlook, several companies announced additional reductions in the second half of the year. Kennecott Utah Copper Corp. closed its higher cost North concentrator at its Bingham Canyon Mine at midyear. (For details, see USGS Mineral Industry Surveys, Copper in April 2001.) In October, citing further deterioration in the near-term economic outlook following the September 11 terrorist attacks, Phelps Dodge announced that it would curtail an additional 220,000 tons per year of U.S. production by mid-January 2002. Phelps Dodge planned to close the Chino (NM) and Miami (AZ) leach operations and halve production at the Sierrita (AZ) and Bagdad (AZ) mines. It also planned to close its Chino smelter and Miami refinery.[7] U.S. refined consumption was projected to decline by 10% in 2001.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	2000	2001[e]		
United States	1,440	1,340	45,000	90,000
Australia	829	900	9,000	23,000
Canada	634	620	10,000	23,000
Chile	4,600	4,650	88,000	160,000
China	590	620	18,000	37,000
Indonesia	1,012	1,080	19,000	25,000
Kazakhstan	430	470	14,000	20,000
Mexico	365	370	15,000	27,000
Peru	554	560	19,000	40,000
Poland	456	450	20,000	36,000
Russia	570	550	20,000	30,000
Zambia	240	320	12,000	34,000
Other countries	1,480	1,570	50,000	105,000
World total (may be rounded)	13,200	13,200	340,000	650,000

World Resources: Land-based resources are estimated to be 1.6 billion tons of copper, and resources in deep-sea nodules are estimated to be 700 million tons. In the United States, discovered copper resources are estimated to contain 350 million tons and undiscovered deposits to contain 290 million tons of copper.

Substitutes: Aluminum substitutes for copper in various products, such as electrical power cables, electrical equipment, automobile radiators, and cooling/refrigeration tubing. Titanium and steel are used in heat exchangers, and steel is used for artillery shell casings. Optical fiber substitutes for copper in some telecommunications applications. Plastics also substitute for copper in water pipe, plumbing fixtures, and many structural applications.

[e]Estimated.
[1]Some electrical components are included in each end use. Distribution by Copper Development Association, 2000.
[2]Less than ½ unit
[3]Defined as primary refined production + copper from old scrap converted to refined metal and alloys + refined imports - refined exports ± changes refined stocks. In 1998, 1999, 2000, and 2001, general imports of 725,000 tons, 915,000 tons, 1,020,000 tons, and 1,350,000 tons, respectively, used to calculate apparent consumption.
[4]Defined as imports - exports + adjustments for Government and industry stock changes for refined copper.
[5]No tariff for Canada and Mexico for items shown.
[6]International Copper Study Group, 2001, Copper Bulletin: Lisbon, Portugal, International Copper Study Group, v. 8, no. 10, 48 p.
[7]Phelps Dodge Corp., 2001, Phelps Dodge addresses current economic environment: Phoenix, Phelps Dodge news release, October 23, 3 p.
[8]See Appendix C for definitions.

DIAMOND (INDUSTRIAL)

(Data in million carats, unless otherwise noted)

Domestic Production and Use: In 2001, production reached a record high for the fifth consecutive year and the United States remained the world's largest market for industrial diamond. All domestic output was synthetic grit and powder. Two firms, one in New Jersey and the other in Ohio, accounted for all of the production. Nine other firms produced polycrystalline diamond from diamond powder. Four companies recovered used industrial diamond as one of their principal operations. The following industry sectors were the major consumers of industrial diamond: computer chip production, construction, machinery manufacturing, mining services (drilling), stone cutting/polishing, and transportation systems (infrastructure and vehicles). Stone cutting and highway building and repair consumed most of the industrial stone. More than 90% of the industrial diamond market now uses synthetic industrial diamonds, whose quality can be controlled and whose properties can be customized to fit specific requirements.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Bort, grit, and dust and powder; natural and synthetic:					
Production:					
Manufactured diamond	125	140	208	248	408
Secondary	10	10	10	10	10
Imports for consumption	254	221	208	291	299
Exports[1]	126	104	98	98	91
Sales from Government stockpile excesses	0.7	([2])	([2])	—	—
Consumption, apparent	264	267	328	451	626
Price, value of imports, dollars per carat	0.43	0.44	0.44	0.42	0.31
Net import reliance[3] as a percentage of apparent consumption	49	44	36	43	33
Stones, natural:					
Production:					
Mine	([2])	([2])	([2])	([2])	([2])
Secondary	0.5	0.5	([2])	([2])	([2])
Imports for consumption[4]	2.8	4.7	3.1	2.5	1.7
Exports[1]	0.6	0.8	0.7	1.6	1.2
Sales from Government stockpile excesses	1.2	0.8	0.6	1.0	0.5
Consumption, apparent	3.9	5.2	3.4	2.2	1.2
Price, value of imports, dollars per carat	7.69	3.92	4.61	5.31	4.47
Net import reliance[3] as a percentage of apparent consumption	87	90	88	86	83

Recycling: Lower prices and greater competition appear to be reducing the number and scale of recycling operations.

Import Sources (1997-2000): Bort, grit, and dust and powder; natural and synthetic: Ireland, 47%; China, 17%; Russia, 7%; and other, 29%. Stones, primarily natural: United Kingdom, 19%; Switzerland, 18%; Ireland, 13%; Belgium, 9%; and other, 41%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Miners' diamond, carbonados	7102.21.1010	Free.
Other	7102.21.1020	Free.
Industrial diamond, natural advanced	7102.21.3000	Free.
Industrial diamond, natural not advanced	7102.21.4000	Free.
Industrial diamond, other	7102.29.0000	Free.
Grit or dust and powder	7105.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7722]**

DIAMOND (INDUSTRIAL)

Government Stockpile:

Stockpile Status—9-30-01[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Industrial stones	1.01	0.614	1.01	1.000	0.501

Events, Trends, and Issues: The United States will continue to be the world's largest market for industrial diamond well into the next decade and will remain a significant producer and exporter of industrial diamond as well. The most dramatic increase in U.S. demand for industrial diamond is likely to occur in the construction sector as the $200 billion Transportation Equity Act for the 21st Century (Public Law 105-178; enacted June 9, 1998) is further implemented. The act provides funding for building and repairing the Nation's highway system through 2003. Industrial diamond coats the cutting edge of saws used to cut cement in highway construction and repair work.

World consumption of industrial diamond during 2001 was estimated to be approximately 1.15 billion carats. World and U.S. demand for diamond grit and powder will grow during the next 5 years. Increases in demand for synthetic grit and powder are expected to be greater than for natural diamond material. Constant-dollar prices of synthetic diamond products probably will continue to decline as production technology becomes more cost effective; the decline is even more likely if competition from low-cost producers in China and Russia increases.

World Mine Production, Reserves, and Reserve Base:[6]

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States	([2])	([2])	Unknown	Unknown
Australia	14.7	15.0	90	230
Botswana	5.0	5.0	130	200
Brazil	0.6	0.6	5	15
China	0.9	0.9	10	20
Congo (Kinshasa)	14.2	14.2	150	350
Russia	11.6	11.7	40	65
South Africa	6.5	6.5	70	150
Other countries	2.1	2.1	80	200
World total (may be rounded)	55.6	56.0	580	1,200

World Resources: Natural diamond resources have been discovered in more than 35 countries. Nevertheless, natural diamond accounts for less than 10% of all industrial diamond used; synthetic diamond accounts for the remainder. At least 15 countries have the technology to produce synthetic diamond.

Substitutes: Materials that can compete with industrial diamond in some applications include manufactured abrasives, such as cubic boron nitride, fused aluminum oxide, and silicon carbide. Synthetic diamond rather than natural diamond is used for more than 90% of industrial applications.

[e]Estimated. — Zero.
[1]Reexports no longer are combined with exports because increasing amounts of U.S. reexports obscure apparent consumption rates.
[2]Less than ½ unit.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]May include synthetic miners' diamond.
[5]See Appendix B for definitions.
[6]Natural industrial diamond only. Note, however, that synthetic diamond production far exceeds natural industrial diamond output. Worldwide production of manufactured industrial diamond totaled at least 570 million carats in 2000; the largest producers included Ireland, Japan, Russia, a the United States.
[7]See Appendix C for definitions.

DIATOMITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: The estimated value of processed diatomite, f.o.b. plant, was $176 million in 2001. Production was from 7 companies with 12 processing facilities in 4 States. California and Nevada were the principal producing States, and accounted for about 87% of U.S. production in 2001. Estimated end uses of diatomite were filter aids, 66%; absorbents, 14%; fillers, 14%; and other (mostly cement manufacture), 6%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production[1]	773	725	747	677	735
Imports for consumption	2	2	([2])	([2])	([2])
Exports	140	138	123	131	131
Consumption, apparent	635	588	625	546	604
Price, average value, dollars per ton, f.o.b. plant	244	248	238	256	256
Stocks, producer, yearend	36	36	36	36	36
Employment, mine and plant, number[e]	1,000	1,000	1,000	1,000	1,000
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (1997-2000): France, 63%; Italy, 17%; and other, 20%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Siliceous fossil meals, including diatomite	2512.00.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Thomas P. Dolley [(703) 648-7710, tdolley@usgs.gov, fax: (703) 648-7722]**

DIATOMITE

Events, Trends, and Issues: Filtration (including purification of beer, wine, liquors, oils, and greases) continued to be the largest end use for diatomite, also known as diatomaceous earth (D.E.). Another application is the removal of microbial contaminants, such as bacteria, viruses, and protozoa, in public water systems. D.E. filter aids have been successfully deployed in about 200 locations throughout the United States for the treatment of potable water. Emerging small-scale applications for diatomite include pharmaceutical processing and use as a nontoxic insecticide.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States[1]	677	735	250,000	500,000
China	350	350		NA
Denmark[5]	185	185		NA
France	75	75		2,000
Japan	190	190		NA
Korea, Republic of	32	32		NA
Mexico	70	70		2,000
Spain	36	36		NA
Former Soviet Union[6]	80	80		NA
Other countries	200	200	550,000	NA
World total (may be rounded)	1,890	1,950	800,000	Large

World Resources: World resources of crude diatomite are adequate for the foreseeable future, but the need for diatomite to be near markets encourages development of new sources for the material.

Substitutes: Many materials can be substituted for diatomite. However, the unique properties of diatomite assure its continuing use for many applications. Expanded perlite and silica sand compete for filtration purposes. Other filtration technologies use ceramic, polymeric, or carbon membrane. Alternate filler materials include talc, ground silica sand, ground mica, clay, perlite, vermiculite, and ground limestone. For thermal insulation, materials such as various clays and special brick, mineral wool, expanded perlite, and exfoliated vermiculite can be used.

[e]Estimated. E Net exporter. NA Not available.
[1]Processed ore sold and used by producers.
[2]Less than ½ unit.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.
[5]Includes sales of moler production.
[6]As constituted before December 1991.

FELDSPAR

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: U.S. feldspar production in 2001 had an estimated value of about $42 million. The three largest producers accounted for about two-thirds of the output, with six other companies supplying the remainder. Operations in North Carolina provided about 40% of the output, and facilities in six other States contributed smaller quantities. Feldspar processors reported coproduct recovery of mica and silica sand.

Feldspar is ground for industry use to about 20 mesh for glassmaking and to 200 mesh or finer for most ceramic and filler applications. It was estimated that feldspar shipments went to at least 30 States and to foreign destinations, including Canada and Mexico. In pottery and glass, feldspar functions as a flux. Estimated 2001 end-use distribution of domestic feldspar was glass, 66%, and pottery and other, 34%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, marketable[e]	900	820	875	790	780
Imports for consumption	9	7	7	7	7
Exports	7	13	10	11	5
Consumption, apparent[e]	902	814	872	786	782
Price, average value, marketable production, dollars per ton[e]	47.00	50.00	49.00	56.00	54.00
Stocks, producer, yearend[1]	NA	NA	NA	NA	NA
Employment, mine and preparation plant, number	400	400	400	400	400
Net import reliance[2] as a percentage of apparent consumption	([3])	E	E	E	([3])

Recycling: Insignificant.

Import Sources (1997-2000): Mexico, 95%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Feldspar	2529.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Michael J. Potter, [(703) 648-7723, mpotter@usgs.gov, fax: (703) 648-7722]**

FELDSPAR

Events, Trends, and Issues: U.S. shipments of glass containers, a major end use of feldspar, were about 1% less in the first 8 months of 2001 than in the comparable period of 2000, according to the U.S. Census Bureau. Plastic containers continued to be strong competitors with glass in the packaging market, especially in the food and beverage segments. A U.S. manufacturer of glass baby food jars announced in June 2001 that it would replace most of its jars with plastic containers.[4] A U.S. brewing company previously began making three of its popular beers available in plastic bottles. However, glass remains the most widely used material for beer containers.[5]

Much feldspar was used in ceramic tile and vitreous plumbing fixtures in new housing and commercial buildings. U.S. housing starts for the first 8 months of 2001 were about 2% more than in the comparable period of 2000, according to U.S. Census Bureau data. There were indications of decreased housing activity in the fourth quarter of 2001, according to the National Association of Home Builders. Imports continued to account for a large share of the U.S. market, about 70% of all tile consumed in 2000. The largest suppliers, in descending order of quantity, were Italy, Spain, Mexico, and Brazil.[6]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[7]
	2000	2001[e]	
United States[e]	790	780	Detailed reserve information is not available.
Argentina	61	60	
Brazil	240	60	
Colombia	55	60	
France	600	600	
Germany	460	460	
Greece	60	60	
India	110	110	
Italy	2,600	2,600	
Japan	52	50	
Korea, Republic of	330	330	
Mexico	334	400	
Norway	75	80	
Portugal	120	120	
Spain	425	430	
Thailand	543	540	
Turkey	1,200	1,200	
Uzbekistan	70	70	
Venezuela	160	150	
Other countries	995	1,100	
World total	9,280	9,260	

World Resources: Identified and hypothetical resources of feldspar are more than adequate to meet anticipated world demand. Quantitative data on resources of feldspar existing in granites, pegmatites, and feldspathic sands generally have not been compiled. There is ample geologic evidence that resources are large, although not always conveniently accessible to the principal centers of consumption.

Substitutes: Feldspar can be replaced in some of its end uses by feldspar-silica mixtures, clays, talc, pyrophyllite, spodumene, or electric-furnace slag. Imported nepheline syenite, however, was the major alternative material.

[e]Estimated. E Net exporter. NA Not available.
[1]Change in stocks assumed to be zero for apparent consumption and net import reliance calculations.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]Negligible.
[4]The Freedonia Group, 2000, Plastic containers to 2004: Cleveland, OH, The Freedonia Group, 213 p.
[5]———2001, World beer containers: Cleveland, OH, The Freedonia Group, 327 p.
[6]Glueck, M.J., 2001, Information presented at Coverings 2001: Washington, DC, Law, Economics, and Consulting Group, LLC.
[7]See Appendix C for definitions.

FLUORSPAR

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: There was a small quantity of metallurgical-grade fluorspar mined and some byproduct calcium fluoride was recovered from industrial waste streams, although data are not available on exact quantities. Material purchased from the National Defense Stockpile or imported was screened and dried for resale to customers. Domestically, about 80% of reported fluorspar consumption went into the production of hydrofluoric acid (HF) in Louisiana and Texas and aluminum fluoride in Texas. HF is the primary feedstock for the manufacture of virtually all organic and inorganic fluorine-bearing chemicals, and is also a key ingredient in the processing of aluminum and uranium. The remaining estimated 20% of the reported fluorspar consumption was consumed as a flux in steelmaking, in iron and steel foundries, primary aluminum production, glass manufacture, enamels, welding rod coatings, cement production, and other uses or products. To supplement domestic fluorine supplies, about 53,000 metric tons of fluorosilicic acid (equivalent to 93,300 tons of 92% fluorspar) was recovered from phosphoric acid plants processing phosphate rock. Fluorosilicic acid was used primarily in water fluoridation, either directly or after processing into sodium silicofluoride, and to make aluminum fluoride for the aluminum industry.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production:					
Finished, all grades[1]	—	—	—	NA	NA
Fluorspar equivalent from phosphate rock	121	118	122	119	93
Imports for consumption:					
Acid grade	485	462	419	484	530
Metallurgical grade	51	41	59	39	33
Fluorspar equivalent from hydrofluoric acid plus cryolite	175	204	192	208	181
Exports[2]	62	24	55	40	21
Shipments from Government stockpile	97	110	131	106	71
Consumption:					
Apparent[3]	551	591	615	601	636
Reported	491	538	515	512	570
Stocks, yearend, consumer and dealer[4]	375	468	373	289	281
Employment, mine and mill, number	—	—	—	5	5
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: An estimated 8,000 to 10,000 tons per year of synthetic fluorspar is recovered from uranium enrichment, stainless steel pickling, and petroleum alkylation. Primary aluminum producers recycled HF and fluorides from smelting operations. HF is recycled in the petroleum alkylation process.

Import Sources (1997-2000): China, 63%; South Africa, 26%; and Mexico, 11%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Acid grade (97% or more CaF_2)	2529.22.0000	Free.
Metallurgical grade (less than 97% CaF_2)	2529.21.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: During fiscal year 2001, the Defense National Stockpile Center (DNSC) made no sales of fluorspar. Under the proposed fiscal year 2002 Annual Materials Plan, the DNSC will be authorized to sell 54,400 metric tons (60,000 short dry tons) of metallurgical grade and 10,900 tons (12,000 short dry tons) of acid grade. In addition to the material below, the stockpile contains 57,000 tons of (62,800 short dry tons) of nonstockpile-grade material.

Stockpile Status—9-30-01[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Acid grade	9	130	9	—	—
Metallurgical grade	46	51	46	54	—

Prepared by **M. Michael Miller [(703) 648-7716, mmiller1@usgs.gov, fax: (703) 648-7722]**

FLUORSPAR

Events, Trends, and Issues: Milford Mining Company, LLC, which started mining in 2000, produced and shipped small amounts of metallurgical-grade fluorspar, kaolinite, and silica from its mine in southern Utah (R.B. Craik, Milford Mining Company, LLC, written commun., September 12, 2001). This was the first domestic production of fluorspar since Ozark-Mahoning Co. closed down operations in early 1996.

U.S. aluminum production decreased by an estimated 30% compared with that of 2000. Alcoa World Alumina temporarily shut down production (effective March 31, 2001) of aluminum fluoride at its Fort Meade, FL, facility because of reduced demand for the product. The Fort Meade plant used fluorosilicic acid from the phosphoric acid industry as its feedstock (Alcoa Inc., February 9, 2001, Alcoa adjusts alumina and aluminum fluoride production, accessed June 17, 2001, at URL http://www.alcoa.com/site/news_release/16767-2001_03_19.asp). This shutdown actually benefited fluorspar consumption, because the only other facility in the United States that produced aluminum fluoride is Alcoa's plant in Point Comfort, TX, which uses fluorspar as its feedstock.

Merchant sales of fluorspar were adversely affected by difficulties experienced by domestic steel producers. Steel companies suffered from foreign competition and slowing demand during the first three quarters of the year when U.S. steel production was down 12% compared with the same period in 2000. The terrorist attacks of September 11 pushed the U.S. further into recession exacerbating the problems. This may not be evident in the consumption data because prior to 2001 data for merchant sales were underreported.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7 8]	Reserve base[7 8]
	2000	2001[e]		
United States	NA	NA	NA	6,000
China	2,450	2,450	23,000	94,000
France	100	100	10,000	14,000
Italy	65	70	6,000	7,000
Kenya	90	100	2,000	3,000
Mexico	635	620	32,000	40,000
Mongolia	199	180	10,000	NA
Morocco	100	80	NA	NA
Namibia	[9]66	[9]83	3,000	5,000
Russia	160	160	Moderate	18,000
South Africa	212	240	41,000	80,000
Spain	133	120	6,000	8,000
Other countries	310	310	100,000	170,000
World total (may be rounded)	4,520	4,510	230,000	440,000

World Resources: Identified world fluorspar resources were approximately 500 million tons of contained fluorspar. Resources of equivalent fluorspar from domestic phosphate rock were approximately 32 million tons. World resources of fluorspar from phosphate rock were estimated at 330 million tons.

Substitutes: Olivine and/or dolomitic limestone were used as substitutes for fluorspar. Byproduct fluorosilicic acid from phosphoric acid production was used as a substitute in aluminum fluoride production, and the potential also exists to use it as a substitute in HF production.

[e]Estimated. NA Not available. — Zero.
[1]Shipments.
[2]Exports are all general imports reexported or National Defense Stockpile material exported.
[3]Excludes fluorspar equivalent of fluorosilicic acid, hydrofluoric acid, and cryolite.
[4]Industry stocks plus National Defense Stockpile material committed for sale pending shipment.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B for definitions.
[7]See Appendix C for definitions.
[8]Measured as 100% calcium fluoride.
[9]Data are in wet tons.

GALLIUM

(Data in kilograms of gallium content, unless otherwise noted)

Domestic Production and Use: No domestic primary gallium recovery was reported in 2001. Two companies in Oklahoma and Utah recovered and refined gallium from scrap and impure gallium metal. Imports of gallium, which supplied most of U.S. gallium consumption, were valued at about $29 million. Gallium arsenide (GaAs) components represented about 98% of domestic gallium consumption. About 32% of the gallium consumed was used in optoelectronic devices, which include light-emitting diodes (LEDs), laser diodes, photodetectors, and solar cells. Integrated circuits represented 66% of gallium demand. The remaining 2% was used in research and development, specialty alloys, and other applications. Optoelectronic devices were used in areas such as consumer goods, medical equipment, industrial components, telecommunications, and aerospace applications. Integrated circuits were used in defense applications and high-performance computers.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, primary	—	—	—	—	—
Imports for consumption	19,100	26,300	24,100	39,400	32,000
Exports	NA	NA	NA	NA	NA
Consumption:					
Reported	23,600	26,900	29,800	39,900	30,000
Apparent	NA	NA	NA	NA	NA
Price, yearend, dollars per kilogram, 99.99999%-pure	595	595	640	640	640
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, refinery, number[e]	20	20	20	20	20
Net import reliance[1] as a percentage of apparent consumption	NA	NA	NA	NA	NA

Recycling: Old scrap, none. Substantial quantities of new scrap generated in the manufacture of GaAs-based devices were reprocessed.

Import Sources (1997-2000): France, 48%; Kazakhstan, 17%; Russia, 14%; Hungary, 5%; and other, 16%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Gallium metal	8112.91.1000	3.0% ad val.
Gallium arsenide wafers, undoped	2851.00.0010	2.8% ad val.
Gallium arsenide wafers, doped	3818.00.0010	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Prepared by **Deborah A. Kramer, [(703) 648-7719, dkramer@usgs.gov, fax: (703) 648-7722]**

GALLIUM

Events, Trends, and Issues: In early 2001, world gallium supplies remained tight, and prices continued to escalate. By March, press reports indicated that prices for high-purity gallium had reached $2,500 per kilogram on the spot market. By midyear, however, spot prices had dropped to about $1,000 per kilogram, still higher than the average selling price of $500 to $600 per kilogram. The slowdown in the U.S. economy resulted in a decline in the cellular telephone market, which had been principally responsible for the growth in gallium consumption in the past few years. Although there is some uncertainty about the potential demand for new cellular telecommunications technology, and ultimately demand for GaAs components in this application, gallium supplies are expected to ease as a 100-metric-ton-per-year gallium extraction facility is due on-stream in Australia in 2002. Even though the market for wireless applications declined somewhat during 2001, some market analysts predicted that the demand for wireless communications equipment will continue to grow. One estimate was that the cellular integrated circuit market would double in revenue between 2001 and 2006 as consumers upgrade their current cellular handsets to ones that provide improved data services.

Imports continued to supply almost all U.S. demand for gallium and decreased from those in 2000 because of the slowdown in the wireless communications industry. Using partial-year data, China, France, Russia, and the United Kingdom were the principal U.S. gallium suppliers in 2001.

Consumption of high-purity gallium in Japan also was projected to increase in 2001. Total gallium consumption was projected to increase 17% to 185 metric tons. Domestic production of 22 metric tons, imports of 69 metric tons, and scrap recycling of 94 metric tons were the components of Japanese consumption. One Japanese gallium refining firm announced that it would construct a 40-metric-ton-per-year gallium refining facility in Shanghai, China, beginning in the fall of 2001. This gallium is expected to be exported to Japan for use by firms there.

A Canadian firm reported a discovery of a gallium deposit in Humboldt County, NV, that contains zones grading as high as 222.6 grams per metric ton gallium, with an average of 82.5 grams per metric ton gallium. The company planned to begin drilling the site in October to delineate the resource further, with plans for eventual recovery of the gallium and other minerals in the deposit.

World Production, Reserves, and Reserve Base: Data on world production of primary gallium are unavailable because data on the output of the few producers are considered to be proprietary. However, in 2001, world primary production was estimated to be about 100 metric tons, the same as that in 2000, with Germany, Japan, Kazakhstan, and Russia being the largest producers. Countries with smaller output were China, Hungary, Slovakia, and Ukraine. Refined gallium production was estimated to be about 110 metric tons. France was the largest producer of refined gallium, using as feed material crude gallium produced in Germany. Japan and the United States were the other large gallium-refining countries. Gallium was recycled from new scrap in Germany, Japan, the United Kingdom, and the United States.

Gallium occurs in very small concentrations in many rocks and in ores of other metals. Most gallium was produced as a byproduct of treating bauxite, and the remainder was produced from zinc-processing residues. Only part of the gallium present in bauxite and zinc ores was recoverable, and the factors controlling the recovery were proprietary. Therefore, a meaningful estimate of current reserves cannot be made. The world bauxite reserve base is so large that much of it will not be mined for many decades; hence, most of the gallium in the bauxite reserve base can be considered to have only long-term availability.

World Resources: Assuming that the average content of gallium in bauxite is 50 parts per million (ppm), U.S. bauxite resources, which are mainly subeconomic deposits, contain approximately 15 million kilograms of gallium. About 2 million kilograms of this metal are present in the bauxite deposits in Arkansas. Some domestic zinc ores contain as much as 50 ppm gallium and, as such, could be a significant resource. World resources of gallium in bauxite are estimated to exceed 1 billion kilograms, and a considerable quantity could be present in world zinc reserves. The foregoing estimates apply to total gallium content; only a small percentage of this metal in bauxite and zinc ores is economically recoverable.

Substitutes: Liquid crystals made from organic compounds are used in visual displays as substitutes for LEDs. Researchers are also working to develop organic-based LEDs that may compete with GaAs in the future. Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific-wavelength applications, and GaAs competes with helium-neon lasers in visible laser diode applications. Silicon is the principal competitor for GaAs in solar cell applications. GaAs-based integrated circuits are used in many defense-related applications because of their unique properties, and there are no effective substitutes for GaAs in these applications.

[e]Estimated. NA Not available. — Zero.

[1]Defined as imports - exports + adjustments for Government and industry stock changes.

GARNET (INDUSTRIAL)[1]

(Data in metric tons of garnet, unless otherwise noted)

Domestic Production and Use: Garnet for industrial use was mined in 2001 by six firms, three in New York, two in Montana, and one in Idaho. Output of crude garnet was valued at more than $6.2 million, while refined material sold or used was valued at $13.4 million. Major end uses for garnet were waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 15%; abrasive powders, 10%; and other end uses, 10%.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production (crude)	64,900	74,000	60,700	60,200	52,500
Sold by producers	53,600	51,900	43,900	51,300	47,400
Imports for consumption[e]	10,000	20,000	12,000	23,000	25,000
Exports[e]	12,000	12,000	10,000	10,000	10,000
Consumption, apparent[e]	46,300	39,900	39,100	63,800	59,600
Price, range of value, dollars per ton[2]	50-2,000	50-2,000	55-2,000	50-2,000	50-2,000
Stocks, producer[e 3]	19,900	39,900	46,700	47,200	50,000
Employment, mine and mill, number	250	230	220	220	220
Net import reliance[4] as a percentage of apparent consumption	E	E	E	20	20

Recycling: Small amounts of garnet reportedly are recycled.

Import Sources (1997-2000)[e]: Australia, 60%; India, 30%; and China, 10%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Emery, natural corundum, natural garnet, and other natural abrasives, crude	2513.20.1000	Free.
Emery, natural corundum, natural garnet, and other natural abrasives, other than crude	2513.20.9000	Free.
Natural abrasives on woven textile	6805.10.0000	Free.
Natural abrasives on paper or paperboard	6805.20.0000	Free.
Natural abrasives sheets, strips, disks, belts, sleeves, or similar form	6805.30.1000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7722]**

GARNET (INDUSTRIAL)

Events, Trends, and Issues: During 2001, U.S. garnet consumption decreased 7%, while domestic production of crude garnet concentrates declined by 18% from that of 2000. In 2001, imports were estimated to have increased 9% over 2000, and exports were estimated to be the same as 2000. The 2001 domestic sales of garnet declined by 8% from their 2000 level. Markets for waterjet cutting continue to grow, while blasting media markets have decreased and water filtration and abrasive powder markets have remained stable. Sweetwater Garnet, Inc., near Dillon, MT, was purchased in July 2000 by Stansbury Holdings Corp. Sweetwater processed accumulated stocks through the end of 2000, and began mining again in 2001. Australia and India continue to grow as important garnet exporters.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2000	2001[e]		
United States	60,200	52,500	5,000,000	25,000,000
Australia	125,000	125,000	1,000,000	7,000,000
China	25,000	25,000	Moderate to Large	Moderate to Large
India	60,000	62,500	100,000	10,000,000
Other countries	20,300	27,000	6,500,000	20,000,000
World total (may be rounded)	291,000	292,000	Moderate	Large

World Resources: World resources of garnet are large and occur in a wide variety of rocks, particularly gneisses and schists. Garnet also occurs as contact-metamorphic deposits in crystalline limestones, pegmatites, serpentinites, and vein deposits. In addition, alluvial garnet is present in many heavy mineral sand and gravel deposits throughout the world. Large domestic resources of garnet also are concentrated in coarsely crystalline gneiss near North Creek, NY, and other significant domestic resources of garnet occur in Idaho, Maine, Montana, New Hampshire, North Carolina, and Oregon. In addition to the United States, major garnet deposits exist in Australia, China, and India, where they are mined for foreign and domestic markets; deposits in Russia and Turkey also have been mined in recent years, primarily for internal markets. Additional garnet resources are located in Canada, Chile, the Czech Republic, Pakistan, South Africa, Spain, Thailand, and Ukraine; small mining operations have been reported in most of these areas.

Substitutes: Other natural and manufactured abrasives can substitute to some extent for all major end uses of garnet. In many cases, however, the substitutes would entail sacrifices in quality or cost. Fused aluminum oxide and staurolite compete with garnet as a sandblasting material. Ilmenite, magnetite, and plastics compete as filtration media. Diamond, corundum, and fused aluminum oxide compete for lens grinding and for many lapping operations. Emery is a substitute in nonskid surfaces. Finally, quartz sand, silicon carbide, and fused aluminum oxide compete for the finishing of plastics, wood furniture, and other products.

[e]Estimated. E Net exporter.

[1]Excludes gem and synthetic garnet.

[2]Includes both crude and refined garnet; most crude concentrate is $50 to $100 per ton, and most refined material is $150 to $400 per ton.

[3]The large increase shown for producer stocks between 1997 and 1998 is based on improved, more accurate stock-estimating methods. Estimate were revised only back to 1998.

[4]Defined as imports - exports + adjustments for industry stock changes.

[5]See Appendix C for definitions.

GEMSTONES[1]

(Data in million dollars, unless otherwise noted)

Domestic Production and Use: Total U.S. gemstone output has decreased in recent years owing to a decline in foreign demand for freshwater shell, a major component of the domestic industry. Domestic gemstone production included agates, amber, beryl, coral, garnet, jade, jasper, opal, pearl, quartz, sapphire, shell, topaz, tourmaline, turquoise, and many other gem materials. Output of natural gemstones was primarily from Tennessee, Arizona, California, Oregon, Utah, Nevada, and Idaho, in decreasing order. Reported output of synthetic gemstones was from five firms in North Carolina, New York, Florida, California, and Arizona, in decreasing order of production. Major uses were jewelry, carvings, and gem and mineral collections.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production:[2]					
Natural[3]	25.0	14.3	16.1	17.2	15.3
Synthetic	21.6	24.2	47.5	37.1	24.5
Imports for consumption	8,380	9,250	10,700	12,900	11,700
Exports, including reexports[4]	2,760	2,980	3,610	4,540	4,590
Consumption, apparent[5]	5,670	6,310	7,150	8,410	7,190
Price	Variable, depending on size, type, and quality				
Employment, mine, number[e]	1,200	1,200	1,200	1,200	1,200
Net import reliance[6] as a percentage of apparent consumption	99	99	99	99	99

Recycling: Insignificant.

Import Sources (1997-2000): Israel, 40%; India, 21%; Belgium, 20%; and other, 19%. Diamond imports accounted for 93% of the total value of gem imports.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Diamonds, unworked or sawn	7102.31.0000	Free.
Diamond, ½ carat or less	7102.39.0010	Free.
Diamond, cut, more than ½ carat	7102.39.0050	Free.
Precious stones, unworked	7103.10.2000	Free.
Precious stones, simply sawn	7103.10.4000	10.5% ad val.
Rubies, cut	7103.91.0010	Free.
Sapphires, cut	7103.91.0020	Free.
Emeralds, cut	7103.91.0030	Free.
Other precious, cut but not set	7103.99.1000	Free.
Other precious stones	7103.99.5000	10.5% ad val.
Imitation precious stones	7018.10.2000	Free.
Synthetic cut, but not set	7104.90.1000	Free.
Pearls, natural	7101.10.0000	Free.
Pearls, cultured	7101.21.0000	Free.
Pearls, imitation, not strung	7018.10.1000	4.0% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: The National Defense Stockpile (NDS) does not contain an inventory of gemstones. However, a small portion of the industrial diamond inventory is of near-gem quality. Additionally, the beryl and quartz inventories contain some gem-quality materials that could be used by the gem industry. The U.S. Department of Defense is currently selling some NDS materials that may be near-gem quality.

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7722]**

GEMSTONES

<u>Events, Trends, and Issues</u>: The Kelsey Lake diamond mine, which is the United States' only commercial diamond mine, straddles the Colorado-Wyoming State line. Kelsey Lake is owned and operated by Great Western Diamond Co., a wholly owned subsidiary of McKenzie Bay International, Ltd. of Canada. In September 2001, McKenzie Bay entered into a contract to sell Great Western to Roberts Construction of North Dakota and BJ&J Ltd. of Colorado.

In 2001, the U.S. market for unset gem-quality diamonds was estimated to be more than $9 billion, accounting for at least one-third of world demand. The domestic market for natural, unset nondiamond gemstones totaled more than $770 million. The United States is expected to dominate global gemstone consumption throughout this decade.

The large jump in reported diamond production for Botswana is due to the new Orapa mine expansion, which came on-stream in May 1999 and was completed during 2000. This expansion was designed to increase the Orapa's production to 12 million carats per year. New tighter controls on diamond smuggling, due to international bans on conflict diamonds, have caused some countries like Angola to reported higher production figures.

<u>World Mine Production,[7] Reserves, and Reserve Base</u>:

	Mine production	
	2000	2001[e]
United States	([9])	([9])
Angola	4,350	4,400
Australia	12,000	13,000
Botswana	19,700	16,000
Brazil	300	300
Canada	2,000	2,300
Central African Republic	400	400
China	230	230
Congo (Kinshasa)	3,500	3,500
Ghana	180	800
Namibia	1,520	1,550
Russia	11,600	11,600
South Africa	4,300	4,800
Venezuela	60	60
Other countries	1,410	1,440
World total (rounded)	61,600	60,400

Reserves and reserve base[8]

World reserves and reserve base of gem diamond are substantial. No reserves or reserve base data are available for other gemstones.

<u>World Resources</u>: Canada's Ekati Mine completed its second full year in 2000, with diamond production of 2.63 million carats valued at $454 million. In the sixteen-month period that ended May 31, 2001, Ekati produced 3.60 million carats of diamond, with an average sale price of $168.30 per carat. Canada's Diavik project is expected to come on-stream in 2003 with production of 6 to 8 million carats per year. Canada's first underground diamond mine, the Snap Lake project, is expected to come on-stream in 2005. When the Diavik and Snap Lake mines begin production, Canada will be producing at least 15% to 20% of total world diamond production.

Natural gem-quality diamonds are among the world's rarest mineral materials. Most diamond-bearing ore bodies have a diamond content that ranges from less than 1 carat per ton to only about 6 carats per ton. The major gem diamond reserves are in southern Africa, Western Australia, Canada, and Russia.

<u>Substitutes</u>: Plastics, glass, and other materials are substituted for natural gemstones. Synthetic gemstones (manufactured materials that have the same chemical and physical properties as gemstones) are common substitutes. Simulants (materials that appear to be gems, but differ in chemical and physical characteristics) also are frequently substituted for natural gemstones.

[e]Estimated.
[1]Excludes industrial diamond and garnet. See Diamond (Industrial) and Garnet (Industrial).
[2]Estimated minimum production.
[3]Includes production of freshwater shell.
[4]Reexports account for more than 90% of the totals.
[5]If reexports were not considered, apparent consumption would be significantly greater.
[6]Defined as imports - exports and reexports + adjustments for Government and industry stock changes.
[7]Data in thousands of carats of gem diamond.
[8]See Appendix C for definitions.
[9]Less than ½ unit.

GERMANIUM

(Data in kilograms of germanium content, unless otherwise noted)

Domestic Production and Use: The value of domestic refinery production of germanium, based upon the 2001 producer price, was $22 million. Industry-generated scrap, imported concentrates, and processed residues from certain domestic base metal ores were the feed materials for the production of refined germanium in 2001. The domestic industry is based on two zinc mining operations, one in Tennessee and the other in Alaska. The mining companies at these operations supplied domestic and export markets with germanium-bearing materials generated from the processing of zinc ores. The germanium refineries in New York and Oklahoma remained in operation, but the one in Pennsylvania was sold to a new company, and its equipment was moved and set up in New York. The refinery in Oklahoma expanded, and a new secondary facility was built in North Carolina. The major end uses for germanium, worldwide, were estimated to be nearly the same as for 2000—fiber-optic systems, 50%; polymerization catalysts, 20%; infrared optics, 15%; electronics/solar electrical applications, 10%; and other (phosphors, metallurgy, and chemotherapy), 5%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, refinery[e]	20,000	22,000	20,000	23,000	20,000
Total imports[1]	23,700	14,600	12,400	8,210	10,000
Exports	NA	NA	NA	NA	NA
Consumption[e]	28,000	28,000	28,000	30,000	29,000
Price, producer, yearend, dollars per kilogram:					
Zone refined	1,475	1,700	1,400	1,250	1,100
Dioxide, electronic grade	950	1,100	900	800	700
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant,[2] number[e]	115	100	85	90	90
Net import reliance[3] as a percentage of apparent consumption	NA	NA	NA	NA	NA

Recycling: More than half of the germanium metal used during the manufacture of most electronic and optical devices is routinely recycled as new scrap. As a result of the low unit use of germanium in various devices, little germanium returns as old scrap. Worldwide, about 25% of the total germanium consumed is produced from recycled materials.

Import Sources (1997-2000):[4] Belgium, 30%; China, 26%; Russia, 20%; Taiwan, 9%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Germanium oxides	2825.60.0000	3.7% ad val.
Waste and scrap	8112.30.3000	Free.
Metal, unwrought	8112.30.6000	2.6% ad val.
Metal, wrought	8112.30.9000	4.4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile:

Stockpile Status—9-30-01[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Germanium	42,523	827	42,523	8,000	5,928

Prepared by **Robert D. Brown, Jr. [(703) 648-4984, rbrown@usgs.gov, fax: (703) 648-7757]**

GERMANIUM

Events, Trends, and Issues: Domestic refinery production of germanium decreased in 2001; that of the rest of the world remained the same as last year. The recycling of new scrap continued to grow and remains a significant supply factor. The only releases from national Government stockpiles were those from the United States. Optical fiber manufacturing increased early in the year, but later demand fell owing to the downturn in the general economy and telecommunications in particular. Polyethylene terephthalate (PET) plastics demand weakened owing to economic conditions in Asia. The automobile night vision system that became popular in 2000 was extended to the bus/truck equipment aftermarket. New uses as catalysts, increases in demand for infrared applications in security, and the potential replacement of gallium arsenide devices by silicon-germanium in wireless telecommunications all portend a bright long-range future for germanium.

Germanium has little or no effect upon the environment because it usually occurs only as a trace element in ores and carbonaceous materials and is used in very small quantities in commercial applications.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production[e]		Reserves[6]	Reserve base[6]
	2000	2001		
United States	23,000	20,000	450,000	500,000
Other countries	48,000	48,000	NA	NA
World total	71,000	68,000	NA	NA

World Resources: The available resources of germanium are associated with certain zinc and lead-zinc-copper sulfide ores. Significant amounts of germanium are contained in ash and flue dust generated in the combustion of certain coals for power generation.

Substitutes: Less expensive silicon can be substituted for germanium in certain electronic applications. Some bimetallic compounds of gallium, indium, selenium, and tellurium can also be substituted for germanium. Germanium is more reliable than competing materials in some high-frequency and high-power electronics applications and is more economical as a substrate for some light-emitting diode applications. In infrared guidance systems, zinc selenide and germanium glass substitute for germanium metal but at the expense of performance.

[e]Estimated. NA Not available.
[1]Gross weight of wrought and unwrought germanium and waste and scrap. Does not include imports of germanium dioxide and other germanium compounds for which data are not available.
[2]Employment related to primary germanium refining is indirectly related to zinc refining.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]Total imports from republics of the former Soviet Union (Estonia, Russia, and Ukraine) accounted for 26% of the imports from 1997 to 2000.
[5]See Appendix B for definitions.
[6]See Appendix C for definitions.

GOLD

(Data in metric tons[1] of gold content, unless otherwise noted)

Domestic Production and Use: Gold was produced at about 55 major lode mines, a dozen or more large placer mines (nearly all in Alaska), and numerous smaller placer mines (mostly in Alaska and in the Western States). In addition, a small amount of domestic gold was recovered as a byproduct of processing base metals, chiefly copper. Thirty mines yielded more than 98% of the gold produced in the United States. In 2001, the value of mine production was more than $3 billion. Commercial-grade refined gold came from about two dozen producers. A few dozen companies, out of several thousand companies and artisans, dominated the fabrication of gold into commercial products. U.S. jewelry manufacturing was heavily concentrated in the New York, NY, and Providence, RI, areas with lesser concentrations in California, Florida, and Texas. Estimated uses were: jewelry and arts, 89%; dental, 7%; and electrical and electronics, 4%.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production:					
Mine	362	366	341	353	350
Refinery:					
Primary	270	277	265	197	220
Secondary (new and old scrap)	100	163	143	82	100
Imports[2]	209	278	221	223	185
Exports[2]	477	522	523	547	580
Consumption, reported	137	219	245	183	200
Stocks, yearend, Treasury[3]	8,140	8,130	8,170	8,140	8,130
Price, dollars per ounce[4]	332	295	280	280	280
Employment, mine and mill, number[5]	16,300	13,400	10,300	10,400	9,800
Net import reliance[6] as a percentage of apparent consumption	E	E	E	E	E

Recycling: 100 metric tons of new and old scrap, equal to 50% of reported consumption, was recycled in 2001.

Import Sources (1997-2000):[2] Canada, 44%; Brazil, 15%; Peru, 8%; Australia, 7%; and other, 26%.

Tariff: Most imports of unwrought gold, including bullion and doré, enter duty free.

Depletion Allowance: 15% (Domestic), 14% (Foreign).

Government Stockpile: The U.S. Department of the Treasury maintains stocks of gold (see salient statistics above) and the U.S. Department of Defense administers a Government-wide secondary precious metals recovery program.

Events, Trends, and Issues: Domestic gold mine production in 2001 was estimated at about the same as the level of 2000, but high enough to maintain the United States' position as the world's second largest gold-producing nation, after South Africa. Domestic output continued to be dominated by California and Nevada, where combined production accounted for more than 80% of the U.S. total. Between July 2000 and June 2001, seven gold mines were closed in the United States. During this 12-month period, the average output per mine had increased, companies merged, and the size of gold mining operations increased. Most of the larger companies were successfully replacing annual production with new reserves, but smaller companies were finding this more difficult. Estimates by an industry association indicate that worldwide gold exploration expenditures decreased for the fourth consecutive year, with 1997 marking the peak of exploration spending for the 1990s. The expenditures of U.S. gold producers continued to fall in 2001 owing to the low gold price.

Prepared by **Earle B. Amey [(703) 648-4969, eamey@usgs.gov, fax: (703) 648-7757]**

GOLD

During the first 9 months of the year, the Engelhard Corporation's daily price of gold ranged from a low of about $257 per troy ounce in April to a high of almost $294 in September. For most of the year, this price range was below $270. The traditional role of gold as a store of value was able to lift the price of gold out of its low trading range when terrorists attacked the United States in September. In 2001, the Swiss National Bank continued selling 1,300 tons of gold (one-half its reserves), and the United Kingdom government completed its drive to sell 415 tons of gold from British gold reserves. Concerns about the true situation on central bank gold sales, prospects for more consolidations within the gold mining sector, and lack of renewed investor interest in gold kept gold prices depressed until the middle of September.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States	353	350	5,600	6,000
Australia	296	290	5,000	6,000
Canada	154	160	1,500	3,500
China[e]	180	185	1,000	4,300
Indonesia	125	120	1,800	2,800
Peru	133	140	200	650
Russia	126	155	3,000	3,500
South Africa	431	400	19,000	36,000
Other countries	735	725	13,000	16,000
World total (may be rounded)	2,550	2,530	50,000	78,000

Of an estimated 140,000 tons of all gold ever mined, about 15% is thought to have been lost, used in dissipative industrial uses, or otherwise unrecoverable or unaccounted for. Of the remaining 120,000 tons, an estimated 33,000 tons are official stocks held by central banks and about 87,000 tons is privately held as coin, bullion, and jewelry.

World Resources: Total world resources of gold are estimated at 100,000 tons, of which 15% to 20% is byproduct resources. South Africa has about one-half of all world resources, and Brazil and the United States have about 9% each. Some of the 9,000-ton U.S. resource would be recovered as byproduct gold.

Substitutes: Base metals clad with gold alloys are widely used in electrical/electronic and jewelry products to economize on gold; many of these products are continually redesigned to maintain high-utility standards with lower gold content. Generally, palladium, platinum, and silver may substitute for gold.

[e]Estimated. E Net exporter. NA Not available.

[1]Metric ton (1,000 kilograms) = 32,150.7 troy ounces.

[2]Refined bullion, doré, ores, concentrates, and precipitates.

Excludes:

a. Waste and scrap.
b. Official monetary gold.
c. Gold in fabricated items.
d. Gold in coins. In 1991, the last year for which estimates are available, net imports amounted to 3.5 tons.
e. Net bullion flow (in tons) to market from foreign stocks at the New York Federal Reserve Bank: 142.8 (1997), 309.9 (1998), 302.7 (1999), 35 (2000), and 516.6 (2001, estimated).

[3]Includes gold in Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.

[4]Englehard Corporation's average gold price quotation for the year.

[5]Data from Mine Safety and Health Administration.

[6]Defined as imports - exports + adjustments for Government and industry stock changes.

[7]See Appendix C for definitions.

GRAPHITE (NATURAL)

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Although natural graphite was not produced domestically in 2001, approximately 200 U.S. firms, primarily in the Northeastern and Great Lakes regions, used it for a wide variety of applications. The major uses of natural graphite remained the same as those of 2000: Refractory applications led the way in use categories with 45%; brake linings was second with 20%; lubricants, 5%, dressings and molds in foundry operations, 5%; and other uses making up the remaining 25%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, mine	—	—	—	—	—
Imports for consumption	58	62	56	61	60
Exports	40	28	29	22	25
Consumption, apparent	18	34	26	39	35
Price, imports (average dollars per ton at foreign ports):					
Flake	622	514	540	550	560
Lump and chip (Sri Lankan)	1,010	1,200	1,100	1,150	1,200
Amorphous (Mexican)	153	192	225	230	230
Stocks, yearend	NA	NA	NA	NA	NA
Net import reliance[1] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Refractory brick and linings, alumina-graphite refractories for continuous metal castings, magnesia-graphite refractory brick for basic oxygen and electric arc furnaces, and insulation brick in particular led the way in recycling of graphite products. Primary recycling of refractory articles is growing with the recycling market being principally in less demanding service conditions, such as brake linings and thermal insulation.

Past research on the technical feasibility of recovering high-quality flake graphite from steelmaking kish may further boost graphite recycling efforts under favorable economic conditions.[2] Abundance of graphite in the world market and continuing low prices, however, inhibit increased recycling efforts. Information on the quantity and value of recycled graphite is not available.

Import Sources (1997-2000): China, 33%; Mexico, 23%; Canada, 22%; Brazil, 9%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Crystalline flake (not including flake dust)	2504.10.1000	Free.
Other	2504.90.0000	Free.

Depletion Allowance: 22% (Domestic lump and amorphous), 14% (Domestic flake), and 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Sri Lanka, amorphous lump	1.60	—	1.60	3.75	3.30
Madagascar, crystalline flake	3.90	—	3.90	—	0.13

Prepared by **Rustu S. Kalyoncu [(703) 648-7720, rkalyonc@usgs.gov, fax: (703) 648-7722]**

GRAPHITE (NATURAL)

Events, Trends, and Issues: Graphite was near supply-demand balance in 2001. Imports of flake from Canada, China, Madagascar, and Mexico; lump and chip from Sri Lanka; and amorphous graphite from China and Mexico generally met demand. There has been a marked decrease in the consumption of graphite electrodes, owing to development of more efficient iron and steel production techniques during the late 1980s. Use of natural graphite in lubrication applications is also decreasing because of changes in requirements for lubricants and in processing technologies. Advances in thermal technology and acid-leaching techniques that enable the production of higher-purity graphite powders are likely to develop new applications for graphite in high-technology fields. Such innovative refining techniques already have enabled the use of improved graphite in friction materials, electronics, foils, and special lubricant applications.[4] Flexible graphite product lines, such as graphoil (a thin graphite cloth), will probably be the fastest growing market. Production of higher purity graphite, using newly developed thermal processing techniques, for such applications as advanced carbon-graphite composites are expected to open new applications for graphite. Large-scale fuel cell applications currently under development could consume as much graphite as all other uses combined.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2000	2001[e]		
United States	—	—	—	1,000
Brazil	12	70	360	1,000
Canada	25	25	—	—
China	220	250	4,800	310,000
India	140	150	800	2,000
Madagascar	13	15	940	960
Mexico	30	35	3,100	3,100
Other countries	131	130	5,100	44,000
World total (may be rounded)	571	675	15,000	360,000

World Resources: Domestic resources are relatively small, but the rest of the world's inferred reserve base exceeds 800 million tons of recoverable graphite.

Substitutes: Manufactured graphite powder, scrap from discarded machined shapes, and calcined petroleum coke compete for use in iron and steel production. Finely ground coke with olivine is a potential competitor in foundry facing applications. Molybdenum disulfide competes as a dry lubricant but is more sensitive to oxidizing conditions.

[e]Estimated. NA Not available. — Zero.

[1]Defined as imports - exports + adjustments for Government and industry stock changes. Data on changes in stocks were not available and were assumed to be zero in the calculations.

[2]Laverty, P.D., Nicks, L.J., and Walters, L.A.,1994, Recovery of flake graphite from steelmaking kish: U.S. Bureau of Mines Report of Investigation 9512, 23 p.

[3]See Appendix B for definitions.

[4]Hand, G.P., 1997, Outlook for graphite and graphite technology: Mining Engineering, v. 49, no. 2, February, p. 34-36.

[5]See Appendix C for definitions.

GYPSUM

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 2001, domestic production of crude gypsum was estimated at 18.8 million tons with an estimated valued of $159 million. The top producing States were, in descending order, Oklahoma, Iowa, Nevada, Michigan, Texas, New Mexico, California, and Indiana, which together accounted for 72% of total output. Overall, 30 companies produced gypsum at 56 mines in 19 States, and 10 companies calcined gypsum at 64 plants in 29 States. Most of domestic consumption, which totaled approximately 33.2 million tons, was accounted for by manufacturers of wallboard and plaster products. More than 3.8 million tons for cement production, approximately 2 million tons for agricultural applications, and small amounts of high-purity gypsum for a wide range of industrial processes, such as smelting and glassmaking, accounted for the remaining uses. At the beginning of 2001, capacity of operating wallboard plants in the United States was 35.2 billion square feet[1] per year, and sales were more than 34.5 billion square feet[1], representing capacity utilization of at least 98%.

Salient Statistics—United States:	1997	1998	1999[2]	2000[2]	2001[e]
Production:					
Crude	18,600	19,000	22,400	19,500	18,800
Synthetic[3]	2,700	3,000	5,200	5,200	6,100
Calcined[4]	17,200	19,400	22,300	21,000	17,700
Wallboard products (million square feet[1])	24,400	26,900	28,700	26,100	29,600
Imports, crude, including anhydrite	8,420	8,680	9,340	9,210	8,460
Exports, crude, not ground or calcined	174	166	112	161	198
Consumption, apparent[5]	29,500	30,500	36,800	33,700	33,200
Price:					
Average crude, f.o.b. mine, dollars per ton	7.11	6.92	6.99	8.44	8.46
Average calcined, f.o.b. plant, dollars per ton	17.58	17.02	17.07	16.81	16.84
Stocks, producer, crude, yearend	1,200	1,500	1,500	1,500	1,500
Employment, mine and calcining plant, number[e]	6,000	6,000	6,000	6,000	5,900
Net import reliance[6] as a percentage of apparent consumption	28	28	25	27	25

Recycling: A portion of more than 4 million tons of gypsum waste, generated every year by wallboard manufacturing, wallboard installation, and building demolition, was recycled. The recycled gypsum was used chiefly for agricultural purposes and new wallboard. Other potential markets for recycled gypsum waste are in cement production, as a stucco additive, in sludge drying, in water treatment, in grease absorption, and for marking athletic fields.

Import Sources (1997-2000): Canada, 68%; Mexico, 23%; Spain, 8%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Gypsum; anhydrite	2520.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7722]**

GYPSUM

Events, Trends, and Issues: Housing starts leveled out and declined slightly during some months of 2001. This suggests that the trend of annual increases in U.S. gypsum consumption has come to an end or at least slowed. However, construction rates for new office and commercial buildings continued to stimulate wallboard demand. Some forecasts indicate that gypsum demand in North American markets will remain level for the next few years. This demand, however, will depend principally on the strength of the construction industry, particularly in the United States, where more than 95% of the gypsum consumed is used for wallboard products, building plasters, and the manufacture of portland cement. Federal funding that was authorized in 1998 for road building and repair through 2003 will continue to spur gypsum consumption in the cement industry. More large wallboard plants under construction and designed to use only synthetic gypsum will accelerate substitution significantly as they become operational within the next 2 years.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States	19,500	18,800	700,000	Large
Australia	3,800	4,000		
Canada	8,550	9,000	450,000	Large
China	6,800	6,800		
Egypt	2,000	2,200		
France	4,500	4,500		
India	2,210	2,220		
Iran	11,000	11,000		
Italy	1,300	1,300	Reserves and reserve base are large in major producing countries, but data are not available.	
Japan	5,600	6,000		
Mexico	7,000	7,600		
Poland	1,700	1,300		
Spain	7,500	7,500		
Thailand	5,830	6,000		
United Kingdom	1,500	1,400		
Other countries	17,200	20,100		
World total (rounded)	106,000	110,000	Large	Large

World Resources: Domestic resources are adequate but unevenly distributed. Large imports from Canada augment domestic supplies for wallboard manufacturing on the eastern seaboard of the United States, where there are no significant gypsum deposits. Large imports from Mexico augment domestic supplies for wallboard manufacturing on the U.S. western seaboard. Large deposits occur in the Great Lakes region, midcontinental region, and California. Foreign resources are large and widely distributed; more than 90 countries produce gypsum.

Substitutes: Other construction materials may be substituted for gypsum, especially cement, lime, lumber, masonry, and steel. Gypsum has no practical substitute in the manufacturing of portland cement. Synthetic gypsum generated by various industrial processes including flue gas desulfurization of stack emissions, is becoming very important as a substitute for mined gypsum in wallboard manufacturing, cement production, and agricultural applications. In 2001, synthetic gypsum accounted for more than 15% of the total domestic gypsum supply.

[e]Estimated.
[1]The standard unit used in the U.S. wallboard industry is square feet. Multiply square feet by (9.29×10^{-2}) to convert to square meters.
[2]Some data revised to correspond with new information published in the USGS Mineral Industry Surveys Annual Review of gypsum for 2000.
[3]Data refer to amount sold or used, not produced.
[4]From domestic crude.
[5]Defined as crude + total synthetic reported used + net import reliance.
[6]Defined as imports - exports + adjustments for industry stock changes.
[7]See Appendix C for definitions.

HELIUM

(Data in million cubic meters of contained helium gas,[1] unless otherwise noted)

Domestic Production and Use: During 2001, the estimated value of Grade-A helium (99.995% or better) extracted by private industry was about $225 million. There are 11 private industry plants (6 in Kansas, 4 in Texas, and 1 in Oklahoma) that extract helium from natural gas and produce only a crude helium product that varies from 50% to 80% helium. There are 10 private industry plants (4 in Kansas, 2 in Texas, and 1 each in Colorado, Oklahoma, Utah, and Wyoming) that extract helium from natural gas and produce an intermediate process stream of crude helium (about 70% helium and 30% nitrogen) and continue processing the stream to produce a Grade-A helium product. There are six private industry plants (four in Kansas, one in Texas, and one in Oklahoma) that accept a crude helium product from other producers and the Bureau of Land Management (BLM) pipeline and purify this to a Grade-A helium product. The estimated 2001 domestic consumption of 83 million cubic meters (3.0 billion cubic feet) was used for cryogenic applications, 24%; for pressurizing and purging, 20%; for welding cover gas, 18%; for controlled atmospheres, 16%; leak detection, 6%; breathing mixtures, 3%; and other, 13%.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Helium extracted from natural gas[2]	116	114	114	98	100
Withdrawn from storage[3]	(9.3)	(0.7)	3	29	37
Grade-A helium sales	107	114	117	127	137
Imports for consumption	—	—	—	—	—
Exports[4]	29.5	27.8	26.8	37.0	48.1
Consumption, apparent[4]	77.4	84.7	90.3	89.6	83.3
Employment, plant, number[e]	605	530	500	320	325
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Price: The Government price for crude helium was $1.803 per cubic meter ($50.00 per thousand cubic feet) in fiscal year (FY) 2001. The price for the Government-owned helium is mandated by Public Law 104-273. Private industry's estimated price range for Grade-A gaseous helium was about $1.51 to $1.80 per cubic meter ($42 to $50 per thousand cubic feet), with some producers posting surcharges to this price.

Recycling: In the United States, helium used in large-volume applications is seldom recycled. Some low-volume or liquid boil-off recovery systems are used. In Western Europe and Japan, helium recycling is practiced when economically feasible.

Import Sources (1997-2000): None.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Helium	2804.29.0010	3.7% ad val.

Depletion Allowance: Allowances are applicable to natural gas from which helium is extracted, but no allowance is granted directly to helium.

Government Stockpile: Under the Helium Privatization Act of 1996 (Public Law 104-273), the BLM operates the Federal Helium Program, including a helium storage system. Because the BLM can no longer supply Federal agencies with Grade-A helium, private firms that sell Grade-A helium to the Federal agencies are now required to purchase a like amount of crude helium (in-kind) from the BLM. In FY-2001, privately owned companies purchased nearly 6.52 million cubic meters (235 million cubic feet) of in-kind crude helium. During FY 2001, BLM's Amarillo Field Office, Helium Operations (AMFO) accepted more than 17.4 million cubic meters (627 million cubic feet) of private helium for storage and redelivered nearly 61.9 million cubic meters (2,233 million cubic feet). As of September 30, 2001, 83.2 million cubic meters (3.0 billion cubic feet) of helium was owned by private firms.

Stockpile Status—9-30-01[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Helium	810.7	16.6	810.7	6.52	6.90

Prepared by **Norbert Pacheco[7] [(806) 324-2656, Norbert_Pacheco@blm.gov, fax: (806) 324-2633]**

HELIUM

Events, Trends, and Issues: During 2001, BOC Gases, Inc., Air Products and Chemicals Inc., and Praxair, Inc., announced helium price increases. The increases were in response to rising costs of purchasing, producing and distributing helium. The higher costs for helium are due to increased worldwide helium demand which has shifted supply to higher cost natural gas used for helium refining and from which helium is extracted. It is anticipated that the trend toward higher costs will continue as the industry experiences helium shortages. The helium shortages will result from continued depletion of U.S. helium reserves and the worldwide increase in demand for helium. It is anticipated that demand for helium will grow at a rate of about 8% per year through the end of 2002. During 2001, helium exports increased significantly due to continued increased European demand for helium. In early 2001, the AMFO initiated work on the drafting of helium regulations to provide guidance for the Federal helium program. Prior to starting the work on the regulations, several public meetings were conducted to obtain feedback from any and all interested parties; drafting of the regulations was underway in late 2001.

World Production, Reserves, and Reserve Base:

	Production		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States	98	100	6,000	8,900
Algeria	14	14	2,000	3,000
Canada	NA	NA	NA	2,000
China	NA	NA	NA	1,100
Poland	1	1	40	280
Former Soviet Union[8]	4	4	1,700	6,700
Other countries	NA	NA	NA	2,800
World total (rounded)	117	119	NA	25,000

World Resources: The identified helium resources of the United States were estimated to be about 8.9 billion cubic meters (323 billion cubic feet) as of January 1, 2000. This includes 0.95 billion cubic meters (34.3 billion cubic feet) of helium stored in the Cliffside Field, 4.1 billion cubic meters (147 billion cubic feet) of helium in helium-rich natural gas (0.30% helium or more) from which helium is currently being extracted, and 3.1 billion cubic meters (111 billion cubic feet) in helium-lean natural gas (less than 0.30% helium). The Hugoton (Kansas, Texas, and Oklahoma), Panhandle West, Panoma, and Riley Ridge Fields are currently depleting gasfields and contain an estimated 4.0 billion cubic meters (143 billion cubic feet) of helium. Future supplies will probably come from known helium-rich natural gas with little fuel value and from helium-lean resources.

Helium resources of the world exclusive of the United States were estimated to be about 15 billion cubic meters (540 billion cubic feet). The locations and volumes of the principal deposits, in billion cubic meters, are the former Soviet Union, 7; Algeria, 3; Canada, 2; China, 1; Poland, 0.3. As of December 31, 2001, AMFO had analyzed nearly 21,000 gas samples from 26 countries and the United States in a program to identify world helium resources.

Substitutes: There is no substance that can be substituted for helium in cryogenic applications if temperatures below -429° F are required. Argon can be substituted for helium in welding, and hydrogen can be substituted for helium in some lighter-than-air applications in which the flammable nature of hydrogen is not objectionable. Hydrogen is also being investigated as a substitute for helium in deep-sea diving applications below 1,000 feet.

[e]Estimated. E Net exporter. NA Not available. — Zero.

[1]Measured at 101.325 kilopascals absolute (14.696 psia) and 15° C, 27.737 cubic meters of helium = 1 Mcf of helium at 70° F and 14.7 psia.

[2]Helium from both Grade-A and crude helium.

[3]Extracted from natural gas in prior years (injected in parentheses).

[4]Grade-A helium.

[5]Defined as imports - exports + adjustments for Government and industry stock changes.

[6]See Appendix B for definitions.

[7]Team Leader, Resources Evaluation, Bureau of Land Management, Amarillo Field Office, Helium Operations, Amarillo, TX.

[8]See Appendix C for definitions.

[9]As constituted before December 1991.

INDIUM

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Indium was not recovered from ores in the United States in 2001. Domestically produced standard grade indium was derived from the upgrading of lower grade imported indium metal. Two companies, one each in New York and Rhode Island, were the major producers of indium metal and indium products in 2001. Several firms produced high-purity indium shapes, alloys, and compounds. Thin-film coatings, which are used in applications such as liquid crystal displays (LCDs) and electroluminescent lamps, continued to be the largest end use. Indium semiconductor compounds were used in infrared detectors, high-speed transistors, and high-efficiency photovoltaic devices. The estimated distribution of uses in 2001 indicated a moderate increase in semiconductors and stable consumption in other sectors: coatings, 49%; solders and alloys, 33%; electrical components and semiconductors, 15%; and research and other, 3%. The estimated value of primary indium metal consumed in 2001, based upon the annual average price, was more than $8.5 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, refinery	—	—	—	—	—
Imports for consumption	85.5	75	77	69	72
Exports	NA	NA	NA	NA	NA
Consumption[e]	50	50	52	55	58
Price, annual average, dollars per kilogram (99.97% indium)	309	296	303	188	147
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number	NA	NA	NA	NA	NA
Net import reliance[1] as a percentage of estimated consumption	100	100	100	100	95

Recycling: Small quantities of old scrap were recycled. Recycling of new scrap, the scrap from fabrication of indium products, is becoming more significant. Recycling occurred previously when the price of indium was relatively very high and/or increasing rapidly. Now it has become a very important part of foreign production, and it is becoming significant in the United States.

Import Sources (1997-2000): Canada, 42%; China, 28%; Russia, 10%; France, 10%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Unwrought, waste and scrap	8112.91.3000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert D. Brown, Jr. [(703) 648-4984, rbrown@usgs.gov, fax: (703) 648-7757]**

INDIUM

Events, Trends, and Issues: Estimated domestic indium consumption increased modestly to about 58 tons in 2001. The last indium held by the Government stockpile was sold in December 1998. After 3 years of relative stability, the annual average price of indium dropped considerably in 2000 and then remained steady at just under $150 per kilogram in 2001. Expanding LCD manufacture kept demand strong for indium-tin oxide, while the use of indium phosphide for optical communications systems increased rapidly. The ready availability of low-priced indium from China—with increases in both capacity and production—kept world prices down. The long range outlook for the indium market remains promising despite possible near term market fluctuations caused by economic uncertainties.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production[e]		Reserves[2]	Reserve base[2]
	2000	2001		
United States	—	—	300	600
Belgium	40	40	([3])	([3])
Canada	45	45	700	2,000
China	95	100	400	1,000
France	65	65	([3])	([3])
Japan	50	50	100	150
Peru	5	5	100	150
Russia	15	15	200	300
Other countries	20	20	800	1,500
World total (may be rounded)	335	340	2,600	5,700

World Resources: Indium occurs predominantly in solid solution in sphalerite, a sulfide ore of zinc. Large quantities of indium also are contained in ores of copper, lead, and tin, but there is not enough information to formulate reliable estimates of indium resources, and most of these deposits are subeconomic for indium. Indium is recovered almost exclusively as a byproduct of zinc. Estimates of the average indium content of the Earth's crust range from 50 to 200 parts per billion. The average indium content of zinc deposits ranges from less than 1 part per million to 100 parts per million. The highest known concentrations of indium occur in vein or replacement sulfide deposits, usually associated with tin-bearing minerals. However, this type of deposit is usually difficult to process economically.

Substitutes: Gallium arsenide can substitute for indium phosphide in solar cells and semiconductor applications. Silver-zinc oxide or tin oxide are lower cost substitutes for indium-tin oxide in transparent conductive coatings for glass. Hafnium can replace indium alloys for use in nuclear reactor control rods.

[e]Estimated. NA Not available. — Zero.

[1]Defined as imports - exports + adjustments for Government and industry stock changes; exports were assumed to be no greater than the differen between imports and consumption.

[2]Estimate based on the indium content of zinc ores. See Appendix C for definitions.

[3]Reserves for European countries are included in "Other countries."

IODINE

(Data in thousand kilograms, elemental iodine, unless otherwise noted)

Domestic Production and Use: Iodine produced in 2001 from three companies operating in Oklahoma accounted for 100% of the elemental iodine value estimated at $21 million. The operation at Woodward, OK, continued production of iodine from subterranean brines. A second company operated a miniplant in Kingfisher County, OK, using waste brine associated with oil and a plant in Woodward, OK. A third company continued production at Vici, OK, for domestic use and export to Germany. Of the consumers that participate in the annual survey, 25 plants reported consumption of iodine in 2000. Major consumers were located in the Eastern United States. Several consumers of iodine were undergoing organizational changes, sales, and mergers. Prices of crude iodine in drums, published for November, ranged between $19 and $21 per kilogram. Imports of iodine through August averaged $14.28 per kilogram. Establishing an accurate end-use pattern for iodine was difficult because intermediate iodine compounds were marketed before reaching their final end uses. Estimated world consumption of iodine was 19,000 metric tons.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	1,320	1,490	1,620	1,470	1,700
Imports for consumption, crude content	6,380	5,960	5,430	4,790	5,200
Exports	2,760	2,790	1,130	900	1,000
Shipments from Government stockpile excesses	204	291	221	949	83
Consumption:					
Apparent	5,140	4,950	5,990	6,320	6,000
Reported	4,500	4,100	4,540	3,990	NA
Price, average c.i.f. value, dollars per kilogram, crude	14.66	16.45	16.15	14.42	14.28
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number	40	40	40	30	30
Net import reliance[1] as a percentage of apparent consumption	65	70	62	77	72

Recycling: Small amounts of iodine were recycled, but no data are reported.

Import Sources (1997-2000): Chile, 67%; Japan, 21%; and Russia, 11%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Iodine, crude	2801.20.0000	Free.
Iodide, calcium or of copper	2827.60.1000	Free.
Iodide, potassium	2827.60.2000	2.8% ad val.
Iodides and iodide oxides, other	2827.60.5000	4.2% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: In October, the Defense National Stockpile Center announced the fiscal year 2002 Annual Materials Plan would include sales of 454 tons (1,000,000 pounds) of crude iodine.

Stockpile Status—9-30-01[2]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Stockpile-grade	1,629	42	1,629	454	83

Prepared by **Phyllis A. Lyday [(703) 648-7713, plyday@usgs.gov, fax: (703) 648-7722]**

IODINE

Events, Trends, and Issues: Chile was the largest producer of iodine in the world, and production was a coproduct from surface mineral deposits used to produce nitrate fertilizer. Japan was the second largest producer, and production was associated with gas brines.

The 4th Symposium on Iodine Utilization was held in November in Chiba, Japan. Lecturers and poster presentations by industry, government and academic representatives addressed the function of iodine in biological organisms and the use of iodine in electrically conductive polymers.

A Canadian company constructed a plant to produce iodine from nitrate deposits in the Atacama Desert of Chile. The plant came on line in April 2001. Total production reached 79 tons by October. Average production after October was reported at 21.5 tons per month; output gradually will be increased to 60 tons per month. Russia was seeking investors to increase production at the Troitsk Iodine Plant.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2000	2001[e]		
United States	1,470	1,700	250,000	550,000
Azerbaijan	300	300	170,000	340,000
Chile	10,500	10,500	9,000,000	18,000,000
China	500	500	400,000	400,000
Indonesia	70	70	100,000	200,000
Japan	6,100	6,100	4,900,000	7,000,000
Russia	300	300	120,000	240,000
Turkmenistan	150	150	170,000	350,000
World total (rounded)	19,400	19,600	15,000,000	27,000,000

World Resources: In addition to the fields listed in the reserve base, seawater contains 0.05 part per million iodine, or approximately 34 million tons. Seaweeds of the Laminaria family are able to extract and accumulate up to 0.45% iodine on a dry basis. Although not as economical as the production of iodine as a byproduct of gas, oil, and nitrate, the seaweed industry represented a major source of iodine prior to 1959 and is a large resource.

Substitutes: Bromine and chlorine could be substituted for most of the biocide, ink, and colorant uses of iodine, although they are usually considered less desirable than iodine. Antibiotics and mercurochrome also substitute for iodine as biocides. Salt crystals and finely divided carbon may be used for cloud seeding. There are no substitutes for iodine in some catalytic, nutritional, pharmaceutical, animal feed, and photographic uses.

[e]Estimated. NA Not available.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix B for definitions.
[3]See Appendix C for definitions.

IRON ORE[1]

(Data in million metric tons of usable ore,[2] unless noted)

Domestic Production and Use: The value of usable ore shipped from mines in Minnesota, Michigan, and three other States in 2001 was estimated at $1.5 billion. Thirteen iron ore production complexes with 13 mines, 10 concentration plants, and 10 pelletizing plants were in operation during the year. The mines included 12 open pits and 1 underground operation. Virtually all ore was concentrated before shipment. Nine mines operated by five companies accounted for 99% of production. The United States produced 6% of the world's iron ore and consumed about 7%.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001e**
Production, usable	63.0	62.9	57.7	63.1	60.0
Shipments	62.8	63.2	60.7	61.0	60.0
Imports for consumption	18.6	16.9	14.3	15.7	12.0
Exports	6.3	6.0	6.1	6.1	6.0
Consumption:					
Reported (ore and total agglomerate)[3]	79.5	78.2	75.1	76.5	65.0
Apparent	73.0	71.1	70.1	70.2	70.8
Price,[4] U.S. dollars per metric ton	29.60	31.14	25.52	25.6	25.0
Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore	27.9	30.6	26.4	28.8	24.0
Employment, mine, concentrating and pelletizing plant, quarterly average, number	7,450	7,290	6,800	6,814	6,000
Net import reliance[5] as a percentage of apparent consumption (iron in ore)	14	12	18	10	15

Recycling: None.

Import Sources (1997-2000): Canada, 51%; Brazil, 35%; Venezuela, 6%; Australia, 5%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Concentrates	2601.11.0030	Free.
Coarse ores	2601.11.0060	Free.
Fine ores	2601.11.0090	Free.
Pellets	2601.12.0030	Free.
Briquettes	2601.12.0060	Free.
Sinter	2601.12.0090	Free.

Depletion Allowance: 15% (Domestic), 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Worldwide, nearly all iron ore is used in steelmaking. In the United States, as an example, steelmaking accounts for about 98% of iron ore consumption. Annual world production of iron ore is usually about a billion tons, with most of it concentrated in a few countries. In 2001 for example, iron ore was produced in about 50 countries, but the 7 largest of these countries produced more than 80% of the world total, and no other country had as much as a 5% share. Globally, the consolidation begun in 2000 continued. The result was that the three largest iron ore producers had about 70% of the export market.

A large portion of world iron ore production, about 450 million tons per year, is exported because most iron ore is not consumed in the country in which it is produced. Australia and Brazil, for example, rank 1st and 2d, respectively, in world production (Fe content) but 6th and 15th, respectively, in pig iron production (China produces more ore than any other nation, but its ore is low grade). The vast majority of exports are seaborne.

Iron ore consumption data are available for the United States, but not for the rest of the world. Because almost all iron ore is consumed in blast furnaces, the product of the blast furnace, pig iron, is used as the indicator of iron ore consumption. Consumption is also concentrated in a few countries. Pig iron was produced in more than 50 countries. As with iron ore production, pig iron production occurs in many countries, but most production is concentrated in a few. World pig iron production is generally about 550 million metric tons. The top five pig iron producing countries account for almost 60% of world production. No other country has as much as 5%.

Prepared by **William S. Kirk [(703) 648-4962, wkirk@usgs.gov, fax: (703) 648-7757]**

IRON ORE

Iron ore production in the United States declined nearly 5% to about 60 million tons in 2001. Consumption of iron ore and pig iron production also fell. At the beginning of the year, there were seven iron ore producers in Minnesota and two producers in Michigan whose combined output accounted for 99% of U.S. iron ore production. One of them closed permanently and was sold, 100% of a second and 70% of a third were put up for sale, and 45% of a fourth and 12.5% of a fifth were sold. All of the portions of mines that were sold and for sale were owned by steel companies. All the equity was purchased by the largest North American iron ore company. Six of the eight mines that did not close experienced shutdowns during the year. One-half of these eight cut production and another one-half laid off employees. A small iron ore producer in Missouri closed as did an iron ore research laboratory on the Mesabi Iron Range in northern Minnesota.

Congress approved an appropriations bill that included money to begin building a new lock at the Soo Locks, Sault Ste. Marie, MI, that provides the only access from Lake Superior to the lower Great Lakes. Three of the four locks are too small to handle the 1,000-foot-long ore boats that are the most efficient. The new lock will replace the two oldest locks and will be the same size as the Poe Lock, 1,200 feet long and 110 feet wide.

The U.S. Department of Commerce was asked by Members of Congress to conduct an investigation to determine whether imports of semifinished steel and iron ore constituted a threat to the national security of the United States. Hearings were held and the Secretary of Commerce made a recommendation to the President.

World Mine Production, Reserves, and Reserve Base:[6]

	Mine production		Crude ore		Iron content	
	2000	2001[e]	Reserves	Reserve base	Reserves	Reserve base
United States	63	60	6,900	15,000	2,100	4,600
Australia	168	160	18,000	40,000	11,000	25,000
Brazil	195	200	7,600	19,000	4,800	12,000
Canada	35	35	1,700	3,900	1,100	2,500
China	224	220	25,000	50,000	7,800	15,000
India	75	72	2,800	6,200	1,800	3,900
Kazakhstan	16	15	8,300	19,000	4,500	10,000
Mauritania	12	10	700	1,500	400	1,000
Russia	87	88	25,000	56,000	14,000	31,000
South Africa	34	35	1,000	2,300	650	1,500
Sweden	21	20	3,500	7,800	2,200	5,000
Ukraine	56	55	22,000	50,000	12,000	28,000
Other countries	77	75	17,000	38,000	10,000	23,000
World total (may be rounded)	1,060	1,000	140,000	310,000	72,000	160,000

World Resources: World resources are estimated to exceed 800 billion tons of crude ore containing more than 230 billion tons of iron. U.S. resources are estimated to be about 110 billion tons of ore containing about 27 billion tons of iron. U.S. resources are mainly low-grade taconite-type ores from the Lake Superior district that require beneficiation and agglomeration for commercial use.

Substitutes: Iron ore is the only source of primary iron. In some operations, ferrous scrap constitutes as much as 7% of the blast furnace burden. Scrap is extensively used in steelmaking and in iron and steel foundries.

[e]Estimated.
[1]See also Iron and Steel and Iron and Steel Scrap.
[2]Agglomerates, concentrates, direct-shipping ore, and byproduct ore for consumption.
[3]Includes weight of lime, flue dust, and other additives used in producing sinter for blast furnaces. Consumption data are not entirely comparable to those of 1987 and earlier years owing to changes in data collection.
[4]Calculated from value of ore at mines.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix C for definitions.

IRON AND STEEL[1]

(Data in million metric tons of metal, unless otherwise noted)

Domestic Production and Use: The iron and steel industry and ferrous foundries produced goods valued at about $72 billion. The steel industry consisted of about 105 companies that produced raw steel at about 144 locations, with combined raw steel production capability of about 119 million tons. Indiana accounted for about 23% of total raw steel production, followed by Ohio, 16%, and Pennsylvania, 7%. Pig iron was produced by 13 companies operating integrated steel mills, with about 35 blast furnaces in continuous operation. The distribution of steel shipments was estimated as follows: warehouses and steel service centers, 25%; transportation (predominantly for automotive production), 13%; construction, 16%; cans and containers, 3%; and others, 43%. Ferrous foundries, numbering about 1,100, continued to be importers of pig iron into the United States, mainly from Brazil, Russia, and Ukraine.

Salient Statistics—United States:[1]	1997	1998	1999	2000	2001[e]
Pig iron production[2]	49.6	48.2	46.3	47.9	44.2
Steel production:	98.5	98.6	97.4	102	92.9
Basic oxygen furnaces, percent	56.2	54.9	53.7	53.0	53.2
Electric arc furnaces, percent	43.8	45.1	46.3	47.0	46.8
Continuously cast steel, percent	94.7	95.5	95.9	96.3	96.8
Shipments:					
Steel mill products	96.0	92.9	96.3	99	92.6
Steel castings[3]	1.2	1.3	1.2	1.0	1.0
Iron castings[3]	9.6	9.8	9.8	9.5	9.5
Imports of steel mill products	28.3	37.7	32.4	34.4	26.2
Exports of steel mill products	5.5	5.0	4.9	5.9	5.6
Apparent steel consumption[4]	114	118	116	119	118
Producer price index for steel mill products (1982=100)[5]	116.4	113.8	105.3	108.4	100.7
Steel mill product stocks at service centers yearend[6]	6.6	7.7	7.7	7.8	7.1
Total employment, average, number[7]					
Blast furnaces and steel mills	163,000	160,000	[e]160,000	[e]160,000	160,000
Iron and steel foundries	130,000	132,000	[e]132,000	[e]132,000	132,000
Net import reliance[8] as a percentage of apparent consumption	15	22	17	18	15

Recycling: See Iron and Steel Scrap and Iron and Steel Slag.

Import Sources (1997-2000): European Union, 19%; Canada, 14%; Japan, 10%; Mexico, 9%; and other, 48%.

Tariff:[9] Item	Number	Normal Trade Relations[9] 12/31/01	Mexico 12/31/01
Pig iron	7201.10.0000	Free	Free.
Carbon steel:			
Semifinished	7207.12.0050	1.3% ad val.	0.8% ad val.
Structural shapes	7216.33.0090	0.3% ad val.	0.1% ad val.
Bars, hot-rolled	7213.20.0000	0.6% ad val.	0.3% ad val.
Sheets, hot-rolled	7208.39.0030	1.5% ad val.	0.9% ad val.
Hot-rolled, pickled	7208.27.0060	1.5% ad val.	1.0% ad val.
Cold-rolled	7209.18.2550	1.0% ad val.	0.6% ad val.
Galvanized	7210.49.0090	2.0% ad val.	1.3% ad val.
Stainless steel:			
Semifinished	7218.91.0015	1.6% ad val.	1.0% ad val.
	7218.99.0015	1.6% ad val.	1.0% ad val.
Bars, cold-finished	7222.20.0075	3.2% ad val.	2.1% ad val.
Pipe and tube	7304.41.3045	2.3% ad val.	Free.
Cold-rolled sheets	7219.33.0035	3.0% ad val.	2.0% ad val.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Prepared by **Michael D. Fenton [(703) 648-4972, mfenton@usgs.gov, fax: (703) 648-7757]**

IRON AND STEEL

Events, Trends, and Issues: During the first 8 months of 2001, monthly pig iron production fluctuated near 4.1 million tons, and monthly raw steel production fluctuated near 8.5 million tons. Production totals during these periods decreased about 12% for pig iron and 10% for steel from those of 2000. Shipments of steel mill products estimated for 2001 were down 7% compared with those of 2000. Raw steel production was beginning a downward trend during the second half of 2001.

To the detriment of steel producers, the longest economic expansion in U.S. history was showing signs of weakening through the third quarter in 2001. Industrial activity declined in September 2001—the 12th straight month of decline and the first of this duration since November 1944 through October 1945. Decreasing demand for vehicles and consumer goods and the steel to make them caused manufacturing operating capacity to decline in September 2001. Concurrently, steel imports began to increase in 2000 and continued to grow in the first half of 2001 as prices for steel products plunged to record low levels. By mid-2001, the United States had 119 antidumping and countervailing duty orders in place on steel imports, and 36 others were being considered.

The International Trade Commission began a Section 201 investigation under the Trade Act of 1974 to determine whether the U.S. steel industry had been significantly harmed by excessive steel importation. Although the focus by all involved was on alleged dumping by foreign steelmakers, it was becoming clear that a more fundamental problem existed—the United States and the world had excess steelmaking capacity that needed to be reduced.

A unique aspect of this latest round of economic difficulty for the domestic steel industry, allegedly caused by steel import dumping, was the high number of bankruptcies declared by steelmakers. In bankruptcy, as of mid-October 2001, were Acme Steel Co., Bethlehem Steel Corp., Erie Forge & Steel Inc., GS Industries Inc., LTV Steel Corp., Republic Technologies International LLC, and Wheeling-Pittsburgh Steel Corp.

World Production:

	Pig iron		Raw steel	
	2000	2001[e]	2000	2001[e]
United States	47.9	44.2	102	92.9
Brazil	27.7	27.1	27.8	26.3
China	131	140	127	135
European Union	91.6	91.3	158	157
Japan	81.1	79.2	106	104
Korea, Republic of	24.9	25.9	43.1	43.8
Russia	44.6	44.8	59.1	57.8
Ukraine	25.7	26.5	31.8	33.5
Other countries	96.5	92.7	190	178
World total (may be rounded)	571	573	845	828

World Resources: Not applicable. See Iron Ore.

Substitutes: Iron is the least expensive and most widely used metal. In most applications, iron and steel compete either with less expensive nonmetallic materials or with more expensive materials having a performance advantage. Iron and steel compete with lighter materials, such as aluminum and plastics, in the motor vehicle industry; aluminum, concrete, and wood in construction; and aluminum, glass, paper, and plastics in containers.

[e]Estimated.

[1]Production and shipments data source is the American Iron and Steel Institute; see also Iron Ore and Iron and Steel Scrap.

[2]More than 95% of iron made is transported molten to steelmaking furnaces located at the same site.

[3]U.S. Department of Commerce, Census Bureau.

[4]Defined as steel shipments + imports - exports + adjustments for industry stock changes + adjustment for imports of semifinished steel products.

[5]Bureau of Labor Statistics.

[6]Steel Service Center Institute.

[7]Bureau of Labor Statistics. Blast furnaces and steel mills: SIC 3312; Iron and steel foundries: SIC 3320.

[8]Defined as imports - exports + adjustments for Government and industry stock changes.

[9]No tariff for Canada, Israel, and certain Caribbean and Andean nations.

IRON AND STEEL SCRAP[1]

(Data in million metric tons of metal, unless otherwise noted)

Domestic Production and Use: Total value of domestic purchases (receipts of ferrous scrap by all domestic consumers from brokers, dealers, and other outside sources) and exports was estimated at $5.1 billion in 2001, down about 7% from that of 2000. Manufacturers of pig iron, raw steel, and steel castings accounted for nearly 80% of scrap consumption by the domestic steel industry, using scrap together with pig iron and direct-reduced iron to produce steel products for the construction, transportation, oil and gas, machinery, container, appliance, and various other consumer industries. The ferrous castings industry consumed most of the remaining 20% to produce cast iron and steel products, such as motor blocks, pipe, and machinery parts. Relatively small quantities of scrap were used for producing ferroalloys, for the precipitation of copper, and by the chemical industry; these uses totaled less than 1 million tons.

Raw steel production in 2001 was an estimated 92 million tons, down nearly 10% from that of 2000, as capacity utilization declined to its lowest level since December 2000 during the fourth quarter of 2001. Net shipments of steelmill products were estimated at about 91.8 million tons compared with 98.9 million tons for 2000. The domestic ferrous castings industry shipped an estimated 11 million tons of all types of iron castings in 2001 and an estimated 1.4 million tons of steel castings, including investment castings.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Home scrap	20	20	19	20	21
Purchased scrap[2]	59	56	53	56	55
Imports for consumption[3]	3	3	4	3	3
Exports[3]	9	6	6	6	7
Consumption, reported	73	73	71	74	73
Price, average, dollars per metric ton delivered, No. 1 Heavy Melting composite price, Iron Age Average, Pittsburgh, Philadelphia, Chicago	125.80	104.07	90.98	92.61	75.17
Stocks, consumer, yearend	5.5	5.2	4.8	5.3	4.3
Employment, dealers, brokers, processors, number[4]	37,000	37,000	37,000	37,000	37,000
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Recycling: All recycled iron and steel scrap is a vital raw material for the production of new steel and cast iron products. The steel and foundry industries in the United States have been structured to recycle scrap, and, as a result, are highly dependent upon scrap. The steel industry in North America has been recycling steel scrap for over 200 years. The automotive recycling industry alone recycled nearly 14 million vehicles in 2000 through more than 200 car shredders to supply more than 14 million tons of shredded steel scrap to the steel industry for recycling. More than 12,000 vehicle dismantlers throughout North America resell parts. In the United States alone, an estimated 73 million tons of steel was recycled in steel mills and foundries in 2001. Recycling of scrap plays an important role in the conservation of energy because the remelting of scrap requires much less energy than the production of iron or steel products from iron ore. Also, consumption of iron and steel scrap by remelting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment. Recycled scrap consists of approximately 29% home scrap (recirculating scrap from current operations), 24% prompt scrap (produced in steel-product manufacturing plants), and 47% post-consumer (old) scrap.

Import Sources (1997-2000): Canada, 61%; United Kingdom, 18%; Netherlands, 5%; Mexico, 3%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Iron and steel waste and scrap:		
No. 1 bundles	7204.41.0020	Free.
No. 1 Heavy Melting	7204.49.0020	Free.
No. 2 Heavy Melting	7204.49.0040	Free.
Shredded	7204.49.0070	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Prepared by **Michael Fenton [(703) 648-4972, mfenton@usgs.gov, fax: (703) 648-7757]**

IRON AND STEEL SCRAP

Events, Trends, and Issues: To the detriment of steel producers and their raw material suppliers, including the scrap iron and steel industry, the longest economic expansion in U.S. history was showing signs of weakening through the third quarter in 2001. Industrial activity declined in September 2001—the 12th straight month of decline and the first of this duration since November 1944 through October 1945. Decreasing demand for vehicles and consumer goods and the steel to make them caused manufacturing operating capacity to decline in September 2001. Prices for steel products and scrap plunged to record low levels during the first three quarters of 2001, but additional price declines were not expected. The steel-producing and scrap industries were convinced that they, if not the national economy as a whole, were in a recession. Few, if any, analysts and executives in these industries were predicting a significant upturn in scrap demand during 2001, especially after the market downturn resulting from the terrorist attacks in the United States on September 11.

Ferrous scrap prices were lower, on average, during 2001 than in 2000. Composite prices published by Iron Age Scrap Price Bulletin for No. 1 Heavy Melting steel scrap delivered to purchasers in Chicago, Philadelphia, and Pittsburgh averaged about $75 per metric ton in 2001. As reported by Iron Age Scrap Price Bulletin, the average price for nickel-bearing stainless steel scrap delivered to purchasers in Pittsburgh was about $652 per ton in 2001, which was significantly lower than the 2000 average price of $761 per ton. Exports of ferrous scrap increased from 5.8 million tons during 2000 to about 7.0 million tons in 2001. Export scrap value increased from $1.0 billion in 2000 to an estimated $1.15 billion in 2001.

In the United States, the primary source of obsolete steel scrap is the automobile. The recycling rate for automobiles for the 5-year period 1996-2000 was about 95%. The recycling rates for appliances and steel cans for the past 5 years overall were about 78% and 58%, respectively. Recycling rates for construction materials in 2000 were about 95% for plates and beams and 48% for rebar and other materials. The recycling rates for appliance, can, and construction steel are expected to increase not only in the United States, but also in emerging industrial countries. As environmental regulations increase, recycling becomes more profitable and convenient, and public interest in recycling continues to grow.

World Mine Production, Reserves, and Reserve Base: Not applicable.

World Resources: Not applicable.

Substitutes: About 2.2 million tons of direct-reduced iron was used in the United States in 2000 as a substitute for iron and steel scrap.

[e]Estimated. E Net exporter.
[1]See also Iron Ore and Iron and Steel.
[2]Receipts - shipments by consumers + exports - imports.
[3]Includes used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping.
[4]Estimated, based on 1992 Census of Wholesale Trade.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.

IRON AND STEEL SLAG

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Ferrous slags are valuable coproducts of iron- and steelmaking. In 2001, over 18 million tons of domestic iron and steel slags, valued at about $157 million[1] (f.o.b.), were consumed. Of this, iron or blast furnace slag accounted for about 69% of the tonnage sold, and was worth about $134 million. Steel slags, produced from open hearth,[2] basic oxygen, and electric arc furnaces accounted for the remainder. There were 15 slag-processing companies servicing either iron and steel or just steel facilities at about 100 locations, iron slags at about 30 sites in a dozen States, and steel slags at about 90 sites in about 30 States. The mid-Atlantic region (Maryland, New York, Pennsylvania, and West Virginia) accounted for 45% of blast furnace slag sold or used in the United States, and the North-Central region (Illinois, Indiana, Michigan, and Ohio) accounted for 41% of the sales. The major uses of iron slag were for road bases, 37%; asphaltic aggregates 19%; cement and concrete applications, 16%; and fill, 9%. Steel slags were mainly used for road bases, 33%; fill 20%; and asphaltic aggregates, 18%. About 78% of iron and steel slag shipments was by truck, generally to customers within approximately 80 kilometers of the plant. Rail and waterway transport accounted for about 6% and 16% of shipments, respectively. These included destinations farther afield.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production, marketed[3]	18,900	18,400	17,000	16,300	18,000
Imports for consumption	663	700	920	1,200	1,100
Exports	9	10	12	20	20
Consumption, apparent[4]	19,600	19,000	18,000	20,200	19,000
Price average value, dollars per ton, f.o.b. plant	7.70	8.00	8.80	8.60	8.60
Stocks, yearend	NA	NA	NA	NA	NA
Employment, number[e]	2,500	2,700	2,750	2,750	2,700
Net import reliance[5] as a percentage of reported consumption	3	4	5	10	8

Recycling: Ferrous slags are viewed as valuable byproducts of iron- and steelmaking, and are among the highest quantities of recycled materials. Apart from the large outside markets for slag in the construction sector, some iron and steel slags are used internally being recycled to the furnaces as ferrous and flux feed. Entrained metal, particularly in steel slag, is routinely recovered during slag processing for return to the furnaces. However, data for such furnace feed uses are unavailable.

Import Sources (1997-2000): Year-to-year import data for ferrous slags show variations in both tonnages and unit values; most of the data contain unresolved discrepancies. Slag was imported from 1997 to 2000 mainly from Canada, Italy, and Brazil; prior sources were mainly Canada and Japan. Data, for 2001 only, are: Canada, 27%; Italy, 23%; Brazil, 15%; France, 10%; other, 25%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Granulated slag	2618.00.0000	Free.
Basic slag	3103.20.0000	Free.
Ferrous scale	2619.00.9000	Free.
Slag, dross, scalings, from manufacture of iron and steel	2619.00.3000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Prepared by **Rustu S. Kalyoncu [(703) 648-7720, rkalyonc@usgs.gov, fax: (703) 648-7722]**

IRON AND STEEL SLAG

Events, Trends, and Issues: Sales of iron and steel slags depend mostly on the price and availability of natural aggregates, which are slag's main competitor in the construction sector. Demand for granulated blast furnace slag (as a pozzolan or cement additive) has steadily been increasing in the United States. This material makes up the bulk of slag imports, as reflected in the import reliance for 2001 (7.7%). The future availability of iron slag in the United States may show a decline owing to closing of aging blast furnaces. No new blast furnaces are under construction or planned. Domestic decline, if it occurs, will be compensated for by increased imports. Iron and steel slags have been proposed for regulation under various waste classifications by Federal and State agencies. Citing slag's widespread marketability and chemical inertness, the industry has thus far succeeded in keeping iron and steel slags exempt from such regulation. No new Government regulation is pending.

World Mine Production, Reserves, and Reserve Base: Slag is not a mined material. Production data for the world are unavailable, but it is estimated that current annual world iron and steel slag output is on the order of 250 to 275 million tons, based on typical ratios of slag to crude iron and steel output.

World Resources: Not applicable.

Substitutes: Crushed stone and sand and gravel are common aggregate substitutes in the construction sector. Certain rock types, as well as silica fume and fly ash, are pozzolan substitutes in blended cements and concrete. Fly ash represents the bulk of the substitutes, with about 2 million tons of the total 9 million tons of fly ash used in cement manufacture, either as raw feed or cement additive.

[e]Estimated. NA Not available.
[1]The reported value of $157 million (obtained from annual survey of processors) represents the quantities sold rather than processed, and exclud value of any entrained metal that may be recovered during slag processing and returned to the iron and, especially, steel furnaces. Value data fo recovered metal were unavailable.
[2]Sales of open-hearth furnace steel slag were from stockpiles; there was no domestic open-hearth steel production in 2001.
[3]Data for actual production of marketable slag are unavailable, and the data shown are for sales, largely from stockpiles. Production may be estim as equivalent to 25% to 30% of crude (pig) iron production and 10% to 15% of crude steel output.
[4]Defined as production + imports - exports.
[5]Defined as imports - exports. Data are unavailable to allow adjustments for changes in stocks.

KYANITE AND RELATED MINERALS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: One firm in Virginia with integrated mining and processing operations produced kyanite from hard-rock open pit mines. One company produced synthetic mullite in Georgia. Of the kyanite-mullite output, 90% was estimated to have been used in refractories and 10% in other uses. Of the refractory usage, 50% to 60% was estimated to have been used in iron and steelmaking and the remainder in the manufacture of chemicals, glass, nonferrous metals, and other materials.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Mine	W	[e]90	[e]90	[e]90	90
Synthetic mullite	W	[e]39	[e]39	[e]40	40
Imports for consumption (andalusite)	8	10	6	6	5
Exports[e]	35	35	35	35	35
Shipments from Government stockpile excesses	1	—	—	—	—
Consumption, apparent	W	[e]104	[e]100	[e]101	100
Price, average, dollars per metric ton:					
U.S. kyanite, raw	154	157	158	165	165
U.S. kyanite, calcined	262	267	268	279	279
Andalusite, Transvaal, South Africa, 57%[1] Al_2O_3	190	190	200	161	162
Andalusite, Transvaal, South Africa, 58%[2] Al_2O_3	230	230	225	189	210
Stocks, producer	NA	NA	NA	NA	NA
Employment, kyanite mine and plant, number[e]	150	150	150	150	150
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1997-2000): South Africa, 100%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Andalusite, kyanite, and sillimanite	2508.50.0000	Free.
Mullite	2508.60.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[4]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Kyanite, lump	0.1	—	0.1	—	—

Prepared by **Michael J. Potter [(703) 648-7723, mpotter@usgs.gov, fax: (703) 648-7722]**

KYANITE AND RELATED MINERALS

Events, Trends, and Issues: Kyanite, on conversion to mullite at high temperature, expands irreversibly by up to 18%, thereby offsetting the firing shrinkage of other raw materials, especially clay, in ceramic bodies and refractories. Andalusite expands from 4% to 6%; it imparts high-temperature creep resistance in refractories.[5]

The steel industry continued to be the largest user of refractories in general, consuming an estimated 55% to 60% of total refractory output. For the first 8 months of 2001, U.S. crude steel shipments were 11.5% less than in the comparable period of 2000, according to the International Iron and Steel Institute. Output in the 15 European Union countries for the comparable period was 1.9% less than in 2000. For the 64 countries reporting to the Institute, total crude steel output was about the same for the first 8 months of 2001 as it was for the comparable period of 2000.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[6]
	2000	2001[e]	
United States	[e]90	90	Large in the United States. South Africa reports reserve base of about 51 million tons of aluminosilicates ore (andalusite and sillimanite).
France	65	65	
India	17	17	
South Africa	185	215	
Other countries	11	3	
World total	368	390	

World Resources: Large resources of kyanite and related minerals are known to exist in the United States. The chief resources are in deposits of micaceous schist and gneiss mostly in the Appalachian Mountain area and in Idaho. Other resources are in aluminous gneiss in southern California. These resources are not economical to mine at present, but some may be eventually. The characteristics of kyanite resources in the rest of the world are thought to be similar to those in the United States.

Substitutes: Two types of synthetic mullite (fused and sintered), superduty fire clays, and high-alumina materials are substitutes for kyanite in refractories. Principal raw materials for synthetic mullite are bauxite, kaolin and other clays, and silica sand.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]From 1997-99, 57.5% Al_2O_3.
[2]From 1997-99, 59.5% Al_2O_3.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B for definitions.
[5]Dixon, G., Jamerson, H., and Brown, J., 2001, Sillimanite minerals: Mining Engineering, v. 53, no. 6, June, p. 58-59.
[6]See Appendix C for definitions.

LEAD

(Data in thousand metric tons of lead content, unless otherwise noted)

Domestic Production and Use: The value of recoverable mined lead in 2001, based on the average U.S. producer price, was $404 million. Seven lead mines in Missouri plus lead-producing mines in Alaska, Idaho, and Montana yielded most of the total. Primary lead was processed at two smelter-refineries in Missouri and at a smelter in Montana. Of the 26 plants that produced secondary lead, 15 had annual capacities of 15,000 tons or more and accounted for more than 98% of secondary production. Lead was consumed at about 140 manufacturing plants. The transportation industries were the principal users of lead, consuming 76% of it for batteries, fuel tanks, solder, seals, bearings, and wheel weights. Electrical, electronic, communications uses (including batteries), ammunition, television glass, construction (including radiation shielding), and protective coatings accounted for approximately 22% of consumption. The balance was used in ballast and counterweights, ceramics and crystal glass, tubes and containers, type metal, foil, wire, and specialized chemicals.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production:					
Mine, lead in concentrates	459	493	520	468	420
Primary refinery	343	337	350	341	300
Secondary refinery, old scrap	1,040	1,060	1,060	1,080	1,030
Imports for consumption, lead in concentrates	18	33	12	31	30
Exports, lead in concentrates	42	72	94	117	100
Imports for consumption, refined metal, wrought and unwrought	272	275	323	365	310
Exports, refined metal, wrought and unwrought	53	40	37	49	35
Shipments from Government stockpile excesses, metal	26	50	61	32	30
Consumption:					
Reported	1,620	1,630	1,680	1,720	1,630
Apparent	1,610	1,690	1,760	1,740	1,650
Price, average, cents per pound:					
North American Producer	46.5	45.3	43.7	43.6	44
London Metal Exchange	28.3	24.0	22.8	20.6	21
Stocks, metal, producers, consumers, yearend	101	89	91	123	105
Employment:					
Mine and mill (peak), number	1,200	1,200	1,100	1,100	1,000
Primary smelter, refineries	450	450	450	450	400
Secondary smelters, refineries	1,800	1,800	1,700	1,700	1,600
Net import reliance[1] as a percentage of apparent consumption	14	18	20	18	20

Recycling: About 1.1 million tons of secondary lead was produced, an amount equivalent to 67% of domestic lead consumption. Nearly all of it was recovered from old (post-consumer) scrap. About 1 million tons (equivalent to 61% of domestic lead consumption) was recovered from used batteries alone.

Import Sources (1997-2000): Lead in concentrates: Peru, 25%; Mexico, 16%; Australia, 10%; Canada, 8%; and other, 41%. Metal, wrought and unwrought: Canada, 64%; Mexico, 15%; Australia, 5%; Peru, 2%; and other, 14%. Total lead content: Canada, 61%; Mexico, 15%; Australia, 5%; Peru, 4%; and other, 15%.

Tariff: Item	**Number**	**Normal Trade Relations[2] 12/31/01**
Unwrought (refined)	7801.10.0000	2.5% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[3]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 2001**	**Disposals FY 2001**
Lead	186	11	186	54	24

Prepared by **Gerald R. Smith [(703) 648-4983, grsmith@usgs.gov, fax: (703) 648-7757]**

LEAD

Events, Trends, and Issues: During 2001, the price for lead decreased in the United States and world markets. The average North American Producer and London Metal Exchange prices for the first 9 months of the year were 0.2% and 4.5%, respectively, below the averages for 2000. Worldwide demand for lead declined by about 1% in 2001, mainly owing to a decrease in demand in the United States. Use of lead in Europe decreased slightly, further contributing to the overall decline. These decreases in demand more than offset the rise in demand for lead in Asia, particularly in China. Total output of refined lead worldwide decreased by about 2% in 2001. Production cutbacks in Belgium, France, Germany, Italy, and the United States more than offset the increases in production of refined lead in China, Israel, and Malaysia. A supply deficit of refined lead was anticipated in the industrialized world in 2001, largely due to an insufficient supply of concentrates, according to a report issued by the International Lead and Zinc Study Group at its 46th Session in New Delhi, India, in October.

U.S. mine production declined by about 10%, mainly as a result of production decreases implemented by one major producer during the year, and secondary refinery production declined by about 5%. U.S. apparent consumption of lead decreased by 5% compared with the previous year, as the lack of temperature extremes in most of the heavily populated regions of the country reduced the rate of automotive-type battery failures and the consequent rate of demand for replacement batteries. In addition, the slowdown in the U.S. economy reduced the demand for automotive-type batteries in new vehicles, as well as industrial-type batteries in telecommunications and motive power applications.

A U.S. company announced the indefinite suspension of operations at its lead smelter, beginning in April 2001. The smelter was constructed in the late 1800s to process the output of lead concentrate from mines located in the northwestern United States. Production capacity of the smelter is about 60,000 tons per year of lead bullion, which then is principally exported for further refining. According to the company, the smelter likely would reopen when market conditions and the supply of lead concentrates and other raw materials improved sufficiently for economic operation.

The development of higher voltage automotive-type lead-acid batteries continued during 2001 in response to the expected need for greater electrical power in automobiles during the next few years. These newly designed batteries will supply sufficient power for a host of automotive features and in-car luxuries, including regenerative power recovery, windscreen heating, and electrically driven power steering.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	468	420	8,700	20,000
Australia	699	700	15,000	28,000
Canada	143	150	1,600	9,000
China	570	560	9,000	30,000
Kazakhstan	40	30	2,000	2,000
Mexico	156	160	1,000	2,000
Morocco	80	82	500	1,000
Peru	271	270	2,000	3,000
South Africa	75	80	2,000	3,000
Sweden	108	100	500	1,000
Other countries	490	420	22,000	33,000
World total (may be rounded)	3,100	2,970	64,000	130,000

World Resources: In recent years, significant lead resources have been demonstrated in association with zinc and/or silver or copper in the United States (Alaska), Australia, Canada, China, Ireland, Mexico, Peru, and Portugal. Identified lead resources of the world total more than 1.5 billion tons.

Substitutes: Substitution of plastics has reduced the use of lead in building construction, electrical cable covering, cans, and containers. Aluminum, tin, iron, and plastics compete with lead in other packaging and protective coatings, and tin has replaced lead in solder for new or replacement potable water systems in the United States.

[e]Estimated.

[1]Defined as imports - exports + adjustments for Government and industry stock changes.

[2]No tariff for Mexico and Canada for item shown.

[3]See Appendix B for definitions.

[4]See Appendix C for definitions.

LIME[1]

(Data in thousand metric tons, unless otherwise noted)[2]

Domestic Production and Use: In 2001, quicklime and hydrate producers (excluding commercial hydrators) at 108 plants in 34 States and Puerto Rico sold or used 18.7 million metric tons (20.6 million short tons) of lime valued at about $1.12 billion, a decrease of about 900,000 tons (990,000 short tons) and a decrease of about $70 million from 2000 levels. Five companies, operating 38 lime plants and 6 hydrating plants, accounted for about 70% of the total output. Principal producing States, each with production over 1 million tons, were Alabama, Kentucky, Missouri, Ohio, Pennsylvania, and Texas. These six States produced about 10.7 million tons (11.8 million short tons), or 57% of the total output. Major markets for lime were steel, flue gas desulfurization, mining, construction, pulp and paper, precipitated calcium carbonate, and water treatment.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production[3]	19,700	20,100	19,700	19,600	18,700
Imports for consumption	276	231	140	113	104
Exports	80	56	59	73	90
Consumption, apparent	19,900	20,300	19,800	19,600	18,800
Quicklime average value, dollars per ton at plant	57.80	57.60	57.30	57.50	59.00
Hydrate average value, dollars per ton at plant	80.20	78.90	80.20	85.00	76.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and plant, number	5,600	5,600	5,600	5,600	5,500
Net import reliance[4] as a percentage of apparent consumption	1	1	([5])	([5])	([5])

Recycling: Large quantities of lime are regenerated by paper mills. Some municipal water treatment plants regenerate lime from softening sludge. Quicklime is regenerated from waste hydrated lime in the carbide industry. Data for these sources were not included as production in order to avoid duplication.

Import Sources (1997-2000): Canada, 90%; Mexico, 8%; and other, 2%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12/31/01**
Quicklime	2522.10.0000	Free.
Slaked lime	2522.20.0000	Free.
Hydraulic lime	2522.30.0000	Free.
Calcined dolomite	2518.20.0000	3% ad val.

Depletion Allowance: Limestone produced and used for lime production, 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Graymont Ltd. acquired Con-Lime Inc., a producer of lime, limestone, and dimension stone, near Bellefonte, PA. Con-Lime operates two rotary kilns with a combined capacity of about 136,000 tons per year (150,000 short tons per year). Graymont already operates two plants in the area (Bellefonte plant and Pleasant Gap plant).[6]

Mississippi Lime Co. acquired Ash Grove Cement Co.'s lime plant located at Springfield, MO. The plant produces quicklime and hydrate, including Type S hydrate for construction and food grade hydrate.[7]

Lime sales to the steel industry (lime's largest market) were adversely affected by difficulties experienced by domestic steel producers. Steel companies suffered from low priced imports and slowing demand during the first 3 quarters of the year when U.S. steel production was down more than 10% compared with the same period in 2000. The terrorist attacks of September 11 deepened the contraction of the U.S. economy, and steel production in the fourth quarter was expected to decrease significantly. By the end of October, U.S. steel mills were only operating at 65% of capacity.

In 2000, the price of natural gas increased dramatically and peaked in the winter of 2000-2001 at levels that were 4 to 5 times higher than average prices in 1998 and 1999. Prices came down during 2001, but were still 40% to 50% higher than the 1998 and 1999 average. Consequently, the U.S. lime industry, which routinely consumes natural gas in vertical shaft kilns, shut down individual gas-fired kilns and in some case entire lime plants during 2000 and 2001.

Prepared by **M. Michael Miller [(703) 648-7716, mmiller1@usgs.gov, fax: (703) 648-7722]**

LIME

World Lime Production and Limestone Reserves and Reserve Base:

	Production 2000	Production 2001[e]	Reserves and reserve base[8]
United States	19,600	18,700	Adequate for all countries listed.
Belgium	1,750	1,700	
Brazil	5,700	6,300	
Canada	2,600	2,500	
China	21,500	22,000	
France	2,400	2,400	
Germany	7,600	7,600	
Italy[9]	3,500	3,500	
Japan (quicklime only)	7,650	7,600	
Mexico	6,500	6,000	
Poland	2,500	2,500	
Romania	1,700	1,500	
Russia	8,000	8,000	
South Africa (sales)	1,345	1,300	
United Kingdom	2,500	2,500	
Other countries	21,200	21,000	
World total (rounded)	116,000	115,000	

World Resources: Domestic and world resources of limestone and dolomite suitable for lime manufacture are adequate.

Substitutes: Limestone is a substitute for lime in many applications, such as agriculture, fluxing, and sulfur removal. Limestone contains less reactive material, is slower to react, and may have other disadvantages compared with lime depending on the application; however, limestone is considerably less expensive than lime. Calcined gypsum is an alternative material in industrial plasters and mortars. Cement and lime kiln dust and fly ash are potential substitutes for some construction uses of lime. Magnesium hydroxide is a substitute for lime pH control, and magnesium oxide is a substitute for lime flux in steelmaking.

[e]Estimated. NA Not available.
[1]Data are for quicklime, hydrated lime, and refractory dead-burned dolomite. Excludes Puerto Rico, unless noted.
[2]To convert metric tons to short tons, multiply metric tons by 1.1023.
[3]Sold or used by producers.
[4]Defined as imports - exports + adjustments for Government and industry stock changes; stock changes are assumed to be zero for apparent consumption and net import reliance calculations.
[5]Less than ½ unit.
[6]National Lime Association, 2001a, Graymont acquires Con-Lime: Limelites, v. 67, no. 4, April-June, p. 4.
[7]———2001b, Mississippi Lime acquires Ash Grove's Springfield lime plant: Limelites, v. 67, no. 4, April-June, p. 4.
[8]See Appendix C for definitions.
[9]Includes hydraulic lime.

LITHIUM

(Data in metric tons of lithium content, unless otherwise noted)

Domestic Production and Use: Chile was the largest lithium chemical producer in the world; Argentina, China, Russia, and the United States were large producers also. Australia, Canada, and Zimbabwe were major producers of lithium ore concentrates. The United States remained the leading consumer of lithium minerals and compounds and the leading producer of value-added lithium materials. Because only one company produced lithium compounds from domestic resources, reported production and value of production data cannot be published. Estimation of value for the lithium mineral compounds produced in the United States is extremely difficult because of the large number of compounds used in a wide variety of end uses and the great variability of the prices for the different compounds.

The use of lithium compounds in ceramics, glass, and primary aluminum production represented more than 60% of estimated domestic consumption. Other major end uses for lithium were in the manufacture of lubricants and greases and in the production of synthetic rubber.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	W	W	W	W	W
Imports for consumption	975	2,590	2,640	2,880	2,500
Exports	2,200	1,400	1,330	1,310	1,500
Consumption:					
Apparent	W	W	W	W	W
Estimated	2,800	2,800	2,800	2,800	2,200
Price, yearend, dollars per kilogram:					
Lithium carbonate	4.47	4.47	4.47	4.47	4.47
Lithium hydroxide, monohydrate	5.74	5.74	5.74	5.74	5.74
Employment, mine and mill, number[e]	230	100	100	100	100
Net import reliance[1] as a percentage of apparent consumption	E	E	<50%	>50%	>50%

Recycling: Insignificant, but growing through the recycling of lithium batteries.

Import Sources (1997-2000): Chile, 80%; Argentina, 16%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Other alkali metals	2805.19.0000	5.5% ad val.
Lithium oxide and hydroxide	2825.20.0000	3.7% ad val.
Lithium carbonate:		
U.S.P. grade	2836.91.0010	3.7% ad val.
Other	2836.91.0050	3.7% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

Prepared by **Joyce A. Ober [(703) 648-7717, jober@usgs.gov, fax: (703) 648-7722]**

LITHIUM

Events, Trends, and Issues: The only active lithium carbonate plant remaining in the United States was at a brine operation in Nevada. Subsurface brines have become the dominant raw material for lithium carbonate production worldwide because of lower production costs as compared with the costs for hard rock ores. Two brine operations in Chile dominate the world market; a facility at a brine deposit in Argentina produced lithium chloride and a limited quantity of lithium carbonate. Most of the lithium minerals mined in the world were consumed as ore concentrates rather than feedstock for lithium carbonate and other lithium compounds.

Two companies produced a large array of downstream lithium compounds in the United States from domestic or South American lithium carbonate. A U.S. recycling company produced a small quantity of lithium carbonate from solutions recovered during the recycling of lithium batteries.

When a Chilean fertilizer producer entered the lithium carbonate market in 1997, it undercut prices by about 50% to establish market share and to increase total demand, especially in new uses. Higher cost facilities closed, but markets have stayed steady. Prices increased by about 10% at the end of 1999 and again in 2000, although U.S. list prices have not reflected any changes since 1997.

Interest in lithium batteries for electric vehicles (EVs) continued; acceptance, however, of battery-powered EVs was not expanding significantly. Other rechargeable lithium batteries were growing in popularity for powering portable computers and telephones, video cameras, and cordless tools. Nonrechargeable lithium batteries were used in calculators, cameras, computers, electronic games, and watches.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[2]	Reserve base[2]
	2000	2001[e]		
United States	W	W	38,000	410,000
Argentina[e]	200	200	NA	NA
Australia[e]	2,400	2,400	150,000	160,000
Bolivia	—	—	—	5,400,000
Brazil	30	30	910	NA
Canada	710	700	180,000	360,000
Chile	5,300	6,400	3,000,000	3,000,000
China	2,400	2,500	NA	NA
Portugal	140	140	NA	NA
Russia[e]	2,000	2,000	NA	NA
Zimbabwe	740	700	23,000	27,000
World total (may be rounded)	[3]14,000	[3]15,100	3,400,000	9,400,000

World Resources: The identified lithium resources total 760,000 tons in the United States and more than 12 million tons in other countries.

Substitutes: Substitutes for lithium compounds are possible in manufactured glass, ceramics, greases, and batteries. Examples are sodic and potassic fluxes in ceramics and glass manufacture; calcium and aluminum soaps as substitutes for stearates in greases; and zinc, magnesium, calcium, and mercury as anode material in primary batteries. Lithium carbonate is not considered to be an essential ingredient in aluminum potlines. Substitutes for aluminum-lithium alloys as structural materials are composite materials consisting of glass, polymer, or boron fibers in engineering resins.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix C for definitions.
[3]Excludes U.S. production.

MAGNESIUM COMPOUNDS[1]

(Data in thousand metric tons of magnesium content, unless otherwise noted)

Domestic Production and Use: Seawater and natural brines accounted for about 60% of U.S. magnesium compounds production. Magnesium oxide and other compounds were recovered from seawater by two companies in Delaware and Florida, from well brines by three companies in Michigan, and from lake brines by two companies in Utah. Magnesite was mined by one company in Nevada, brucite was mined by one company in Nevada and one company in Texas, and olivine was mined by two companies in North Carolina and Washington. About 69% of the magnesium compounds consumed in the United States was used for refractories. The remaining 31% was used in agricultural, chemical, construction, environmental, and industrial applications.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	402	374	395	370	360
Imports for consumption	259	344	321	395	280
Exports	56	49	52	56	50
Consumption, apparent	605	669	664	709	590
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant, number[e]	600	600	550	450	450
Net import reliance[2] as a percentage of apparent consumption	34	44	41	48	39

Recycling: Some magnesia-base refractories are recycled, either for reuse as refractory material or for use as construction aggregate.

Import Sources (1997-2000): China, 65%; Canada, 8%; Australia, 8%; Austria, 4%; and other, 15%.

Tariff:[3] Item	Number	Normal Trade Relations 12/31/01
Crude magnesite	2519.10.0000	Free.
Dead-burned and fused magnesia	2519.90.1000	Free.
Caustic-calcined magnesia	2519.90.2000	Free.
Kieserite	2530.20.1000	Free.
Epsom salts	2530.20.2000	Free.
Magnesium hydroxide	2816.10.0000	3.1% ad val.
Magnesium chloride	2827.31.0000	1.5% ad val.
Magnesium sulfate (synthetic)	2833.21.0000	3.7% ad val.

Depletion Allowance: Brucite, 10% (Domestic and foreign); dolomite, magnesite, and magnesium carbonate, 14% (Domestic and foreign); magnesium chloride (from brine wells), 5% (Domestic and foreign); and olivine, 22% (Domestic) and 14% (Foreign).

Government Stockpile: None.

Prepared by **Deborah A. Kramer, [(703) 648-7719, dkramer@usgs.gov, fax: (703) 648-7722]**

MAGNESIUM COMPOUNDS

Events, Trends, and Issues: Consumption of magnesia in refractory applications declined in 2001, mainly because U.S. steel production declined. Through midyear, U.S. steel production was about 12% lower than that in 2000. Although the total quantity of magnesia imported from China declined, this country remained the largest magnesia supplier to the United States. In February, the Chinese Magnesite Export Association was established with 23 companies as members, who represented the bulk of the country's caustic-calcined, dead-burned, and fused magnesia producers. The association was formed to replace the two separate export groups that were formed in 2000. Its stated goals were to stabilize prices, ensure a supply of quality products, and ensure customer service. The Chinese export license fee for 2001 was $42 per metric ton of magnesite and was distributed among individual companies based on export records of each company for 1995 to 2000. China's accession into the World Trade Organization, for which negotiations were completed on September 17, may have a significant impact on the structure of its export licensing system.

One magnesia producer in Michigan sold its refractory operations to another U.S. company in the second quarter, but it planned to continue to manufacture refractory products for the buyer for 2 years under the sales agreement. The Michigan firm had been looking for a buyer for this business since mid-2000.

An Australian company advanced its plans to construct a 50,000-ton-per-year seawater magnesia plant in Western Australia with a successful initial public offering of stock in June. Most of the output from the plant, which is expected to be completed by 2004, would be used by the country's lateritic nickel industry where is it used as a neutralizing agent.

World Mine Production, Reserves, and Reserve Base:

	Magnesite production		Magnesite reserves and reserve base[4]	
	2000	**2001[e]**	**Reserves**	**Reserve base**
United States	W	W	10,000	15,000
Australia	101	100	NA	NA
Austria	216	210	15,000	20,000
Brazil	89	90	45,000	65,000
China[e]	721	720	37,000	86,000
Greece	187	190	30,000	30,000
India	105	100	14,000	55,000
Korea, North[e]	288	300	450,000	750,000
Russia[e]	288	250	650,000	730,000
Slovakia[e]	245	250	20,000	30,000
Spain	144	150	10,000	30,000
Turkey	576	570	65,000	160,000
Other countries	131	130	430,000	490,000
World total (may be rounded)	[5]3,090	[5]3,060	1,800,000	2,500,000

In addition to magnesite, there are vast reserves of well and lake brines and seawater from which magnesium compounds can be recovered.

World Resources: Resources from which magnesium compounds can be recovered range from large to virtually unlimited and are globally widespread. Identified world resources of magnesite total 12 billion tons, and of brucite, several million tons. Resources of dolomite, forsterite, and magnesium-bearing evaporite minerals are enormous, and magnesia-bearing brines are estimated to constitute a resource in billions of tons. Magnesium hydroxide can be recovered from seawater.

Substitutes: Alumina, silica, and chromite substitute for magnesia in some refractory applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]See also Magnesium Metal.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]Tariffs are based on gross weight.
[4]See Appendix C for definitions.
[5]Excludes U.S. production.

MAGNESIUM METAL[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: At the beginning of 2001, two companies in Utah and Washington produced primary magnesium, but by yearend, only the company in Utah remained in production. An electrolytic process was used at the plant in Utah to recover magnesium from lake brines, and a thermic process was used to recover magnesium from dolomite in Washington. The largest use for magnesium, which accounted for 53% of total domestic consumption, was as a constituent of aluminum-base alloys that were used for packaging, transportation, and other applications. Structural uses of magnesium (castings and wrought products) accounted for 30% of domestic primary metal use. Desulfurization of iron and steel accounted for 12% of U.S. consumption of primary metal; reducing agent in nonferrous metals production, 1%; and other uses, 4%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
U.S. primary production capacity, yearend	145	145	80	83	43
Production:					
Primary	125	106	W	W	W
Secondary (new and old scrap)	80	77	86	82	80
Imports for consumption	65	83	91	91	70
Exports	41	35	29	24	20
Consumption:					
Reported, primary	100	107	131	104	100
Apparent	185	185	179	[2]160	[2]120
Price, yearend:					
Metals Week, U.S. spot Western, dollars per pound, average	1.65	1.57	1.48	1.27	1.25
Metal Bulletin, free market, dollars per metric ton, average	2,525	1,975	2,500	2,000	1,750
Stocks, producer and consumer, yearend	21	22	W	W	W
Employment, number[e]	1,300	700	700	700	375
Net import reliance[3] as a percentage of apparent consumption	16	25	38	43	44

Recycling: In 2001, about 30,000 tons of the secondary production was recovered from old scrap.

Import Sources (1997-2000): Canada, 44%; China, 19%; Russia, 17%; Israel, 10%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Unwrought metal	8104.11.0000	8.0% ad val.
Unwrought alloys	8104.19.0000	6.5% ad val.
Wrought metal	8104.90.0000	14.8¢/kg on Mg content + 3.5% ad val.

Depletion Allowance: Dolomite, 14% (Domestic and foreign); magnesium chloride (from brine wells), 5% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: After an investigation that began in 2000, the U.S. International Trade Commission (ITC) established duties on imports of magnesium from China, Israel, and Russia in November. Antidumping duties for pure magnesium were set as follows: China, from 24.67% to 305.56% ad valorem, depending on the exporter; Israel, 0%; and Russia, 0%. Although antidumping duties for magnesium imported from China existed, this determination covered granular magnesium that had been excluded from the previous determinations. The ITC determined that imports of granular magnesium from Israel constituted less than 3% of the total imported in the previous 12-month period so, in addition to the 0% antidumping duty rate, a 0% countervailing duty rate also was set.

In June, the magnesium producer in Washington announced that it would close its 45,000-ton-per-year plant on October 1. High production costs and unfavorable market conditions were cited as the reasons for the closure. The parent company of the Utah magnesium producer filed for chapter 11 bankruptcy in August reporting that the price pressures from imports have prevented the company from generating enough profits to service its long-term debt. The company had begun installing new, larger electrolytic cells that it claimed could reduce thermal emissions by 30% and capture 99.9% of chlorine emissions. The company also reported that its operating costs with the new cells were 20% lower.

Prepared by **Deborah A. Kramer [(703) 648-7719, dkramer@usgs.gov, fax: (703) 648-7722]**

MAGNESIUM METAL

A new magnesium producer in Canada began operating a 63,000-ton-per-year plant in February and expected to produce 30,000 tons of magnesium in 2001. In Europe, the Norwegian producer announced that it would close its 42,000-ton-per-year plant by April 2002, and the closure of the 17,000-ton-per-year plant in France was announced in October. Competition from low-priced imports of Chinese magnesium were cited as the reason for the closure of both of these plants. Closure of these two plants leaves Western Europe with no primary magnesium production capacity.

In Australia, two potential magnesium producers suffered setbacks. An initial public offering of stock in June to finance the proposed 60,000-ton-per-year magnesium plant in Queensland did not generate enough support. After the company obtained loan guarantees from the Federal and State governments and additional capital from one of its partners, it issued a smaller public offering in October. The company that had proposed a 95,000-ton-per-year magnesium plant in Tasmania chose to put the project on hold because of its inability to obtain financing. Conversely, magnesium plants planned for South Australia (65,000 tons per year) and Northern Territory (50,000 tons per year) were proceeding on schedule, with completion of both plants set for 2003.

A presidential decree was signed in June appointing a steering committee to assist in the implementation of a proposed 60,000-ton-per-year magnesium plant in Congo (Brazzaville). The steering committee will report directly to the presidency and was expected to fast-track development of the project. In Ukraine, a new company was established to run a 17,000-ton-per-year magnesium plant that had been closed since January 1999. The company was expected to reopen the plant in 2002.

With the introduction of the new 2002 model cars, industry executives estimated that the average magnesium content in the car will increase to 4.1 kilograms (9 pounds) compared with 3.9 kilograms (8.5 pounds) for the 2001 model year. Magnesium producers and auto manufacturers were developing new families of creep-resistant magnesium alloys that may have the potential to replace aluminum and iron in some large powertrain components such as engine blocks and transmission cases; this could increase the use of magnesium in automotive applications.

World Primary Production, Reserves, and Reserve Base:

	Primary production	
	2000	**2001**[e]
United States	W	W
Brazil	9	9
Canada	80	100
China	[e]140	195
France	14	7
Israel	34	30
Kazakhstan	[e]10	10
Norway	35	30
Russia	[e]45	50
Yugoslavia	1	1
World total[5]	368	432

Reserves and reserve base[4]

Domestic magnesium metal production is derived from natural brines and dolomite, and the reserves and reserve base for this metal are sufficient to supply current and future requirements. To a limited degree, the existing natural brines may be considered to be a renewable resource wherein any magnesium removed by humans may be renewed by nature in a short span of time.

World Resources: Resources from which magnesium may be recovered range from large to virtually unlimited and are globally widespread. Resources of dolomite and magnesium-bearing evaporite minerals are enormous. Magnesium-bearing brines are estimated to constitute a resource in the billions of tons, and magnesium can be recovered from seawater at places along world coastlines where salinity is high.

Substitutes: Aluminum and zinc may substitute for magnesium castings and wrought products. For iron and steel desulfurization, calcium carbide may be used instead of magnesium.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]See also Magnesium Compounds.
[2]Rounded to two significant digits to protect proprietary data.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.
[5]Excludes U.S. production.

MANGANESE

(Data in thousand metric tons, gross weight, unless otherwise specified)

Domestic Production and Use: Manganese ore containing 35% or more manganese was not produced domestically in 2001. Manganese ore was consumed mainly by about 15 firms with plants principally in the Eastern United States and the Midwestern United States. The majority of ore consumption was related to steel production, directly in pig iron manufacture and indirectly through upgrading ore to ferroalloys and metal. Additional quantities of ore were used for such nonmetallurgical purposes as production of dry cell batteries, as an ingredient in plant fertilizers and animal feed, and as a colorant for brick. Manganese ferroalloys were produced at one smelter. Leading identifiable end uses of manganese were in products for construction, machinery, and transportation, which were estimated to be 28%, 13%, and 12%, respectively, of total manganese demand. Most of the rest went to a variety of other iron and steel applications. Value of domestic consumption was estimated from foreign trade data to be about $360 million.

Salient Statistics—United States:[1]	1997	1998	1999	2000	2001[e]
Production, mine[2]	—	—	—	—	—
Imports for consumption:					
Manganese ore	355	332	460	430	420
Ferromanganese	304	339	312	312	225
Silicomanganese[3]	306	346	301	378	290
Exports:					
Manganese ore	84	8	4	10	8
Ferromanganese	12	14	12	8	6
Shipments from Government stockpile excesses:[4]					
Manganese ore	115	97	76	63	58
Ferromanganese	31	37	35	33	29
Consumption, reported:[5]					
Manganese ore[6]	510	499	479	486	380
Ferromanganese	337	290	281	300	280
Consumption, apparent, manganese[7]	643	776	719	774	700
Price, average value, 46% to 48% Mn metallurgical ore, dollars per mtu cont. Mn, c.i.f. U.S. ports	2.44	2.40	2.26	2.39	2.47
Stocks, producer and consumer, yearend:					
Manganese ore[6]	241	163	172	226	210
Ferromanganese	21	26	40	31	28
Net import reliance[8] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Scrap recovery specifically for manganese was negligible, but a significant amount was recycled through processing operations as a minor component of ferrous and nonferrous scrap and steel slag.

Import Sources (1997-2000): Manganese ore: Gabon, 66%; Mexico, 10%; Australia, 9%; South Africa, 7%; and other, 8%. Ferromanganese: South Africa, 44%; France, 23%; Mexico, 9%; Australia, 7%; and other, 17%. Manganese contained in all manganese imports: South Africa, 29%; Gabon, 19%; Australia, 13%; Mexico, 9%; and other, 30%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Ore and concentrate	2602.00.0040/60	Free.
Manganese dioxide	2820.10.0000	4.7% ad val.
High-carbon ferromanganese	7202.11.5000	1.5% ad val.
Silicomanganese	7202.30.0000	3.9% ad val.
Metal, unwrought	8111.00.4500	14% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: In addition to the data tabulated, the stockpile contained in uncommitted inventory 331,000 tons of nonstockpile-grade metallurgical ore, all of which was authorized for disposal.

Prepared by **Thomas S. Jones [(703) 648-4973, tjones@usgs.gov, fax: (703) 648-7757]**

MANGANESE

Stockpile Status—9-30-01[9]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Battery:					
Natural ore	103	0.2	103	27	1
Synthetic dioxide	3	—	3	3	—
Chemical ore	134	4	134	36	—
Metallurgical ore	516	96	516	227	1
Ferromanganese:					
High-carbon	772	58	582	68	45
Electrolytic metal	4	0.2	4	4	2

Events, Trends, and Issues: Through August, steel production, the principal determinant of manganese demand, was at about the same record level globally as in 2000, but was down significantly in the United States. Thus, while manganese ore price increased moderately to the highest level since 1996, prices in the U.S. market for ferromanganese trended downward. Competition with imports was an issue for several manganese materials; this contributed to the termination of domestic production of manganese metal in the first part of the year. Manganese is an essential nutritional element for people, animals, and plants, but it can be harmful in excessive amounts. Thus, manganese can be an industrial poison, but generally is not a hazard.

World Mine Production, Reserves, and Reserve Base (metal content):

	Mine production 2000	Mine production 2001[e]	Reserves[10]	Reserve base[10]
United States	—	—	—	—
Australia	787	820	32,000	82,000
Brazil	[e]920	880	18,000	51,000
China	[e]800	830	40,000	100,000
Gabon	[e]800	900	20,000	160,000
India	[e]590	600	34,000	50,000
Mexico	156	150	4,000	9,000
South Africa	[e]1,580	1,450	370,000	4,000,000
Ukraine	[e]930	920	140,000	520,000
Other countries	[e]710	710	Small	Small
World total (rounded)	[e]7,280	7,260	670,000	5,000,000

World Resources: Land-based resources are large but irregularly distributed; those of the United States are very low grade and have potentially high extraction costs. South Africa and the former Soviet Union (FSU) account for more than 80% of the world's identified resources; South Africa accounts for more than 80% of the total exclusive of China and the FSU. Some of the data for reserves and reserve base have been revised from those previously published.

Substitutes: Manganese has no satisfactory substitute in its major applications.

[e]Estimated. — Zero.

[1]Manganese content typically ranges from 35% to 54% for manganese ore and from 74% to 95% for ferromanganese.

[2]Excludes insignificant quantities of low-grade manganiferous ore.

[3]Imports more nearly represent amount consumed than does reported consumption; internal evaluation indicates that reported consumption of silicomanganese is considerably understated.

[4]Net quantity. Data in parentheses denote increases in inventory.

[5]Total manganese consumption cannot be approximated from consumption of manganese ore and ferromanganese because of the use of ore in n manganese ferroalloys and metal.

[6]Exclusive of that consumed at iron and steel plants.

[7]Thousand tons, manganese content; based on estimates of average content for all significant components except imports, for which content is reported.

[8]Defined as imports - exports + adjustments for Government and industry stock changes.

[9]See Appendix B for definitions.

[10]See Appendix C for definitions.

MERCURY

(Data in metric tons of mercury content, unless otherwise noted)[1]

Domestic Production and Use: Recovery of mercury from obsolete or wornout items remains the principal source of domestic mercury production. Several companies in the eastern and central United States recovered mercury from a variety of secondary sources, such as batteries, chloralkali wastewater sludges, dental amalgams, electrical apparatus, fluorescent light tubes, and measuring instruments. Domestic mine production of mercury was limited to a very small quantity of byproduct production from fewer than 10 gold mines in California, Nevada, and Utah. The value of mercury used in the United States was estimated at approximately $1 million. The manufacture of chlorine and caustic soda, along with its use in electrical and electronic applications probably accounted for two-thirds to three-fourths of the mercury consumed domestically. The remainder was used in other applications such as measuring and control instruments and dental amalgams.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Mine	W	NA	NA	NA	NA
Secondary, industrial	389	NA	NA	NA	NA
Imports for consumption (gross weight)	164	128	62	103	50
Exports (gross weight)	134	63	181	178	50
Consumption, reported	346	NA	NA	NA	NA
Price, average value, dollars per flask, free market	159.52	139.84	140.00	140.00	140.00
Stocks, industry, yearend[2]	203	NA	NA	NA	NA
Net import reliance[3] as a percentage of apparent consumption	NA	NA	NA	NA	NA

Recycling: Recycling of old scrap represented essentially all of the domestic mercury production in 2001.

Import Sources (1997-2000): United Kingdom, 29%; Kyrgyzstan, 12%; Kazakhstan, 11%; Taiwan, 9%; and other, 39%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Mercury	2805.40.0000	1.7% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: In addition to the quantities shown below, 146 tons of secondary mercury was held by the U.S. Department of Energy at Oak Ridge, TN.

Stockpile Status—9-30-01[4]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Mercury	4,435	—	4,435	—	—

Prepared by **Robert G. Reese, Jr. [(703) 648-4981, rreese@usgs.gov, fax: (703) 648-7757]**

MERCURY

Events, Trends, and Issues: Federal, State, and local governments are concerned about the toxic effects of mercury and therefore regulate mercury emissions and/or the final disposition of mercury-bearing products. As a result, stringent environmental standards are likely to continue as the major determinants of domestic mercury supply and demand. The major component of supply will remain the secondary industry, owing to the recycling of many worn out or obsolete products and various wastes to avoid deposition in landfills. Domestic primary production is expected to remain limited to byproduct production where the mercury is recovered to avoid emissions to the environment. Domestic mercury consumption will continue to decline as mercury is gradually eliminated in many products or as substitute products are developed.

Sales from the National Defense Stockpile remain suspended pending completion of an analysis of the potential environmental impact of the sales.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2000	2001[e]		
United States	NA	NA	—	7,000
Algeria	240	220	2,000	3,000
Italy	—	—	—	69,000
Kyrgyzstan	260	250	7,500	13,000
Spain	500	500	76,000	90,000
Other countries	350	400	38,000	61,000
World total (may be rounded)	1,350	1,400	120,000	240,000

World Resources: World mercury resources are estimated at nearly 600,000 tons, principally in Kyrgyzstan, Russia, Slovenia, Spain, and Ukraine. These are sufficient for another century or more, especially with declining consumption rates.

Substitutes: Lithium, nickel-cadmium, and zinc-air batteries are substitutes for mercury-zinc batteries. Indium compounds substitute for mercury in alkaline batteries. Diaphragm and membrane cells replace mercury cells in the electrolytic production of chlorine and caustic soda. Ceramic composites can replace dental amalgams; organic compounds have replaced mercury fungicides in latex paint. Digital instruments have replaced mercury thermometers in many applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]One metric ton (1,000 kilograms) = 29.0082 flasks.
[2]Consumer stocks only.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B for definitions.
[5]See Appendix C for definitions.

MICA (NATURAL), SCRAP AND FLAKE[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Scrap and flake mica production, excluding low-quality sericite, was estimated to be 95,000 metric tons in 2001. North Carolina accounted for about 47% of U.S. production. The remaining output came from Georgia, New Mexico, South Carolina, and South Dakota. Scrap mica was recovered principally from mica and sericite schist and as a byproduct from feldspar, kaolin, and industrial sand beneficiation. The majority of domestic production was processed into small particle-size mica by either wet or dry grinding. Primary uses were joint compound, paint, roofing, oil well drilling additives, and rubber products. The value of 2001 scrap mica production was estimated at $16.3 million. Ground mica sales in 2000 were valued at $37.5 million. There were nine domestic producers of scrap and flake mica.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production:[2 3]					
Mine	112	87	95	101	95
Ground	110	104	111	112	106
Imports, mica powder and mica waste	23	23	21	29	32
Exports, mica powder and mica waste	8	8	11	10	10
Consumption, apparent[4]	122	137	125	119	118
Price, average, dollars per ton, reported:					
Scrap and flake	83	87	148	125	140
Ground:					
Wet	1,080	909	849	751	800
Dry	176	179	192	169	180
Stocks, producer, yearend[e]	NA	NA	NA	NA	NA
Employment, mine, number[5]	347	367	NA	NA	NA
Net import reliance[6] as a percentage of apparent consumption	10	13	10	15	19

Recycling: None.

Import Sources (1997-2000): Canada, 68%; India, 20%; Finland, 4%; China, 2%; and other, 6%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12/31/01**
Mica powder	2525.20.0000	Free.
Mica waste	2525.30.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7722]**

MICA (NATURAL), SCRAP AND FLAKE

Events, Trends, and Issues: Domestic production of ground mica decreased in 2001. The decrease primarily resulted from reduced production in Georgia, New Mexico, North Carolina, South Carolina, and South Dakota. Development continued at a recent mica operation in Arizona and the associated processing plant produced several wet ground mica products. The United States remained a major world producer of scrap and flake mica. Imported mica scrap and flake is primarily used for making mica paper and as a filler and reinforcer in plastics.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States[2]	101	95	Large	Large
Brazil	5	5	Large	Large
Canada	17	17	Large	Large
India	2	2	Large	Large
Korea, Republic of	30	30	Large	Large
Russia	100	100	Large	Large
Other countries	35	35	Large	Large
World total (may be rounded)	290	280	Large	Large

World Resources: Resources of scrap and flake mica are available in granite, pegmatite, schist, and clay deposits and are considered more than adequate to meet anticipated world demand in the foreseeable future.

Substitutes: Some of the lightweight aggregates, such as diatomite, vermiculite, and perlite, may be substituted for ground mica when used as a filler. Ground synthetic fluorophlogopite, a fluorine-rich mica, may replace natural ground mica for uses that require the thermal and electrical properties of mica.

[e]Estimated. NA Not available.
[1]See also Mica (Natural), Sheet.
[2]Sold or used by producing companies.
[3]Excludes low-quality sericite used primarily for brick manufacturing.
[4]Based on ground mica.
[5]Total employment at mines and mills where mica was produced and processed, excluding feldspar companies with byproduct production. Employ were not assigned to specific commodities in calculating employment.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix C for definitions.

MICA (NATURAL), SHEET[1]

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: A minor amount of sheet mica was produced in 2001, incidental to scrap and flake mica production and the mining of a gemstone-bearing pegmatite in Virginia. The domestic consuming industry was dependent upon imports and shipments of U.S. Government stockpile excesses to meet demand for sheet mica. During 2001, an estimated 3,440 tons of unworked mica split block and mica splittings valued at $2.0 million was consumed by 14 companies in 7 States, mainly in the East and Midwest. Most was fabricated into parts for electronic and electrical equipment. An additional estimated 1,100 tons of imported worked mica valued at $12.5 million was also consumed.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production, mine[e]	([2])	([2])	([2])	W	W
Imports, plates, sheets, and strips; worked mica; split block; splittings; other > $1.00/kg	5,760	4,380	4,550	5,430	4,580
Exports, plates, sheets, and strips; worked mica; crude and rifted into sheet or splittings > $1.00/kg	1,060	1,280	1,290	1,150	244
Shipments from Government stockpile excesses	326	557	708	1,230	1,810
Consumption, apparent	5,030	3,660	3,980	5,500	6,160
Price, average value, dollars per kilogram, muscovite and phlogopite mica, reported:					
Block	28	26	20	23	21
Splittings	1.69	1.67	1.67	1.81	1.74
Stocks, fabricator and trader, yearend	NA	NA	NA	NA	NA
Net import reliance[3] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1997-2000): India, 63%; Belgium, 14%; Germany, 9%; China, 4%; and other, 10%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Split block mica	2525.10.0010	Free.
Mica splittings	2525.10.0020	Free.
Unworked—other	2525.10.0050	Free.
Plates, sheets, and strips of agglomerated or reconstructed mica	6814.10.0000	2.7% ad val.
Worked mica and articles of mica—other	6814.90.0000	2.6% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[4]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 2001**	**Disposals FY 2001**
Block:					
Muscovite (stained and better)	8	57	8	([5])	62
Phlogopite	([2])	11	([2])	—	—
Film, muscovite	([2])	([2])	([2])	([5])	([2])
Splittings:					
Muscovite	3,555	735	3,555	([5])	1,750
Phlogopite	230	1	230	([5])	2

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7722]**

MICA (NATURAL), SHEET

Events, Trends, and Issues: Demand for sheet mica increased in 2001. Imports of splittings from India increased as demand for electrical equipment rebounded, especially for transformers. Imports remained the principal source of sheet mica, and shipments from U.S. Government stockpile excesses continued to be a significant source of supply. The availability of good quality mica remained in short supply. There were no environmental problems associated with the manufacture of mica products.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	2000[e]	2001[e]		
United States	W	W	Very small	Small
India	3,500	3,500	Very large	Very large
Russia	1,500	1,500	Moderate	Large
Other countries	200	200	Moderate	Large
World total	[7]5,200	[7]5,200	Large	Large

World Resources: There has been no formal evaluation of world resources of sheet mica because of the sporadic occurrence of this material. Large deposits of mica-bearing rock are known to exist in countries such as Brazil, India, and Madagascar. Limited resources of sheet mica are available in the United States. These domestic resources are uneconomic because of the high cost of hand labor required to mine and process the sheet mica.

Substitutes: Many materials can be substituted for mica in numerous electrical and electronic uses. Substitutes include acrylic, Benelex®, cellulose acetate, Delrin®, Duranel® N, fiberglass, fishpaper, Kapton®, Kel F®, Kydex®, Lexan®, Lucite®, Mylar®, nylon, nylatron, Nomex®, Noryl®, phenolics, Plexiglass®, polycarbonate, polyester, styrene, Teflon®, vinyl-PVC, and vulcanized fiber. Mica paper made from scrap mica can be substituted for sheet mica in electrical and insulation applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]See also Mica (Natural), Scrap and Flake.
[2]Less than ½ unit.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B for definitions.
[5]The total disposal plan for all categories of mica in the National Defense Stockpile is undifferentiated at 1,814 metric tons (4,000,000 pounds).
[6]See Appendix C for definitions.
[7]Excludes U.S. production.

MOLYBDENUM

(Data in metric tons of molybdenum content, unless otherwise noted)

Domestic Production and Use: In 2001, molybdenum, valued at about $199 million (based on average oxide price), was produced by six mines. Molybdenum ore was produced at two mines, one in Colorado and one in Idaho, whereas four mines in Arizona, New Mexico, and Utah recovered molybdenum as a byproduct. Three plants converted molybdenite (MoS_2) concentrate to molybdic oxide, from which intermediate products, such as ferromolybdenum, metal powder, and various chemicals, were produced. Iron and steel producers accounted for about 75% of the molybdenum consumed. End-use applications were as follows: machinery, 35%; electrical, 15%; transportation, 15%; chemicals, 10%; oil and gas industry, 10%; and other, 15%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, mine	60,100	53,300	42,400	41,100	38,300
Imports for consumption	13,200	14,400	13,800	14,400	14,600
Exports, all primary forms	62,100	41,700	27,900	21,900	32,300
Consumption:					
Reported	20,000	18,800	18,700	18,600	16,300
Apparent	23,000	21,100	32,500	34,200	22,300
Price, average value, dollars per kilogram[1]	9.46	5.90	5.90	5.64	5.20
Stocks, mine and plant concentrates, product, and consumer materials	11,300	16,200	12,000	11,400	9,700
Employment, mine and plant, number	700	600	475	390	290
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Secondary molybdenum in the form of molybdenum metal or superalloys was recovered, but the amount was small. About 1,000 metric tons of molybdenum was reclaimed from spent catalysts. Although molybdenum is not recovered from scrap steel, recycling of steel alloys is significant, and molybdenum content is reutilized. Data on the quantities of molybdenum recycled in this manner are not available.

Import Sources (1997-2000): China, 35%; United Kingdom, 21%; Chile, 20%; Canada, 12%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Molybdenum ore and concentrates, roasted	2613.10.0000	12.9¢/kg + 1.8% ad val.
Molybdenum ore and concentrates, other	2613.90.0000	18.2¢/kg.
Molybdenum chemicals:		
Molybdenum oxides and hydroxides	2825.70.0000	3.2% ad val.
Molybdates of ammonium	2841.70.1000	4.3% ad val.
Molybdates, all others	2841.70.5000	3.7% ad val.
Molybdenum pigments:		
Molybdenum orange	3206.20.0020	3.7% ad val.
Ferroalloys:		
Ferromolybdenum	7202.70.0000	4.5% ad val.
Molybdenum metals:		
Powders	8102.10.0000	10.1¢/kg + 1.3% ad val.
Unwrought	8102.91.1000	13.9¢/kg + 1.9% ad val.
Waste and scrap	8102.91.5000	Free.
Wrought	8102.92.3000	6.6% ad val.
Wire	8102.93.0000	4.8% ad val.
Other	8102.99.0000	4.1% ad val.

Depletion Allowance: 22% (Domestic); 14% (Foreign).

Government Stockpile: None.

Prepared by **John W. Blossom [(703) 648-4964, jblossom@usgs.gov, fax: (703) 648-7757]**

MOLYBDENUM

Events, Trends, and Issues: U.S. mine output of molybdenum in 2001 decreased an estimated 7% from that of 2000. U.S. imports for consumption were about the same as those of 2000, while the U.S. exports increased 47% over those of 2000. U.S. reported consumption of 2001 decreased 12% from that of 2000.

Prices of concentrates and molybdenum products moderated toward the end of the year. The domestic price for technical-grade molybdic oxide averaged $5.20 per kilogram of contained molybdenum during 2001. Mine capacity utilization was about 40%.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2000	2001[e]	(thousand metric tons)	
United States	41,100	38,300	2,700	5,400
Armenia	2,700	2,700	20	30
Canada	6,830	6,800	450	910
Chile	29,100	35,000	1,100	2,500
China	28,900	28,900	500	1,000
Iran	1,600	1,600	50	140
Kazakhstan	600	600	130	200
Kyrgyzstan	250	300	100	180
Mexico	6,890	6,900	90	230
Mongolia	1,340	1,400	30	50
Peru	7,190	7,200	140	230
Russia[e]	2,400	2,400	240	360
Uzbekistan[e]	350	400	60	150
World total (rounded)	129,000	133,000	5,600	11,000

World Resources: Identified resources amount to about 5.5 million metric tons of molybdenum in the United States and about 12 million metric tons in the world. Molybdenum occurs as the principal metal sulfide in large low-grade porphyry molybdenum deposits and as an associated metal sulfide in low-grade porphyry copper deposits. Resources of molybdenum are adequate to supply world needs for the foreseeable future.

Substitutes: There is little substitution for molybdenum in its major application as an alloying element in steels and cast irons. In fact, because of the availability and versatility of the metal, industry has sought to develop new materials that benefit from the alloying properties of molybdenum. Potential substitutes for molybdenum include chromium, vanadium, columbium (niobium), and boron in alloy steels; tungsten in tool steels; graphite, tungsten, and tantalum for refractory materials in high-temperature electric furnaces; and chrome-orange, cadmium-red, and organic-orange pigments for molybdenum orange.

[e]Estimated. E Net exporter.

[1]Major producer price per kilogram of molybdenum contained in technical-grade molybdic oxide.

[2]Defined as imports - exports + adjustments for Government and industry stock changes.

[3]See Appendix C for definitions.

NICKEL

(Data in metric tons of nickel content, unless otherwise noted)

Domestic Production and Use: The only nickel smelter in the United States—a ferronickel operation near Riddle, OR—was decommissioned in 2000 after 45 years of operation. Limited amounts of byproduct nickel are recovered from copper and palladium-platinum ores mined in the Western United States. On a monthly or annual basis, 152 facilities reported nickel consumption. The principal consuming State was Pennsylvania, followed by West Virginia, Illinois, and Ohio. Approximately 39% of the primary nickel consumed went into stainless and alloy steel production, 38% into nonferrous alloys and superalloys, 13% into electroplating, and 10% into other uses. Ultimate end uses were as follows: transportation, 32%; chemical industry, 12%; electrical equipment, 11%; construction, 8%; fabricated metal products, 7%; petroleum, 6%; household appliances, 6%; machinery, 6%; and other, 12%. Estimated value of apparent primary consumption was $758 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production: Mine	—	—	—	—	—
Plant	16,000	4,290	—	—	—
Shipments of purchased scrap:[1]	97,600	89,700	93,000	123,000	111,000
Imports: Ore	17,600	1,420	—	—	—
Primary	147,000	148,000	139,000	156,000	138,000
Secondary	11,000	8,500	9,480	10,700	15,800
Exports: Primary	16,400	8,440	7,440	8,150	9,040
Secondary	40,200	35,100	31,400	49,900	52,700
Consumption: Reported, primary	120,000	116,000	116,000	115,000	90,100
Reported, secondary	68,400	63,100	71,000	84,000	74,600
Apparent, primary	154,000	149,000	140,000	147,000	128,000
Total[2]	222,000	212,000	211,000	231,000	202,000
Price, average annual, London Metal Exchange:					
Cash, dollars per metric ton	6,927	4,630	6,011	8,638	5,929
Cash, dollars per pound	3.142	2.100	2.727	3.918	2.689
Stocks: Government, yearend	8,530	2,600	—	—	—
Consumer, yearend	16,100	16,000	9,920	14,300	11,100
Producer, yearend[3]	12,600	13,100	12,700	12,300	13,500
Employment, yearend, number: Mine	7	7	1	1	1
Smelter and port	286	7	7	—	—
Net import reliance[4] as a percentage of apparent consumption	56	64	63	56	56

Recycling: About 75,000 tons of nickel was recovered from purchased scrap in 2001. This represented about 45% of reported consumption for the year.

Import Sources (1997-2000): Canada, 40%; Norway, 14%; Russia, 13%; Australia, 9%; and other, 24%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Nickel oxide, chemical grade	2825.40.0000	Free.
Ferronickel	7202.60.0000	Free.
Nickel oxide, metallurgical grade	7501.20.0000	Free.
Unwrought nickel, not alloyed	7502.10.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: The U.S. Government sold the last of the nickel in the National Defense Stockpile in 1999. The U.S. Department of Energy is holding 6,000 tons of nickel scrap contaminated by low-level radioactivity.

Events, Trends, and Issues: Stainless steel accounts for two-thirds of the primary nickel consumed in the world. U.S. demand for austenitic (i.e., nickel bearing) stainless steel was down 23% from the record 1.57 million tons of 2000. The sharp decrease was due to the buildup of recessionary forces in late 2000 and the economic upheaval that followed the tragic events of September 11, 2001. Imported steels accounted for 24% of total U.S. stainless steel consumption in 2001, down slightly from a record 27% the previous year. U.S. production of austenitic stainless steel exceeded 1.24 million tons in 2000, 3% less than the near record 1.28 million tons achieved in 1999. On June 5, 2001, the U.S. Government launched a steel trade initiative aimed at reducing excess production capacity worldwide and curtailing the dumping of excess foreign production in the United States at below market prices.

Prepared by **Peter H. Kuck [(703) 648-4965, pkuck@usgs.gov, fax: (703) 648-7757]**

NICKEL

World nickel demand grew faster than supply in the second half of 2000, causing a gradual drawdown of stocks in London Metal Exchange (LME) approved warehouses. By January 2001, LME stocks had fallen to levels unseen since 1991. Producer stock levels, though, were nearly unchanged because mine production was at an alltime high. In mid-2001, significant production from several newly commissioned mines began reaching the market, causing prices to weaken. For the week ending November 23, 2001, the LME cash price for 99.8%-pure nickel averaged $5,256 per metric ton ($2.38 per pound). Twelve months earlier, the cash price was $7,198 per ton ($3.26 per pound).

Production was being ramped up at three new laterite mines in Western Australia. Nickel was being recovered onsite using advanced pressure acid leach (PAL) technology. All three operators had to overcome startup problems associated with the new technology. At least four other Australian PAL projects were in varying stages of development. Competitors were considering employing PAL technology in Cuba, Indonesia, and the Philippines. In April 2001, a Canadian company launched an innovative PAL project in New Caledonia. If the New Caledonian laterite project is successful, the company will use the technology in Newfoundland to recover nickel and cobalt from sulfide concentrates. The concentrates would come from the Voisey's Bay nickel-copper sulfide deposit in northeastern Labrador. In late 2001, development of the Voisey's Bay deposit was still in limbo. The Canadian company and the Government of Newfoundland resumed negotiations in June 2001, but have been unable to agree on critical concepts.

Several automobile manufacturers were using nickel-metal hydride (NiMH) batteries to power their gasoline-electric hybrid and pure electric vehicles for the 2001 and 2002 model years. In the first quarter of 2001, more than 12,400 hybrid automobiles were operating on U.S. highways. An additional 4,000 battery electric automobiles, vans, and light trucks have been leased or sold in the United States since 1996. Most of the NiMH batteries were being made in France, Germany, Japan, or the United States.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2000	2001[e]		
United States	—	—	—	2,500,000
Australia	168,300	184,000	20,000,000	25,000,000
Botswana	34,465	32,700	880,000	1,400,000
Brazil	45,317	44,900	670,000	6,000,000
Canada	190,728	183,000	6,600,000	15,000,000
China	51,100	50,700	3,700,000	7,900,000
Colombia	58,927	62,800	920,000	1,200,000
Cuba	68,305	71,000	5,600,000	23,000,000
Dominican Republic	39,943	29,000	750,000	1,300,000
Greece	19,535	19,900	450,000	900,000
Indonesia	98,200	105,000	3,200,000	13,000,000
New Caledonia	127,493	126,000	4,500,000	15,000,000
Philippines	23,500	23,700	410,000	11,000,000
Russia	270,000	265,000	6,600,000	7,300,000
South Africa	36,616	36,300	2,500,000	12,000,000
Venezuela	2,472	10,600	610,000	610,000
Zimbabwe	8,160	7,480	240,000	260,000
Other countries	8,200	7,800	450,000	12,000,000
World total (rounded)	1,250,000	1,260,000	58,000,000	160,000,000

World Resources: Identified land-based resources averaging 1% nickel or greater contain at least 130 million tons of nickel. About 60% is in laterites and 40% in sulfide deposits. In addition, extensive deep-sea resources of nickel are in manganese crusts and nodules covering large areas of the ocean floor, particularly in the Pacific Ocean.

Substitutes: With few exceptions, substitutes for nickel would result in increased cost or some tradeoff in the economy or performance of the product. Aluminum, coated steels, and plastics can replace stainless steel to a limited extent in many construction and transportation applications. Nickel-free specialty steels are sometimes used in place of stainless steel within the power generating, petrochemical, and petroleum industries. Titanium alloys or specialty plastics can substitute for nickel metal or nickel-based superalloys in some highly corrosive chemical environments.

[e]Estimated. — Zero.
[1]Scrap receipts - shipments by consumers + exports - imports + adjustments for consumer stock changes.
[2]Apparent primary consumption + reported secondary consumption.
[3]Stocks of producers, agents, and dealers held only in the United States.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.

NITROGEN (FIXED)—AMMONIA

(Data in thousand metric tons of nitrogen, unless otherwise noted)

Domestic Production and Use: Ammonia was produced by 23 companies at 39 plants in the United States during 2001. Fifty-five percent of total U.S. ammonia production capacity was centered in Louisiana, Oklahoma, and Texas because of their large reserves of natural gas, the dominant domestic feedstock. High natural gas prices at the beginning of the year, followed by weather-related decreases in demand and high product inventory levels, resulted in U.S. ammonia producers operating at significantly less than rated capacity in 2001. The United States remained the world's second largest ammonia producer and consumer following China. Urea, ammonium nitrate, ammonium phosphates, nitric acid, and ammonium sulfate were the major derivatives of ammonia in the United States, in descending order of importance.

Approximately 89% of apparent domestic ammonia consumption was for fertilizer use, including anhydrous ammonia for direct application, urea, ammonium nitrates, ammonium phosphates, and other nitrogen compounds. Ammonia was also used to produce plastics, synthetic fibers and resins, explosives, and numerous other chemical compounds.

Salient Statistics—United States:[1]	1997	1998	1999	2000	2001[e]
Production[2]	13,300	13,800	12,900	12,300	9,500
Imports for consumption	3,530	3,460	3,890	3,880	5,000
Exports	395	614	562	662	670
Consumption, apparent	15,800	17,100	16,300	15,400	13,500
Stocks, producer, yearend	1,530	[3]1,050	[3]996	[3]1,120	[3]1,500
Price, dollars per ton, average, f.o.b. Gulf Coast[3]	173	121	109	169	150
Employment, plant, number[e]	2,500	2,500	2,200	2,000	1,800
Net import reliance[4] as a percentage of apparent consumption	16	19	21	20	29

Recycling: None.

Import Sources (1997-2000): Trinidad and Tobago, 59%; Canada, 31%; Mexico, 5%; and other, 5%. In addition, the United States imports significant quantities of ammonia from Russia and Ukraine, but until 2001, U.S. Census Bureau import quantity data were suppressed, so these data were not included in the calculation of import sources.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Ammonia, anhydrous	2814.10.0000	Free.
Ammonia, aqueous	2814.20.0000	Free.
Urea	3102.10.0000	Free.
Ammonium sulfate	3102.21.0000	Free.
Ammonium nitrate	3102.30.0000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: Because of high natural gas prices at the beginning of the year (about $10 per million Btu), almost 40% of the U.S. production capacity for ammonia was shut down. By mid-February, however, the price had dropped to about $5 per million Btu, and most of the closed plants were back on-stream, although some were not operating at full capacity. This restart coincided with the peak season for fertilizer demand. After the spring fertilizer application season, several ammonia plants closed or reduced output because of weather-related decreases in demand and high product inventory levels. Much of this reduction continued throughout the summer, even though natural gas prices continued to decline. By the beginning of October, when natural gas prices had fallen to less than $2 per million Btu, much of the idled capacity was restarted. A 497,000-ton-per-year (N content) ammonia plant in Beaumont, TX, was permanently closed at the end of June, and a 399,000-ton-per-year (N content) ammonia plant in Avondale, LA, was shut down in July.

Because of low U.S. production levels, imports of ammonia were significantly higher in 2001. Based on partial-year data, Trinidad and Tobago (49%), Ukraine (17%), Canada (12%), and Russia (7%) were the largest source countries.

Prepared by **Deborah A. Kramer [(703) 648-7719, dkramer@usgs.gov, fax: (703) 648-7722]**

NITROGEN (FIXED)—AMMONIA

Progress continued on new ammonia plants in Australia, Egypt, Oman, Qatar, Trinidad and Tobago, and the United Arab Emirates; one plant in Germany closed.

In July, the International Trade Administration set an antidumping duty of 156.29% ad valorem on imports of ammonium nitrate from Ukraine. U.S. ammonium nitrate producers claimed that ammonium nitrate was being imported from Ukraine to replace material that had been imported from Russia before a suspension agreement signed in 2000 limited U.S. imports of ammonium nitrate from Russia.

In September, the World Trade Organization (WTO) concluded negotiations with China regarding the terms of its full membership. Under the agreement, China will work toward better integration into the world economy and offer a more predictable environment for trade and foreign investment. For fertilizers, the commitments mean that imports of fertilizers by State and non-State purchasers must be allowed. China also must provide nondiscriminatory treatment to all WTO members, eliminate dual pricing practices, eliminate price controls as a means of protecting domestic industries, and not introduce any export subsidies on agricultural products. China's imports of fertilizer products could begin in January 2002.

Nitrogen compounds are also an environmental concern. Overfertilization and the subsequent runoff of excess fertilizer may contribute to nitrogen accumulation in watersheds. Nitrogen in excess fertilizer runoff has been theorized to be a cause of the hypoxic zone that occurs in the Gulf of Mexico during the summer. Scientists continue to study the effects of fertilization on the Nation's environmental health.

World Ammonia Production, Reserves, and Reserve Base:

	Plant production		Reserves and reserve base[5]
	2000	2001[e]	
United States	12,300	9,500	Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries.
Canada	4,130	3,450	
China	28,000	29,000	
Egypt	1,510	1,850	
France	1,700	1,600	
Germany	2,470	2,600	
India	10,100	9,000	
Indonesia	4,000	3,400	
Netherlands	2,540	2,000	
Pakistan	1,880	1,900	
Poland	1,860	1,900	
Russia	8,740	8,700	
Saudi Arabia	1,740	1,400	
Trinidad and Tobago	2,690	3,000	
Ukraine	3,300	3,600	
Other countries	21,700	22,200	
World total (rounded)	109,000	105,000	

World Resources: The availability of nitrogen from the atmosphere for fixed nitrogen production is unlimited. Mineralized occurrences of sodium and potassium nitrates, found in the Atacama Desert of Chile, contribute minimally to global nitrogen supply.

Substitutes: Nitrogen is an essential plant nutrient that has no substitute. Also, there are no known practical substitutes for nitrogen explosives and blasting agents.

[e]Estimated.
[1]U.S. Department of Commerce (DOC) data unless otherwise noted.
[2]Annual and preliminary data as reported in Current Industrial Reports MA325B and MQ325B (DOC).
[3]Source: Green Markets.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.

PEAT

(Data in thousand metric tons, unless otherwise noted)[1]

Domestic Production and Use: The estimated f.o.b. plant value of marketable peat production in the conterminous United States was about $21 million in 2001. Peat was harvested and processed by about 60 producers in 16 of the conterminous States, and several producers in Alaska, which were canvassed independently by the Alaska Department of Natural Resources. Florida, Michigan, and Minnesota were the largest producing States, in order of quantity produced. Reed-sedge peat accounted for 81% of the total volume followed by hypnum moss, 7%, sphagnum moss and humus each accounted for 6%. Approximately 95% of domestic peat was sold for horticulture use, including general soil improvement, potting soils, earthworm culture, nursery business, and golf course maintenance and construction. Other applications included seed inoculants, vegetable cultivation and mushroom culture, mixed fertilizers, and packing for flowers and plants. In the industrial sector, peat was used as an oil absorbent and as an efficient filtration medium for the removal of waterborne contaminants in mine waste streams and municipal storm drainage.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	661	685	731	755	812
Commercial sales	753	791	834	847	936
Imports for consumption	754	761	752	786	800
Exports	22	30	40	37	25
Consumption, apparent[2]	1,310	1,430	1,580	1,500	1,620
Price, average value, f.o.b. mine, dollars per ton	23.23	24.26	26.48	26.85	23.00
Stocks, producer, yearend	421	408	272	279	250
Employment, mine and plant, number[e]	800	800	800	800	800
Net import reliance[3] as a percentage of apparent consumption	50	52	54	50	50

Recycling: None.

Import Sources (1997-2000): Canada, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Peat	2703.00.0000	Free.

Depletion Allowance: 5% (Domestic).

Government Stockpile: None.

Prepared by **Stephen M. Jasinski [(703) 648-7711, sjasinsk@usgs.gov, fax: (703) 648-7722]**

PEAT

Events, Trends, and Issues: Imports of sphagnum peat moss increased for the fourth consecutive year, accounting for 50% of consumption. The United States is the largest importer of Canadian peat moss.

Development of new horticultural peat operations or expansion of existing operations has become increasingly difficult in the United States. Numerous Federal, State, and local wetlands protection regulations apply to permitting, harvesting, and reclamation of peat bogs and often overlap. The cost of compliance and the time required to obtain the proper permits have led some smaller companies to stop harvesting peat.

Peat demand is anticipated to continue to grow at a steady rate for the near future, with the percentage of peat from Canada increasing concurrently. Soil blending companies that import peat from Canada stand to benefit from growing demand for high-quality sphagnum moss. The outlook for the domestic peat producers will by governed by several variables, chiefly, the ability to permit new bogs, the level of Canadian competition, and competition from composted yard wastes.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	755	812	15,000	6,400,000
Belarus	2,100	2,000	([5])	([5])
Canada	1,230	1,300	22,000	30,000,000
Estonia	1,000	700	([5])	([5])
Finland	7,400	7,400	64,000	3,000,000
Germany	2,980	3,000	42,000	450,000
Ireland	5,500	5,000	160,000	820,000
Latvia	650	400	([5])	([5])
Lithuania	350	350	([5])	([5])
Moldova	475	475	([5])	([5])
Russia	2,000	2,000	([5])	([5])
Sweden	700	800	([5])	([5])
Ukraine	1,000	1,000	([5])	([5])
United Kingdom	500	500	([5])	([5])
Other countries	760	961	4,900,000	160,000,000
World total (rounded)	27,400	26,700	5,200,000	200,000,000

World Resources: U.S. resources of peat were estimated at more than 110 billion tons, with more than 50% located in undisturbed areas of Alaska. World resources of peat were estimated to be 2 trillion tons, of which the former Soviet Union has about 770 billion tons and Canada about 510 billion tons.

Substitutes: Natural organic materials may be composted and compete in certain applications. The superior water-holding capacity and physiochemical properties of peat limit substitution alternatives.

[e]Estimated.
[1]See Appendix A for conversion to short tons.
[2]Defined as production + imports - exports + adjustments for industry stocks.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.
[5]Included with “Other countries.”

PERLITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: The estimated value (f.o.b. mine) of processed perlite produced in 2001 was $20.5 million. Crude ore production came from 10 mines operated by 8 companies in 7 Western States. New Mexico continued to be the major producing State. Processed ore was expanded at 62 plants in 31 States. The principal end uses were building construction products, 69%; horticultural aggregate,12%; filter aid, 8%; fillers, 7%; and other, 4%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production[1]	706	685	711	672	650
Imports for consumption[e]	135	150	144	180	185
Exports[e]	38	42	47	43	39
Consumption, apparent	803	793	808	809	796
Price, average value, dollars per ton, f.o.b. mine	33.04	31.91	33.40	33.78	31.55
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill	135	140	150	150	145
Net import reliance[2] as a percentage of apparent consumption	12	14	12	17	18

Recycling: Not available.

Import Sources (1997-2000): Greece, 100%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Mineral substances, not specifically provided for	2530.10.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Wallace P. Bolen [(703) 648-7727, wbolen@usgs.gov, fax: (703) 648-7722]**

PERLITE

Events, Trends, and Issues: Production[1] of domestic perlite decreased 3.3% and imports of perlite increased 2.8% compared with that of 2000. Domestic perlite continued to encounter transportation cost disadvantages in some areas of the Eastern United States compared with Greek imports. However, U.S. perlite exports to Canada partially offset imports into the Eastern United States.

Perlite mining generally took place in remote areas, and environmental problems were not severe. The overburden, reject ore, and mineral fines produced during ore mining and processing are used to reclaim the mined-out areas, and, therefore, little waste is produced. Airborne dust is captured by baghouses, and there is practically no runoff that contributes to water pollution.

New uses of perlite that are being researched may increase domestic consumption.

World Processed Perlite Production, Crude Ore Reserves, and Reserve Base:

	Production		Reserves[3]	Reserve base[3]
	2000	2001[e]		
United States	672	650	50,000	200,000
Greece	500	500	50,000	300,000
Hungary	250	250	([4])	([4])
Japan	250	250	([4])	([4])
Turkey	130	150	([4])	([4])
Other countries	210	200	600,000	1,500,000
World total (may be rounded)	2,010	2,000	700,000	2,000,000

World Resources: Insufficient information is available in perlite-producing countries to estimate resources with any reliability.

Substitutes: Alternative materials can be substituted for all uses of perlite, if necessary. Long-established competitive commodities include diatomite, expanded clay and shale, pumice, slag, and vermiculite.

[e]Estimated. NA Not available.
[1]Processed perlite sold and used by producers.
[2]Defined as imports - exports + adjustments for Government and industry stock changes; changes in stocks not available and assumed to be zero apparent consumption and net import reliance calculations.
[3]See Appendix C for definitions.
[4]Included with "Other countries."

PHOSPHATE ROCK

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Phosphate rock ore was mined by nine firms in four States, and upgraded to an estimated 34.2 million tons of marketable product valued at $855 million, f.o.b. mine. Florida and North Carolina accounted for 85% of total domestic output, with the remainder produced in Idaho and Utah. More than 90% of the U.S. phosphate rock ore mined was used to manufacture wet-process phosphoric acid and superphosphoric acid, which were used as intermediates in the manufacture of granular and liquid ammonium phosphate fertilizers and animal feed supplements. More than 50% of the wet-process phosphoric acid produced was exported in the form of upgraded granular diammonium and monoammonium phosphate fertilizer, triple superphosphate fertilizer, and merchant grade phosphoric acid. Phosphate rock mined by two companies in Idaho was consumed as feedstock for elemental phosphorus production at two wholly owned electric furnace facilities. Elemental phosphorus was used to produce high-purity phosphoric acid and phosphorus compounds, which were used in a variety of industrial and food-additive applications.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, marketable	45,900	44,200	40,600	38,600	34,200
Sold or used by producers	42,100	43,700	41,600	37,400	32,500
Imports for consumption	1,830	1,760	2,170	1,930	2,000
Exports	335	378	272	299	50
Consumption[1]	43,600	45,000	43,500	39,000	34,500
Price, average value, dollars per ton, f.o.b. mine[2]	24.40	25.46	30.56	24.14	25.00
Stocks, producer, yearend	7,910	7,920	6,920	8,170	9,400
Employment, mine and beneficiation plant, number[e]	7,500	7,700	7,200	6,300	6,000
Net import reliance[3] as a percentage of apparent consumption	—	3	7	1	2

Recycling: None.

Import Sources (1997-2000): Morocco, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Natural calcium phosphates:		
Unground	2510.10.0000	Free.
Ground	2510.20.0000	Free.

Depletion Allowance: 14% (Domestic), 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: With more than 90% of all phosphate rock mined the United States consumed for fertilizer and animal feed supplements, agricultural demand dictates the direction of the industry. Producers in Florida and North Carolina, which are heavily dependent on exports sales of fertilizers, continued to be affected by the downturn in the world phosphate market that began in 1999. Domestic consumption of phosphate fertilizer fell by 4.4% in 2001 owing to reduced acreage planted, lower application rates, low crop prices, and higher input costs. The combination of these factors caused estimated domestic production, sales, and use of phosphate rock to reach their lowest points since 1969 and estimated consumption was the lowest since 1986. Worldwide consumption of phosphate fertilizers was estimated to have fallen by more than 3% from 1999 to 2001. China and India have been the major destinations for U.S. exports of phosphate fertilizers in the past several years. However, since late-1999, exports to both countries have dropped substantially owing to reduced demand caused by poor weather during the planting season, high inventories, Indian Government subsidy programs, and to a lesser extent, foreign competition. In addition, new fertilizer plants that have opened in Australia and India have reduced import requirements in those countries. The weak market conditions resulted in the temporary closure of several phosphoric acid and fertilizer plants in Florida and Louisiana and reduced output from other mines and plants in the Florida and North Carolina region. U.S. Western producers were unaffected by the world problems because phosphate rock from the region was used for domestic fertilizers or elemental phosphorus for industrial applications.

A company that only produced phosphoric acid and fertilizers began permitting procedures to develop a new mine in Hardee County, FL. The proposed mine would produce about 2.7 million tons per year for 30 years, according to the

Prepared by **Stephen M. Jasinski, [(703) 648-7711, sjasinsk@usgs.gov, fax: (703) 648-7722]**

PHOSPHATE ROCK

company. The firm anticipated opening the mine in 2005, which is when its phosphate rock purchasing contract with another company in Florida expires.

One of two elemental phosphorus plants in the United States was closed at the end of 2001 to reduce operating expenditures. The company opened a new purified wet-process phosphoric acid plant in Idaho, which can manufacture high purity acid at a much lower cost than by using elemental phosphorus. Earlier in the year, three of four furnaces at the facility were closed because of the rising cost of electricity. Mine production in Idaho will not be affected, because the phosphate rock will be used at the purified acid plant. With the closure, there is only one elemental phosphorus plant in the United States. Elemental phosphorus production has decreased steadily worldwide in the past decade because of high production cost and environmental problems associated with operating the plants and increased competition from purified wet-process acid technology.

World demand for phosphate fertilizers will continue to expand in relation to increased world population and food requirements, with the largest growth occurring in developing nations. Projections by various analysts and international organizations indicate that consumption of phosphate in fertilizer could increase by nearly 5% in 2002 based upon encouraging signs in China, India, and North America. For the period 2001-05, phosphate consumption was forecasted to increase by 3.6% annually. Domestic fertilizer consumption was projected to increase by more than 3% in 2002 because of higher fertilizer application rates. The United States remains the world's largest producer of phosphate rock and processed phosphates and the leading supplier of diammonium phosphate. However, increased foreign competition has removed a significant portion of U.S. sales. Weak market conditions will likely prevail until the full impact of new plants in Asia is felt and how quickly domestic manufacturers can increase sales in other regions, especially China. Phosphate rock production is likely to remain below capacity in the Florida and North Carolina region, as companies adjust production to meet demand and prolong reserves. The several new mines that are planned to open in the next 5 years would primarily be replacements for existing mines and not have a significant impact on annual production capacity.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	38,600	34,200	1,000,000	4,000,000
Brazil	4,900	5,000	330,000	370,000
China	19,400	20,000	1,000,000	10,000,000
Israel	4,110	4,000	180,000	800,000
Jordan	5,510	5,500	900,000	1,700,000
Morocco and Western Sahara	21,600	22,000	5,700,000	21,000,000
Russia	11,100	10,500	200,000	1,000,000
Senegal	1,800	2,000	50,000	160,000
South Africa	2,800	2,800	1,500,000	2,500,000
Syria	2,170	2,100	100,000	800,000
Togo	1,370	800	30,000	60,000
Tunisia	8,340	8,100	100,000	600,000
Other countries	11,300	11,100	1,200,000	4,000,000
World total (rounded)	133,000	128,000	12,000,000	47,000,000

World Resources: Foreign reserve data were derived from information received from Government sources, individual companies, and independent sources. Reserve data for China were revised with data from a study prepared for a company that is developing a new mine in Hubei Province. Domestic reserve data were based on U.S. Geological Survey and individual company information. Phosphate rock resources occur principally as sedimentary marine phosphorites. The largest deposits are found in northern Africa, China, the Middle East, and the United States. Significant igneous occurrences are found in Brazil, Canada, Russia, and South Africa. Large phosphate resources have been identified on the continental shelves and on seamounts in the Atlantic Ocean and the Pacific Ocean, but cannot be recovered economically with current technology.

Substitutes: There are no substitutes for phosphorus in agriculture.

[e]Estimated. — Zero.
[1]Defined as sold or used plus imports minus exports.
[2]Marketable phosphate rock, weighted value, all grades, domestic and export.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.

PLATINUM-GROUP METALS

(Platinum, palladium, rhodium, ruthenium, iridium, osmium)
(Data in kilograms, unless otherwise noted)

Domestic Production and Use: The Stillwater Mine is the only primary platinum-group metals (PGM) producer in the United States. The mine, near Nye, MT, processed more than 400,000 metric tons of ore and recovered more than 15,000 kilograms of palladium and platinum in 2001. Small quantities of PGM were also recovered as byproducts of copper refining by two companies in Texas and Utah. Automobile catalysts for air pollution abatement continued to be the largest demand sector for PGM. In the United States, more than 100,000 kilograms of PGM were used by the automotive industry in the manufacture of catalysts. Catalysts are also used in other air-pollution-abatement processes to remove organic vapors, odors, or carbon monoxide. Chemical uses include catalysts for organic synthesis, production of nitric acid, and fabrication of laboratory equipment. Platinum alloys, in cast or wrought form, are commonly used for jewelry. Platinum, palladium, and a variety of complex gold-silver-copper alloys are used as dental restorative materials. The primary medical use of PGM is in cancer chemotherapy. Other medical uses include platinum-iridium alloys in prosthetic and biomedical devices.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Mine production:[1]					
Platinum	2,610	3,240	2,920	3,110	3,600
Palladium	8,400	10,600	9,800	10,300	12,000
Imports for consumption:					
Platinum	77,300	96,700	125,000	94,000	73,000
Palladium	148,000	176,000	189,000	181,000	220,000
Rhodium	14,400	13,500	10,300	18,200	11,000
Ruthenium	11,500	8,880	11,400	20,900	5,500
Iridium	1,860	1,950	2,270	2,700	3,500
Osmium	54	71	23	133	70
Exports:					
Platinum	23,000	14,300	19,400	25,000	29,000
Palladium	43,800	36,700	43,800	58,600	42,000
Rhodium	282	811	114	797	1,400
Price,[2] dollars per troy ounce:					
Platinum	396.59	374.61	378.94	549.31	540.00
Palladium	184.14	289.76	363.20	691.84	770.00
Rhodium	298.00	619.83	904.35	1,990.00	1,800.00
Ruthenium	40.51	47.95	40.70	129.76	130.00
Employment, mine, number	550	620	954	1,290	1,300
Net import reliance as a percentage of apparent consumption:[e]					
Platinum	NA	94	96	78	66
Palladium	NA	90	92	84	87

Recycling: An estimated 70 metric tons of PGM were recovered from new and old scrap in 2000.

Import Sources (1997-2000): Platinum: South Africa, 50%; United Kingdom, 15%; Germany, 6%; Russia, 6%; and other, 23%. Palladium: Russia, 52%; South Africa, 14%; Belgium, 8%; United Kingdom, 7%; and other, 19%.

Tariff: All unwrought and semimanufactured forms of PGM can be imported duty free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Platinum	4,704	—	4,704	3,888	1,960
Palladium	16,715	—	16,714	18,662	9,331
Iridium	784	—	2	—	—

Prepared by **Henry E. Hilliard, [(703) 648-4970, hhilliar@usgs.gov, fax: (703) 648-7757]**

PLATINUM-GROUP METALS

Events, Trends, and Issues: In the first quarter of 2001, the average price of palladium and platinum increased by 90% and 45%, respectively, from 2000 averages. The price of rhodium and ruthenium also experienced large increases. The price increases for platinum and rhodium can be attributed to increased demand, mainly from the automobile sector. Palladium prices, for the third consecutive year, were influenced by unreliable exports from Russia. Russia accounted for more than 50% of U.S. palladium supply and about 3% of U.S. platinum supply in 2001. Prices for ruthenium increased sharply to an average of more than $129 per troy ounce in 2001 from $41 per ounce in 1999. Ruthenium prices were driven by increased demand from the electronics sector and reports of the development of new ruthenium-based superalloys for use in aerospace applications. Higher prices were followed by an increase in the pace of exploration for PGM, and a growing number of joint ventures were signed in recognition of the strong fundamentals for these metals.

Palladium's rise to more than $1,000 per ounce prompted the substitution of silver and base metals along with a reduction in the palladium content of its major end-use applications. Lower consumption by automobile manufacturers, a slowdown in the electronics sector, and increased production by Russia and South Africa caused palladium prices to fall to around $450 per ounce by September 2001. Lower demand by the automobile industry and a slumping global economy in the second half of 2001 caused platinum prices to fall but not nearly as precipitously as prices for palladium. Unlike palladium, platinum, and rhodium, ruthenium has been able to sustain its $130 per ounce price through September 2001.

World Mine Production, Reserves, and Reserve Base:

	Mine production				PGM	
	Platinum		Palladium		Reserves[4]	Reserve base[4]
	2000	2001[e]	2000	2001[e]		
United States	3,110	3,600	10,300	12,000	1,700,000	2,200,000
Canada	5,450	6,000	8,600	9,000	310,000	390,000
Russia	30,000	29,000	94,000	90,000	6,200,000	6,600,000
South Africa	114,000	122,000	55,900	59,000	63,000,000	63,000,000
Other countries	1,530	2,000	5,360	7,400	700,000	850,000
World total (rounded)	155,000	163,000	174,000	177,000	72,000,000	73,000,000

World Resources: World resources of PGM in mineral concentrations currently or potentially economic to mine are estimated to total more than 100 million kilograms. The largest reserves are in the Bushveld Complex in South Africa. In 2001, there were 10 producing mines in the Bushveld Complex; of these, 9 are producing from the Merensky Reef and UG2 Chromite Layer, and one is producing from the Platreef, on the northern limb of the Complex.

Substitutes: Some motor vehicle manufacturers have substituted platinum for the more expensive palladium in catalytic converters. In addition, electronic parts manufacturers are reducing the average palladium content of the conductive pastes used to form the electrodes of multilayer ceramic capacitors by substituting base metals or silver-palladium pastes that contain significantly less palladium.

[e]Estimated. NA Not available. — Zero.
[1]Estimates from published sources.
[2]Handy & Harman quotations.
[3]See Appendix B for definitions.
[4]See Appendix C for definitions.

POTASH

(Data in thousand metric tons of K_2O equivalent, unless otherwise noted)

Domestic Production and Use: In 2001, the value of production of marketable potash, f.o.b. mine, was about $280 million, sales decreased relative to 2000, and prices declined for New Mexico producers. Domestic potash production was from Michigan, New Mexico, and Utah. Most of the production was from southeastern New Mexico, where two companies operated three mines. New Mexico potash ores, both sylvinite and langbeinite, were beneficiated by flotation, heavy media separation, dissolution-recrystallization, or combinations of these processes, and provided more than 70% of U.S. producer total sales.

In Utah, which has three potash operations, one company brought underground potash to the surface by solution mining. The potash was recovered from the brine by solar evaporation to crystals and flotation. Another Utah company collected subsurface brines from an interior basin for solar evaporation to crystals and flotation. The third Utah company collected lake brines for solar evaporation to crystals, flotation, and dissolution-recrystallization. In Michigan, a company used deep well solution mining and mechanical evaporation for recrystallization to produce finished product.

The fertilizer industry used about 90% of the U.S. potash sales, and the chemical industry used the remainder. More than 50% of the potash was produced as potassium chloride (muriate of potash). Potassium sulfate (sulfate of potash) and potassium magnesium sulfate (sulfate of potash-magnesia), required by certain crops and soils, were also sold.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production, marketable	1,400	[1]1,300	[1]1,200	[1]1,300	[1]1,200
Imports for consumption	5,490	4,780	4,470	4,600	4,500
Exports	466	477	459	367	410
Consumption, apparent	6,500	[2]5,600	[2]5,100	[2]5,600	[2]5,400
Price, dollars per metric ton of K_2O, average, muriate, f.o.b. mine[3]	140	145	145	155	155
Employment, number:					
Mine	850	730	660	610	585
Mill	800	780	725	665	670
Net import reliance[4] [5] as a percentage of apparent consumption	80	80	80	80	80

Recycling: None.

Import Sources (1997-2000): Canada, 93%; Russia, 4%; Belarus, 2%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Crude salts, sylvinite, etc.	3104.10.0000	Free.
Potassium chloride	3104.20.0000	Free.
Potassium sulfate	3104.30.0000	Free.
Potassium nitrate	2834.21.0000	Free.
Potassium-sodium nitrate mixtures	3105.90.0010	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The world's largest potash producers operated at reduced capacity for another year owing to potential oversupply. The Canadian potash industry operated for the first half of the year at about 70% of capacity, which was a decrease from the first half of 2000; one company operated at less than 60% of its capacity. At the end of 2000, North American producer stocks built up to more than 2 million tons. Since the Asian Pacific region purchases were down for the first half of 2001, and other countries' purchases were relatively unchanged, North American production was lower for the second half of the year. Again, this was accomplished through extended summer vacations and turnarounds at the mines and mills. Potash producers in the former Soviet Union continued operating at reduced capacity while many other producers around the world operated at normal capacity. Belarus, Germany, and Russia faced marginally increasing demand in their home markets, but are important exporters to Asia Pacific farmers. Grain prices were still relatively low in grain-producing countries, which reduced the demand for potash in those countries. One group of potash consumers was the grain farmers of the world, but China, which had used intensive agriculture in the 1970s and 80s (fertilizers and pest controls on the same amount of land) and extensive agriculture in the 1990s (adding more land) had a grain surplus and exported corn.

Prepared by **James P. Searls [(703) 648-7724, jsearls@usgs.gov, fax: (703) 648-7722]**

POTASH

The offshore potash exporter for Canadian potash producers, Canpotex, Ltd., agreed to help the Jt.St.Co. Uralkali in Perm, Russia, to export potash to Asian areas.[6] Norsk Hydro Ltd. of Norway altered its company strategy and withdrew its participation from Asia Pacific Potash Corporation's Thailand potash mine development.[7]

Based on data from the first half of 2001, estimated potash consumption in Africa, the Middle East, and Oceania accounted for about 5% of the world total and was about 10% more than that group's consumption in 2000. On the same basis, potash consumption in Asia was about 29% of the world total and had declined by about 9%. Potash consumption in Central Europe, Eastern Europe, and Central Asia was about 8% of the world total and declined by about 6%. Potash consumption in Latin America was about 17% of the world total and increased by more than 8%, while potash consumption in North America was about 23% of the world total and declined by less than 4%. Western European potash consumption was about 18% of the world total and declined by more than 9%.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	2000	2001[e]		
United States	[1]1,300	[1]1,200	90,000	300,000
Azerbaijan	[e]5	5	NA	NA
Belarus	3,400	3,500	750,000	1,000,000
Brazil	350	320	300,000	600,000
Canada	8,600	8,800	4,400,000	9,700,000
Chile	23	23	10,000	50,000
China	250	320	140,000	460,000
France	321	270	500	NA
Germany	3,409	3,340	710,000	850,000
Israel	1,710	1,840	[9]40,000	[9]580,000
Jordan	1,110	1,220	[9]40,000	[9]580,000
Russia	3,700	4,400	1,800,000	2,200,000
Spain	522	580	20,000	35,000
Ukraine	30	35	25,000	30,000
United Kingdom	600	520	22,000	30,000
Other countries	—	—	50,000	140,000
World total (may be rounded)	25,300	27,400	8,400,000	17,000,000

World Resources: Estimated domestic potash resources total about 6 billion tons. Most of this lies at depths between 1,830 and 3,050 meters in a 3,110-square-kilometer area of Montana and North Dakota as an extension of the Williston Basin deposits in Saskatchewan, Canada. The Paradox Basin in Utah contains approximately 2 billion tons, mostly at depths of more than 1,220 meters. A large potash resource lies about 2,130 meters under central Michigan. The U.S. reserves figure above contains approximately 62 million tons of reserves in central Michigan. Estimated world resources total about 250 billion tons. The potash deposits in the former Soviet Union contain large amounts of carnallite; it is not clear if this can be mined in a free market, competitive economy. Based on information from a Canadian company, there are an estimated 180 million tons of reserves in the Sanboon deposit in Thailand. There are tentative plans to develop this deposit in the near future.

Substitutes: There are no substitutes for potassium as an essential plant nutrient and essential requirement for animals and humans. Manure and glauconite are low-potassium-content sources that can be profitably transported only short distances to the crop fields.

[e]Estimated. NA Not available. — Zero.

[1]Rounded to the nearest 0.1 million ton to protect proprietary data.

[2]Rounded to the nearest 0.2 million ton to protect proprietary data.

[3]Average prices based on actual sales; excludes soluble and chemical muriates.

[4]Defined as imports - exports + adjustments for Government and industry stock changes.

[5]Rounded to one significant digit to protect proprietary data.

[6]Fertilizer Week, 2001a, Canpotex, Uralkali keep FSU MOP exports robust: Fertilizer Week, v. 15, no. 13, August 6, p. 1-2.

[7]———2001b, Hydro in retreat on Thai potash project: Fertilizer Week, v. 14, no. 46, April 2, p. 1-2.

[8]See Appendix C for definitions.

[9]Total reserves and reserve base in the Dead Sea are equally divided between Israel and Jordan.

PUMICE AND PUMICITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: The estimated value of pumice and pumicite sold or used in 2001 was $16.9 million. Domestic output came from 15 producers in 6 States. The principal producing States were California, Idaho, New Mexico, and Oregon, with combined production accounting for about 98% of the national total. The remaining production was from Arizona and Kansas. About 67% of the pumice was consumed for building blocks, and the remaining 33% was used in abrasives, concrete, horticulture, landscaping, stone-washing laundries, and other applications.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, mine[1]	577	583	643	697	687
Imports for consumption	265	288	354	385	390
Exports[e]	12	22	23	27	25
Consumption, apparent	830	849	974	1,060	1,050
Price, average value, dollars per ton, f.o.b. mine or mill	27.90	21.59	27.69	24.27	24.53
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number	70	75	85	85	80
Net import reliance[2] as a percentage of apparent consumption	30	31	34	34	35

Recycling: Not available.

Import Sources (1997-2000): Greece, 84%; Italy, 10%; Turkey, 5%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Crude or in irregular pieces, including crushed pumice	2513.11.0000	Free.
Other	2513.19.0000	Free.

Depletion Allowance: 5% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Wallace P. Bolen [(703) 648-7727, wbolen@usgs.gov, fax: (703) 648-7722]**

PUMICE AND PUMICITE

Events, Trends, and Issues: The amount of pumice and pumicite sold or used in 2001 decreased slightly when compared with that of 2000. Imports increased about 1.3% compared with those of 2000 as more Greek pumice was brought into the eastern half of the United States. Total consumption fell about 4.5% from the record levels achieved in 2000. Consumption decreased because the slowing National economy decreased demand for lightweight-block and lightweight-concrete products. Stone-washing laundry use of pumice continued to decline in 2001.

In 2002, domestic mine production of pumice and pumicite is expected to be about 700,000 tons, with U.S. apparent consumption at approximately 1,100,000 tons. Imports, mainly from Greece, will continue to supply markets in the East Coast and Gulf Coast States of the United States.

Although pumice and pumicite are plentiful in the Western United States, changes in laws and public land designations could decrease access to many deposits. Pumice and pumicite are sensitive to mining costs, and, if domestic production costs were to increase, imports and competing materials might replace pumice in many domestic markets.

All domestic mining of pumice in 2001 was by open pit methods, and generally occurred in relatively remote areas where land-use conflicts were not severe. Although the generation and disposal of reject fines in mining and milling resulted in a dust problem at some operations, the environmental impact was restricted to a small geographic area.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2000	2001[e]		
United States[1]	697	687	Large	Large
Chile	650	800	NA	NA
France	450	450	NA	NA
Germany	600	600	NA	NA
Greece	1,600	1,600	NA	NA
Italy	4,600	4,600	NA	NA
Spain	600	600	NA	NA
Turkey	600	600	NA	NA
Other countries	2,200	2,200	NA	NA
World total (rounded)	12,000	12,000	NA	NA

World Resources: The identified U.S. domestic resources of pumice and pumicite in the West are estimated to be at least 25 million tons. The estimated resources in the Western and Great Plains States are 250 million to 450 million tons.

Substitutes: Transportation cost determines the maximum distance that pumice and pumicite can be shipped and remain competitive with alternate materials. Competitive materials that can be substituted for pumice and pumicite for several end uses include expanded shale and clay, diatomite, and crushed aggregates.

[e]Estimated. NA Not available.
[1]Quantity sold and used by producers.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.

QUARTZ CRYSTAL (INDUSTRIAL)

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Domestic production of cultured quartz crystal in 2001 remained near 2000 levels. Lascas[1] mining and processing in Arkansas was stopped at the end of 1997, but three U.S. firms continued to produce cultured quartz crystals by using imported and stockpiled lascas as feed material. Electronic applications accounted for most industrial uses of quartz crystal; other uses included special optical applications.

Virtually all quartz crystal used for electronics was cultured rather than natural crystal. Electronic-grade quartz crystal was essential for making filters, frequency controls, and timers in electronic circuits employed for a wide range of products, such as communications equipment, computers, and many other consumer goods, such as televisions and electronic games.

Salient Statistics—United States: Production of cultured quartz crystals was estimated to be about 200 tons. Trade data for cultured quartz crystal and devices with mounted quartz crystal are available, but lascas import data are not available. Exports of cultured quartz crystals were about 74 tons, and imports were about 31 tons in 2001. The average value of exports and imports was $308,000 per ton and $461,000 per ton, respectively. Other salient statistics were not available.

Recycling: None.

Import Sources (1997-2000): The United States is 100% import reliant. Brazil, Germany, and Madagascar are reportedly the major sources for lascas. Other possible sources of lascas include China, South Africa, and Venezuela.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Sands:		
95% or greater silica	2505.10.10.00	Free.
Less than 95% silica	2505.10.50.00	Free.
Quartz (including lascas)	2506.10.00.50	Free.
Piezo-electric quartz	7104.10.00.00	3% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Prepared by **Thomas P. Dolley [(703) 648-7710, tdolley@usgs.gov, fax: (703) 648-7722]**

QUARTZ CRYSTAL (INDUSTRIAL)

Government Stockpile:

Stockpile Status—9-30-01[2]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Quartz crystal	105	([3])	—	—	—

Events, Trends, and Issues: Trends indicate that demand for quartz crystal devices should continue to grow, and consequently, quartz crystal production should remain strong well into the future. Growth of the consumer electronics market (for products such as personal computers, electronic games, and cellular telephones), particularly in the United States, will continue to promote domestic production. The growing global electronics market may require additional production capacity worldwide.

World Mine Production, Reserves, and Reserve Base: This information is unavailable, but the global reserve base for lascas is thought to be large.

World Resources: Limited resources of natural quartz crystal suitable for direct electronic or optical use are available throughout the world. World dependence on these resources will continue to decline because of the increased acceptance of cultured quartz crystal as an alternative material; however, use of cultured quartz crystal will mean an increased dependence on lascas for growing cultured quartz.

Substitutes: Quartz crystal is the best material for frequency-control oscillators and frequency filters in electronic circuits. Other materials, such as dipotassium tartrate, are usable only in specific applications, such as oscillators and filters.

— Zero.
[1]Lascas is a nonelectronic-grade quartz used as a feedstock for growing cultured quartz crystal and for production of fused quartz.
[2]See Appendix B for definitions.
[3]Less than ½ unit.

RARE EARTHS[1]

(Data in metric tons of rare-earth oxide (REO) content, unless otherwise noted)

Domestic Production and Use: Rare earths were mined by one company in 2001. Bastnasite, a rare-earth fluocarbonate mineral, was mined as a primary product by a firm in Mountain Pass, CA. The United States was a leading producer and processor of rare earths and continued to be a major exporter and consumer of rare-earth products. Domestic ore production was valued at an estimated $28 million. The estimated value of refined rare earths consumed in the United States was more than $1 billion. The approximate distribution in 2000 by end use was as follows: automotive catalytic converters, 22%; glass polishing and ceramics, 39%; permanent magnets, 16%; petroleum refining catalysts, 12%; metallurgical additives and alloys, 9%; rare-earth phosphors for lighting, televisions, computer monitors, radar, and x-ray-intensifying film, 1%; and miscellaneous, 1%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, bastnasite concentrates[e]	10,000	5,000	5,000	5,000	5,000
Imports:[2]					
Thorium ore (monazite)	11	—	—	—	—
Rare-earth metals, alloy	529	953	1,780	2,470	1,670
Cerium compounds	1,810	4,940	3,990	4,310	4,940
Mixed REOs	974	2,530	5,980	2,190	3,080
Rare-earth chlorides	1,450	1,680	1,530	1,330	1,830
Rare-earth oxides, compounds	7,060	3,720	7,760	11,200	9,070
Ferrocerium, alloys	121	117	120	118	138
Exports:[2]					
Rare-earth metals, alloys	991	724	1,600	1,650	965
Cerium compounds	5,890	4,640	3,960	4,050	4,810
Other rare-earth compounds	1,660	1,630	1,690	1,650	1,930
Ferrocerium, alloys	3,830	2,460	2,360	2,250	2,500
Consumption, apparent[3]	19,400	11,500	11,500	12,100	15,600
Price, dollars per kilogram, yearend:					
Bastnasite concentrate, REO basis[e]	3.53	4.19	4.85	5.51	5.51
Monazite concentrate, REO basis	0.73	0.73	0.73	0.73	0.73
Mischmetal, metal basis, metric ton quantity[4]	8-12	6-8	5-7	5-7	5-7
Stocks, producer and processor, yearend	W	W	W	W	W
Employment, mine and mill, number	327	183	102	77	85
Net import reliance[5] as a percentage of apparent consumption	E	56	70	71	68

Recycling: Small quantities, mostly permanent magnet scrap.

Import Sources (1997-2000): Monazite: Australia, 67%; and France, 33%. Rare-earth metals, compounds, etc.: China, 74%; France, 21%; Japan, 3%; United Kingdom, 1%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Thorium ores and concentrates (monazite)	2612.20.0000	Free.
Rare-earth metals, whether or not intermixed or interalloyed	2805.30.0000	5.0% ad val.
Cerium compounds	2846.10.0000	5.5% ad val.
Mixtures of REOs except cerium oxide	2846.90.2010	Free.
Mixtures of rare-earth chlorides, except cerium chloride	2846.90.2050	Free.
Rare-earth compounds, individual REOs (excludes cerium compounds)	2846.90.8000	3.7% ad val.
Ferrocerium and other pyrophoric alloys	3606.90.3000	5.9% ad val.

Depletion Allowance: Monazite, 22% on thorium content and 14% on rare-earth content (Domestic), 14% (Foreign); bastnasite and xenotime, 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7722]**

RARE EARTHS

Events, Trends, and Issues: Domestic demand for rare earths in 2001 was higher than that of 2000. U.S. imports of rare earths remained at high levels in most trade categories as a result of the temporary closure of the rare-earth separation plant at Mountain Pass, CA. The plant is expected to resume separation operations. The mine at Mountain Pass continued to produce bastnasite concentrates and cerium concentrates. The trend is for continued increased use of the rare earths in many applications, especially automotive catalytic converters, permanent magnets, and rechargeable batteries.

The *Rare Earths—2001* conference was held in Sao Paolo, Brazil, during September 22-26, 2001. The *23rd Rare Earth Research Conference* is scheduled for July 13-18, 2002, in Davis, CA, USA. The *17th International Workshop on Rare-Earth Magnets and their Applications* is scheduled for August 19-22, 2002, in Newark, DE, USA. The *Fifth International Conference on f-Elements* is planned for August 24-29, 2003, in Geneva, Switzerland. A scandium symposium is being arranged for August 17-23, 2003, in Oslo, Norway.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves[6]	Reserve base[6]
	2000	2001		
United States	5,000	5,000	13,000,000	14,000,000
Australia	—	—	5,200,000	5,800,000
Brazil	200	200	82,000	310,000
Canada	—	—	940,000	1,000,000
China	73,000	75,000	43,000,000	48,000,000
India	2,700	2,700	1,100,000	1,300,000
Malaysia	450	450	30,000	35,000
South Africa	—	—	390,000	400,000
Sri Lanka	120	120	12,000	13,000
Former Soviet Union[7]	2,000	2,000	19,000,000	21,000,000
Other countries	—	—	21,000,000	21,000,000
World total (rounded)	83,500	85,500	100,000,000	110,000,000

World Resources: Rare earths are relatively abundant in the Earth's crust, but discovered minable concentrations are less common than for most other ores. U.S. and world resources are contained primarily in bastnasite and monazite. Bastnasite deposits in China and the United States constitute the largest percentage of the world's rare-earth economic resources, while monazite deposits in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, and the United States constitute the second largest segment. Xenotime, rare-earth-bearing (ion adsorption) clays, loparite, phosphorites, apatite, eudialyte, secondary monazite, cheralite, and spent uranium solutions make up most of the remaining resources. Undiscovered resources are thought to be very large relative to expected demand.

Substitutes: Substitutes are available for many applications, but generally are less effective.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Data includes lanthanides and yttrium, but excludes most scandium. See also Scandium and Yttrium.
[2]REO equivalent or contents of various materials were estimated. Data from U.S. Census Bureau.
[3]Monazite concentrate production was not included in the calculation of apparent domestic consumption and net import reliance. Net import relian
defined as imports - exports + adjustments for Government and industry stock changes.
[4]Price range from Elements - Rare Earths, Specialty Metals and Applied Technology, Trade Tech, Denver, CO.
[5]U.S. Department of Energy, Ames Laboratory, 2000, Versatile set of alloys could enhance performance of cryocoolers: Ames, IA, Ames Laborato
news release, August 21, 2 p.
[6]See Appendix C for definitions.
[7]As constituted before December 1991.

RHENIUM

(Data in kilograms of rhenium content, unless otherwise noted)

Domestic Production and Use: During 2001, ores containing rhenium were mined by six operations. Rhenium compounds are included in molybdenum concentrates derived from porphyry copper deposits in the Southwestern United States, and rhenium is recovered as a byproduct from roasting such molybdenum concentrates. Rhenium-containing products included ammonium perrhenate, perrhenic acid, and metal powder. The major uses of rhenium were in petroleum-reforming catalysts and in high-temperature superalloys used in turbine engine components, representing about 40% and 50%, respectively, of the total demand. Rhenium was used in petroleum-reforming catalysts for the production of high-octane hydrocarbons, which are used in the production of lead-free gasoline. Bimetallic platinum-rhenium catalysts have replaced many of the monometallic catalysts. Rhenium is used in superalloys, improving the strength properties, at high temperatures (1,000^o C), of nickel-based alloys. Some of the uses for rhenium alloys were in thermocouples, temperature controls, heating elements, ionization gauges, mass spectrographs, electron tubes and targets, electrical contacts, metallic coatings, vacuum tubes, crucibles, electromagnets, and semiconductors. The estimated value of rhenium consumed in 2001 was $42 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production[1]	15,400	14,000	12,000	12,600	9,700
Imports for consumption	15,100	25,200	15,500	18,100	24,700
Exports	NA	NA	NA	NA	NA
Consumption:					
Estimated	17,900	28,600	32,500	32,000	35,000
Apparent	NA	NA	NA	NA	NA
Price, average value, dollars per kilogram:					
Metal powder, 99.99% pure	900	500	1,100	1,110	1,200
Ammonium perrhenate	300	400	750	780	840
Stocks, yearend, consumer, producer, dealer	NA	NA	NA	NA	NA
Employment, number	Small	Small	Small	Small	Small
Net import reliance[2] as a percentage of estimated consumption	84	88	48	57	71

Recycling: Small amounts of molybdenum-rhenium and tungsten-rhenium scrap have been processed by several companies during the past few years. All spent platinum-rhenium catalysts were recycled.

Import Sources (1997-2000): Chile, 55%; Kazakhstan, 17%; Germany 14%; Russia, 6%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Other inorganic acids, other—rhenium, etc.	2811.19.6050	4.2% ad val.
Salts of peroxometallic acids, other—ammonium perrhenate	2841.90.2000	3.1% ad val.
Rhenium, etc., (metals) waste and scrap	8112.91.0500	Free.
Rhenium, (metals) unwrought; powders	8112.91.5000	3% ad val.
Rhenium, etc., (metals) wrought; etc.	8112.99.0000	4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **John W. Blossom [(703) 648-4964, jblossom@usgs.gov, fax: (703) 648-7757]**

RHENIUM

Events, Trends, and Issues: During 2001, the average rhenium prices were $1,200 per kilogram for metal and $840 per kilogram for ammonium perrhenate. The supply increased by 12%, and the consumption increased by 9%. The United States relied on imports for much of its supply of rhenium. Imports of rhenium increased by about 36% in 2001 compared with those of 2000. Chile and Kazakhstan supplied the majority of the rhenium imported. The increased estimated consumption was for catalysts for petroleum refining and superalloys for turbine engines.

For 2002, U.S. consumption of rhenium is estimated to be about 40,000 kilograms.

Owing to the scarcity and minor output of rhenium, its production and processing pose no known threat to the environment. In areas where it is recovered, pollution control equipment for sulfur dioxide also prevents most of the rhenium from escaping into the atmosphere.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves[3]	Reserve base[3]
	2000	2001		
United States	12,600	9,700	390,000	4,500,000
Armenia	700	700	95,000	120,000
Canada	1,600	1,600	—	1,500,000
Chile	2,200	2,200	1,300,000	2,500,000
Kazakhstan	2,400	3,000	190,000	250,000
Peru	4,800	5,000	45,000	550,000
Russia	1,100	1,200	310,000	400,000
Other countries	3,000	3,000	91,000	360,000
World total (rounded)	28,400	26,400	2,400,000	10,000,000

World Resources: Most rhenium occurs with molybdenum in porphyry copper deposits. Identified U.S. resources are estimated to be about 5 million kilograms, and the identified resources of the rest of the world are approximately 6 million kilograms. In Kazakhstan, rhenium also exists in sedimentary copper deposits.

Substitutes: Substitutes for rhenium in platinum-rhenium catalysts are being evaluated continually. Iridium and tin have achieved commercial success in one such application. Other metals being evaluated for catalytic use include gallium, germanium, indium, selenium, silicon, tungsten, and vanadium. The use of these and other metals in bimetallic catalysts may decrease rhenium's share of the catalyst market. Materials that can substitute for rhenium in various end uses are as follows: cobalt and tungsten for coatings on copper x-ray targets, rhodium and rhodium-iridium for high-temperature thermocouples, tungsten and platinum-ruthenium for coatings on electrical contacts, and tungsten and tantalum for electron emitters.

[e]Estimated. NA Not available. — Zero.

[1]Calculated rhenium contained in MoS_2 concentrates. Recovered quantities are considerably less and are withheld.

[2]Defined as imports - exports + adjustments for Government and industry stock changes.

[3]See Appendix C for definitions.

RUBIDIUM

(Data in kilograms of rubidium content, unless otherwise noted)

Domestic Production and Use: Although rubidium is not recovered from any domestically mined ores, at least one domestic company manufactured rubidium products from imported lepidolite ore. Small quantities of rubidium, usually in the form of chemical compounds, were used mainly in research and development. Rubidium also was used in electronic and medical applications.

Salient Statistics—United States: Salient statistics, such as production, consumption, imports, and exports, are not available. The domestic rubidium market is very small, with annual consumption probably amounting to only a few thousand kilograms. There is no active trading of the metal, and, therefore, no market price. However, several companies publish prices for rubidium and rubidium compounds. These prices have remained relatively stable for several years. The per-unit price for the metal or compounds varies inversely with the quantity of material purchased. For example, in 2001, one company offered 1-gram ampoules of 99.8%-grade rubidium metal at $52.00; the price for 100 grams of the same material from this company was $998.00, or $9.98 per gram.

Recycling: None.

Import Sources (1997-2000): The United States is 100% import reliant. Although there is no information on the countries shipping rubidium-bearing material to the United States, Canada is thought to be the major source of this raw material.

Tariff:

Item	Number	Normal Trade Relations 12/31/01
Alkali metals, other	2805.19.0000	5.5% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert G. Reese, Jr. [(703) 648-4981, rreese@usgs.gov, fax: (703) 648-7757]**

RUBIDIUM

Events, Trends, and Issues: Rubidium and its compounds were largely the subject of laboratory study and were of little commercial significance. No major breakthroughs or developments were anticipated that would change the production or consumption patterns. Domestic rubidium production is entirely dependent upon imported lepidolite ores. Because of the small scale of production of rubidium products, no significant environmental problems have been encountered.

World Mine Production, Reserves, and Reserve Base: Rubidium forms no known minerals in which it is the predominant metallic element. Rather, it substitutes for potassium in a number of minerals, especially those that crystallize late in the formation of pegmatites. Lepidolite, a potassium lithium mica that may contain up to 3.15% rubidium, is the principal ore of rubidium. Pollucite, the cesium aluminosilicate mineral, may contain up to 1.35% rubidium. Rubidium-bearing minerals are mined as byproducts or coproducts with other pegmatite minerals.

World Resources: Total world resources of rubidium are unknown.

Substitutes: The properties of cesium and its compounds are so similar to those of rubidium and its compounds that compounds of rubidium and cesium are used interchangeably in many applications.

SALT

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Domestic production of salt increased slightly in 2001, with total value estimated at $1 billion. Thirty-two companies operated 69 plants in 15 States. The estimated percentage of salt sold or used, by type, was salt in brine, 52%; rock salt, 31%; vacuum pan, 10%; and solar salt, 7%.

The chemical industry consumed about 42% of total salt sales, with salt in brine representing about 92% of the type of salt used for feedstock. Chlorine and caustic soda manufacture was the main consuming sector within the chemical industry. Salt for highway deicing accounted for 36% of U.S. demand. The remaining markets for salt, in declining order, were distributors, 7%; industrial, 6%; agricultural, 4%; food, 3%; primary water treatment, 1%; and other combined with exports, 1%.

Salient Statistics—United States:[1]	**1997**	**1998**	**1999**	**2000**	**2001**[e]
Production	41,400	41,200	44,900	45,600	45,100
Sold or used by producers	40,600	40,800	44,400	43,300	45,100
Imports for consumption	9,160	8,770	8,870	8,960	10,000
Exports	748	731	892	642	900
Consumption:					
Reported	49,500	44,200	50,000	54,000	54,200
Apparent	49,000	48,800	52,400	51,600	54,200
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant:					
Vacuum and open pan salt	119.61	114.93	112.49	113.95	117.00
Solar salt	38.81	37.56	52.08	50.46	42.00
Rock salt	20.50	21.90	22.55	20.67	20.00
Salt in brine	6.67	5.93	6.65	5.70	6.00
Stocks, producer, yearend[e 2]	800	400	500	2,300	—
Employment, mine and plant, number	4,150	4,150	4,100	4,100	4,100
Net import reliance[3] as a percentage of apparent consumption	17	17	15	16	17

Recycling: None.

Import Sources (1997-2000): Canada, 45%; Chile, 22%; Mexico, 15%; The Bahamas, 10%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Iodized salt	2501.00.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Dennis S. Kostick [(703) 648-7715, dkostick@usgs.gov, fax: (703) 648-7722]**

SALT

Events, Trends, and Issues: A major U.S. salt producer that was the third largest salt producer in the world sold its North American operations for $640 million to an entity formed by affiliates of a private investment firm based in New York. The sale includes the vacuum pan salt plant in Kansas, the rock salt mine in Louisiana, the vacuum pan salt facility in Michigan, the salt marketing rights to a plant in Tennessee, the solar salt, sulfate of potash, and magnesium chloride facilities in Utah, and the rock salt and vacuum pan salt plants in Canada.

A major U.S. salt company sold its Australian solar salt operation at Port Hedland, Western Australia, to its Australian salt competitor for $95 million plus some additional payments contingent on future performance. The acquisition made the company the world's largest salt exporter. The plant produced and exported about 3 million tons annually.

A salt-tolerant tomato was genetically engineered to grow in saline environments. The new tomato is able to divert the intake of sodium to the leaves instead of to the tomato itself. Irrigation in arid areas often results in an accumulation of salt deposits that reduces the yield in cropland because salt is toxic to many plants. An estimated 25% of the total irrigated land in the world is threatened by this salt buildup, and that 1% of the global irrigated land is lost annually to salinization. Genetic modification of other salt-sensitive crops was being conducted to increase crop yield in dry sections of China, India, Pakistan, and the Western United States.

Demand for chlorine and coproduct caustic soda was lower than expected in 2001. Rising energy costs and a downturn in the domestic economy contributed to a decline in polyvinyl chloride (PVC) production for construction supplies, such as PVC pipe and tubing, siding, and window and door frames. As a result, several chloralkali facilities were idled or curtailed production until the economy showed signs of recovery which was not apparent by yearend.

Consumption of salt in 2002 is expected to be higher than that of 2001.

World Production, Reserves, and Reserve Base:

	Production		Reserves and reserve base[4]
	2000	2001[e]	
United States[1]	45,600	45,100	Large. Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans contain an inexhaustible supply of salt.
Australia	8,800	8,000	
Brazil	6,000	7,000	
Canada	11,900	12,500	
China	31,300	32,000	
France	7,000	7,100	
Germany	15,700	15,800	
India	14,500	14,500	
Italy	3,600	3,600	
Mexico	8,900	8,600	
Poland	4,200	4,500	
Russia	3,200	3,000	
Spain	3,200	3,300	
Ukraine	2,390	2,400	
United Kingdom	5,800	5,700	
Other countries	41,900	41,000	
World total (may be rounded)	214,000	214,000	

World Resources: World resources of salt are practically unlimited. Domestic resources of rock salt and salt from brine are in the Northeast, Central Western, and southern Gulf Coast States. Saline lakes and solar evaporation salt facilities are near populated regions in the Western United States. Almost every country in the world has salt deposits or solar evaporation operations of various sizes.

Substitutes: There are no economic substitutes or alternates for salt. Calcium chloride and calcium magnesium acetate, hydrochloric acid, and potassium chloride can be substituted for salt in deicing, certain chemical processes, and food flavoring, but at a higher cost.

[e]Estimated. — Zero.
[1]Excludes Puerto Rico production.
[2]Reported stock data are incomplete. For apparent consumption and net import reliance calculations, changes in annual stock totals are assumed be the difference between salt produced and salt sold or used.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.

SAND AND GRAVEL (CONSTRUCTION)[1]

(Data in million metric tons, unless otherwise noted)[2]

Domestic Production and Use: Construction sand and gravel valued at $5.5 billion was produced by an estimated 3,900 companies from 6,200 operations in 50 States. Leading States, in order of tonnage, were California, Texas, Michigan, Ohio, Arizona, Washington, and Colorado, which combined accounted for about 45% of the total output. It is estimated that about 46% of the 1.12 billion metric tons of construction sand and gravel produced in 2001 was for unspecified uses. Of the remaining total, about 44% was used as concrete aggregates; 23% for road base and coverings and road stabilization; 13% as asphaltic concrete aggregates and other bituminous mixtures; 13% as construction fill; 2% for concrete products, such as blocks, bricks, pipes, etc.; 2% for plaster and gunite sands; and the remainder for snow and ice control, railroad ballast, roofing granules, filtration, and other miscellaneous uses.

The estimated output of construction sand and gravel in the 48 conterminous States shipped for consumption in the first 9 months of 2001 was about 844 million tons, which represents an increase of 0.9% compared with the same period of 2000. The estimated output of crushed stone in the 48 conterminous States shipped for consumption in the first 9 months of 2001 was 1.23 billion tons, which represents an increase of 5.5% compared with the same period of 2000. Additional production information by quarter for each State, geographic region, and the United States is published by the U.S. Geological Survey in its quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	952	1,070	1,110	1,120	1,120
Imports for consumption	2	1	2	3	3
Exports	2	2	2	2	2
Consumption, apparent	952	1,070	1,110	1,120	1,120
Price, average value, dollars per ton	4.47	4.57	4.73	4.81	4.90
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e]	33,900	35,600	37,300	37,500	37,500
Net import reliance[3] as a percentage of apparent consumption	—	—	—	([4])	([4])

Recycling: Asphalt road surfaces and cement concrete surfaces and structures were recycled on an increasing basis.

Import Sources (1997-2000): Canada, 65%; Mexico, 15%; The Bahamas, 8%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Sand, construction	2505.90.0000	Free.
Gravel, construction	2517.10.0000	Free.

Depletion Allowance: Common varieties, 5% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Wallace P. Bolen [(703) 648-7727, wbolen@usgs.gov, fax: (703) 648-7722]**

SAND AND GRAVEL (CONSTRUCTION)

Events, Trends, and Issues: Construction sand and gravel output remained at approximately 1.12 billion tons, about equal to that of 2000. It is estimated that 2002 domestic production and U.S. apparent consumption will be about 1.15 billion tons each, a slight increase. Aggregate consumption is expected to continue to grow slowly in response to the slowing economy and recession. Although some areas of the country should experience increased sales and consumption of sand and gravel, other areas will have negative growth and overall growth should be flat to slightly positive.

The construction sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions. Shortages of construction sand and gravel in urban and industrialized areas were expected to continue to increase. Movement of sand and gravel operations away from highly populated centers was expected to continue where local zoning and land development regulations discourage sand and gravel operations.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2000	2001[e]	
United States	1,120	1,120	The reserves and reserve base are controlled largely by land use and/or environmental constraints.
Other countries	NA	NA	
World total	NA	NA	

World Resources: Sand and gravel resources of the world are large. However, because of their geographic distribution, environmental restrictions, and quality requirements for some uses, their extraction is uneconomic in some cases. The most important commercial sources of sand and gravel have been river flood plains, river channels, and glacial deposits. Offshore deposits are being used presently in the United States, mostly for beach erosion control. Other countries mine offshore deposits of aggregates for onshore construction projects.

Substitutes: Crushed stone remains the predominant choice for construction aggregate use.

[e]Estimated. NA Not available. — Zero.
[1]See also Sand and Gravel (Industrial).
[2]See Appendix A for conversion to short tons.
[3]Defined as imports - exports + adjustments for Government and industry stock changes; changes in stocks not available and assumed to be zero
[4]Less than ½ unit.
[5]See Appendix C for definitions.

SAND AND GRAVEL (INDUSTRIAL)

(Data in thousand metric tons, unless otherwise noted)[1]

Domestic Production and Use: Industrial sand and gravel valued at about $560 million was produced by 69 companies from 154 operations in 37 States. Leading States, in order of tonnage, were Illinois, Michigan, Wisconsin, California, Texas, New Jersey, North Carolina, and Oklahoma. Combined production from these States represented 59% of the domestic total. About 38% of the U.S. tonnage was used as glassmaking sand, 22% as foundry sand, 5% as abrasive sand, 5% as hydraulic fracturing sand, and the remaining 30% for other uses.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	28,500	28,200	28,900	28,400	28,800
Imports for consumption	39	44	211	247	122
Exports	980	2,400	1,670	1,660	1,490
Consumption, apparent	27,600	26,200	27,400	27,400	27,400
Price, average value, dollars per ton	17.93	18.19	18.64	19.58	19.50
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e]	1,450	1,400	1,400	1,400	1,400
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: There is some recycling of foundry sand, and recycled cullet (pieces of glass) represents a significant proportion of reused silica.

Import Sources (1997-2000): Canada, 56%; Mexico, 23%; Australia, 16%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
95% or more silica and not more than 0.6% iron oxide	2505.10.1000	Free.

Depletion Allowance: Industrial sand or pebbles, 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Thomas P. Dolley [(703) 648-7710, tdolley@usgs.gov, fax: (703) 648-7722]**

SAND AND GRAVEL (INDUSTRIAL)

Events, Trends, and Issues: Domestic sales of industrial sand and gravel in 2001 increased by about 1% compared with those of 2000. U.S. apparent consumption reached slightly more than 27 million tons in 2001, unchanged from that of the preceding 2 years. Imports dropped 51% in 2001 compared with those of 2000. Import levels in 2000 had been the highest reported in at least the past 20 years. Imports of silica are generally of two types: small-quantity shipments of very-high-purity silica or a few large shipments of lower grade silica that were shipped only under special circumstances (e.g., very low freight rates).

The United States was the world's largest producer and consumer of industrial sand and gravel based on estimated world production figures. It was difficult to collect definitive numbers on silica sand and gravel production in most nations because of the wide range of terminology and specifications for silica from country to country. The United States remained a major exporter of silica sand, shipping sand to almost every region of the world. This was attributed to the high quality and advanced processing techniques for a large variety of grades of silica, meeting virtually every specification for silica sand and gravel.

In 2002, estimated domestic production and apparent consumption will be about 29 million tons and 27 million tons, respectively.

The industrial sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions in 2001. Local shortages were expected to continue to increase owing to local zoning regulations and land development alternatives. These situations are expected to continue to cause a movement of sand and gravel operations away from high-population centers.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves and reserve base[3]
	2000	**2001**	
United States	28,400	28,800	
Australia	2,500	2,500	Large. Silica is abundant in the Earth's crust. The reserves and reserve base are determined mainly by the location of population centers.
Austria	6,000	5,800	
Belgium	2,400	2,400	
Brazil	2,700	2,700	
Canada	2,000	2,000	
France	6,500	6,600	
Germany	7,000	6,800	
India	1,300	1,400	
Italy	3,000	3,000	
Japan	2,800	2,700	
Mexico	1,800	1,900	
Netherlands	3,000	3,000	
South Africa	2,200	2,100	
Spain	6,000	6,000	
United Kingdom	4,000	4,000	
Other countries	15,000	15,000	
World total (rounded)	97,000	97,000	

World Resources: Sand and gravel resources of the world are sizable. However, because of their geographic distribution, environmental restrictions, and quality requirements for some uses, extraction of these resources is sometimes uneconomic. Quartz-rich sand and sandstones, the main source of industrial silica sand, occur throughout the world.

Substitutes: Silica sand continues to be the major material used for glassmaking and for foundry and molding sands; alternatives are zircon, olivine, staurolite, and chromite sands.

[e]Estimated. E Net exporter. NA Not available.
[1]See Appendix A for conversion to short tons.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.

SCANDIUM

(Data in kilograms of scandium oxide content, unless otherwise noted)

Domestic Production and Use: Demand for scandium increased slightly in 2001. Although scandium was not mined domestically in 2001, quantities sufficient to meet demand were available in domestic tailings. Principal sources were imports from China, Russia, and Ukraine. Companies that processed scandium ores, concentrates, and low-purity compounds to produce refined scandium products were in Mead, CO; Urbana, IL; and Knoxville, TN. Capacity to produce ingot and distilled scandium metal was located in Phoenix, AZ; Urbana, IL; and Ames, IA. Scandium used in the United States was essentially derived from foreign sources. Principal uses for scandium in 2001 were aluminum alloys for sporting equipment, metallurgical research, high-intensity metal halide lamps, analytical standards, electronics, and laser research.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Price, yearend, dollars:					
Per kilogram, oxide, 99.0% purity	1,400	1,100	900	700	700
Per kilogram, oxide, 99.9% purity	2,900	2,300	2,000	2,000	2,300
Per kilogram, oxide, 99.99% purity	4,400	3,400	3,000	3,000	2,700
Per kilogram, oxide, 99.999% purity	6,750	5,750	4,000	6,000	4,100
Per gram, dendritic, metal[1]	285.00	285.00	270.00	270.00	279.00
Per gram, metal[2]	172.00	172.00	175.00	175.00	198.00
Per gram, scandium bromide, 99.99% purity[3]	90.00	90.00	91.80	91.80	94.60
Per gram, scandium chloride, 99.9% purity[3]	38.80	38.80	39.60	39.60	40.80
Per gram, scandium fluoride, 99.9% purity[3]	78.50	78.50	80.10	80.10	173.00
Per gram, scandium iodide, 99.999% purity[3]	148.00	148.00	151.00	151.00	156.00
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1997-2000): NA.

Tariff: **Item**	**Number**	**Normal Trade Relations 12/31/01**
Mineral substances not elsewhere specified or included, including scandium ores	2530.90.0000	Free.
Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed including scandium	2805.30.0000	5.0% ad val.
Mixtures of rare-earth oxides except cerium oxide, including scandium oxide mixtures	2846.90.2010	Free.
Rare-earth compounds, including individual rare-earth oxides, hydroxides, nitrates, and other individual compounds, including scandium oxide	2846.90.8000	3.7% ad val.
Aluminum alloys, other, including scandium-aluminum	7601.20.9090	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Nominal prices for domestically produced scandium compounds decreased from the previous year. The supply of domestic and foreign scandium remained strong despite increased demand. Although demand increased in 2001, the total market remained very small. Domestic increases in demand were primarily from recently developed applications in welding wire, scandium-aluminum baseball and softball bats, scandium-aluminum bicycle frames, and high-strength, lightweight handgun frames and cylinders. Future demand is expected to be in fuel cells.

Prepared by **James B. Hedrick, [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7722]**

SCANDIUM

Scandium's use continued to increase in metal halide lighting. Scandium additions, as the metal or the iodide, mixed with other elements, were added to halide light bulbs to adjust the color to appear like natural sunlight. Demand also continued to increase for scandium-aluminum alloys. Future development is expected to occur in alloys for aerospace and specialty markets, including sports equipment. Market activity has increased since 1998, primarily to meet demand for alloying. Scandium's availability from the former Soviet Union increased substantially in 1992, after export controls were relaxed, and sales to the Western World, especially from Ukraine, have been increasing. China also continued to supply goods to the U.S. market.

The price of scandium materials varies greatly based on purity and quantity. The weight-to-price ratio of scandium metals and compounds was generally much higher for gram quantities than for kilogram purchases. Kilogram prices for scandium metal ingot were typically double the cost of the starting scandium compound, while higher purity distilled or sublimed metal ranged from four to six times the cost of the starting material.

World Mine Production, Reserves, and Reserve Base: Scandium was produced as a byproduct material in China, Kazakhstan, Ukraine, and Russia. Foreign mine production data were not available. No scandium was mined in the United States in 2001. Scandium occurs in many ores in trace amounts, but has not been found in sufficient quantities to be considered a reserve or reserve base.[5] As a result of its low concentration, scandium has been produced exclusively as a byproduct during processing of various ores or recovered from previously processed tailings or residues.

World Resources: Resources of scandium are abundant, especially when considered in relation to actual and potential demand. Scandium is rarely concentrated in nature due to its lack of affinity to combine with the common ore forming anions. It is widely dispersed in the lithosphere and forms solid solutions in over 100 minerals. In the Earth's crust, scandium is primarily a trace constituent of ferromagnesium minerals. Concentrations in these minerals (amphibole-hornblende, pyroxene, and biotite) typically range from 5 to 100 parts per million equivalent Sc_2O_3. Ferromagnesium minerals commonly occur in the igneous rocks, basalt, and gabbro. Enrichment of scandium also occurs in rare-earth minerals, wolframite, columbite, cassiterite, beryl, garnet, muscovite, and the aluminum phosphate minerals. Recent domestic production has primarily been from the scandium-yttrium silicate mineral, thortveitite, and from byproduct leach solutions from uranium operations. One of the principal domestic scandium resources is the fluorite tailings from the Crystal Mountain deposit near Darby, MT. Tailings from the mined-out fluorite operations, which were generated from 1952 to 1971, contain thortveitite and associated scandium-enriched minerals. Resources are also contained in the tantalum residues previously processed at Muskogee, OK. Smaller resources are contained in tungsten, molybdenum, and titanium minerals from the Climax molybdenum deposit in Colorado, and in kolbeckite, varisite, and crandallite at Fairfield, UT. Other lower grade domestic resources are present in ores of aluminum, cobalt, iron, molybdenum, nickel, phosphate, tantalum, tin, titanium, tungsten, zinc, and zirconium. Process residues from tungsten operations in the United States also contain significant amounts of scandium.

Foreign resources are known in Australia, China, Kazakhstan, Madagascar, Norway, Russia, and Ukraine. Resources in Australia are contained in nickel and cobalt deposits in Syerston and Lake Innes, New South Wales. China's resources are in tin, tungsten, and iron deposits in Jiangxi, Guangxi, Guangdong, Fujian, and Zhejian Provinces. Resources in Russia and Kazakhstan are in the Kola Peninsula apatites and in uranium-bearing deposits, respectively. Scandium in Madagascar is contained in pegmatites in the Befanomo area. Resources in Norway are dispersed in the thortveitite-rich pegmatites of the Iveland-Evje Region and a deposit in the northern area of Finnmark. In Ukraine, scandium is recovered as a byproduct of iron ore processing at Zheltye Voda. An occurrence of the mineral thortveitite is reported from Kobe, Japan. Undiscovered scandium resources are thought to be very large.

Substitutes: In applications, such as lighting and lasers, scandium is generally not subject to substitution. In metallurgical applications, titanium and aluminum high-strength alloys and carbon fiber may substitute in sporting goods, especially bicycle frames.

[e]Estimated. NA Not available.

[1]Less than 250 micron, 99.9% purity, 1995 through 2000 prices converted from 0.5-gram price, from Alfa Aesar, a Johnson Matthey company. Me pieces, distilled dendritic, 99.9% purity.

[2]Lump, sublimed dendritic 99.99% purity, from Alfa Aesar, a Johnson Matthey company, 1997 through 2000. Metal pieces 99.9% purity for 2001.

[3]Bromide, chloride, and fluoride in crystalline or crystalline aggregate form and scandium iodide as ultradry powder from Alfa Aesar, a Johnson Ma company.

[4]Defined as imports - exports + adjustments for Government and industry stock changes.

[5]See Appendix C for definitions.

SELENIUM

(Data in metric tons of selenium content, unless otherwise noted)

Domestic Production and Use: Primary selenium was recovered from anode slimes generated in the electrolytic refining of copper. Two copper refineries in Texas accounted for domestic production of primary selenium. Anode slimes from other primary electrolytic refiners were exported for processing. The estimated consumption of selenium by end use was as follows: glass manufacturing, 35%; chemicals and pigments, 20%; electronics, 12%; and other, including agriculture and metallurgy, 33%. In glass manufacturing, selenium was used to decolor container glass and other soda-lime silica glasses and to reduce solar heat transmission in architectural plate glass. Cadmium sulfoselenide red pigments, which have good heat stability, were used in ceramics and plastics. Chemical uses included rubber compounding chemicals, gun bluing, catalysts, human dietary supplements, and antidandruff shampoos. Dietary supplementation for livestock was the largest agricultural use. Combinations of bismuth and selenium were added to brasses to replace lead in plumbing applications. Selenium was added to copper, lead, and steel alloys to improve their machinability. In electronics, high-purity selenium was used primarily as a photoreceptor on the drums of plain paper copiers; but this application has reached the replacement only stage because selenium has been supplanted by newer materials in currently manufactured copiers.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, refinery	W	W	W	W	W
Imports for consumption, metal and dioxide	346	339	326	452	500
Exports, metal, waste and scrap	127	151	233	89	75
Consumption, apparent[1]	W	W	W	W	W
Price, dealers, average, dollars per pound, 100-pound lots, refined	2.94	2.49	2.55	3.82	3.85
Stocks, producer, refined, yearend	W	W	W	W	W
Employment, number	NA	NA	NA	NA	NA
Net import reliance[2] as a percentage of apparent consumption	W	W	W	W	W

Recycling: There was no domestic production of secondary selenium. Scrap xerographic materials were exported for recovery of the contained selenium. An estimated 25 tons of selenium metal recovered from scrap was imported in 2001.

Import Sources (1997-2000): Canada, 38%; Philippines, 34%; Belgium, 10%; United Kingdom, 5%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Selenium metal	2804.90.0000	Free.
Selenium dioxide	2811.29.2000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert D. Brown, Jr. [(703) 648-4984, rbrown@usgs.gov, fax: (703) 648-7757]**

SELENIUM

Events, Trends, and Issues: Domestic selenium consumption increased slightly when compared with that of 2000. World selenium demand and production were steady, so the long-term oversupply situation was not eased slightly in 2001. Lower production of selenium was caused by the use of ores with lower selenium content, the use of solvent extraction in place of older slime-producing technology, and the closure of some copper operations owing to low copper prices. The price of selenium was nearly constant at $3.65 per pound for the first half of the year. Concern over supply caused the price to increase to more than $4.00 per pound in the second half of the year.

The use of selenium in glass remained strong. The use in copiers continued to decline, while the use in metallurgical additives increased. The use of selenium as an additive to no-lead, free-machining brasses for plumbing applications continued to increase as more stringent regulations on lead in drinking water were met (ordinary free-machining brass contains up to 7% lead). Alloys with bismuth/selenium additions are dominating this market. Selenium also reduces the quantity of bismuth needed, without adverse effects on alloy properties.

Research continued to confirm the effectiveness of dietary selenium supplementation for human cancer prevention, and the use of selenium supplements in the plant-animal-human food chain increased. However, even if proven safe and effective, the dosage requirement for direct human consumption would be small, 200 to 400 micrograms per day per person; consequently, selenium demand would not change dramatically. Increased supplementation of fertilizer could be another way to achieve this public health benefit. Selenium already is added to fertilizer used to improve feed for livestock.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[3]	Reserve base[3]
	2000	2001[e]		
United States	W	W	10,000	19,000
Belgium	150	200	—	—
Canada	350	360	7,000	15,000
Chile	49	45	19,000	30,000
Finland	26	25	—	—
Germany	100	100	—	—
Japan	612	600	—	—
Peru	23	25	2,000	5,000
Philippines	40	40	2,000	3,000
Sweden	20	20	—	—
Yugoslavia	15	20	1,000	1,000
Zambia	10	10	3,000	6,000
Other countries[4]	10	10	27,000	55,000
World total (rounded)	[5]1,410	[5]1,460	70,000	130,000

World Resources: In addition to the reserve base of selenium, which is contained in identified economic copper deposits, 2.5 times this quantity of selenium was estimated to exist in copper or other metal deposits that were undeveloped, of uneconomic grade, or as yet undiscovered. Coal contains an average of 1.5 parts per million of selenium, which is about 80 times the average for copper deposits, but recovery of selenium from coal appears unlikely in the foreseeable future.

Substitutes: High-purity silicon has replaced selenium in high-voltage rectifiers and is the major substitute for selenium in low- and medium-voltage rectifiers. Other inorganic semiconductor materials, such as silicon, cadmium, tellurium, gallium, and arsenic, as well as organic photoconductors, substitute for selenium in photoelectric applications. Other substitutes include cerium oxide in glass manufacturing; tellurium in pigment and rubber compounding; bismuth, lead, and tellurium in free-machining alloys; and bismuth and tellurium in lead-free brasses.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Defined as reported shipments + imports of selenium metal - estimated exports of selenium metal, excluding scrap.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.
[4]In addition to the countries listed, Australia, China, India, Kazakhstan, Russia, the United Kingdom, and Zimbabwe are known to produce refined selenium.
[5]Excludes U.S. production.

SILICON

(Data in thousand metric tons of silicon content, unless otherwise noted)

Domestic Production and Use: Estimated value of silicon metal and alloys (excluding semiconductor-grade silicon) produced in the United States in 2001 was about $300 million. Ferrosilicon was produced by five companies in five plants, and silicon metal was produced by three companies in four plants. Two of the six companies in the industry produced both products. All but one of the active ferrosilicon and silicon metal plants were east of the Mississippi River. Most ferrosilicon was consumed in the ferrous foundry and steel industries, predominantly in the eastern one-half of the United States. The main consumers of silicon metal were producers of aluminum and aluminum alloys and the chemical industry. The semiconductor industry, which manufactures chips for computers from high-purity silicon, accounted for only a few percent of silicon demand.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production	430	429	423	367	301
Imports for consumption	256	241	286	361	235
Exports	50	47	61	41	25
Consumption, apparent	628	616	643	689	518
Price,[1] average, cents per pound Si:					
Ferrosilicon, 50% Si	54.8	52.1	49.1	45.0	43
Ferrosilicon, 75% Si	48.0	43.1	40.2	35.4	31
Silicon metal	81.4	70.5	58.1	54.8	52
Stocks, producer, yearend	44	50	54	52	45
Net import reliance[2] as a percentage of apparent consumption	32	30	34	47	42

Recycling: Insignificant.

Import Sources (1997-2000): Norway, 27%; South Africa, 15%; Russia, 11%; Canada, 10%; and other, 37%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12/31/01**
Ferrosilicon, 55%-80% Si:		
More than 3% Ca	7202.21.1000	1.1% ad val.
Other	7202.21.5000	1.5% ad val.
Ferrosilicon, 80%-90% Si	7202.21.7500	1.9% ad val.
Ferrosilicon, more than 90% Si	7202.21.9000	5.8% ad val.
Ferrosilicon, other:		
More than 2% Mg	7202.29.0010	Free.
Other	7202.29.0050	Free.
Silicon, more than 99.99% Si	2804.61.0000	Free.
Silicon, 99.00%-99.99% Si	2804.69.1000	5.3% ad val.
Silicon, other	2804.69.5000	5.5% ad val.

Depletion Allowance: Quartzite, 14% (Domestic and foreign); gravel, 5% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic apparent consumption of silicon for 2001 is projected to be the least since 1991. Of the 2001 total, the share accounted for by ferrosilicon is estimated to have decreased to 53%, while that for silicon metal increased to 47%. The annual growth rate for ferrosilicon demand usually falls in the range of 1% to 2%, in line with long-term trends in steel production. Through the first one-half of 2001, however, domestic steel production was 13% less than for 2000. During recent years, the annual growth rate for overall silicon metal demand has been in the vicinity of 5%. This rate probably was not sustained, at least in part because of lagging global demand by the chemical industry, principally for silicones. Formerly, the growth rate in chemical demand has averaged about 8%.

Domestic production in 2001, expressed in terms of contained silicon, is projected to have declined significantly. For all silicon materials combined, the overall decline was nearly 20% to the lowest level since 1982. Production was curtailed or stopped at some plants because of high power costs and/or slackening demand.

Prepared by **Thomas S. Jones [(703) 648-4973, tjones@usgs.gov, fax: (703) 648-7757]**

SILICON

Through the first 9 months of 2001, price trends in the U.S. market for silicon materials were downward for ferrosilicon and slightly upward for silicon metal. Compared with those at the beginning of the year, prices as of the end of September were lower by 8% to 10% for ferrosilicon and higher by 1% for silicon metal. Year-average prices were projected to be lower than those for 2000 for all forms of silicon; the largest percentage decline was expected for 75% ferrosilicon. The price for silicon metal was projected to be the least since 1977. At the end of September, the range in dealer import price, in cents per pound of contained silicon, was 40 to 42.5 for 50% ferrosilicon, 30 to 31 for 75% ferrosilicon, and 49 to 52 for silicon metal.

U.S. imports and exports of silicon materials in 2001, projected on the basis of data for the first 6 months of the year, were significantly less than those in 2000. The smallest overall percentage decline was for imports of silicon metal. Net import reliance declined but was still high in comparison with that for most prior years.

World Production, Reserves, and Reserve Base:

	Production[e]		Reserves and reserve base[3]
	2000	2001	
United States	367	301	The reserves and reserve base in most major producing countries are ample in relation to demand. Quantitative estimates are not available.
Brazil	292	235	
Canada	66	59	
China	910	975	
France	145	137	
Iceland	46	48	
India	39	36	
Kazakhstan	78	88	
Norway	397	379	
Poland	47	44	
Russia	463	468	
Slovakia	46	39	
South Africa	98	97	
Spain	55	52	
Ukraine	210	211	
Venezuela	39	37	
Other countries	211	206	
World total (rounded)	3,500	3,400	

Production quantities given above are combined totals of estimated content for ferrosilicon and silicon metal, as applicable. For the world, ferrosilicon accounts for about four-fifths of the total. The leading countries for ferrosilicon production were China, Norway, Russia, Ukraine, and the United States, and for silicon metal Brazil, China, France, Norway, and the United States. China was by far the largest producer of ferrosilicon and may well have been the largest producer of silicon metal. China's production of silicon metal is not included in this tabulation because data are not available.

World Resources: World and domestic resources for making silicon metal and alloys are abundant, and, in most producing countries, adequate to supply world requirements for many decades. The source of the silicon is silica in various natural forms, such as quartzite.

Substitutes: Aluminum, silicon carbide, and silicomanganese can be substituted for ferrosilicon in some applications. Gallium arsenide and germanium are the principal substitutes for silicon in semiconductor and infrared applications.

[e]Estimated.
[1]Based on U.S. dealer import price.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.

SILVER

(Data in metric tons[1] of silver content, unless otherwise noted)

Domestic Production and Use: In 2001, U.S. mine production of silver was about 1,800 tons with an estimated value of $290 million. Nevada was the largest producer, with more than 600 tons. Precious metal ores accounted for approximately one-half of domestic silver production; the other one-half was recovered as a byproduct from processing of copper, lead, and zinc ores. There were 22 principal refiners of commercial-grade silver with an estimated output of approximately 2,800 tons. About 30 fabricators accounted for more than 90% of the silver consumed in arts and industry. The remainder was consumed mostly by small companies and artisans. Aesthetic uses of silver for decorative articles, jewelry, tableware, and coinage were overshadowed by industrial and technical uses. Industrial and technical uses include photographic materials, electrical and electronic products, catalysts, brazing alloys, dental amalgam, and bearings.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Mine	2,180	2,060	1,950	1,860	1,800
Refinery:					
Primary	2,200	2,300	2,000	2,780	2,800
Secondary	1,360	1,700	1,500	1,680	1,700
Imports for consumption[2]	2,540	3,330	2,660	3,810	2,900
Exports[2]	2,980	2,250	481	279	470
Consumption, apparent[e]	4,980	5,300	5,500	6,300	5,800
Price, dollars per troy ounce[3]	4.89	5.54	5.25	5.00	5.00
Stocks, yearend:					
Treasury Department[4]	484	582	617	220	100
COMEX, CBT[5]	3,430	2,360	2,360	2,920	2,900
National Defense Stockpile	1,220	1,030	778	458	200
Employment, mine and mill,[6] number	1,550	1,550	1,500	1,500	1,300
Net import reliance[7] as a percentage of apparent consumption[e]	E	43	39	43	44

Recycling: About 1,680 tons of silver was recovered from old and new scrap in 2000.

Import Sources[2] (1997-2000): Mexico, 38%; Canada, 37%; Peru, 8%; United Kingdom, 8%; and other, 9%.

Tariff: No duties are imposed on imports of unrefined silver or refined bullion.

Depletion Allowance: 15% (Domestic), 14% (Foreign).

Government Stockpile: The Defense Logistics Agency (DLA) delivered all of the remaining 467 tons of silver in the National Defense Stockpile to the U.S. Mint for use in its coinage program. Under an agreement with the U.S. Treasury Department, the metal will continue to be carried as DLA stocks until the metal is consumed by the Mint. The transfer marked the end of the silver stockpile era.

Stockpile Status—9-30-01[8]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Silver	321	—	321	404	147

Prepared by **Henry E. Hilliard [(703) 648-4970, hhilliar@usgs.gov, fax: (703) 648-7757]**

SILVER

Events, Trends, and Issues: Photographic applications account for about 28% of total silver demand, and digital imaging is considered to be a potential threat to this sector of the market. In contrast to the use of silver halide film in conventional photography, digital technology converts images directly into electronic form, thereby avoiding the need for silver. Silver halide pictures may also be scanned into electronic form, which necessitates the use of silver in taking and printing the picture, but eliminates the need for silver halide technology in further processing.

After maintaining a price range $4.20 to $4.30 per troy ounce for most of 2001, silver prices began to fall in the first week of August. The London fix on August 7 was $4.14 per ounce, down $0.12 from levels in July and down $0.78 from levels in the first week of August 2000. The $4.14 per ounce fix was the lowest in 8 years. Depressed prices were mostly responsible for the closing of the Sunshine Mine, ID, and reduced operations at the Lucky Friday Mine, ID. Silver production at Lucky Friday is expected to be only 109 tons in 2001 compared with 140 tons if the mine had continued normal production.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[9]	Reserve base[9]
	2000	2001[e]		
United States	1,860	1,800	30,000	75,000
Australia	1,720	2,060	33,000	37,000
Canada	1,246	1,200	35,000	47,000
Mexico	2,338	2,600	37,000	40,000
Peru	2,217	2,500	25,000	37,000
Other countries	8,230	8,160	120,000	190,000
World total (may be rounded)	17,700	18,300	280,000	430,000

World Resources: More than two-thirds of world silver resources are associated with copper, lead, and zinc deposits, often at great depths. The remainder is in vein deposits in which gold is the most valuable metallic component. Although most recent discoveries have been primarily gold and silver deposits, significant future reserves and resources are expected from major base metal discoveries that contain byproduct silver. Although the price of silver and improved technology may appear to increase the reserves and reserve base, the extraction of silver from these resources will be driven by demand for the primary base metals.

Substitutes: Aluminum and rhodium can be substituted for silver in mirrors and other reflecting surfaces. Tantalum can be used in place of silver for surgical plates, pins, and sutures. Stainless steel is an alternate material used widely in the manufacture of table flatware. Nonsilver batteries being developed may replace silver batteries in some applications. Silverless black and white film, xerography, and film with reduced silver content are alternatives to some uses of silver in photography.

[e]Estimated. E Net exporter. — Zero.
[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Refined bullion, plus silver content of ores, concentrates, precipitates, and doré; excludes coinage, waste, and scrap material.
[3]Handy & Harman quotations.
[4]Balance in U.S. Mint only.
[5]COMEX: Commodity Exchange Inc., New York. CBT: Chicago Board of Trade.
[6]Source: Mine Safety and Health Administration.
[7]Defined as imports - exports + adjustments for Government and industry stock changes.
[8]See Appendix B for definitions.
[9]Includes silver recoverable from base metal ores. See Appendix C for definitions.

SODA ASH

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Four companies in Wyoming operating five plants, one company in California with one plant, and one company with one plant in Colorado composed the U.S. soda ash (sodium carbonate) industry, which was the largest in the world. The six producers have a combined annual nameplate capacity of 14.5 million tons. Sodium bicarbonate, sodium sulfate, potassium chloride, potassium sulfate, borax, and other minerals were produced as coproducts from sodium carbonate production in California. Sodium bicarbonate, sodium sulfite, sodium tripolyphosphate, and chemical caustic soda were manufactured as coproducts at several of the Wyoming soda ash plants. Sodium bicarbonate was produced as a coproduct at the Colorado operation. The total estimated value of domestic soda ash produced in 2001 was $780 million.[1]

Based on final 2000 data, the estimated 2001 reported distribution of soda ash by end use was glass, 50%; chemicals, 27%; soap and detergents, 11%; distributors, 6%; flue gas desulfurization and pulp and paper, 2% each; and water treatment and other, 1% each.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production[2]	10,700	10,100	10,200	10,200	10,300
Imports for consumption	101	83	92	75	40
Exports	4,190	3,660	3,620	3,900	4,100
Consumption:					
Reported	6,480	6,550	6,430	6,390	6,200
Apparent	6,670	6,560	6,740	6,430	6,200
Price:					
Quoted, yearend, soda ash, dense, bulk, f.o.b. Green River, WY, dollars per short ton	105.00	105.00	105.00	105.00	105.00
F.o.b. Searles Valley, CA, same basis	130.00	130.00	130.00	130.00	130.00
Average sales value (natural source), f.o.b. mine or plant, same basis	77.25	75.30	69.11	66.23	69.00
Stocks, producer, yearend	259	273	248	245	275
Employment, mine and plant, number	2,800	2,700	2,600	2,600	2,700
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: There is no recycling of soda ash by producers; however, glass container producers are using cullet glass, thereby reducing soda ash consumption.

Import Sources (1997-2000): Canada, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Disodium carbonate	2836.20.0000	1.2% ad val.

Depletion Allowance: Natural, 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The domestic market for soda ash continued to decrease but was partially offset with an increase in export sales. To alleviate some of the oversupply that has affected the industry, about 2.4 million tons of nameplate capacity was idled by three U.S. producers. This included the entire Granger, WY, facility and a U.S. producer's synthetic soda ash plant in Amherstburg, Ontario, Canada. Rising energy costs also adversely affected the operating economics of the facilities. To counter this, soda ash producers announced a temporary $7 per ton energy surcharge on top of a $10 price increase that was to go into effect October 1 or as contracts permitted. The surcharge was rescinded late in the year but was followed by a $5 price increase, making a total of $15 for the proposed price increase.

U.S. soda ash exports increased an estimated 5%. This was partially attributed to the closure of the synthetic soda ash plant at Kita Kyushu, Japan, in March. The operation had a capacity of 350,000 tons per year. The company, which was a joint venture partner with a Wyoming soda ash producer, will import its soda ash requirements from the United States.

Prepared by **Dennis S. Kostick [(703) 648-7715, dkostick@usgs.gov, fax: (703) 648-7722]**

SODA ASH

Production of glass containers which declined about 6% in 2001 contributed to reduced soda ash consumption. A major baby food manufacturing company began packaging its products in polyethylene terephthalate (PET) plastic jars in lieu of glass. Another promising sector for increased use of PET is the beer industry. More arenas and stadiums were selling beer in plastic bottles because of their safety and lightweight. Increased demand for PET for these products will cause a corresponding decline in soda ash sales.

The United States will continue to be the largest supplier of soda ash in the world; however, China is rapidly expanding its soda ash manufacturing capability. It is anticipated that competition with China for markets in Asia will be strong in the future. Notwithstanding the economic and energy problems in certain areas of the world, the overall world demand for soda ash is expected to grow 1.5% to 2% annually in the early part of this century. Domestic demand should be slightly higher in 2002.

World Production, Reserves, and Reserve Base:

	Production		Reserves[4] [5]	Reserve base[5]
Natural:	2000	2001[e]		
United States	10,200	10,300	[6]23,000,000	[6]39,000,000
Botswana	225	200	400,000	NA
Kenya	246	230	7,000	NA
Mexico	—	—	200,000	450,000
Turkey	—	—	200,000	240,000
Uganda	NA	NA	20,000	NA
Other countries	—	—	260,000	220,000
World total, natural (may be rounded)	10,700	10,700	24,000,000	40,000,000
World total, synthetic (rounded)	23,500	22,300	—	—
World total (rounded)	34,200	33,000	—	—

World Resources: Soda ash is obtained from trona and sodium carbonate-rich brines. The world's largest deposit of trona is in the Green River Basin of Wyoming. About 47 billion metric tons of identified soda ash resources could be recovered from the 56 billion tons of bedded trona and the 47 billion tons of interbedded or intermixed trona and halite that are in beds more than 1.2 meters thick. About 34 billion tons of reserve base soda ash could be obtained from the 36 billion tons of halite-free trona and the 25 billion tons of interbedded or intermixed trona and halite that are in beds more than 1.8 meters thick. Underground room-and-pillar mining, using a combination of conventional, continuous, and shortwall mining equipment is the primary method of mining Wyoming trona ore. The method has an average 45% mining recovery, which is higher than the 30% average mining recovery from solution mining. Improved solution mining techniques, such as horizontal drilling to establish communication between well pairs, could increase this extraction rate and enable companies to develop some of the deeper economic trona. Wyoming trona resources are being depleted at the rate of about 15 million tons per year (8.3 million tons of soda ash). Searles Lake and Owens Lake in California contain an estimated 815 million tons of soda ash reserves. There are at least 62 identified natural sodium carbonate deposits in the world, some of which have been quantified. Although soda ash can be manufactured from salt and limestone, both of which are practically inexhaustible, synthetic soda ash is more costly to produce and generates environmentally deleterious wastes.

Substitutes: Caustic soda can be substituted for soda ash in certain uses, particularly in the pulp and paper, water treatment, and certain chemical sectors. Soda ash, soda liquors, or trona can be used as feedstock to manufacture chemical caustic soda, which is an alternative to electrolytic caustic soda.

[e]Estimated. E Net exporter. NA Not available. — Zero.

[1]Does not include values for soda liquors and mine waters.

[2]Natural only.

[3]Defined as imports - exports + adjustments for Government and industry stock changes.

[4]The reported quantities are sodium carbonate only. About 1.8 tons of trona yields 1 ton of sodium carbonate.

[5]See Appendix C for definitions.

[6]From trona, nahcolite, and dawsonite sources.

SODIUM SULFATE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: The domestic natural sodium sulfate industry consisted of two producers operating two plants in California and Texas. Fourteen companies operating 17 plants in 16 States recovered byproduct sodium sulfate from various manufacturing processes or products, including ascorbic acid, battery reclamation, cellulose, rayon, and silica pigments. More than one-half of total output was a byproduct of these plants. The total value of natural and synthetic sodium sulfate sold was an estimated $60 million. Estimates of U.S. sodium sulfate consumption by end use were soap and detergents, 46%; textiles, 12%; pulp and paper, 13%; glass, 11%; carpet fresheners, 7%; and miscellaneous, 11%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, total (natural and synthetic)[1]	640	571	599	491	510
Imports for consumption	150	110	87	73	40
Exports	86	90	137	165	220
Consumption, apparent (natural and synthetic)	697	591	549	399	330
Price, quoted, sodium sulfate (100% Na_2SO_4), bulk, f.o.b. works, East, dollars per short ton	114.00	114.00	114.00	114.00	114.00
Employment, well and plant, number[e]	225	225	225	225	225
Net import reliance[2] as a percentage of apparent consumption	9	3	E	E	E

Recycling: There was some recycling of sodium sulfate by consumers, particularly in the pulp and paper industry, but no recycling by sodium sulfate producers.

Import Sources (1997-2000): Canada, 95%; Mexico, 4%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Disodium sulfate:		
Saltcake (crude)	2833.11.1000	Free.
Other:	2833.11.5000	0.4% ad val.
Anhydrous	2833.11.5010	0.4% ad val.
Other	2833.11.5050	0.4% ad val.

Depletion Allowance: Natural, 14% (Domestic and foreign); synthetic, none.

Government Stockpile: None.

Prepared by **Dennis S. Kostick [(703) 648-7715, dkostick@usgs.gov, fax: (703) 648-7722]**

SODIUM SULFATE

Events, Trends, and Issues: The closure of byproduct sodium sulfate operations in Mobile, AL, and Monument, NM, and the natural sodium sulfate operation in Inglebright, Saskatchewan, Canada, helped reduce the oversupply situation for sodium sulfate in North America. These three facilities had a combined annual capacity of about 260,000 tons. The tightening of supply and the impact of rising energy costs prompted producers to raise prices in April. Various producers raised prices between $10 per short ton to $13 per short ton; some customers who had price-protected contracts were requested to pay an energy surcharge of $9 per short ton.

Sodium sulfate demand continued to decline in 2001. Although powdered home laundry detergents may contain as much as 50% sodium sulfate in their formulation, the market for liquid detergents, which do not contain any sodium sulfate, continued to grow. Sodium sulfate consumption in the textile industry also has been declining because of imports of less expensive textile products. Declining domestic demand resulted in a decrease in imports, especially from Canada. However, the growth in the detergent and textile sectors in Central America and South America caused U.S. sodium sulfate exports to increase. Exports are expected to continue increasing in the next few years.

The outlook for sodium sulfate in 2002 is expected to be comparable with that of 2001, with detergents remaining the largest sodium sulfate-consuming sector. World production and consumption of sodium sulfate have been stagnant but are expected to grow in the next few years, especially in Asia and South America.

World Production, Reserves, and Reserve Base: Although data on mine production for natural sodium sulfate are not available, total world production of natural sodium sulfate is estimated to be about 4 million tons. Total world production of byproduct sodium sulfate is estimated between 1.5 million and 2.0 million tons.

	Reserves[3]	Reserve base[3]
United States	860,000	1,400,000
Canada	84,000	270,000
Mexico	170,000	230,000
Spain	180,000	270,000
Turkey	100,000	NA
Other countries	1,900,000	2,400,000
World total (rounded)	3,300,000	4,600,000

World Resources: Sodium sulfate resources are sufficient to last hundreds of years at the present rate of world consumption. In addition to the countries listed above with reserves, the following countries also contain identified resources of sodium sulfate: Botswana, China, Egypt, Italy, Mongolia, Romania, and South Africa. Commercial production from domestic resources is from deposits in California and Texas. The brine in Searles Lake, CA, contains about 450 million tons of sodium sulfate resource, representing about 35% of the lake brine. In Utah, about 12% of the dissolved salts in the Great Salt Lake is sodium sulfate, representing about 400 million tons of resource. An irregular, 21-meter-thick mirabilite deposit is associated with clay beds 4.5 to 9.1 meters below the lake bottom near Promontory Point, UT. Several playa lakes in west Texas contain underground sodium-sulfate-bearing brines and crystalline material. Other economic and subeconomic deposits of sodium sulfate are near Rhodes Marsh, NV, Grenora, ND, Okanogan County, WA, and Bull Lake, WY. Sodium sulfate can also be obtained as a byproduct from the production of ascorbic acid, boric acid, cellulose, chromium chemicals, lithium carbonate, rayon, resorcinol, and silica pigments. The quantity and availability of byproduct sodium sulfate are dependent on the production capabilities of the primary industries and the sulfate recovery rates.

Substitutes: In pulp and paper, emulsified sulfur and caustic soda (sodium hydroxide) can replace sodium sulfate. In detergents, a variety of products can substitute for sodium sulfate. In glassmaking, soda ash and calcium sulfate have been substituted for sodium sulfate with less effective results.

[e]Estimated. E Net exporter. NA Not available.
[1]Source: U.S. Census Bureau. Synthetic production data are revised in accordance with recent updated Census statistics.
[2]Defined as imports - exports + adjustments for Government and industry stock changes (if available).
[3]See Appendix C for definitions.

STONE (CRUSHED)[1]

(Data in million metric tons, unless otherwise noted)[2]

Domestic Production and Use: Crushed stone valued at $9 billion was produced by 1,400 companies operating 3,700 active quarries in 49 States. Leading States, in order of production, were Texas, Pennsylvania, Florida, Ohio, Illinois, Georgia, Missouri, Virginia, North Carolina, and California, together accounting for 52.5% of the total output. It is estimated that, of the 1.6 billion tons of crushed stone produced in 2001, about 44% was for unspecified uses of which 15% was estimated for nonrespondents. Of the remaining 869 million tons, 82% was used as construction aggregates mostly for highway and road construction and maintenance; 15% for chemical and metallurgical uses, including cement and lime manufacture; 2% for agricultural uses; and 1% for special and miscellaneous uses and products. To provide a more meaningful estimate of the consumption patterns for crushed stone, the "unspecified uses" as defined in the U.S. Geological Survey (USGS) Minerals Yearbook, are not included in the above percentages. Of the total crushed stone produced in 2001, about 70% was limestone and dolomite; 16%, granite; 7%, traprock; and the remaining 7%, was shared, in descending order of quantity, by sandstone and quartzite, miscellaneous stone, marble, calcareous marl, slate, shell, and volcanic cinder and scoria.

The estimated output of crushed stone in the 48 conterminous States shipped for consumption in the first 9 months of 2001 was 1.2 billion tons, which represents an increase of 5.5% compared with the same period of 2000. The estimated output of construction sand and gravel produced for consumption in the first 9 months of 2001 was 845 million metric tons, an increase of only 0.9% compared with the same period of 2000. Additional production information, by quarter for each State, geographic division, and the United States, is published in the USGS quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production	1,410	1,510	1,530	1,560	1,620
Imports for consumption	12	14	12	13	15
Exports	4	4	4	4	4
Consumption, apparent	1,418	1,520	1,548	1,569	1,631
Price, average value, dollars per metric ton	5.64	5.39	5.35	5.39	5.53
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e 3]	77,600	78,500	79,000	78,800	79,200
Net import reliance[4] as a percentage of apparent consumption	1	1	1	1	1

Recycling: Road surfaces made of asphalt and crushed stone and, to a lesser extent, cement concrete surfaces and structures were recycled on a limited but increasing basis in most States.

Import Sources (1997-2000): Canada, 53%; Mexico, 33%; The Bahamas, 8%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Crushed stone	2517.10.00	Free.

Depletion Allowance: For some special uses, 14% (Domestic and foreign); if used as riprap, ballast, road material, concrete aggregate, and similar purposes, 5% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Valentin V. Tepordei, [(703) 648-7728, vtepordei@usgs.gov, fax: (703) 648-7975]**

STONE (CRUSHED)

Events, Trends, and Issues: Crushed stone output increased 3.8% in 2001 to 1.6 billion tons. It is estimated that in 2002, domestic production and apparent consumption will be about 1.65 billion tons each, a 2% increase. The Transportation Equity Act for the 21st Century (Public Law 105-178) appropriated $205 billion through 2003, a 44% increase compared to the previous Intermodal Surface Transportation Efficiency Act legislation. The law guarantees that $165 billion will be obligated for highways and $35 billion for transit work. The guaranteed amounts are linked to actual Highway Trust Fund receipts, and can only be used for highways and highway safety programs. The States are also guaranteed a return of at least 90.5% of their contributions to the Highway Trust Fund. The legislation also established timetables for determining if States are complying with the U.S. Environmental Protection Agency's new air quality standards for particulate matter, also known as PM 2.5. The Aviation Investment and Reform Act for the 21st Century (Public Law 106-181) was signed into law on April 5, 2000. The law is a 3-year reauthorization of Federal Aviation Administration programs that released an estimated $3.2 billion in fiscal year 2001 funding that will increase to $3.3 billion in fiscal year 2002 and to $3.4 billion in fiscal year 2003.

The crushed stone industry continues to be concerned with safety regulations and environmental restrictions. Local zoning regulations and land-development alternatives that discourage quarrying are expected to continue to cause a relocation of crushed stone quarries away from high-population centers. Shortages of crushed stone in some urban and industrialized areas are expected to continue to increase.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2000	2001[e]	
United States	1,560	1,620	Adequate except where special
Other countries	NA	NA	types are needed or where
World total	NA	NA	local shortages exist.

World Resources: Stone resources of the world are very large. High-purity limestone and dolomite suitable for specialty uses are limited in many geographic areas. The largest resources of high-purity limestone and dolomite in the United States are in the central and eastern parts of the country.

Substitutes: Crushed stone substitutes for roadbuilding include sand and gravel and slag. Substitutes for construction aggregates include sand and gravel, slag, sintered or expanded clay or shale, and perlite or vermiculite.

[e]Estimated. NA Not available.
[1]See also Stone (Dimension).
[2]See Appendix A for conversion to short tons.
[3]Including office staff.
[4]Defined as imports - exports + adjustments for Government and industry stock changes. Changes in stocks were assumed to be zero in the net import reliance and apparent consumption calculations because data on stocks were not available.
[5]See Appendix C for definitions.

STONE (DIMENSION)[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Approximately 1.3 million tons of dimension stone, valued at $235 million, was sold or used in 2001. Dimension stone was produced by 116 companies, operating 165 quarries, in 33 States and Puerto Rico. Leading producer States, in descending order by tonnage, were Indiana, Vermont, Wisconsin, Texas, and Georgia. These five States accounted for 48% of the tonnage output. Leading producer States, in descending order by value, were Indiana, Vermont, Minnesota, South Dakota, and North Carolina. These States contributed 49% of the value of domestic production. Approximately 35%, by tonnage, of dimension stone sold or used was limestone, followed by granite (33%), sandstone (18%), marble (3%), slate (2%), and miscellaneous stone (9%). By value, the largest sales or uses were for granite (48%), followed by limestone (28%), sandstone (10%), slate (6%), marble (3%), and miscellaneous stone (5%). Rough block represented 55% of the tonnage and 46% of the value of all the dimension stone sold or used by domestic producers, including exports. The largest uses of rough block, by tonnage, were in construction (50%) and irregular-shaped stone (19%). Dressed stone was sold for flagging (28%), ashlars and partially squared pieces (20%), and curbing (10%), by tonnage.

Salient Statistics—United States:[2]	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production:					
Tonnage	1,180	1,140	1,250	1,250	1,300
Value, million dollars	225	225	254	235	235
Imports for consumption, value, million dollars	548	698	808	925	1,030
Exports, value, million dollars	55	60	55	60	60
Consumption, apparent, value, million dollars	718	863	1,010	1,100	1,200
Price	Variable, depending on type of product				
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[3]	3,000	3,000	3,000	3,000	3,000
Net import reliance[4] as a percentage of apparent consumption (based on value)	69	74	75	78	80
Granite only:					
Production	444	420	437	415	415
Imports for consumption	NA	NA	NA	NA	NA
Exports (rough and finished)	166	145	166	134	134
Consumption, apparent	NA	NA	NA	NA	NA
Price	Variable, depending on type of product				
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[3]	1,500	1,500	1,500	1,500	1,500
Net import reliance[4] as a percentage of apparent consumption (based on tonnage)	NA	NA	NA	NA	NA

Recycling: Small amounts of dimension stone were recycled principally by restorers of old stone work.

Import Sources (1997-2000 by value): Dimension stone: Italy, 40%; Canada, 20%; India, 14%; Spain, 9%; and other, 17%. Granite only: Italy, 42%; Brazil, 15%; Canada, 13%; India, 12%; and other, 18%.

Tariff: Dimension stone tariffs ranged from free to 6.5% ad valorem for countries with normal trade relations in 2001, according to type, degree of preparation, shape, and size. Most crude or rough trimmed stone was imported for 3.0% ad valorem or less.

Depletion Allowance: 14% (Domestic and foreign); slate used or sold as sintered or burned lightweight aggregates, 7.5% (Domestic and foreign); dimension stone used for rubble and other nonbuilding purposes, 5% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Thomas P. Dolley [(703) 648-7710, tdolley@usgs.gov, fax: (703) 648-7722]**

STONE (DIMENSION)

Events, Trends, and Issues: Domestic production increased to about 1.3 million tons valued at $235 million in 2001. Imports increased by 12% in value to $1.04 billion. Dimension stone exports held steady at $60 million. Apparent consumption, by value, was $1.2 billion in 2001—a $100 million increase over that of 2000. Dimension stone is being used more commonly in residential markets. Additionally, improved quarrying, finishing, and handling technology, as well as a greater variety of stone and the rising costs of alternative construction materials, are among the factors that suggest a continuing increase in demand for dimension stone during the next 5 to 10 years.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2000	2001[e]	
United States	1,250	1,300	Adequate except for certain special types and local shortages.
Other countries	NA	NA	
World total	NA	NA	

World Resources: Dimension stone resources of the world are sufficient. Resources can be limited on a local level or occasionally on a regional level by the lack of a particular kind of stone that is suitable for dimension purposes.

Substitutes: In some applications, substitutes for dimension stone include brick, concrete, steel, aluminum, resin-agglomerated stone, ceramic tile, plastics, and glass.

[e]Estimated. NA Not available.
[1]See also Stone (Crushed).
[2]Includes Puerto Rico.
[3]Excluding office staff.
[4]Defined as imports - exports + adjustments for Government and industry stock changes. Changes in stocks were assumed to be zero in the net import reliance and apparent consumption calculations because data on stocks were not available.
[5]See Appendix C for definitions.

STRONTIUM

(Data in metric tons of strontium content,[1] unless otherwise noted)

Domestic Production and Use: No strontium minerals have been produced in the United States since 1959. The most common strontium mineral celestite, which consists primarily of strontium sulfate, was imported exclusively from Mexico. A company in Georgia was the only major U.S. producer of strontium compounds. Primary strontium compounds were used in the faceplate glass of color television picture tubes, 77%; ferrite ceramic magnets, 8%; pyrotechnics and signals, 9%; and other applications, 6%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, strontium minerals	—	—	—	—	—
Imports for consumption:					
Strontium minerals	12,500	10,600	13,700	11,000	7,900
Strontium compounds	26,000	25,000	26,800	29,900	30,600
Exports, compounds	599	875	2,890	4,520	1,040
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, apparent, celestite and compounds	37,900	34,700	37,600	36,400	37,500
Price, average value of mineral imports at port of exportation, dollars per ton	72	60	73	62	62
Net import reliance[2] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1997-2000): Strontium minerals: Mexico, 100%. Strontium compounds: Mexico, 92%; Germany, 6%; and other, 2%. Total imports: Mexico, 94%; Germany, 4%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Celestite	2530.90.0010	Free.
Strontium metal	2805.22.1000	3.7% ad val.
Compounds:		
Strontium carbonate	2836.92.0000	4.2% ad val.
Strontium nitrate	2834.29.2000	4.2% ad val.
Strontium oxide, hydroxide, peroxide	2816.20.0000	4.2% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: Although 5,100 tons of celestite is in the National Defense Stockpile, none of it is stockpile grade; its total value is listed as zero. The stockpile goal for celestite was reduced to zero in 1969, and at that time, the stockpile contained stockpile- and nonstockpile-grade material. Since then, all the stockpile-grade celestite has been sold. Although the nonstockpile-grade celestite has been offered for sale, none has been sold since 1979. The fiscal year 2002 Annual Materials Plan, announced at the end of October 2001 by the Defense National Stockpile Center, listed 3,270 tons of celestite to be offered for disposal. Because the remaining material does not meet the quality specifications of celestite purchasers, the material will be difficult to dispose of in the traditional markets. It might be attractive as a low-cost replacement for barite in drilling mud applications.

Prepared by **Joyce A. Ober [(703) 648-7717, jober@usgs.gov, fax: (703) 648-7722]**

STRONTIUM

Events, Trends, and Issues: With the capacity to produce 95,000 and 103,000 tons per year, respectively, Germany and Mexico have been the largest producers of strontium carbonate for many years. The German producer uses imported celestite, and Mexican producers use domestic ore to supply their plants. Operations in both countries were believed to be operating near capacity. In recent years, Chinese strontium carbonate capacity has expanded tremendously to about 140,000 tons per year, although actual production is believed to be about 100,000 tons per year. The Chinese strontium carbonate is marketed in Asia and Europe, causing decreases in celestite and strontium carbonate prices in those regions. Chinese celestite reserves are smaller and of lower quality than the ores in major producing countries including Mexico, Spain, and Turkey, raising the question of whether Chinese producers will be able to maintain high production levels to meet the demand at strontium carbonate plants for an extended period of time.

The demand for strontium carbonate for television faceplate glass continues and increases as the popularity of larger screen sizes increases. China, Europe, and North America are the most important markets for televisions. Southeast Asia and Latin America have higher growth rates, representing potentially huge markets for television manufacturers and thus the strontium carbonate industry. Flat screen technology likely will diminish the demand for strontium carbonate for television displays when the technology becomes affordable and commonplace. Industry experts, however, do not expect flat screens to present significant competition for the next 10 years.

World Mine Production, Reserves, and Reserve Base:[3]

	Mine production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	—	—	—	1,400,000
Argentina	3,000	3,000		
China	[e]200,000	200,000		
Iran	2,000	2,000		
Mexico	157,000	160,000	Other:	Other:
Pakistan	600	600	6,800,000	11,000,000
Spain	130,000	130,000		
Tajikistan	NA	NA		
Turkey	25,000	25,000		
World total (may be rounded)	520,000	520,000	6,800,000	12,000,000

World Resources: Resources in the United States are several times the reserve base. Although not thoroughly evaluated, world resources are thought to exceed 1 billion tons.

Substitutes: Although it is possible to substitute other materials for strontium in some of its applications, such a change would adversely affect product performance and/or cost. For example, barium could replace strontium in color television picture tube glass only after extensive circuit redesign to reduce operating voltages that produce harmful secondary x rays. Barium replacement of strontium in ferrite ceramic magnets would decrease the maximum energy and temperature characteristics of the magnets. Substituting for strontium in pyrotechnics would be impractical because the desired brilliance and visibility are imparted only by strontium and its compounds.

[e]Estimated. NA Not available. — Zero.
[1]The strontium content of celestite is 43.88%; this amount was used to convert units of celestite.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]Metric tons of strontium minerals.
[4]See Appendix C for definitions.

SULFUR

(Data in thousand metric tons of sulfur, unless otherwise noted)

Domestic Production and Use: In 2001, elemental sulfur and byproduct sulfuric acid were produced at 128 operations in 30 States and the U.S. Virgin Islands. Total shipments were valued at about $200 million. Elemental sulfur production was 9.3 million tons; Louisiana and Texas accounted for about 50% of domestic production. Elemental sulfur was recovered at petroleum refineries, natural-gas-processing plants, and coking plants by 39 companies at 117 plants in 26 States and the U.S. Virgin Islands. Mining of elemental sulfur using the Frasch method, ended in 2000. Byproduct sulfuric acid, representing 11% of sulfur in all forms, was recovered at 10 nonferrous smelters in 7 States by 8 companies. Three copper smelters that previously generated byproduct sulfuric acid were idle. Domestic elemental sulfur provided 70% of domestic consumption, and byproduct acid accounted for 8%. The remaining 22% of sulfur consumed was provided by imported sulfur and sulfuric acid. About 90% of sulfur was consumed in the form of sulfuric acid. Agricultural chemicals (primarily fertilizers) composed 63% of reported sulfur demand; petroleum refining, 14%; metal mining, 5%; and organic and inorganic chemicals, 5%. Other uses, accounting for 13% of demand, were widespread because a multitude of industrial products required sulfur in one form or another during some stage of their manufacture.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production:					
Frasch[e]	2,820	1,800	1,780	900	—
Recovered elemental	7,650	8,220	8,220	8,380	8,200
Other forms	1,550	1,610	1,320	1,030	1,000
Total[e] (may be rounded)	12,000	11,600	11,300	10,300	9,200
Shipments, all forms	11,900	12,100	11,100	10,500	9,100
Imports for consumption:					
Recovered, elemental	2,060	2,270	2,580	2,330	1,700
Sulfuric acid, sulfur content	659	668	447	463	480
Exports:					
Frasch and recovered elemental	703	889	685	762	760
Sulfuric acid, sulfur content	39	51	51	62	80
Consumption, apparent, all forms	13,900	14,100	13,400	12,500	10,400
Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and/or plant	36.06	29.14	37.81	24.73	18.00
Stocks, producer, yearend	761	283	451	208	300
Employment, mine and/or plant, number	3,100	3,100	3,000	3,000	2,700
Net import reliance[1] as a percentage of apparent consumption	13	18	16	18	12

Recycling: Between 3 and 5 million tons of spent sulfuric acid was reclaimed from petroleum refining and chemical processes.

Import Sources (1997-2000): Elemental: Canada, 68%; Mexico, 22%; Venezuela, 8%; and other, 2%. Sulfuric acid: Canada, 70%; Mexico, 10%; Japan, 8%; and other, 12%. Total sulfur imports: Canada, 68%; Mexico, 20%; Venezuela, 6%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Sulfur, crude or unrefined	2503.00.0010	Free.
Sulfur, all kinds, other	2503.00.0090	Free.
Sulfur, sublimed or precipitated	2802.00.0000	Free.
Sulfuric acid	2807.00.0000	Free.

Depletion Allowance: 22% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Joyce A. Ober [(703) 648-7717, jober@usgs.gov, fax: (703) 648-7722]**

SULFUR

Events, Trends, and Issues: Total sulfur production decreased significantly in 2001 because the final U.S. Frasch mine closed in 2000. Production of recovered elemental sulfur from petroleum refineries will continue its steady growth, supported by new facilities being installed to increase refining capacity and the capability of current operations to handle higher sulfur crude oil. Additional equipment will be installed at many refineries to reduce the sulfur in gasoline and diesel fuel to comply with the new environmental regulations enacted in 2000 and 2001. Recovered sulfur from natural gas processing decreased. Byproduct sulfuric acid production continued at low rates. A Frasch operation in Poland closed, leaving one in operation there. Despite decreased native sulfur production, world production remained about the same because of expanded recovered sulfur production worldwide. Pyrites production decreased because of environmental and cost considerations.

Significantly decreased production in the domestic phosphate fertilizer industry resulted in dramatically lower sulfur consumption. Increased production of phosphate fertilizers could raise sulfur consumption to about 11.2 million tons in 2002. Increased imports will be required to meet most increased demand. Additional facilities for importing formed sulfur were under development to increase the alternative sources available.

World Production, Reserves, and Reserve Base:

	Production—All forms		Reserves[2]	Reserve base[2]
	2000	2001[e]		
United States	10,300	9,200	80,000	230,000
Australia	689	750	NA	NA
Belgium	410	400	NA	NA
Canada	9,900	9,500	160,000	330,000
Chile	1,100	1,100	NA	NA
China	5,220	5,000	100,000	250,000
Finland	850	850	NA	NA
France	1,110	1,000	10,000	20,000
Germany	1,240	1,250	NA	NA
Iran	1,350	1,500	NA	NA
Italy	693	700	NA	NA
Japan	3,500	3,500	5,000	15,000
Kazakhstan	1,500	1,700	NA	NA
Korea, Republic of	490	500	NA	NA
Kuwait	675	600	NA	NA
Mexico	1,310	1,350	75,000	120,000
Netherlands	512	550	NA	NA
Poland	1,700	1,300	100,000	300,000
Russia	5,900	6,400	NA	NA
Saudi Arabia	2,400	2,100	100,000	130,000
South Africa	448	400	NA	NA
Spain	685	500	50,000	300,000
United Arab Emirates	1,120	1,200	NA	NA
Uzbekistan	460	470	NA	NA
Venezuela	450	500	NA	NA
Other countries	3,200	3,200	630,000	1,800,000
World total (may be rounded)	57,200	55,500	1,300,000	3,500,000

World Resources: Resources of elemental sulfur in evaporite and volcanic deposits and sulfur associated with natural gas, petroleum, tar sands, and metal sulfides amount to about 5 billion tons. The sulfur in gypsum and anhydrite is almost limitless, and some 600 billion tons are contained in coal, oil shale, and shale rich in organic matter, but low-cost methods have not been developed to recover sulfur from these sources. The domestic resource is about one-fifth of the world total. Elemental sulfur deposits have become marginal reserves unless the deposits are already developed. Sulfur from petroleum and metal sulfides may be recovered where they are refined, which may be in the country of origin or in an importing nation. The rate of sulfur recovery from refineries is dependent on the environmental regulations where refining is accomplished, most of which are becoming more stringent.

Substitutes: Substitutes for sulfur at present or anticipated price levels are not satisfactory; some acids, in certain applications, may be substituted for sulfuric acid.

[e]Estimated. NA Not available. — Zero.

[1]Defined as imports - exports + adjustments for Government and industry stock changes.

[2]See Appendix C for definitions.

TALC AND PYROPHYLLITE

(Data in thousand metric tons, unless noted)

Domestic Production and Use: The total estimated crude ore value of 2001 domestic talc production was $25 million. There were nine talc-producing mines in six States in 2001. Companies in Montana, New York, Texas, and Vermont accounted for most of the domestic production. Ground talc was consumed in ceramics, 28%; paint, 21%; paper, 20%; roofing, 8%; plastics, 5%; rubber, 4%; cosmetics, 3%; and other, 11%. Three firms in California and North Carolina accounted for all of the domestic pyrophyllite production, which decreased from that of 2000. Consumption was, in decreasing order, in ceramics, refractories, and paint.

Salient Statistics—United States:[1]	**1997**	**1998**	**1999**	**2000**	**2001**[e]
Production, mine	1,050	971	925	851	914
Sold by producers	942	870	881	831	808
Imports for consumption	123	165	208	270	147
Exports	179	146	147	154	136
Shipments from Government stockpile excesses	—	—	([2])	—	—
Consumption, apparent	992	990	986	967	925
Price, average, processed dollars per ton	118	126	116	116	118
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill	776	730	690	640	620
Net import reliance[3] as a percentage of apparent consumption	E	2	6	12	1

Recycling: Insignificant.

Import Sources (1997-2000): China, 45%; Canada, 22%; France, 11%; Japan, 7%; and other, 15%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12/31/01**
Crude, not ground	2526.10.0000	Free.
Ground, washed, powdered	2526.20.0000	Free.
Cut or sawed	6815.99.2000	Free.

Depletion Allowance: Block steatite talc, 22% (Domestic), 14% (Foreign); other, 14% (Domestic and foreign).

Government Stockpile:

Stockpile Status—9-30-01[4]
(Metric tons)

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 2001**	**Disposals FY 2001**
Talc, block and lump	907	—	907	907	2
Talc, ground	988	—	988	—	—

Prepared by **Robert L. Virta [(703) 648-7726, rvirta@usgs.gov, fax: (703) 648-7722]**

TALC AND PYROPHYLLITE

Events, Trends, and Issues: Production increased 7% and sales decreased 3% from those of 2000. Apparent consumption decreased 4%. Exports decreased by 12% compared with those of 2000. Canada was the major destination for U.S. talc exports, accounting for about 38% of the tonnage. U.S. imports of talc decreased by 46% compared with those of 2000, bringing them more in line with recent consumption trends. Canada, China, and Japan supplied approximately 75% of the imported talc. Imports from China declined by about 50% in 2001 compared with those of 2000.

In 2000, the U.S. Department of Health and Human Services, National Toxicology Program (NTP), considered including talc on its list of carcinogens in its *10th Report on Carcinogens* (RoC) for Congress. The NTP Board of Scientific Counselors Report on Carcinogens Subcommittee voted against listing talc not containing asbestiform fibers and talc containing asbestiform fibers in its annual report. Several members of the panel did not feel that human and animal data were sufficient to warrant listing in the report and questions arose about possible contamination of the talc mentioned in several of the health studies cited.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2000	2001[e]		
United States[1]	851	914	140,000	540,000
Brazil	452	450	14,000	54,000
China	3,500	3,500	Large	Large
India	545	550	4,200	7,300
Japan	743	740	160,000	200,000
Korea, Republic of	776	770	14,000	18,000
Other countries	2,770	2,570	Large	Large
World total (rounded)	9,640	9,490	Large	Large

World Resources: The United States is self-sufficient in most grades of talc and related minerals. Domestic and world resources are estimated to be approximately five times the quantity of reserves.

Substitutes: The major substitutes for talc are clays and pyrophyllite in ceramics, kaolin and mica in paint, kaolin in paper, clays and mica in plastics, and kaolin and mica in rubber.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Excludes pyrophyllite.
[2]Less than ½ unit.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B for definitions.
[5]See Appendix C for definitions.

TANTALUM

(Data in metric tons of tantalum content, unless otherwise noted)

Domestic Production and Use: There has been no significant domestic tantalum mining since 1959. Domestic tantalum resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Most metal, alloys, and compounds were produced by three companies; tantalum units were obtained from imported concentrates and metal and from foreign and domestic scrap. Tantalum was consumed mostly in the form of metal powder, ingot, fabricated forms, compounds, and alloys. The major end use for tantalum was in the production of electronic components, more than 60% of use, mainly in tantalum capacitors. Major end uses for tantalum capacitors include portable telephones, pagers, personal computers, and automotive electronics. The value of tantalum consumed in 2001 was estimated at about $190 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
Concentrate, metal, alloys	467	588	564	901	1,000
Other[1]	NA	NA	NA	NA	NA
Exports, concentrate, metal, alloys, waste, and scrap[e]	340	440	480	530	700
Government stockpile releases[e 2]	20	213	5	242	(53)
Consumption:					
Reported, raw material	NA	NA	NA	NA	NA
Apparent	570	738	555	650	550
Price, tantalite, dollars per pound[3]	33.00	34.00	34.00	160.00	39.00
Stocks, industry, processor, yearend	NA	NA	NA	NA	NA
Employment	NA	NA	NA	NA	NA
Net import reliance[4] as a percentage of apparent consumption	80	80	80	80	80

Recycling: Combined prompt industrial and obsolete scrap consumed represented about 20% of apparent consumption.

Import Sources (1997-2000): Australia, 44%; China, 13%; Thailand, 10%; Japan, 9%; and other, 24%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Synthetic tantalum-columbium concentrates	2615.90.3000	Free.
Tantalum ores and concentrates	2615.90.6060	Free.
Tantalum oxide	2825.90.9000	3.7% ad val.
Potassium fluotantalate	2826.90.0000	3.1% ad val.
Tantalum, unwrought:		
Waste and scrap	8103.10.3000	Free.
Powders	8103.10.6030	2.5% ad val.
Alloys and metal	8103.10.6090	2.5% ad val.
Tantalum, wrought	8103.90.0000	4.4% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: For fiscal year 2001, ending September 30, 2001, the Defense National Stockpile Center (DNSC) sold about 2 tons of tantalum contained in tantalum carbide powder valued at about $1.34 million, about 20 tons of tantalum capacitor-grade metal powder valued at about $14.3 million, about 18 tons of tantalum vacuum-grade metal ingots valued at about $16.1 million, about 5 tons of tantalum contained in tantalum minerals valued at about $4.11 million, and about 9 tons of tantalum contained in tantalum oxide valued at about $2.55 million from the National Defense Stockpile (NDS). The DNSC also proposed maximum disposal limits in fiscal year 2002 of about 2 tons of tantalum contained in tantalum carbide powder, about 23 tons[5] of tantalum capacitor-grade metal powder, about 18 tons of tantalum vacuum-grade metal ingots, about 227 tons of tantalum contained in tantalum minerals, and about 9 tons of tantalum contained in tantalum oxide. The NDS uncommitted inventories shown below include a small quantity in nonstockpile-grade tantalum capacitor-grade metal powder and about 325 tons of tantalum contained in nonstockpile-grade minerals.

Prepared by **Larry D. Cunningham [(703) 648-4977, lcunning@usgs.gov, fax: (703) 648-7757]**

TANTALUM

Stockpile Status—9-30-01[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Tantalum:					
Carbide powder	6	—	6	2	2
Metal:					
Capacitor-grade powder	18	16	2	23	20
Ingots	64	—	9	18	18
Minerals	866	—	866	227	5
Oxide	25	7	25	9	9

Events, Trends, and Issues: Total consumption of tantalum in 2001 decreased owing to a slowdown in the electronics sector. There was an apparent drawdown of excess tantalum inventories. Industry sources indicated that forecasts for electronic products in 2001 were overly optimistic. Overall tantalum imports increased. Imports for consumption of tantalum mineral concentrates rose by about 10%, with Australia supplying about 75% of quantity and about 60% of value. Exports increased; Brazil, China, Germany, Israel, Japan, and the Netherlands were the major recipients of the tantalum materials. In early November, quoted spot price ranges for tantalum ore (per pound tantalum pentoxide content), in three published sources, were $30 to $40, $32 to $42, and $40 to $50, substantially lower than the $180 to $240, $250 to $300, and $145 to $175 quoted in early January. Weak demand for tantalum products from the electronics sector, increased inventories, and a downturn in the global economy contributed to the price decrease. The most recent published industry source (August 1999) on tantalum product prices indicated that the average selling prices per pound tantalum content for some tantalum products were as follows: capacitor-grade powder, $135 to $260; capacitor wire, $180 to $270; and vacuum-grade metal for superalloys, $75 to $100. Presumably these prices have increased owing to the tantalum ore price surge that occurred in 2000, but public information on current prices for these products was not available. No domestic mine production is expected in 2001, and it is estimated that U.S. apparent consumption will be about 600 tons.

World Mine Production, Reserves, and Reserve Base:

	Mine production[7]		Reserves[8]	Reserve base[8]
	2000	2001[e]		
United States	—	—	—	Negligible
Australia	485	640	36,000	58,000
Brazil	90	300	NA	53,000
Canada	57	50	3,000	5,000
Congo (Kinshasa)	130	60	NA	NA
Ethiopia	38	30	NA	NA
Nigeria	4	4	NA	7,000
Other countries[9]	32	30	NA	NA
World total (may be rounded)	836	1,100	39,000	120,000

World Resources: Most of the world's resources of tantalum occur outside the United States. On a worldwide basis, identified resources of tantalum are considered adequate to meet projected needs. These resources are largely in Australia, Brazil, Canada, Congo (Kinshasa), and Nigeria. The United States has about 1,500 tons of tantalum resources in identified deposits, all of which were considered uneconomic at 2001 prices.

Substitutes: The following materials can be substituted for tantalum, but usually with less effectiveness: columbium in carbides; aluminum and ceramics in electronic capacitors; columbium, glass, platinum, titanium, and zirconium in corrosion-resistant equipment; and columbium, hafnium, iridium, molybdenum, rhenium, and tungsten in high-temperature applications.

[e]Estimated. NA Not available. — Zero.
[1]Synthetic concentrates, tin slags, tantalum oxide, potassium fluotantalate, and waste and scrap.
[2]Net quantity (uncommitted inventory). Parentheses indicate negative number (increase in inventory).
[3]Yearend average value, contained pentoxides.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]Actual quantity limited to remaining sales authority or inventory.
[6]See Appendix B for definitions.
[7]Excludes production of tantalum contained in tin slags.
[8]See Appendix C for definitions.
[9]Bolivia, China, Russia, and Zambia also produce (or are thought to produce) tantalum, but available information is inadequate to make reliable estimates of output levels.

TELLURIUM

(Data in metric tons of tellurium content, unless otherwise noted)

Domestic Production and Use: Tellurium and tellurium dioxide of commercial grades were recovered in the United States at one copper refinery, principally from anode slimes, but also from lead refinery skimmings. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide. Tellurium was used mainly in the production of free-machining steels. It was used as a minor additive in copper and lead alloys and malleable cast iron, as an accelerator in rubber compounding, in thermoelectric applications, and as a semiconductor in thermal-imaging and photoelectric applications. Tellurium was added to selenium-base photoreceptor alloys to increase the photo speed. In 2001, the estimated distribution of uses, worldwide, was as follows: iron and steel products, 50%; catalysts and chemicals, 25%; additives to nonferrous alloys, 10%; photoreceptors and thermoelectric devices, 8%; and other, 7%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, refinery	W	W	W	W	W
Imports for consumption, unwrought, waste and scrap[1]	64	89	38	52	30
Exports	NA	NA	NA	NA	NA
Consumption, apparent	NA	NA	NA	NA	NA
Price, dollars per pound, 99.7% minimum[2]	19	18	15	14	13
Stocks, producer, refined, yearend	W	W	W	W	W
Employment, number	NA	NA	NA	NA	NA
Net import reliance[3] as a percentage of apparent consumption	NA	NA	NA	NA	NA

Recycling: There was no domestic secondary production of tellurium. However, some tellurium may have been recovered abroad from selenium-base photoreceptor scrap exported by the United States for recycling.

Import Sources (1997-2000): United Kingdom, 28%; Philippines, 28%; Belgium, 18%; Canada, 11%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Metal	2804.50.0020	Free.

Depletion Allowance: 15% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert D. Brown, Jr. [(703) 648-4984, rbrown@usgs.gov, fax: (703) 648-7757]**

TELLURIUM

Events, Trends, and Issues: Domestic and world tellurium demand decreased slightly in 2001. World production was steady; oversupply remained a problem. Detailed information on the world tellurium market was not available.

Cadmium telluride is one of the most promising thin-film photovoltaic module compounds for power generation, achieving some of the highest power conversion ratios yet obtained. A possible application of this technology that would significantly affect tellurium demand is for power supplies in remote areas, mainly in developing countries, where the largest percentage increases in power consumption are expected to occur early in this century.

Tellurium is used in a germanium-antimony-tellurium alloy for optical storage in digital video discs (DVDs). This is a rapidly growing market, but the amount of tellurium used for each disc is very small.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[4]	Reserve base[4]
	2000	2001[e]		
United States	W	W	3,000	6,000
Canada	65	80	700	1,500
Japan	35	36	—	—
Peru	25	22	500	1,600
Other countries[5]	NA	NA	16,000	29,000
World total (may be rounded)	[6]125	[6]140	20,000	38,000

World Resources: The figures shown for reserves and reserve base include only tellurium contained in economic copper deposits. In addition, significant quantities of tellurium are contained in economic gold and lead deposits, but currently none is recovered. Deposits of coal, copper, and other metals that are of subeconomic grade contain several times the amount of tellurium contained in identified economic copper deposits. However, it is unlikely that tellurium contained in these deposits can be recovered economically.

Substitutes: The chief substitutes for tellurium are selenium, bismuth, and lead in metallurgical applications; selenium and sulfur in rubber compound applications; and selenium, germanium, and organic compounds in electronic applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.

[1]Imports of boron and tellurium are grouped together under the Harmonized Tariff Schedule; however, imports of boron are thought to be small rel tellurium.

[2]Yearend prices quoted by the sole producer.

[3]Defined as imports - exports + adjustments for Government and industry stock changes.

[4]See Appendix C for definitions. Estimates include tellurium contained in copper resources only.

[5]In addition to the countries listed, Australia, Belgium, China, France, Germany, Kazakhstan, the Philippines, Russia, and the United Kingdom produce refined tellurium, but output is not reported and available information is inadequate for formulation of reliable production estimates.

[6]Excludes U.S. refinery production.

THALLIUM

(Data in kilograms of thallium content, unless otherwise noted)

Domestic Production and Use: Thallium is a byproduct metal recovered in some countries from flue dusts and residues collected in the smelting of copper, zinc, and lead ores. Although thallium was contained in ores mined or processed in the United States, it was not recovered domestically in 2001. Consumption of thallium metal and its compounds continued in most of their established end uses. These uses included a semiconductor material for selenium rectifiers, an activator in gamma radiation detection equipment, an electrical resistance component in infrared radiation detection and transmission equipment, and a crystalline filter for light diffraction in acousto-optical measuring devices. Other uses included an alloying component with mercury for low-temperature measurements, an additive in glass to increase its refractive index and density, a catalyst or intermediate in the synthesis of organic compounds, and a high-density liquid for sink-float separation of minerals. Also, the use of radioactive thallium compounds for medical purposes in cardiovascular imaging was continued in 2001.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production, mine[1]	—	—	—	—	—
Imports for consumption[2]	168	104	838	100	1,900
Exports	NA	NA	NA	NA	NA
Consumption[e]	300	300	380	300	800
Price, metal, dollars per kilogram[3]	1,280	1,280	1,295	1,295	1,295
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1997-2000): Belgium, 47%; Canada, 35%; Germany, 12%; United Kingdom, 4%; and France, 2%.

Tariff: Item	**Number**	**Normal Trade Relations[5] 12/31/01**
Unwrought, waste and scrap, powders	8112.91.6000	4.0% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Gerald R. Smith [(703) 648-4983, grsmith@usgs.gov, fax: (703) 648-7757]**

THALLIUM

Events, Trends, and Issues: Research and development activities of both a basic and applied nature were conducted during 2001 to improve and expand the use of thallium. These activities focused principally on the development of high-temperature superconducting materials for such applications as magnetic resonance imaging, storage of magnetic energy, magnetic propulsion, and electric power generation and transmission. Particular emphasis was directed toward the development of more efficient, smaller, lighter weight and less expensive superconductive wire or tape for electric power transmission. Consideration continued to be given to the use of a thallium-oxide superconductor in these electric power transmission components. Further use of radioactive thallium in clinical diagnostic applications, including cardiovascular and oncological imaging, also was studied during 2001.

Thallium metal and its compounds are highly toxic materials and are strictly controlled to prevent a threat to humans and the environment. Thallium and its compounds can be absorbed into the human body by skin contact, ingestion, or inhalation of dust or fumes. Special concern regarding the toxicity of thallium was evident in 2001 after workers at a North American lead smelter were discovered to have been exposed to elevated levels of thallium. The workers were conducting routine maintenance to remove scale from inside one of the boilers at the facility. Measures were taken immediately by the company to correct procedural deficiencies that allowed the workers to be exposed. Medical experts believed that there would be no long-term adverse health effects to the workers as a result of this incident of exposure to thallium.

World Mine Production, Reserves, and Reserve Base:[6]

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001		
United States[1]	—	—	32,000	120,000
Other countries	15,000	15,000	350,000	530,000
World total (may be rounded)	15,000	15,000	380,000	650,000

World Resources: World resources of thallium contained in zinc resources total about 17 million kilograms; most are located in Canada, Europe, and the United States. An additional 630 million kilograms is in world coal resources. The average thallium content of the Earth's crust has been estimated at 0.7 part per million.

Substitutes: While other light-sensitive materials can substitute for thallium and its compounds in specific electronic applications, ample supplies of thallium discourage development of substitute materials.

[e]Estimated. NA Not available. — Zero.
[1]Thallium contained in mined base-metal ores, estimated at 450 to 500 kilograms per year, is separated from the base metals but not extracted for commercial use.
[2]Unwrought; waste and scrap; powders, including thallium contained in compounds.
[3]Estimated price of 99.999%-pure granules in 100-gram lots.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]By the North American Free Trade Agreement, there is no tariff for Canada or Mexico.
[6]Estimates, based on thallium content of zinc ores.
[7]See Appendix C for definitions.

THORIUM

(Data in metric tons of thorium oxide (ThO_2) equivalent, unless otherwise noted)

Domestic Production and Use: The primary source of the world's thorium is the rare-earth and thorium phosphate mineral, monazite. Monazite was not recovered as a salable product during domestic processing of heavy mineral sands in 2001. Past production had been as a byproduct during processing for titanium and zirconium minerals, and monazite was recovered for its rare-earth content. Essentially all thorium compounds and alloys consumed by the domestic industry were derived from imports, stocks of previously imported materials, or materials shipped from U.S. Government stockpiles. About eight companies processed or fabricated various forms of thorium for nonenergy uses, such as high-temperature ceramics, catalysts, and welding electrodes. The value of thorium metal, alloys, and compounds used by the domestic industry was estimated to be about $100,000.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	20	—	—	—	—
Thorium ore and concentrates (monazite), ThO_2 content	1.40	—	—	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	13.50	7.45	5.29	11.10	1.80
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	10.00	5.51	3.91	8.20	2.00
Exports:					
Thorium ore and concentrates (monazite), gross weight	—	—	—	—	—
Thorium ore and concentrates (monazite), ThO_2 content	—	—	—	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	0.24	1.13	2.52	4.64	6.86
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	0.18	0.84	1.86	3.43	7.60
Shipments from Government stockpile excesses ($ThNO_3$)	—	—	—	—	—
Consumption: Reported, (ThO_2 content[e])	13.0	7.0	7.0	6.0	NA
Apparent	12.0	4.7	3.1	7.7	E
Price, yearend, dollars per kilogram:					
Nitrate, welding-grade[2]	5.46	5.46	5.46	5.46	5.46
Nitrate, mantle-grade[3]	27.00	27.00	27.00	27.00	27.00
Oxide, yearend:					
99.9% purity[4]	82.50	82.50	82.50	82.50	82.50
99.99% purity[4]	107.25	107.25	107.25	107.25	107.25
Stocks, industrial, yearend	12.8	NA	NA	NA	NA
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1997-2000): Monazite: France, 100%. Thorium compounds: France, 72%; Canada, 11%; Japan, 4%; Singapore, 2%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Thorium ores and concentrates (monazite)	2612.20.0000	Free.
Thorium compounds	2844.30.1000	5.5% ad val.

Depletion Allowance: Monazite, 23% on thorium content, 15% on rare-earth and yttrium content (Domestic); 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-01[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Thorium nitrate (gross weight)	3,219	—	2,947	3,218	—

Events, Trends, and Issues: Domestic mine production of thorium-bearing monazite ceased at the end of 1994 as world demand for ores containing naturally occurring radioactive thorium declined. Imports and existing stocks supplied essentially all thorium consumed in the United States in 2001. Domestic demand for thorium ores, compounds, metals, and alloys has exhibited a long-term declining trend. Thorium consumption in the United States decreased in 2000 to 2.0 tons; however, most material was consumed in a nonrecurring application. In 2001, thorium consumption, primarily for use in catalyst applications, is estimated to decrease. On the basis of data

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7722]**

THORIUM

through August 2001, the average value of imported thorium compounds decreased to $36.58 per kilogram from the 2000 average of $47.76 per kilogram (gross weight). A researcher at Los Alamos National Laboratory announced it had derived the first estimates of thorium abundances from the Lunar Prospector mission to Earth's moon. The elemental distribution maps from the Lunar Prospector mission provide twice the resolution of previous missions. Thorium is an important element in modeling lunar evolution because it is a constituent of the mixture potassium-rare earth elements-phosphorous and known to geologists by its acronym, KREEP. KREEP is the last material to solidify from a geologic melt and are evidence of the original material beneath the moon's crust. The existence of KREEP on the moon's surface is indicative of a lunar volcanic event or strong meteor impact that penetrated the crust.[7]

A company in the United States announced that it had developed all-oxide thorium fuel seed, which is reportedly standard for domestic nuclear reactors. Previous thorium fuel seeds had been metallic. In addition the company's fuel technology group developed an 18-month thorium fuel cycle, an increase from the previous 12-month cycle.[8]

The use of thorium in the United States has decreased significantly since the 1980s, when consumption averaged 45 tons per year. Increased costs to monitor and dispose of thorium have caused the domestic processors to switch to thorium-free materials. Real and potential costs related to compliance with State and Federal regulations, proper disposal, and monitoring of thorium's radioactivity have limited its commercial value. It is forecast that thorium's use will continue to decline unless a low-cost disposal process is developed or new technology creates renewed demand.

World Refinery Production, Reserves, and Reserve Base:[9]

	Refinery production		Reserves[10]	Reserve base[10]
	2000	2001		
United States	—	—	160,000	300,000
Australia	—	—	300,000	340,000
Brazil	NA	NA	16,000	18,000
Canada	NA	NA	100,000	100,000
India	NA	NA	290,000	300,000
Malaysia	—	—	4,500	4,500
Norway	—	—	170,000	180,000
South Africa	—	—	35,000	39,000
Other countries	NA	NA	90,000	100,000
World total (rounded)	NA	NA	1,200,000	1,400,000

Reserves and reserve base are contained primarily in the rare-earth ore mineral, monazite. Without demand for the rare earths, monazite would probably not be recovered for its thorium content. Other ore minerals with higher thorium contents, such as thorite, would be more likely sources if demand significantly increased. No new demand, however, is expected. Reserves exist primarily in recent and ancient placer deposits. Lesser quantities of thorium-bearing monazite reserves occur in vein deposits and carbonatites.

World Resources: Thorium resources occur in provinces similar to those of reserves. The largest share are contained in placer deposits. Resources of more than 500,000 tons are contained in placer, vein, and carbonatite deposits. Disseminated deposits in various other alkaline igneous rocks contain additional resources of more than 2 million tons. Large thorium resources are found in Australia, Brazil, Canada, Greenland, India, South Africa, and the United States.

Substitutes: Nonradioactive substitutes have been developed for many applications for thorium. Yttrium compounds have replaced thorium compounds in incandescent lamp mantles. A magnesium alloy containing lanthanides, zirconium, and yttrium can substitute for magnesium-thorium alloys in aerospace applications.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]All domestically consumed thorium was derived from imported materials.
[2]Source: U.S. Department of Defense, Defense Logistics Agency. Based on sales from the National Defense Stockpile.
[3]Source: Rhodia Canada, Inc., f.o.b. port of entry, duty paid, ThO_2 basis.
[4]Source: Rhodia Rare Earths, Inc., 1-950 kilogram quantities, f.o.b. port of entry, duty paid.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B for definitions.
[7]Los Alamos National Laboratory, 1999, Thorium maps reveal complicated lunar history: Los Alamos, NM, Los Alamos National Laboratory, news release, March 16, 1 p.
[8]Thorium Power, Inc., 2001, What's New—2001: Washington, DC, Thorium Power, Inc., February, 1 p.
[9]Estimates, based on thorium contents of rare-earth ores.
[10]See Appendix C for definitions.

TIN

(Data in metric tons of tin content, unless otherwise noted)

Domestic Production and Use: In 2001, no tin was mined domestically. Production of tin at the only U.S. tin smelter, at Texas City, TX, stopped in 1989. Twenty-five firms consumed about 77% of the primary tin. The major uses were as follows: cans and containers, 30%; electrical, 20%; construction, 10%; transportation, 10%; and other, 30%. On the basis of the New York composite price, the estimated values of some critical items were as follows: primary metal consumed, $278 million; imports for consumption, refined tin, $326 million; and secondary production (old scrap), $50 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Secondary (old scrap)	7,830	8,500	7,750	6,600	7,000
Secondary (new scrap)	4,540	7,800	8,650	8,450	8,500
Imports for consumption, refined tin	40,600	44,000	47,500	44,900	45,000
Exports, refined tin	4,660	5,020	6,770	6,640	6,800
Shipments from Government stockpile excesses	11,700	12,200	765	12,000	12,000
Consumption, reported:					
Primary	36,200	37,100	38,000	38,100	38,700
Secondary	8,250	8,620	8,890	8,940	9,050
Consumption, apparent	55,300	60,600	59,700	57,160	56,900
Price, average, cents per pound:					
New York market	264	261	255	255	219
New York composite	381	373	366	370	326
London	256	251	245	246	212
Kuala Lumpur	252	246	241	244	225
Stocks, consumer and dealer, yearend	11,200	10,500	10,700	10,400	10,700
Net import reliance[1] as a percentage of apparent consumption	86	85	85	88	88

Recycling: About 18,000 tons of tin from old and new scrap was recycled in 2001. Of this, about 7,000 tons was recovered from old scrap at 5 detinning plants and 46 secondary nonferrous metal processing plants.

Import Sources (1997-2000): China, 22%; Peru, 22%; Indonesia, 16%; Brazil, 13%; Bolivia, 12%; and other, 15%.

Tariff: Most major imports of tin, including unwrought metal, waste and scrap, and unwrought tin alloys, enter duty free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: The Defense National Stockpile Center (DNSC) no longer sells tin on a monthly basis. Two DNSC tin sales are now held each year, normally in the spring and in the fall, for about 6,000 tons each. The DNSC announced that its Annual Materials Plan for fiscal year 2002 calls for sales of up to 12,000 tons of stockpile tin. Stockpile tin is warehoused at four depots, with the largest holdings at Hammond, IN, and Baton Rouge, LA.

Stockpile Status—9-30-01[2]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Pig tin	53,019	6,974	53,019	12,000	5,226

Prepared by **James F. Carlin, Jr. [(703) 648-4985, jcarlin@usgs.gov, fax: (703) 648-7757]**

TIN

Events, Trends, and Issues: The Steel Recycling Institute (SRI), Pittsburgh, PA, announced that the domestic steel can recycling rate was 58% in 2000 compared with 58% in 1999. Tin, as well as steel, is recovered in can recycling. SRI noted that 200 million Americans had access to steel can recycling programs.

Tin prices continued to decline in 2001. Industry observers attributed lower prices to an oversupply of tin in the market. World tin consumption also was believed to have declined somewhat during the year.

The world and domestic tinplate industry continued to be characterized by more mergers and consolidations. In most cases, this resulted in some tin mill capacity being eliminated.

The world's major tin research and development laboratory, ITRI Ltd. (based in the United Kingdom), reached its sixth year as a privatized institution. The laboratory, which is funded by numerous tin producing and consuming firms, has focused its efforts on possible new uses for tin that would take advantage of tin's relative nontoxicity to replace other metals in products—lead-free solders, antimony-free flame-retardant chemicals, and lead-free shotgun pellets.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2000	2001[e]		
United States	—	—	20,000	40,000
Australia	9,000	9,000	210,000	600,000
Bolivia	12,000	12,000	450,000	900,000
Brazil	13,000	15,000	540,000	2,500,000
China	97,000	95,000	2,100,000	3,900,000
Indonesia	48,000	50,000	800,000	900,000
Malaysia	6,000	7,000	1,200,000	1,400,000
Peru	37,000	38,000	710,000	1,000,000
Portugal	1,000	1,000	70,000	80,000
Russia	5,000	5,000	300,000	350,000
Thailand	2,000	2,000	340,000	400,000
Other countries	8,000	8,000	180,000	200,000
World total (may be rounded)	238,000	242,000	6,900,000	12,000,000

World Resources: U.S. resources of tin, primarily in Alaska, were insignificant compared with those of the rest of the world. Sufficient world resources, principally in western Africa, southeastern Asia, Australia, Bolivia, Brazil, China, and Russia are available to sustain recent annual production rates well into the 21st century.

Substitutes: Aluminum, glass, paper, plastic, or tin-free steel substitute for tin in cans and containers. Other materials that substitute for tin are epoxy resins for solder; aluminum alloys, copper-base alloys, and plastics for bronze; plastics for bearing metals that contain tin; and compounds of lead and sodium for some tin chemicals.

[e]Estimated. — Zero.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix B for definitions.
[3]See Appendix C for definitions.

TITANIUM MINERAL CONCENTRATES[1]

(Data in thousand metric tons of contained TiO_2, unless otherwise noted)

Domestic Production and Use: Two firms produced ilmenite and rutile concentrates from heavy-mineral sands operations in Florida and Virginia. The value of titanium mineral concentrates consumed in the United States in 2001 was about $470 million. The major coproduct of mining from ilmenite and rutile deposits was zircon. About 95% of titanium mineral concentrates was consumed by TiO_2 pigment producers. The remainder was used in welding rod coatings and for manufacturing metal, carbides, and chemicals.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production[2] (ilmenite and rutile, rounded)	400	400	300	300	300
Imports for consumption:					
Ilmenite and slag	651	732	776	647	686
Rutile, natural and synthetic	311	365	324	413	300
Exports,[e] all forms	15	38	6	12	6
Consumption, reported:					
Ilmenite and slag	1,060	[3] 980	[3]963	[3]919	[3]835
Rutile, natural and synthetic	383	392	413	497	445
Price, dollars per metric ton:					
Ilmenite, bulk, 54% TiO_2, f.o.b. Australian ports	83	77	98	94	93
Rutile, yearend, bulk, f.o.b. Australian ports	530	500	473	485	480
Slag:[e]					
80% TiO_2, f.o.b. Sorel, Quebec	294	338	390	547	510
85% TiO_2, f.o.b. Richards Bay, South Africa	390	385	406	425	434
Stocks, mine, consumer, yearend:					
Ilmenite	234	270	343	262	260
Rutile	80	111	96	101	100
Employment, mine and mill, number[e]	480	490	450	470	470
Net import reliance[4] as a percentage of consumption	68	76	75	79	72

Recycling: None.

Import Sources (1997-2000): South Africa, 47%; Australia, 35%; Canada, 10%; Ukraine, 4%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Synthetic rutile	2614.00.3000	Free.
Ilmenite and ilmenite sand	2614.00.6020	Free.
Rutile concentrate	2614.00.6040	Free.
Titanium slag	2620.90.5000	Free.

Depletion Allowance: Ilmenite and rutile; 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

Prepared by **Joseph Gambogi [(703) 648-7718, jgambogi@usgs.gov, fax: (703) 648-7722]**

TITANIUM MINERAL CONCENTRATES

Events, Trends, and Issues: Owing to a slowing world economy, global consumption of titanium concentrates was estimated to have decreased moderately in 2001 when compared with that of 2000. Decreased demand for titanium dioxide pigment resulted in an estimated 10% decrease in domestic consumption of titanium mineral concentrates compared with that of 2000. The United States continued its reliance on imported mineral concentrates primarily from Australia, Canada, and South Africa. In 2001, imports of titanium concentrates decreased an estimated 7% compared with those of 2000.

Several companies were increasing production capacity in 2001. In the United States, capacity at the Old Hickory operation near Stony Creek, VA, was increasing to 225,000 tons per year of ilmenite (a 50% increase). In Australia, the first commercial mining of the Murray Basin began at the Wemen deposit. At full production, the Wemen operation is expected to produce 60,000 tons per year of titanium mineral concentrates. In South Africa, KwaZulu-Natal province, mining began at the Hillendale deposit where capacity is expected to ultimately reach 115,000 tons per year of titanium mineral concentrates. Worldwide exploration and development efforts continued in Australia, Canada, The Gambia, India, Kenya, Mozambique, South Africa, and the United States.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2000	2001[e]		
Ilmenite:				
United States[2]	[6]300	[6]300	13,000	59,000
Australia	1,230	1,190	[7]110,000	[7]130,000
Canada[8]	760	720	31,000	36,000
India	205	200	30,000	38,000
Norway[8]	275	270	40,000	40,000
South Africa[8]	935	1,000	63,000	63,000
Ukraine	242	240	5,900	13,000
Other countries	331	320	49,000	84,000
World total (may be rounded)	4,300	4,200	340,000	470,000
Rutile:				
United States	([9])	([9])	750	1,800
Australia	225	220	[7]21,000	[7]32,000
India	16	15	6,600	7,700
South Africa	94	90	8,300	8,300
Ukraine	56	55	2,500	2,500
Other countries	4	4	8,000	17,000
World total (rounded)	390	380	47,000	69,000
World total (ilmenite and rutile, rounded)	4,700	4,600	380,000	540,000

World Resources: Ilmenite supplies about 90% of the world's demand for titanium minerals. World ilmenite resources total about 1 billion tons of titanium dioxide. Identified world resources of rutile (including anatase) total about 230 million tons of contained TiO_2.

Substitutes: Ilmenite, leucoxene, rutile, slag, and synthetic rutile compete as feedstock sources for producing TiO_2 pigment, titanium metal, and welding rod coatings. In the future, commercial processes may be developed to use anatase and perovskite.

[e]Estimated.
[1]See also Titanium and Titanium Dioxide.
[2]Production rounded to one significant digit to avoid revealing company proprietary data.
[3]Excludes ilmenite used to produce synthetic rutile.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.
[6]Includes rutile to avoid revealing company proprietary data.
[7]Derived from data published by the Australian Geological Survey Organisation.
[8]Mine production is primarily used to produce titaniferous slag. Reserves and reserve base are ilmenite.
[9]Included with ilmenite to avoid revealing company proprietary data.

TITANIUM AND TITANIUM DIOXIDE[1]

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Titanium sponge metal was produced by two firms with operations in Nevada and Utah. Ingot was made by the two sponge producers and by nine other firms in seven States. About 30 firms consumed ingot to produce forged components, mill products, and castings. In 2001, an estimated 65% of the titanium metal used was in aerospace applications. The remaining 35% was used in armor, chemical processing, power generation, marine, medical, sporting goods, and other nonaerospace applications. The value of sponge metal consumed was about $174 million, assuming an average selling price of $7.91 per kilogram. The value of ingot produced from sponge and scrap was estimated to be $600 million.

In 2001, titanium dioxide (TiO_2) pigment, valued at about $3.0 billion, was produced by four companies at eight facilities in seven States. Estimated use of TiO_2 pigment by end use was paint, varnishes, and lacquers, 50%; paper, 20%; plastics, 20%; and other, 10%. Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Titanium sponge metal:					
Production	W	W	W	W	W
Imports for consumption	16,100	10,900	6,000	7,240	11,500
Exports	976	348	807	1,930	2,180
Shipments from Government stockpile excesses	227	1,384	515	4,870	4,410
Consumption, reported	32,000	28,200	18,100	18,200	22,000
Price, dollars per kilogram, yearend	9.70	9.70	9.37	9.37	7.91
Stocks, industry yearend[e]	5,470	10,600	7,970	5,010	6,000
Employment, number[e]	300	300	300	300	300
Net import reliance[2] as a percentage of reported consumption	47	39	44	72	58
Titanium dioxide:					
Production	1,340,000	1,330,000	1,350,000	1,400,000	1,340,000
Imports for consumption	194,000	200,000	225,000	218,000	200,000
Exports	405,000	398,000	384,000	464,000	432,000
Consumption, apparent	1,130,000	1,140,000	1,160,000	1,150,000	1,100,000
Price, rutile, list, dollars per pound, yearend	1.05	0.98	1.01	1.01	1.00
Stocks, producer, yearend	108,000	103,000	137,000	141,000	153,000
Employment, number[e]	4,600	4,600	4,600	4,600	4,600
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: New scrap metal recycled by the titanium industry totaled about 18,000 tons in 2001. Estimated use of titanium as scrap and in the form of ferrotitanium made from scrap by the steel industry was about 6,000 tons; by the superalloy industry, 900 tons; and, in other industries, 700 tons. Old scrap reclaimed totaled about 500 tons.

Import Sources (1997-2000): Sponge metal: Russia, 47%; Japan, 37%; Kazakhstan, 12%; and other, 4%. Titanium dioxide pigment: Canada, 36%; Germany, 14%; France, 8%; Spain, 6%; and other, 36%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Titanium oxides (unfinished TiO_2 pigment)	2823.00.0000	5.5% ad val.
TiO_2 pigments, 80% or more TiO_2	3206.11.0000	6.0% ad val.
TiO_2 pigments, other	3206.19.0000	6.0% ad val.
Ferrotitanium and ferrosilicon titanium	7202.91.0000	3.7% ad val.
Titanium waste and scrap metal	8108.10.1000	Free.
Unwrought titanium metal	8108.10.5000	15.0% ad val.
Wrought titanium metal	8108.90.6000	15.0% ad val.
Other titanium metal articles	8108.90.3000	5.5% ad val.

Depletion Allowance: Not applicable.

Prepared by **Joseph Gambogi [(703) 648-7718, jgambogi@usgs.gov, fax: (703) 648-7722]**

TITANIUM AND TITANIUM DIOXIDE

Government Stockpile: The Defense National Stockpile Center (DNSC) continued to solicit offers for the sale of titanium sponge held in the Government stockpile. For fiscal year 2002, 4,540 tons of sponge is planned for disposal. In support of an armor upgrade program, DNSC provided the U.S. Army with 227 tons of sponge. In addition to the quantities shown below, the stockpile contained 10,600 tons of nonstockpile-grade sponge.

Stockpile Status—9-30-01[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Titanium sponge	11,277	788	11,277	4,540	4,350

Events, Trends, and Issues: In 2001, domestic production of TiO_2 pigment was 1.34 million tons, a 5% decrease compared with 2000. Imports of pigment decreased 8% compared with 2000, while exports decreased 7%. Apparent consumption of pigment decreased 5% and published prices of rutile-grade pigment decreased slightly.

Although consumption of titanium metal in 2001 increased an estimated 21% compared with that of 2000, consumption of titanium metal in 2002 was expected to decrease significantly because of reduced demand from commercial aircraft.

One of the major titanium metal producers idled its 6,800-ton-per-year titanium sponge plant at Albany, OR. The closure leaves only one major domestic producer of titanium sponge. Domestic sponge capacity decreased from 21,600 tons per year in 2000 to 14,800 tons per year in 2001. Owing to high operational costs, plans were made to idle the 44,000-ton-per-year sulfate-route TiO_2 pigment plant at Baltimore, MD. The 50,000-ton-per-year chloride-route pigment plant at the Baltimore facility was expected to continue operating.

World Sponge Metal Production and Sponge and Pigment Capacity:

	Sponge production		Capacity 2001[4]	
	2000	2001[e]	Sponge	Pigment
United States	W	W	14,800	1,540,000
Australia	—	—	—	189,000
Belgium	—	—	—	70,000
Canada	—	—	—	75,000
China[e]	1,900	2,000	6,900	45,000
Finland	—	—	—	100,000
France	—	—	—	238,000
Germany	—	—	—	360,000
Italy	—	—	—	80,000
Japan	18,800	20,000	26,000	322,000
Kazakhstan[e]	8,380	8,500	22,000	1,000
Mexico	—	—	—	120,000
Russia[e]	20,000	20,000	26,000	20,000
Spain	—	—	—	65,000
Ukraine[e]	4,000	4,000	6,000	120,000
United Kingdom	—	—	—	304,000
Other countries	—	—	—	632,000
World total (rounded)	[5]54,000	[5]55,000	102,000	4,300,000

World Resources:[6] Resources and reserves of titanium minerals (ilmenite and rutile) are discussed in Titanium Mineral Concentrates. Titanium for domestic sponge production was obtained from rutile or rutile substitutes. The feedstock sources for pigment production were ilmenite, slag, and synthetic rutile.

Substitutes: There are few substitutes for titanium in aircraft and space use without some sacrifice of performance. For industrial uses, high-nickel steel, zirconium, and, to a limited extent, the superalloy metals may be substituted. In certain applications, ground calcium carbonate, precipitated calcium carbonate, kaolin, and talc compete with titanium dioxide as a white pigment.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]See also Titanium Mineral Concentrates.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B for definitions.
[4]Operating capacity.
[5]Excludes U.S. production.
[6]See Appendix C for definitions.

TUNGSTEN

(Data in metric tons of tungsten content, unless otherwise noted)

Domestic Production and Use: The last recorded U.S. production of tungsten concentrates was in 1994. In 2001, approximately eight companies in the United States processed tungsten concentrates, ammonium paratungstate, tungsten oxide, and/or scrap to make tungsten powder, tungsten carbide powder, and/or tungsten chemicals. Nearly 70 industrial consumers were surveyed on a monthly or annual basis. Data reported by these consumers indicates that 65% of the tungsten consumed in the United States was used in cemented carbide parts for cutting and wear-resistant materials primarily in the metalworking, oil and gas drilling, mining, and construction industries. The remaining tungsten was consumed in making lamp filaments, electrodes, and other components for the electrical and electronics industries; steels, superalloys, and wear-resistant alloys; and chemicals for catalysts and pigments. The total estimated value of tungsten consumed in 2001 was $350 million.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Mine	—	—	—	—	—
Secondary	2,930	3,350	4,980	5,120	6,000
Imports for consumption:					
Concentrate	4,850	4,750	2,870	2,370	2,400
Other forms	7,980	8,490	8,230	7,810	8,000
Exports:					
Concentrate	12	10	26	70	140
Other forms	2,570	3,640	2,860	2,800	5,000
Government stockpile shipments:					
Concentrate	—	—	([1])	1,240	1,700
Other forms	—	—	([1])	591	900
Consumption:					
Reported, concentrate	6,590	[2]3,210	[2]2,100	W	W
Apparent, all forms	12,200	12,300	12,900	14,300	14,000
Price, concentrate, dollars per mtu WO_3,[3] average:					
U.S. spot market, Platts Metals Week	64	52	47	47	64
European market, Metal Bulletin	47	44	40	45	66
Stocks, industry, yearend:					
Concentrate	658	514	W	W	W
Other forms	2,550	2,780	2,490	2,270	1,900
Net import reliance[4] as a percentage of apparent consumption	84	77	65	67	59

Recycling: During 2001, the tungsten content of scrap consumed by processors and end users was estimated at 6,000 tons. This represented approximately 43% of apparent consumption of tungsten in all forms.

Import Sources (1997-2000): Tungsten content of ores and concentrates, intermediate and primary products, wrought and unwrought tungsten, and waste and scrap: China, 41%; Russia, 21%; Germany, 5%; Portugal, 5%; and other, 28%.

Tariff: Item	Number	Normal Trade Relations[5] 12/31/01
Ore	2611.00.3000	Free.
Concentrate	9902.26.1100	Free.
Ferrotungsten	7202.80.0000	5.6% ad val.
Tungsten powders	8101.10.0000	7.0% ad val.
Ammonium tungstate	2841.80.0010	5.5% ad val.
Tungsten carbide	2849.90.3000	7.0% ad val.
Tungsten oxide	2825.90.3000	5.5% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: Sales of National Defense Stockpile tungsten began in 1999. In addition to the data listed in the table below, as of September 30, 2001, the stockpile also contained the following quantities of uncommitted nonstockpile-grade materials authorized for disposal (tons of tungsten content): ores and concentrates, 6,410; ferrotungsten, 342; and metal powder, 151.

Prepared by **Kim B. Shedd [(703) 648-4974, kshedd@usgs.gov, fax: (703) 648-7757]**

TUNGSTEN

Stockpile Status—9-30-01[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Carbide powder	—	151	—	454	377
Ferrotungsten	201	36	201	136	200
Metal powder	529	—	529	136	136
Ores and concentrates	23,700	1,980	23,700	1,810	1,870

Events, Trends, and Issues: World tungsten supply continued to be dominated by Chinese production and exports. Beginning in 1999 and continuing into 2001, the Chinese Government took several steps to control the release of Chinese tungsten into the world market and to increase prices. During the latter half of 2000, prices for ammonium paratungstate and tungsten concentrates began to rapidly increase. The Metal Bulletin price for tungsten concentrates leveled off in February 2001, and then began to decline in August. The Metal Bulletin European free market price for ammonium paratungstate increased until April 2001, leveled off, and then began to decline in June. Nevertheless, these relatively high prices, in combination with the desire by western processors to diversify the sources of their tungsten raw materials, resulted in renewed interest in increasing tungsten mine production outside China. Projects to increase production from operating mines, to restart production from closed mines, and to develop new mines were under consideration and development.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States	—	—	140,000	200,000
Australia	—	—	7,000	79,000
Austria	1,600	1,700	10,000	15,000
Bolivia	381	390	53,000	100,000
Brazil	14	15	8,500	20,000
Burma	82	90	15,000	34,000
Canada	—	—	260,000	490,000
China	30,000	37,000	770,000	1,100,000
Korea, North	700	600	NA	35,000
Korea, Republic of	—	—	58,000	77,000
Portugal	750	800	25,000	25,000
Russia	3,500	3,600	250,000	420,000
Thailand	30	50	30,000	30,000
Uzbekistan	200	150	NA	20,000
Other countries	155	190	300,000	450,000
World total (rounded)	37,400	44,600	1,900,000	3,100,000

World Resources: Although world tungsten resources are geographically widespread, China has many deposits, including some of the largest in the world. As a result, China ranks number one in terms of tungsten resources and reserves. Canada, Kazakhstan, Russia, and the United States also have significant tungsten resources.

Substitutes: Cemented tungsten carbide remained a primary cutting-tool insert material because of its versatility in meeting technical requirements in many turning and milling operations. However, ceramics, ceramic-metallic composites, and other materials continued to be developed and utilized as substitutes to meet the changing needs of the world market. Increased quantities of carbide cutting-tool inserts were coated with alumina, diamond, titanium carbide, and/or titanium nitride to extend the life of the inserts. Tungsten remained the preferred and essentially unsubstitutable material for filaments, electrodes, and contacts in lamp and lighting applications. However, an electrodeless, nontungsten lamp is available for commercial and industrial use.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Less than ½ unit.
[2]Excludes 6 months of withheld data.
[3]A metric ton unit (mtu) of tungsten trioxide (WO_3) contains 7.93 kilograms of tungsten.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]Special tariff rates apply for Canada and Mexico.
[6]See Appendix B for definitions.
[7]See Appendix C for definitions.

VANADIUM

(Data in metric tons of vanadium content, unless otherwise noted)

Domestic Production and Use: Eight firms make up the U.S. vanadium industry. These firms produce ferrovanadium, vanadium pentoxide, vanadium metal, and vanadium-bearing chemicals or specialty alloys by processing materials such as petroleum residues, spent catalysts, utility ash, and vanadium-bearing iron slag. Metallurgical use, primarily as an alloying agent for iron and steel, accounts for about 95% of the vanadium consumed domestically. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts for the production of maleic anhydride and sulfuric acid. With regard to total domestic consumption, major end-use distribution was as follows: carbon steel 34%; high-strength low-alloy steel, 26%; full alloy steel, 19%; tool steel, 6%; and other, 15%.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production, mine, mill	W	W	W	—	—
Imports for consumption:					
Ash, ore, residues, slag	2,950	2,400	1,650	1,890	2,000
Vanadium pentoxide, anhydride	711	847	208	902	700
Oxides and hydroxides, other	126	33	—	14	40
Aluminum-vanadium master alloys (gross weight)	11	298	1,210	16	10
Ferrovanadium	1,840	1,620	1,930	2,510	2,600
Exports:					
Vanadium pentoxide, anhydride	614	681	747	653	100
Oxides and hydroxides, other	385	232	70	100	100
Aluminum-vanadium master alloys (gross weight)	974	856	514	677	400
Ferrovanadium	446	579	213	172	100
Shipments from Government stockpile	260	—	—	—	—
Consumption, reported	4,710	4,380	3,620	3,520	3,600
Price, average, dollars per pound V_2O_5	3.90	5.47	1.99	1.82	1.40
Stocks, consumer, yearend	323	336	348	282	200
Employment, mine and mill, number	400	400	400	400	400
Net import reliance[1] as a percentage of reported consumption	94	78	76	100	100

Recycling: Some tool steel scrap was recycled primarily for its vanadium content, and vanadium was recycled from spent chemical process catalysts, but these two sources together accounted for only a very small percentage of total vanadium used.

Import Sources (1997-2000): Ferrovanadium: Canada, 35%; South Africa, 21%; China, 21%; Austria, 9%; and other, 14%. Vanadium pentoxide: South Africa, 99%; and other, 1%.

Tariff: Ash, residues, slag, and waste and scrap enter duty-free.

Item	Number	Normal Trade Relations 12/31/01
Vanadium pentoxide anhydride	2825.30.0010	8.6% ad val.
Vanadium oxides and hydroxides, other	2825.30.0050	8.6% ad val.
Vanadates	2841.90.1000	7.2% ad val.
Ferrovanadium	7202.92.0000	4.2% ad val.
Aluminum-vanadium master alloys	7601.20.9030	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

Prepared by **Robert G. Reese, Jr. [(703) 648-4981, rreese@usgs.gov, fax: (703) 648-7757]**

VANADIUM

Events, Trends, and Issues: Preliminary data indicate that U.S. vanadium consumption in 2001 decreased 7% from that in 2000. Among the major uses for vanadium, carbon steel accounted for 33% of domestic consumption. Full alloy steel and high-strength low-alloy steel accounted for 21% and 24% of domestic consumption, respectively.

Both ferrovanadium and vanadium pentoxide prices remained low during 2001. Articles in various industry-related publications attributed the falling prices primarily to an increased supply of material.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[2]	Reserve base[2]
	2000	2001[e]		
United States	—	—	45,000	4,000,000
China	16,000	16,000	2,000,000	3,000,000
Russia	9,000	9,000	5,000,000	7,000,000
South Africa	[e]17,000	17,000	3,000,000	12,000,000
Other countries	1,000	1,000	NA	1,000,000
World total (may be rounded)	43,000	43,000	10,000,000	27,000,000

World Resources: World resources of vanadium exceed 63 million tons. Vanadium occurs in deposits of titaniferous magnetite, phosphate rock, and uraniferous sandstone and siltstone, in which it constitutes less than 2% of the host rock. Significant amounts are also present in bauxite and carboniferous materials, such as crude oil, coal, oil shale, and tar sands. Because vanadium is usually recovered as a byproduct or coproduct, demonstrated world resources of the element are not fully indicative of available supplies. While domestic resources are adequate to supply current domestic needs, a substantial part of U.S. demand is currently met by foreign material because of price advantages.

Substitutes: Steels containing various combinations of other alloying elements can be substituted for steels containing vanadium. Metals, such as columbium, manganese, molybdenum, titanium, and tungsten, are to some degree interchangeable with vanadium as alloying elements in steel. Platinum and nickel can replace vanadium compounds as catalysts in some chemical processes. There is currently no acceptable substitute for vanadium in aerospace titanium alloys.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix C for definitions.

VERMICULITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Two companies with mining and processing facilities produced vermiculite concentrate. One company had its operation in South Carolina, and the other company had an operation in Virginia and an operation in South Carolina run by its subsidiary company. Most of the vermiculite concentrate was shipped to 19 exfoliating plants in 10 States. The end uses for exfoliated vermiculite were estimated to be lightweight concrete aggregates (including concrete, plaster, and cement premixes), 15%; and insulation, agricultural, and other, 85%.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production[1]	W	W	[e 2]175	[e 3]150	150
Imports for consumption[e]	67	68	71	59	60
Exports[e]	9	11	13	5	5
Consumption, apparent, concentrate	W	W	[e]240	[e]204	205
Consumption, exfoliated[e]	155	170	175	165	165
Price, average value, concentrate, dollars per ton, f.o.b. mine	W	W	W	[3 4]114	114
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number[e]	230	230	230	230	230
Net import reliance[5] as a percentage of apparent consumption	W	W	[e]27	[e]26	27

Recycling: Insignificant.

Import Sources (1997-2000): South Africa, 71%; China, 25%; and other, 4%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12/31/01**
Vermiculite, perlite and chlorites, unexpanded	2530.10.0000	Free.
Exfoliated vermiculite, expanded clays, foamed slag, and similar expanded materials	6806.20.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Michael J. Potter [(703) 648-7723, mpotter@usgs.gov, fax: (703) 648-7722]**

VERMICULITE

Events, Trends, and Issues: Vermiculite use in insulation includes moderately high-temperature applications. Vermiculite is used with selective binders (sodium and potassium silicate) and compressed into blocks, boards, or special shapes. Bonded refractory boards and shapes are used as backup insulation behind hot refractory surfaces or as hot face media themselves. In lower-temperature, metal-melting industries, vermiculite can be used in contact with the molten metal and can withstand heat and flame up to 1,200° C. Vermiculite shapes are used in the aluminum industry in particular because vermiculite has a nonwetting characteristic with aluminum. Vermiculite also is used in refractory concretes, such as ramming mixes and castables.[6]

South Africa and the United States have been the largest producers of vermiculite. China had an estimated output of 40,000 tons in 2000. In Uganda, a Canadian firm, Canmin Resources Ltd., began commercial mining and production in 2001 with 2,000 tons of vermiculite being mined for stockpiling. The company expected to serve markets for insulation and horticulture in the Middle East.[7] In Zimbabwe, Samrec Vermiculite (Pvt.) Ltd., the Imerys Group-owned operator of the Shawa Mine, was completing work to double its vermiculite capacity to more than 40,000 tons per year. Two-thirds of the production was being sold to Europe with the remainder going to Asia and the Middle East. The increased production would be marketed worldwide.[8]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[9]	Reserve base[9]
	2000	2001[e]		
United States	[e 3]150	150	25,000	100,000
Brazil	23	25	NA	NA
China	40	50	NA	NA
Russia	25	25	NA	NA
South Africa	209	162	20,000	80,000
Zimbabwe	19	15	NA	NA
Other countries[10]	46	40	5,000	20,000
World total (may be rounded)	512	470	50,000	200,000

World Resources: Marginal reserves of vermiculite, occurring in Colorado, Nevada, North Carolina, Texas, and Wyoming, are estimated to be 2 to 3 million tons. Resources in other countries may include material that does not exfoliate as well as United States and South African vermiculite.

Substitutes: Expanded perlite is a substitute for vermiculite in lightweight concrete and plaster. Other more dense but less costly material substitutes in these applications are expanded clay, shale, slate, and slag. Alternate materials for loosefill fireproofing insulation include fiberglass, perlite, and slag wool. In agriculture, substitutes include peat, perlite, sawdust, bark and other plant materials, and synthetic soil conditioners.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Concentrate sold and used by producers.
[2]Roskill Information Services, Ltd., 1999, The economics of vermiculite: London, Roskill Information Services, Ltd., July, 99 p. plus appendix.
[3]Moeller, E.M., 2001, Vermiculite: Mining Engineering, v. 53, no. 6, June, p. 65.
[4]Average of price range of $60 to $168 per ton, depending on sized grades.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]Russell, Alison, 2000, Vermiculite: Financial Times Executive Commodity Reports, p. 16.
[7]Industrial Minerals, 2001a, Mineral notes: Industrial Minerals, no. 407, August, p. 77.
[8]———2001b, World of minerals: Industrial Minerals, no. 408, September, p. 19.
[9]See Appendix C for definitions.

YTTRIUM[1]

(Data in metric tons of yttrium oxide (Y_2O_3) content, unless otherwise noted)

Domestic Production and Use: The rare-earth element yttrium was mined as a constituent of the mineral bastnasite at Mountain Pass, CA, but was not recovered as a separate element during processing. Bastnasite, a rare-earth fluocarbonate mineral, was mined as a primary product. Bastnasite's yttrium content is very small and represents a potential minor source of the element. Yttrium used by the domestic industry was imported primarily as compounds.

Yttrium was used in many applications. Principal uses were in phosphors used in color televisions and computer monitors, trichromatic fluorescent lights, temperature sensors, and x-ray-intensifying screens. As a stabilizer in zirconia, yttrium was used in abrasives, wear-resistant and corrosion-resistant cutting tools, seals and bearings, high-temperature refractories for continuous-casting nozzles, jet engine coatings, oxygen sensors in automobile engines, and simulant gemstones. In electronics, yttrium-iron-garnets were components in microwave radar to control high frequency signals. Yttrium was an important component in yttrium-aluminum garnet laser crystals used in industrial cutting and welding, medical and dental surgical procedures, temperature and distance sensing, photoluminescence, photochemistry, digital communications, and nonlinear optics. Yttrium was also used in heating-element alloys, superalloys, and high-temperature superconductors. The approximate distribution in 2000 by end use was as follows: lamp and cathode-ray-tube phosphors, 70%; oxygen sensors, laser crystals, miscellaneous, 17%; ceramics and abrasives, 8%; and alloys, 5%.

Salient Statistics—United States:	**1997**	**1998**	**1999**	**2000**	**2001[e]**
Production, mine	—	—	—	—	—
Imports for consumption:					
In monazite (yttrium oxide content[e])	0.22	—	—	—	—
Yttrium compounds, greater than 19% to less than 85% oxide equivalent (gross weight)	48	107	268	97	69
Exports, in ore and concentrate	NA	NA	NA	NA	NA
Consumption, estimated[2]	292	516	428	454	400
Price, dollars:					
Monazite concentrate, per metric ton[3]	400	400	400	400	400
Yttrium oxide, per kilogram, 99.0% to 99.99% purity[4]	17-85	22-85	22-85	25-200	22-88
Yttrium metal, per kilogram, 99.0% to 99.9% purity[4]	80-100	80-100	80-100	95-115	95-115
Stocks, processor, yearend	NA	NA	NA	NA	NA
Net import reliance[e 5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Small quantities, primarily from laser crystals and synthetic garnets.

Import Sources (1997-2000):[e] Yttrium compounds, >19% to < 85% weight percent yttrium oxide equivalent: China, 69%; France, 21%; Japan, 4%; Germany, 2%; and other, 4%. Import sources based on Journal of Commerce data (year 2000 only): China, 74%; Japan, 22%; United Kingdom, 3%; and Germany, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12/31/01**
Thorium ores and concentrates (monazite)	2612.20.0000	Free.
Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed	2805.30.0000	5.0% ad val.
Yttrium bearing materials and compounds containing by weight >19% to <85% Y_2O_3	2846.90.4000	Free.
Rare-earth compounds, including yttrium oxide, yttrium nitrate, and other individual compounds	2846.90.8000	3.7% ad val.

Depletion Allowance: Monazite, thorium content, 22% (Domestic), 14% (Foreign); yttrium, rare-earth content, 14% (Domestic and foreign); and xenotime, 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7722]**

YTTRIUM

Events, Trends, and Issues: Yttrium demand in the United States increased in 2000 and declined slightly in 2001 as the U.S. economy experienced a recessionary period. International yttrium markets continued to be competitive, although China was the source of most of the world's supply. The decrease in domestic yttrium demand is primarily the result of an overall slow down in the domestic economy and the continued strength of the U.S. dollar against many foreign currencies. Yttrium was consumed primarily in the form of high-purity compounds, especially the oxide and nitrate.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e 6] 2000	Mine production[e 6] 2001	Reserves[7]	Reserve base[7]
United States	—	—	120,000	130,000
Australia	—	—	100,000	110,000
Brazil	—	—	400	1,500
Canada	—	—	3,300	4,000
China	2,300	2,300	220,000	240,000
India	55	55	36,000	38,000
Malaysia	11	11	13,000	21,000
South Africa	—	—	4,400	5,000
Sri Lanka	2	2	240	260
Thailand	—	—	600	600
Former Soviet Union[8]	26	26	9,000	10,000
World total (rounded)	2,400	2,400	510,000	560,000

World Resources: Large resources of yttrium in monazite and xenotime are available worldwide in ancient and recent placer deposits (monazite and xenotime), weathered clay deposits (ion-adsorption ore), carbonatites, and uranium ores. Additional large subeconomic resources of yttrium occur in other monazite-bearing deposits, apatite-magnetite rocks, sedimentary phosphate deposits, deposits of columbium-tantalum minerals, and certain uranium ores, especially those of the Blind River District in Canada. It is probable that the world's resources are very large.

Substitutes: Substitutes for yttrium are available for some applications, but generally are much less effective. In most uses, especially in phosphors, electronics, and lasers, yttrium is not subject to substitution by other elements. As a stabilizer in zirconia ceramics, yttria (yttrium oxide) may be substituted with calcia (calcium oxide) or magnesia (magnesium oxide), but they generally are not as resilient.

[e]Estimated. NA Not available. — Zero.
[1]See also Rare Earths and Scandium.
[2]Essentially all yttrium consumed domestically was imported or refined from imported ores and concentrates.
[3]Monazite concentrate prices derived from U.S. Census Bureau data (1997-2000).
[4]Yttrium oxide and metal prices from Elements—Rare Earths, Specialty Metals and Applied Technology (a High Tech Materials on-line publication a www.rareearthsmarketplace.com), Rhodia Rare Earths, Inc., Shelton, CT, and the China Rare Earth Information Center, Baotou, China.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]Includes yttrium contained in rare-earth ores.
[7]See Appendix C for definitions.
[8]As constituted before December 1991.

ZINC

(Data in thousand metric tons of zinc content, unless otherwise noted)

Domestic Production and Use: The value of zinc mined in 2001, based on contained zinc recoverable from concentrate, was about $824 million. It was produced in 6 States by 19 mines operated by 8 companies. Alaska, Missouri, New York, and Tennessee accounted for 98% of domestic mine output; Alaska alone accounted for about three-fourths of production. Three primary and 12 large- and medium-sized secondary smelters refined zinc metal of commercial grade in 2001. Of zinc metal consumed, about 75% was used in Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania, mostly by steel companies. Of the total zinc consumed, about 55% was used in galvanizing, 17% in zinc-base alloys, 13% in brass and bronze, and 15% in other uses. Zinc compounds and dust were used principally by the agriculture, chemical, paint, and rubber industries. Major coproducts of zinc mining and smelting, in order of decreasing tonnage, were lead, sulfur, cadmium, silver, gold, and germanium.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production:					
Mine, zinc in ore[1]	632	755	813	829	830
Primary slab zinc	226	234	241	228	230
Secondary slab zinc	140	134	131	143	133
Imports for consumption:					
Ore and concentrate	50	46	75	53	50
Refined zinc	876	879	966	915	850
Exports:					
Ore and concentrate	461	552	531	523	530
Refined zinc	4	2	2	3	2
Shipments from Government stockpile	32	26	22	39	22
Consumption:					
Apparent, refined zinc	1,260	1,290	1,340	1,330	1,210
Apparent, all forms	1,490	1,580	1,610	1,610	1,500
Price, average, cents per pound:					
Domestic producers[2]	64.6	51.4	53.5	55.6	45.0
London Metal Exchange, cash	59.7	46.5	48.8	51.1	42.0
Stocks, slab zinc, yearend	88	68	84	77	100
Employment:					
Mine and mill, number[e]	2,500	2,400	2,500	2,600	2,400
Smelter primary, number[e]	1,000	1,000	1,000	1,000	900
Net import reliance[3] as a percentage of apparent consumption:					
Refined zinc	70	71	72	72	70
All forms of zinc	59	58	60	60	60

Recycling: In 2001, an estimated 440,000 tons of zinc was recovered from waste and scrap; about 30% was recovered in the form of slab zinc and the remainder in alloys, oxide, and chemicals. Of the total amount of scrap recycled, 330,000 tons was derived from new scrap and 110,000 tons was derived from old scrap. About 12,000 tons of scrap was exported, mainly to Taiwan, and 43,000 tons was imported, mainly from Canada.

Import Sources (1997-2000): Ore and concentrate: Peru, 48%; Mexico, 20%; Australia, 19%; and other, 13%. Metal: Canada, 55%; Mexico, 9%; Kazakhstan, 7%; and other, 29%. Combined total: Canada, 53%; Mexico, 10%; Peru, 7%; and other, 30%.

Tariff: Item	Number	Normal Trade Relations[4] 12/31/01
Ore and concentrate	2608.00.0030	Free.
Unwrought metal	7901.11.0000	1.5% ad val.
Alloys, casting-grade	7901.12.1000	3% ad val.
Alloys	7901.20.0000	3% ad val.
Waste and scrap	7902.00.0000	Free.
Hard zinc spelter	2620.11.0000	Free.
Zinc oxide	2817.00.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Prepared by **Jozef Plachy [(703) 648-4982, jplachy@usgs.gov, fax: (703) 648-7757]**

ZINC

Government Stockpile:

Stockpile Status—9-30-01[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Zinc	114	6	114	45	24

Events, Trends, and Issues: In 2001, the price of zinc on the London Metal Exchange reached its lowest level in over a decade. Since the global economy is showing little, if any, sign of improvement and because new zinc production continues to come on-stream, a price recovery seems unlikely. Reaction to declining price by mining companies ranged from curtailment of mine production to outright closure of some mines through the sale of mining operations.

U.S. mine production greatly exceeded smelter capacity, necessitating exports of concentrate. More than one-third of all concentrate exports, which were supplied entirely by the Red Dog Mine in Alaska, was processed at the Trail smelter in Canada; the remaining two-thirds went mainly to Asian smelters. The United States is the world's largest exporter of zinc concentrates; it is also the largest importer of zinc metal.

Decline in domestic zinc consumption in 2001 reflected slowdown of the U.S. economy. Despite declining consumption, the United States remained one of the largest consumers of zinc and zinc products. However, domestic metal production capacity, both primary and secondary, accounts for less than one-third of the quantity consumed. Canada and Mexico are the leading sources of zinc for the United States because of their geographical proximity and because all three main forms of zinc trade—concentrate, metal, and scrap—can be imported duty free from those sources.

World Mine Production, Reserves, and Reserve Base:

	Mine production[6]		Reserves[7]	Reserve base[7]
	2000	2001[e]		
United States	829	830	25,000	80,000
Australia	1,420	1,500	32,000	80,000
Canada	936	950	11,000	31,000
China	1,710	1,700	34,000	93,000
Mexico	393	390	6,000	8,000
Peru	910	1,050	8,000	13,000
Other countries	2,530	2,510	74,000	130,000
World total (may be rounded)	8,730	8,930	190,000	440,000

World Resources: Identified zinc resources of the world are about 1.9 billion tons.

Substitutes: Aluminum, steel, and plastics substitute for galvanized sheet. Aluminum, plastics, and magnesium are major competitors as diecasting materials. Plastic coatings, paint, and cadmium and aluminum alloy coatings replace zinc for corrosion protection; aluminum alloys are used in place of brass. Many elements are substitutes for zinc in chemical, electronic, and pigment uses.

[e]Estimated.
[1]Zinc recoverable after smelting and refining was reported for mine production prior to Mineral Commodity Summaries 2001.
[2]Platts Metals Week price for North American Special High Grade zinc.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]No tariff for Canada and Mexico for items shown.
[5]See Appendix B for definitions.
[6]Zinc content of concentrate and direct shipping ore.
[7]See Appendix C for definitions.

ZIRCONIUM AND HAFNIUM

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Zircon sand was produced at two mines in Florida and at one mine in Virginia. Zirconium and hafnium metal were produced from zircon sand by two domestic producers, one in Oregon and the other in Utah. Typically, both metals are in the ore in a Zr to Hf ratio of 50:1. Primary zirconium chemicals were produced by the Oregon metal producer and at a plant in New Jersey. Secondary zirconium chemicals were produced by 10 other companies. Zirconia (ZrO_2) was produced from zircon sand at plants in Alabama, New Hampshire, New York, Ohio, and by the metal producer in Oregon. Zircon ceramics, opacifiers, refractories, and foundry applications are the largest end uses for zirconium. Other end uses of zirconium include abrasives, chemicals, metal alloys, welding rod coatings, and sandblasting. The largest market for hafnium metal is as an addition in superalloys.

Salient Statistics—United States:	1997	1998	1999	2000	2001[e]
Production: Zircon (ZrO_2 content)[1]	100,000	100,000	100,000	100,000	100,000
Imports:					
Zirconium, ores and concentrates (ZrO_2 content)	40,600	58,200	37,500	42,400	40,000
Zirconium, alloys, waste and scrap (ZrO_2 content)	929	1,210	1,160	1,400	1,100
Zirconium oxide (ZrO_2 content)[2]	4,220	3,900	3,140	3,950	3,300
Hafnium, unwrought, waste and scrap	8	12	9	11	8
Exports:					
Zirconium ores and concentrates (ZrO_2 content)	28,800	26,600	45,200	47,400	38,300
Zirconium, alloys, waste and scrap (ZrO_2 content)	188	216	211	259	280
Zirconium oxide (ZrO_2 content)[2]	1,970	1,540	1,680	2,100	2,600
Consumption, zirconium ores and concentrates, apparent (ZrO_2 content)	W	W	W	W	W
Prices:					
Zircon, dollars per metric ton (gross weight):					
Domestic[3]	419	320	300	340	350
Imported, f.o.b.[4]	445	355	311	396	370
Zirconium sponge, dollars per kilogram[5]	20-26	20-26	20-26	20-26	20-26
Hafnium sponge, dollars per kilogram[5]	165-209	165-209	165-209	165-209	165-209
Net import reliance[6] as a percentage of apparent consumption:					
Zirconium	W	W	W	W	W
Hafnium	NA	NA	NA	NA	NA

Recycling: Zirconium metal was recycled by four companies, one each in California, Michigan, New York, and Texas. Most of the zirconium recycled came from scrap generated during metal production and fabrication. Zircon foundry mold cores and spent or rejected zirconia refractories are often recycled. Recycling of hafnium metal was insignificant.

Import Sources (1997-2000): Zirconium ores and concentrates: South Africa, 55%; Australia, 41%; and other, 4%. Zirconium, wrought, unwrought, waste and scrap: France, 68%; Germany, 14%; Japan, 6%; Canada, 4%; and other, 8%. Hafnium, unwrought, waste and scrap: France, 82%; Germany, 7%; United Kingdom, 2%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12/31/01
Zirconium ores and concentrates	2615.10.0000	Free.
Germanium oxides and ZrO_2	2825.60.0000	3.7% ad val.
Ferrozirconium	7202.99.1000	4.2% ad val.
Zirconium, waste and scrap	8109.10.3000	Free.
Zirconium, other unwrought, powders	8109.10.6000	4.2% ad val.
Zirconium, other wrought, alloys	8109.90.0000	3.7% ad val.
Unwrought hafnium, waste and scrap	8112.91.2000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: In addition to 15,726 tons of baddeleyite ore (gross weight) held in the National Defense Stockpile, the U.S. Department of Energy (DOE) held over 500 tons of zirconium in various forms. DOE also maintained a stockpile of approximately 35 tons of hafnium.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7722]**

ZIRCONIUM AND HAFNIUM

Stockpile Status—9-30-01[7]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2001	Disposals FY 2001
Baddeleyite	—	—	—	17,383	—

Events, Trends, and Issues: The global supply and demand of zirconium mineral concentrates was largely balanced in 2001. This trend is expected to continue over the next few years. In the long-term, however, supply shortages may occur unless new production sources of zirconium concentrates are developed. U.S. imports of zirconium ores and concentrates were estimated to have decreased 55%, while exports increased 44% compared with those of 2000. A mining operation at Stony Creek, VA, began production of zircon and other heavy minerals in 1998. Initial capacity was expected to include up to 30,000 tons per year of zircon. An expansion at the mine began in 2001 with completion scheduled for 2002. The availability of hafnium continued to exceed supply. Surpluses were stockpiled in the form of hafnium oxide. The demand for nuclear-grade zirconium metal, the production of which necessitates hafnium's removal, produces more hafnium than can be consumed by the metal's markets.

World Mine Production, Reserves, and Reserve Base: World primary hafnium production statistics are not available. Hafnium occurs with zirconium in the minerals zircon and baddeleyite.

	Zirconium				Hafnium	
	Mine production (thousand metric tons)		Reserves[8] (million metric tons, ZrO_2)	Reserve base[8]	Reserves[8] (thousand metric tons, HfO_2)	Reserve base[8]
	2000	2001[e]				
United States[1]	100	100	3.4	5.3	68	97
Australia	400	400	9.1	30.08	180	600
Brazil	19	30	1.9	1.9	7	7
China	[e]15	15	0.5	1.0	NA	NA
India	19	19	3.4	3.8	42	46
South Africa	400	300	14.0	14.0	260	260
Ukraine	[e]65	75	4.0	6.0	NA	NA
Other countries	23	30	0.9	4.1	NA	NA
World total (may be rounded)	1,040	1,070	36	65	560	1,000

World Resources: Resources of zircon in the United States included about 14 million tons associated with titanium resources in heavy-mineral sand deposits. Phosphate and sand and gravel deposits have the potential to yield substantial amounts of zircon as a future byproduct. Eudialyte and gittinsite are zirconium silicate minerals that have a potential for zirconia production. Identified world resources of zircon exceed 60 million tons.

Resources of hafnium in the United States are estimated to be about 130,000 tons, available in the 14-million-ton domestic resources of zircon. World resources of hafnium are associated with those of zircon and baddeleyite and exceed 1 million tons.

Substitutes: Chromite and olivine can be used instead of zircon for some foundry applications. Dolomite and spinel refractories can also substitute for zircon in certain high-temperature applications. Columbium (niobium), stainless steel, and tantalum provide limited substitution in nuclear applications, while titanium and synthetic materials may substitute in some chemical plant uses.

Silver-cadmium-indium control rods are used in lieu of hafnium at numerous nuclear powerplants. Zirconium can be used interchangeably with hafnium in certain superalloys; in others, only hafnium produces the desired or required grain boundary refinement.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Rounded to one significant digit to avoid revealing company proprietary data. ZrO_2 content of zircon is typically 65%.
[2]Includes germanium oxides and zirconium oxides.
[3]E.I. du Pont de Nemours & Co. and Iluka Resources, Inc., average price.
[4]U.S. Census Bureau trade data.
[5]American Metal Market, daily, Miscellaneous prices. Converted from pounds.
[6]Defined as imports - exports.
[7]See Appendix B for definitions.
[8]See Appendix C for definitions.

APPENDIX A

Abbreviations and Units of Measure

1 carat (metric) (diamond)	= 200 milligrams
1 flask (fl)	= 76 pounds, avoirdupois
1 karat (gold)	= one twenty-fourth part
1 kilogram (kg)	= 2.2046 pounds, avoirdupois
1 long ton (lt)	= 2,240 pounds, avoirdupois
1 long ton unit (ltu)	= 1% of 1 long ton or 22.4 pounds avoirdupois
long calcined ton (lct)	= excludes water of hydration
long dry ton (ldt)	= excludes excess free moisture
Mcf	= 1,000 cubic feet
1 metric ton (t)	= 2,204.6 pounds, avoirdupois or 1,000 kilograms
1 metric ton (t)	= 1.1023 short ton
1 metric ton unit (mtu)	= 1% of 1 metric ton or 10 kilograms
1 pound (lb)	= 453.6 grams
1 short ton (st)	= 2,000 pounds, avoirdupois
1 short ton unit (stu)	= 1% of 1 short ton or 20 pounds, avoirdupois
1 short dry ton (sdt)	= 2,000 pounds, avoirdupois, excluding moisture content
1 troy ounce (tr oz)	= 1.09714 avoirdupois ounces or 31.103 grams
1 troy pound	= 12 troy ounces

APPENDIX B

Definitions of Selected Terms Used in This Report

Terms Used for Materials in the National Defense Stockpile and Helium Stockpile

Uncommitted inventory refers to material in the stockpile, whether stockpile-grade or nonstockpile-grade. In the tables for this report, only stockpile-grade material is listed; if appropriate, nonstockpile-grade material is cited in the text.

Committed inventory refers to both stockpile-grade materials and nonstockpile-grade materials that have been sold or traded from the stockpile, either in the current fiscal year or in prior years, but not yet removed from stockpile facilities.

Authorized for disposal refers to quantities that are in excess of the stockpile goal for a material, and for which Congress has authorized disposal over the long term at rates designed to maximize revenue but avoid undue disruption of the usual markets and loss to the United States.

Disposal plan FY 2001 indicates the total amount of a material in the National Defense Stockpile that the U.S. Department of Defense is permitted to sell under the Annual Materials Plan approved by Congress for the fiscal year. Fiscal year 2001 is the period October 1, 2000, through September 30, 2001. Note that, unlike the National Defense Stockpile, helium stockpile sales by the Bureau of Land Management under the Helium Privatization Act of 1996 are permitted to exceed disposal plans.

Disposals FY 2001 refers to material sold or traded from the stockpile in fiscal year 2001; it may or may not have been removed by the buyers.

Depletion Allowance

The depletion allowance is a business tax deduction analogous to depreciation, but applies to an ore reserve rather than equipment or production facilities. Federal tax law allows this deduction from taxable corporate income, recognizing that an ore deposit is a depletable asset that must eventually be replaced.

APPENDIX C

A Resource/Reserve Classification for Minerals[1]

INTRODUCTION

Through the years, geologists, mining engineers, and others operating in the minerals field have used various terms to describe and classify mineral resources, which as defined herein include energy materials. Some of these terms have gained wide use and acceptance, although they are not always used with precisely the same meaning.

The U.S. Geological Survey collects information about the quantity and quality of all mineral resources. In 1976, the Survey and the U.S. Bureau of Mines developed a common classification and nomenclature, which was published as U.S. Geological Survey Bulletin 1450-A—*"Principles of the Mineral Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey."* Experience with this resource classification system showed that some changes were necessary in order to make it more workable in practice and more useful in long-term planning. Therefore, representatives of the U.S. Geological Survey and the U.S. Bureau of Mines collaborated to revise Bulletin 1450-A. Their work was published in 1980 as U.S. Geological Survey Circular 831—*"Principles of a Resource/Reserve Classification for Minerals."*

Long-term public and commercial planning must be based on the probability of discovering new deposits, on developing economic extraction processes for currently unworkable deposits, and on knowing which resources are immediately available. Thus, resources must be continuously reassessed in the light of new geologic knowledge, of progress in science and technology, and of shifts in economic and political conditions. To best serve these planning needs, known resources should be classified from two standpoints: (1) purely geologic or physical/chemical characteristics—such as grade, quality tonnage, thickness, and depth—of the material in place: and (2) profitability analyses based on costs of extracting and marketing the material in a given economy at a given time. The former constitutes important objective scientific information of the resource and a relatively unchanging foundation upon which the latter more valuable economic delineation can be based.

The revised classification systems, designed generally for all mineral materials, is shown graphically in figures 1 and 2; their components and usage are described in the text. The classification of mineral and energy resources is necessarily arbitrary, because definitional criteria do not always coincide with natural boundaries. The system can be used to report the status of mineral and energy-fuel resources for the Nation or for specific areas.

RESOURCE/RESERVE DEFINITIONS

A dictionary definition of resource, "something in reserve or ready if needed," has been adapted for mineral and energy resources to comprise all materials, including those only surmised to exist, that have present to anticipated future value.

Resource.—A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Original Resource.—The amount of a resource before production.

Identified Resources.—Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and sub-economic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into measured, indicated, and inferred.

Demonstrated.—A term for the sum of measured plus indicated.

Measured.—Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and(or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurements are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resource are well established.

Indicated.—Quantity and grade and(or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observation.

Inferred.—Estimates are based on an assumed continuity beyond measured and(or) indicated resources, for which there is geologic evidence. Inferred resources may or may not be supported by samples or measurements.

Reserve Base.—That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources). The term "geologic reserve" has been applied by others generally to the reserve-base category, but it also may include the inferred-reserve-base category;

[1]Based on U.S. Geological Survey Circular 831, 1980.

it is not a part of this classification system.

Inferred Reserve Base.—The in-place part of an identified resource from which inferred reserves are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a deposit and for which there may be no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base, for which there is geologic evidence.

Reserves.—That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

Marginal Reserves.—That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technological factors.

Economic.—This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Subeconomic Resources.—The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources.—Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. Undiscovered resources may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, undiscovered resources may be divided into two parts.

Hypothetical Resources.—Undiscovered resources that are similar to known mineral bodies and that may be reasonably expected to exist in the same producing district or region under analogous geologic conditions. If exploration confirms their existence and reveals enough information about their quality, grade, and quantity, they will be reclassified as identified resources.

Speculative Resources.—Undiscovered resources that may occur either in known types of deposits in favorable geologic settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources/Reserves.—That part of any resource/reserve category that is restricted from extraction by laws or regulations. For example, restricted reserves meet all the requirements of reserves except that they are restricted from extraction by laws or regulations.

Other Occurrences.—Materials that are too low grade or for other reasons are not considered potentially economic, in the same sense as the defined resource, may be recognized and their magnitude estimated, but they are not classified as resources. A separate category, labeled other occurrences, is included in figures 1 and 2. In figure 1, the boundary between subeconomic and other occurrences is limited by the concept of current or potential feasibility of economic production, which is required by the definition of a resource. The boundary is obviously uncertain, but limits may be specified in terms of grade, quality, thickness, depth, percent extractable, or other economic-feasibility variables.

Cumulative Production.—The amount of past cumulative production is not, by definition, a part of the resource. Nevertheless, a knowledge of what has been produced is important to an understanding of current resources, in terms of both the amount of past production and the amount of residual or remaining in-place resource. A separate space for cumulative production is shown in figure 1. Residual material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

FIGURE 1.—Major Elements of Mineral-Resource Classification, Excluding *Reserve Base* and *Inferred Reserve Base*

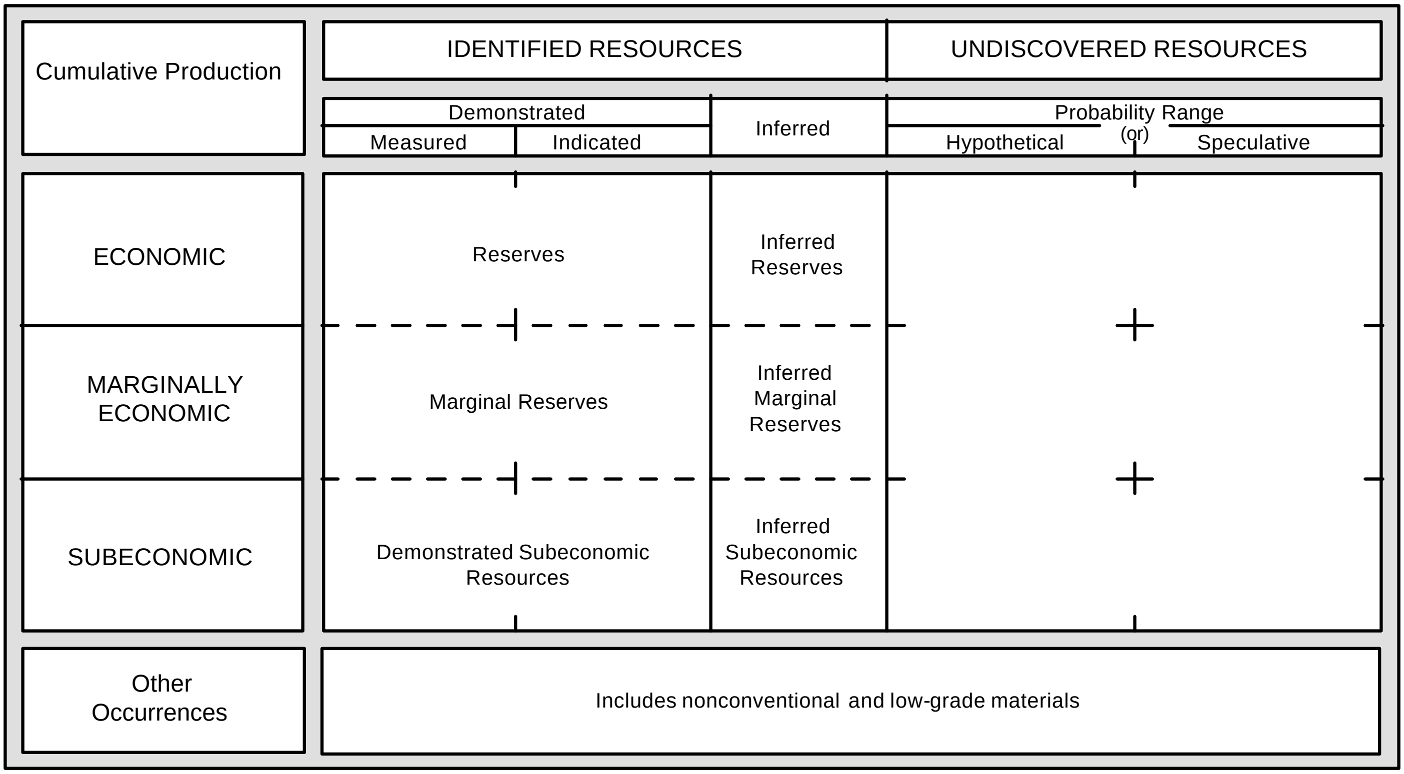
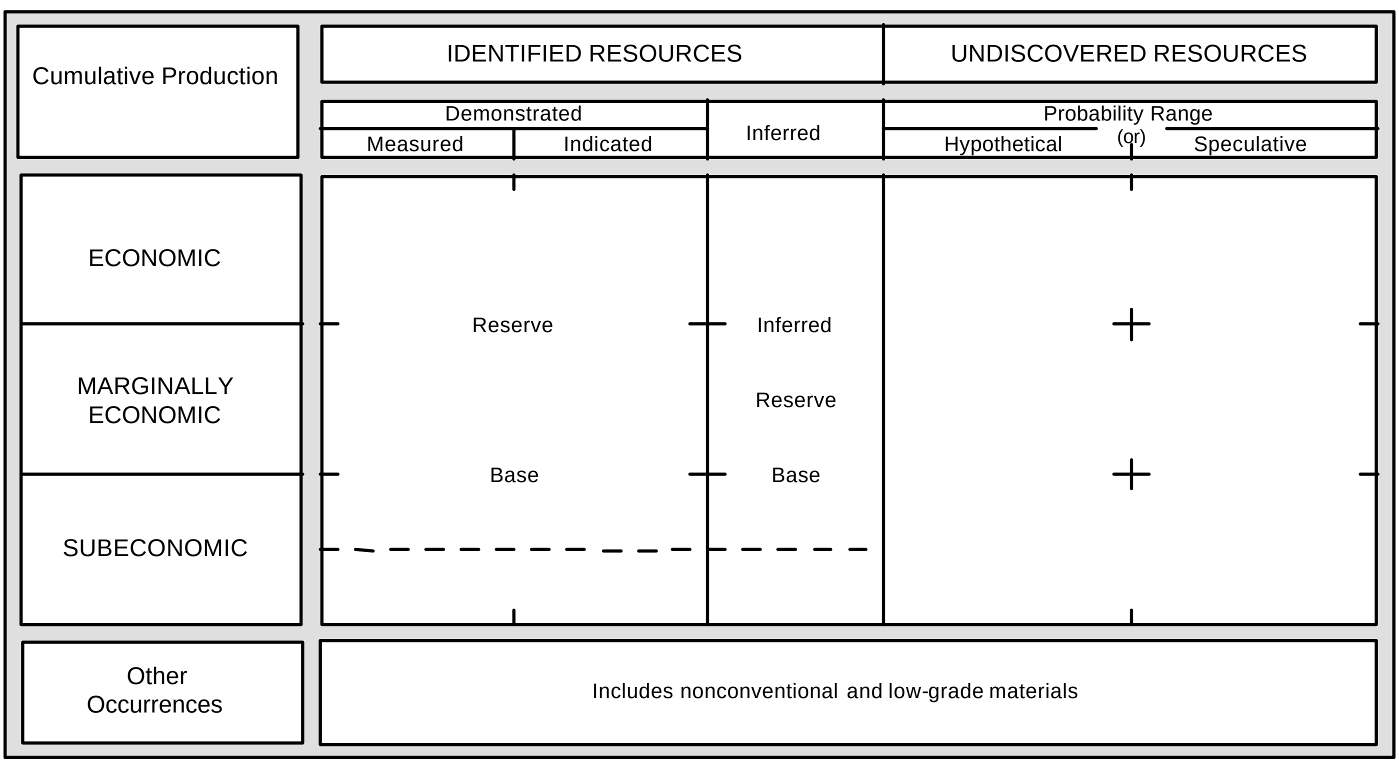


FIGURE 2.—*Reserve Base* and *Inferred Reserve Base* Classification Categories



APPENDIX D

Country Specialists Directory

Minerals information country specialists at the U.S. Geological Survey collect and analyze information on the mineral industries of more than 170 nations throughout the world. The specialists are available to answer minerals-related questions concerning individual countries.

Africa and the Middle East

Algeria	Philip M. Mobbs
Angola	George J. Coakley
Bahrain	Philip M. Mobbs
Benin	Philip Szczesniak
Botswana	George J. Coakley
Burkina Faso	Philip Szczesniak
Burundi	Tom Yager
Cameroon	Philip Szczesniak
Cape Verde	Philip Szczesniak
Central African Republic	Philip Szczesniak
Chad	Philip M. Mobbs
Comoros	Tom Yager
Congo (Brazzaville)	George J. Coakley
Congo (Kinshasa)	George J. Coakley
Côte d'Ivoire	Philip Szczesniak
Cyprus	Philip M. Mobbs
Djibouti	Tom Yager
Egypt	Philip M. Mobbs
Equatorial Guinea	Philip M. Mobbs
Eritrea	Tom Yager
Ethiopia	Tom Yager
Gabon	Philip Szczesniak
The Gambia	Philip Szczesniak
Ghana	George J. Coakley
Guinea	Philip Szczesniak
Guinea-Bissau	Philip Szczesniak
Iran	Philip M. Mobbs
Iraq	Philip M. Mobbs
Israel	Tom Yager
Jordan	Tom Yager
Kenya	Tom Yager
Kuwait	Philip M. Mobbs
Lebanon	Tom Yager
Lesotho	George J. Coakley
Liberia	Philip Szczesniak
Libya	Philip M. Mobbs
Madagascar	Tom Yager
Malawi	Tom Yager
Mali	Philip Szczesniak
Mauritania	Philip Szczesniak
Mauritius	Tom Yager
Morocco & Western Sahara	Philip Szczesniak
Mozambique	Tom Yager
Namibia	George J. Coakley
Niger	Philip Szczesniak
Nigeria	Philip M. Mobbs
Oman	Philip M. Mobbs
Qatar	Philip M. Mobbs
Reunion	Tom Yager
Rwanda	Tom Yager
São Tomé & Principe	Philip Szczesniak
Saudi Arabia	Philip M. Mobbs
Senegal	Philip Szczesniak
Seychelles	Tom Yager
Sierra Leone	Philip Szczesniak
Somalia	Tom Yager
South Africa	George J. Coakley
Sudan	Philip M. Mobbs
Swaziland	George J. Coakley
Syria	Tom Yager
Tanzania	Tom Yager
Togo	Philip Szczesniak
Tunisia	Philip M. Mobbs
Turkey	Philip M. Mobbs
Uganda	Tom Yager
United Arab Emirates	Philip M. Mobbs
Yemen	Philip M. Mobbs
Zambia	George J. Coakley
Zimbabwe	George J. Coakley

Asia and the Pacific

Afghanistan	Travis Q. Lyday
Australia	Travis Q. Lyday
Bangladesh	Chin S. Kuo
Bhutan	Chin S. Kuo
Brunei	John C. Wu
Burma	John C. Wu
Cambodia	John C. Wu
China	Pui-Kwan Tse
Christmas Island	Travis Q. Lyday
Fiji	Travis Q. Lyday
India	Chin S. Kuo
Indonesia	Pui-Kwan Tse
Japan	John C. Wu
Korea, North	Pui-Kwan Tse
Korea, Republic of	Pui-Kwan Tse
Laos	John C. Wu
Malaysia	John C. Wu
Mongolia	Pui-Kwan Tse
Nepal	Chin S. Kuo
New Caledonia	Travis Q. Lyday
New Zealand	Travis Q. Lyday
Pakistan	Travis Q. Lyday
Papua New Guinea	Travis Q. Lyday
Philippines	Travis Q. Lyday
Singapore	Pui-Kwan Tse
Solomon Islands	Travis Q. Lyday
Sri Lanka	Chin S. Kuo
Taiwan	Pui-Kwan Tse
Thailand	John C. Wu
Tonga	Travis Q. Lyday
Vanuatu	Travis Q. Lyday
Vietnam	John C. Wu

Europe and Central Eurasia

Albania	Walter G. Steblez
Armenia	Richard M. Levine
Austria	Harold R. Newman
Azerbaijan	Richard M. Levine
Belarus	Richard M. Levine

Belgium	Harold R. Newman
Bosnia and Herzegovina	Walter G. Steblez
Bulgaria	Walter G. Steblez
Croatia	Walter G. Steblez
Czech Republic	Walter G. Steblez
Denmark and Greenland	Chin S. Kuo
Estonia	Chin S. Kuo
Finland	Chin S. Kuo
France	Harold R. Newman
Georgia	Richard M. Levine
Germany	Harold R. Newman
Greece	Harold R. Newman
Hungary	Walter G. Steblez
Iceland	Chin S. Kuo
Ireland	Harold R. Newman
Italy	Harold R. Newman
Kazakhstan	Richard M. Levine
Kyrgyzstan	Richard M. Levine
Latvia	Chin S. Kuo
Lithuania	Chin S. Kuo
Luxembourg	Harold R. Newman
Macedonia	Walter G. Steblez
Malta	Harold R. Newman
Moldova	Richard M. Levine
Netherlands	Harold R. Newman
Norway	Chin S. Kuo
Poland	Walter G. Steblez
Portugal	Harold R. Newman
Romania	Walter G. Steblez
Russia	Richard M. Levine
Slovakia	Walter G. Steblez
Slovenia	Walter G. Steblez
Spain	Harold R. Newman
Sweden	Chin S. Kuo
Switzerland	Harold R. Newman
Tajikistan	Richard M. Levine
Turkmenistan	Richard M. Levine
Ukraine	Richard M. Levine
United Kingdom	Harold R. Newman
Uzbekistan	Richard M. Levine
Yugoslavia	Walter G. Steblez

North America, Central America, and the Caribbean

Antigua and Barbuda	Philip Szczesniak
Aruba	Philip Szczesniak
The Bahamas	Philip Szczesniak
Barbados	Philip Szczesniak
Belize	Pablo Velasco
Bermuda	Philip Szczesniak
Canada	Alfredo C. Gurmendi
Costa Rica	Pablo Velasco
Cuba	Ivette E. Torres
Dominica	Philip Szczesniak
Dominican Republic	Ivette E. Torres
El Salvador	Pablo Velasco
Grenada	Philip Szczesniak
Guadeloupe	Philip Szczesniak
Guatemala	Pablo Velasco
Haiti	Philip Szczesniak
Honduras	Pablo Velasco
Jamaica	Philip Szczesniak
Martinique	Philip Szczesniak
Mexico	Ivette E. Torres
Montserrat	Philip Szczesniak
Netherlands Antilles	Philip Szczesniak
Nicaragua	Pablo Velasco
Panama	Pablo Velasco
St. Kitts and Nevis	Philip Szczesniak
St. Lucia	Philip Szczesniak
St. Vincent & the Grenadines	Philip Szczesniak
Trinidad and Tobago	Philip Szczesniak

South America

Argentina	Ivette E. Torres
Bolivia	Pablo Velasco
Brazil	Alfredo C. Gurmendi
Chile	Pablo Velasco
Colombia	Ivette E. Torres
Ecuador	Pablo Velasco
French Guiana	Philip Szczesniak
Guyana	Philip Szczesniak
Paraguay	Pablo Velasco
Peru	Alfredo C. Gurmendi
Suriname	Philip Szczesniak
Uruguay	Pablo Velasco
Venezuela	Ivette E. Torres

Country specialist	Telephone	E-mail
George J. Coakley	(703) 648-7738	gcoakley@usgs.gov
Alfredo C. Gurmendi	(703) 648-7745	agurmend@usgs.gov
Chin S. Kuo	(703) 648-7748	ckuo@usgs.gov
Richard M. Levine	(703) 648-7741	rlevine@usgs.gov
Travis Q. Lyday	(703) 648-7749	tlyday@usgs.gov
Philip M. Mobbs	(703) 648-7740	pmobbs@usgs.gov
Harold R. Newman	(703) 648-7742	hnewman@usgs.gov
Walter G. Steblez	(703) 648-7743	wsteblez@usgs.gov
Philip Szczesniak	(703) 648-7744	pszczesn@usgs.gov
Ivette E. Torres	(703) 648-7746	itorres@usgs.gov
Pui-Kwan Tse	(703) 648-7750	ptse@usgs.gov
Pablo Velasco	(703) 648-7747	pvelasco@usgs.gov
John C. Wu	(703) 648-7751	jwu@usgs.gov
Tom Yager	(703) 648-7739	tyager@usgs.gov