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

MINERAL COMMODITY SUMMARIES 2007

Abrasives
Aluminum
Antimony
Arsenic
Asbestos
Barite
Bauxite
Beryllium
Bismuth
Boron
Bromine
Cadmium
Cement
Cesium
Chromium
Clays
Cobalt
Columbium
Copper
Diamond
Diatomite
Feldspar
Fluorspar
Gallium
Garnet
Gemstones
Germanium
Gold
Graphite
Gypsum
Hafnium
Helium
Indium
Iodine
Iron Ore
Iron and Steel
Kyanite
Lead
Lime
Lithium
Magnesium
Manganese
Mercury
Mica
Molybdenum
Nickel
Nitrogen
Peat
Perlite
Phosphate Rock
Platinum
Potash
Pumice
Quartz Crystal
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Rubidium
Salt
Sand and Gravel
Scandium
Selenium
Silicon
Silver
Soda Ash
Sodium Sulfate
Stone
Strontium
Sulfur
Talc
Tantalum
Tellurium
Thallium
Thorium
Tin
Titanium
Tungsten
Vanadium
Vermiculite
Yttrium
Zinc
Zirconium

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Hafnium
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Iodine
Iron Ore
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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 (1-888-275-8747).

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 three volumes that make up the Minerals Yearbook are 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 analyzes and forecasts the economic health of three metal industries (primary metals, steel, and copper) using leading and coincident indexes.

Nonmetallic Mineral Products Industry Indexes—This monthly publication analyzes the leading and coincident indexes for the nonmetallic mineral products industry (NAICS 327).

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.

Recycling Reports—These materials flow studies illustrate the recycling of metal commodities and identify recycling trends.

Historical Statistics for Mineral and Material Commodities in the United States (Data Series 140)—This report provides a compilation of statistics on production, trade, and use of more than 80 mineral commodities during the past 100 years.

WHERE TO OBTAIN PUBLICATIONS

- *Mineral Commodity Summaries* and the *Minerals Yearbook* are sold by the U.S. Government Printing Office, Superintendent of Documents. Orders are accepted over the Internet at URL <http://bookstore.gpo.gov>, by telephone toll free (866) 512-1800; Washington, DC area (202) 512-1800, by fax (202) 512-2250, or through the mail (Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954).

- All current and many past publications are available in PDF format (and some are available in XLS format) through URL <http://minerals.usgs.gov/minerals>.

INTRODUCTION

Each chapter of the 2007 edition of the U.S. Geological Survey (USGS) Mineral Commodity Summaries (MCS) includes information on events, trends, and issues for each mineral commodity as well as discussions and tabular presentations on domestic industry structure, Government programs, tariffs, 5-year salient statistics, and world production and resources. The MCS is the earliest comprehensive source of 2006 mineral production data for the world. More than 90 individual minerals and materials are covered by 2-page synopses.

The principal sources for the reserves and reserve base information provided for most mineral commodities are trade journals and Government reports from Australia, Brazil, Canada, Chile, China, Germany, India, Japan, Mexico, Morocco, Peru, South Africa, the United Kingdom, and the United States.

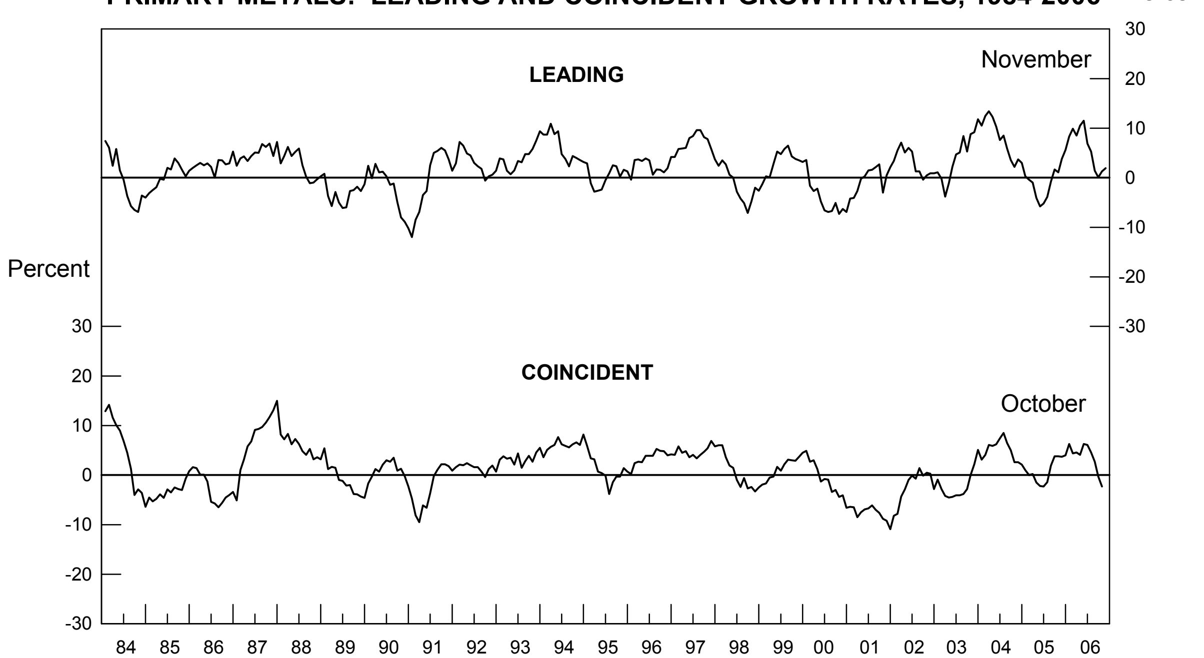
The "Significant Events, Trends, and Issues" section is an overview of domestic and international events affecting minerals that are important to the U.S. economy. Of particular note in 2006 was the increase in value of about 18% compared with that of 2005 for nonfuel minerals and mineral materials mined in the United States. Asian economies grew rapidly (China's increase in real gross domestic product was estimated at about 10.5% and India's was about 8.5%) and played increasingly important roles as both producers and consumers of minerals and materials. Many mineral-producing companies reported significant profits, owing to high prices for some metals as well as increased production for most nonfuel mineral commodities. Worldwide expenditures for exploration for nonferrous metals were expected to surpass $7 billion, a record high and almost 40% over that of last year. Primary areas for exploration were Latin America, followed by Canada and Africa. Exploration for gold, base metals, diamond, platinum-group metals, silver, molybdenum, cobalt, mineral sands, and some industrial minerals other than diamond all reached record levels in 2006.

Abbreviations and units of measure, and definitions of selected terms used in the report, are in Appendix A and Appendix B, respectively. A resource/reserve classification for minerals, based on USGS Circular 831 (published with the U.S. Bureau of Mines) is Appendix C, and a directory of USGS minerals information country specialists and their responsibilities is Appendix D.

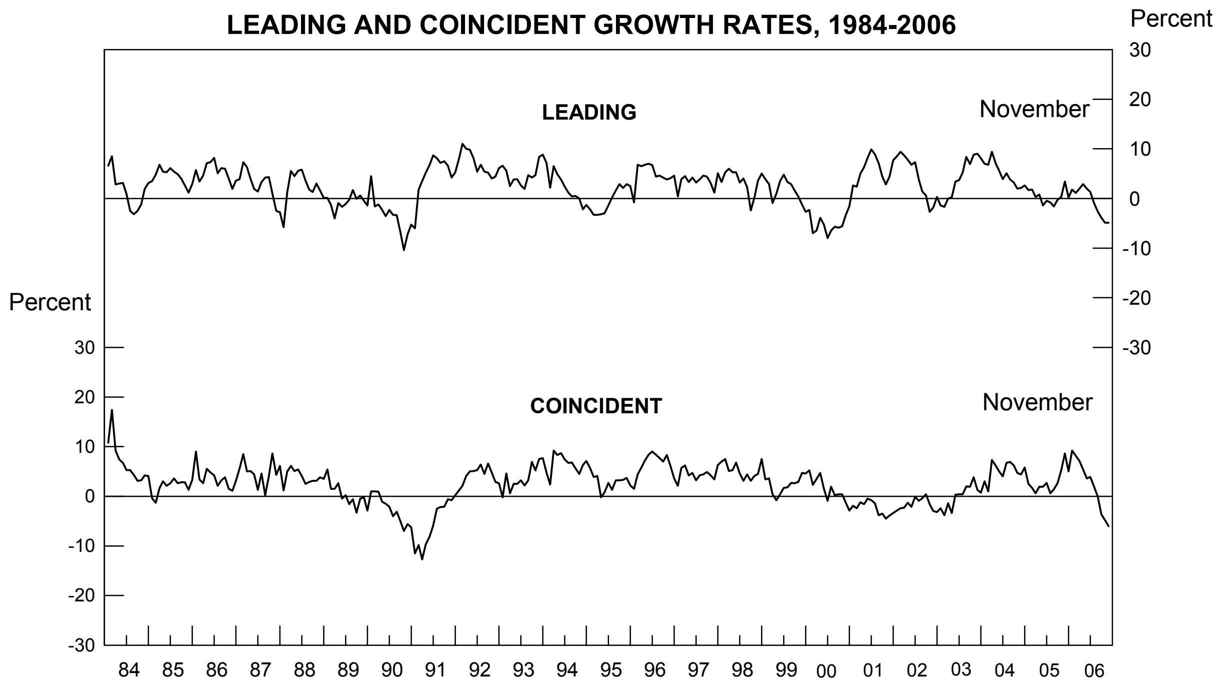
The USGS continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the MCS 2007 are welcomed.

GROWTH RATES OF LEADING AND COINCIDENT INDEXES FOR MINERAL PRODUCTS

PRIMARY METALS: LEADING AND COINCIDENT GROWTH RATES, 1984-2006



NONMETALLIC MINERAL PRODUCTS:
LEADING AND COINCIDENT GROWTH RATES, 1984-2006

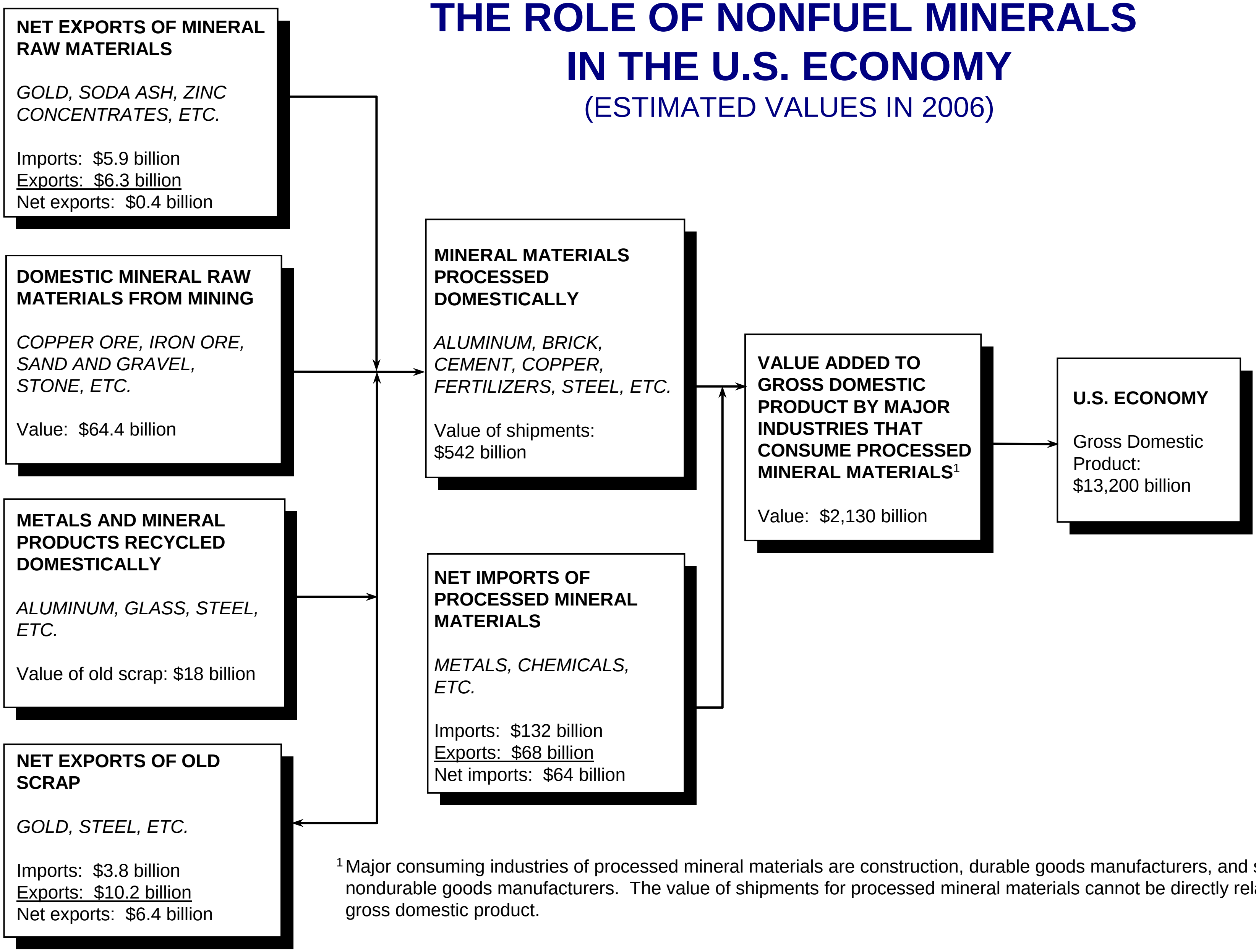


The leading indexes historically give signals several months in advance of major changes in the corresponding coincident index, which measures current industry activity. The growth rates, which can be viewed as trends, are expressed as compound annual rates based on the ratio of the current month's index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

Sources: U.S. Geological Survey, *Metal Industry Indicators* and *Nonmetallic Mineral Products Industry Indexes.*

THE ROLE OF NONFUEL MINERALS IN THE U.S. ECONOMY

(ESTIMATED VALUES IN 2006)



[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.

2006 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS

Commodity	Percent	Major Import Sources (2002-05)[1]
ARSENIC (trioxide)	100	China, Morocco, Mexico, Chile
ASBESTOS	100	Canada
BAUXITE and ALUMINA	100	Jamaica, Guinea, Australia, Brazil
COLUMBIUM (niobium)	100	Brazil, Canada, Estonia, Germany
FLUORSPAR	100	China, Mexico, South Africa, Mongolia
GRAPHITE (natural)	100	China, Mexico, Canada, Brazil
INDIUM	100	China, Canada, Japan, Russia
MANGANESE	100	South Africa, Gabon, Australia, China
MICA, sheet (natural)	100	India, Belgium, China, Brazil
QUARTZ CRYSTAL (industrial)	100	Brazil, Germany, Madagascar, Canada
RARE EARTHS	100	China, France, Japan, Russia
RUBIDIUM	100	Canada
STRONTIUM	100	Mexico, Germany
THALLIUM	100	Russia, Belgium
THORIUM	100	France
VANADIUM	100	Czech Republic, Swaziland, Canada, Austria
YTTRIUM	100	China, Japan, France, Austria
GALLIUM	99	China, Japan, Ukraine, Russia
GEMSTONES	99	Israel, India, Belgium, South Africa
BISMUTH	96	Belgium, Mexico, China, United Kingdom
PLATINUM	95	South Africa, United Kingdom, Germany, Canada
STONE (dimension)	89	Italy, Turkey, China, Mexico
ANTIMONY	88	China, Mexico, Belgium
RHENIUM	87	Chile, Germany
TANTALUM	87	Australia, Canada, China, Japan
BARITE	83	China, India
DIAMOND (natural industrial stone)	82	Ireland, Botswana, Ghana, Belgium
PALLADIUM	82	Russia, South Africa, United Kingdom, Belgium
COBALT	81	Norway, Russia, Finland, Canada
POTASH	80	Canada, Belarus, Russia, Germany
TIN	79	Peru, Bolivia, China, Indonesia
CHROMIUM	75	South Africa, Kazakhstan, Zimbabwe, Russia
TITANIUM (sponge)	72	Kazakhstan, Japan, Russia
IODINE	71	Chile, Japan
TITANIUM MINERAL CONCENTRATES	71	South Africa, Australia, Canada, Ukraine
TUNGSTEN	66	China, Canada, Germany, Portugal
SILVER	65	Mexico, Canada, Peru, Chile
ZINC	63	Canada, Mexico, Peru, Australia
NICKEL	60	Canada, Russia, Norway, Australia
SILICON (ferrosilicon)	60	China, Venezuela, Russia, Norway
PEAT	59	Canada
MAGNESIUM METAL	54	Canada, Russia, China, Israel
GARNET (industrial)	53	Australia, India, China, Canada
MAGNESIUM COMPOUNDS	53	China, Canada, Australia, Austria
DIAMOND (dust, grit and powder)	51	China, Ireland, Ukraine, Russia
ALUMINUM	44	Canada, Russia, Venezuela, Brazil
NITROGEN (fixed), AMMONIA	42	Trinidad and Tobago, Canada, Russia, Ukraine
COPPER	40	Chile, Canada, Peru, Mexico
PERLITE	35	Greece
VERMICULITE	31	South Africa, China
MICA, scrap and flake (natural)	30	Canada, China, India, Finland
CADMIUM	29	Australia, Canada, Belgium, Peru
GYPSUM	27	Canada, Mexico, Spain, Dominican Republic
SULFUR	26	Canada, Mexico, Venezuela
CEMENT	24	Canada, Thailand, China, Venezuela
IRON and STEEL	21	Canada, European Union, Mexico, Brazil
SALT	16	Canada, Chile, The Bahamas, Mexico
PUMICE	12	Greece, Italy, Turkey
TALC	11	China, Canada, France, Japan
IRON and STEEL SLAG	7	Canada, Italy, France, Japan
PHOSPHATE ROCK	6	Morocco
IRON ORE	5	Canada, Brazil, Chile, Australia
LEAD	2	Canada, Australia, China, Mexico
LIME	1	Canada, Mexico
SAND AND GRAVEL (construction)	1	Canada, Mexico, The Bahamas

[1] In descending order of import share

SIGNIFICANT EVENTS, TRENDS, AND ISSUES[1]

The Mineral Sector of the U.S. Economy

Minerals are fundamental to the U.S. economy, contributing to the real gross domestic product (GDP) at several levels—mining, processing, and manufacturing finished products. The estimated growth rate for the real GDP of the United States for 2006 was 3.2%; the nominal GDP was about $13.2 trillion. The increase in the prime interest rate, from 7.25% at the beginning of 2006 to 8.25% in November, was reflected in the gradual rise of home mortgage rates through the summer of 2006, which in turn had a dampening effect on the housing market. Housing starts declined 13% from 2005 to 2006, the largest annual decrease since the 1990-91 recession; however, the number of housing starts in 2005 was the highest in 33 years. The overall unemployment rate in the United States was estimated at 4.6% in 2006, down from 5.1% in 2005; employment rose in all mining industry groups in 2006 except the nonmetallic industry group. The Nation's international trade deficit in goods and services decreased to $58.9 billion in October from $64.3 billion (revised) in September, as exports increased and imports decreased. The deficit in October 2005 was $66.6 billion.

The value of minerals mined in the United States in 2006 rose significantly because of increased unit prices for some metals—particularly copper, zinc, and other base metals. There was also a significant reduction of metal stocks. Infrastructure expansion and manufacturing in China and India have been absorbing a significant portion of world output. Domestic production increased for some industrial mineral materials, mainly cement and construction sand and gravel. Production of crushed stone declined less than 1% in 2006 compared with production in 2005, but the value increased almost 7%, owing partly to a higher profit margin, as well as to high energy prices and other costs passed along to consumers.

Mine production of 10 mineral commodities was worth more than $1 billion each in the United States in 2006. These were crushed stone, cement, copper, construction sand and gravel, gold, iron ore (shipped), molybdenum (concentrates), zinc, lime, and salt, listed in decreasing order of value.

The estimated value of all nonfuel mineral materials processed in the United States during 2006 totaled $542 billion, 10% more than that in 2005 (p. 5). The total value of U.S. raw nonfuel mineral production alone was about $64.4 billion (p. 5), $10 billion (18%) more than that in 2005. The value of metals accounted for about 37% of the total and increased $8 billion compared with the value of metal mine production in 2005. Most of the increase in value of metals was due to increases in unit prices and production of copper, gold, iron ore, and zinc. The value of mine production of industrial minerals (nonmetallic minerals) increased by 5%.

The United States continues to rely heavily on foreign sources for raw and processed mineral materials. In 2006, the United States supplied more than one-half of its apparent consumption of 45 mineral commodities through imports and was 100% import reliant for 17 of those (p. 6). The value of raw and processed mineral material exports increased by 27% to about $74 billion. The value of imports increased 28% from the previous year's level to $138 billion. The value of net imports of raw and processed mineral materials during 2006 increased by about $14.3 billion, or 29%, from the 2005 level. As in recent years, aluminum, copper, and iron and steel were among the leading imports in terms of value. The value of exported ores and concentrates of metals and industrial minerals in 2006 was $6.3 billion; the value of imports was $5.9 billion (U.S. Census Bureau, 2006§[2]).

The construction industry led the demand for nonfuel mineral materials. The value of new highway and bridge construction increased by 16% to $76 billion, in part because of the passage of the SAFETEA-LU bill on August 10, 2005. Commercial building construction continued to grow throughout 2006, in contrast with residential construction. If the U.S economy continues to expand and mortgage rates remain steady, housing starts may increase in 2007. Home mortgage rates began to rise in the fall of 2005, fluctuated through the first three quarters of 2006, and appeared to be declining slowly in the last quarter. They continue to remain low compared with rates prior to August 2002 (Freddie Mac, 2006§).

Estimated value of U.S. metal mine production in 2006 was more than $23.5 billion, about 51% more than that of 2005. Principal contributors to the total value of mine production in 2006 were copper (36%), gold (22%), iron ore (13%), molybdenum (13%), zinc (10%), and lead (3%). Metals with the largest increases in value of mine production were zinc (117%), copper (97%), palladium (65%), gold (68%), platinum (36%), and iron ore (31%). The value of molybdenum production declined by 18% in 2006, from an alltime high in 2005. The value of gold production (lode and placer) increased by $2 billion to $5.1 billion. Zinc production more than doubled in value from 2005 to 2006, yielding a unit value of $3,197 per metric ton.

In 2006, 21 States each produced more than $1 billion worth of nonfuel mineral commodities. These States were, in descending order, Arizona, Nevada, California, Utah, Texas, Alaska, Florida, Minnesota, Missouri, Michigan, Georgia, Colorado, Pennsylvania, New Mexico, New York, Illinois, Ohio, Wyoming, Virginia, Alabama, and Montana. The mineral production of these States accounted for about 80% of the U.S. total output value (table 3). (Concealment of some production to avoid disclosing company proprietary data may have altered the ranking of some States.)

In fiscal year 2006, the Defense Logistics Agency (DLA) sold $503 million of excess mineral materials from the

[1]Staff, U.S. Geological Survey

[2]References that include a section mark (§) are found in the Internet References Cited section.

TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

	2002	2003	2004	2005	2006[e]
Total mine production:[1]					
Metals	8,200	8,500	12,300	15,600	23,500
Industrial minerals	29,700	30,900	33,300	38,900	40,900
Coal	19,700	19,200	22,200	26,700	27,800
Employment:[2]					
Coal mining	63	59	59	61	68
Metal mining	21	20	20	22	27
Industrial minerals, except fuels	80	78	81	83	80
Chemicals and allied products	532	525	520	515	524
Stone, clay, and glass products	399	375	388	385	385
Primary metal industries	396	370	364	365	369
Average weekly earnings of production workers:[3]					
Coal mining	934	964	1,029	1,071	1,091
Metal mining	879	957	1,034	1,002	979
Industrial minerals, except fuels	748	771	790	827	860
Chemicals and allied products	760	784	820	831	832
Stone, clay, and glass products	647	665	688	700	711
Primary metal industries	750	768	800	815	846

[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.

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

	2002	2003	2004	2005	2006[e]
Gross domestic product (billion dollars)	10,470	10,961	11,712	12,456	13,200
Industrial production (2002=100):					
Total index	100	101	104	107	111
Manufacturing	100	101	104	108	113
Nonmetallic mineral products	100	101	104	108	112
Primary metals:	100	99	109	107	113
Iron and steel	100	96	116	110	118
Aluminum	100	96	96	102	99
Nonferrous metals (except aluminum)	100	107	104	103	107
Chemicals	100	100	103	108	111
Mining:	100	100	99	98	100
Coal	100	98	101	102	107
Oil and gas extraction	100	99	96	93	94
Metals	100	94	94	102	102
Nonmetallic minerals	100	101	106	107	106
Capacity utilization (percent):					
Total industry	75	76	78	80	82
Mining:	86	88	88	88	91
Metals	75	72	72	79	79
Nonmetallic minerals	82	83	86	86	86
Housing starts (thousands)	1,710	1,850	1,950	2,070	1,810
Light vehicle sales (thousands)[1]	13,500	13,300	13,500	13,500	12,800
Highway construction, value, put in place (billion dollars)	59	59	60	66	76

[e]Estimated.

[1]Excludes imports.

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

National Defense Stockpile (NDS). Additional detailed information can be found in the "Government Stockpile" sections in the mineral commodity reports that follow. Under the authority of the Defense Production Act of 1950, the U.S. Geological Survey advises the DLA on acquisition and disposals of NDS mineral materials. At the end of the fiscal year, mineral materials valued at almost $1.56 billion remained in the stockpile.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2006[p, 1]

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$1,200,000	20	1.86	Cement (portland), stone (crushed), lime, sand and gravel (construction), cement (masonry).
Alaska	2,850,000	6	4.43	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	6,710,000	1	10.42	Copper, molybdenum concentrates, sand and gravel (construction), cement (portland), lime.
Arkansas	617,000	32	0.96	Stone (crushed), bromine, cement (portland), sand and gravel (construction), lime.
California	4,500,000	3	6.99	Sand and gravel (construction), cement (portland), boron minerals, stone (crushed), soda ash.
Colorado	1,670,000	12	2.59	Molybdenum concentrates, sand and gravel (construction), cement (portland), gold, stone (crushed).
Connecticut[2]	169,000	42	0.26	Stone (crushed), sand and gravel (construction), stone (dimension), clays (common), gemstones (natural).
Delaware[2]	22,200	50	0.03	Sand and gravel (construction), magnesium compounds, stone (crushed), gemstones (natural).
Florida	2,790,000	7	4.33	Stone (crushed), phosphate rock, cement (portland), sand and gravel (construction), cement (masonry).
Georgia	1,970,000	11	3.06	Clays (kaolin), stone (crushed), clays (fuller's earth), sand and gravel (construction), cement (portland).
Hawaii	107,000	45	0.17	Stone (crushed), sand and gravel (construction), gemstones (natural).
Idaho	810,000	26	1.26	Molybdenum (concentrates), sand and gravel (construction), phosphate rock, silver, stone (crushed).
Illinois	1,280,000	16	1.99	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), clays (fuller's earth).
Indiana	963,000	22	1.50	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Iowa	704,000	30	1.09	Cement (portland), stone (crushed), sand and gravel (construction), gypsum (crude), lime.
Kansas	913,000	24	1.42	Cement (portland), helium (Grade-A), stone (crushed), salt, helium (crude).
Kentucky	918,000	23	1.43	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (ball).
Louisiana	362,000	37	0.56	Salt, sand and gravel (construction), stone (crushed), clays (common), sand and gravel (industrial).
Maine	155,000	43	0.24	Sand and gravel (construction), cement (portland), stone (crushed), stone (dimension), peat.
Maryland[2]	596,000	33	0.93	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts[2]	262,000	38	0.41	Stone (crushed), sand and gravel (construction), lime, stone (dimension), clays (common).
Michigan	2,010,000	10	3.12	Iron ore (usable shipped), cement (portland), sand and gravel (construction), stone (crushed), salt.
Minnesota[2]	2,740,000	8	4.25	Iron ore (usable shipped), sand and gravel (construction), stone (crushed), sand and gravel (industrial), stone (dimension).
Mississippi	212,000	39	0.33	Sand and gravel (construction), stone (crushed), cement (portland), clays (fuller's earth), clays (ball).
Missouri	2,130,000	9	3.31	Stone (crushed), cement (portland), lead, lime, zinc.
Montana	1,040,000	21	1.61	Copper, molybdenum (concentrates), platinum metal, palladium metal, sand and gravel (construction).
Nebraska[2]	112,000	44	0.17	Cement (portland), sand and gravel (construction), stone (crushed), lime, clays (common).

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2006[p, 1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Nevada	$5,240,000	2	8.14	Gold, copper, sand and gravel (construction), lime, silver.
New Hampshire[2]	100,000	47	0.16	Stone (crushed), sand and gravel (construction), stone (dimension), gemstones (natural).
New Jersey	$369,000	36	0.57	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.
New Mexico	1,460,000	14	2.27	Copper, potash, sand and gravel (construction), molybdenum (concentrates), cement (portland).
New York	1,330,000	15	2.07	Stone (crushed), cement (portland), salt, sand and gravel (construction), wollastonite.
North Carolina[2]	872,000	25	1.35	Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), feldspar.
North Dakota	56,000	48	0.09	Sand and gravel (construction), lime, sand and gravel (industrial), stone (crushed), clays (common).
Ohio	1,260,000	17	1.96	Stone (crushed), sand and gravel (construction), salt, lime, cement (portland).
Oklahoma	622,000	31	0.97	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), iodine (crude).
Oregon	428,000	35	0.66	Sand and gravel (construction), stone (crushed), cement (portland), diatomite, lime.
Pennsylvania[2]	1,670,000	13	2.59	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Rhode Island[2]	38,400	49	0.06	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), gemstones (natural).
South Carolina[2]	730,000	28	1.13	Stone (crushed), cement (portland), cement (masonry), sand and gravel (construction), sand and gravel (industrial).
South Dakota	204,000	41	0.32	Cement (portland), sand and gravel (construction), stone (crushed), stone (dimension), gold.
Tennessee	807,000	27	1.25	Stone (crushed), cement (portland), sand and gravel (construction), clays (ball), sand and gravel (industrial).
Texas	2,910,000	5	4.52	Cement (portland), stone (crushed), sand and gravel (construction), salt, lime.
Utah	3,990,000	4	6.20	Copper, molybdenum (concentrates), gold, cement (portland), sand and gravel (construction).
Vermont[2]	101,000	46	0.16	Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural).
Virginia	1,230,000	19	1.91	Stone (crushed), cement (portland), sand and gravel (construction), lime, zirconium (concentrates).
Washington	720,000	29	1.12	Sand and gravel (construction), zinc, stone (crushed), cement (portland), diatomite.
West Virginia	211,000	40	0.33	Stone (crushed), cement (portland), lime, sand and gravel (industrial), cement (masonry).
Wisconsin[2]	591,000	34	0.92	Stone (crushed), sand and gravel (construction), lime, sand and gravel (industrial), stone (dimension).
Wyoming	1,250,000	18	1.94	Soda ash, clays (bentonite), helium (Grade-A), sand and gravel (construction), cement (portland).
Undistributed	395,000	XX	0.61	
Total	64,400,000	XX	100.00	

[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."

Significant International Events

Economic Conditions

As 2006 began, the economic expansion that began in 2003 continued. In the first quarter, GDP grew between 2% to 3% year-on-year in the developed economies of the United States, the European Union, and Japan. Growth in the five most populous developing countries was mixed. In China, the GDP grew at about 10.5%, and the Indian economy grew at a surprising rate of about 8.5%. In Russia, GDP growth slowed to 5.5% in the first quarter of 2006 from 7% in the fourth quarter of 2005. Economic growth in Indonesia and Brazil, 4.6%

and 3.4% respectively, was slow for developing countries (Economist, 2006b, c). A cause for economic concern was high commodity prices. Throughout 2005, the prices of many mineral commodities had increased. Oil prices had increased by about 33% in 2005 and began 2006 at about $60 per barrel; a number of metals, most dramatically iron ore, had increased in price. Commodity prices continued to rise in the first quarter of 2006 and then rose rapidly in the second quarter. Oil prices increased 25% to reach $75 per barrel in late summer before falling to $60 per barrel late in 2006. High prices for commodities, especially for oil, were part of the reason for slowing U.S. economic growth (Sumerlin, 2006), but the U.S. economy faced other immediate challenges, including a shrinking manufacturing sector (Aeppel, 2006), and growing trade and budget deficits. Some economists expressed concerns that the long-term outlook for the U.S. economy was for slower growth (Economist, 2006a).

A significant slowing in the rate of U.S. economic growth would have raised concerns for the state of the global economy in earlier times as U.S. consumers have been one of the main engines of global economic growth for the past decade. However, rapid growth in developing countries including, but not exclusively, China, has changed that perception among some analysts. Developing countries now account for more than 50% of global economic output when measured in purchasing power parity. As a result, some analysts believe that even if growth of the U.S. economy declines, demand from Asia will be sufficient to maintain growth of the global economy (Economist, 2006g, h).

The transformation of China's economy has raised new challenges for the government, including a widening gap in incomes (Batson and Oster, 2006), issues related to confiscation of farmers' land by local authorities, growing corruption, and increasing environmental problems (Deen, 2006). Another challenge that faces China is its growing use of energy and minerals. China is the second leading consumer of oil using 7 million barrels a day in 2006; its use is expected to rise to 7.4 million barrels per day in 2007. China imported about 2.8 million barrels per day in 2006 (Peng, 2006§). As a result of greater dependence upon imported oil and other minerals, China has been aggressively pursuing foreign sources of petroleum and minerals in Africa and Latin America (Economist, 2006e). China would like to decrease its dependency on oil and coal and increase use of alternative energy sources, such as wind, solar, and nuclear power (Oster, 2006). However, earlier plans to decrease use of coal and oil by increasing the use of natural gas have not met expectations and China's recently approved power plants have nearly all been coal-fired (Oster and Barta, 2006). China is not only import-dependent for oil, but also for a number of metals and other minerals. In May, the Ministry of Land and Resources announced that over the next 4 years it will build reserves of aluminum, copper, manganese, uranium, and other minerals (Areddy, 2006).

A further challenge posed by China's economic development is the increasing trade imbalance between China and the United States. The United States would like to see a significant revaluation of the yuan relative to the dollar but the Chinese fear that such a revaluation could be disruptive to China's economic growth, which could exacerbate domestic unrest (King, 2006).

Double-digit economic growth is no longer a new story in China; however, double-digit growth in India is a new story. For the 3 months ending September 30, India's GDP rose 9.2% from a year earlier, and India's finance minister has said that if the economy continues to open to private and foreign investment, India could achieve double-digit growth within the next 5 years (Bellman, 2006b). India's growth is based upon a number of macroeconomic reforms, including sound monetary policy by the central bank that has kept inflation in check, a floating exchange rate and adequate foreign exchange reserves, reform of the tax system, and budget discipline (Feldstein, 2006). The rate of recent growth, however, has caused some analysts concern that India's current rate of growth is too fast and may lead to a rise in inflation (Bellman, 2006a). India is intent upon replicating China's economic success and has been adopting some of the policies China has used to jump-start economic growth.

Russia's economy, which grew more than 7% in 2003 and 2004, slowed to a 6.4% growth rate in 2005. Growth for 2006 should be about the same as that for 2005 or perhaps slightly higher, depending upon fourth quarter results. The Russian economy has benefited from macroeconomic policies that have included the reduction of foreign debt; however, challenges remain. Russia's economic growth has derived from exports of energy and minerals rather than from reforms to its economy and to foreign investment. As Russia's economy has improved, it has become less open to foreign investment, especially in energy and mineral projects (Economist, 2006f).

A number of countries in Africa and Latin America benefited from high energy and mineral prices in 2006. West African nations, such as Angola, Equatorial Guinea, Gabon, Nigeria, and even war-torn Côte d'Ivoire, have received foreign investment for oil. Copper producer Zambia is expected to have increased its GDP by 6% as a result of high commodity prices (Economist, 2006d). In Latin America, Argentina and Venezuela, which have both adopted populist economic policies, have experienced high rates of growth of their GDP, and even higher rates of increase in consumer prices. Bolivia and Ecuador elected leaders that promised populist economic policies. Bolivia proceeded to nationalize its oil and gas industry and threatened to do the same with minerals but was deterred because of a lack of funds to carry out the program (Mining Journal, 2006). Chile benefited from high copper prices and continued macroeconomic stability, while Peru, which also benefited from high copper prices, recorded GDP growth of over 6%, and consumer prices increased less than 2%.

Minerals Markets

Producers faced a number of problems meeting high metal demand, including strikes, shortages of supplies, and mine accidents. Because most mines were operating at or near capacity, producer problems translated into higher commodity prices for most mineral commodities.

Mergers and Acquisitions

In 2006, there were a number of significant mergers. The biggest deal of the year was the Mittal Steel Co. N.V.'s acquisition of European steel giant Arcelor Ltd. The combined entity will be the world's leading steel producer. Falconbridge Ltd. and Inco Ltd., which had initially proposed merging, became the objects of multiple offers from Companhia Vale do Rio Doce (CVRD), Phelps Dodge Corp., Teck Cominco Corp., and Xstrata Plc. CVRD emerged with Inco, and Xstrata emerged with Falconbridge. This left Phelps Dodge as a possible target for acquisition, and in November, Freeport McMoRan Inc. and Phelps Dodge agreed to a merger. Mergers have already led to high levels of production consolidation in the iron ore industry. In addition, Tata Steel Ltd. made an offer for Corus Group plc, a much larger European firm. In aluminum, Russian producers RUSAL and SUAL began talks to merge.

Exploration

Global nonferrous metals mineral exploration budgets were expected to rise to $7.1 billion in 2006 from $5.1 billion in 2005. This is the highest level since the Metals Economic Group began surveying companies about their intended expenditures in 1989. Latin America continued to draw the largest expenditure of funds (O'Neil, 2006).

Government Involvement

High prices for minerals has led not only to labor demanding a larger share of the profits from those prices, but has also led governments to try to increase their control of minerals and to gain a large share of the profits from their exploitation. Resource nationalism has reemerged with higher prices. The mildest expressions of this nationalism have been widespread and have taken the form of higher royalties or new takes on production. Some countries have structured royalties to encourage local processing of minerals. Russia's new law governing foreign ownership has effectively required local ownership for significant mineral projects. Threats of nationalization and other coercive measures are leading some companies to rethink their exploration priorities (Duff-Brown, 2006§).

Outlook

The extent to which economic growth in developing countries, especially China and India, can lead global economic growth will be of increasing significance. China's economic development has been the main impetus for higher commodity prices in the last few years. If China is able to continue that development to the level of Europe, Japan, and the United States and if India also continues to develop its economy, mineral consumption is likely to continue to grow for a number of years. In the short term, the question of whether the high prices evidenced in 2006 will continue at or near those levels will likely be determined by the level of growth in the United States and in particular by the health of the U.S. housing market.

References Cited

Aeppel, Timothy, 2006, U.S. 'birthrate' for new factories is steadily falling: Wall Street Journal, March 15, p. A4.

Areddy, J.T., 2006, China, worried about resources, to build up mineral reserves: Wall Street Journal, May 10, p. A7.

Batson, Andrew, and Oster, Shai, 2006, As China booms, the poorest lose ground: Wall Street Journal, November 22, p. A4.

Bellman, Eric, 2006a, India's growth brings optimism for present but concern for future: Wall Street Journal, December 1, p. A9.

Bellman, Eric, 2006b, Indian finance official expects pickup in growth: Wall Street Journal, December 9-10, p. A4.

Deen, Jason, 2006, How capitalist transformation exposes holes in China's government: Wall Street Journal, December 18, p. A2.

Economist, 2006a, A falling speed limit: The Economist, v. 381, no. 8501, October 28, p. 17.

Economist, 2006b, Economic and financial indicators: The Economist, various issues from January 7 through November 25, various pages.

Economist, 2006c, Emerging-market indicators: The Economist, various issues from January 7 through November 25, various pages.

Economist, 2006d, It's looking up a bit: The Economist, v. 379, no. 8482, June 17, p. 56.

Economist, 2006e, Never too late to scramble: The Economist, v. 381, no. 8501, October 28, p. 53-55.

Economist, 2006f, Richer, bolder—And sliding back: The Economist, v. 380, no. 8485, July 15, p. 23-25.

Economist, 2006g, Surprise!: The Economist, v. 380, no. 8495, September 16, p. 13.

Economist, 2006h, The alternative engine: The Economist, v. 381, no. 8500, October 21, p. 79.

Feldstein, Martin, 2006, There's more to growth than China…: Wall Street Journal, February 16, p. A16.

King, Neil, Jr., 2006, U.S. tensions rise over China: Wall Street Journal, March 16, p. A4.

Mining Journal, 2006, Bolivia—Bolivia reassures investors: Mining Journal, October 20, p. 5.

O'Neil, Tim, 2006, The drift of things: Mining Engineering, v. 58, no. 10, April, p. 4.

Oster, Shai, 2006, China plans to curb oil, coal use despite expected demand growth: Wall Street Journal, February 14, p. A17.

Oster, Shai, and Barta, Patrick, 2006, China stumbles in attempt to cut use of coal and oil: Wall Street Journal, March 3, p. A1, A8.

Sumerlin, Marc, 2006, The upside of the oil curse: Wall Street Journal, January 10, p. A14.

Internet References Cited

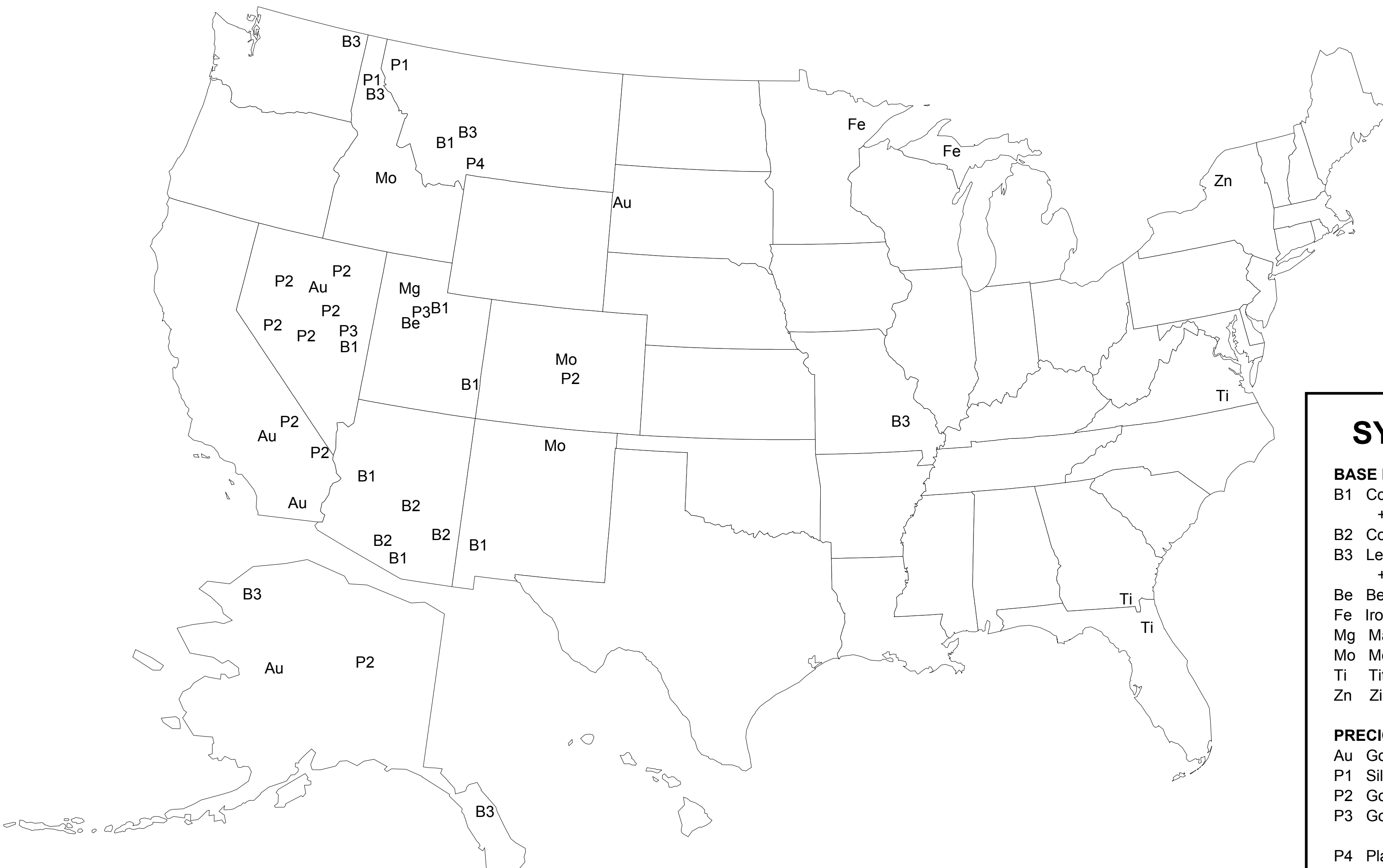
Duff-Brown, Beth, 2006 (May 11), Mining companies fret over Bolivia plan, Washington Post, accessed January 3, 2007, at URL http://www.washingtonpost.com/wp-dyn/content/article/2006/05/11/AR2006051101421.html.

Freddie Mac, 2006 (November 30), 30-year fixed rate mortgages, accessed December 1, 2006, at URL http://www.freddiemac.com/pmms/pmms30.htm.

Peng, Renya, 2006 (December 24), China Nov crude oil imports up 30.9% on year, Morningstar, accessed December 26, 2006, at URL http://news.morningstar.com/news/ViewNews.asp?article=/DJ/200612242120DOWJONESDJONLINE000317_univ.xml&Cat=ForMkts.

U.S. Census Bureau, 2006 (December 12), Foreign trade statistics, accessed December 18, 2006, via URL http://censtats.census.gov/sitc/sitc.shtml.

MAJOR METAL-PRODUCING AREAS



SYMBOLS

BASE METALS

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

PRECIOUS METALS

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

MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART I

MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART II

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 two companies at three plants in the United States and Canada. Production of regular-grade fused aluminum oxide had an estimated value of $2.80 million, and production of high-purity fused aluminum oxide was estimated to have a value of more than $4.63 million. Silicon carbide was produced by two companies at two plants in the United States. Domestic production of crude silicon carbide had an estimated value of about $23.7 million. Bonded and coated abrasive products accounted for most abrasive uses of fused aluminum oxide and silicon carbide.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production,[1] United States and Canada (crude):					
Fused aluminum oxide, regular	20,000	20,000	20,000	10,000	10,000
Fused aluminum oxide, high-purity	10,000	5,000	5,000	5,000	5,000
Silicon carbide	30,000	35,000	35,000	35,000	35,000
Imports for consumption (U.S.):					
Fused aluminum oxide	179,000	164,000	232,000	244,000	258,000
Silicon carbide	165,000	169,000	209,000	201,000	179,000
Exports (U.S.):					
Fused aluminum oxide	10,300	11,800	13,900	13,900	15,100
Silicon carbide	13,600	13,200	13,900	15,600	21,100
Consumption, apparent (U.S.):					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	181,000	189,000	230,000	220,000	193,000
Price, dollars per ton United States and Canada:					
Fused aluminum oxide, regular	271	279	323	144	240
Fused aluminum oxide, high-purity	494	514	544	656	624
Silicon carbide	532	529	614	603	643
Net import reliance[2] as a percentage of apparent consumption (U.S.):					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	83	82	85	84	82

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

Import Sources (2002-05): Fused aluminum oxide, crude: China, 77%; Canada, 11%; Venezuela, 11%; and other, 1%. Fused aluminum oxide, grain: China, 38%; Germany, 15%; Brazil, 14%; Austria, 10%; and other, 23%. Silicon carbide, crude: China, 74%; Venezuela, 9%; Netherlands, 6%; Romania, 5%; and other, 6%. Silicon carbide, grain: China, 35%; Brazil, 24%; Russia, 10%; Venezuela, 10%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

Government Stockpile: During fiscal year 2006, the Department of Defense sold 2,140 tons of fused aluminum oxide abrasive grain from the National Defense Stockpile for $883,000.

Stockpile Status—9-30-06[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Fused aluminum oxide, grain	4,085	88	4,085	4,085	2,140

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ABRASIVES (MANUFACTURED)

Events, Trends, and Issues: Imports and higher operating costs continued to challenge producers in the United States and Canada. 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	
	2005	**2006[e]**	**2005**	**2006[e]**
United States and Canada	60,400	60,400	42,600	42,600
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	700,000	700,000	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	25,000	25,000	60,000	60,000
Mexico	—	—	45,000	45,000
Norway	—	—	80,000	80,000
Venezuela	—	—	30,000	30,000
Other countries	80,000	80,000	190,000	190,000
World total (rounded)	1,190,000	1,190,000	1,010,000	1,010,000

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 2006, 5 companies operated 13 primary aluminum smelters; 6 smelters were temporarily idled. Based upon published market prices, the value of primary metal production was $6 billion. Aluminum consumption was centered in the East Central United States. Transportation accounted for an estimated 40% of domestic consumption; the remainder was used in packaging, 28%; building, 13%; consumer durables, 7%; electrical, 5%; and other, 7%.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Primary	2,707	2,703	2,516	2,481	2,300
Secondary (from old scrap)	1,170	1,070	1,160	1,060	1,100
Imports for consumption	4,060	4,130	4,720	5,330	5,400
Exports	1,590	1,540	1,820	2,370	2,800
Consumption, apparent[2]	6,320	6,130	6,590	6,460	6,100
Price, ingot, average U.S. market (spot), cents per pound	64.9	68.1	84.0	91.0	120.0
Stocks:					
Aluminum industry, yearend	1,320	1,400	1,470	1,430	1,400
LME, U.S. warehouses, yearend[3]	45	207	116	209	180
Employment, number[4]	61,700	58,000	57,500	58,400	59,000
Net import reliance[5] as a percentage of apparent consumption	39	38	44	45	44

Recycling: In 2006, aluminum recovered from purchased scrap was about 3 million tons, of which about 64% came from new (manufacturing) scrap and 36% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 18% of apparent consumption.

Import Sources (2002-05): Canada, 55%; Russia, 18%; Venezuela, 4%; Brazil, 4%; and other, 19%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

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ALUMINUM

Events, Trends, and Issues: Domestic primary aluminum production decreased slightly owing to cutbacks attributed to increased energy and alumina costs. Domestic smelters operated at about 62% of rated or engineered capacity.

Imports for consumption increased slightly, filling some of the supply deficit created by the decrease in domestic production. Canada and Russia accounted for approximately two-thirds of total imports. U.S. exports also increased in 2006. China, Canada, and Mexico, in descending order, received more than three-fourths of total U.S. exports. Most of the shipments to China (95%) were in the form of aluminum scrap.

The price of primary aluminum fluctuated through September 2006, but was generally higher than that of 2005. In January, the average monthly U.S. market price for primary ingot quoted by Platts Metals Week was $1.118 per pound; it reached a high of $1.355 per pound in May; and in September, the price was $1.170 per pound. Prices on the London Metal Exchange (LME) followed the trend of U.S. market prices. The monthly average LME cash price for September was $1.121 per pound.

World primary aluminum production continued to increase as capacity expansions outside the United States were brought onstream. Inventories of metal held by producers, as reported by the International Aluminium Institute, decreased through the end of September to about 2.9 million tons from 3.2 million tons at yearend 2005. Inventories of primary aluminum metal held by the LME increased during the year to 691,000 tons at the end of September from 644,000 tons at yearend 2005.

World Smelter Production and Capacity:

	Production		Yearend capacity	
	2005	2006[e]	2005	2006[e]
United States	2,481	2,300	3,700	3,700
Australia	1,900	1,900	1,900	1,950
Bahrain	751	830	750	850
Brazil	1,500	1,600	1,500	1,600
Canada	2,890	3,000	2,900	3,060
China	7,800	8,700	10,000	10,500
Germany	668	530	670	670
India	898	1,000	950	1,150
Mozambique	555	560	560	570
Norway	1,370	1,360	1,390	1,360
Russia	3,650	3,720	3,700	3,800
South Africa	851	890	860	900
United Arab Emirates, Dubai	750	770	750	770
Venezuela	610	615	650	650
Other countries	5,190	5,340	5,800	5,900
World total (rounded)	31,900	33,100	36,100	37,400

World Resources: Domestic aluminum requirements cannot be met by domestic bauxite resources. 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 future.

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

[e]Estimated.
[1]See also Bauxite and Alumina.
[2]Domestic primary metal production + recovery from old aluminum scrap + net import reliance.
[3]Includes aluminum alloy.
[4]Alumina and aluminum production workers (North American Industry Classification System—3313). Source: U.S. Department of Labor, Bureau of Labor Statistics.
[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: There was no domestic mine production of antimony in 2006. The only domestic source of antimony, a silver mine that produced antimony as a byproduct, closed early in 2001 with no output in that year. Primary antimony metal and oxide was produced by one company in Montana, using foreign feedstock. The estimated distribution of antimony uses was as follows: flame retardants, 40%; transportation, including batteries, 22%; chemicals, 14%; ceramics and glass, 11%; and other, 13%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Mine (recoverable antimony)	—	—	—	—	—
Smelter:					
Primary	W	W	W	W	W
Secondary	5,350	5,600	3,650	3,670	3,400
Imports for consumption	28,500	26,700	33,500	29,200	28,300
Exports of metal, alloys, oxide, and waste and scrap[1]	4,250	3,680	3,810	2,140	2,900
Shipments from Government stockpile	4,630	2,070	—	—	—
Consumption, apparent[2]	34,200	29,400	36,800	31,400	27,600
Price, metal, average, cents per pound[3]	88	108	130	161	225
Stocks, yearend	5,060	6,320	2,830	2,130	3,300
Employment, plant, number[e]	35	30	30	10	10
Net import reliance[4] as a percentage of apparent consumption	84	81	90	88	88

Recycling: Traditionally, the bulk of secondary antimony has been recovered as antimonial lead, most of which was generated by and then consumed by the battery industry. Changing trends in that industry in recent years, however, have generally reduced the amount of secondary antimony produced; the trend to low-maintenance batteries has tilted the balance of consumption away from antimony and toward calcium as an additive.

Import Sources (2002-05): Metal: China, 67%; Mexico, 14%; Peru, 7%; and other, 12%. Ore and concentrate: China, 74%; Austria, 14%; Mexico, 2%; and other, 10%. Oxide: China, 42%; Mexico, 40%; Belgium, 15%; and other, 3%. Total: China, 48%; Mexico, 35%; Belgium, 9%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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: None.

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ANTIMONY

Events, Trends, and Issues: In 2006, antimony production from domestic source materials was derived entirely from the recycling of lead-acid batteries. Recycling supplied only a minor portion of estimated domestic consumption. In recent years, the number of primary antimony smelters has been reduced, as smelters in New Jersey and Texas were closed in 2004. Only one domestic smelter in Montana continues to make antimony products.

The price of antimony started the year at about $1.85 per pound and rose steadily to about $2.63 per pound by mid-May. From there the price softened over the next 2 months to settle at about $2.38 per pound by mid-July, then increased to about $2.60 per pound by mid-September.

During 2006, antimony use in the United States and most antimony-consuming countries declined. On the supply side, major world producers, especially in China, continued to experience production constraints. The net result was a continuation of a world supply deficit, helping to fuel price rises.

World Mine Production, Reserves, and Reserve Base: Reserve estimates for the United States were revised to zero because there has been no U.S. production since 2000.

	Mine production		Reserves[5]	Reserve base[5]
	2005	2006[e]		
United States	—	—	—	90,000
Bolivia	3,100	5,000	310,000	320,000
China	120,000	110,000	790,000	2,400,000
Guatemala	1,000	1,000	NA	NA
Russia (recoverable)	3,000	3,300	350,000	370,000
South Africa	5,000	5,700	44,000	200,000
Tajikistan	2,000	2,000	50,000	150,000
Other countries	3,300	3,500	150,000	330,000
World total (rounded)	137,000	131,000	1,700,000	3,900,000

World Resources: U.S. resources of antimony 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. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Gross weight, for metal, alloys, waste, and scrap.
[2]Domestic mine production + secondary production from old scrap + net import reliance.
[3]New York dealer price for 99.5% to 99.6% metal, c.i.f. U.S. ports.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.

ARSENIC

(Data in metric tons of arsenic unless otherwise noted)

Domestic Production and Use: Foreign sources have supplied arsenic trioxide and arsenic metal to arsenic-using industries in the United States since 1985, when the last domestic arsenic plant, a copper smelter, closed. During 2001-03, imports of arsenic compounds averaged over 20,000 tons and were used mainly in the production of chromated copper arsenate (CCA) wood preservatives. Arsenic compounds were also used in fertilizers, fireworks, herbicides, and insecticides. Arsenic metal was used as an antifriction additive for bearings, in lead shot, in clip-on wheel weights, and to strengthen the lead grids in lead-acid storage batteries. Addition of less than a percent of arsenic hardens small-arms ammunition used by the United States military. High-purity arsenic (99.9999%) was used by the electronics industry for gallium-arsenide semiconductors that are used for telecommunication, solar cells, and space research. Arsenic may be used for germanium-arsenide-selenide specialty optical materials. Indium-gallium-arsenide is used for short wave infrared technology. The value of arsenic compounds and metal consumed domestically in 2006 was estimated to be about $7 million.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Imports for consumption:					
Metal	880	990	870	810	850
Compounds	18,800	20,800	6,150	8,330	8,500
Exports, metal	100	173	220	320	400
Estimated consumption[1]	19,600	21,600	6,800	8,800	9,000
Value, cents per pound, average:[2]					
Metal (China)	120	87	88	95	95
Trioxide (China)	44	45	49	18	35
Trioxide (Mexico)	33	34	32	67	NA
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: Arsenic is one of several hazardous elements contained in electronic products. Circuit boards, relays, switches, and other electronic components that contain arsenic may be disposed of at hazardous waste sites. In celebration of “Earth Day” some organizations post drop-off sites for recycling or “e-cycling” of electronics which may contain arsenic. At wood treatment plants where CCA is used, arsenic in the process water was recycled and reused. Gallium-arsenide scrap from semiconductor manufacturing was processed for recovery of the arsenic. There was no recovery or recycling of arsenic from arsenic-containing residues and dusts at nonferrous smelters in the United States.

Import Sources (2002-05): Metal: China, 85%; Japan, 14%; and other, 1%. Trioxide: China, 65%; Morocco, 22%; Mexico, 4%; Chile, 3%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Metal	2804.80.0000	Free.
Trioxide	2811.29.1000	Free.
Sulfide	2813.90.1000	Free.
Acid	2811.19.1000	2.3% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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ARSENIC

Events, Trends, and Issues: By yearend 2004, arsenic trioxide imports, mainly from China, had dropped to 6,150 tons for the year compared with 20,800 tons by yearend 2003. This 70% decline was because of a voluntary decision by the wood-preserving industry to stop using CCA as a wood preservative for deck materials and outdoor residential use by yearend 2003. Imports have increased since 2004, rising slightly from 2005 to 2006, but are still below 10,000 tons per year. Wood used for nonresidential applications may still be treated with CCA, which is preferred because of known performance and lower cost. The long-term demand for arsenic, mainly as arsenic trioxide, will be affected by human health concerns, increased regulation, use of alternative wood preservative treatments, and use of concrete or plasticized wood products. Global government and university research is expected to continue on the geologic sources and effects of high levels of arsenic in ground water. Arsenic may also be released from anthropogenic sources, such as buried World War I ammunition, Civil War-era cemeteries, and coal-burning powerplant emissions. In the aftermath of Hurricane Katrina, arsenic was one of several contaminants deposited in sludge across New Orleans. Exposure to arsenic may affect breathing and heart rhythm and may increase the risk for bladder cancer. Research indicates that arsenic trioxide may be used to treat leukemia.

World Production, Reserves, and Reserve Base:

	Production (arsenic trioxide)		Reserves and reserve base[4] (arsenic content)
	2005	2006[e]	
Belgium	1,000	1,000	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.
Chile	11,500	11,500	
China	30,000	30,000	
France	1,000	1,000	
Kazakhstan	1,500	1,500	
Mexico	1,650	1,300	
Morocco	6,900	6,900	
Peru	3,600	3,500	
Russia	1,500	1,500	
Other countries	790	1,000	
World total (rounded)	59,400	59,200	

World Resources: Arsenic may be obtained from a variety of sources. These include copper, gold, and lead smelter dust or from roasting arsenopyrite, perhaps the most abundant ore mineral of arsenic, or from realgar and orpiment. Arsenic resources are also contained in enargite, a copper ore, and associated alteration products; realgar and orpiment, in China, northern Peru, and the Philippines; copper-gold ores in Chile; and associated with gold occurrences in Canada. Orpiment and realgar from remote gold mines in Sichuan Province, China, are stockpiled for transport and later recovery of arsenic. Global resources of copper and lead contain approximately 11 million tons of arsenic.

Substitutes: Alkaline copper quaternary, ammoniacal copper quaternary, ammoniacal copper zinc arsenate, copper azole, and copper citrate may be substituted for CCA. In humid areas, silver-containing biocides are being considered as an alternative wood preservative. Concrete, steel, plasticized wood scrap, or plastic composites may also be substituted for CCA-treated wood.

[e]Estimated. NA Not available.
[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]See Appendix C for definitions.

ASBESTOS

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: There has been no asbestos mining in the United States since 2002, so the United States is totally dependent on imports to meet manufacturing needs. Asbestos consumption in the United States was estimated to be 55% for roofing products, 26% for coatings and compounds, and 19% for other applications.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production (sales), mine	3	—	—	—	—
Imports for consumption	7	5	3	3	2
Exports[1]	7	3	2	2	3
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, estimated	7	5	3	3	2
Price, average value, dollars per ton[2]	160	220	255	255	NA
Stocks, producer, yearend	NA	NA	—	—	—
Employment, mine and mill, number	15	2	—	—	—
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2002-05): Canada, 89%; and other, 11%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Asbestos	2524.00.0000	Free.

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

Government Stockpile: None.

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ASBESTOS

Events, Trends, and Issues: There was no production of asbestos in the United States. U.S. exports increased to an estimated 3,380 tons in 2006 from 1,510 tons in 2005. Exports may include some nonasbestos materials and reexports, as U.S. production of asbestos ceased in 2002. Imports decreased to an estimated 2,340 tons in 2006 from 2,530 tons in 2005. Domestic use of asbestos declined to an estimated 2,340 tons in 2006 from 2,530 tons in 2005. All the asbestos used in the United States was chrysotile. Canada remained the leading supplier of asbestos for domestic consumption.

The Mine Safety and Health Administration reviewed testimony related to its proposed reduction of the 8-hour time-weighted average permissible exposure level to 0.1 fiber per cubic centimeter from 2.0 fibers per cubic centimeter for asbestos. No deadline has been set for a decision concerning this action. Health research and asbestos cleanup continued in Libby, MT, where vermiculite contaminated with asbestos was mined and processed, and at several vermiculite processing plants across the country. The health risk posed by asbestos exposure in populated areas, such as housing developments, hiking trails, and school settings, remained a contentious topic of discussion, particularly in El Dorado County, CA. This issue arose because residential development, particularly in California, expanded into areas where outcrops of asbestos occur.

A United Nations committee did not reach a consensus with regard to the inclusion of chrysotile under its Prior Informed Consent (PIC) Procedure of the Rotterdam Convention. A final decision will be made at their next meeting in 2008. Under the PIC procedure, countries exporting PIC-listed materials would have to inform the recipient countries of the hazardous content prior to shipment. The importing country would then decide whether or not to accept the shipment. All other forms of asbestos are included on the PIC list.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2005	2006[e]		
United States	—	—	Small	Large
Brazil	195	236	Moderate	Moderate
Canada	200	240	Large	Large
China	520	400	Large	Large
Kazakhstan	355	350	Large	Large
Russia	925	925	Large	Large
Zimbabwe	122	110	Moderate	Moderate
Other countries	84	80	Moderate	Large
World total (rounded)	2,400	2,300	Large	Large

World Resources: The world has 200 million tons of identified resources. The U.S. resources are large, but are composed mostly of short-fiber asbestos, whose use is more limited than long-fiber asbestos in asbestos-based products.

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 or rocks, such as perlite, serpentine, silica, and talc, are considered to be possible asbestos substitutes for products in which the reinforcement properties of fibers were not required. No single substitute was as versatile 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; however, imports account for 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 totaled about 540,000 tons in 2006 valued at about $21 million, an increase in production of about 10% from 2005. The majority of production came from three major mines in Nevada followed by a significantly smaller sales volume from a single mine in Georgia. In 2006, an estimated 3.2 million tons of barite (from domestic production and imports) was sold by crushers and grinders in five States. Nearly 95% of the barite sold in the United States was used as a weighting agent in gas and oil well drilling fluids. Nevada shipments of ground barite went mostly to Colorado and Wyoming gas drilling customers, but some crude barite was shipped to out-of-State grinding mills. Colorado and Wyoming continued to be prime areas for natural gas exploration; between late October 2005 and late October 2006, the combined rig count in these two States increased from 174 to 193. The imports to the Louisiana and Texas ports went primarily to offshore drilling operations in the Gulf of Mexico and to onshore operations in Texas, Louisiana, New Mexico, and Oklahoma. The Gulf of Mexico and these four States account for about 70% of natural gas production in the United States and represent the major regional market for barite.

Barite is used as a filler, extender, or weighting agent in products such as paints, plastics, and rubber. Some specific uses include its use in brake and clutch pads for automobiles, automobile paint primer for metal protection and gloss, and to add weight to rubber mudflaps on trucks and to the cement jacket around petroleum pipelines under water. In the metal casting industry, barite is part of the mold-release compounds. Because barite significantly blocks X-ray and gamma-ray emissions, it is used as aggregate in high-density concrete for radiation shielding around X-ray units in hospitals, nuclear powerplants, and university nuclear research facilities. Ultrapure barite consumed as liquid is used as a contrast medium in medical X-ray examinations. It is the raw material for barium chemicals, such as barium carbonate, which is an ingredient in faceplate glass in the cathode-ray tubes of televisions and computer monitors.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Sold or used, mine	420	468	532	489	540
Imports for consumption:					
Crude barite	1,510	1,620	1,960	2,570	2,710
Ground barite	5	([1])	5	84	12
Other	31	33	34	29	15
Exports	47	44	70	93	78
Consumption, apparent[2] (crude and ground)	1,920	2,080	2,460	3,080	3,200
Consumption[3] (ground and crushed)	1,980	2,230	2,440	2,720	3,200
Price, average value, dollars per ton, f.o.b. mine	28.90	29.70	35.10	35.90	39.00
Employment, mine and mill, number[e]	320	340	340	340	330
Net import reliance[4] as a percentage of apparent consumption	78	77	78	84	83

Recycling: None.

Import Sources (2002-05): China, 90%; India, 8%; and other, 2%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-06**
Crude barite	2511.10.5000	$1.25/t.
Ground barite	2511.10.1000	Free.
Oxide, hydroxide, and peroxide	2816.40.2000	2% ad val.
Other chlorides	2827.39.4500	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.

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BARITE

Events, Trends, and Issues: Fueled by the dramatic increase in oil and gas prices, the increase in domestic exploration (especially for natural gas) has followed suit. The average monthly U.S. rig count has nearly doubled since 2002 (from 830 to 1,636). This increased drilling activity has pushed domestic barite production up by 29% and imports of crude barite up by 79% during the same period. During the same period, the international rig count (excluding the United States) has increased by about 28%.

In an effort to extend barite reserves in Nevada and to hold down future price increases, one of the major oil-service companies introduced a new grade of barite with a slightly lower specific gravity of 4.1 compared with the American Petroleum Institute specific gravity specification of 4.2. The company performed an engineering analysis that showed that on a highly weighted drilling mud, only about an additional 1% of barite will be required to achieve the desired mud weight, and there are no effects on the performance of the typical drilling fluid system. The company started producing the new product in July and has reported no negative feedback from customers.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2005	2006[e]		
United States	489	540	25,000	55,000
Algeria	53	50	9,000	15,000
Brazil	61	60	2,100	5,000
Bulgaria	95	95	NA	NA
China	4,200	4,300	62,000	360,000
France	82	75	2,000	2,500
Germany	95	89	1,000	1,500
India	[6]1,000	1,000	53,000	80,000
Iran	280	280	NA	NA
Kazakhstan	120	120	NA	NA
Mexico	275	250	7,000	8,500
Morocco	360	420	10,000	11,000
Russia	63	65	2,000	3,000
Thailand	120	120	9,000	15,000
Turkey	155	200	4,000	20,000
United Kingdom	60	60	100	600
Vietnam	116	110	NA	NA
Other countries	250	250	14,000	160,000
World total (rounded)	7,870	8,080	200,000	740,000

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[5] in all categories are about 2 billion tons, but only about 740 million tons is identified.

Substitutes: In the drilling mud market, alternatives to barite include celestite, ilmenite, iron ore, and 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]Less than ½ unit.
[2]Sold or used by domestic mines – exports + imports.
[3]Domestic and imported crude barite sold or used by domestic grinding establishments.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.
[6]Data are for fiscal year ending March 31 of the year shown.

BAUXITE AND ALUMINA[1]

(Data in thousand metric dry tons unless otherwise noted)

Domestic Production and Use: Nearly all bauxite consumed in the United States was imported; of the total, more than 90% was converted to alumina. Of the total alumina used, about 90% went to primary aluminum smelters and the remainder went to nonmetallurgical uses. Annual alumina capacity was 5.75 million tons, with all four Bayer refineries operating during the year. Domestic bauxite was used in the production of nonmetallurgical products, such as abrasives, chemicals, and refractories.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, bauxite, mine	NA	NA	NA	NA	NA
Imports of bauxite for consumption[2]	7,710	8,860	10,500	10,400	9,500
Imports of alumina[3]	3,010	2,310	1,650	1,860	1,700
Exports of bauxite[2]	52	89	75	62	45
Exports of alumina[3]	1,270	1,090	1,230	1,200	1,500
Shipments of bauxite from Government stockpile excesses[2]	297	1,710	66	—	—
Consumption, apparent, bauxite and alumina (in aluminum equivalents)[4]	2,860	2,580	2,810	2,940	2,500
Price, bauxite, average value U.S. imports (f.a.s.) dollars per ton	20	19	22	26	28
Stocks, bauxite, industry, yearend[2]	1,280	3,830	3,120	2,730	2,000
Net import reliance,[5] bauxite and alumina, as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2002-05):[6] Bauxite: Jamaica, 31%; Guinea, 30%; Brazil, 17%; Guyana, 12%; and other, 10%. Alumina: Australia, 50%; Suriname, 29%; Jamaica, 9%; and other, 12%. Total: Jamaica, 23%; Guinea, 19%; Australia, 19%; Brazil, 12%; and other, 27%.

Tariff: Import duties on bauxite and alumina were abolished in 1971 by Public Law 92-151. Duties can be levied only on such imports from nations with nonnormal trade relations. However, all countries that supplied commercial quantities of bauxite or alumina to the United States during the first 8 months of 2006 had normal-trade-relations status.

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

Government Stockpile:

Stockpile Status—9-30-06[7]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 2006**	**Disposals FY 2006**
Bauxite, metal grade:					
Jamaica-type	—	4,040	—	2,030	—
Suriname-type	—	—	—	406	—
Bauxite, refractory-grade	—	—	—	68	—

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BAUXITE AND ALUMINA

Events, Trends, and Issues: Increased supply caused spot prices for metallurgical-grade alumina, as published by Metal Bulletin, to decrease dramatically by the end of the third quarter. The published price range began the year at $580 to $590 per ton of alumina. By the end of April, the price range had peaked at $620 to $635 per ton. The price range then began a dramatic downward slide that lasted through mid-October to a range of $240 to $290 per ton.

World production of bauxite and alumina increased compared with that of 2005. Based on production data from the International Aluminium Institute, world alumina production during the first 2 quarters of 2006 increased 9% compared with that for the same period in 2005.

World Bauxite Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	2005	2006[e]		
United States	NA	NA	20,000	40,000
Australia	60,000	61,400	5,800,000	7,900,000
Brazil	19,800	21,000	1,900,000	2,500,000
China	18,000	20,000	700,000	2,300,000
Greece	2,450	2,000	600,000	650,000
Guinea	15,000	15,200	7,400,000	8,600,000
Guyana	1,500	1,500	700,000	900,000
India	12,000	13,000	770,000	1,400,000
Jamaica	14,100	14,900	2,000,000	2,500,000
Kazakhstan	4,800	4,900	350,000	360,000
Russia	6,400	7,200	200,000	250,000
Suriname	4,580	4,800	580,000	600,000
Venezuela	5,900	6,000	320,000	350,000
Other countries	4,620	4,820	3,400,000	4,000,000
World total (rounded)	169,000	177,000	25,000,000	32,000,000

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 U.S. 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-base refractories. Although more costly, silicon carbide and alumina-zirconia substitute for bauxite-base 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 all forms of bauxite, expressed as dry equivalent weights.

[3]Calcined equivalent weights.

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

[5]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 6% for alumina in 2006. For the years 2002-05, the net import reliance was 100% for bauxite and ranged from 7% to 29% for alumina.

[6]Aluminum equivalents.

[7]See Appendix B for definitions.

[8]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, which it converted, along with imported beryl and beryl from the National Defense Stockpile, into beryllium hydroxide. Some of the beryllium hydroxide was shipped to the company's plant in Ohio, where it was converted into beryllium copper master alloy, metal, and/or oxide, and some was sold. Estimated beryllium consumption of 90 tons was valued at about $25 million, based on the estimated unit value for beryllium-copper master alloy. About 45% of beryllium use was estimated to be in computer and telecommunications products, and the remainder was in aerospace and defense applications, appliances, automotive electronics, industrial components, and other applications.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, mine shipments[e]	80	85	90	110	100
Imports for consumption[1]	141	163	85	93	70
Exports[2]	165	269	217	201	160
Government stockpile releases[3]	90	33	106	79	80
Consumption:					
Apparent[4]	156	57	69	84	90
Reported, ore	120	140	130	160	NA
Unit value, average annual, beryllium-copper master alloy, dollars per pound contained beryllium[5]	123	113	125	99	120
Stocks, ore, consumer, yearend	90	45	40	35	NA
Net import reliance[6] as a percentage of apparent consumption	49	E	E	E	E

Recycling: Beryllium was recycled mostly from new scrap generated during the manufacture of beryllium products. Detailed data on the quantities of beryllium recycled are not available, but may represent as much as 10% of apparent consumption.

Import Sources (2002-05):[1] Kazakhstan, 26%; Germany and Japan, 20% each; United Kingdom, 6%; and other, 28%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Beryllium ores and concentrates	2617.90.0030	Free.
Beryllium oxide and hydroxide	2825.90.1000	3.7% ad val.
Beryllium-copper master alloy	7405.00.6030	Free.
Beryllium:		
Unwrought powders	8112.12.0000	8.5% ad val.
Waste and scrap	8112.13.0000	Free.
Other	8112.19.0000	5.5% ad val.

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

Government Stockpile: The Defense Logistics Agency, U.S. Department of Defense, had a goal of retaining 45 tons of hot-pressed beryllium powder in the National Defense Stockpile. Disposal limits for beryllium materials in the proposed fiscal year 2007 Annual Materials Plan were unchanged from those of fiscal year 2006.

Stockpile Status—9-30-06[7]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Beryl ore (11% BeO)	—	107	—	[8]145	138
Beryllium-copper master alloy	3	—	3	[9]44	—
Beryllium metal:					
Hot-pressed powder	155	—	110	—	—
Vacuum-cast	14	53	14	[9]36	27

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BERYLLIUM

Events, Trends, and Issues: During the first half of 2006, demand for beryllium alloys for the aerospace, automotive electronics, computer and telecommunications, and industrial components industries was strong. Demand for beryllium X-ray windows for medical equipment and beryllium materials for acoustic applications also was strong. During the second half of the year and into 2007, 4.4 tons of beryllium blanks were to be supplied to an experimental nuclear fusion reactor in Europe.

The leading U.S. beryllium producer planned to build a new primary beryllium facility at its operations in Ohio. The engineering and design of the new facility was being funded by the Department of Defense's Defense Production Act Title III Program, and was expected to be completed before the end of 2007. Construction and startup of the facility was expected to take 2 to 3 years; funding would require additional Title III approval. Primary beryllium is the feedstock used to make beryllium metal products. The only primary beryllium facility in the United States was closed in 2000.

A Canadian resource company acquired seven beryl mines in Uganda and agreed to purchase the mineral exploration rights to two beryl properties in Brazil. An Australian oil and gas exploration company acquired an interest in a beryllium project in Angola.

Because of the toxic nature of beryllium, various international, national, and state guidelines and regulations have been established regarding beryllium in air, water, and other media. Industry must maintain careful control over the quantity of beryllium dust, fumes, and mists in the workplace. Control of potential health hazards adds to the final cost of beryllium products.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e] 2005	Mine production[e] 2006
United States	110	100
China	20	20
Mozambique	6	6
Other countries	1	1
World total (rounded)	138	127

Reserves and reserve base[10]

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 16,000 tons of contained beryllium. World beryllium reserves and reserve base are not sufficiently well delineated to report consistent figures for all countries.

World Resources: World resources in known deposits of beryllium have been estimated to be more than 80,000 tons. About 65% of these resources is in nonpegmatite deposits 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: Because 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 copper alloys containing nickel and silicon, titanium, or other alloying elements or phosphor bronze alloys (copper-tin-phosphorus) may be substituted for beryllium-copper alloys, but these substitutions can result in substantially reduced performance. In some applications, aluminum nitride or boron nitride may be substituted for beryllium oxide.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Includes estimated beryllium content of imported ores and concentrates, oxide and hydroxide, unwrought metal (including powders), beryllium articles, waste and scrap, and beryllium-copper master alloy.
[2]Includes estimated beryllium content of exported unwrought metal (including powders), beryllium articles, and waste and scrap.
[3]Change in total inventory level from prior yearend inventory; includes committed and uncommitted inventories.
[4]The sum of U.S. mine shipments and net import reliance.
[5]Calculated from gross weight and customs value of imports; beryllium content estimated to be 4%.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]See Appendix B for definitions.
[8]Actual quantity will be limited to remaining inventory.
[9]Represents inventory sold, but not yet shipped.
[10]See Appendix C for definitions.

BISMUTH

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

Domestic Production and Use: The United States ceased production of primary refined bismuth in 1997 and is thus highly import dependent for its supply. A small amount of bismuth is recycled by some domestic firms. Bismuth is contained in some lead ores mined domestically, but the bismuth-containing residues are not processed domestically and may be exported. The value of bismuth consumed was approximately $24 million. About 49% of the bismuth was used for metallurgical additives; 29% in fusible alloys, solders, and ammunition cartridges; 21% in pharmaceuticals and chemicals; and 1% in other uses.

The Safe Drinking Water Act Amendment of 1996 required that all new and repaired fixtures and pipes for potable water supply be lead free after August 1998. Bismuth use in water meters and fixtures is one particular application that has increased in recent years. An application with major growth potential is the use of zinc-bismuth alloys to achieve thinner and more uniform galvanization. Bismuth was also used domestically in the manufacture of ceramic glazes, crystal ware, and pigments; as an additive to free-machining steels; and as an additive to malleable iron castings.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, refinery	—	—	—	—	—
Imports for consumption, metal	1,930	2,320	1,980	2,530	2,600
Exports, metal, alloys, and scrap	131	108	109	141	150
Consumption, reported	2,320	2,120	2,420	2,340	2,500
Price, average, domestic dealer, dollars per pound	3.14	2.87	3.35	3.91	4.40
Stocks, yearend, consumer	111	279	134	136	150
Net import reliance[1] as a percentage of apparent consumption	95	95	95	96	96

Recycling: All types of bismuth-containing alloy scrap were recycled and contributed about 10% of U.S. bismuth consumption, or 250 tons.

Import Sources (2002-05): Belgium, 38%; Mexico, 23%; China, 20%; United Kingdom, 10%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Bismuth and articles thereof, including waste and scrap	8106.00.0000	Free.

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

Government Stockpile: None.

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BISMUTH

Events, Trends, and Issues: Owing to its unique properties, bismuth has a wide variety of applications including use in free-machining steels, brass, pigments, and solders, as nontoxic replacements for lead; in pharmaceuticals including bismuth subsalicylate, the active ingredient in over-the-counter stomach remedies; in the foundry industry, as an additive to enhance metallurgical quality; in the construction field, as a triggering mechanism for fire sprinklers; and in holding devices for grinding optical lenses. Currently, researchers in the European Union, Japan, and the United States are investigating possibilities for bismuth in lead-free solders. Researchers are looking at liquid lead-bismuth coolants for use in nuclear reactors. Work is proceeding toward developing a bismuth-containing metal polymer bullet.

The price of bismuth remained fairly steady during the first quarter of 2006 finishing the quarter within a range of $4.45 to $4.70 per pound; the price drifted lower during the second quarter, ending the quarter at $4.20 to $4.50 per pound; the price rose somewhat in the third quarter, ending the quarter at $4.60 to $4.80 per pound. The estimated annual average bismuth price rose about 13% above that for 2005.

Around the world, there were several bismuth exploration activities that seemed promising: in Canada, an exploration firm announced that its cobalt-gold-bismuth deposit in the Northwest Territories was undergoing a feasibility study and that an agreement was reached to sell all of its eventual bismuth production to an undisclosed firm; another Canadian exploration firm announced increased expenditures to develop its property in Vietnam that contains bismuth, fluorspar, and tungsten.

World Mine Production, Reserves, and Reserve Base: Reserve estimates for the United States were revised to zero because there has been no reported mine production of bismuth in the United States since 1997.

	Mine production		Reserves[2]	Reserve base[2]
	2005	2006[e]		
United States	—	—	—	14,000
Bolivia	60	40	10,000	20,000
Canada	190	190	5,000	30,000
China	3,000	3,000	240,000	470,000
Kazakhstan	140	160	5,000	10,000
Mexico	970	1,100	10,000	20,000
Peru	1,000	960	11,000	42,000
Other countries	160	160	39,000	74,000
World total (rounded)	5,500	5,600	320,000	680,000

World Resources: Bismuth, at an estimated 8 parts per billion by weight, is the 69th element in order of abundance in the Earth's crust and is about twice as abundant as gold. World reserves of bismuth are usually based on bismuth content of lead resources because bismuth production is most often a byproduct of processing lead ores; in China, bismuth production is a byproduct of tungsten and other metal ore processing. Bismuth minerals rarely occur in sufficient quantities to be mined as principal products; the Tasna Mine in Bolivia and a mine in China are the only mines that produced bismuth from a bismuth ore. The Tasna Mine has been on standby status since the mid-1990s awaiting a significant rise in the metal price. Several bismuth-containing deposits are in varying stages of mining feasibility review. These polymetallic deposits include Bonfim in Brazil, NICO in Canada, and Nui Phao in Vietnam.

Substitutes: Bismuth can be replaced in pharmaceutical applications by alumina, antibiotics, and magnesia. 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 alloys for holding metal shapes during machining, and glycerine-filled glass bulbs can replace bismuth alloys in triggering devices for fire sprinklers. Free-machining alloys can contain lead, selenium, or tellurium as a replacement for bismuth.

Bismuth, on the other hand, is an environmentally friendly substitute for lead in plumbing and many other applications, including fishing weights, hunting ammunition, lubricating greases, and soldering alloys.

[e]Estimated. — Zero.
[1]Defined as imports – exports + adjustments for Government and industry stock changes.
[2]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 2006 was $265 million. Domestic production of boron minerals, primarily as sodium borates, was done by three companies in southern California. The leading producer operated an open pit tincal and kernite mine and associated compound plants. The majority of the remaining output was produced using saline brines as the raw material. A third company that previously processed calcium and calcium sodium borates was selling from stocks. A fourth company was idle during most of 2003 and all of 2004 and 2005. Boron minerals and chemicals were principally consumed in the North Central and the Eastern United States. The estimated distribution pattern for boron compounds consumed in the United States in 2005 was glass and ceramics, 70%; soaps and detergents, 5%; fire retardants, 4%; agriculture, 2%; and other, 19%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production[1]	543	605	637	612	612
Imports for consumption, gross weight:					
Borax	([2])	([2])	([2])	1	1
Boric acid	49	47	49	52	60
Colemanite	32	24	21	31	25
Ulexite	125	80	110	103	90
Exports, gross weight:					
Boric acid	84	70	61	183	200
Colemanite	5	23	18	—	—
Refined sodium borates	150	131	135	308	360
Consumption:					
Apparent	492	532	509	439	400
Reported	359	366	385	NA	NA
Price, dollars per ton, granulated pentahydrate borax in bulk, carload, works[3]	376	400-425	400-425	400-425	400-425
Stocks, yearend[4]	NA	NA	NA	NA	NA
Employment, number	1,300	1,300	1,300	1,300	1,300
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2002-05): Boric acid: Turkey, 57%; Chile, 31%; Peru, 5%; Russia, 3%; and other, 4%.

Tariff:

Item	Number	Normal Trade Relations 12-31-06
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.

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BORON

Events, Trends, and Issues: The United States was the world's leading producer of refined boron compounds during 2006, and about one-half of domestic production was exported. U.S. processed products had fewer impurities and were produced with lower emissions than in other countries. The U.S. industry produced boron minerals with a higher productivity per worker hour than those produced in other countries. It was reported that a leading indicator for demand for refined borates was a strong housing market. The demand for housing decreased at yearend 2006.

In 2006, Rio Tinto Borax, Luzenac Talc, and Dampier Salt were combined to form a new organization, Rio Tinto Minerals, located in Colorado.[6] Together with Rio Tinto Iron & Titanium, the two will form the Industrial Minerals product group, effective in 2007.[7] The Boron Mine in southern California continues to be the leading producer of domestic boron compounds. Production of borates during 2005 was reported to be 560,000 tons, a decrease of 1% from 2004 production.

Salta Mining and Energy Resources, located in Salta Province in northern Argentina, increased exports of boric acid, lithium chloride, colemanite, and sodium octaborate to China during 2006.[8]

Exported U.S. borate materials competed with borax, boric acid, colemanite, and ulexite, primarily from Turkey, the leading producer of boron ore in the world.

World Production, Reserves, and Reserve Base:[9]

	Production—All forms		Reserves[10]	Reserve base[10]
	2005	2006[e]		
United States	1,150	1,150	40,000	80,000
Argentina	820	650	2,000	9,000
Bolivia	68	60	NA	NA
Chile	590	460	NA	NA
China	140	140	25,000	47,000
Iran	3	2	1,000	1,000
Kazakhstan	30	30	NA	NA
Peru	9	10	4,000	22,000
Russia	400	400	40,000	100,000
Turkey	1,700	1,850	60,000	150,000
World total (rounded)	4,910	4,750	170,000	410,000

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 can use other glass-producing substances, such as phosphates. Insulation substitutes include cellulose, foams, and mineral wools.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Minerals and compounds sold or used by producers; includes both actual mine production and marketable products.
[2]Less than ½ unit.
[3]Chemical Market Reporter.
[4]Stocks data are not available and are assumed to be zero for net import reliance and apparent consumption calculations.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]Jones, Laura, 2005, World leaders in borates, talc, and salt combine to form Rio Tinto Minerals: Toulouse, France, Rio Tinto Group press release, November 8, 1 p.
[7]Rio Tinto Group, 2005, Finding and processing the earth's minerals 2005, accessed December 6, 2006, at URL http://www.riotinto.com/library/annualreview05/operations/minerals.aspx.
[8]Prensa Latina, 2006, Argentina ups mineral exports to China, accessed May 29, 2006, at URL http://www.prensa-latina.org.
[9]Gross weight of ore in thousand metric tons.
[10]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 three companies operating in Arkansas and Michigan accounted for 100% of elemental bromine production. Arkansas, with six plants, led the Nation in bromine production, and bromine was the leading mineral commodity in terms of value produced in the State. In Michigan, bromine was produced as a byproduct of magnesium compounds production. Three bromine companies in the United States accounted for more than one-third of world production.

A major domestic company reported that bromine is used in the manufacture of dyes, fire retardants, insect repellents, oilfield completion fluids, perfumes, pharmaceuticals, photographic chemicals, water-treatment chemicals, and other chemicals. 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:	2002	2003	2004	2005	2006[e]
Production[1]	222	216	222	226	226
Imports for consumption, elemental bromine and compounds[2]	7	7	10	10	10
Exports, elemental bromine and compounds	13	13	8	11	11
Consumption, apparent[3]	216	210	220	225	225
Price, cents per kilogram, bulk, purified bromine	74.7	71.7	86.0	74.3	74.2
Employment, number	1,700	1,700	1,500	1,200	1,200
Net import reliance[4] as a percentage of apparent consumption	—	E	E	E	E

Recycling: Some bromide solutions were recycled to obtain elemental bromine and prevent the solutions from being disposed of as hazardous waste. This recycled bromine is not included in the virgin bromine production reported by the companies, but is included in data collected by the U.S. Census Bureau.

Import Sources (2002-05): Israel, 93%; United Kingdom, 2%; Indonesia, 1%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Ammonium, calcium, or zinc bromide	2827.59.2500	Free.
Bromides and bromide oxides	2827.59.5000	3.6% ad val.
Bromine	2801.30.2000	5.5% ad val.
Bromochloromethane	2903.49.1000	Free.
Decabromodiphenyl and octabromodiphenyl oxide	2909.30.0700	5.5% 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	5.5% ad val.
Vinyl bromide, methyl bromide	2903.30.1520	Free.

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

Government Stockpile: None.

Events, Trends, and Issues: Israel and the United States were the leading producers of bromine in the world. Approximately 90% of Israel's production was for export, accounting for about 80% of international trade in bromine and bromine compounds to more than 100 countries. Exports from Israel were used to produce bromine compounds at a plant in the Netherlands for export to other countries.

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BROMINE

Tetra Technologies Inc. announced plans to invest $100 million in a project to produce bromine from brine. The plant will process bromine, calcium chloride, and sodium chloride from brine reserves around Magnolia, AR. The bromine produced would replace bromine now being imported and would have negligible effect on current producers.[5]

A silver bromide bacteria coating would give biomedical implants bacteria-fighting capabilities. By adding a silver salt to a copolymer silver bromide, particles are captured by the polymer. Because silver bromide is sparingly soluble, there is no uncontrolled dissolution of silver. The coatings can kill gram-positive and gram-negative bacteria on surfaces and in solution.[6]

Price increases for many bromine compounds were announced reflecting the rising market value of the bromine and to cover major increases in the costs of energy, raw materials, regulatory compliance, and transportation.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2005	2006[e]		
United States[1]	226	226	11,000	11,000
Azerbaijan	2	2	300	300
China	43	44	130	3,500
France	2	2	1,600	1,600
Germany	0.5	0.5	([8])	([8])
India	1.5	1.5	([9])	([9])
Israel	210	210	([10])	([10])
Italy	0.3	0.3	([9])	([9])
Japan	20	20	([11])	([11])
Jordan	46	46	([10])	([10])
Spain	0.1	0.1	1,400	1,400
Turkmenistan	0.15	0.15	700	700
Ukraine	3	3	400	400
World total (rounded)	555	556	Large	Large

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. Bromine is also recovered from seawater as a coproduct during evaporation to produce salt.

Substitutes: Chlorine and iodine may be substituted for bromine in a few chemical reactions and for sanitation purposes. There are no comparable substitutes for bromine in various oil and gas well completion and packer applications that do not harm the permeability of the production zone and that control well "blowouts." Because plastics have a low ignition temperature, alumina, magnesium hydroxide, organic chlorine compounds, and phosphorous compounds can be substituted for bromine as fire retardants in some uses. Bromine compounds and bromine acting as a synergist with other materials are used as fire retardants in plastics, such as those found in electronics.

[e]Estimated. E Net exporter. — 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]Chemical & Engineering News, 2006, Tetra slates bromine output: Chemical & Engineering News, v. 84, no. 9, February 27, p. 20.
[6]Halford, Bethany, 2006, Silver bromide bacteria fighter: Chemical & Engineering News, v. 84, no. 29, July 27, p. 8.
[7]See Appendix C for definitions.
[8]From waste bitterns associated with potash production.
[9]From waste bitterns associated with solar salt.
[10]From the Dead Sea.
[11]From seawater.

CADMIUM

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

Domestic Production and Use: Three companies in the United States produced cadmium metal in 2006. Two companies recovered cadmium as a byproduct of zinc leaching from roasted sulfide concentrates. One company operated in Illinois, the other in Tennessee. A third company produced cadmium metal in Pennsylvania from spent nickel-cadmium (NiCd) batteries and other cadmium-bearing scrap. Based on the average New York dealer price, U.S. cadmium metal production was valued at about $2.50 million in 2006. Between 2002 and 2006, domestic consumption of cadmium metal declined by about 14% in response to environmental concerns. Cadmium use in batteries amounted to 82% of apparent consumption. The remaining 18% was distributed as follows: pigments, 9%; coatings and plating, 7%; stabilizers for plastics, 1.2%; and nonferrous alloys, photovoltaic devices, and other, 0.8%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, refinery[1]	1,430	1,420	1,010	1,070	892
Imports for consumption, metal only	56	74	102	207	143
Imports for consumption, metal, alloys, scrap	81	112	263	288	144
Exports of metal, alloys, scrap	264	615	154	686	597
Shipments from Government stockpile excesses	627	146	—	—	—
Consumption of metal, apparent	1,460	637	1,170	656	1,250
Price, metal, average annual[2]					
Dollars per kilogram	0.64	1.31	1.20	3.30	2.80
Dollars per pound	0.29	0.59	0.55	1.50	1.27
Stocks, yearend, producer and distributor	2,160	2,580	2,540	2,550	1,740
Net import reliance[3] as a percentage of apparent consumption	2	E	13	E	29

Recycling: Cadmium is recovered from spent NiCd batteries, copper-cadmium alloy scrap, some complex nonferrous alloy scrap, and cadmium-containing dust from electric arc furnaces (EAF). The amount of cadmium recycled was not disclosed. In 2006, the U.S. steel industry generated about 0.7 million tons of EAF dust, typically containing 0.003% to 0.07% cadmium.

Import Sources (2002-05): Metal:[4] Australia, 46%; Canada, 20%; Belgium[5], 10%; Peru, 9%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations[6] 12-31-06
Cadmium oxide	2825.90.7500	Free.
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 and powders	8107.20.0000	Free.
Cadmium waste and scrap	8107.30.0000	Free.
Cadmium other	8107.90.0000	4.4% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: Improved prices for zinc in 2006 triggered a resurgence of sphalerite mining in the United States, leading to a buildup of byproduct cadmium feedstocks at North American and Asian refineries. The Red Dog Mine in Alaska continued to be the leading U.S. source of cadmium-bearing sphalerite concentrate, followed by the Pend Oreille Mine in Washington State. A Canadian company reopened the Balmat Mine in upstate New York and began shipping sphalerite concentrate to Canada, where the zinc and byproduct cadmium were recovered and refined. A British-based company acquired the zinc refinery at Sauget, IL. The Sauget refinery was completely refurbished in 1998-2003 by its Korean seller and has been an important producer of cadmium metal and oxide since at least 1937. The refinery, which traditionally processed lead-zinc concentrates from mines in Illinois, Missouri, and Tennessee, is now being modified to recover zinc from steel mill EAF dusts and other recyclable zinc-rich wastes.

During the past decade, increased environmental awareness in many developed countries has resulted in regulatory pressure to reduce or even eliminate the use of cadmium. In the United States, Federal and State environmental agencies regulate industrial releases of cadmium and other metals with a high toxic potential. The U.S. Environmental Protection Agency (EPA) has identified cadmium as a persistent and bioaccumulative toxic pollutant.

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CADMIUM

In 2003, the European Union (EU) adopted a set of environmental regulations that are having a profound impact on electronics and semiconductor manufacturing worldwide. One particular directive in this set—The Restriction of the Use of Hazardous Substances (RoHS)—prohibits the incorporation of cadmium in most electrical and electronic equipment sold in the EU after July 1, 2006. Cadmium plating of electronic components is exempt from RoHS. China's Ministry of Information Industry issued a regulation similar to RoHS in 2005. Most North American manufacturers of electronics now sell RoHS-compliant products. The EU issued a revised batteries directive (2006/66), making battery manufacturers and distributors responsible for collecting and recycling spent batteries. The directive bans, with some exemptions, portable NiCd batteries containing more than 0.002% cadmium by weight. The ban, which begins on September 26, 2008, does not apply to NiCd batteries used in alarm and emergency systems, cordless power tools, or medical equipment. The use of cadmium in electric vehicle and industrial batteries is prohibited unless the manufacturer can obtain an environmental exemption from regulatory authorities. EU member states must collect and recycle at least 25% of the portable batteries discarded annually by 2012, and 45% by 2016. Member states must monitor collection rates on a yearly basis, using sales formulas prescribed in the directive.

Although demand for cadmium in traditional uses, such as pigments and stabilizers, is decreasing, potential new uses for cadmium in the electronics sector are emerging. For example, in 2005, researchers in Berkeley, CA, synthesized ultrathin photovoltaic films comprised of cadmium selenide (CdSe) and cadmium telluride (CdTe) nanocrystals. If the efficiencies of these films for converting sunlight to electricity can be improved, solar cells could become an important market for cadmium. Such new electronic demand for cadmium could partially absorb the cadmium projected to be available from the forecast growth in zinc refining. Increased demand for cadmium could encourage recycling, while discouraging stockpiling of cadmium-bearing jarosite and other zinc refinery wastes.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production[5]		Reserves[7]	Reserve base[7]
	2005	2006[e]		
United States	1,070	892	90,000	270,000
Australia[8]	374	425	53,000	91,000
Canada	1,703	1,820	55,000	100,000
China	3,000	4,500	90,000	380,000
Germany	640	640	—	8,000
India	417	420	3,000	5,000
Japan	2,297	2,400	10,000	15,000
Kazakhstan	2,000	2,210	50,000	100,000
Korea, Republic of	2,900	2,800	—	—
Mexico	1,600	1,400	35,000	40,000
Netherlands	575	500	—	—
Peru	481	420	12,000	13,000
Russia	1,000	1,100	16,000	30,000
Other countries	1,400	1,400	120,000	540,000
World total (rounded)	19,400	20,900	540,000	1,600,000

World Resources: The bulk of the cadmium being recovered is associated with ores of sphalerite (ZnS). Estimated world identified resources of cadmium were about 6 million tons, based on identified zinc resources of 1.9 billion tons containing about 0.3% cadmium. Zinc-bearing coals of the Central United States and Carboniferous age coals of other countries also contain large subeconomic resources of cadmium.

Substitutes: Lithium-ion and nickel-metal hydride batteries are replacing NiCd batteries in some applications. However, the higher cost of these substitutes restricts their use in less expensive products. Except where the surface characteristics of a coating are critical (e.g., fasteners for aircraft), coatings of zinc or vapor-deposited aluminum can be substituted for cadmium in many plating applications. Cerium sulfide is used as a replacement for cadmium pigments, mostly in plastics.

[e]Estimated. E Net exporter. — Zero.
[1]Cadmium metal and oxide produced as a byproduct of lead-zinc refining plus metal from recycling.
[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]Imports only of unwrought metal and metal powders (Tariff no. 8107.20.0000).
[5]Belgium halted byproduct production of cadmium at Overpelt in 1992 and Balen in 2002.
[6]No tariff for Australia, Canada, and Mexico for items shown.
[7]See Appendix C for definitions.
[8]Reserves and reserve base estimates for Australia were revised downward based on new data published by Geoscience Australia in 2006.

CEMENT

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: About 94 million tons of portland cement and almost 6 million tons of masonry cement were produced in 2006 at 113 plants in 37 States; total cement capacity was about 115 million tons. Cement was also produced at two plants in Puerto Rico. Sales prices increased significantly during the year and implied a value of cement production, excluding that of Puerto Rico, of about $9.8 billion. The value of total sales, including imported cement, was about $12.6 billion. Most of the cement was used to make concrete, worth at least $54 billion. About 74% of cement sales went to ready-mixed concrete producers, 14% to concrete product manufacturers, 6% to contractors (mainly road paving), 3% to building materials dealers, and 3% to other users. Total imports of cement and clinker (especially clinker) rose owing to continued high demand; imported cement accounted for about 24% of the total cement sales. Texas, California, Pennsylvania, Florida, Michigan, and Alabama, in descending order, were the six leading cement-producing States and accounted for about 48% of U.S. production.

Salient Statistics—United States:[1]	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Portland and masonry cement[2]	89,732	92,843	97,434	99,319	99,800
Clinker	81,517	81,882	86,658	87,405	90,000
Shipments to final customers, includes exports	108,778	112,929	120,731	127,361	129,000
Imports of hydraulic cement for consumption	22,198	21,015	25,396	30,403	32,000
Imports of clinker for consumption	1,603	1,808	1,630	2,858	3,500
Exports of hydraulic cement and clinker	834	837	749	766	800
Consumption, apparent[3]	110,020	114,090	121,980	128,280	131,000
Price, average mill value, dollars per ton	76.00	75.00	79.50	91.00	98.00
Stocks, cement, yearend	7,680	6,610	6,710	7,390	8,500
Employment, mine and mill, number[e]	16,400	16,500	16,200	16,300	16,300
Net import reliance[4] as a percentage of apparent consumption	20	20	21	23	24

Recycling: Cement kiln dust is routinely recycled to the kilns, which also can burn a variety of waste fuels and recycled raw materials such as slags and fly ash. Certain secondary materials can be incorporated in blended cements and in the cement paste in concrete. Cement is not directly recycled, but there is recycling of some concrete for use as aggregate.

Import Sources (2002-05):[5] Canada, 20%; Thailand, 12%; China, 10%; Venezuela, 8%; and other, 50%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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: Delays to new projects and damage to existing property and infrastructure from hurricanes that hit the Gulf States in August, September, and October 2005 constrained cement consumption in the fourth quarter of that year, but helped to generate very high levels of cement and concrete consumption in the first quarter of 2006. This was also true for imports, which rose dramatically through May 2006. Thereafter in 2006, overall U.S. cement consumption and imports began to decline in response to a significant falloff in new home construction, and consumption for the full year was only modestly higher than in 2005. The public sector component of construction demand, especially for transportation infrastructure, remained strong, owing in part to the August 2005 signing of the $244.1 billion SAFETEA-LU bill, which was the successor to the expired TEA-21 bill.

Negotiations, begun in 2005 to reduce or eliminate antidumping duties on imported Mexican cement, culminated in a January 2006 agreement that reduced tariffs on Mexican cement to a nominal amount but established a 3-year import quota. Imports of cement from Mexico, which even with full tariffs had increased dramatically in 2004-05, grew only modestly in 2006 and remained well below the agreed-upon quota level at yearend.

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CEMENT

A number of environmental issues, especially carbon dioxide emissions, can potentially affect the cement industry. Carbon dioxide reduction strategies by the cement industry were aimed at lowering emissions per ton of cement product rather than by plant. These strategies included installation of more fuel-efficient kiln technologies, partial substitution of noncarbonate sources of calcium oxide in the kiln raw materials, and partial substitution of supplementary cementitious materials (SCM) additives, such as pozzolans, for portland cement in the finished cement products and in concrete. The United States lags behind many foreign countries in the use of SCM. Because SCM do not require the energy-intensive clinker manufacturing (kiln) phase of cement production, their use, or the use of inert additives or extender, reduces the unit monetary and environmental costs of the cement component of concrete. A recent revision of the major portland cement standard ASTM-C150 allows for the incorporation of up to 5% ground limestone as an inert extender, but has yet to lead to widespread adoption of this practice, mainly because the limestone addition had yet to be adopted into the otherwise similar AASHTO standard that governs most cement and concrete specifications for public transportation sector construction projects.

Fossil fuel cost increases were of continued concern to the cement industry; even in times of cement shortages, the industry found it difficult to fully pass on the cost increases to the customers. Some cement companies burn 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 burned hinge on current and future environmental regulations and their associated costs. The trend appears to be toward increased use of waste fuels.

World Production and Capacity:

	Cement production		Yearend clinker capacity[e]	
	2005	2006[e]	2005	2006
United States (includes Puerto Rico)	101,000	101,000	104,000	104,000
Brazil	36,700	37,000	45,000	45,000
China	1,040,000	1,100,000	950,000	980,000
Egypt	[e]29,000	29,000	35,000	35,000
France	21,300	21,000	22,000	22,000
Germany	30,600	30,000	31,000	31,000
India	[e]145,000	155,000	150,000	150,000
Indonesia	[e]37,000	40,000	42,000	42,000
Iran	32,700	33,000	34,000	35,000
Italy	46,400	46,000	46,000	46,000
Japan	69,600	68,000	74,000	74,000
Korea, Republic of	51,400	52,000	62,000	62,000
Mexico	[e]36,000	40,000	40,000	40,000
Russia	48,700	54,000	65,000	65,000
Saudi Arabia	26,100	26,000	24,000	27,000
Spain	50,300	50,000	42,000	42,000
Thailand	37,900	40,000	50,000	50,000
Turkey	42,800	45,000	40,000	41,000
Vietnam	29,000	33,000	17,000	20,000
Other countries (rounded)	[e]400,000	500,000	327,000	389,000
World total (rounded)	2,310,000	2,500,000	2,200,000	2,300,000

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 future.

Substitutes: Virtually all portland cement is used either in making concrete or mortars and, as such, competes in the construction sector with concrete substitutes such as aluminum, asphalt, clay brick, rammed earth, fiberglass, glass, steel, stone, and wood. A number of materials, especially fly ash and ground granulated blast furnace slag, develop good hydraulic cementitious properties (the ability to set and harden under water) by reacting with the lime released by the hydration of portland cement. These SCM are increasingly being used as partial substitutes for portland cement in 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 (revised to include clinker) – exports + adjustments for Government (nil) and industry stock changes.

[5]Hydraulic cement and clinker.

CESIUM

(Data in kilograms of cesium content unless otherwise noted)

Domestic Production and Use: Cesium is obtained from its principal ore mineral, pollucite, which occurs in some zoned pegmatites. Pollucite is not mined in the United States; however, there are occurrences of pollucite in pegmatites in Maine and South Dakota. Pollucite is imported as concentrate from Canada by one company in the United States to produce cesium. Its high density makes cesium ideal as a component in specialty, high-density drilling fluids used throughout the world for oil and gas exploration. The U.S. Naval Observatory, Washington, DC, relies on cesium to maintain the accuracy of its atomic clocks, and the master clock there provides a reference time, available to the public at (202) 762-1401. Cesium atomic clocks are accurate to a few hundred trillionths of a second and used to synchronize the positions of the jets that track returning U.S. space shuttles. The accuracy of cesium atomic clocks is important to global positioning satellites, Internet and cell phone transmissions, and missile guidance systems. Cesium is also used in DNA separation techniques, infrared detectors, night vision devices, photoelectric cells, and traffic controls. Cesium-137, a reactor-produced radioactive isotope of cesium, is used in industrial gauges, mining and geophysical instruments, and for sterilization of food, sewage, and surgical equipment. This isotope may also be used in cancer treatment, specifically brachytherapy, where a cesium-137 source is placed within the cancerous area. Cesium-131, another cesium isotope, is used specifically to treat prostate cancer because of its high initial dose and short half-life.

Salient Statistics—United States: Since the late 1980s, production, consumption, import, and export data for cesium have not been available. Similarly, U.S. consumption and world mine production are unavailable. Cesium is not traded, and therefore no market price is available. Cesium consumption in the United States is small and may amount to only a few thousand kilograms per year. In 2006, one company offered 1-gram ampoules of 99.8% (metals basis) cesium for $42.50 each and 99.98% (metals basis) cesium for $55.90. The price for 50 grams of 99.8% (metals basis) cesium was $558.00, and 100 grams of 99.98% (metals basis) cesium was priced at $1,534.00.

Recycling: None.

Import Sources (2002-05): Canada is the chief source of cesium ore imported by the United States, and the United States is 100% import reliant.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Alkali metals, other	2805.19.9000	5.5% ad val.
Chlorides, other	2827.39.5000	3.7% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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CESIUM

Events, Trends, and Issues: The United States is reliant on imports of pollucite concentrate from Canada for its cesium supply and, unless there is a change in the cesium market, such as new or increased end uses, domestic cesium occurrences will remain uneconomic. Applications of cesium metal are limited because of cost and reactivity. Cesium has minimal environmental impact, and there are no human health issues associated with cesium. Its chief use is in specialty, high-density drilling muds, also called cesium formate fluids, for the oil and gas exploration industry. Cesium-131 and cesium-137, isotopes of cesium, have applications in cancer treatment; however, the International Atomic Energy Agency has indicated that cesium-137 and other radioactive materials may be used in radiological dispersion devices or “dirty bombs.”

World Mine Production, Reserves, and Reserve Base: Resource and mine production data on cesium are either limited or not available. The reserves and reserve base are estimated based on occurrences of pollucite that are mined as a byproduct with the lithium mineral lepidolite, which is another mineral found in pegmatites. Granitic rocks with exceptionally large crystals are classified as pegmatites. Pollucite is a hydrated aluminosilicate mineral that may form in association with lithium-rich, lepidolite-bearing or petalite-bearing zoned pegmatites. Concentrates of pollucite may contain about 20% cesium by weight. The Canadian deposit at Lac du Bonnet, Canada, which also contains tantalum, contains approximately 300,000 tons of pollucite that grades 24% Cs_2O. The next largest deposit thought to be potentially economic is in Zimbabwe.

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

World Resources: World resources of cesium have not been estimated. Cesium may be associated with lithium-bearing pegmatites worldwide, and cesium resources have been identified in Namibia and Zimbabwe. Cesium occurrences are also known in brines in Chile and China and in geothermal systems in Germany, India, and Tibet.

Substitutes: Cesium and rubidium may be used interchangeably in many applications because of similar physical properties, proximity on the Periodic Table, and similar atomic radii.

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 2006, the United States consumed about 9% of world chromite ore production in various forms of imported materials, such as chromite ore, chromium chemicals, chromium ferroalloys, and chromium metal. One U.S. company began mining chromite ore in Oregon. This was the first U.S chromite ore mine production since 1961. Imported chromite was consumed by one chemical firm to produce chromium chemicals. Stainless and heat-resisting steel producers were the leading consumers of ferrochromium. Superalloys require chromium. The value of chromium material consumption was about $468 million.

Salient Statistics—United States:[1]	2002	2003	2004	2005	2006[e]
Production:					
Primary	—	—	—	—	W
Secondary	174	180	168	124	125
Imports for consumption	263	317	326	353	355
Exports	29	46	35	57	60
Government stockpile releases	62	83	94	91	90
Consumption:					
Reported (excludes scrap)	241	245	268	257	260
Apparent[2] (includes scrap)	479	532	555	511	510
Unit value, average annual import (dollars per metric ton):					
Chromite ore (gross weight)	60	54	114	140	203
Ferrochromium (chromium content)	646	835	1,322	1,425	1,220
Chromium metal (gross weight)	5,767	5,271	5,823	8,007	7,727
Stocks, yearend, held by U.S consumers	8	10	8	9	9
Net import reliance[3] as a percentage of apparent consumption	64	66	70	76	75

Recycling: In 2006, chromium contained in reported stainless steel scrap receipts accounted for 25% of apparent consumption.

Import Sources (2002-05): Chromium contained in chromite ore and chromium ferroalloys and metal: South Africa, 50%; Kazakhstan, 30%; Zimbabwe, 8%; Russia, 7%; and other, 5%.

Tariff:[4] Item	Number	Normal Trade Relations 12-31-06
Ore and concentrate	2610.00.0000	Free.
Ferrochromium:		
Carbon more than 4%	7202.41.0000	1.9% ad val.
Carbon more than 3%	7202.49.1000	1.9% ad val.
Other:		
Carbon more than 0.5%	7202.49.5010	3.1% ad val.
Other	7202.49.5090	3.1% ad val.
Ferrochromium silicon	7202.50.0000	10% ad val.
Chromium metal:		
Unwrought powder	8112.21.0000	3% ad val.
Waste and scrap	8112.22.0000	Free.
Other	8112.29.0000	3% ad val.

Depletion Allowance: 23% (Domestic), 15% (Foreign).

Government Stockpile: The Defense Logistics Agency, U.S. Department of Defense, implemented the Annual Materials Plan for fiscal year (FY) 2006, which was in effect until September 30, 2006. Quantity available for sale was to be limited to sales authority or inventory. The Agency reported sales in FY 2006 of 61,500 tons of high-carbon ferrochromium, 42,692 tons of low-carbon ferrochromium, and 905 tons of chromium metal. Ferrochromium silicon and chemical- and metallurgical-grade chromite ore stocks have been exhausted. The last of the ferrochromium silicon stocks were shipped in June 2002; chemical-grade chromite ore, in September 2006; and metallurgical-grade chromite ore, in December 2003. At the current rate of disposal, refractory grade chromite ore will be exhausted in FY 2007; high-carbon ferrochromium, FY 2011; low-carbon ferrochromium, FY 2010; and chromium metal, FY 2012.

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CHROMIUM

Stockpile Status—9-30-06[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006	Average chromium content
Chromite ore:						
Chemical-grade	—	—	—	90.7	—	28.6%
Refractory-grade	—	1.16	—	90.7	—	[e]23.9%
Ferrochromium:						
High-carbon	265	2.30	265	[6]136	61.5	71.4%
Low-carbon	134	0.502	134	([6])	42.7	71.4%
Chromium metal	5.28	0.174	5.28	0.454	0.905	100%

Events, Trends, and Issues: The price of ferrochromium declined from historically high levels reached in 2005. World stainless steel production, the source of ferrochromium demand, was expected to rise by more than 10% compared to that of 2005. China's importance as a consumer of raw materials increased owing to its strong economic growth and the expansion of its stainless steel production capacity. China's growth was generally recognized as the leading cause of increased chromium demand. Chinese stainless steel production exceeded that of the United States in 2004. In 2007, when China's stainless steel production capacity has been projected to exceed its demand, China's current stainless steel suppliers (Asian and European countries) will have to export their production to other countries, a situation that could result in abundant supply. The price of nickel reached a 17-year high. High chromium and nickel prices resulted in higher stainless steel prices, which stimulated the use of less costly stainless steel grades, other metals, or nonmetallic materials. If stainless steel users shift to less costly stainless grades, nickel demand would fall without depressing chromium demand. If stainless consumers shift to other alloys, metals, or materials, demand for both chromium and nickel would decrease.

The percentage of chromite ore mined in South Africa that was sold in South Africa increased to 88% in 2004 from 71% in 1996, reflecting its progress in producing value added products from its raw material resources. Chinese demand for chromite ore resulted in increased exports of South African chromite ore after 3 consecutive years of declining chromite ore exports. The U.S. Environmental Protection Agency regulates chromium releases to the environment.

World Mine Production, Reserves, and Reserve Base:

	Mine production[7]		Reserves[8]	Reserve base[8]
	2005	2006[e]	(shipping grade)[9]	
United States	—	W	110	120
India	3,260	3,300	25,000	57,000
Kazakhstan	3,580	3,600	290,000	470,000
South Africa	7,500	8,000	160,000	270,000
Other countries	4,970	5,000	NA	NA
World total (rounded)	19,300	20,000	NA	NA

World Resources: World resources are greater than 12 billion tons of shipping-grade chromite, sufficient to meet conceivable demand for centuries. About 95% of the world's chromium resources is geographically concentrated in Kazakhstan and southern Africa; U.S. chromium resources are mostly in the Stillwater Complex in Montana.

Substitutes: Chromium has no substitute in stainless steel, the leading end use, or in superalloys, the major strategic end use. Chromium-containing scrap can substitute for ferrochromium in metallurgical uses.

[e]Estimated. NA Not available. — Zero.
[1]Data in thousand metric tons of contained chromium unless otherwise noted.
[2]Calculated consumption of chromium; equal to production (from mines and scrap) + imports – exports + stock adjustments.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]In addition to the tariff items listed, certain imported chromium materials (see United States Code, title 26, sections 4661, 4662, and 4672) are subject to excise tax.
[5]See Appendix B for definitions.
[6]Disposal plan for ferrochromium without distinction between high-carbon and low-carbon ferrochromium; total included in high-carbon.
[7]Mine production units are thousand metric tons, gross weight, of marketable chromite ore.
[8]See Appendix C for definitions. Reserves and reserve base data are not comparable among countries because the criteria used to determine the resources of India (Indian Bureau of Mines), Kazakhstan (open literature reports in trade journals and at conferences), and South Africa (JORC compliant, company annual reports) were different.
[9]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 2006, clay and shale production was reported in 42 States. About 220 companies operated approximately 800 clay pits or quarries. The leading 20 firms supplied about 50% of the tonnage and 80% of the value for all types of clay sold or used in the United States. In 2006, domestic producers estimated that sales or use will be 41.3 million tons valued at $1.62 billion, excluding attapulgite-type fuller's earth. Major uses for specific clays were estimated to be as follows: ball clay—40% floor and wall tile, 31% sanitaryware, and 29% other uses; bentonite—26% absorbents, 23% foundry sand bond, 22% drilling mud, 13% iron ore pelletizing, and 16% other uses; common clay—61% brick, 16% lightweight aggregate, 15% cement, and 8% other uses; fire clay—46% refractories and 54% heavy clay products; fuller's earth—86% absorbent uses and 14% other uses; and kaolin—61% paper and 39% other uses.

Salient Statistics—United States:[1]	**2002**	**2003**	**2004**	**2005**	**2006**[e]
Production, mine:					
Ball clay	1,120	1,310	1,220	1,210	1,200
Bentonite	3,970	3,770	4,550	4,710	4,620
Common clay	23,000	23,100	24,600	24,500	24,400
Fire clay	446	345	307	353	350
Fuller's earth	2,730	3,610	3,260	[2]2,990	[2]2,980
Kaolin	8,010	7,680	7,760	7,800	7,740
Total[3]	39,300	39,800	41,700	[2]41,600	[2]41,300
Imports for consumption:					
Artificially activated clay and earth	27	21	25	16	16
Kaolin	158	224	205	262	290
Other	32	34	21	23	24
Total[3]	217	279	251	301	330
Exports:					
Ball clay	127	139	107	141	137
Bentonite	722	721	915	847	1,230
Fire clay[4]	251	285	332	368	350
Fuller's earth	60	48	49	55	73
Kaolin	3,350	3,520	3,640	3,580	3,480
Clays, not elsewhere classified	449	416	586	634	620
Total[3]	4,960	5,130	5,630	5,620	5,890
Consumption, apparent	34,600	34,900	36,300	36,300	35,700
Price, average, dollars per ton:					
Ball clay	42	43	44	44	45
Bentonite	45	44	45	46	47
Common clay	6	6	7	7	7
Fire clay	24	28	28	30	31
Fuller's earth	90	96	101	104	108
Kaolin	119	122	121	110	114
Stocks, yearend[5]	NA	NA	NA	NA	NA
Employment, number:[e]					
Mine	1,350	1,320	1,250	1,270	1,270
Mill	5,200	5,000	4,980	5,000	5,100
Net import reliance[6] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2002-05): Brazil, 74%; Mexico, 6%; United Kingdom, 6%; Canada, 4%; and other, 10%.

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CLAYS

Tariff: Item	Number	Normal Trade Relations 12-31-06
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); clay 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: Domestic sales or use of clays was estimated to be 41.3 million tons, excluding attapulgite-type fuller's earth, a decrease from 41.6 million tons in 2005. Imports for consumption increased to 330,000 tons. The major sources of imported clay were Brazil (kaolin), Canada (bentonite), Mexico (activated clay), and the United Kingdom (kaolin). Exports increased to 5.89 million tons. Major markets for exported clays, by descending order of tonnage, were Canada, Japan, Mexico, Republic of Korea, France, India, and Germany.

World Mine Production, Reserves, and Reserve Base:[7] Reserves and reserve base are large in major producing countries, but data are not available.

	Mine production					
	Bentonite		Fuller's earth		Kaolin	
	2005	2006[e]	2005	2006[e]	2005	2006[e]
United States (sales)	4,710	4,620	[2]2,990	[2]2,980	7,800	7,740
Brazil (beneficiated)	227	221	—	—	2,200	2,400
Commonwealth of Independent States (crude)	750	800	—	—	6,240	6,240
Czech Republic (crude)	200	200	—	—	4,000	4,000
Germany (sales)	410	400	[8]500	—	3,750	3,770
Greece (crude)	950	950	—	—	60	60
Italy	500	500	30	30	10	10
Korea, Republic of (crude)	—	—	—	—	2,770	3,000
Mexico	426	450	107	110	877	900
Spain	150	150	720	700	350	350
Turkey	925	900	—	—	580	600
United Kingdom (sales)	—	—	140	140	2,400	2,400
Other countries	2,450	2,610	1,120	1,200	13,700	13,300
World total (rounded)	11,700	11,800	5,610	5,160	44,700	44,800

World Resources: Resources of all clays are extremely large.

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

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Excludes Puerto Rico.
[2]Does not include attapulgite-type fuller's earth.
[3]Data may not add to totals shown because of independent rounding.
[4]Also includes some refractory-grade kaolin.
[5]Data on stocks are not available and are assumed to be zero for apparent consumption and net import reliance calculations.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]See Appendix C for definitions.
[8]May represent double counting of bentonite as fuller's earth.

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 2006; 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 cemented carbide scrap, spent catalysts, and superalloy scrap. Of the two producers of extra-fine cobalt powder in the United States, one produced powder from imported primary metal and another produced powder from cemented carbide scrap. Seven companies were known to produce cobalt compounds. Nearly 70 industrial consumers were surveyed on a monthly or annual basis. Data reported by these consumers indicate that nearly one-half of the cobalt consumed in the United States was for use in superalloys, which are used mainly in aircraft gas turbine engines; 9% was for use in cemented carbides for cutting and wear-resistant applications; 18%, for various other metallic applications; and 24%, for a variety of chemical applications. The total estimated value of cobalt consumed in 2006 was $350 million.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Mine	—	—	—	—	—
Secondary	2,750	2,130	2,300	2,030	2,200
Imports for consumption	8,450	8,080	8,720	11,100	11,800
Exports	2,080	2,710	2,510	2,440	2,900
Shipments from Government stockpile excesses	524	2,380	1,630	1,110	200
Consumption:					
Reported (includes secondary)	7,880	7,590	8,450	8,430	8,800
Apparent[1] (includes secondary)	9,830	10,000	9,920	11,900	11,300
Price, average annual spot for cathodes, dollars per pound	6.91	10.60	23.93	15.96	15.90
Stocks, industry, yearend	1,140	1,010	1,240	1,150	1,150
Net import reliance[2] as a percentage of apparent consumption	72	79	77	83	81

Recycling: In 2006, cobalt contained in purchased scrap represented an estimated 25% of cobalt reported consumption.

Import Sources (2002-05): Cobalt contained in metal, oxide, and salts: Norway, 21%; Russia, 17%; Finland, 14%; Canada, 9%; and other, 39%.

Tariff: Item	Number	Normal Trade Relations[3] 12-31-06
Unwrought cobalt, alloys	8105.20.3000	4.4% ad val.
Unwrought cobalt, other	8105.20.6000	Free.
Cobalt mattes and other intermediate products; cobalt powders	8105.20.9000	Free.
Cobalt waste and scrap	8105.30.0000	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 disposal limit for cobalt in the fiscal year 2007 Annual Materials Plan was reduced to 1,590 tons.

Stockpile Status—9-30-06[4]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Cobalt	1,360	106	1,360	2,720	200

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COBALT

Events, Trends, and Issues: The worldwide availability of refined cobalt was slightly lower during the first half of 2006 compared with that of the first half of 2005 primarily because of reduced shipments of cobalt from the National Defense Stockpile. World demand for cobalt reportedly was slightly higher during the first half of 2006 than that of the first half of 2005. The price of cobalt cathode fluctuated between $12.75 and $20.50 per pound during the first 10 months of 2006.

In recent years, exports of cobalt-rich ores from Congo (Kinshasa) to refineries mainly in China have helped to balance world cobalt supply and demand. Future export of these ores could be affected by declining ore grades, higher copper prices (which could influence miners and smelters to shift to copper production), the availability and increasing cost of transportation, efforts by the Government of Congo (Kinshasa) to require that cobalt ores be processed before being exported, and increased involvement of international mining companies in Congo (Kinshasa).

A North Carolina plant that produced extra-fine cobalt powder was to cease operations by the end of the third quarter. The company planned to continue to produce cobalt powders at plants in Belgium, Canada, and China.

Health, safety, and environmental issues are becoming increasingly significant with respect to such metals as cobalt. The European Commission's new chemicals policy, if implemented as proposed, would affect suppliers of cobalt materials to the European market by requiring them to collect and submit risk assessment data on each material produced in or imported into the European Union.

World Mine Production, Reserves, and Reserve Base: Reserves and/or reserve base estimates for Australia, Brazil, and Canada were revised based on new information reported by mining companies or foreign Governments.

	Mine production		Reserves[5]	Reserve base[5]
	2005	2006[e]		
United States	—	—	NA	860,000
Australia	6,000	6,000	1,400,000	1,700,000
Brazil	1,200	1,000	29,000	40,000
Canada	5,500	5,600	120,000	350,000
China	1,300	1,400	72,000	470,000
Congo (Kinshasa)	22,000	22,000	3,400,000	4,700,000
Cuba	3,600	4,000	1,000,000	1,800,000
Morocco	1,600	1,500	20,000	NA
New Caledonia[6]	1,200	1,100	230,000	860,000
Russia	5,000	5,100	250,000	350,000
Zambia	9,300	8,600	270,000	680,000
Other countries	1,200	1,200	130,000	1,100,000
World total (rounded)	57,900	57,500	7,000,000	13,000,000

World Resources: Identified cobalt resources of the United States are estimated to be about 1 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 future cobalt production from these deposits would be as a byproduct of another metal. Identified world cobalt resources are about 15 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: In most applications, 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; cobalt-manganese-nickel in lithium-ion batteries; and cerium, iron, lead, manganese, or vanadium in paints.

[e]Estimated. NA Not available. — Zero.
[1]The sum of U.S. secondary production, as estimated from consumption of purchased scrap, and net import reliance.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]No tariff for Canada or Mexico. Tariffs for other countries for some items may be eliminated under special trade agreements.
[4]See Appendix B for definitions.
[5]See Appendix C for definitions.
[6]Overseas territory of France.

COLUMBIUM (NIOBIUM)

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

Domestic Production and Use: No significant U.S. columbium mine production has been reported since 1959. Domestic columbium resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Five companies produced ferrocolumbium and columbium compounds, metal, and other alloys from imported columbium minerals, oxides, and ferrocolumbium. Consumption was mainly as ferrocolumbium by the steel industry and as columbium alloys and metal by the aerospace industry. Major end-use distribution of reported columbium consumption was as follows: carbon steels, 35%; superalloys, 32%; high-strength low-alloy steels, 12%; alloy steels, 10%; stainless and heat-resisting steels, 10%; and other, 1%. In 2006, the estimated value of reported columbium consumption, in the form of ferrocolumbium and nickel-columbium alloy, was $118 million. Reported columbium consumption for 2002, 2003, and 2004 was revised based on review of existing survey data.

Salient Statistics—United States:[1]	**2002**	**2003**	**2004**	**2005**	**2006**[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
Mineral concentrates[e]	273	181	167	142	112
Columbium metal and alloys[e]	673	743	940	1,380	1,450
Columbium oxide[e]	654	585	633	660	710
Ferrocolumbium[e]	4,030	4,080	5,180	5,430	8,490
Exports, concentrate, metal, alloys[e]	111	143	196	340	560
Government stockpile releases[e, 2]	19	182	112	128	85
Consumption, reported, ferrocolumbium[e, 3]	2,740	3,220	3,760	4,170	4,620
Consumption, apparent	5,520	5,600	6,750	7,410	10,300
Price, ferrocolumbium, dollars per pound[4]	6.60	6.58	6.56	7.32	7.62
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Columbium was recycled when columbium-bearing steels and superalloys were recycled; scrap recovery specifically for columbium content was negligible. The amount of columbium recycled is not available, but it may be as much as 20% of apparent consumption.

Import Sources (2002-05): Brazil, 80%; Canada, 10%; Estonia, 3%; Germany, 2%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Columbium ores and concentrates	2615.90.6030	Free.
Columbium oxide	2825.90.1500	3.7% ad val.
Ferrocolumbium:		
Less than 0.02% of P or S, or less than 0.4% of Si	7202.93.4000	5.0% ad val.
Other	7202.93.8000	5.0% ad val.
Columbium, unwrought:		
Waste and scrap	8112.92.0500	Free.
Alloys, metal, powders	8112.92.4000	4.9% ad val.
Columbium, other	8112.99.0100	4.0% ad val.

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

Government Stockpile: For fiscal year 2006, the Defense National Stockpile Center (DNSC), Defense Logistics Agency, disposed of 76 tons of columbium contained in columbium-tantalum mineral concentrates (no columbium value was obtained, as the columbium was contained within tantalum minerals) and about 9 tons of vacuum-grade columbium metal valued at about $261,000 from the National Defense Stockpile. The DNSC's ferrocolumbium inventory was exhausted in fiscal year 2001, and its columbium carbide inventory was exhausted in fiscal year 2002. The DNSC announced maximum disposal limits for fiscal year 2007 of about 254 tons[6] of columbium contained in columbium concentrates and about 9 tons[6] of columbium metal ingots.

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COLUMBIUM (NIOBIUM)

Stockpile Status—9-30-06[7]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Columbium:					
Concentrates	22	—	22	254	—
Metal	10	—	10	9	9

Events, Trends, and Issues: Columbium ferroalloys domestic demand in steelmaking increased about 19% compared with that of 2005, columbium demand in superalloys (mostly for aircraft engine components) decreased about 2% compared with that of 2005, and overall apparent consumption rose about 38%. Columbium imports increased about 41% compared with those of 2005, driven by a 56% increase in ferrocolumbium imports. Brazil accounted for about 84% of the total quantity of imports and about 84% of the value. Overall exports rose 66% owing to a 45% increase in ferrocolumbium exports to Canada, to about 467 tons in 2006 from about 322 tons in 2005. The published price for standard-grade (steelmaking-grade) ferrocolumbium was quoted at $7.62 per pound of columbium content. Public information on current prices for other columbium products was not available. According to industry sources, prices for columbium oxide, columbium metal, other columbium chemicals, and various columbium alloys are variable and depend on product specifications, volume, and processing considerations. Pricing is normally established by negotiation between buyer and seller.

World Mine Production, Reserves, and Reserve Base:

	Mine production 2005	Mine production 2006[e]	Reserves[8]	Reserve base[8]
United States	—	—	—	Negligible
Australia	200	200	29,000	NA
Brazil	35,000	56,000	4,300,000	5,200,000
Canada	3,310	3,500	110,000	NA
Congo (Kinshasa)	25	25	NA	NA
Ethiopia	7	11	NA	NA
Mozambique	34	35	NA	NA
Nigeria	40	80	NA	NA
Rwanda	63	65	NA	NA
Other countries[9]	NA	NA	NA	NA
World total (rounded)	38,700	59,900	4,400,000	5,200,000

World Resources: World resources are more than adequate to supply projected needs. Most of the world's identified resources of columbium occur mainly as pyrochlore in carbonatite deposits and are outside the United States. The United States has approximately 150,000 tons of columbium resources in identified deposits, all of which were considered uneconomic at 2006 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]Revisions principally based on reevaluation of import and export data.
[2]Net quantity (uncommitted inventory).
[3]Includes nickel columbium.
[4]Average of yearend trade journal reported prices, per pound of contained columbium, standard (steelmaking) grade; columbite prices were not available.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]Actual quantity limited to remaining sales authority; additional legislative authority is required.
[7]See Appendix B for definitions.
[8]See Appendix C for definitions. Reserve and reserve base entries indicated by "NA" are believed to be small compared with the totals shown.
[9]Bolivia, Burundi, China, Russia, Zambia, and Zimbabwe also produce (or are believed to produce) columbium mineral concentrates, but available information is inadequate to 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 2006 rose to more than 1.2 million tons and was valued at about $8.6 billion. The principal mining States, in descending order of production—Arizona, Utah, New Mexico, Nevada, and Montana—accounted for 99% of domestic production; copper was also recovered at mines in two other States. Although copper was recovered at 26 mines operating in the United States, 17 mines accounted for more than 99% of production. Three primary smelters, 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 30 brass mills; 16 rod mills; and 500 foundries, chemical plants, and miscellaneous consumers. Copper and copper alloy products were used in building construction, 49%; electric and electronic products, 20%; transportation equipment, 11%; consumer and general products, 11%; and industrial machinery and equipment, 9%.[1]

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Mine	1,140	1,120	1,160	1,140	1,220
Refinery:					
Primary	1,440	1,250	1,260	1,210	1,290
Secondary	70	53	55	51	50
Copper from all old scrap	208	206	186	182	170
Imports for consumption:					
Ores and concentrates	72	27	23	([2])	([2])
Refined	927	882	807	1,000	1,120
Unmanufactured	1,230	1,140	1,060	1,130	1,300
Exports:					
Ores and concentrates	23	9	24	137	140
Refined	26	93	118	40	90
Unmanufactured	506	703	789	820	920
Consumption:					
Reported refined	2,370	2,290	2,410	2,270	2,260
Apparent unmanufactured[3]	2,610	2,430	2,550	2,400	2,440
Price, average, cents per pound:					
Domestic producer, cathode	75.8	85.2	133.9	173	320
London Metal Exchange, high-grade	70.7	80.7	130.0	168	309
Stocks, yearend, refined, held by U.S. producers, consumers, and metal exchanges	1,030	657	134	66	115
Employment, mine and mill, thousands[e]	7.0	6.8	7.0	7.0	7.2
Net import reliance[4] as a percentage of apparent consumption	37	40	43	42	40

Recycling: Old scrap, converted to refined metal and alloys, provided 170,000 tons of copper, equivalent to 7% of apparent consumption. Purchased new scrap, derived from fabricating operations, yielded 840,000 tons of contained copper; about 88% 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 74%; miscellaneous manufacturers, foundries, and chemical plants, 12%; ingot makers, 10%; and copper smelters and refiners, 4%. Copper in all old and new, refined or remelted scrap contributed about 31% of the U.S. copper supply.

Import Sources (2002-05): Unmanufactured: Chile, 34%; Canada, 33%; Peru, 19%; Mexico, 6%; and other, 8%. Refined copper accounted for 78% of unwrought copper imports.

Tariff: **Item**	**Number**	**Normal Trade Relations[5] 12-31-06**
Copper ores and concentrates	2603.00.0000	1.7¢/kg lead content.
Unrefined copper; anodes	7402.00.0000	Free.
Refined and alloys; unwrought	7403.00.0000	1.0% ad val.
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. Details on inventories of beryllium-copper master alloys (4% beryllium) can be found in the section on beryllium.

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COPPER

Events, Trends, and Issues: Copper prices continued their upward trend during the first 5 months of the year, and in May the COMEX spot price reached a record-high price of $4.08 per pound, nearly twice the previous record-high price of $2.28 set in December 2005. The refined copper production deficit that had persisted over the preceding 3 years resulted in tight supplies, limited stock availability, and concerns over supply adequacy. Higher metal prices also led to increased speculative interest in metal markets. Global mine production in 2006 fell short of expectations owing to production problems in Indonesia, Chile, and the United States, as well as labor disruptions in Chile and Mexico. According to data compiled by the International Copper Study Group,[6] world production and use of refined copper during the first 7 months of 2006 were essentially balanced. China remained the largest user, accounting for about 20% of world consumption. Though volatile, prices remained at unprecedented levels, and the COMEX spot price averaged about $3.54 per pound during the third quarter of the year. Record-high profits led to competition for and consolidation of international copper mining companies.

In the United States, mine production rose to its highest level since 2001, following return to full production of mines affected by a 16-week strike in 2005; startup of new mines in Montana, Nevada, and Utah; and restart of concentrate production at a major mine in Arizona. After final permits were received, construction began on a major new mine-for-leach operation in Arizona. Consumption of refined copper declined slightly owing to the compound effects of a turndown in the housing market, substitution for copper tubing occasioned by the high copper prices, and greater import penetration by foreign copper wire rod. By yearend, at least one copper tube mill had closed. U.S. mine and refinery production were expected to increase in 2007 as the new operations started up or reached capacity.

World Mine Production, Reserves, and Reserve Base: Official reserves reported by Poland include properties being considered for future development.

	Mine production		Reserves[7]	Reserve base[7]
	2005	2006[e]		
United States	1,140	1,220	35,000	70,000
Australia	927	950	24,000	43,000
Canada	567	600	9,000	20,000
Chile	5,320	5,400	150,000	360,000
China	755	760	26,000	63,000
Indonesia	1,070	800	35,000	38,000
Kazakhstan	402	430	14,000	20,000
Mexico	429	380	30,000	40,000
Peru	1,010	1,050	30,000	60,000
Poland	523	525	30,000	48,000
Russia	700	720	20,000	30,000
Zambia	436	540	19,000	35,000
Other countries	1,720	1,920	60,000	110,000
World total (rounded)	15,000	15,300	480,000	940,000

World Resources: A recent assessment of U.S. copper resources indicated 550 million tons of copper in identified (260 million tons) and undiscovered resources (290 million tons), more than double the previous estimate.[8] A preliminary assessment similarly indicates that global land-based resources exceed 3 billion tons, about double the previously published estimate. Deep-sea nodules were estimated to contain 700 million tons of copper.

Substitutes: Aluminum substitutes for copper in power cables, electrical equipment, automobile radiators, and cooling/refrigeration tube; titanium and steel are used in heat exchangers; optical fiber substitutes for copper in some telecommunications applications; and plastics substitute for copper in water pipe, drain pipe, and plumbing fixtures.

[e]Estimated.
[1]Some electrical components are included in each end use. Distribution for 2005 by the Copper Development Association, 2006.
[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 in refined stocks. In 2002, 2003, 2004, 2005, and 2006, general imports of 1,060,000 tons, 687,000 tons, 704,000 tons, and 977,000 tons, and 1,120,000 tons, respectively, were 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. Tariffs for other countries for some items may be eliminated under special trade agreements.
[6]International Copper Study Group, 2006, July 2006 data: Lisbon, Portugal, International Copper Study Group press release, October 17, 1 p.
[7]See Appendix C for definitions.
[8]U.S. Geological Survey National Mineral Resource Assessment Team, 2000, 1998 assessment of undiscovered deposits of gold, silver, copper, lead, and zinc in the United States: U.S. Geological Survey Circular 1178, 21 p.

DIAMOND (INDUSTRIAL)

(Data in million carats unless otherwise noted)

Domestic Production and Use: In 2006, domestic production was estimated to be approximately 258 million carats, and the United States remained the world's leading market for industrial diamond. All domestic output was synthetic grit and powder. Two firms, one in Pennsylvania and the other in Ohio, accounted for all of the production. Nine 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 for mineral, oil, and gas exploration), stone cutting/polishing, and transportation systems (infrastructure and vehicles). Stone cutting and highway building and repair consumed most of the industrial stone. About 99% of the U.S. industrial diamond market now uses synthetic industrial diamond because its quality can be controlled and its properties can be customized to fit specific requirements.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Bort, grit, and dust and powder; natural and synthetic:					
Production:					
Manufactured diamond[e]	219	236	252	256	258
Secondary	5.7	4.7	4.6	4.6	34.5
Imports for consumption	185	250	240	284	389
Exports[1]	82	74	86	93	83
Sales from Government stockpile excesses	—	—	—	—	—
Consumption, apparent	328	417	411	452	599
Price, value of imports, dollars per carat	0.34	0.26	0.25	0.27	0.21
Net import reliance[2] as a percentage of apparent consumption	31	42	38	42	51
Stones, natural:					
Production:					
Mine	—	—	—	—	—
Secondary	([3])	([3])	([3])	0.53	0.53
Imports for consumption[4]	2.0	1.8	1.8	2.1	2.3
Exports[1]	1.1	0.3	0.5	—	—
Sales from Government stockpile excesses	0.4	0.4	0.4	—	—
Consumption, apparent	1.6	2.1	2.1	2.6	2.8
Price, value of imports, dollars per carat	5.43	3.09	7.77	13.91	11.31
Net import reliance[2] as a percentage of apparent consumption	81	91	80	81	82

Recycling: In 2006, the amount of diamond bort, grit, and dust and powder recycled was estimated to be 34.5 million carats. Lower prices of newly produced industrial diamond appear to be reducing the number and scale of diamond stone recycling operations. In 2006, it was estimated that 527,000 carats of diamond stone were recycled.

Import Sources (2002-05): Bort, grit, and dust and powder; natural and synthetic: China, 33%; Ireland, 32%; Ukraine, 10%; Russia, 7%; and other, 18%. Stones, primarily natural: Ireland, 29%; Botswana, 14%; Ghana, 8%; Belgium, 8%; and other, 41%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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).

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DIAMOND (INDUSTRIAL)

Government Stockpile:

Stockpile Status—9-30-06[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Industrial stones	0.520	—	0.520	0.520	—

Events, Trends, and Issues: The United States will continue to be the world's leading market for industrial diamond into the next decade and will remain a significant producer and exporter of industrial diamond as well. Increase in U.S. demand for industrial diamond is likely to continue in the construction sector as the United States builds and repairs the Nation's highway system. Industrial diamond coats the cutting edge of saws used to cut cement in highway construction and repair work. One U.S. company has developed a chemical vapor deposition (CVD) method of growing nearly 100%-pure diamond. One research group has developed a CVD method which is even faster and uses microwave plasma technology. The greatest potential for CVD diamond will be in computing, where it will be able to function as a semiconductor at much higher speeds and temperatures than silicon.

World demand for diamond grit and powder will continue growing. About 87% of the world industrial diamond market now uses synthetic industrial diamond. Demand for synthetic diamond grit and powder is expected to remain 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 continues increasing.

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

	Mine production		Reserves[7]	Reserve base[7]
	2005	2006[e]		
United States	([3])	([3])	NA	NA
Australia	20	25	90	230
Botswana	8	8	130	230
China	1	1	10	20
Congo (Kinshasa)	25	24	150	350
Russia	15	15	40	65
South Africa	9	9	70	150
Other countries	3	3	85	210
World total (rounded)	81	85	580	1,300

World Resources: Natural diamond resources have been discovered in more than 35 countries. Natural diamond accounts for about 10% of all industrial diamond used, while 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 about 90% of industrial applications.

[e]Estimated. NA Not available. — Zero.
[1]Reexports no longer are combined with exports because increasing amounts of U.S. reexports obscure apparent consumption rates.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]Less than ½ unit.
[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 563 million carats in 2005; the leading producers included Ireland, Japan, Russia, South Africa, and the United States.
[7]See Appendix C for definitions.

DIATOMITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2006, domestic production of diatomite was estimated at 653,000 tons with an estimated processed value of $179 million, f.o.b. plant. Production was from 7 diatomite-producing companies with 11 mining areas and 9 processing facilities in California, Oregon, Nevada, and Washington. California and Nevada were the principal producing States and accounted for about 78% of U.S. production in 2006. Estimated end uses of diatomite were filter aids, 75%; fillers, 11%; absorbents, 7%; and other (mostly cement manufacture and thermal insulation), 7%.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production[1]	624	599	620	653	655
Imports for consumption	([2])	([2])	1	1	1
Exports	128	136	143	142	145
Consumption, apparent	496	463	478	512	510
Price, average value, dollars per ton, f.o.b. plant	270	255	258	264	274
Stocks, producer, yearend[e]	36	36	36	40	40
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 (2002-05): France, 60%; Italy, 21%; Spain, 9%; Mexico, 8%; and other, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Siliceous fossil meals, including diatomite	2512.00.0000	Free.

Depletion Allowance: 4% (Domestic and foreign).

Government Stockpile: None.

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DIATOMITE

Events, Trends, and Issues: The amount of domestically produced diatomite sold or used in 2006 increased slightly compared with that of 2005. Filtration (including the purification of beer, liquors, and wine and the cleansing of greases and oils) continued to be the largest end use for diatomite, also known as diatomaceous earth (D.E.). Other applications include the removal of microbial contaminants, such as bacteria, protozoa, and viruses, in public water systems, and the filtration of human blood plasma. Emerging applications for diatomite include pharmaceutical processing and use as an insecticide that is nontoxic to humans.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2005	2006[e]		
United States[1]	653	655	250,000	500,000
Chile	30	27	NA	NA
China	410	420	110,000	410,000
Commonwealth of Independent States	80	80	NA	13,000
Czech Republic	35	35	4,500	4,800
Denmark[5] (processed)	234	234	NA	NA
France	75	75	NA	2,000
Germany	55	55	NA	NA
Japan	130	130	NA	NA
Mexico	60	60	NA	2,000
Peru	35	35	2,000	5,000
Romania	30	2	NA	NA
Spain	35	35	NA	NA
Other countries	156	181	550,000	NA
World total (rounded)	2,020	2,020	920,000	Large

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

Substitutes: Many materials can be substituted for diatomite; however, the unique properties of diatomite assure its continued use in many applications. Expanded perlite and silica sand compete for filtration. Synthetic filters, notably ceramic, polymeric, or carbon membrane filters and filters made with cellulose fibers, are also becoming competitive as filter media. Alternate filler materials include clay, ground limestone, ground mica, ground silica sand, perlite, talc, and vermiculite. For thermal insulation, materials such as various clays, exfoliated vermiculite, expanded perlite, mineral wool, and special brick 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.

FELDSPAR

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: U.S. feldspar production in 2006 had an estimated value of about $43 million. The three leading producers accounted for about two-thirds of the production, with six other companies supplying the remainder. Operations in North Carolina provided more than 45% of the output; facilities in Virginia, California, Oklahoma, Georgia, Idaho, and South Dakota, in descending order of estimated production, produced the remainder. Feldspar processors reported coproduct recovery of mica and silica sand.

Feldspar is ground 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. The estimated 2006 end-use distribution of domestic feldspar was glass, 64%, and pottery and other, 36%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, marketable[e]	790	800	770	750	760
Imports for consumption	5	8	21	26	5
Exports	10	9	10	15	10
Consumption, apparent[e]	785	799	781	761	755
Price, average value, marketable production, dollars per ton[e]	54	54	57	57	57
Stocks, producer, yearend[1]	NA	NA	NA	NA	NA
Employment, mine, preparation plant, and office, number[e]	400	400	400	400	400
Net import reliance[2] as a percentage of apparent consumption	E	E	1	1	E

Recycling: There is no recycling of feldspar by producers; however, glass container producers use cullet (recycled glass), thereby reducing feldspar consumption.

Import Sources (2002-05): Turkey, 61%; Mexico, 38%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Feldspar	2529.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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FELDSPAR

Events, Trends, and Issues: Glass, including beverage containers and insulation for housing and building construction, continued to be the leading end use of feldspar in the United States. U.S. shipments of glass containers in the first 8 months were about the same as in the comparable period of 2005, according to the U.S. Census Bureau.

Feldspar use in tile and vitreous sanitaryware was reflected in housing construction. U.S. housing starts for the first 9 months were about 9% lower than in the same period of 2005, according to the U.S Census Bureau. Much of the U.S. demand for ceramic tile and plumbing fixtures in recent years has been supplied by imports.

Worldwide sales of ceramic tiles were over 6.9 billion square meters (most recent data), according to a nongovernment source. Eight countries, in descending order of output, produced about 65% of global sales—China, Spain, Italy, Brazil, Indonesia, Turkey, India, and Mexico. China reportedly had sales volumes of more than 2.1 billion square meters (most recent data). Much of the Chinese output was being sold to its large domestic market and about 20% was being exported.[3]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2005	2006[e]		
United States[e]	750	760	NA	NA
Colombia	100	100	NA	NA
Czech Republic	400	450	25,000	68,000
Egypt	350	350	NA	NA
France	650	650	NA	NA
Germany	500	500	NA	NA
India	150	180	NA	NA
Iran	250	260	NA	21,000
Italy	2,500	2,500	NA	NA
Japan	1,000	1,000	NA	NA
Korea, Republic of	540	500	NA	NA
Mexico	350	450	NA	NA
Poland	300	300	11,300	87,000
Portugal	120	125	NA	NA
Spain	450	450	NA	NA
Thailand	1,000	1,000	NA	NA
Turkey	2,200	2,500	NA	NA
Venezuela	180	180	NA	NA
Other countries	1,110	1,000	NA	NA
World total (rounded)	12,900	13,300	Large	Large

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 feldspathic sands, granites, and pegmatites 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 clays, electric furnace slag, feldspar-silica mixtures, pyrophyllite, spodumene, or talc. 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]Stentiford, Martin, 2006, A versatile market for minerals: Industrial Minerals, no. 461, February, p. 44-48.
[4]See Appendix C for definitions.

FLUORSPAR

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: There was little or no domestic mining of fluorspar in 2006. 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 85% 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 15% of the reported fluorspar consumption was 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. An estimated 40,000 tons of fluorosilicic acid (equivalent to about 70,000 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.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Finished, all grades	—	—	—	—	—
Fluorspar equivalent from phosphate rock	92	94	90	86	70
Imports for consumption:					
Acid grade	466	533	546	586	550
Metallurgical grade	28	34	53	43	54
Total fluorspar imports	494	567	599	629	604
Fluorspar equivalent from hydrofluoric acid plus cryolite	182	180	197	209	233
Exports[1]	24	31	21	36	15
Shipments from Government stockpile	23	75	62	28	78
Consumption:					
Apparent[2]	477	589	691	616	684
Reported	588	616	618	582	600
Price, average value, dollars per ton, c.i.f. U.S. port					
Acid grade	128	138	167	202	220
Metallurgical grade	89	85	83	93	100
Stocks, yearend, consumer and dealer[3]	245	206	105	131	88
Employment, mine and mill, number	—	—	—	—	—
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	100

Recycling: A few thousand tons per year of synthetic fluorspar is recovered primarily from uranium enrichment, but also from petroleum alkylation and stainless steel pickling. Primary aluminum producers recycled HF and fluorides from smelting operations. HF is recycled in the petroleum alkylation process.

Import Sources (2002-05): China, 63%; Mexico, 16%; South Africa, 16%; Mongolia, 4%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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 2006, the Defense National Stockpile Center (DNSC) sold about 24,700 tons (27,200 short dry tons) of metallurgical-grade fluorspar and 4,420 tons (4,870 short dry tons) of acid-grade fluorspar from the National Defense Stockpile. Under the proposed fiscal year 2007 Annual Materials Plan, the DNSC will be authorized to sell 54,400 tons (60,000 short dry tons) of metallurgical grade and 10,900 tons (12,000 short dry tons) of acid grade, although actual quantities will be limited to remaining inventory.

Stockpile Status—9-30-06[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Acid grade	—	—	—	11	4
Metallurgical grade	8	18	8	54	25

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FLUORSPAR

Events, Trends, and Issues: Hastie Mining Co. and Moodie Mineral Co. began a drilling program for fluorspar in Livingston County, KY, northeast of the former Klondike Fluorspar Mine. The partners are exploring a previously unmined vein deposit, and the preliminary results were described as quite promising. Hastie Mining, a supplier of acid-grade and metallurgical-grade fluorspar to assorted U.S. markets, has sourced the majority of its supply from National Defense Stockpile purchases since the mid-1990s. With the National Defense Stockpile almost exhausted and import sources uncertain, the company has decided to explore restarting fluorspar production from the Illinois-Kentucky Fluorspar Mining District. The company also has been stockpiling fluorspar ore produced as a byproduct at its limestone quarry in Hardin County, IL, and owns the mineral rights to several former fluorspar properties in Illinois. Hastie is installing a heavy media separation plant at the quarry and purchased an idle flotation plant at Salem, KY.[6]

Fluorspar prices remained high (especially for acid grade) and supplies were tight as China continued to restrict exports in order to supply its own growing fluorochemicals markets. Closures of fluorspar mines in France and Italy coupled with production difficulties in South Africa further exacerbated supply problems.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7, 8]	Reserve base[7, 8]
	2005	2006[e]		
United States	—	—	NA	6,000
China	2,700	2,750	21,000	110,000
France	90	40	10,000	14,000
Kenya	97	100	2,000	3,000
Mexico	873	950	32,000	40,000
Mongolia	368	370	12,000	16,000
Morocco	95	115	NA	NA
Namibia	[9]116	[9]127	3,000	5,000
Russia	210	210	Moderate	18,000
South Africa	265	240	41,000	80,000
Spain	140	150	6,000	8,000
Other countries	306	300	110,000	180,000
World total (rounded)	5,260	5,350	240,000	480,000

World Resources: Identified world fluorspar resources were approximately 500 million tons of contained fluorspar. The quantity of fluorine present in phosphate rock deposits is enormous. Current U.S. reserves of phosphate rock are estimated to be 1.0 billion tons, which at 3.5% fluorine would contain 35 million tons of fluorine, equivalent to about 72 million tons of fluorspar. World reserves of phosphate rock are estimated to be 18 billion tons, equivalent to 630 million tons of fluorine and 1.29 billion tons of fluorspar.

Substitutes: Olivine and/or dolomitic limestone have been used as substitutes for fluorspar. Byproduct fluorosilicic acid from phosphoric acid production has been used as a substitute in aluminum fluoride production, and also has the potential to be used as a substitute in HF production.

[e]Estimated. NA Not available. — Zero.
[1]Exports are all general imports reexported or National Defense Stockpile material exported.
[2]Excludes fluorspar equivalent of fluorosilicic acid, hydrofluoric acid, and cryolite.
[3]Industry stocks for three leading consumers, fluorspar distributors, and National Defense Stockpile material committed for sale pending shipment.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix B for definitions.
[6]J. Watson, Jr., Plant Manager, Hastie Mining Co., oral commun., October 2006.
[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 2006. One company in Utah recovered and refined gallium from scrap and impure gallium metal, and one company in Oklahoma refined gallium from impure metal. Imports of gallium, which supplied most of U.S. gallium consumption, were valued at about $5.5 million. Gallium arsenide (GaAs) and gallium nitride (GaN) electronic components represented about 98% of domestic gallium consumption. About 63% of the gallium consumed was used in integrated circuits. Optoelectronic devices, which include light-emitting diodes (LEDs), laser diodes, photodetectors, and solar cells, represented 22% of gallium demand. The remaining 15% was used in research and development, specialty alloys, and other applications. Optoelectronic devices were used in areas such as aerospace, consumer goods, industrial equipment, medical equipment, and telecommunications. Integrated circuits were used in defense applications, high-performance computers, and telecommunications.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, primary	—	—	—	—	—
Imports for consumption	13,100	14,300	19,400	15,800	17,500
Exports	NA	NA	NA	NA	NA
Consumption:					
Reported	18,600	20,100	21,500	18,700	20,000
Apparent	NA	NA	NA	NA	NA
Price, yearend, dollars per kilogram, 99.99999%-pure[1]	530	411	550	538	500
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, refinery, number[e]	20	20	20	20	20
Net import reliance[2] as a percentage of reported consumption[e]	99	99	99	99	99

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

Import Sources (2002-05): China, 37%; Japan, 17%; Ukraine, 12%; Russia, 10%; and other, 24%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Gallium metal	8112.92.1000	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.

Events, Trends, and Issues: Imports of gallium and GaAs wafers continued to supply almost all U.S. demand for gallium and were higher than those in 2005.

Prices for low-grade (99.99%-pure) gallium were relatively stable throughout 2006. After an increase at the end of 2005 to about $400 per kilogram, prices for gallium from China fell to about $350 per kilogram in February. Prices fell slightly in March to a range of $330 to $340 per kilogram, remaining at this level throughout the rest of the year.

Japan’s supply of gallium was expected to increase slightly from 139 metric tons in 2005 to 140 metric tons in 2006. Production was estimated to be 8 metric tons; recycled scrap, 90 metric tons; and imports, 42 metric tons. Included in the imports was 9.6 metric tons of 99%-pure gallium from the Republic of Korea and Taiwan; this is most likely recycled scrap.

In May, the gallium recycler in Utah and a gallium recycler in the United Kingdom jointly purchased the 35,000-kilogram-per-year gallium production facility in Stade, Germany. The facility will operate as a joint venture with each company receiving 50% of the output; the plant reportedly was producing about 12,000 kilograms per year. In August, the United Kingdom firm announced that it completed construction of a gallium refining plant in Shenzhen, Guangdong Province, China. Output from this plant would be targeted toward the Asian markets. No capacity was given for the new plant. Production from the Stade plant had been refined at a plant in France, which was owned by the previous owner of the Stade facility.

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GALLIUM

A zinc producer in China announced plans to recover gallium and germanium from concentrate processed at the plant. Estimated production capacity for each metal would be about 50 metric tons per year. No timetable for project completion was given.

In anticipation of a surge in demand for semi-insulating GaAs substrates, primarily for cellular telephone handsets, companies increased production. Market analysts predicted that after a 16% increase in market value from 2004 to 2005, GaAs demand for advanced cellular telephone handsets would continue to be strong until at least 2008. Separate market analysis of the handset market forecast a growth of 18% in sales from 2005 to 2006, based on 2 quarters of sales figures. In addition to power amplifiers (the principal use of GaAs components in handsets), the market for GaAs-base LEDs in cellular telephone applications also was expected to continue to grow in areas such as keypad backlighting and camera flashes. Even with growth in GaAs components predicted, GaAs manufacturers continued to consolidate, leading to fewer companies marketing GaAs in the future.

The market for blue, green, and white GaN-base LEDs reached $3.2 billion in 2005, with white LEDs accounting for more than 50% of the total GaN LED market. Future high-growth GaN devices include high-power LEDs for lighting as well as deep-ultraviolet emitters and laser diodes. The latter was expected to be used in the next generation of optical storage technology.

Interest in GaAs-base solar cells has picked up in 2006. Several firms received contracts for terrestrial solar cells, which will be used to supply energy to homes in the United States and Australia. One U.S. firm received an extension of an existing contract for satellite solar cells and two contracts from European customers for terrestrial solar cells.

World Production, Reserves, and Reserve Base:[3] 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 2006, world primary production was estimated to be about 69 metric tons, the same as that in 2005. China, Germany, Japan, and Ukraine were the leading producers; countries with smaller output were Hungary, Kazakhstan, Russia, and Slovakia. Refined gallium production was estimated to be about 99 metric tons; this figure includes some scrap refining. France was the leading 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. World primary gallium production capacity in 2006 was estimated to be 160 metric tons; refinery capacity, 152 tons; and recycling capacity, 73 tons.

Gallium occurs in very small concentrations in ores of other metals. Most gallium is produced as a byproduct of treating bauxite, and the remainder is produced from zinc-processing residues. Only part of the gallium present in bauxite and zinc ores is recoverable, and the factors controlling the recovery are proprietary. Therefore, an estimate of current reserves that is comparable to the definition of reserves of other minerals 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 cannot be considered to be available in the short term.

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 is 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 also are working to develop organic-base LEDs that may compete with GaAs in the future. Indium phosphide components can be substituted for GaAs-base 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-base 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. GaAs in heterojunction bipolar transistors is being challenged in some applications by silicon-germanium.

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

[1]Estimated average values of U.S. imports for 99.9999%- and 99.99999%-pure gallium.

[2]Defined as imports – exports + adjustments for Government and industry stock changes.

[3]See Appendix C for definitions.

GARNET (INDUSTRIAL)[1]

(Data in metric tons of garnet unless otherwise noted)

Domestic Production and Use: Garnet for industrial use was mined in 2006 by four firms, one in Idaho, one in Montana, and two in New York. The estimated value of crude garnet production was about $3.38 million, while refined material sold or used had an estimated value of $6.20 million. Major end uses for garnet were abrasive blasting media, 35%; waterjet cutting, 30%; water filtration, 15%; abrasive powders, 10%; and other end uses, 10%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production (crude)	38,500	29,200	28,400	40,100	35,300
Sold by producers	37,500	33,100	30,400	23,100	23,100
Imports for consumption[e]	27,200	34,800	36,500	41,800	52,300
Exports[e]	10,400	11,000	10,900	13,400	13,200
Consumption, apparent[e, 2]	55,300	53,000	54,000	68,600	74,300
Price, range of value, dollars per ton[3]	50-2,000	50-2,000	50-2,000	50-2,000	50-2,000
Stocks, producer	NA	NA	NA	NA	NA
Employment, mine and mill, number[e]	200	180	160	160	160
Net import reliance[4] as a percentage of apparent consumption	30	45	47	41	53

Recycling: Small amounts of garnet reportedly are recycled.

Import Sources (2002-05):[e] Australia, 39%; India, 25%; China, 22%; Canada, 10%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

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GARNET (INDUSTRIAL)

Events, Trends, and Issues: During 2006, U.S. garnet consumption increased 8%, while domestic production of crude garnet concentrates decreased by 12% compared with the production of 2005. In 2006, imports were estimated to have increased 25% compared with 2005, and exports were estimated to have decreased slightly from those of 2005. The 2006 estimated domestic sales of garnet remained at about the same level as sales of 2005. In 2006, the United States was a net importer. Garnet imports have displaced U.S. production in the domestic market, with Australia, Canada, China, and India being major garnet suppliers.

The garnet market is very competitive. To increase profitability and remain competitive with foreign imported material, other salable minerals that occur with garnet may be produced.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2005	2006[e]		
United States	40,100	35,300	5,000,000	25,000,000
Australia	155,000	160,000	1,000,000	7,000,000
China	29,000	30,000	Moderate to Large	Moderate to Large
India	65,000	65,000	90,000	5,400,000
Other countries	34,900	35,200	6,500,000	20,000,000
World total (rounded)	324,000	326,000	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; 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, Czech Republic, Pakistan, South Africa, Spain, Thailand, and Ukraine; small mining operations have been reported in most of these countries.

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. NA Not available.
[1]Excludes gem and synthetic garnet.
[2]Defined as crude production + net imports.
[3]Includes both crude and refined garnet; most crude concentrate is $50 to $120 per ton, and most refined material is $150 to $450 per ton.
[4]Defined as imports – exports.
[5]See Appendix C for definitions.

GEMSTONES[1]

(Data in million dollars unless otherwise noted)

Domestic Production and Use: The combined value of U.S. natural and synthetic gemstone output decreased by 6% in 2006 from that of 2005. The value of natural gemstone production decreased by 1% during 2006. Domestic gemstone production included agate, amber, beryl, coral, garnet, jade, jasper, opal, pearl, quartz, sapphire, shell, topaz, tourmaline, turquoise, and many other gem materials. In decreasing order, Tennessee, Oregon, Arizona, California, Arkansas, Montana, and Nevada produced 81% of U.S. natural gemstones. The value of laboratory-created (synthetic) gemstones production decreased by more than 7% during the year. Laboratory-created gemstones were manufactured by four firms in North Carolina, Florida, Massachusetts, and Arizona, in decreasing order of production. Major gemstone uses were jewelry, carvings, and gem and mineral collections.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:[2]					
Natural[3]	12.6	12.5	14.5	13.4	13.3
Laboratory-created (synthetic)	18.1	33.4	30.7	51.1	47.4
Imports for consumption	12,800	13,600	15,400	17,200	18,300
Exports, including reexports[4]	4,880	5,490	7,230	8,850	9,930
Consumption, apparent[5]	7,950	8,160	8,220	8,410	8,430
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 (2002-05 by value): Israel, 46%; India, 20%; Belgium, 18%; South Africa, 4%; and other, 12%. Diamond imports accounted for 94% of the total value of gem imports.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Diamond, 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 stones, 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 very small portion of the industrial diamond stone inventory is of near-gem quality. Additionally, the beryl and quartz crystal inventories contain some gem-quality material 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.

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GEMSTONES

Events, Trends, and Issues: In 2006, the U.S. market for unset gem-quality diamonds was estimated to have exceeded $16.2 billion, accounting for more than an estimated 35% of world demand. The domestic market for natural, unset nondiamond gemstones was estimated to be about $996 million. The United States is expected to dominate global gemstone consumption throughout this decade.

Canada's Ekati Mine completed its seventh full year in 2005, with diamond production of 3.23 million carats. The Diavik Diamond Mine completed its third full year in 2005, with diamond production of 8.3 million carats. Diamond exploration is continuing in Canada, and many new deposits have been found. Canada produced about 7% of the world's natural gemstone diamond production in 2005. The success of Canadian diamond mines has stimulated interest in exploration for commercially feasible diamond deposits in the United States. Currently, there are no operating commercial diamond mines in the United States.

Mine production in 2006 for Angola, Botswana, Canada, the Central African Republic, Congo (Kinshasa), Côte d'Ivoire, Guinea, Guyana, Sierra Leone, South Africa, and Tanzania increased, while production for Russia decreased, and production in Australia, Brazil, China, and Namibia remained the same compared with that of 2005, based on submissions from country sources.

World Mine Production,[7] Reserves, and Reserve Base:

	Mine production	
	2005	2006[e]
United States	([9])	([9])
Angola	5,580	7,500
Australia	20,000	20,000
Botswana	23,900	24,000
Brazil	300	300
Canada	12,300	12,600
Central African Republic	265	400
China	100	100
Congo (Kinshasa)	6,300	6,600
Côte d'Ivoire	201	300
Ghana	760	850
Guinea	411	600
Guyana	357	1,600
Namibia	1,900	1,900
Russia	23,000	22,400
Sierra Leone	318	650
South Africa	5,780	6,400
Tanzania	175	180
Other countries[10]	175	175
World total (rounded)	102,000	107,000

Reserves and reserve base[8]

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

World Resources: Most diamond-bearing ore bodies have a diamond content that ranges from less than 1 carat per ton to about 6 carats per ton. The major gem diamond reserves are in southern Africa, Australia, Canada, and Russia.

Substitutes: 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 about 78% 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.
[10]In addition to countries listed, Gabon, India, Indonesia, Liberia, and Venezuela are known to produce gem diamonds.

GERMANIUM

(Data in kilograms of germanium content unless otherwise noted)

Domestic Production and Use: The value of domestic refinery production of germanium, based upon an estimated 2006 producer price, was $4.0 million. Germanium production in the United States comes from either the refining of imported germanium compounds or industry-generated scrap. The production series for refined germanium was revised significantly downward to avoid double-counting of material imported in chemical form and directly consumed or consumed in the production of other germanium compounds. Germanium was recovered from zinc concentrates produced at two domestic zinc mines, one in Alaska and the other in Washington, that were exported to Canada for processing. Another mine in Tennessee produced germanium-rich zinc concentrates until its closure in mid-2003.

A germanium refinery in Utica, NY, produced germanium tetrachloride for optical fiber production. Another refinery in Oklahoma produced refined germanium compounds for the production of fiber optics, infrared devices, and substrates for electronic devices. Six companies account for most of the U.S. germanium consumption. The major end uses for germanium, worldwide, were estimated to be polymerization catalysts, 31%; fiber-optic systems, 24%; infrared optics, 23%; electronics/solar electric applications, 12%; and other (phosphors, metallurgy, and chemotherapy), 10%. Domestically, these end uses varied and were estimated to be fiber-optic systems, 40%; infrared optics, 30%; electronics/solar electric applications, 20%; and other (phosphors, metallurgy, and chemotherapy), 10%. Germanium is not used in polymerization catalysts in the United States.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, refinery[e]	4,900	4,700	4,400	4,500	4,600
Total imports[1]	19,900	15,500	24,400	28,500	38,000
Total exports[1]	20,100	6,200	13,800	10,100	7,100
Shipments from Government stockpile excesses	681	1,760	7,190	4,510	4,000
Consumption, estimated	28,000	20,000	25,000	27,000	38,000
Price, producer, yearend, dollars per kilogram:					
Zone refined	620	380	600	660	880
Dioxide, electronic grade	400	245	400	405	760
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant[2] number[e]	85	65	65	65	65
Net import reliance[3] as a percentage of estimated consumption	NA	NA	NA	NA	NA

Recycling: Worldwide, about 35% of the total germanium consumed is produced from recycled materials. During the manufacture of most electronic and optical devices, more than 60% of the germanium metal used is routinely recycled as new scrap. Little domestic germanium returns as old scrap because there is a low unit use of germanium in most electronic and infrared devices. Because new European directives on Waste Electrical and Electronic Equipment (WEEE) mandate the recycling of electronics, the supply of old scrap within the European Union is expected to increase.

Import Sources (2002-05):[4] Belgium, 40%; Canada, 21%; China, 12%; Russia, 6%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Germanium oxides	2825.60.0000	3.7% ad val.
Waste and scrap	8112.30.0000	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: The Defense National Stockpile Center (DNSC) started the Basic Ordering Agreement (BOA) sales program for germanium using weekly postings on Thursdays on the DNSC Web site. BOA sales began on July 20, 2006.

Stockpile Status—9-30-06[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Germanium	23,728	—	23,728	8,000	4,302

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GERMANIUM

Events, Trends, and Issues: For 2006, an estimated 100 metric tons of germanium was produced worldwide, with an estimated U.S. production of 4,600 kilograms. Total domestic imports of germanium in 2006 were 38,000 kilograms, with Belgium and Canada being the leading import sources. The supply deficit evident in 2005 increased in 2006 owing to a further growth in demand and resulting in price increases. This deficit was expected to shrink in 2007 as output is raised and recycling increases. Recycling of new scrap continued to increase and remained a significant supply factor, but the primary supply of germanium was well below the level of consumption. Supply capacity, defined as availability of primary material and recyclable waste material, was expected to meet future demand. Also, there has been some renewed interest in the recovery of germanium from coal fly ash in areas outside of China and Russia. The current high prices of germanium metal should provide incentive for the collection of flue dusts by zinc smelters and ash from the combustion of coal.

Demand for germanium increased in 2006 because of the growth of fiber-optic production, the increased use of germanium-base infrared devices for night-vision applications in luxury cars, and the continued demand for military security and surveillance equipment. Germanium consumption in catalysts for polyethylene terephthalate (PET) production remained stable.

Silicon-germanium (SiGe) is beginning to replace gallium arsenide (GaAs) in wireless communications devices. SiGe chips, with high-speed properties, can be made with low-cost, well-established production techniques of the silicon-chip industry. A tarnish-proof sterling silver alloy, trademarked Argentium, requires 1.2% germanium. The recent rise in energy cost has improved the economics of solar panels, a potential major new use of germanium. Research continued on germanium-on-insulator substrates as a replacement for silicon on miniaturized chips, and on germanium-base solid-state light-emitting diodes (LEDs).

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]
	2005	2006		
United States	4,500	4,600	450,000	500,000
Other countries	85,500	95,400	NA	NA
World total	90,000	100,000	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. Reserves and reserve base figures exclude germanium contained in coal ash.

Substitutes: A new titanium-base catalyst for PET production was used in Asia at the beginning of 2005. Silicon is less expensive and can be substituted for germanium in certain electronic applications. Although some metallic compounds that contain gallium, indium, selenium, and tellurium can be substituted for germanium, it is more reliable than competing materials in many high-frequency and high-power electronics applications and is more economical as a substrate for some LED applications. Zinc selenide and germanium glass substitute for germanium metal in infrared applications systems but often at the expense of performance.

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

[1]In addition to the gross weight of wrought and unwrought germanium and waste and scrap, this series was revised to include estimated germanium dioxide metal content. This series does not include germanium tetrachloride 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]Imports are based on the gross weight of wrought and unwrought germanium and waste and scrap; includes estimated germanium dioxide, metal content; does not include germanium tetrachloride and other germanium compounds for which data are not available.

[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 50 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 99% of the gold produced in the United States. In 2006, the value of mine production was about $5.1 billion. Commercial-grade refined gold came from about 2 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 New York, NY, and Providence, RI; areas with lesser concentrations include California, Florida, and Texas. Estimated uses were jewelry and arts, 84%; electrical and electronics, 6%; dental and other, 10%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Mine	298	277	258	256	260
Refinery:					
Primary	196	194	222	163	180
Secondary (new and old scrap)	78	89	92	76	80
Imports[2]	217	249	283	341	285
Exports[2]	257	352	257	324	340
Consumption, reported	163	183	185	183	185
Stocks, yearend, Treasury[3]	8,140	8,140	8,140	8,140	8,140
Price, dollars per ounce[4]	311	365	411	446	610
Employment, mine and mill, number[5]	7,600	7,300	7,550	7,910	7,900
Net import reliance[6] as a percentage of apparent consumption	E	E	8	4	E

Recycling: 80 tons of new and old scrap, equal to about 43% of reported consumption, was recycled in 2006.

Import Sources (2002-05):[2] Canada, 41%; Peru, 29%; Colombia, 8%; Brazil, 7%; and other, 15%.

Tariff: Most imports of unwrought gold, including bullion and doré, enter the United States 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 2006 was estimated to be 2% more than the level of 2005, which elevated United States into a tie with Australia as the second leading gold-producing nation, after South Africa. An increase in gold production from newly opened mines in Alaska and Nevada was partially offset by the closure of one mine and reduced output from other mines. Domestic mine output continued to be dominated by Nevada, where production accounted for about 82% of the U.S. total. The United States returned to being a net exporter of gold in 2006 after 2 years of being a net importer.

The continued rise in costs at South African gold mines, owing to the strengthening of the rand, caused several mines to curtail expansion operations and reduce gold production. Gold mining in China has steadily increased, and China is now the fourth leading producer of gold worldwide.

Gold Exchange-Traded Funds (ETFs) have gained popularity with investors. According to some industry analysts, traditional gold investments have difficulties in access, insurance, high markups, and storage. The claimed advantage of the ETF is that the investor can purchase gold ETF shares through a stockbroker without being concerned about these problems. Each share represents one-tenth of an ounce of allocated gold.

During the first 9 months of 2006, the Engelhard Corporation's daily price of gold ranged from a low of about $526 per troy ounce in January to a high of about $726 per troy ounce in mid-May.

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GOLD

World Mine Production, Reserves, and Reserve Base:

	Mine production 2005	Mine production 2006[e]	Reserves[7]	Reserve base[7]
United States	256	260	2,700	3,700
Australia	262	260	5,000	6,000
Canada	119	120	1,300	3,500
China	225	240	1,200	4,100
Indonesia	140	145	1,800	2,800
Peru	208	210	3,500	4,100
Russia	169	162	3,000	3,500
South Africa	295	270	6,000	36,000
Other countries	793	840	[8]17,000	[8]26,000
World total (rounded)	2,470	2,500	42,000	90,000

World Resources: An assessment of U.S. gold resources indicated 33,000 tons of gold in identified (15,000 tons) and undiscovered resources (18,000 tons).[9] Nearly one-quarter of the gold in undiscovered resources was estimated to be contained in porphyry copper deposits. The gold resources in the United States, however, are only a small portion of global gold resources.

Substitutes: Base metals clad with gold alloys are widely used in electrical/electronic products and jewelry 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.
[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: 39.6 (2002), 29.9 (2003), 3.0 (2004), 0.0 (2005), and 0.0 (2006 estimate).
[3]Includes gold in Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.
[4]Engelhard 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.
[8]Reserves and reserve base for the "Other countries" category does not include some countries for which reliable data were not available.
[9]U.S. Geological Survey National Mineral Resource Assessment Team, 2000, 1998 assessment of undiscovered deposits of gold, silver, copper, lead, and zinc in the United States: U.S. Geological Survey Circular 1178, 21 p.

GRAPHITE (NATURAL)

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Although natural graphite was not produced in the United States in 2006, approximately 100 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 in 2006 were refractory applications, 27%; brake linings, 15%; and batteries, foundry operations, and lubricants, 8%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, mine	—	—	—	—	—
Imports for consumption	45	52	64	65	55
Exports	22	22	46	22	22
Consumption, apparent[1]	24	30	18	43	33
Price, imports (average dollars per ton at foreign ports):					
Flake	529	619	485	578	528
Lump and chip (Sri Lankan)	1,220	2,270	2,420	2,730	2,459
Amorphous	137	152	177	197	194
Stocks, yearend	NA	NA	NA	NA	NA
Net import reliance[2] 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 led the way in recycling of graphite products. The market for recycled refractory graphite material is growing with material being recycled into products, such as brake linings and thermal insulation.

Recovering high-quality flake graphite from steelmaking kish is technically feasible, but not practiced at the present time. Abundance of graphite in the world market and continuing low prices inhibit increased recycling efforts. Information on the quantity and value of recycled graphite is not available.

Import Sources (2002-05): China, 42%; Mexico, 30%; Canada, 18%; Brazil, 6%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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—9-30-06[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Sri Lanka, amorphous lump	—	51	—	—	—
Malagasy, crystalline flake	56	134	56	—	—

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GRAPHITE (NATURAL)

Events, Trends, and Issues: Graphite was near supply-demand balance in 2006. Leading sources for graphite imports were: flake graphite from China, Canada, Brazil, and Madagascar (in descending order of tonnage), graphite lump and chip from Sri Lanka; and amorphous graphite from Mexico and China (in descending order of tonnage). Advances in thermal technology and acid-leaching techniques that enable the production of higher purity graphite powders are likely to lead to development of new applications for graphite in high-technology fields. Such innovative refining techniques have enabled the use of improved graphite in carbon-graphite composites, electronics, foils, friction materials, and special lubricant applications. Flexible graphite product lines, such as graphoil (a thin graphite cloth), probably will be the fastest growing market. Large-scale fuel-cell applications are being developed that could consume as much graphite as all other uses combined.

World Mine Production, Reserves, and Reserve Base: Reserves and reserve base estimates for the Czech Republic were revised downward from those previously published based on information reported by the Government of the Czech Republic.

	Mine production		Reserves[4]	Reserve base[4]
	2005	2006[e]		
United States	—	—	—	1,000
Brazil	77	76	360	1,000
Canada	30	30	([5])	([5])
China	720	720	64,000	220,000
Czech Republic	10	5	1,300	14,000
Germany	3	3	([5])	([5])
India	130	120	800	3,800
Korea, North	32	32	([5])	([5])
Madagascar	15	15	940	960
Mexico	11	13	3,100	3,100
Norway	2	2	([5])	([5])
Sri Lanka	3	3	([5])	([5])
Turkey	6	30	([5])	([5])
Ukraine	8	8	([5])	([5])
Zimbabwe	6	6	([5])	([5])
Other countries	2	2	5,100	44,000
World total (rounded)	1,060	1,070	76,000	290,000

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.
[2]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.
[3]See Appendix B for definitions.
[4]See Appendix C for definitions.
[5]Included with "Other countries."

GYPSUM

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2006, domestic production of crude gypsum was estimated to be 21.2 million tons with a value of about $159 million. The leading crude gypsum-producing States were, in descending order, Oklahoma, Iowa, Nevada, New York, California, Arkansas, Texas, Indiana, and Michigan, which together accounted for 84% of total output. Overall, 18 companies produced gypsum in the United States at 45 mines in 14 States, and 9 companies calcined gypsum at 58 plants in 29 States. Almost 91% of domestic consumption, which totaled approximately 41.6 million tons, was accounted for by manufacturers of wallboard and plaster products. Approximately 3.0 million tons for cement production, 1.1 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 tonnage. At the beginning of 2006, the capacity of operating wallboard plants in the United States was about 37.6 billion square feet[1] per year.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Crude	15,700	16,700	17,200	21,100	21,200
Synthetic[2]	9,900	8,300	8,400	8,690	9,000
Calcined[3]	18,600	20,400	23,200	21,100	22,000
Wallboard products (million square feet[1])	29,900	33,300	34,300	36,200	37,200
Imports, crude, including anhydrite	7,970	8,300	10,100	11,200	11,500
Exports, crude, not ground or calcined	295	341	149	148	150
Consumption, apparent[4]	32,700	33,000	35,700	40,800	41,600
Price:					
Average crude, f.o.b. mine, dollars per ton	7.31	6.90	2.21	7.48	7.50
Average calcined, f.o.b. plant, dollars per ton	18.42	20.01	21.10	20.25	20.50
Stocks, producer, crude, yearend	1,500	1,500	1,500	1,500	1,500
Employment, mine and calcining plant, number[e]	5,900	5,900	5,900	5,900	5,900
Net import reliance[5] as a percentage of apparent consumption	27	26	25	27	27

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

Import Sources (2002-05): Canada, 68%; Mexico, 23%; Spain, 8%; Dominican Republic, 1%; and other, <1%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Gypsum; anhydrite	2520.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The U.S. gypsum industry stabilized in 2006 after the rise in demand in 2005, owing to the strong housing market and the hurricanes and flooding in the Southeast. The construction of new wallboard plants and the expansion of existing plants that began in 2005 continued into 2006. These plants are expected to come online in 2007 and 2008 and will result in an increase in annual domestic wallboard production capacity to about 42 billion square feet. Much of the production at new and expanded facilities will consume synthetic gypsum produced by scrubbing emissions from coal-fired electric powerplants.

Demand caused by hurricanes and floods offset the small downturn in the new home market. The net result was a small overall increase in gypsum production for the year. Increasing demand for gypsum depends principally on the strength of the construction industry—particularly in the United States, where about 95% of the gypsum consumed is used for wallboard products, building plasters, and the manufacture of portland cement. Road building and repair will continue to spur gypsum consumption in the cement industry. The construction of large wallboard plants designed to use synthetic gypsum will increase the substitution of synthetic for natural gypsum as the new plants become operational. In 2005 and 2006, shortages in wallboard supplies were met by increased imports.

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GYPSUM

World Mine Production, Reserves, and Reserve Base:

	Mine production 2005	Mine production 2006[e]	Reserves[6]	Reserve base[6]
United States	21,100	21,200	700,000	Large
Australia	4,000	4,000		
Algeria	1,460	1,460		
Austria	1,000	1,000		
Brazil	1,480	1,500	1,300,000	Large
Canada	9,400	9,450	450,000	Large
China	7,300	7,400		
Egypt	2,000	2,000		
France	3,500	3,500		
Germany	1,580	1,580		
India	2,400	2,500		
Iran	13,000	13,000		
Italy	1,210	1,220	Reserves and reserve base are large in major producing countries, but data are not available.	
Japan	5,890	5,900		
Mexico	7,200	7,400		
Poland	1,300	1,300		
Russia	2,200	2,400		
Spain	11,500	11,500		
Thailand	6,920	7,100		
United Kingdom	1,500	1,500		
Uruguay	1,130	1,130		
Other countries	10,900	11,000		
World total (rounded)	118,000	119,000	Large	Large

World Resources: Domestic resources are adequate but unevenly distributed. Large imports from Canada augment domestic supplies for wallboard manufacturing in the United States in regions where there are no significant gypsum deposits. Imports from Mexico augment domestic supplies for wallboard manufacturing along portions of the U.S. western seaboard. Large gypsum deposits occur in the Great Lakes region, the midcontinent region, and several Western States. Foreign resources are large and widely distributed; more than 90 countries produce gypsum. Iran is second to the United States in production and supplies much of the gypsum needed for construction and reconstruction in the Middle East. Spain is the largest European producer and supplies both crude gypsum and gypsum products to much of Western Europe. Increased wallboard use in Asia and new gypsum product plants in Thailand and India led to increased production in those countries. As more cultures recognize the economics and efficiency of building with wallboard, worldwide production of gypsum should increase proportionally.

Substitutes: In such applications as stucco and plaster, cement and lime may be substituted; brick, glass, metallic or plastic panels, and wood may be substituted for wallboard. Gypsum has no practical substitute in the manufacturing of portland cement. Synthetic gypsum generated by various industrial processes, including flue gas desulfurization of smokestack emissions, is very important as a substitute for mined gypsum in wallboard manufacturing, cement production, and agricultural applications (in descending tonnage order). In 2005, synthetic gypsum accounted for 24% 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]Data refer to the amount sold or used, not produced.

[3]From domestic crude.

[4]Defined as crude + total synthetic reported used + imports – exports + adjustments for industry stock changes.

[5]Defined as imports – exports + adjustments for industry stock changes.

[6]See Appendix C for definitions.

HELIUM

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

Domestic Production and Use: The estimated value of Grade-A helium (99.995% or better) extracted domestically during 2006 by private industry was about $400 million. Nine industry plants (five in Kansas and four in Texas) extracted helium from natural gas and produced only a crude helium product that varied from 50% to 80% helium. Nine industry plants (four in Kansas, and one each in Colorado, Oklahoma, Texas, Utah, and Wyoming) extracted helium from natural gas and produced an intermediate process stream of crude helium (about 70% helium and 30% nitrogen) and continued processing the stream to produce a Grade-A helium product. Six industry plants (four in Kansas, one in Oklahoma, and one in Texas) accepted a crude helium product from other producers and the Bureau of Land Management (BLM) pipeline and purified it to a Grade-A helium product. Estimated 2006 domestic consumption of 79 million cubic meters (2.8 billion cubic feet) was used for cryogenic applications, 28%; for pressurizing and purging, 26%; for welding cover gas, 20%; for controlled atmospheres, 13%; leak detection, 4%; breathing mixtures, 2%; and other, 7%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Helium extracted from natural gas[2]	87	87	86	76	76
Withdrawn from storage[3]	40	35	44	57	58
Grade-A helium sales	127	122	130	133	134
Imports for consumption	—	—	—	—	—
Exports[4]	39.5	41.3	44.9	51.4	55.0
Consumption, apparent[4]	87.6	80.7	85.1	81.6	79.0
Employment, plant, number[e]	325	325	325	325	325
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Price: The Government price for crude helium was $2.037 per cubic meter ($56.50 per thousand cubic feet) in fiscal year (FY) 2006. The price for the Government-owned helium is mandated by the Helium Privatization Act of 1996 (Public Law 104-273). The estimated price range for private industry's Grade-A gaseous helium was about $2.88 to $3.06 per cubic meter ($80 to $85 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 boiloff recovery systems are used. In Western Europe and Japan, helium recycling is practiced when economically feasible.

Import Sources (2002-05): None.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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 Public Law 104-273, the BLM manages the Federal Helium Program, which includes all operations of the Cliffside helium storage reservoir and the Government's crude helium pipeline system. The BLM no longer supplies Federal agencies with Grade-A helium. Private firms that sell Grade-A helium to Federal agencies are required to purchase a like amount of crude helium (in-kind) from the BLM.

In FY 2006, privately owned companies purchased nearly 5.1 million cubic meters (182 million cubic feet) of in-kind crude helium. In addition to this, the privately owned companies also purchased 60.1 million cubic meters (2,165 million cubic feet) of open market sales helium. During FY 2006, BLM's Amarillo Field Office, Helium Operations (AMFO) accepted about 20.2 million cubic meters (730 million cubic feet) of private helium for storage and redelivered nearly 76.3 million cubic meters (2,751 million cubic feet). As of September 30, 2006, about 17.3 million cubic meters (625 million cubic feet) of privately owned helium remained in storage at Cliffside Field.

Stockpile Status—9-30-06[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Helium	662.3	16.6	662.3	63.8	65.2

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HELIUM

Events, Trends, and Issues: During FY 2006, most helium suppliers again announced price increases of 12% to 15%. These adjustments were necessary because of sustained record-high energy and transportation costs, continuing increases in crude helium costs, rising utility and labor costs, and regulatory compliance costs. In addition to price increases, most of the companies will continue cost-recovery efforts through various charges and surcharges. It is anticipated that helium costs will continue to rise along with increasing production costs as U.S. helium reserves continue to be depleted. Even with escalating helium prices, helium demand is expected to continue to grow slowly at about 2.5% to 3.5% per year. Based on helium export totals through July 2006, calendar year 2006 exports are expected to increase by 10% to 12% from 2005 exports. During FY 2006, the AMFO conducted four open market helium sales. Sales totaled 60.1 million cubic meters (2,165 million cubic feet). During FY 2006, the BOC/Linde merger was approved, first by the European Union in June, followed by the Federal Trade Commission in September. Two overseas helium projects at Skikda, Algeria, and Qatar came onstream in late 2005. The Skikda expansion project, designed to increase production capacity by 16.6 million cubic meters (600 million cubic feet) per year came onstream at about one-half of capacity, but operational problems have so far resulted in less output. The Qatar project, a new helium extraction facility with a production capacity of 8.3 million cubic meters (300 million cubic feet), also had operational problems, and output has so far been less than expected.

World Production, Reserves, and Reserve Base:

	Production		Reserves[8]	Reserve base[8]
	2005	2006[e]		
United States (extracted from natural gas)	76	76	3,500	[9]8,300
United States (from Cliffside Field)	57	58	([10])	([10])
Algeria	17	22	1,850	8,400
Canada	NA	NA	NA	2,000
China	NA	NA	NA	1,100
Poland	3	3	29	280
Qatar	0.2	7	NA	10,000
Russia	7	7	1,680	6,700
Other countries	NA	NA	NA	2,800
World total (rounded)	160	170	NA	40,000

World Resources: The identified helium resources of the United States were estimated to be about 8.5 billion cubic meters (305 billion cubic feet) as of January 1, 2003. This includes 0.87 billion cubic meters (31.4 billion cubic feet) of helium stored in the Cliffside Field Government Reserve (these resources are included in the reserves and reserve base figures above), 3.7 billion cubic meters (133 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 (112 billion cubic feet) in helium-lean natural gas (less than 0.30% helium). The Hugoton (Kansas, Texas, and Oklahoma), Panhandle West, Panoma, Riley Ridge, and Cliffside Fields are currently depleting gasfields and contain an estimated 3.6 billion cubic meters (130 billion cubic feet) of helium. Future helium supplies will probably come from known helium-rich natural gas with little fuel value and from helium-lean gas resources.

Helium resources of the world exclusive of the United States were estimated to be about 31 billion cubic meters (1.1 trillion cubic feet). The locations and volumes of the major deposits, in billion cubic meters, are Qatar, 10; Algeria, 8; Russia, 7; Canada, 2; and China, 1. As of December 31, 2006, AMFO had analyzed more than 21,700 gas samples from 26 countries and the United States in a program to identify world helium resources.

Substitutes: There is no substitute 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.
[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]All domestic measured and indicated helium resources in the United States.
[10]Included in United States (extracted from natural gas) reserves and reserve base.

INDIUM

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Indium was not recovered from ores in the United States in 2006. Indium-containing zinc concentrates produced in Alaska were exported to Canada for processing. Two companies, one in New York and the other in Rhode Island, produced indium metal and indium products by upgrading lower grade imported indium metal. High-purity indium shapes, alloys, and compounds were also produced from imported indium by several additional firms.

Thin-film coatings, which are used in applications such as for electroluminescent lamps and for liquid crystal displays (LCDs) in flat-panel video screens, continued to be the leading end use. Indium semiconductor compounds were used in infrared detectors, high-speed transistors, and high-efficiency photovoltaic devices. Major uses were coatings, 70%; electrical components and semiconductors, 12%; solders and alloys, 12%; and research and other, 6%. The estimated value of primary indium metal consumed in 2006, based upon the annual average price, was about $107 million.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, refinery	—	—	—	—	—
Imports for consumption[1]	112	123	143	142	150
Exports	[e]10	NA	NA	NA	NA
Consumption, estimated	85	90	100	115	125
Price, annual average, dollars per kilogram (99.97% indium)	97	170	643	827	855
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number	NA	NA	NA	NA	NA
Net import reliance[2] as a percentage of estimated consumption	100	100	100	100	100

Recycling: In the United States, only small amounts of indium scrap were recycled in 2006. The reason for the low recycling rate is the lack of domestic infrastructure for collecting indium-containing products. Recycling of indium could expand significantly in the United States if the current price of indium is sustained or continues to increase. Indium tin oxide (ITO) use is highly inefficient, as only about 15% of ITO is consumed to make LCDs; the rest is scrap. The major problem in recycling the ITO scrap is the high cost associated with the process. The process takes about 12 weeks from collection of scrap to fabrication of secondary indium products. A recycler may have millions of dollars worth of indium in the recycling loop at any one time. A large increase in ITO scrap could be difficult for the recycling industry to handle because of large capital costs, environmental restrictions, and storage space.

Import Sources (2002-05):[1] China, 44%; Canada, 22%; Japan, 15%; Russia, 5%; and other, 14%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Unwrought indium, including powder	8112.92.3000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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INDIUM

Events, Trends, and Issues: Estimated domestic indium consumption rose about 10% from that in 2005. Continued strong sales of flat-panel displays and other LCD products increased global consumption of ITO, mostly in Japan, the Republic of Korea, the Philippines, and Taiwan. The indium price started 2006 at $930 per kilogram, and rose to $980 per kilogram by late February. In July, the price decreased to $790 per kilogram where it remained through October. Although the short-range outlook for indium demand remained positive, market supply remained questionable because of its heavy dependence on the strength of zinc production. With the increasing capacity of ITO refineries and LCD plants in Japan, the Republic of Korea, the Philippines, and Taiwan, and with China opening new ITO refineries and LCD plants, the availability of primary indium feedstock will be further reduced. Recycling efforts, especially in Japan, have done much to offset shortages in supply and to alleviate price pressures.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[3]	Reserve base[3]
	2005	2006[e]		
United States	—	—	300	600
Belgium	30	30	([4])	([4])
Canada	50	50	1,000	2,000
China	300	300	280	1,300
France	10	10	([4])	([4])
Germany	10	—	NA	NA
Japan	70	55	100	150
Peru	6	6	100	150
Russia	15	15	200	300
Other countries	10	10	800	1,500
World total (rounded)	500	480	2,800	6,000

World Resources: Indium is a rare element and ranks 61st in abundance in the Earth's crust at an estimated 240 parts per billion by weight. This makes it about three times more abundant than silver or mercury.

Indium occurs predominantly in the zinc-sulfide ore mineral, sphalerite. The average indium content of zinc deposits from which it is recovered ranges from less than 1 part per million to 100 parts per million. Although the geochemical properties of indium are such that it occurs with other base metals—copper, lead, and tin—and to a lesser extent with bismuth, cadmium, and silver, most deposits of these metals are subeconomic for indium.

Vein stockwork deposits of tin and tungsten host the highest known concentrations of indium. However, the indium from this type of deposit is usually difficult to process economically. Other major geologic hosts for indium mineralization include volcanic-hosted massive sulfide deposits, sediment-hosted exhalative massive sulfide deposits, polymetallic vein-type deposits, epithermal deposits, active magmatic systems, porphyry copper deposits, and skarn deposits.

Substitutes: Indium has substitutes in many, perhaps most, of its uses; however, the substitutes usually lead to losses in production efficiency or product characteristics. Silicon has largely replaced germanium and indium in transistors. Although more expensive, gallium can be used in some applications as a substitute for indium in several alloys. In glass-coating applications, silver-zinc oxides or tin oxides can be used. Although technically inferior, zinc-tin oxides can be used in LCDs. Another possible substitute for indium glass coating is transparent carbon nanotubes, which are untested in mass production of LCDs. Indium phosphide can be substituted by gallium arsenide in solar cells and in many semiconductor applications. Hafnium can replace indium alloys in nuclear reactor control rods.

[e]Estimated. NA Not available. — Zero.
[1]Imports for consumption are based on U.S. Department of Commerce, U.S. Treasury, and U.S. International Trade Commission data for unwrought indium and waste and scrap (includes indium powder after 2002).
[2]Defined as imports – exports + adjustments for Government and industry stock changes; exports were assumed to be no greater than the difference between imports and consumption.
[3]Estimate based on the indium content of zinc ores. See Appendix C for definitions.
[4]Reserves and reserve base for this country and other European nations are included with "Other countries."

IODINE

(Data in thousand kilograms elemental iodine unless otherwise noted)

Domestic Production and Use: Iodine produced in 2006 by three companies operating in Oklahoma accounted for 100% of the elemental iodine value, estimated to be about $23 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. A third company continued production at Vici, OK, for domestic use and export. Of the consumers that participate in the annual survey, 18 plants reported consumption of iodine in 2005. Major consumers were located in the Eastern United States. Strong demand increased the price of iodine as demand increased for liquid crystal display screens for computers and televisions. The average value of iodine imports through September was $16.79 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 25,300 metric tons.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production	1,420	1,090	1,130	1,570	1,220
Imports for consumption, crude content	6,200	5,800	5,700	6,250	5,200
Exports	1,580	1,600	1,270	2,660	2,700
Shipments from Government stockpile excesses	25	361	245	444	465
Apparent	6,520	5,240	5,560	5,600	4,190
Reported	4,540	3,930	4,070	4,680	NA
Price, average c.i.f. value, dollars per kilogram, crude	12.70	11.81	13.38	16.11	18.69
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number	30	30	30	30	30
Net import reliance[1] as a percentage of apparent consumption	77	81	81	72	71

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

Import Sources (2002-05): Chile, 71%; Japan, 27%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Iodine, crude	2801.20.0000	Free.
Iodide, calcium or 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 that the fiscal year 2007 Annual Materials Plan would include sales of 454 tons (1,000,000 pounds) of crude iodine.

Stockpile Status—9-30-06[2]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2005
Stockpile-grade	456	—	456	454	457

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IODINE

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

The Defense National Stockpile Center issued amendments 1, 2, 3, and 5 during 2006 to DLA-IODINE-005 Basic Ordering Agreement (BOA) for crude iodine. The BOA solicits offers for the sale of 454 metric tons (1,000,000 pounds) of crude iodine in fiscal year 2007, with quarterly sales of approximately 113,400 kilograms (250,000 pounds). Awards were subject to the certification of the Drug Enforcement Administration. The iodine offered for sale, located at New Haven, IN, and Somerville, NJ, was of Chilean, Japanese, and unknown origin.

Atacama Minerals Corp. announced the closure of a private stock placement with gross proceeds of Canadian $27.5 million, the net proceeds of which were to be used towards the ongoing development of the Aguas Blancas Mine in Chile. An agitated leach pilot plant was commissioned in April 2006, and a full-sized plant was expected in 2007 with a minimum capacity of 1,500 tons per year.[3]

Sociedad Química y Minera de Chile S.A. (SQM) acquired the iodine business of DSM Minera for $72 million in cash. The assets include mining and water rights, annual capacity for 2,200 metric tons per year of iodine, and an iodine derivatives plant. DSM Minera was part of the unit of the DSM Fine Chemicals business group and consisted of two companies: DSM Minera S.C.M. in Chile and DSM Minera B.V. in the Netherlands. DSM Minera S.C.M. was a producer of iodine and iodine derivatives. The company owned and operated iodine mining facilities and derivative production facilities in Iquique, Chile. DSM Minera B.V. marketed iodine and iodine derivatives through DSM's worldwide sales network and managed other iodine derivative production with toll manufacturers in Europe. DSM Minera employed 120 people, excluding 300 contractor employees.[4]

The production of iodocompounds from photosynthesis in the Atlantic and Indian Oceans reportedly would increase during global warming, resulting in a net cooling of the earth system and a negative climate feedback mechanism, mitigating global warming.[5]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	2005	2006[e]		
United States	1,570	1,220	250,000	550,000
Azerbaijan	300	300	170,000	340,000
Chile	15,000	15,300	9,000,000	18,000,000
China	550	550	4,000	120,000
Indonesia	75	75	100,000	200,000
Japan	7,300	7,300	4,900,000	7,000,000
Russia	300	300	120,000	240,000
Turkmenistan	270	270	170,000	350,000
Uzbekistan	2	2	NA	NA
World total (rounded)	25,400	25,300	15,000,000	27,000,000

World Resources: In addition to the reserve base shown above, 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, nitrate, and oil, the seaweed industry represented a major source of iodine prior to 1959 and remains a large resource.

Substitutes: Bromine and chlorine could be substituted for most of the biocide, colorant, and ink uses of iodine, although they are usually considered less desirable than iodine. Antibiotics and boron are also substitutes for iodine as biocides. Salt crystals and finely divided carbon may be used for cloud seeding. There are no substitutes for iodine in some animal feed, catalytic, nutritional, pharmaceutical, 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]Posey, E.F., 2006, Atacama announces cdn$27.5 million private placement: Vancouver, British Columbia, Canada, Atacama Minerals Corp. press release, June 30, 1 p.
[4]Pave, C., 2006, SQM informs the acquisition of the iodine business of DSM company: Santiago, Chile, Sociedad Química y Minera de Chile S.A. press release, January 19, 1 p.
[5]Smythe-Wright, D., Boswell, S.M., Breithaupt, P., Davidson, R.D., Dimmer, D.H., and Eiras Diaz, L.B., 2006, Methyl iodide production in the ocean—Implications for climate change. Global Biogeochemical Cycles, v. 20, no. 10, p. 1029.
[6]See Appendix C for definitions.

IRON ORE[1]

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

Domestic Production and Use: In 2006, 98% of the usable ore produced, having an estimated value of $2.8 billion, was shipped from mines in Michigan and Minnesota. Ten iron ore mines, 8 concentration plants, and 8 pelletizing plants were in operation during the year. The mines included 10 open pits and no underground operations. Almost all ore was concentrated before shipment. Eight mines operated by three companies accounted for greater than 99% of production. The United States produced about 3% of the world's iron ore output and also consumed approximately 3%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, usable	51.6	48.6	54.7	54.3	54.0
Shipments	51.5	46.1	54.9	53.2	53.0
Imports for consumption	12.5	12.6	11.8	13.0	11.0
Exports	6.8	6.8	8.4	11.8	8.0
Consumption:					
Reported (ore and total agglomerate)[3]	59.7	61.6	64.5	60.1	62.0
Apparent[4]	57.0	55.2	[e]57.9	[e]56.6	57.0
Price,[5] U.S. dollars per metric ton	26.04	32.30	37.92	44.50	52.00
Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore[4]	18.3	17.5	[e]17.6	[e]16.5	16.5
Employment, mine, concentrating and pelletizing plant, quarterly average, number	4,740	4,670	4,410	4,450	4,450
Net import reliance[6] as a percentage of apparent consumption (iron in ore)	10	12	6	4	5

Recycling: None (see Iron and Steel Scrap section).

Import Sources (2002-05): Canada, 52%; Brazil, 40%; Chile, 2%; Australia, 1%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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: Following a year of greater than 70% worldwide price increases in 2005, increases of almost 20% for lump and fines in 2006 have resulted from the continued supply deficit. Major iron-ore-mining companies continue to reinvest profits in mine development. It is anticipated that increased capacity within the next few years will bring supply back in line with demand. Iron ore demand growth continues to be dominated by China. In 2005, it is estimated that China increased production of mostly lower grade ores by greater than 30%. Estimates of Chinese imports of higher grade ores, mostly from Australia and Brazil, show an increase of over 20% compared with those of 2005, a slowdown from the one-third growth between 2004 and 2005.

The key indicators of iron ore consumption—international iron ore trade and production of iron ore and pig iron—clearly show that iron ore consumption in China is the major factor upon which the expansion of the international iron ore industry depends. China's increasing activity in overseas joint ventures, increased imports of iron ore, and an expansion in domestic production of low-grade ores indicate that growth of iron ore consumption will continue.

In December 2003, a major Chinese steel company purchased a minority interest in an insolvent iron ore producer in northeastern Minnesota. Pellet production has continued since then, with China accepting iron ore transfer for most of their portion of the United States production from the majority partner's Canadian affiliate. In 2005, production increases on the order of 20% in comparison with those of 2004 were attained by the joint-venture operation. Opening or reopening of lower grade iron ore deposits is being investigated by several small miners in Alaska, Arizona, Missouri, Nevada, New Mexico, and Utah, owing to increased prices and interest by Chinese importers.

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IRON ORE

Research and development testing on a value-added iron product—the Mesabi Nugget project—determined that iron ore produced in Minnesota could be converted to direct-reduced iron nuggets of 96% to 98% iron content using noncoking coals, while emitting lower levels of pollutants. Permitting and financing activities for a plant to be built in Minnesota progressed during 2005 and into 2006.

Increased profits and an improved steel market have allowed U.S. iron ore producers to initiate mine and plant improvements. Plant recoveries have been enhanced, and alternative fuel systems with reduced air emissions are being developed at pelletizing plants.

Offsetting these operational improvements are increased operating costs, which have been affecting U.S. iron ore operations. Fuel costs, although leveling off, are substantially higher than originally projected in the fuel-intensive iron ore industry. Lower mining equipment availability may be incurred owing to a worldwide shortage of heavy-equipment tires, exacerbated by recent expansions in the mining industry, increased prices for petroleum-based products, and increased demand for large tires by producers in Australia, Brazil, and China, as the worldwide mining boom continues.

World Mine Production, Reserves, and Reserve Base:[7] The mine production estimates for China are based on crude ore, rather than usable ore, which is reported for the other countries.

	Mine production		Crude ore		Iron content	
	2005	2006[e]	Reserves	Reserve base	Reserves	Reserve base
United States	54	54	6,900	15,000	2,100	4,600
Australia	262	270	15,000	40,000	8,900	25,000
Brazil	280	300	23,000	61,000	16,000	41,000
Canada	30	33	1,700	3,900	1,100	2,500
China	420	520	21,000	46,000	7,000	15,000
India	140	150	6,600	9,800	4,200	6,200
Iran	19	20	1,800	2,500	1,000	1,500
Kazakhstan	16	15	8,300	19,000	3,300	7,400
Mauritania	11	11	700	1,500	400	1,000
Mexico	12	13	700	1,500	400	900
Russia	97	105	25,000	56,000	14,000	31,000
South Africa	40	40	1,000	2,300	650	1,500
Sweden	23	24	3,500	7,800	2,200	5,000
Ukraine	69	73	30,000	68,000	9,000	20,000
Venezuela	20	20	4,000	6,000	2,400	3,600
Other countries	42	43	11,000	30,000	6,200	17,000
World total (rounded)	1,540	1,690	160,000	370,000	79,000	180,000

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, used directly or converted to briquettes, concentrates, pellets, or sinter, is the only source of primary iron. In some operations, ferrous scrap constitutes as much as 7% of the blast furnace feedstock. Scrap is extensively used in steelmaking and in iron and steel foundries, but availability of scrap has become an issue during the past several years. Price increases for iron ore of 19% for lump and fine ores during the past year were offset somewhat by a 3% decrease in the price of pellets. The margin between iron ore and scrap export prices has continued to decrease; therefore, the relative attractiveness of scrap has increased.

[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 in sinter and pellets for blast furnaces.
[4]Information regarding consumer stocks at receiving docks and plants was not available after 2003 (these stock changes were estimated).
[5]Estimated from reported value of ore at mines.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]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 in 2006 that were valued at about $150 billion. The industry consisted of about 59 companies that produced raw steel at about 106 plants, with combined production capability of about 112 million tons. Indiana accounted for about 24% of total raw steel production, followed by Ohio, 16%, and Pennsylvania and Michigan with 6% each. Pig iron was produced by 8 companies operating integrated steel mills in 18 locations. The distribution of steel shipments was estimated to be: warehouses and steel service centers, 22%; construction, 16%; transportation (predominantly for automotive production), 13%; cans and containers, 2%; and other, 47%. About 1,100 ferrous foundries continued to import pig iron into the United States, mainly from Brazil, Russia, and Ukraine.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Pig iron production[2]	40.2	40.6	42.3	37.2	39.3
Steel production:	91.6	93.7	99.7	94.9	96.4
Basic oxygen furnaces, percent	49.6	49.0	47.9	45.0	43.4
Electric arc furnaces, percent	50.4	51.0	52.1	55.0	56.6
Continuously cast steel, percent	97.2	97.3	97.1	96.8	96.8
Shipments:					
Steel mill products	90.7	96.1	101	95.2	102
Steel castings[3]	0.7	0.7	0.7	0.7	0.7
Iron castings[3]	7.8	7.5	7.5	7.4	7.4
Imports of steel mill products	29.6	21.0	32.5	29.1	46.6
Exports of steel mill products	5.4	2.5	7.2	8.5	9.8
Apparent steel consumption[4]	107	107	117	109	130
Producer price index for steel mill products (1982=100)[5]	104.8	109.5	147.2	161.3	180.5
Steel mill product stocks at service centers yearend[6]	13.7	12.3	14.4	11.7	12.0
Total employment, average, number:[7]					
Blast furnaces and steel mills	124,000	127,000	123,000	122,000	122,000
Iron and steel foundries[e]	116,000	116,000	116,000	115,000	115,000
Net import reliance[8] as a percentage of apparent consumption	15	10	14	15	21

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

Import Sources (2002-05): Canada, 18%; European Union[9], 18%; Mexico, 13%; Brazil, 8%; and other, 43%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Pig iron	7201.10.0000	Free.
Carbon steel:		
Semifinished	7207.12.0050	Free.
Structural shapes	7216.33.0090	Free.
Bars, hot-rolled	7213.20.0000	Free.
Sheets, hot-rolled	7208.39.0030	Free.
Hot-rolled, pickled	7208.27.0060	Free.
Cold-rolled	7209.18.2550	Free.
Galvanized	7210.49.0090	Free.
Stainless steel:		
Semifinished	7218.91.0015	Free.
	7218.99.0015	Free.
Bars, cold-finished	7222.20.0075	Free.
Pipe and tube	7304.41.3045	Free.
Cold-rolled sheets	7219.33.0035	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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IRON AND STEEL

Events, Trends, and Issues: Gross domestic product (GDP) growth may be considered a predictor of the health of the steelmaking and steel manufacturing industries worldwide and domestically. In 2005, the World Bank forecast that the world's GDP growth would increase to 3.5% in 2007 from 3.2% in 2006, and the U.S. GDP growth would increase to 3.6% in 2007 from 3.5% in 2006. The U.S. Congressional Budget Office forecast U.S. GDP growth declining to 3.1% on average from 2008 through 2011, and to 3.4% in 2007 from 3.6% in 2006.

The Organisation for Economic Co-operation and Development forecast that global raw steelmaking capacity will increase to more than 1.31 billion tons in 2006 from 1.27 billion tons in 2005. Global steel production may reach 1.18 billion tons in 2007. The International Iron and Steel Institute estimated that global consumption of finished steel products will increase by 7.3% in 2006, but by only 5.8% in 2007, compared with that of the previous year. Demand in the United States is expected to increase in 2006 and 2007 by 5.0% and 6.7%, respectively; in the European Union, by 3.9% and 1.5%, respectively; in Russia and Ukraine, by 3.2% and 1.6%, respectively; and in China and India, by 14% and 10%, respectively.

Economic activity in China, which is the world's leading steel producer, continued to be an important influence on the world economy and steel markets. China's steel production was 350 million tons in 2005, up from 280 million tons in 2004, and may reach an estimated 420 million tons in 2006. China's steel-product consumption is expected to grow by 14% in 2006, compared with that of 2005, accounting for 35% of world demand. Hot-rolled steel capacity in China was forecast to increase by 214% to 160 million tons per year in 2010 from 51 million tons per year in 2004. Cold-rolled steel capacity is expected to increase by 27% by 2008 compared with that of 2006.

World Production:

	Pig iron		Raw steel	
	2005	2006[e]	2005	2006[e]
United States	37	39	95	96
Brazil	33	35	33	32
China	330	380	349	420
France*	13	14	20	20
Germany	29	29	45	45
Italy*	10	12	29	29
Japan	83	83	113	114
Korea, Republic of	27	28	48	48
Russia	48	52	66	70
Ukraine	31	32	39	40
United Kingdom*	10	10	13	14
Other countries	*174	*144	*280	*272
World total (rounded)	825	858	1,130	1,200

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 that have 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. *Corrections posted on July 9, 2007, to replace European Union by adding France, Italy, and the United Kingdom and making resulting revisions to data for "Other countries."

[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 in molten form to steelmaking furnaces located at the same site.

[3]U.S. Census Bureau.

[4]Defined as steel shipments + imports - exports + industry stock changes + imports excluding semifinished steel products.

[5]U.S. Department of Labor, Bureau of Labor Statistics.

[6]Metals Service Center Institute.

[7]U.S. Department of Labor, Bureau of Labor Statistics. Blast furnaces and steel mills: NAICS 33111; Iron and steel foundries: NAICS 33151.

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

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 to be $18.7 billion in 2006, up about 42% from that of 2005. U.S. apparent steel consumption, an indicator of economic growth, rose to about 130 million tons in 2006. Manufacturers of pig iron, raw steel, and steel castings accounted for 86% of scrap consumption by the domestic steel industry, using scrap together with pig iron and direct-reduced iron to produce steel products for the appliance, construction, container, machinery, oil and gas, transportation, and various other consumer industries. The ferrous castings industry consumed most of the remaining 14% 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 collectively totaled less than 1 million tons.

During 2006, raw steel production was an estimated 96 million tons, about 2% more than that of 2005; annual steel mill capability utilization was about the same as that of 2005. Net shipments of steel mill products were estimated to have been about 102 million tons compared with 95 million tons for 2005. The domestic ferrous castings industry shipped an estimated 11.7 million tons of all types of iron castings in 2006 and an estimated 1.1 million tons of steel castings.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Home scrap	17	17	14	14	19
Purchased scrap[2]	56	56	59	58	57
Imports for consumption[3]	3	4	5	4	5
Exports[3]	9	11	12	13	11
Consumption, reported	69	65	67	65	55
Price, average, dollars per metric ton delivered, No. 1 Heavy Melting composite price, Iron Age Average, Pittsburgh, Philadelphia, Chicago	88.21	108.00	205.00	188.51	275
Stocks, consumer, yearend	4.9	4.4	5.4	5.1	5.1
Employment, dealers, brokers, processors, number[4]	30,000	30,000	30,000	30,000	30,000
Net import reliance[5] as a percentage of reported consumption	E	E	E	E	E

Recycling: 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 more than 200 years. The automotive recycling industry alone recycled an estimated 17 million vehicles in 2006 through more than 200 car shredders to supply an estimated 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 55 million tons of steel was recycled in steel mills and foundries in 2006. 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 50% post-consumer (old, obsolete) scrap, 29% prompt scrap (produced in steel-product manufacturing plants), and 21% home scrap (recirculating scrap from current operations).

Import Sources (2002-05): Canada, 62%; United Kingdom, 18%; Sweden, 7%; Netherlands, 3%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

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IRON AND STEEL SCRAP

Events, Trends, and Issues: Hot-rolled steel prices decreased steadily until mid-2005, and then increased steadily until August 2006, at which time they began to decline for the rest of the year. The producer price index for steel mill products continued to rise from 101.3 in 2001 to 187.00 in September 2005. Steel mill capability utilization peaked at 97.3% in September 2004, before decreasing to 77.1% in July 2005, and then rebounding to 90.5% in June 2006.

Scrap prices fluctuated widely between about $125 per ton and about $240 per ton through 2005 and the first half of 2006. 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 $225 per metric ton during the first 5 months of 2006. As reported by Iron Age Scrap Price Bulletin, the average price for nickel-bearing stainless steel scrap delivered to purchasers in Pittsburgh was about $2,009 per ton in 2006, which was higher than the 2005 average price of $1,555 per ton. Exports of ferrous scrap decreased to an estimated 11.3 million tons from 13 million tons during 2005, mainly to China, the Republic of Korea, Canada, and Mexico, in descending order. Export scrap value increased from $3.4 billion in 2005 to an estimated $3.6 billion in 2006.

In the United States, the primary source of old steel scrap is the automobile. The recycling rate for automobiles in 2005, the latest year for which statistics were available, was 102%. A recycling rate greater than 100% is a result of the steel industry recycling more steel from automobiles than was used in the domestic production of new vehicles. The recycling rates for appliances and steel cans in 2006 were 90% and 63%, respectively. Recycling rates for construction materials in 2006 were about 98% for plates and beams and 63% 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.

On August 29, 2005, Hurricane Katrina caused the closure of the Port of New Orleans and briefly adversely affected steel production and transportation of finished steel products on the Mississippi River. The devastation produced a glut of scrap from demolished buildings and from crippled scrap yards emptying inventories for repair work. Seizing the opportunity, 12 North American steel companies committed $1.1 million in a Gulf Coast Steel Initiative to help rebuild the U.S. Gulf Coast region, especially by converting from traditional construction materials to steel framing and roofing. The storm destroyed an estimated 205,000 wood-frame homes. The Initiative would also provide business owners and consumers with information on where they can take their steel products for recycling.

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

World Resources: Not applicable.

Substitutes: About 1.6 million tons of direct-reduced iron was used in the United States in 2006 as a substitute for iron and steel scrap, down from 1.8 million tons in 2005.

[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 for 2001, and 2002 Census of Wholesale Trade for 2002 through 2005.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.

IRON AND STEEL SLAG

(Data in million metric tons unless otherwise noted)

Domestic Production and Use: Ferrous slags are marketable coproducts of iron- and steelmaking. In 2006, about 21.5 million tons of domestic iron and steel slag, valued at about $375 million[1] (f.o.b.), was consumed. Iron or blast furnace slag accounted for about 60% of the tonnage sold and was worth about $340 million; about 90% of this value was granulated slag. Steel slag, produced from basic oxygen and electric arc furnaces, accounted for the remainder.[2] Slag was processed by about 30 companies servicing active iron and/or steel facilities or reprocessing old slag piles: iron slag at about 40 sites in 14 States and steel slag at about 100 sites in 30 States. Included in these data are about a dozen facilities that grind and sell ground granulated blast furnace slag (GGBFS) based on imported unground feed.

The prices listed in the table below are the weighted average for a variety of ferrous slag types. Actual prices per ton range from about $0.25 for steel slags in areas where natural aggregates are abundant to nearly $90 for some GGBFS. The major uses of air-cooled iron slag and for steel slag are as aggregates for asphaltic paving, fill, and road bases, and as a feed for cement kilns. Air-cooled slag also is used as an aggregate for concrete. In contrast, GGBFS is mainly used as a partial substitute for portland cement in concrete mixes and in blended cements. Owing to their low unit values, most slag types are shipped by truck over short distances only (rail and waterborne transportation can be longer). Because of its much higher unit value, GGBFS can be shipped economically over longer distances.

Salient Statistics—United States:[3]	2002	2003	2004	2005	2006[e]
Production, marketed[1, 4]	19.1	19.7	21.2	21.6	21.5
Imports for consumption	1.1	1.1	1.0	1.6	1.5
Exports	0.1	0.1	0.1	([5])	([5])
Consumption, apparent[6]	19.1	19.7	21.1	21.6	21.5
Price average value, dollars per ton, f.o.b. plant	15.50	15.00	15.50	17.20	17.50
Stocks, yearend	NA	NA	NA	NA	NA
Employment, number[e]	2,700	2,700	2,700	2,600	2,500
Net import reliance[7] as a percentage of apparent consumption	5	5	4	7	7

Recycling: Apart from the large outside markets for slag in the construction sector, some iron and steel slags are returned 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 (2002-05): Canada, 43%; Italy, 23%, France, 21%; Japan, 7%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Granulated slag	2618.00.0000	Free.
Basic slag	3103.20.0000	Free.
Slag, dross, scale, from manufacture of iron and steel	2619.00.3000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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IRON AND STEEL SLAG

Events, Trends, and Issues: Domestic supplies of air-cooled blast furnace slag are in decline owing to depletion of old slag piles and the closure of many blast furnaces over the years for economic and/or environmental reasons. No new blast furnaces are under construction or are planned. Steel slag from integrated works also is in decline, but slag from electric arc furnaces (largely fed with steel scrap) remains abundant. Both of these slag types compete with natural aggregates. Demand is growing for GGBFS in concrete; this demand and the much higher unit sales price for GGBFS have led to two new granulators being added in recent years to existing blast furnaces, and the construction of a number of grinding facilities at independent sites or at cement plants to process imported granulated slag. Against this expansion of GGBFS-production capacity was the likely permanent idling, in mid-2005, of one blast furnace that had long been equipped with a granulator. Also, production at an import-based grinding plant in Louisiana ceased from the end of August 2005 for about 6 months owing to damage sustained during Hurricane Katrina. Pelletized slag, used mainly as a lightweight aggregate, remains in limited supply. Overall, most of the demand for slag is in large-scale (mostly public-sector) construction projects and fluctuates with levels of construction spending.

World Mine Production, Reserves, and Reserve Base:[8] Slag production data for the world are unavailable, but it is estimated that annual world iron slag output is on the order of 200 to 240 million tons, and steel slag about 115 to 180 million tons, based on typical ratios of slag to crude iron and steel output.

World Resources: Not applicable.

Substitutes: Slag competes with crushed stone and sand and gravel as aggregates in the construction sector. Fly ash, certain rock types, and silica fume, are common alternatives to GGBFS as cementitious additives in blended cements and concrete. Slags (especially steel slag) can be used as a partial substitute for limestone and some other natural (rock) materials as raw material for cement kilns.

[e]Estimated. NA Not available.
[1]The data (obtained from an annual survey of slag processors) pertain to the quantities of processed slag sold rather than that processed or produced during the year. The data exclude any entrained metal that may be recovered during slag processing and returned to iron and, especially, steel furnaces, or any slag itself returned to the furnaces. Data for such recovered metal and returned slag were unavailable.
[2]There were very minor sales of open hearth furnace steel slag from stockpiles but no domestic production of this slag type in 2002-06.
[3]Owing to inclusion of more complete information (especially for granulated slag), data in 2002-06 are not strictly comparable to those of recent years prior to 2002.
[4]The data include sales of imported granulated blast furnace slag, either after domestic grinding or still unground, and exclude sales of pelletized slag (proprietary but very small). Overall, actual production of blast furnace slag may be estimated as equivalent to 25% to 30% of crude (pig) iron production and steel furnace slag as about 10% to 15% of crude steel output.
[5]Less than ½ unit.
[6]Defined as total sales of slag (includes that from imported feed) – exports. Calculation is based on unrounded original data.
[7]Defined as total sales of imported slag – exports of slag. Data are not available to allow adjustments for changes in stocks.
[8]See Appendix C. for definitions. Slag is not a mined material, and the concept of reserves thus does not apply to this commodity.

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. Another 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, an estimated 60% to 65% was used in ironmaking and steelmaking and the remainder in the manufacture of chemicals, glass, nonferrous metals, and other materials.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Mine[e]	90	90	90	90	90
Synthetic mullite[e]	40	40	40	40	40
Imports for consumption (andalusite)	5	4	4	6	5
Exports[e]	35	35	35	35	35
Shipments from Government stockpile excesses	—	—	0.1	—	—
Consumption, apparent[e]	100	99	99	101	100
Price, average, dollars per metric ton:					
U.S. kyanite, raw[1]	165	NA	NA	NA	NA
U.S. kyanite, calcined[1]	279	279	272	272	313
Andalusite, Transvaal, South Africa	191	220	238	238	248
Stocks, producer	NA	NA	NA	NA	NA
Employment, kyanite mine, office, and plant, number[e]	140	125	120	130	135
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2002-05): South Africa, 100%.

Tariff:

Item	Number	Normal Trade Relations 12-31-06
Andalusite, kyanite, and sillimanite	2508.50.0000	Free.
Mullite	2508.60.0000	Free.

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

Government Stockpile: None

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KYANITE AND RELATED MINERALS

Events, Trends, and Issues: The steel industry worldwide continued to be the leading consumer of refractories. According to the International Iron and Steel Institute, world crude steel production for the first 8 months of 2006 was about 9% higher than in the comparable period of 2005. The three leading producing countries were China with about 34%; Japan, 9%; and the United States, 8%.

China is also the leading producer of refractories. Output is about 23 million tons, which is approaching a level four times greater than the highest U.S. production (in 1979).[3]

The use of monolithic (unshaped) refractories, such as castables, gunning mixes, and plastics, continues to increase compared with bricks and shapes. In Japan and the United States, monolithics make up about 65% and 53% of total production, respectively. In China, monolithic production is probably less than 30% but is continuously increasing.[4]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2005	2006[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	22	23	
South Africa	235	235	
Other countries	8	8	
World total (rounded)	420	420	

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 Mountains area and in Idaho. Other resources are in aluminous gneiss in southern California. These resources are not economical to mine at present. 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. — Zero.
[1]Prices from trade journals.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]Semler, C.E., 2006, Refractories review, destination, St. Louis: Ceramic Industry, v. 156, no. 8, p. 11.
[4]Semler, C.E., 2006, Refractories review, industry snapshot: Ceramic Industry, v. 156, no. 1, p. 10.
[5]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 2006, based on the average U.S. producer price, was $702 million. Six lead mines in Missouri, plus lead-producing mines in Alaska, Idaho, Montana, and Washington, yielded most of the total. Primary lead was processed at one smelter-refinery in Missouri. Of the 22 plants that produced secondary lead, 14 had annual capacities of 15,000 tons or more and accounted for more than 99% of secondary production. Lead was consumed at about 110 manufacturing plants. The lead-acid battery industry continued to be the principal user of lead, accounting for 88% of the reported U.S. lead consumption for 2006. Lead-acid batteries were primarily used as starting-lighting-ignition (SLI) batteries for automobiles and trucks. Lead-acid batteries were also used as industrial-type batteries for uninterruptible power-supply equipment for computer and telecommunications networks and hospitals; for load-leveling equipment for commercial electrical power system; and as traction batteries used in airline ground equipment, industrial forklifts, mining vehicles, golf carts, etc. About 9% of lead was used in ammunition; casting material; sheets (including radiation shielding), pipes, traps and extruded products; cable covering, caulking lead, and building construction; solder; and oxides for glass, ceramics, pigments, and chemicals. The balance was used in ballast and counter weights, brass and bronze, foil, terne metal, type metal, wire, and other undistributed consumption.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Mine, lead in concentrates	451	460	445	426	430
Primary refinery	262	245	148	143	135
Secondary refinery, old scrap	1,070	1,120	1,100	1,130	1,130
Imports for consumption, lead in concentrates	([1])	—	—	—	([1])
Exports, lead in concentrates	241	253	292	390	275
Imports for consumption, refined metal, wrought and unwrought	218	183	202	310	360
Exports, refined metal, wrought and unwrought	43	123	83	65	86
Shipments from Government stockpile excesses, metal	6	60	42	29	13
Consumption:					
Reported	1,440	1,390	1,480	1,460	1,550
Apparent[2]	1,450	1,470	1,440	1,430	1,590
Price, average, cents per pound:					
North American Producer	43.6	43.8	55.1	61.0	76.5
London Metal Exchange (LME)	20.5	23.3	40.2	44.2	57.1
Stocks, metal, producers, consumers, yearend	111	85	59	65	50
Employment:					
Mine and mill (peak), number[3]	930	830	880	870	850
Primary smelter, refineries	320	320	240	240	240
Secondary smelters, refineries	1,600	1,600	1,600	1,600	1,600
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	2

Recycling: About 1.15 million tons of secondary lead was produced, an amount equivalent to 74% of reported domestic lead consumption. Nearly all of it was recovered from old (post-consumer) scrap.

Import Sources (2002-05): Metal, wrought and unwrought: Canada, 77%; Australia, 6%; China, 6%; Mexico, 5%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations[5] 12-31-06
Unwrought (refined)	7801.10.0000	2.5% ad val.

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

Government Stockpile:

Stockpile Status—9-30-06[6]
(Metric tons)

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Lead	491	—	491	54,000	25,300

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LEAD

Events, Trends, and Issues: During 2006, the price of refined lead continued to increase in the U.S. and world markets. The average North American Producer and LME prices through October were 76.06 cents per pound and 55.19 cents per pound, respectively. These averages increased 25% from the average prices for 2005.

Estimated world use of lead again increased by 3% to 4% in 2006. Much of the growth was attributed to increased production of SLI and industrial batteries in China. Growth also was attributed to increased manufacture of SLI batteries for automobiles and industrial batteries for the telecommunications and information technology industries. Global mine production increased by approximately 1% in 2006. Increases in lead production are anticipated in the near future in Canada, China, India, and several European countries. Consequently, the supply of refined lead is expected to slightly exceed demand, at least in the western world, for the next couple of years.

U.S. lead mine production in 2006 decreased slightly from that of 2005 to about 430,000 tons, and production of secondary refined lead, mostly derived from spent lead-acid batteries, was unchanged. Exports (lead in concentrates) decreased 29%, and imports of refined metal increased 16%, resulting in an increase in U.S. apparent consumption of lead of about 10%.

Shipments of replacement lead-acid auto batteries in North America have been greater in 2006 than 2005. According to the Battery Council International, 12 months of shipments through June 2006 were 96 million units, a slight increase over those of the previous 12-month period. North American shipments in the smaller original equipment auto battery market were 21.6 million units, or 3.3% less than those of the previous 12-month period.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2005	2006[e]		
United States	426	430	8,100	20,000
Australia	776	780	15,000	28,000
Canada	73	79	2,000	9,000
China	1,000	1,050	11,000	36,000
India	58	60	NA	NA
Ireland	64	65	NA	NA
Kazakhstan	44	55	5,000	7,000
Mexico	130	140	1,500	2,000
Morocco	31	42	500	1,000
Peru	319	320	3,500	4,000
Poland	48	60	NA	5,400
South Africa	42	50	400	700
Sweden	61	61	500	1,000
Other countries	198	170	19,000	30,000
World total (rounded)	3,270	3,360	67,000	140,000

World Resources: In recent years, significant lead resources have been demonstrated in association with zinc and/or silver or copper deposits in Australia, Canada, China, Ireland, Mexico, Peru, Portugal, and the United States (Alaska). 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, iron, plastics, and tin 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. In the electronics industry, there has been a move towards lead-free solders with varying compositions of tin, bismuth, silver, and copper.

[e]Estimated. E Net exporter. NA Not available; included in "Other countries." — Zero.
[1]Less than ½ unit.
[2]Apparent consumption series revised to reflect a total raw material balance. Apparent consumption defined as mine production + secondary refined + imports (concentrates and refined) – exports (concentrates and refined) + adjustments for Government and industry stock changes.
[3]Includes only mines for which lead was the principal product. In 2006, approximately 540 people were employed at zinc mines where lead was a significant byproduct or coproduct.
[4]Defined as imports – exports + adjustments for Government and industry stock changes. Includes trade in both concentrates and refined lead.
[5]No tariff for Mexico and Canada for item shown.
[6]See Appendix B for definitions.
[7]See Appendix C for definitions.

LIME[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2006, 21.2 million metric tons (23.5 million short tons) of quicklime and hydrate was produced (excluding commercial hydrators) in 35 States and Puerto Rico. Production was valued at more than $1.7 billion. Six companies accounted for about 75% of the total output. Principal producing States, each with production of more than 1 million tons, were Alabama, Kentucky, Missouri, Nevada, Ohio, Pennsylvania, and Texas. These seven States produced about 13.6 million tons (15.0 million short tons), or 64% of the total output. Major markets for lime were steelmaking, flue gas desulfurization, mining, construction, pulp and paper, precipitated calcium carbonate, and water treatment.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production[2]	17,900	19,200	20,000	20,000	21,200
Imports for consumption	157	202	232	310	286
Exports	106	98	100	133	116
Consumption, apparent	17,900	19,300	20,200	20,200	21,500
Quicklime average value, dollars per ton at plant	59.20	61.40	64.80	72.10	80.50
Hydrate average value, dollars per ton at plant	88.50	84.80	89.80	91.10	93.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and plant, number	5,400	5,350	5,350	5,300	5,300
Net import reliance[3] as a percentage of apparent consumption	([4])	([4])	1	1	1

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 (2002-05): Canada, 73%; Mexico, 26%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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: In 2006, production of lime increased by more than 6% compared with 2005. Strong demand by the steel and construction markets help push up production to a record level, breaking the previous high set in 1998. U.S. production of raw steel was up an estimated 4.5% for the year, which helped the sales of high-calcium and dolomitic quicklime. Steel and other iron-related uses have consumed about 30% of all lime in the United States in recent years. More than 60% of lime consumed in construction markets is used in soil stabilization, primarily in road and highway construction projects.

The recent trend of large price increases (by historic industry standards) continued in 2006 as the average value per ton of quicklime increased by about $8 per metric ton. Hydrate prices increased by a more modest $2 per metric ton. Quicklime values have increased by more than $21 per metric ton since 2002, an increase of 36%.

In September, the U.S. Environmental Protection Agency announced final revisions to its national air quality standards for fine particulate matter and some coarse particles. When breathed, these particles can accumulate in the respiratory system and are associated with numerous health effects. For fine particles [≤2.5 micrometers (µm) in diameter], the 24-hour standard was strengthened to 35 micrograms per cubic meter (µg/m^3) from 65 µg/m^3 and the annual standard was retained at 15 µg/m^3. For inhalable coarse particles (>2.5 and <10 µm), the existing 24-hour standard of 150 µg/m^3 was retained. Under the final rule, only two additional lime plants (located in particulate matter nonattainment areas) will be affected and may require additional air monitoring and possibly installation of additional control technologies.[5]

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LIME

World Lime Production and Limestone Reserves and Reserve Base:

	Production 2005	Production 2006[e]	Reserves and reserve base[6]
United States	20,000	21,200	Adequate for all countries listed.
Austria	2,000	2,000	
Belgium	2,000	2,000	
Brazil	6,500	6,900	
Bulgaria	2,500	2,500	
Canada	2,250	2,410	
China	24,000	25,000	
France	3,000	3,000	
Germany	6,700	6,800	
Iran	2,500	2,500	
Italy[7]	3,000	3,000	
Japan (quicklime only)	8,600	8,900	
Mexico	5,700	5,800	
Poland	2,000	1,800	
Romania	2,000	2,000	
Russia	8,200	8,500	
South Africa (sales)	1,400	1,600	
Turkey (sales)	3,400	3,400	
United Kingdom	2,000	2,000	
Other countries	19,000	19,000	
World total (rounded)	127,000	130,000	

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, which 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 in pH control, and magnesium oxide is a substitute for dolomitic lime as a flux in steelmaking.

[e]Estimated. NA Not available.
[1]Data are for quicklime, hydrated lime, and refractory dead-burned dolomite. Includes Puerto Rico.
[2]Sold or used by producers.
[3]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.
[4]Less than ½ unit.
[5]National Lime Association, 2006, Final PM standard issued—More lenient than proposed rule: Limelites, July-September, p. 8.
[6]See Appendix C for definitions.
[7]Includes hydraulic lime.

LITHIUM

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

Domestic Production and Use: Chile was the leading lithium chemical producer in the world; Argentina, China, Russia, and the United States also were major producers. 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.

Although lithium markets vary by location, one major international lithium company identified its end-use markets as ceramics and glass, 21%; batteries, 19%; lubricating greases, 16%; pharmaceuticals and polymers, 9%; air conditioning, 8%; primary aluminum production, 6%; and other uses, 21%. Lithium use in batteries expanded significantly in recent years because rechargeable lithium batteries were being used increasingly in portable electronic devices and electrical tools.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production	W	W	W	W	W
Imports for consumption	1,920	2,200	2,910	3,580	3,450
Exports	1,620	1,520	1,690	1,720	1,500
Consumption:					
Apparent	W	W	W	W	W
Estimated	1,100	1,400	1,900	2,500	2,600
Employment, mine and mill, number[e]	100	100	100	100	100
Net import reliance[1] as a percentage of apparent consumption	≤50%	≤50%	>50%	>50%	>50%

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

Import Sources (2002-05): Chile, 74%; Argentina, 24%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Other alkali metals	2805.19.9000	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.

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LITHIUM

Events, Trends, and Issues: The only active lithium carbonate plant 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 mining and processing costs for hard-rock ores. Two brine operations in Chile dominate the world market; a facility at a brine deposit in Argentina produced lithium carbonate and lithium chloride. Most of the lithium minerals mined in the world were used directly as ore concentrates in ceramics and glass applications 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.

The market for lithium compounds with the largest potential for growth is batteries, especially rechargeable batteries. Demand for rechargeable lithium batteries continued to grow for use in video cameras, portable computers and telephones, and cordless tools. Several laptop computer companies issued recall notices for a particular type of lithium ion battery contained in their devices that was prone to dangerous overheating. Interest continued in lithium batteries for hybrid electric vehicles, vehicles with an internal combustion engine and a battery-powered electric motor. Most commercially available hybrid vehicles use other types of batteries, although future models may use lithium. Nonrechargeable lithium batteries were used in calculators, cameras, computers, electronic games, watches, and other devices.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[2]	Reserve base[2]
	2005	2006[e]		
United States	W	W	38,000	410,000
Argentina[e]	1,980	2,000	NA	NA
Australia[e]	3,770	3,800	160,000	260,000
Bolivia	—	—	—	5,400,000
Brazil	242	475	190,000	910,000
Canada	707	710	180,000	360,000
Chile	8,270	8,300	3,000,000	3,000,000
China	2,820	3,000	540,000	1,100,000
Portugal	320	325	NA	NA
Russia	2,200	2,200	NA	NA
Zimbabwe	260	250	23,000	27,000
World total (rounded)	[3]20,600	[3]21,100	4,100,000	11,000,000

World Resources: The identified lithium resources total 760,000 tons in the United States and more than 13 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 calcium, magnesium, mercury, and zinc 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 boron, glass, or polymer fibers in engineering resins.

[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.
[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 52% of U.S. magnesium compounds production in 2006. Magnesium oxide and other compounds were recovered from seawater by three companies in California, Delaware, and Florida; from well brines by two 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 60% of the magnesium compounds consumed in the United States was used for refractories. The remaining 40% was used in agricultural, chemical, construction, environmental, and industrial applications.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production	312	329	292	301	305
Imports for consumption	337	332	356	391	370
Exports	66	53	35	31	30
Consumption, apparent	583	608	613	661	645
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant, number[e]	450	370	370	370	370
Net import reliance[2] as a percentage of apparent consumption	46	46	52	54	53

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

Import Sources (2002-05): China, 73%; Canada, 8%; Australia, 5%; Austria, 3%; and other, 11%.

Tariff:[3] Item	Number	Normal Trade Relations 12-31-06
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.

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MAGNESIUM COMPOUNDS

Events, Trends, and Issues: The U.S. producer of magnesium hydroxide in Manistee, MI, announced plans to nearly double its magnesium hydroxide capacity to 50,000 tons per year by the end of 2007. The company planned to market the increased production to the building materials, industrial chemicals, and wire and cable markets.

One of two U.S. producers of fused magnesia moved its 20,000-ton-per-year Midway, TN, plant to Coahuila, Mexico, after the fused magnesia operation was purchased by a Mexican firm at the end of 2005. Most of the Tennessee plant's customers were in Asia and Mexico, and the company had to import caustic-calcined magnesia feedstock for the plant. The Mexico location is close to the customers and has a captive supply of caustic-calcined magnesia. This move leaves the United States with one fused magnesia production plant in Alabama.

A leading German-based refractories producer signed a joint-venture agreement with a Chinese firm to construct a new 100,000-ton-per-year dead-burned and fused magnesia plant in Liaoning Province to supply the refractories producer's plants in China. Construction was expected to be completed in two stages, with the first stage online in mid-2007 and the second stage in 2008.

The leading magnesite producer in Russia began producing caustic-calcined magnesia in November; this was the first caustic-calcined magnesia plant in the country. Mining at a newly developed deposit began in August and when at full capacity, 200,000 tons per year of raw magnesite will be produced. Magnesite from the deposit will feed a 95,000-ton-per-year caustic-calcined magnesia plant, of which 62,000 tons per year will be used as feedstock for a fused magnesia plant scheduled to be built in the future, and the remaining 33,000 tons per year will be sold as caustic-calcined magnesia.

World Mine Production, Reserves, and Reserve Base:

	Magnesite production		Magnesite reserves and reserve base[4]	
	2005	2006[e]	Reserves	Reserve base
United States	W	W	10,000	15,000
Australia	97	100	100,000	120,000
Austria	202	200	15,000	20,000
Brazil	107	166	45,000	65,000
China	1,350	1,400	380,000	860,000
Greece	144	145	30,000	30,000
India	104	105	14,000	55,000
Korea, North	346	350	450,000	750,000
Russia	317	330	650,000	730,000
Slovakia	288	130	45,000	320,000
Spain	151	150	10,000	30,000
Turkey	980	850	65,000	160,000
Other countries	120	120	390,000	440,000
World total (rounded)	[5]4,210	[5]4,050	2,200,000	3,600,000

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, magnesium-bearing evaporite minerals, and magnesia-bearing brines are estimated to constitute a resource in billions of tons. Magnesium hydroxide can be recovered from seawater.

Substitutes: Alumina, chromite, and silica 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 the United States.

MAGNESIUM METAL[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2006, magnesium was produced by one company in Utah by an electrolytic process that recovered magnesium from brines from the Great Salt Lake. Structural uses of magnesium (castings and wrought products) were the leading use for primary magnesium, accounting for 55% of apparent consumption. Magnesium used as a constituent of aluminum-base alloys that were used for packaging, transportation, and other applications accounted for 30% of primary metal use. Desulfurization of iron and steel accounted for 7% of U.S. consumption of primary metal, and other uses were 8%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Primary	W	W	W	W	W
Secondary (new and old scrap)	74	70	72	73	75
Imports for consumption	88	83	99	85	80
Exports	25	20	12	10	13
Consumption:					
Reported, primary	102	102	101	100	100
Apparent[2]	110	120	140	130	120
Price, yearend:					
Metals Week, U.S. spot Western, dollars per pound, average	1.16	1.14	1.58	1.23	1.15
Metal Bulletin, European free market, dollars per metric ton, average	1,930	1,900	1,875	1,595	2,000
Stocks, producer and consumer, yearend	W	W	W	W	W
Employment, number[e]	400	400	400	400	400
Net import reliance[3] as a percentage of apparent consumption	55	53	61	60	54

Recycling: In 2006, about 20,000 tons of the secondary production was recovered from old scrap.

Import Sources (2002-05): Canada, 43%; Russia, 21%; China, 12%; Israel, 12%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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: In 2005, the U.S. International Trade Commission (ITC) instituted reviews of countervailing duties on pure and alloy magnesium from Canada and the antidumping duty on pure magnesium from China. As a result of these reviews, which were completed in 2006, the ITC determined that revocation of the countervailing duties on pure and alloy magnesium from Canada would be unlikely to lead to continuation or recurrence of material injury to an industry in the United States, but that revocation of the antidumping duty on pure magnesium from China would be likely to lead to a recurrence of material injury. As a result of these determinations, the countervailing duty on magnesium from Canada was revoked as of August 2005.

The United States magnesium producer had filed a scope ruling request with the Department of Commerce, International Trade Administration (ITA) in 2005, alleging that magnesium from one producer in Canada and a recycler in France evaded U.S. antidumping duties by remelting ingots or pure magnesium pieces from China and Russia and exporting them to the United States as Canadian- or French-origin magnesium. In September 2006, the ITA made a preliminary determination that pure magnesium ingot and butt ends from China that are remelted in France do not undergo a substantial transformation and are therefore subject to antidumping duties. The ITA also determined that magnesium from China and Russia that was transformed into billet in Canada before it was shipped to the United States was not subject to antidumping duties.

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MAGNESIUM METAL

Magnesium prices in China increased steadily in 2006 after the export rebate on all magnesium products was reduced to 5% from 13% at the end of 2005. By September 2006, the export rebate was removed entirely.

In July, the Norwegian magnesium producer announced that it planned to exit the magnesium business and would try to sell its magnesium plants in Canada, China, and Germany. The company operated a 51,000-ton-per-year primary magnesium plant in Becancour, Quebec, Canada (the largest capacity operating facility in the world); a 15,000-ton-per-year recycling plant in Xi'an, China; and a 15,000-ton-per-year recycling facility in Bottrop, Germany. The company also said that it would close these facilities if it could not find a buyer for the plants. Competition from magnesium from China, weak prices, and a rise in energy prices in Canada were cited as some of the reasons for the decision. The company had closed its magnesium casthouse operation in Porsgrunn, Norway, in June. (A primary magnesium plant in Porsgrunn was closed in 2002, but continued to operate as a 20,000-ton-per-year recycling and remelting facility at the site.) If the magnesium plant in Canada is closed instead of sold, U.S. supplies of magnesium could be tight, particularly those of magnesium alloy. In 2005, Canada supplied 46% of the total U.S. magnesium imports and 61% of the U.S. magnesium alloy imports, most of which came from the plant in Becancour. Through August 2006, Canada supplied more than one-half of the imports of all forms of magnesium. Imports of magnesium from China have been nearly eliminated because of the antidumping duties established for pure, alloy, and granule magnesium. Russia and Israel, both of which are significant United States magnesium suppliers, may need to become even more important sources, although material imported from these countries is mainly pure magnesium; however, some alloy has been imported from Israel.

Burgeoning demand for titanium metal may increase the use of magnesium in the titanium production process. Titanium producers in Japan, Russia, and the United States have proposed substantial increases in capacity within the next few years. The Russian titanium producers, however, are associated with magnesium production plants. If additional magnesium is used to produce titanium, there may be less material available for export.

Work continued on proposed primary magnesium plants in Congo (Brazzaville) and Egypt, but both continued to seek additional financing, so it is unlikely that these plants will be completed.

World Primary Production, Reserves, and Reserve Base:

	Primary production	
	2005	**2006[e]**
United States	W	W
Brazil	6	6
Canada	54	50
China	470	490
Israel	28	28
Kazakhstan	20	20
Russia	45	50
Serbia and Montenegro	2	2
Ukraine	2	1
World total[5] (rounded)	626	650

Reserves and reserve base[4]

Magnesium metal is derived from seawater, natural brines, dolomite, and other minerals. 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.

Substitutes: Aluminum and zinc may substitute for magnesium in 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 the United States.

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 2006. Manganese ore was consumed mainly by eight firms with plants principally in the East and Midwest. Most ore consumption was related to steel production, directly in pig iron manufacture and indirectly through upgrading ore to ferroalloys. Additional quantities of ore were used for such nonmetallurgical purposes as production of dry cell batteries, plant fertilizers and animal feed, and as a brick colorant. Manganese ferroalloys were produced at two smelters, although one operated nominally for 3 months. Construction, machinery, and transportation end uses accounted for about 24%, 9%, and 9%, respectively, of manganese demand. Most of the rest went to a variety of other iron and steel applications. The value of domestic consumption, estimated from foreign trade data, was about $513 million.

Salient Statistics—United States:[1]	**2002**	**2003**	**2004**	**2005**	**2006**[e]
Production, mine[2]	—	—	—	—	—
Imports for consumption:					
Manganese ore	427	347	451	656	442
Ferromanganese	275	238	429	255	339
Silicomanganese[3]	247	267	422	327	369
Exports:					
Manganese ore	15	18	123	13	2
Ferromanganese	9	11	9	14	30
Shipments from Government stockpile excesses:[4]					
Manganese ore	56	74	392	213	57
Ferromanganese	38	38	49	49	96
Consumption, reported:[5]					
Manganese ore[6]	360	398	441	368	340
Ferromanganese	253	248	315	267	290
Consumption, apparent, manganese[7]	696	643	1,030	766	870
Price, average value, 46% to 48% Mn metallurgical ore, dollars per mtu contained Mn, c.i.f. U.S. ports	2.30	2.41	2.89	4.39	3.61
Stocks, producer and consumer, yearend:					
Manganese ore[6]	151	156	159	337	300
Ferromanganese	21	20	16	30	30
Net import reliance[8] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Manganese was recycled incidentally as a minor constituent of ferrous and nonferrous scrap; however, scrap recovery specifically for manganese was negligible. Manganese is recovered along with iron from steel slag.

Import Sources (2002-05): Manganese ore: Gabon, 72%; South Africa, 14%; Australia, 8%; Brazil, 2%; and other, 4%. Ferromanganese: South Africa, 51%; China, 10%; Brazil, 7%; France, 7%; and other, 25%. Manganese contained in all manganese imports: South Africa, 34%; Gabon, 24%; Australia, 9%; China, 5%; and other, 28%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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	8111.00.4700/4900	14% ad val.

Depletion Allowance: 23% (Domestic), 15% (Foreign).

Government Stockpile: In addition to the quantities shown below, the stockpile contained 151,000 metric tons of nonstockpile-grade metallurgical ore, all of which was authorized for disposal.

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MANGANESE

Stockpile Status—9-30-06[9]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Manganese ore:					
Battery grade	—	18	—	27	—
Chemical grade	—	20	—	36	31
Metallurgical grade	151	224	151	454	—
Ferromanganese, high-carbon	549	6	549	91	75
Electrolytic metal	—	—	—	2	—
Synthetic dioxide	—	3	—	3	3

Events, Trends, and Issues: One domestic manganese ferroalloy plant, shut down since November 2005, was sold in January 2006 to a Delaware corporation owned by a large Ukrainian company. After refurbishment, the newly acquired plant started silicomanganese production in late October. Apparent consumption in 2006 was estimated to be about 14% higher than that of 2005, owing to increased demand by the domestic steel industry. The annual growth rate for manganese ferroalloy consumption usually falls in the range of 1% to 2%, in line with long-term trends in steel production; however, through the first 8 months of 2006, domestic steel production was 10% higher than that for the same period in 2005. Manganese alloy spot-market prices rose as a result of this increase in domestic steel production coupled with high energy costs. By the end of October 2006, U.S. weekly average spot prices for medium-carbon ferromanganese, high-carbon ferromanganese, and silicomanganese were about 30%, 25%, and 7% higher, respectively, than those at the beginning of the year. Domestic manganese ore prices followed the percentage decrease in the international price for metallurgical-grade ore set between Japan and major suppliers in late 2005.

World Mine Production, Reserves, and Reserve Base (metal content): Data for reserves and reserve base have been revised upward from those previously published for Australia, based on information reported by the Government of Australia; reserves are based on estimates of demonstrated resources.

	Mine production		Reserves[10]	Reserve base[10]
	2005	2006[e]		
United States	—	—	—	—
Australia	1,450	1,500	73,000	160,000
Brazil	1,590	1,600	25,000	51,000
China	[e]1,100	1,200	40,000	100,000
Gabon	[e]1,290	1,550	20,000	160,000
India	[e]640	650	93,000	[11]160,000
Mexico	180	133	4,000	9,000
South Africa	2,100	2,200	32,000	[11]4,000,000
Ukraine	[e]770	770	140,000	520,000
Other countries	1,390	1,390	Small	Small
World total (rounded)	[e]10,500	11,000	440,000	5,200,000

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 accounts for about 80% of the world's identified resources, and Ukraine accounts for 20%.

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.
[4]Net quantity, defined as stockpile shipments – receipts.
[5]Manganese consumption should not be estimated as the sum of manganese ore and ferromanganese consumption because so doing would count manganese in ore used to produce ferromanganese twice.
[6]Exclusive of ore consumed at iron and steel plants.
[7]Thousand metric 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.
[11]Includes inferred resources.

MERCURY

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

Domestic Production and Use: Mercury has not been mined as a primary mineral commodity in the United States since 1992, when the McDermitt Mine in Nevada closed. Byproduct mercury was produced primarily from gold-silver precipitates from several mines in Nevada; however, production data have not been reported to the U.S. Geological Survey since 1992. Byproduct mercury is also produced from calomel, a mercury-chlorine compound, obtained from domestic and foreign sources. Calomel is collected from pollution control devices at gold smelters; however, these data are not reported. In the United States, the chlorine-caustic soda industry is the leading end user of mercury. The mercury is used as an electrolyte to separate chlorine from caustic soda. Some of that mercury is recycled in-plant and the Chlorine Institute reports that approximately 100 tons of replacement mercury is purchased yearly. Some of that mercury is recycled in-plant. Mercury-containing chlor-alkali waste, as "amalgam" (not chemically defined), was exported to Canada and landfilled. In the United States, mercury use is declining because of environmental and human health concerns about mercury releases from chlorine-caustic soda plants, coal-fired power plants, and other sources, such as car switches or medical incinerators. Mercury-containing batteries and paints are no longer manufactured in the United States. Mercury is still widely used for chlorine-caustic soda production, small-scale gold mining outside the United States, and in button-type batteries, cleansers, fireworks, folk medicines, pesticides, and skin-lightening creams and soaps in many parts of the world.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Mine	NA	NA	NA	NA	NA
Secondary	NA	NA	NA	NA	NA
Imports for consumption (gross weight)	209	46	50	212	225
Exports (gross weight)	201	287	300	319	350
Price, average value, dollars per flask, free market	155.00	170.00	400.00	775.00	650.00
Net import reliance[2] as a percentage of apparent consumption[e]	NA	E	E	E	E

Recycling: In 2006, approximately 50 companies were listed as mercury recyclers; however, most of these companies collect mercury-containing consumer products, such as dental amalgam or fluorescent lamps, and move them on to larger companies with retorting facilities. Therefore, only five companies account for the majority of secondary reclamation and production. Mercury may be reclaimed and recycled from a variety of sources that primarily include automobile convenience switches, dental amalgam, mercury vapor and fluorescent lamps, and medical equipment. Barometers, computers, gym flooring, manometers, thermometers, thermostats, and toys also contain mercury that may be reclaimed and recycled. This reservoir of mercury-containing products available for recycling is shrinking because of recycling of those products and human health concerns. The availability of nonmercury substitute devices such as digital thermometers, digital thermostats, or devices using mercury substitutes such as galistan indicate that each year, fewer and fewer end-of-life products will be available from which mercury may be recycled.

Import Sources (2002-05): Chile, 30%; Peru, 26%; Australia, 20%; Germany, 12%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Mercury	2805.40.0000	1.7% ad val.

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

Government Stockpile: An inventory of 4,436 tons of mercury was held at several sites in the United States; however, the Defense Logistics Agency has indicated that consolidated storage is the preferred alternative. Sales of mercury from the National Defense Stockpile remained suspended. An additional 146 tons of mercury was held by the U.S. Department of Energy at Oak Ridge, TN.

Stockpile Status—9-30-06[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Mercury	4,436	—	4,436	—	—

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MERCURY

Events, Trends, and Issues: According to trade journals, the average cost of a flask of mercury was $775.00 in 2005. The average cost of a flask of mercury was $650.00 in 2006. Mercury prices are tied to global demand for mercury in artisanal gold mining, the diminishing supply of mercury that can be reclaimed and recycled from end-of-life mercury-containing products that were manufactured during past decades, and regional production such as in China. The ultimate closure of mercury-cell chlor-alkali plants in the United States, Europe, and elsewhere will put tons of mercury on the market for recycling, sale, or storage. Governmental regulations and environmental standards are likely to continue as major factors in domestic mercury recycling, supply, and demand. In the United States, legislation such as the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation, and Liability Act traditionally mandated regulation of production, use, generation, treatment, and disposal of products that contain mercury. In 2006, the Mercury Market Minimization Act (S. 3627) and the Missing Mercury in Manufacturing Monitoring and Mitigation Act (S. 3631) were introduced into the U.S. Senate. Byproduct mercury production is expected to continue from gold-silver processing, as is recycling of mercury from a diminishing supply of mercury-containing consumer products. The U.S. Environmental Protection Agency and several industry sectors have signed an agreement creating a national program for the recovery of mercury switches from scrapped cars before the vehicles are shredded. Domestic mercury consumption will continue to decline as nonmercury-containing products are substituted for mercury-containing products.

World Mine Production, Reserves, and Reserve Base: Reserves have been revised to zero for Spain because it no longer mines mercury.

	Mine production		Reserves[4]	Reserve base[4]
	2005	2006[e]		
United States	NA	NA	—	7,000
Algeria	—	—	—	3,000
China	1,100	1,100	—	—
Italy	—	—	—	69,000
Kyrgyzstan	200	160	7,500	13,000
Spain	—	—	—	90,000
Other countries	125	125	38,000	61,000
World total (rounded)	1,450	1,400	46,000	240,000

World Resources: There are mercury occurrences in Alaska, Arkansas, California, Nevada, and Texas. China, Kyrgyzstan, Russia, Slovenia, Spain, and Ukraine have most of the world's estimated 600,000 tons of mercury resources. Spain, once a leading producer of mercury from its centuries-old Almaden Mine, stopped mining in 2003, and therefore, its reserves have been revised. Almaden will become a repository for European mercury. In consideration of declining consumption of mercury, these resources are sufficient for another century or more of use. Byproduct mercury and calomel may be produced at copper, gold, lead, and zinc mines worldwide; there are, however, no data on the amount of mercury produced from these sources.

Substitutes: The mercury used in thermometers, perhaps once the most visible consumer use of mercury, has been replaced by "galistan," an alloy of gallium, indium, and tin, or alternatively, digital thermometers. Mercury cells are being replaced by newer diaphragm and membrane cell technology in the global production of chlorine and caustic soda. Light-emitting diodes (LEDs) that contain indium, such as those used at the Thomas Jefferson Memorial in Washington, DC, substitute for mercury-containing fluorescent lamps. Many dentists use ceramic composites as substitutes for mercury-containing dental amalgam. Lithium, nickel-cadmium, and zinc-air batteries replace mercury-zinc batteries in the United States, indium compounds substitute for mercury in alkaline batteries, and organic compounds have been substituted for mercury fungicides in latex paint.

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

[1]Some international data and dealer prices are reported in flasks. One metric ton (1,000 kilograms) = 29.0082 flasks, and 1 flask = 76 pounds, or 34.5 kilograms, or 0.034 ton.

[2]Defined as imports – exports + adjustments for Government and industry stock changes.

[3]See Appendix B for definitions.

[4]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 93,000 tons in 2006. North Carolina accounted for about 46% of U.S. production. The remaining output came from Alabama, Georgia, 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, oil-well-drilling additives, paint, roofing, and rubber products. The value of 2006 scrap mica production was estimated to be $18 million. Ground mica sales in 2005 were valued at about $47 million and were expected to decline in value in 2006. There were eight domestic producers of scrap and flake mica.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:[2, 3]					
Mine	81	79	99	78	93
Ground	99	94	98	120	100
Imports, mica powder and mica waste	35	35	42	36	48
Exports, mica powder and mica waste	10	10	10	9	7
Consumption, apparent[4]	106	103	132	105	133
Price, average, dollars per ton, reported:					
Scrap and flake	90	213	155	247	200
Ground:					
Wet	960	938	NA	704	200
Dry	180	205	269	205	250
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine, number[5]	NA	NA	NA	NA	NA
Net import reliance[6] as a percentage of apparent consumption	24	24	25	26	30

Recycling: None.

Import Sources (2002-05): Canada, 43%; China, 24%; India, 23%; Finland, 5%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Mica powder	2525.20.0000	Free.
Mica waste	2525.30.0000	Free.

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

Government Stockpile: None.

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MICA (NATURAL), SCRAP AND FLAKE

Events, Trends, and Issues: Domestic production of ground mica increased in 2006. The increase primarily resulted from higher production in Alabama and Georgia. Production in North Carolina in 2006 was estimated to be higher than that of 2005, while production in Georgia increased substantially. Canada remained the main source of imported phlogopite mica for the United States. 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]
	2005	2006[e]		
United States[2]	78	93	Large	Large
Brazil	5	4	Large	Large
Canada	18	18	Large	Large
France	10	10	Large	Large
India	4	3	Large	Large
Korea, Republic of	50	40	Large	Large
Russia	100	100	Large	Large
Other countries	29	15	Large	Large
World total (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, perlite, and vermiculite, 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. Employees 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 2006, 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 2006, an estimated 448 tons of imported unworked mica split block and mica splittings valued at $700,000 was consumed by five companies in four States, mainly in the East and the Midwest. Most was fabricated into parts for electronic and electrical equipment. An additional estimated 1,390 tons of imported worked mica valued at $20.5 million also was consumed.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, mine[e]	([2])	([2])	([2])	([2])	([2])
Imports, plates, sheets, strips; worked mica; split block; splittings; other > $1.00/kg	1,580	1,130	1,400	1,390	1,840
Exports, plates, sheets, strips; worked mica; crude and rifted into sheet or splittings > $1.00/kg	723	1,030	979	1,430	1,380
Shipments from Government stockpile excesses	894	1,280	1,170	38	6
Consumption, apparent	1,750	1,390	1,760	[3]3	[3]465
Price, average value, dollars per kilogram, muscovite and phlogopite mica, reported:					
Block	67	67	67	72	70
Splittings	1.82	1.74	1.80	1.73	1.77
Stocks, fabricator and trader, yearend	NA	NA	NA	NA	NA
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2002-05): India, 27%; Belgium, 22%; China, 13%; Brazil, 9%; and other, 29%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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—9-30-06[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Block:					
Muscovite (stained and better)	([2])	4.44	([2])	([6])	([2])
Film, muscovite	—	—	—	—	—
Splittings:					
Muscovite	6.82	—	6.82	([6])	—
Phlogopite	—	—	—	—	10.7

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MICA (NATURAL), SHEET

Events, Trends, and Issues: Demand for sheet mica increased in 2006, following a slight decline in 2005. Imports of worked sheet increased for "plates, sheets, and strips of agglomerated or reconstituted mica," and declined for "mica, worked, and articles of mica not classified elsewhere." U.S. imports of split block declined as imports of mica splittings increased. Shipments from the National Defense Stockpile (NDS) declined in 2006 as remaining stocks decreased. Stocks of muscovite film in the NDS were depleted by fiscal year 2004. Stocks of phlogopite splittings were sold out in fiscal year 2005. Imports were the principal source of the domestic supply of sheet mica in 2006. Significant stocks of mica previously sold from the NDS to various mica traders and brokers were exported, however, causing the United States to appear to have minor apparent consumption in 2005 and possibly resulting in undersating apparent consumption in 2006. Stocks of mica remaining in the NDS declined in 2006, and future supplies are expected to come increasingly from imports, primarily from China, India, and Russia. Prices for imported sheet mica also are expected to increase. Good quality sheet mica remained in short supply. There were no environmental concerns associated with the manufacture and use of mica products.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves[7]	Reserve base[7]
	2005	2006		
United States	([2])	([2])	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	5,200	5,200	Very large	Very 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 sheet mica from pegmatites.

Substitutes: Many materials can be substituted for mica in numerous electrical, electronic, and insulation 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. E Net exporter. NA Not available. — Zero.
[1]See also Mica (Natural), Scrap and Flake.
[2]Less than ½ unit.
[3]See explanation in the Events, Trends, and Issues section.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix B for definitions.
[6]The total disposal plan for all categories of mica in the National Defense Stockpile is limited to remaining inventory.
[7]See Appendix C for definitions.

MOLYBDENUM

(Data in metric tons of molybdenum content unless otherwise noted)

Domestic Production and Use: In 2006, molybdenum, valued at about $3.2 billion (based on average oxide price), was produced by nine mines. Molybdenum ore was produced as a primary product at three mines, one each in Colorado, Idaho, and New Mexico, whereas six copper mines (two in Arizona, one each in Montana, Nevada, New Mexico, and Utah) recovered molybdenum as a byproduct. Three roasting plants converted molybdenite concentrate to molybdic oxide, from which intermediate products, such as ferromolybdenum, metal powder, and various chemicals, were produced. Iron and steel and superalloy producers accounted for about 74% of the molybdenum consumed.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, mine	32,300	33,500	41,500	58,000	60,500
Imports for consumption	11,500	11,900	17,300	20,700	17,300
Exports	23,700	21,900	34,500	41,400	33,500
Consumption:					
Reported	15,300	16,400	17,400	18,900	19,300
Apparent	20,700	26,200	24,100	35,400	44,500
Price, average value, dollars per kilogram[1]	8.27	11.75	36.73	70.68	53.10
Stocks, mine and plant concentrates, product, and consumer materials	10,000	7,200	7,500	9,400	9,250
Employment, mine and plant, number	489	510	630	880	910
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Molybdenum in the form of molybdenum metal or superalloys was recovered, but the amount was small. Although molybdenum is not recovered from scrap steel, recycling of steel alloys is significant, and some molybdenum content is reutilized. The amount of molybdenum recycled as part of new and old steel and other scrap may be as much as 30% of the apparent supply of molybdenum.

Import Sources (2002-05): Ferromolybdenum: China, 88%; United Kingdom, 4%; Chile 3%; and other, 5%. Molybdenum ores and concentrates: Canada, 36%; Chile, 30%; Mexico, 29%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Molybdenum ore and concentrates, roasted	2613.10.0000	12.8¢/kg + 1.8% ad val.
Molybdenum ore and concentrates, other	2613.90.0000	17.8¢/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	9.1¢/kg + 1.2% ad val.
Unwrought	8102.94.0000	13.9¢/kg + 1.9% ad val.
Wrought bars and rods	8102.95.3000	6.6% ad val.
Wrought plates, sheets, strips, etc.	8102.95.6000	6.6% ad val.
Wire	8102.96.0000	4.4% ad val.
Waste and scrap	8102.97.0000	Free.
Other	8102.99.0000	3.7% ad val.

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

Government Stockpile: None.

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MOLYBDENUM

Events, Trends, and Issues: U.S. mine output of molybdenum in concentrate in 2006 increased about 4% from that of 2005. U.S. imports for consumption decreased an estimated 16% from those of 2005, while the U.S. exports decreased about 19% from those of 2005. More molybdenum concentrates being processed into products in the United States reduced the need for imports to meet domestic demand as concentrates represent the largest import/export category. The decrease in exports reflects the return to full production levels of domestic roasters by the end of 2005 and an additional roaster being brought online at a plant in Langeloth, PA, in 2006. U.S. reported consumption increased 2% from that of 2005. Mine capacity utilization in 2006 was about 82%.

China's high level of steel production and consumption provided strong internal demand for molybdenum. Coupled with supply disruptions in the Huludao area of Laioning Province, this led to reduced Chinese exports in 2005 and 2006. Reduced Chinese exports and the continued roaster bottleneck in the west continued to support historically high molybdenum prices. Most byproduct and primary molybdenum mines maintained high production levels in 2006. High copper prices and a refined copper supply deficit allowed the Bagdad and Sierrita Mines in Arizona to maintain production at full capacity. The Bingham Canyon Mine near Salt Lake City, UT, which optimized its mill operation to maximize molybdenum recovery and more than doubled molybdenum production from 2004 to 2005, maintained high production levels in 2006. Production capacity at the Henderson Mine, Empire, CO, was expanded to about 18,100 metric tons per year of contained molybdenum in 2006. The Robinson Mine, near Ely, NV, restarted its molybdenum circuit in 2006.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2005	2006[e]	(thousand metric tons)	
United States	58,000	60,500	2,700	5,400
Armenia	2,750	2,750	200	400
Canada	7,910	8,460	450	910
Chile	47,748	38,700	1,100	2,500
China	40,000	41,000	3,300	8,300
Iran	2,000	2,200	50	140
Kazakhstan	230	400	130	200
Kyrgyzstan	250	250	100	180
Mexico	4,246	2,500	135	230
Mongolia	1,188	1,200	30	50
Peru	17,325	17,500	140	230
Russia[e]	3,000	3,000	240	360
Uzbekistan[e]	500	500	60	150
World total (rounded)	185,000	179,000	8,600	19,000

World Resources: Identified resources amount to about 5.4 million tons of molybdenum in the United States and about 13 million tons in the rest of 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 molybdenum, industry has sought to develop new materials that benefit from the alloying properties of the metal. 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]Time-average price per kilogram of molybdenum contained in technical-grade molybdic oxide, as reported by Platts Metals Week.

[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 United States did not have any active nickel mines in 2006. Limited amounts of byproduct nickel, though, were recovered from copper and palladium-platinum ores mined in the Western United States. On a monthly or annual basis, 161 facilities reported nickel consumption. The principal consuming State was Pennsylvania, followed by Kentucky, West Virginia, and Indiana. Approximately 48% of the primary nickel consumed went into stainless and alloy steel production, 36% into nonferrous alloys and superalloys, 11% into electroplating, and 5% into other uses. End uses were as follows: transportation, 29%; chemical industry, 14%; electrical equipment, 10%; construction, 9%; fabricated metal products, 8%; household appliances, 7%; machinery, 7%; petroleum industry, 7%; and other, 9%. Estimated value of apparent primary consumption was $3.51 billion.

Salient Statistics—United States:[1]	**2002**	**2003**	**2004**	**2005**	**2006**[e]
Production, refinery byproduct	W	W	W	W	W
Shipments of purchased scrap[2]	114,000	119,000	113,000	117,000	107,000
Imports: Primary	121,000	125,000	136,000	143,000	161,000
Imports: Secondary	9,110	11,500	18,800	15,500	20,900
Exports: Primary	6,520	6,330	8,000	7,630	15,200
Exports: Secondary	39,400	47,300	48,300	55,600	48,600
Consumption: Reported, primary	88,200	87,300	98,900	96,800	102,000
Consumption: Reported, secondary	83,900	83,500	83,300	77,300	79,300
Consumption: Apparent, primary	121,000	117,000	128,000	137,000	147,000
Consumption: Total[3]	205,000	200,000	212,000	214,000	226,000
Price, average annual, London Metal Exchange:					
Cash, dollars per metric ton	6,772	9,629	13,823	14,738	23,871
Cash, dollars per pound	3.072	4.368	6.270	6.685	10.828
Stocks: Consumer, yearend	11,600	11,100	11,000	11,500	10,200
Stocks: Producer, yearend[4]	6,150	8,040	6,580	4,380	4,100
Net import reliance[5] as a percentage of apparent consumption	52	50	55	56	60

Recycling: About 79,300 tons of nickel was recovered from purchased scrap in 2006. This represented about 35% of reported secondary plus apparent primary consumption for the year.

Import Sources (2002-05): Canada, 41%; Russia, 16%; Norway, 10%; Australia, 8%; and other, 25%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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 9,400 tons of nickel ingot contaminated by low-level radioactivity plus 6,000 tons of contaminated shredded nickel scrap. Planned decommissioning activities at former nuclear defense sites are expected to generate an additional 20,000 tons of shredded scrap.

Events, Trends, and Issues: World nickel mine production was at an alltime high in 2006, but was barely keeping up with demand. Stainless steel accounts for two-thirds of global primary nickel use. U.S. production of austenitic (nickel-bearing) stainless steel reached a record high of 1.55 million tons in 2004, but slipped 10% to 1.41 million tons (revised) in 2005. Since 1950, stainless steel production in the Western World has been growing at an average rate of 6.0% per year. Demand for stainless steel in China has been particularly robust since 2000 and exceeded the combined output of Germany and Spain in 2006. Chinese and Australian companies have teamed up to explore for nickel in China. China imported nickel from Australia, Canada, Cuba, Russia, and Spain to help supply its growing stainless steel-producing industry. Brazil was expected to become a significant supplier of nickel by 2010. Nickel prices passed the 1989 high of $16,920 per metric ton in mid-2005 and continued to climb to unprecedented levels in 2006. For the month of November 2006, the London Metal Exchange cash mean for 99.8%-pure nickel averaged $32,100 per metric ton ($14.56 per pound).

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NICKEL

Acquisitions and mergers have completely changed the structure of the global nickel industry since 2004. The two largest nickel producers in Canada were taken over by even larger foreign mining companies' intent on diversification. Regulatory authorities in Canada, the European Union, and the United States approved both takeovers after extensive antitrust investigations. Shortly afterwards, the largest nickel producer in the world—a Russian company—moved to acquire an Ohio-based company with important downstream nickel processing facilities. Some nickel consumers were concerned that global demand for the metal would outstrip supply before key, new mining projects could be completed. The larger of the two Canadian takeover targets has been constructing a laterite mining complex at Goro near the southeastern tip of New Caledonia. The New Caledonian nickel was to be recovered onsite using advanced pressure acid leach (PAL) technology. Australia's leading nickel producer was also developing a large laterite deposit near Ravensthorpe, Western Australia. Nickel and cobalt were to be leached from the ore and converted onsite to an intermediate hydroxide, which was to be shipped to Yabulu in Queensland for refining. Several other companies were considering employing some form of acid leach technology to recover nickel at greenfield sites in Cuba, Guatemala, Indonesia, Kazakhstan, and the Philippines. A new type of heap-leaching process was being used to recover nickel in Turkey. At least five automobile manufacturers planned to use nickel-metal hydride (NiMH) batteries to power their gasoline-electric hybrid vehicles for the 2008 and 2009 model years. Demand for gasoline-electric hybrid vehicles has been gradually building in the United States since their introduction in late 1999, and has accelerated dramatically with the sharp increases in gasoline prices in 2005-06. One leading manufacturer was expanding operations so that it could produce more than 1 million hybrid vehicles annually by 2010.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	2005	2006[e]		
United States	—	—	—	—
Australia	189,000	191,000	24,000,000	27,000,000
Botswana	28,000	28,000	490,000	920,000
Brazil	52,000	74,200	4,500,000	8,300,000
Canada	198,000	230,000	4,900,000	15,000,000
China	77,000	79,000	1,100,000	7,600,000
Colombia	89,000	90,000	830,000	1,100,000
Cuba	72,000	73,800	5,600,000	23,000,000
Dominican Republic	46,000	46,000	720,000	1,000,000
Greece	23,200	24,000	490,000	900,000
Indonesia	160,000	145,000	3,200,000	13,000,000
New Caledonia[7]	112,000	112,000	4,400,000	12,000,000
Philippines	26,600	42,000	940,000	5,200,000
Russia	315,000	320,000	6,600,000	9,200,000
South Africa	42,500	41,000	3,700,000	12,000,000
Venezuela	20,000	20,000	560,000	630,000
Zimbabwe	9,500	9,000	15,000	260,000
Other countries	25,000	25,000	2,100,000	5,900,000
World total (rounded)	1,490,000	1,550,000	64,000,000	140,000,000

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 a tradeoff in performance of the product. Aluminum, coated steels, plain chromium 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-base alloys in highly corrosive chemical environments. Recent cost savings in manufacturing lithium ion batteries allow them to compete against NiMH in certain applications.

[e]Estimated. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Changes in this section are due to revisions of 2002-04 ferrous scrap data.
[2]Scrap receipts – shipments by consumers + exports – imports + adjustments for consumer stock changes.
[3]Apparent primary consumption + reported secondary consumption.
[4]Stocks of producers, agents, and dealers held only in the United States.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]See Appendix C for definitions.
[7]Overseas territory of France.

NITROGEN (FIXED)—AMMONIA

(Data in thousand metric tons of nitrogen unless otherwise noted)

Domestic Production and Use: Ammonia was produced by 15 companies at 26 plants in 16 States in the United States during 2006; 2 additional plants were idle for the entire year. Fifty-six 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. In 2006, U.S. producers operated at about 78% of their rated capacity. The United States was one of the world's leading producers and consumers of ammonia. 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 90% 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 also was used to produce plastics, synthetic fibers and resins, explosives, and numerous other chemical compounds.

Salient Statistics—United States:[1]	2002	2003	2004	2005	2006[e]
Production[2]	10,300	8,450	8,990	8,040	7,900
Imports for consumption	4,670	5,720	5,900	6,520	6,000
Exports	437	400	381	525	240
Consumption, apparent	14,500	13,900	14,400	14,100	13,600
Stocks, producer, yearend	286	195	298	197	250
Price, dollars per ton, average, f.o.b. Gulf Coast[3]	137	245	274	314	300
Employment, plant, number[e]	1,700	1,550	1,300	1,150	1,150
Net import reliance[4] as a percentage of apparent consumption	29	39	38	43	42

Recycling: None.

Import Sources (2002-05): Trinidad and Tobago, 54%; Canada, 17%; Russia, 13%; Ukraine, 7%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Ammonia, anhydrous	2814.10.0000	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: High natural gas prices fell significantly in 2006. At the beginning of 2006, the Henry Hub natural gas price was nearly $10.00 per million British thermal units, falling to a low of $4.00 per million British thermal units by the beginning of October before beginning an upward climb. The average Gulf Coast ammonia price also fell from $360 per short ton to its low for the year of $244 per short ton at the end of June before beginning to increase. The U.S. Department of Energy, Energy Information Administration, projected that Henry Hub natural gas spot prices would average $7.30 per million British thermal units in 2007. Two bills that could increase U.S. natural gas supplies were introduced in 2006—H.R. 4761, the "Deep Ocean Energy and Resources Act," and S. 3711, the "Gulf of Mexico Energy Security Act." H.R. 4761 would allow the lifting of a 25-year-old moratorium on exploration for natural gas in waters within the jurisdiction of the United States. S. 3711 would expand natural gas exploration and drilling in the Gulf of Mexico by offering leases in these currently restricted areas.

In July, the U.S. energy producer that owns the 128,000-ton-per-year ammonia plant in Dumas, TX, decided to close this plant, nearly one-half of which had been idle since December 2001. The company was investigating converting the ammonia facility into a hydrogen plant for use by the company's nearby petroleum refinery. The energy producer, however, continued to operate a 3,200-kilometer ammonia pipeline through one of its subsidiaries. Production capacity at the Coffeyville, KS, ammonia plant was increased by about 10% to about 400,000 tons by midyear. Improvements to the petroleum refinery resulted in increased hydrogen production, which was converted to ammonia. The Coffeyville ammonia plant is the only plant in the United States that uses petroleum coke as a feedstock.

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NITROGEN (FIXED)—AMMONIA

To combat thefts of ammonia for methamphetamine production, researchers at Iowa State University introduced a calcium nitrate inhibitor that can be added to ammonia, which would decrease the effective yield from 42% to 2% in methamphetamine production. The calcium nitrate has been tested to be nontoxic and safe for food supplies, has no adverse effect on the environment or farm equipment, and reduces the purity of the methamphetamine.

Two ammonia plants outside the United States were opened in 2006—a 400,000-ton-per-year plant in Egypt and a 680,000-ton-per-year plant in Iran. Several companies announced plans to build new ammonia plants in Brazil, Egypt, India, and Venezuela, which, if completed on time, would add 3.2 million tons of annual capacity by the end of 2009.

According to 10-year projections by the U.S. Department of Agriculture, Economic Research Service, plantings for the eight major field crops in the United States will increase slowly from the 2005 level. Corn, soybeans, and wheat will account for about 87% of area planted for the eight major field crops. During the 10-year period, the crop mix is expected to shift to corn and away from soybeans. Corn used to produce ethanol in the United States was projected to more than double from the 2004-05 level by 2015-16. This increase reflects the Renewable Fuel Program of the Energy Policy Act of 2005, which requires that gasoline sold in the United States contain specified quantities of ethanol, increasing from 4.0 billion gallons in 2006 to 7.5 billion gallons by 2012. Increased feeding of distillers dried grains, a coproduct of dry mill ethanol production, would help meet growing livestock feed demand; feed use of corn would rise only slowly in the projections.

Nitrogen compounds also are an environmental concern. Overfertilization and the subsequent runoff of excess fertilizer may contribute to nitrogen accumulation in watersheds. Nitrogen in excess fertilizer runoff is suspected to be a cause of the hypoxic zone that takes place 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]
	2005	2006[e]	
United States	8,040	7,900	Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries.
Canada	4,000	3,700	
China	37,800	39,000	
Egypt	1,640	1,650	
Germany	2,700	2,300	
India	10,800	10,800	
Indonesia	4,400	4,400	
Netherlands	1,700	1,700	
Pakistan	2,110	2,100	
Poland	2,000	2,000	
Qatar	1,700	1,800	
Russia	10,000	10,000	
Saudi Arabia	1,780	1,800	
Trinidad and Tobago	4,200	5,200	
Ukraine	4,300	4,300	
Other countries	23,700	23,700	
World total (rounded)	121,000	122,000	

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 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 $21.9 million in 2006. Peat was harvested and processed by about 52 companies in 15 of the conterminous States. The Alaska Department of Commerce, Office of Minerals Development, which conducted its own canvass of producers, reported that 60,000 cubic meters of peat was produced in 2005; output was reported only by volume.[2] A production estimate was unavailable for Alaska for 2006. Florida, Michigan, and Minnesota were the leading producing States, in order of quantity harvested. Reed-sedge peat accounted for approximately 86% of the total volume produced, followed by hypnum moss 6%, and humus and sphagnum moss, each with 4%. More than 85% of domestic peat was sold for horticultural use, including general soil improvement, potting soils, earthworm culture, nurseries, and golf course construction. Other applications included seed inoculants, vegetable cultivation, mushroom culture, mixed fertilizers, and packing for flowers and plants. In the industrial sector, peat was used as oil absorbent and as an efficient filtration medium for the removal of waterborne contaminants in mine waste streams, municipal storm drainage, and septic systems.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production	642	634	696	685	618
Commercial sales	728	632	741	751	721
Imports for consumption	763	767	786	891	930
Exports	32	29	29	36	35
Consumption, apparent[3]	1,420	1,400	1,380	1,600	1,510
Price, average value, f.o.b. mine, dollars per ton	28.85	29.74	28.64	27.76	30.31
Stocks, producer, yearend	207	180	251	195	200
Employment, mine and plant, number[e]	750	700	700	700	700
Net import reliance[4] as a percentage of apparent consumption	55	55	50	57	59

Recycling: None.

Import Sources (2002-05): Canada, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Peat	2703.00.0000	Free.

Depletion Allowance: 5% (Domestic).

Government Stockpile: None.

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PEAT

Events, Trends, and Issues: Peat production was estimated to have decreased in 2006 because of lower production in Florida. Peat is an important component of growing media, and the demand for peat generally follows that of horticultural applications. In the United States, the short-term outlook is for steady to slightly lower production and imported peat from Canada accounting for a greater percentage of domestic consumption.

Peat production in Europe was higher in 2006 owing to a warm, dry summer that allowed for a longer peat harvesting season.

World Mine Production, Reserves, and Reserve Base: Countries that reported by volume only and had insufficient data for conversion to tons were combined and included with "Other countries."

	Mine production		Reserves[5]	Reserve base[5]
	2005	2006[e]		
United States	685	618	150,000	10,000,000
Belarus	1,900	2,300	400,000	4,000,000
Canada	1,330	1,400	720,000	30,000,000
Estonia	800	800	60,000	2,000,000
Finland	9,100	9,000	6,000,000	6,400,000
Ireland	5,400	5,500	([6])	([6])
Latvia	800	700	76,000	1,300,000
Lithuania	370	425	190,000	300,000
Moldova	475	475	([6])	([6])
Russia	2,100	2,100	1,000,000	60,000,000
Sweden	930	1,000	([6])	([6])
Ukraine	1,000	1,000	([6])	([6])
Other countries	1,530	1,700	1,400,000	6,000,000
World total (rounded)	26,400	27,000	10,000,000	120,000,000

World Resources: Peat is a renewable resource, continuing to accumulate on 60% of global peatlands. However, the volume of global peatlands has been decreasing at a rate of 0.05% annually owing to harvesting and land development. Many countries evaluate peat resources based on volume or area, because the variations in densities and thickness of peat deposits make it difficult to estimate tonnage. Volume data have been converted using the average bulk density of peat produced in that county. Reserve and reserve base data were revised using data from International Peat Society publications and were estimated based on the percentage of peat resources available for peat extraction. More than 50% of the U.S. reserve base is contained in peatlands located in undisturbed areas of Alaska. Total world resources of peat were estimated to be between 5 trillion to 6 trillion tons, covering about 400 million hectares.[7]

Substitutes: Natural organic materials such as composted yard waste and coir (coconut fiber) compete with peat in horticultural applications. Shredded paper is used to hold moisture for some grass-seeding 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]Szumigala, D.J., and Hughes, R.A., 2006, Alaska's mineral industry 2005—A summary: Alaska Department of Natural Resources Information Circular 52, p. 15.
[3]Defined as production + imports – exports + adjustments for industry stocks.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.
[6]Included with "Other countries."
[7]Lappalainen, Eino, 1996, Global peat resources: Jyvaskyla, Finland, International Peat Society, p. 55.

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 2006 was $19.5 million. Crude ore production came from nine mines operated by seven companies in seven 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, 61%; horticultural aggregate, 14%; fillers, 11%; filter aid, 7.5%; and other, 6.5%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production[1]	521	493	508	508	457
Imports for consumption[e]	224	245	238	196	275
Exports[e]	42	37	37	32	32
Consumption, apparent	703	701	709	672	700
Price, average value, dollars per ton, f.o.b. mine	36.42	38.20	41.87	40.68	42.72
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill	189	194	133	127	114
Net import reliance[2] as a percentage of apparent consumption	26	30	28	24	35

Recycling: Not available.

Import Sources (2002-05): Greece, 100%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Mineral substances, not specifically provided for	2530.10.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

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PERLITE

Events, Trends, and Issues: The amount of processed perlite sold or used from U.S. mines dropped to its lowest level since 1984 when about 452,000 tons of processed perlite were sold or used. Domestic miners continued to lose market share to imports. One mine in New Mexico was idle in 2006 after decades of continuous operation. Another mine in Utah was closed after some production in the first half of 2006. Imports reached record levels of about 275,000 tons, surpassing the previous high of 245,000 tons imported in 2003. These record imports also established a net import reliance record of 35%, an increase of about 46% compared with that of 2005.

The cost of rail transportation from the mines in the Western United States to some areas of the Eastern United States continued to burden domestic perlite producers with strong cost disadvantages compared with Greek perlite exporters. However, U.S. perlite exports to Canada partially offset losses from competition with imports in Eastern U.S. markets.

Perlite mining generally takes place in remote areas, and its environmental impact is not severe. The mineral fines, overburden, and reject ore produced during ore mining and processing are used to reclaim the mined-out areas, and, therefore, little waste remains. Airborne dust is captured by baghouses, and there is practically no runoff that contributes to water pollution.

World Processed Perlite Production, Reserves, and Reserve Base: Greece surpassed the United States in processed perlite production starting in 2003. Information for China and several other countries is unavailable, making it unclear whether or not Greece and the United States are the world's leading producers.

	Production		Reserves[3]	Reserve base[3]
	2005	2006[e]		
United States	508	457	50,000	200,000
Greece	525	500	50,000	300,000
Hungary	145	70	3,000	([4])
Japan	240	250	([4])	([4])
Mexico	195	200	([4])	([4])
Turkey	140	130	([4])	5,700,000
Other countries	200	210	600,000	1,500,000
World total (rounded)	1,950	1,820	700,000	7,700,000

World Resources: Insufficient information is available to make reliable estimates of resources in perlite-producing countries.

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 for apparent consumption and net import reliance calculations.
[3]See Appendix C for definitions. Reserves and reserve base data are for crude ore.
[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 6 firms at 12 mines in 4 States, and upgraded to an estimated 30.7 million tons of marketable product valued at $852 million, f.o.b. mine. Florida and North Carolina accounted for more than 85% of total domestic output; the remainder was produced in Idaho and Utah. Marketable product refers to beneficiated phosphate rock with a phosphorus pentoxide (P_2O_5) content suitable for phosphoric acid or elemental phosphorus production. More than 95% of the U.S. phosphate rock mined was used to manufacture wet-process phosphoric acid and superphosphoric acid, which were used as intermediate feedstocks in the manufacture of granular and liquid ammonium phosphate fertilizers and animal feed supplements. Approximately 45% of the wet-process phosphoric acid produced was exported in the form of upgraded granular diammonium and monoammonium phosphate (DAP and MAP, respectively) fertilizer, merchant-grade phosphoric acid, and triple superphosphate fertilizer. The balance of the phosphate rock mined was for the manufacture of elemental phosphorus, which was used to produce phosphorus compounds for a variety of food-additive and industrial applications.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, marketable	36,100	35,000	35,800	36,300	30,700
Sold or used by producers	34,700	36,400	36,500	36,000	29,900
Imports for consumption	2,700	2,400	2,500	2,630	2,300
Exports	62	64	—	—	—
Consumption[1]	37,400	37,400	39,000	38,600	32,200
Price, average value, dollars per ton, f.o.b. mine[2]	27.47	27.01	27.79	27.34	27.78
Stocks, producer, yearend	8,860	7,540	7,220	6,970	7,400
Employment, mine and beneficiation plant, number[e]	2,800	2,900	2,700	2,700	2,500
Net import reliance[3] as a percentage of apparent consumption	3	9	7	7	6

Recycling: None.

Import Sources (2002-05): Morocco, 99%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Natural calcium phosphates:		
Unground	2510.10.0000	Free.
Ground	2510.20.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: U.S. phosphate rock production and use dropped to 40-year lows in 2006 owing to a combination of mine and fertilizer plant closures and lower export sales of phosphate fertilizers. China has surpassed the United States as the largest phosphate rock producer. Since late 2005, two phosphate rock mines and four fertilizer plants were closed permanently and one mine was temporarily closed. Additionally, the leading U.S. producer closed its four active mines for 1 month in 2006 to reduce inventories of phosphate rock. Because of the decreased level of phosphoric acid production in 2006, consumption of phosphate rock fell to a 30-year low.

Domestic phosphate rock annual production capacity fell to under 35 million tons in 2006, the lowest level since 1969. It is likely that production capacity will continue to decline gradually owing to depletion of reserves in Florida and increased global competition in the fertilizer industry, which may result in lower domestic phosphoric acid production. Three new mines are planned to open in the next decade in Florida, but only as replacements for existing mines.

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PHOSPHATE ROCK

The United States remained the world's leading consumer, producer, and supplier of phosphate fertilizers; however, its share of the world market has been shrinking. Phosphate fertilizer production increasingly is being located in the large consuming regions of Asia and South America, reducing the need for imported fertilizers to these regions. U.S. exports of phosphate fertilizer to China and India, the two largest consumers of phosphate fertilizers, have dropped significantly since 2000. Exports of DAP to India have rebounded slightly over the past 2 years owing to temporary plant closures in India and increased consumption, but have not returned to the record level of 1999. Exports of MAP to Brazil have increased over the past several years, but declined in 2005-06 owing to lower demand. Domestic consumption of phosphate fertilizers was expected to remain around 4 million tons P_2O_5.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2005	2006[e]		
United States	36,300	30,700	1,200,000	3,400,000
Australia	2,050	2,050	77,000	1,200,000
Brazil	6,100	5,500	260,000	370,000
Canada	1,000	1,000	25,000	200,000
China	30,400	32,000	6,600,000	13,000,000
Egypt	2,730	2,740	100,000	760,000
Israel	2,900	3,000	180,000	800,000
Jordan	6,230	6,400	900,000	1,700,000
Morocco and Western Sahara	25,200	25,300	5,700,000	21,000,000
Russia	11,000	11,000	200,000	1,000,000
Senegal	1,520	1,500	50,000	160,000
South Africa	2,580	2,600	1,500,000	2,500,000
Syria	3,500	3,600	100,000	800,000
Togo	1,220	1,200	30,000	60,000
Tunisia	8,000	8,400	100,000	600,000
Other countries	6,500	6,700	890,000	2,200,000
World total (rounded)	147,000	145,000	18,000,000	50,000,000

World Resources: Foreign reserve data were derived from information received from Government sources, individual companies, and independent sources. Reserve data for China were based on official government data and included deposits of low-grade ore. Production data for China does not include small "artisanal" mines. 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 sedimentary 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 + imports – 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 and East Boulder Mines in south-central Montana are the only primary platinum-group metals (PGMs) mines in the United States and were owned by one company. Small quantities of PGMs were also recovered as byproducts of copper refining by companies in Texas and Utah. Catalysts for air-pollution abatement continued to be the leading demand sector for PGMs. Catalysts were also used in other air-pollution-abatement processes to remove organic vapors, odors, and 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.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Mine production[1]					
Platinum	4,390	4,170	4,040	3,920	4,000
Palladium	14,800	14,000	13,700	13,300	13,600
Imports for consumption:					
Platinum	84,700	88,500	86,400	106,000	170,000
Palladium	117,000	105,000	127,000	139,000	140,000
Rhodium	8,630	12,000	13,200	13,600	17,000
Ruthenium	9,890	15,900	18,800	23,200	30,000
Iridium	2,100	2,200	3,230	3,000	2,500
Osmium	36	53	75	39	80
Exports:					
Platinum	27,800	22,200	20,000	20,700	35,000
Palladium	42,700	22,300	31,500	27,000	40,000
Rhodium	349	479	311	615	400
Other PGMs	94	145	1,086	1,080	3,000
Price,[2] dollars per troy ounce:					
Platinum	542.56	694.44	848.76	899.51	1,200.00
Palladium	339.68	203.00	232.93	203.54	330.00
Rhodium	838.88	530.28	983.24	2,059.73	4,300.00
Ruthenium	66.33	35.43	64.22	74.41	150.00
Iridium	294.62	93.02	185.33	169.51	350.00
Employment, mine, number[1]	1,580	1,540	1,580	1,620	1,600
Net import reliance as a percentage of apparent consumption[e]					
Platinum	91	91	92	93	95
Palladium	82	82	83	84	82

Recycling: An estimated 10,400 kilograms of PGMs was recovered from new and old scrap in 2006.

Import Sources (2002-05): Platinum: South Africa, 41%; United Kingdom, 16%; Germany, 11%; Canada, 8%; and other, 24%. Palladium: Russia, 37%; South Africa, 25%; United Kingdom, 14%; Belgium, 5%; and other, 19%.

Tariff: All unwrought and semimanufactured forms of PGMs can be imported duty free.

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

Government Stockpile:

Stockpile Status—9-30-06[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Platinum	261	—	[4]3,110	388	—
Palladium	—	—	[4]778	756	—
Iridium	123	—	[4]186	254	159

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PLATINUM-GROUP METALS

Events, Trends, and Issues: The desire for an alternative fuel for automobiles has led to a large global public and private effort to develop fuel cell technology. Platinum is the catalyst used by fuel cells to convert hydrogen and oxygen to electricity. Palladium will also likely play a role in the fuel cell. An increase in diesel car sales in Europe can be expected to cause a strong increase in use of platinum in the region in 2006 and beyond. The tightening of emissions regulations in China, Europe, Japan, and other parts of the world is also expected to lead to higher average platinum loadings on catalysts, especially on light-duty diesel vehicles, as particulate matter emissions become more closely controlled. In the United States, thrifting is continuing at most manufacturers and is likely to lead to a reduction in the use of platinum in autocatalysts. The price differential of almost $900 per troy ounce between platinum and palladium has led to the assumption that automobile manufacturers will change PGMs ratios on gasoline-engine vehicles in favor of palladium. The sales of platinum jewelry are expected to drop worldwide as the price continues to be high and white gold and palladium are substituted for platinum.

In 2006, a wildfire caused a small disruption in production at the Stillwater and East Boulder Mines.

World Mine Production, Reserves, and Reserve Base:

	Mine production				PGMs	
	Platinum		Palladium		Reserves[5]	Reserve base[5]
	2005	2006[e]	2005	2006[e]		
United States	3,920	4,000	13,300	13,600	900,000	2,000,000
Canada	6,400	6,700	13,000	13,700	310,000	390,000
Colombia	1,080	1,000	NA	NA	[6]NA	[6]NA
Russia	30,000	32,000	97,400	97,000	6,200,000	6,600,000
South Africa	169,000	172,000	84,900	87,000	63,000,000	70,000,000
Other countries	7,000	7,600	9,900	10,200	800,000	850,000
World total (rounded)	217,000	223,000	219,000	222,000	71,000,000	80,000,000

World Resources: World resources of PGMs in mineral concentrations that can be mined economically are estimated to total more than 100 million kilograms. The largest reserves are in the Bushveld Complex in South Africa.

Substitutes: Some motor vehicle manufacturers have substituted palladium for the more expensive platinum in catalytic converters. Until recently, only platinum could be used in diesel catalytic converters; however, new technologies allow palladium to be used. For most other end uses, PGMs can be substituted for other PGMs, with some losses in efficiency. 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]Engelhard Corporation unfabricated metal.
[3]See Appendix B for definitions.
[4]Actual quantity will be limited to remaining monetary sales authority or inventory.
[5]See Appendix C for definitions.
[6]Included with "Other countries."

POTASH

(Data in thousand metric tons of K_2O equivalent unless otherwise noted)

Domestic Production and Use: In 2006, the production value of marketable potash, f.o.b. mine, was about $411 million. Domestic potash was produced in Michigan, New Mexico, and Utah. Most of the production was from southeastern New Mexico, where two companies operated three mines. New Mexico sylvinite and langbeinite ores were beneficiated by flotation, dissolution-recrystallization, heavy-media separations, or combinations of these processes, and provided more than 77% of total U.S. producer sales. In Utah, which has three operations, one company extracted underground sylvinite ore by deep-well solution mining. Solar evaporation crystallized the sylvinite ore from the brine solution, and a flotation process separated the potassium chloride (muriate of potash or MOP) from byproduct sodium chloride. Two companies processed surface and subsurface brines by solar evaporation and flotation to produce MOP, potassium sulfate (sulfate of potash or SOP) and byproducts. In Michigan, a company used deep-well solution mining and mechanical evaporation for crystallization of MOP and byproduct sodium chloride.

The fertilizer industry used about 85% of U.S. potash sales, and the chemical industry used the remainder. More than 60% of the produced potash was MOP. Potassium magnesium sulfate (sulfate of potash-magnesia or SOPM) and SOP, which are required by certain crops and soils, also were produced.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, marketable[1]	1,200	1,100	1,300	1,200	1,200
Imports for consumption	4,620	4,720	4,920	4,920	4,200
Exports	371	329	233	200	400
Consumption, apparent[2]	5,300	5,400	6,000	6,000	5,200
Price, dollars per metric ton of K_2O, average, muriate, f.o.b. mine[3]	155	170	200	280	290
Employment, number:					
Mine	540	520	520	500	500
Mill	645	620	620	630	630
Net import reliance[4, 5] as a percentage of apparent consumption	80	80	80	80	80

Recycling: None.

Import Sources (2002-05): Canada, 89%; Belarus, 5%; Russia, 3%; Germany, 1%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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: About 93% of the world potash production was consumed by the fertilizer industry. The United States ranked seventh in world production. Potassium chloride is the main fertilizer product, containing an average 61% of K_2O equivalent. The growth of potash consumption that began in 2004 continued throughout 2005 led to rising potash prices. Contract negotiations between major potash importers in Brazil, China, and India, and major potash suppliers in Belarus, Canada, and Israel, were deadlocked for the first half of 2006 causing concerns about growing potash inventories. To alleviate the potential oversupply situation, some producers curtailed production. This included the mines in Allan, Cory, Lanigan, and Rocanville, Canada, and four mines in Belarus.

The stalemate between major world potash consumers and producers was broken in late July 2006 with the new base price rising by an average $25 per ton over the 2005 contract price. Producers had hoped for a $40 per ton increase. Because of the late settlement, the shortened shipping period left in the year, and the unknown effect of these two factors on Chinese demand, the actual tonnages and shipping schedules were unresolved but would be finalized as the year progressed.

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POTASH

A feasibility study was completed on the Kouilou potash project near Pointe-Noire in Congo (Brazzaville). The proposed project was to solution mine a carnallite deposit to produce granular and standard grade potash fertilizer for export. Capital costs were derived for a facility to operate at either 600,000 tons per year or 1.2 million tons per year, depending on market conditions in 2009 when the plant was scheduled for completion. Another new potash project that would produce 2 million tons annually was being considered at the Gremyachinskoye potash deposit in the Volgograd Region in Russia. Reserves were estimated at 1.2 billion tons and inferred reserves estimated at 4.8 billion tons. The plant could be onstream by 2010. Also, a new potash venture was being considered at Dekhanabad in Uzbekistan that would develop the Tobegat potash deposit.

As a result of some technical improvements, potash production will increase by June 2007 at the Rincon Salar in northwest Argentina by 40,000 tons per year to 62,000 tons per year without any capital expenditure. The extra output will generate about $3 million in new revenue from export sales to Asia, Australia, South America, and the United States. Also, a study was completed on a new $735 million potash operation at Potasio Rio Colorado that would have an annual output between 1.6 million tons and 2.4 million tons.

The outlook for the U.S. potash industry in 2007 is optimistic because of a strong international demand and limited supply of potash. Domestic potash inventories declined in 2006, but stocks are expected to rise as production expansions in other nations come onstream in the next couple of years.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	2005	2006[e]		
United States	[1]1,200	[1]1,200	90,000	300,000
Belarus	4,800	4,000	750,000	1,000,000
Brazil	405	405	300,000	600,000
Canada	10,120	10,200	4,400,000	9,700,000
Chile	370	350	10,000	50,000
China	600	700	8,000	450,000
Germany	3,600	3,660	710,000	850,000
Israel	2,060	2,100	[7]40,000	[7]580,000
Jordan	1,230	1,200	[7]40,000	[7]580,000
Russia	5,500	5,300	1,800,000	2,200,000
Spain	500	500	20,000	35,000
Ukraine	65	65	25,000	30,000
United Kingdom	600	600	22,000	30,000
Other countries	—	—	50,000	140,000
World total (rounded)	31,100	30,000	8,300,000	17,000,000

World Resources: Estimated domestic potash resources total about 6 billion tons. Most of this lies at depths between 1,800 and 3,100 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 1,200 meters. A large potash resource lies about 2,100 meters under central Michigan. The U.S. reserve figure above includes approximately 62 million tons in central Michigan. Estimated world resources total about 250 billion tons. The potash deposits in Russia and Thailand contain large amounts of carnallite; it is not clear if this can be mined profitably in a free market economy.

Substitutes: There are no substitutes for potassium as an essential plant nutrient and an essential nutritional requirement for animals and humans. Manure and glauconite (greensand) are low-potassium-content sources that can be profitably transported only short distances to the crop fields.

[e]Estimated. — Zero.
[1]Rounded to within 0.1 million tons to avoid disclosing company proprietary data.
[2]Rounded to within 0.2 million tons to avoid disclosing company 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 avoid disclosing company proprietary data.
[6]See Appendix C for definitions.
[7]Total reserves and reserve base in the Dead Sea are arbitrarily divided equally between Israel and Jordan for inclusion in this tabulation.

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 2006 was about $50 million. Domestic output came from 16 producers at 17 mines in 7 States. Pumice and pumicite was mined in Arizona, Oregon, Idaho, California, New Mexico, Nevada, and Kansas, in descending order of production. About 66% of production came from Arizona, Oregon, and Idaho. About 82% of the pumice was consumed for building blocks. Horticulture consumed 11%; abrasives, 3%; concrete admixture and aggregate, 2%; and the remaining 2% was used in concrete, landscaping, stone-washing laundries, and other applications.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, mine[1]	956	870	1,490	1,270	1,580
Imports for consumption	360	366	402	240	240
Exports[e]	30	25	27	21	22
Consumption, apparent	1,320	1,210	1,870	1,490	1,800
Price, average value, dollars per ton, f.o.b. mine or mill	20.69	25.19	16.80	31.00	32.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number	100	100	100	110	110
Net import reliance[2] as a percentage of apparent consumption	25	28	20	15	12

Recycling: Not available.

Import Sources (2002-05): Greece, 72%; Italy, 25%; Turkey, 3%; and other, <1%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Crude or in irregular pieces, including crushed pumice	2513.11.0000	Free.
Other	2513.19.0000	0.2¢/kg.

Depletion Allowance: 5% (Domestic and foreign).

Government Stockpile: None.

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PUMICE AND PUMICITE

Events, Trends, and Issues: The amount of domestically produced pumice and pumicite sold or used in 2006 increased by 24% to 1.6 million tons compared with 1.3 million tons in 2005. Imports remained about the same as those of 2005. Over 95% of pumice imports were from Greece and Italy to supply markets in the Eastern United States and Gulf Coast. Apparent consumption in 2006 rose by about 21% compared with that of 2005.

In 2007, domestic mine production of pumice and pumicite and U.S. apparent consumption are expected to increase slightly. Although pumice and pumicite are plentiful in the Western United States, changes in laws and public land designations could decrease access to many deposits. Production of pumice and pumicite is sensitive to mining and transportation costs, and, if domestic production costs increase, imports and competing materials might replace pumice in many domestic markets.

All domestic mining of pumice in 2006 was by open pit methods and was generally in 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]
	2005	2006[e]		
United States[1]	1,270	1,580	Large	Large
Algeria	500	500		
Cameroon	600	300		
Chile	1,620	1,600		
Ecuador	830	830	Quantitative estimates of reserves and reserve base for most countries are not available.	
France	450	450		
Greece	2,250	2,200		
Iran	1,200	1,200		
Italy	4,600	4,600		
Spain	600	600		
Syria	650	650		
Turkey	1,000	1,200		
Other countries	1,000	1,100		
World total (rounded)	16,600	16,800	NA	NA

World Resources: The identified U.S. resources of pumice and pumicite in the West are estimated to be more than 25 million tons. The estimated total resources (identified and undiscovered) in the Western and Great Plains States are at least 250 million tons and may total more than 1 billion tons. Italy, Greece, and Chile are the leading producers of pumice and pumicite, followed by the United States, Iran, and Turkey. Recent analysis shows that the production estimates of past years for pumice and pumicite from some countries, notably Greece, Ecuador, and Cameroon, may have been erroneous. More reliable sources were used for the current production figures. There are large resources of pumice and pumicite on all continents.

Substitutes: The costs of transportation determine the maximum distance that pumice and pumicite can be shipped and still remain competitive with alternate materials. Competitive materials that can be substituted for pumice and pumicite for several end uses include crushed aggregates, diatomite, expanded shale and clay, and vermiculite.

[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: Lascas[1] mining and processing in Arkansas ended in 1997, and in 2006, no U.S. firms reported the production of cultured quartz crystals. Cultured quartz crystal production capacity still exists in the United States using imported and stockpiled lascas as feed material. In the past several years, cultured quartz crystal was increasingly produced overseas, primarily in Asia. 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 consumer goods, such as electronic games and television receivers.

Salient Statistics—United States: Production statistics for cultured quartz crystals were withheld to avoid disclosing company proprietary data. The U.S. Department of Commerce (DOC), which is the primary Government source of U.S. trade data, does not provide specific import or export statistics on lascas. The DOC collects export and import statistics on electronic and optical-grade quartz crystal; however, the quartz crystal export and import quantities and values reported in previous years included zirconia that was inadvertently reported to be quartz crystal. The average value of as-grown cultured quartz and lumbered quartz, which is as-grown quartz that has been processed by sawing and grinding, was estimated to be about $156 per kilogram in 2006. Other salient statistics were not available.

Recycling: None.

Import Sources (2002-05): The United States is 100% import reliant. Brazil, Germany, and Madagascar are reportedly the major sources for lascas with Canada becoming an important supplier. Other possible sources of lascas include China, South Africa, and Venezuela.

Tariff:

Item	Number	Normal Trade Relations 12-31-06
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.
Piezoelectric quartz	7104.10.00.00	3% ad val.

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

Government Stockpile:

Stockpile Status—9-30-06[2]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Quartz crystal	7	—	—	—	—

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QUARTZ CRYSTAL (INDUSTRIAL)

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) will continue to promote global production. The growing global electronics market may require additional production capacity worldwide.

World Mine Production, Reserves, and Reserve Base:[3] 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 aluminum orthophosphate (e.g., the very rare mineral berlinite) and lithium tantalate, which have larger piezoelectric coupling constants, have been studied.

[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]See Appendix C for definitions.

RARE EARTHS[1]

(Data in metric tons of rare-earth oxide (REO) content unless otherwise noted)

Domestic Production and Use: Rare earths were not mined domestically in 2006. Bastnäsite, a rare-earth fluocarbonate mineral, was previously mined and processed as a primary product at Mountain Pass, CA. Rare-earth concentrates, intermediate compounds, and individual oxides were available from stocks. The United States continued to be a major exporter and consumer of rare-earth products in 2006. The estimated value of refined rare earths consumed in the United States was more than $1 billion. Based on final 2005 reported data, the estimated 2005 distribution of rare earths by end use was as follows: automotive catalytic converters, 32%; metallurgical additives and alloys, 21%; glass polishing and ceramics, 14%; rare-earth phosphors for lighting, televisions, computer monitors, radar, and X-ray intensifying film, 10%; petroleum refining catalysts, 8%; permanent magnets, 2%; and other, 13%.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, bastnäsite concentrates[e]	5,000	—	—	—	—
Imports:[2]					
Thorium ore (monazite)	—	—	—	—	—
Rare-earth metals, alloy	1,450	1,130	804	880	947
Cerium compounds	2,540	2,630	1,880	2,170	2,530
Mixed REOs	1,040	2,150	1,660	640	1,570
Rare-earth chlorides	1,800	1,890	1,310	2,670	3,410
Rare-earth oxides, compounds	7,260	10,900	11,400	8,550	10,600
Ferrocerium, alloys	89	111	105	130	140
Exports:[2]					
Rare-earth metals, alloys	1,300	1,190	1,010	636	659
Cerium compounds	2,740	1,940	2,280	2,210	2,180
Other rare-earth compounds	1,340	1,450	4,800	2,070	2,760
Ferrocerium, alloys	2,830	2,800	3,720	4,320	3,900
Consumption, apparent	11,000	9,340	5,480	6,030	9,790
Price, dollars per kilogram, yearend:					
Bastnäsite concentrate, REO basis[e]	4.08	4.08	4.08	4.08	4.08
Monazite concentrate, REO basis[3]	0.54	0.50	0.59	0.54	0.54
Mischmetal, metal basis, metric ton quantity[4]	5-6	5-6	5-6	5-6	5-6
Stocks, producer and processor, yearend	W	W	W	W	W
Employment, mine and mill, number	95	90	NA	NA	—
Net import reliance[5] as a percentage of apparent consumption	54	100	100	100	100

Recycling: Small quantities, mostly permanent magnet scrap.

Import Sources (2002-05): Rare-earth metals, compounds, etc.: China, 76%; France, 9%; Japan, 4%; Russia, 3%; and other, 8%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
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); bastnäsite and xenotime, 14% (Domestic and foreign).

Government Stockpile: None.

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RARE EARTHS

Events, Trends, and Issues: Domestic demand for rare earths in 2006 increased overall as rare-earth imports and exports were estimated to be higher than in 2005. Demand increased for cerium compounds used in automotive catalytic converters, glass polishing, and glass additives; rare-earth compounds used in automotive catalytic converters and many other applications; and yttrium compounds used in fiber optics, lasers, oxygen sensors, phosphors for fluorescent lighting, color television, electronic thermometers, X-ray intensifying screens, pigments, superconductors, and other applications. Demand was also higher for mixed rare-earth compounds and for rare-earth metals and their alloys used in permanent magnets, base-metal alloys, superalloys, pyrophoric alloys, lighter flints, and armaments. U.S. demand, however, was lower for rare-earth chlorides used in the production of fluid cracking catalysts used in oil refining. Although the rare-earth separation plant at Mountain Pass, CA, remained on a care-and-maintenance basis, it is expected to resume operations. Bastnäsite concentrates and other rare-earth intermediates and refined products continued to be sold from the mine stocks at Mountain Pass. The trend is for a continued increase in the use of rare earths in many applications, especially automotive catalytic converters, permanent magnets, and rechargeable batteries.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves[6]	Reserve base[6]
	2005	2006		
United States	—	—	13,000,000	14,000,000
Australia	—	—	5,200,000	5,800,000
China	119,000	120,000	27,000,000	89,000,000
Commonwealth of Independent States	NA	NA	19,000,000	21,000,000
India	2,700	2,700	1,100,000	1,300,000
Malaysia	750	200	30,000	35,000
Thailand	—	—	NA	NA
Other countries	400	400	22,000,000	23,000,000
World total (rounded)	123,000	123,000	88,000,000	150,000,000

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 bastnäsite and monazite. Bastnäsite 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. Apatite, cheralite, eudialyte, secondary monazite, loparite, phosphorites, rare-earth-bearing (ion adsorption) clays, spent uranium solutions, and xenotime 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. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Data include lanthanides and yttrium, but exclude 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 price based on monazite exports from Malaysia for 2002 to 2004, and estimated for 2005 and 2006.
[4]Price range from Elements—Rare Earths, Specialty Metals and Applied Technology, Trade Tech, Denver, CO, and Web-based High Tech Materials, Longmont, CO.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]See Appendix C for definitions.

RHENIUM

(Data in kilograms of rhenium content unless otherwise noted)

Domestic Production and Use: During 2006, ores containing rhenium were mined by six operations (two in Arizona, one each in Montana, Nevada, New Mexico, and Utah). Rhenium compounds are included in molybdenum concentrates derived from porphyry copper deposits, 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 superalloys used in high-temperature, turbine engine components, representing an estimated 20% and 60%, respectively, of the end use. 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 improves the high-temperature (1,000° C) strength properties of some nickel-base superalloys. Rhenium alloys were used in crucibles, electrical contacts, electromagnets, electron tubes and targets, heating elements, ionization gauges, mass spectrographs, metallic coatings, semiconductors, temperature controls, thermocouples, vacuum tubes, and other applications. The estimated value of rhenium consumed in 2006 was about $47 million.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production[1]	3,400	3,400	5,900	7,100	6,200
Imports for consumption	16,900	14,500	20,200	28,900	41,500
Exports	NA	NA	NA	NA	NA
Consumption, apparent	20,300	18,000	26,100	36,000	47,700
Price,[2] average value, dollars per kilogram, gross weight:					
Metal powder, 99.99% pure	1,030	1,090	1,090	1,070	1,170
Ammonium perrhenate	820	790	630	680	590
Stocks, yearend, consumer, producer, dealer	NA	NA	NA	NA	NA
Employment, number	Small	Small	Small	Small	Small
Net import reliance[3] as a percentage of apparent consumption	83	81	77	80	87

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 (2002-05): Rhenium metal: Chile, 94%; Germany, 5%; and other, 1%. Ammonium perrhenate: Kazakhstan, 41%; Netherlands, 17%; Germany, 15%; Estonia, 8%; and other, 19%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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	8112.92.0500	Free.
Rhenium, (metals) unwrought; powders	8112.92.5000	3% ad val.
Rhenium, etc., (metals) wrought; etc.	8112.99.0100	4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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RHENIUM

Events, Trends, and Issues: During 2006, average rhenium metal price, based on U.S. Census Bureau customs value, was about $1,170 per kilogram, about 9% more than that of 2005. Rhenium imports increased by about 44% owing to continued strong demand for superalloys in the gas turbine engine market and improved demand in the catalyst market. Rhenium recovery in the United States decreased by about 13% owing to reduced imports of byproduct molybdenum concentrates for roasting in the United States. Byproduct molybdenum production from the six working copper-molybdenum mines maintained production levels near capacity in 2006. The United States continued to rely on imports for much of its supply of rhenium, and Chile and Kazakhstan supplied the majority of the imported rhenium. Although rhenium recovery in Kazakhstan increased significantly in recent years as a result of the formation of a State company, exports of rhenium from Kazakhstan were blocked in February owing to a dispute over payments for past utilities usage and rhenium-bearing residues. As a result, rhenium spot prices rose to $3,000 per kilogram in March, $4,000 per kilogram in April, and reached $5,000 per kilogram in May before settling at about $4,500 per kilogram through September. While the dispute reportedly has been settled, and production has continued, exports from Kazakhstan had not resumed by October.

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 removal also prevents most of the rhenium from escaping into the atmosphere.

World Mine Production, Reserves, and Reserve Base: Reserves estimate for Canada was revised based on information provided by major Canadian producers.

	Mine production[4]		Reserves[6]	Reserve base[6]
	2005	2006		
United States	7,100	6,200	390,000	4,500,000
Armenia	1,200	1,200	95,000	120,000
Canada	1,700	1,700	32,000	1,500,000
Chile[5]	20,500	20,100	1,300,000	2,500,000
Kazakhstan	8,000	8,000	190,000	250,000
Peru	5,000	5,000	45,000	550,000
Russia	1,400	1,400	310,000	400,000
Other countries	1,000	1,000	91,000	360,000
World total (rounded)	45,900	44,600	2,500,000	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 might decrease rhenium's share of the existing catalyst market; however, this would likely be offset by rhenium-bearing catalysts being considered for use in several proposed gas-to-liquid projects. 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.
[1]Based on estimated rhenium contained in MoS_2 concentrates assuming 90% recovery of rhenium content.
[2]Average price per kilogram of rhenium in pellets or ammonium perrhenate, based on U.S. Census Bureau customs value.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]Estimated amount of rhenium recovered in association with copper and molybdenum production.
[5]Estimated rhenium recovered from roaster residues from Belgium, Chile, and Mexico.
[6]See Appendix C for definitions.

RUBIDIUM

(Data in kilograms of rubidium content unless otherwise noted)

Domestic Production and Use: Rubidium may occur with the cesium or lithium minerals, pollucite or lepidolite, respectively, in zoned pegmatites. There are such rubidium occurrences in Maine and South Dakota, and with some evaporite minerals in other States; however, rubidium is not mined in the United States. Rubidium concentrate is imported from Canada for processing in the United States. Overall, uses for rubidium and its compounds are limited; however, applications include DNA separation, fiber optics, inorganic chemicals, lamps, night vision devices, and as standards for atomic absorption analysis. High-purity rubidium (>98%) is used in vapor cells as a wavelength reference. Atomic clocks mainly use cesium as a frequency standard; however, rubidium may also be substituted. Rubidium-82 is used clinically as a tracer of blood flow in the heart. Rubidium-87, a natural decay product of strontium-82, which may be extracted from potassium-bearing minerals such as micas, is used for dating episodes of heating and deformation in rocks.

Salient Statistics—United States: Rubidium imported into the United States is produced as a byproduct from one mine in Canada. Production data are not available, and similarly, U.S. consumption, export, and import data are not available. In the United States, consumption of rubidium is small and may amount to only a few thousand kilograms per year. Rubidium is not traded; therefore, no market price is available. In 2006, one company offered 1-gram ampoules of 99.75%-grade rubidium (metals basis) at $58.20 each, and the price for 100 grams of the same material was $1,118.00.

Recycling: None.

Import Sources (2002-05): Canada is the source of rubidium ore imported by the United States, and the United States is 100% import reliant.

Tariff:

Item	Number	Normal Trade Relations 12-31-06
Alkali metals, other	2805.19.9000	5.5% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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RUBIDIUM

Events, Trends, and Issues: Coal combustion may release small amounts of rubidium to the atmosphere; however, there have been no adverse environmental or human health issues associated with the processing or use of rubidium. Consumption of rubidium and its compounds is not commercially significant, and no change in use patterns is anticipated. Because of the environmental concern for mercury releases from lamps, rubidium halide cathodes are being researched as substitutes for use in low-pressure, mercury-free lamps.

World Mine Production, Reserves, and Reserve Base:[1] During the crystallization of pegmatites, rubidium may be taken up in trace amounts in the lattices of potassium feldspars and micas. The chief rubidium minerals, lepidolite and pollucite, may be found in some zoned pegmatites, which are exceptionally coarse-grained igneous rocks that form late in the crystallization of a silicic magma. Lepidolite, which is a lithium-bearing mica, is the principal ore mineral of rubidium and may contain up to 3.15% rubidium. Pollucite, which is a cesium aluminosilicate mineral, may contain up to 1.35% rubidium. There are no minerals in which rubidium is the predominant metallic element. Canada is the world's leading producer of rubidium, and supplies of rubidium-bearing lepidolite from Canada are adequate for current use patterns.

World Resources: World resources of rubidium are unknown. Rubidium-bearing pegmatites are found in several locations in Canada, and there are also pegmatite occurrences in Afghanistan, Namibia, Peru, Zambia, and other countries. Brines in northern Chile and China have minor amounts of rubidium. Evaporites in France, Germany, and the United States (New Mexico and Utah) are reported to contain rubidium.

Substitutes: Rubidium and cesium are close together on the Periodic Table, have similar atomic radii, and, therefore, have similar physical properties. These metals may be used interchangeably in most applications.

[1]See Appendix C for definitions.

SALT

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Domestic production of salt was adequate in 2006. The total value was estimated to be more than $1 billion. Twenty-nine companies operated 64 plants in 15 States. The estimated percentage of salt sold or used, by type, was salt in brine, 46%; rock salt, 39%; vacuum pan, 8%; and solar salt, 7%.

The chemical industry consumed nearly 39% of total salt sales, with salt in brine representing about 90% of the type of salt used for feedstock. The chlorine and caustic soda manufacturing sector was the main consumer within the chemical industry. Salt for highway deicing accounted for 37% of U.S. demand. The remaining markets for salt, in declining order, were distributors, 8%; industrial, 7%; agricultural, 3%; food, 3%; water treatment, 2%; and other combined with exports, 1%.

Salient Statistics—United States:[1]	2002	2003	2004	2005	2006[e]
Production	40,300	43,700	46,500	45,100	46,000
Sold or used by producers	37,700	41,100	45,000	45,000	46,700
Imports for consumption	8,160	12,900	11,900	12,100	10,000
Exports	689	718	1,110	879	1,000
Consumption:					
Reported	43,600	50,200	50,700	53,100	55,700
Apparent	45,100	53,200	55,800	56,200	55,700
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant:					
Vacuum and open pan salt	120.02	124.24	128.39	128.39	145.00
Solar salt	53.93	53.42	49.25	49.25	52.00
Rock salt	21.62	23.11	25.83	25.83	23.00
Salt in brine	5.89	7.21	7.01	7.01	8.00
Stocks, producer, yearend[e, 2]	NA	NA	NA	NA	NA
Employment, mine and plant, number	4,100	4,100	4,100	4,100	4,100
Net import reliance[3] as a percentage of apparent consumption	17	17	23	20	16

Recycling: None.

Import Sources (2002-05): Canada, 36%; Chile, 29%; The Bahamas, 9%; Mexico, 9%; and other, 17%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Iodized salt	2501.00.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

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SALT

Events, Trends, and Issues: The rising demand for salt in Asia prompted some salt producers to increase production capacity. China, which had relied on imports from India to satisfy its salt requirements, increased production capacity by an additional 6 million tons. In Australia, the world's leading solar salt exporter spent $11 million to raise annual capacity at Lake McLeod by 500,000 tons, bringing total company annual capacity to more than 9 million tons. Another company contemplated constructing a new 3-million-ton-per-year solar salt operation in Yanarrie, Australia. In North America, the company that operates the world's largest underground rock salt mine at Goderich, Ontario, Canada, increased annual capacity by 750,000 tons; that raised the mine's total annual capacity to 7.25 million tons.

By October, water surface temperatures and jet stream patterns over the Pacific Ocean created weak El Niño conditions that reportedly indicated that the winter of 2006-07 was expected to be mild throughout the United States. The warmer winter would result in reduced rock salt consumption for highway deicing. Salt inventories throughout many regions of the country were adequate to handle most snow and ice emergencies.

Domestic consumption of salt in 2006 is expected to be similar to that of 2005. No shortage of rock salt is anticipated for the winter of 2006-07.

World Production, Reserves, and Reserve Base:

	Production 2005	Production 2006[e]	Reserves and reserve base[4]
United States[1]	45,100	46,000	Large. Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans contain a virtually inexhaustible supply of salt.
Australia	12,384	12,400	
Brazil	6,660	7,300	
Canada	14,500	15,000	
Chile	4,940	6,100	
China	44,547	48,000	
Egypt	2,400	2,400	
France	7,000	7,000	
Germany	18,672	18,600	
India	15,503	16,000	
Iran	2,000	2,000	
Italy	3,600	3,600	
Mexico	9,242	8,500	
Netherlands	5,000	5,000	
Poland	5,000	5,000	
Romania	2,445	2,500	
Russia	2,800	2,800	
Spain	3,200	3,200	
Turkey	2,200	2,200	
Ukraine	2,300	2,400	
United Kingdom	5,800	5,800	
Other countries	22,700	18,000	
World total (rounded)	238,000	240,000	

World Resources: World continental resources of salt are practically unlimited, and the salt content in the oceans is virtually inexhaustible. 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. NA Not available.
[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 to 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 $7.9 billion was produced by an estimated 3,800 companies from about 6,000 operations in 50 States. Leading producing States, in order of decreasing tonnage, were California, Arizona, Texas, Michigan, Minnesota, Nevada, Ohio, Washington, Colorado, and Wisconsin, which together accounted for about 54% of the total output. It is estimated that about 49% of the 1.28 billion tons of construction sand and gravel produced in 2006 was for unspecified uses. Of the remaining total, about 45% was used as concrete aggregates; 22% for road base and coverings and road stabilization; 14% as construction fill; 12% as asphaltic concrete aggregates and other bituminous mixtures; 2% for plaster and gunite sands; 1% for concrete products, such as blocks, bricks, and pipes; and the remaining 4% for filtration, railroad ballast, roofing granules, snow and ice control, 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 2006, was about 963 million tons, an increase of 1.4% compared with the revised total for the same period in 2005. Additional production information by quarter for each State, geographic region, and the United States is published by the U.S. Geological Survey (USGS) in its quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production	1,130	1,160	1,240	1,270	1,280
Imports for consumption	4	4	5	7	8
Exports	3	1	1	1	1
Consumption, apparent	1,130	1,160	1,240	1,280	1,290
Price, average value, dollars per ton	5.07	5.16	5.33	5.86	6.15
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mines, mills, and shops, number	37,100	36,500	37,000	37,700	38,000
Net import reliance[3] as a percentage of apparent consumption	([4])	([4])	([4])	1	1

Recycling: Asphalt road surface layers and cement concrete surface layers and structures were recycled on an increasing basis.

Import Sources (2002-05): Canada, 77%; Mexico, 17%; The Bahamas, 2%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Sand, construction	2505.90.0000	Free.
Gravel, construction	2517.10.0000	Free.

Depletion Allowance: Common varieties, 5% (Domestic and foreign).

Government Stockpile: None.

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SAND AND GRAVEL (CONSTRUCTION)

Events, Trends, and Issues: Construction sand and gravel output increased to approximately 1.28 billion tons, a slight increase compared with that of 2005. It is estimated that 2007 domestic production will increase to 1.29 billion tons and U.S. apparent consumption will increase to about 1.3 billion tons. Aggregate consumption in 2006 is expected to grow more slowly than in 2005 in response to a declining housing market and limited growth in outlays for roads and highways. Substantial growth in nonresidential construction should help to offset decreases in home construction. Most areas of the country will likely experience increased sales and consumption of sand and gravel. Crushed stone, the other major construction aggregate, has been replacing natural sand and gravel, especially in more densely populated areas of the Eastern United States.

The construction sand and gravel industry continues to be concerned with environmental, health, and safety regulations. Movement of sand and gravel operations away from densely populated centers is expected to continue where environmental, land development, and local zoning regulations discourage them. Consequently, shortages of construction sand and gravel in industrialized and urban areas also are expected to increase.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2005	2006[e]	
United States	1,270	1,280	The reserves and reserve base are controlled largely by land use and/or environmental concerns.
Other countries[6]	NA	NA	
World total	NA	NA	

World Resources: Sand and gravel resources of the world are large. However, because of environmental restrictions, geographic distribution, and quality requirements for some uses, sand and gravel extraction is uneconomic in some cases. The most important commercial sources of sand and gravel have been glacial deposits, river channels, and river flood plains. Use of offshore deposits in the United States is mostly restricted to beach erosion control and replenishment. Other countries routinely mine offshore deposits of aggregates for onshore construction projects.

Substitutes: Crushed stone remains the predominant choice for construction aggregate use. Increasingly, recycled asphalt and portland cement concretes are being substituted for virgin aggregate, although the percentage of total aggregate supplied by recycled materials remained very small in 2006.

[e]Estimated. NA Not available.
[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 are not available and assumed to be zero.
[4]Less than ½ unit.
[5]See Appendix C for definitions.
[6]No reliable production information for other countries is available owing to the wide variety of ways in which countries report their sand and gravel production. Some countries do not report production for this mineral commodity. Production information for some countries is available in the country chapters of the USGS Minerals Yearbook.

SAND AND GRAVEL (INDUSTRIAL)[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Industrial sand and gravel valued at about $767 million was produced by 73 companies from 151 operations in 34 States. Leading States, in order of tonnage produced, were Illinois, Texas, Wisconsin, California, New Jersey, Michigan, Oklahoma, and Minnesota. Combined production from these States represented 60% of the domestic total. About 35% of the U.S. tonnage was used as glassmaking sand, 18% as foundry sand, 14% as well-packing and cementing sand, 8% as building products, 3% as abrasive sand, and 22% for other uses.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production	27,300	27,500	29,700	30,600	31,900
Imports for consumption	250	440	490	711	789
Exports	1,410	2,620	1,790	2,910	3,000
Consumption, apparent	26,100	25,300	28,400	28,400	29,700
Price, average value, dollars per ton	20.98	22.14	23.06	24.57	23.98
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e]	1,400	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 (2002-05): Mexico, 49%; Canada, 44%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

Events, Trends, and Issues: Domestic sales of industrial sand and gravel in 2006 increased by about 4% compared with those of 2005, owing to a robust construction sector of the U.S. economy and worldwide demand. U.S. apparent consumption was 29.7 million tons in 2006, a 4% increase from that of the previous year. Imports of industrial sand and gravel in 2006 increased by about 11% compared with those of 2005. Mexico's share of imports increased, and Canada's share increased as well. Imports of silica are generally of two types: small shipments of very high-purity silica or a few large shipments of lower grade silica shipped only under special circumstances (for example, very low freight rates). Exports of industrial sand and gravel in 2006 increased by about 3% compared with those of 2005. Strong overseas demand coupled with continued growth in the U.S. home construction sector is expected to help maintain a robust industrial sand and gravel industry.

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SAND AND GRAVEL (INDUSTRIAL)

The United States was the world's leading 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 from country to country. The United States remained a major exporter of silica sand and gravel, shipping it 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 sand and gravel, meeting virtually every specification.

The industrial sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions in 2006. Local shortages were expected to continue to increase owing to local zoning regulations and land development alternatives. These situations are expected to cause future sand and gravel operations to be located farther from high-population centers.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e] 2005	Mine production[e] 2006	Reserves and reserve base[3]
United States	30,600	31,900	
Australia	4,000	4,000	Large. Industrial sand and gravel deposits are widespread. Calculation of the reserves and reserve base is determined mainly by the location of population centers.
Austria	6,800	6,800	
Belgium	1,800	1,800	
Brazil	1,600	1,600	
Canada	1,600	1,600	
France	6,500	6,500	
Gambia	1,530	1,400	
Germany	8,160	8,200	
India	1,600	1,600	
Iran	1,900	1,900	
Italy	3,000	3,000	
Japan	4,750	4,800	
Mexico	2,078	2,100	
Norway	1,600	1,600	
Poland	1,500	1,500	
Romania	1,500	1,500	
Slovakia	2,000	2,000	
Slovenia	11,000	11,000	
South Africa	2,754	2,800	
Spain	6,500	6,500	
Turkey	1,200	1,200	
United Kingdom	4,500	4,500	
Other countries	9,500	9,500	
World total (rounded)	118,000	120,000	

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, extraction of these resources is sometimes uneconomic. Quartz-rich sand and sandstones, the main sources of industrial silica sand, occur throughout the world.

Substitutes: Alternative materials that can be used for glassmaking and for foundry and molding sands are chromite, olivine, staurolite, and zircon sands.

[e]Estimated. E Net exporter. NA Not available.
[1]See also Sand and Gravel (Construction).
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.

SCANDIUM[1]

(Data in kilograms of scandium oxide content unless otherwise noted)

Domestic Production and Use: Demand for scandium increased slightly in 2006. Although scandium was not mined domestically in 2006, quantities sufficient to meet demand were available in domestic tailings. Principal sources were imports from China, Russia, and Ukraine. Domestic companies with scandium-processing capabilities were located in Mead, CO, and Urbana, IL. 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 2006 were aluminum alloys for sporting equipment (baseball and softball bats, bicycle frames, golf clubs, gun frames, lacrosse shafts, and tent poles), metallurgical research, high-intensity metal halide lamps, analytical standards, electronics, oil well tracers, and lasers.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Price, yearend, dollars:					
Per kilogram, oxide, 99.0% purity	700	500	500	500	700
Per kilogram, oxide, 99.9% purity	2,000	1,300	1,300	1,300	1,400
Per kilogram, oxide, 99.99% purity	2,500	2,500	2,500	2,500	1,450
Per kilogram, oxide, 99.999% purity	3,200	3,200	3,200	3,000	1,500
Per kilogram, oxide, 99.9999% purity	NA	NA	NA	NA	2,100
Per gram, dendritic, metal[2]	178.00	185.00	193.60	162.50	208.00
Per gram, metal, ingot[3]	198.00	119.00	124.00	131.00	131.00
Per gram, scandium acetate, 99.99% purity[4]	65.40	68.70	68.70	70.30	74.00
Per gram, scandium chloride, 99.9% purity[4]	40.80	42.40	44.30	48.70	48.70
Per gram, scandium fluoride, 99.9% purity[4]	173.00	180.00	188.20	193.80	193.80
Per gram, scandium iodide, 99.999% purity[4]	156.00	162.00	169.00	174.00	174.00
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2002-05): Not available.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Mineral substances not elsewhere specified or included: Including scandium ores	2530.90.8050	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 increased for the lower grades and decreased for the higher purities from those of the previous year. The supply of domestic and foreign scandium remained strong despite increased demand. Although demand increased in 2006, 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. New demand is expected to come from future fuel-cell markets and aerospace applications.

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SCANDIUM

Scandium's use continued to increase in metal halide lighting. Scandium, as the metal or the iodide, mixed with other elements, was added to halide light bulbs to adjust the color to simulate natural sunlight. Demand also continued to increase for scandium-aluminum alloys in sports equipment. Future development of alloys for aerospace and specialty markets is expected. Scandium's availability from Kazakhstan, Russia, and Ukraine increased substantially in 1992, after export controls were relaxed, and sales continue to provide the Western World with most of its scandium alloys, compounds, and metal. China also continued to supply scandium compounds and metal to the U.S. market.

World Mine Production, Reserves, and Reserve Base:[6] Scandium was produced as a byproduct material in China, Kazakhstan, Russia, and Ukraine. Foreign mine production data were not available. No scandium was mined in the United States in 2006. Scandium occurs in many ores in trace amounts, but has not been found in sufficient quantities to be considered as a reserve or reserve base. 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 because of its lack of affinity to combine with the common ore-forming anions. It is widely dispersed in the lithosphere and forms solid solutions in more than 100 minerals. In the Earth's crust, scandium is primarily a trace constituent of ferromagnesium minerals. Concentrations in these minerals (amphibole-hornblende, biotite, and pyroxene) 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 aluminum phosphate minerals, beryl, cassiterite, columbite, garnet, muscovite, rare-earth minerals, and wolframite. 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 mined-out 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 also are contained in the tantalum residues previously processed at Muskogee, OK. Smaller resources are associated with molybdenum, titanium-tungsten, and tungsten minerals from the Climax molybdenum deposit in Colorado and in crandallite, kolbeckite, and variscite 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 iron, tin, and tungsten deposits in Fujian, Guangdong, Guangxi, Jiangxi, 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]See also Rare Earths.
[2]Scandium pieces, 99.9% purity, distilled dendritic, 2002-06 prices converted from 0.5-gram price, from Alfa Aesar, a Johnson Matthey company.
[3]Metal ingot pieces, 99.9% purity, 2002-06, from Alfa Aesar, a Johnson Matthey company.
[4]Bromide, chloride, and fluoride in crystalline or crystalline aggregate form and scandium iodide as ultradry powder from Alfa Aesar, a Johnson Matthey company.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]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. One copper refinery in Texas reported production of primary selenium. One copper refiner exported semirefined selenium for toll-refining in Asia, and two other refiners generated selenium-containing slimes, which were exported for processing.

In glass manufacturing, selenium is used to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass and is used in architectural plate glass to reduce solar heat transmission. Cadmium sulfoselenide pigments are used in plastics, ceramics, art glass, and other glasses, such as that used in traffic lights to produce a ruby-red color. Selenium is used in catalysts to enhance selective oxidation; in plating solutions, where it improves appearance and durability; in blasting caps and gun bluing; in rubber compounding chemicals; in the electrolytic production of manganese to increase yields; and in brass alloys to improve machinability.

Selenium is used as a human dietary supplement and in antidandruff shampoos. The leading agricultural uses are as a dietary supplement for livestock and as a fertilizer additive to enrich selenium-poor soils. It is used as a metallurgical additive to improve machinability of copper, lead, and steel alloys. Its primary electronic use is as a photoreceptor on the replacement drums for older plain paper photocopiers, which are gradually being replaced by newer models that do not use selenium in the reproduction process. A new use for selenium is in amorphous selenium (aSe) detector technology. The aSe detector enables the direct conversion of X-ray to digital information.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, refinery	W	W	W	W	W
Imports for consumption, metal and dioxide	422	367	412	589	430
Exports, metal, waste and scrap	87	249	160	315	140
Consumption, apparent	W	W	W	W	W
Price, dealers, average, dollars per pound, 100-pound lots, refined	4.27	5.68	24.86	51.44	30.00
Stocks, producer, refined, yearend	W	W	W	W	W
Net import reliance[1] as a percentage of apparent consumption	W	W	W	W	W

Recycling: The amount of domestic production of secondary selenium was unknown. Scrap xerographic materials were exported for recovery of the contained selenium. As electronic recycling continues to increase, a small amount of selenium may become available from other electronics.

Import Sources (2002-05): Belgium, 33%; Canada, 31%; Philippines, 15%; Germany, 6%; and other, 15%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-06**
Selenium metal	2804.90.0000	Free.
Selenium dioxide	2811.29.2000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The supply of selenium is directly affected by the supply of the materials from which it is a byproduct—copper, and to a lesser extent, nickel and cobalt. Estimated domestic selenium production increased in 2006 compared with that of 2005 owing to the resolution of a labor strike at the major domestic producer. The producer continued to operate under Chapter 11 for bankruptcy protection, which it had filed for during 2005.

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SELENIUM

China continued to use selenium as a fertilizer supplement and as an ingredient in glassmaking, and selenium dioxide as a substitute for sulfur dioxide in the manganese refining process. It is believed that consumption of selenium in China declined in 2005 and in the first quarter of 2006. Some of China's manganese refineries closed owing to higher selenium and electricity costs. The price of selenium dropped significantly during 2006 because of a decline in global consumption.

Domestic use of selenium in glass remained unchanged, while its use in copiers continued to decline. The use of selenium as a substitute for lead in free-machining brasses continued to increase as more stringent regulations on the use of lead were implemented. The use of selenium in fertilizers and supplements in the plant-animal-human food chain and as human vitamin supplements increased as its health benefits were documented. Although small amounts of selenium are considered beneficial, it can be hazardous in larger quantities.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[2]	Reserve base[2]
	2005	2006[e]		
United States	W	W	10,000	19,000
Belgium	200	200	—	—
Canada	300	310	6,000	10,000
Chile	82	81	16,000	37,000
Finland	62	62	—	—
Germany	14	12	—	—
India	13	13	—	—
Japan	635	630	—	—
Peru	21	17	5,000	8,000
Philippines	40	40	2,000	3,000
Sweden	20	20	—	—
Other countries[3]	NA	NA	43,000	92,000
World total (rounded)	[4]1,390	[4]1,390	82,000	170,000

World Resources: The reserve base for selenium is based on identified copper deposits. Coal generally contains between 0.5 and 12 parts per million of selenium, or about 80 to 90 times the average for copper deposits. The recovery of selenium from coal, although technically feasible, does not appear likely in the foreseeable future. A recent assessment of U.S. copper resources indicated that total copper resources in identified and undiscovered resources totals about 550 million metric tons, almost 8 times the estimated U.S. copper reserve base.

Substitutes: High-purity silicon has replaced selenium in high-voltage rectifiers. Silicon is also the major substitute for selenium in low- and medium-voltage rectifiers and solar photovoltaic cells. Amorphous silicon and organic photoreceptors are substitutes in plain paper photocopiers. Organic pigments have been developed as substitutes for cadmium sulfoselenide pigments. Other substitutes include cerium oxide as either a colorant or decolorant in glass; tellurium in pigments and rubber; bismuth, lead, and tellurium in free-machining alloys; and bismuth and tellurium in lead-free brasses. Sulfur dioxide can be used as a replacement for selenium dioxide in the production of electrolytic manganese metal.

[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.
[3]In addition to the countries listed, Australia, China, Kazakhstan, Russia, and the United Kingdom are known to produce refined selenium, but output is not reported, and information is inadequate for formulation of reliable production estimates.
[4]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 2006 was about $354 million. Five companies produced silicon materials in six plants. Of those companies, four produced ferrosilicon in four plants. Silicon metal was produced by two companies in four plants. Two of the five companies in the industry produced both products at two plants. All 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 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:	2002	2003	2004	2005	2006[e]
Production:					
Ferrosilicon, all grades[1]	150	117	128	125	143
Silicon metal	111	136	147	145	W
Imports for consumption					
Ferrosilicon, all grades[1]	140	189	173	197	220
Silicon metal	145	126	165	152	147
Exports:					
Ferrosilicon, all grades[1]	7	6	6	8	5
Silicon metal	15	20	18	23	27
Consumption, apparent:					
Ferrosilicon, all grades[1]	301	304	297	317	356
Silicon metal	240	240	291	275	W
Price,[2] average, cents per pound Si:					
Ferrosilicon, 50% Si	41.1	47.7	58.2	55.0	62
Ferrosilicon, 75% Si	32.8	45.3	55.4	48.0	54
Silicon metal	53.2	61.3	81.9	76.2	77
Stocks, producer, yearend:					
Ferrosilicon, all grades[1]	21	17	15	13	14
Silicon metal	4	5	7	6	W
Net import reliance[3] as a percentage of apparent consumption:					
Ferrosilicon, all grades[1]	50	62	57	61	60
Silicon metal	54	43	50	47	≤50

Recycling: Insignificant.

Import Sources (2002-05): Ferrosilicon: China, 26%; Venezuela, 20%; Russia, 11%; Norway, 9%; and other, 34%. Silicon metal: Brazil, 37%; South Africa, 25%; Canada, 14%; Norway, 6%; and other, 18%. Total: Brazil, 20%; China, 16%; South Africa, 13%; Canada, 12%; and other, 39%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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, 15% (Domestic and foreign); gravel, 5% (Domestic and foreign).

Government Stockpile: None.

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SILICON

Events, Trends, and Issues: Domestic ferrosilicon production in 2006, expressed in terms of contained silicon, was expected to increase by 14% from that in 2005. The number of silicon metal producers in the United States fell to two from three during 2006, as one of the existing companies acquired another. As a result, U.S. silicon metal statistics have been withheld to avoid disclosing company proprietary data. Through the first 10 months of 2005, spot market prices trended upward in the U.S. market for silicon materials owing primarily to increased demand for ferrosilicon materials in the summer and disruptions in domestic silicon metal production coupled with high energy costs.

Demand for silicon metal comes primarily from the aluminum and chemical industries. In the first 8 months of 2006, domestic chemical production was nearly unchanged compared with that in 2005. Domestic primary aluminum production was projected to decrease by 7% in 2006. Domestic apparent consumption of ferrosilicon in 2006 was projected to increase by 17% compared with that of 2005. 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, but through the first 8 months of 2006, domestic steel production was 10% higher than that for the same period in 2005.

World Production, Reserves, and Reserve Base:

	Production[e, 4]		Reserves and reserve base[5]
	2005	**2006**	
United States	270	[6]143	The reserves and reserve base in most major producing countries are ample in relation to demand. Quantitative estimates are not available.
Brazil	226	230	
Canada	66	60	
China	2,360	2,400	
France	139	140	
Iceland	78	78	
India	36	36	
Kazakhstan	68	70	
Norway	278	270	
Russia	526	600	
South Africa	131	130	
Spain	55	55	
Ukraine	161	140	
Venezuela	60	60	
Other countries	289	310	
World total (rounded)	4,720	4,700	

Ferrosilicon accounts for about four-fifths of world silicon production (gross-weight basis).The leading countries for ferrosilicon production, in descending order of production, were China, Russia, Norway, Ukraine, and Brazil, and for silicon metal, China, Brazil, and Norway. China was by far the leading producer of both ferrosilicon and silicon metal. An estimated 550,000 tons of silicon metal is included in China's production of silicon materials for 2006.

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. W Withheld to avoid disclosing company proprietary data.
[1]Ferrosilicon grades include the two standard grades of ferrosilicon—50% and 75%—plus miscellaneous silicon alloys.
[2]Based on U.S. dealer import price.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]Production quantities are combined totals of estimated silicon content for ferrosilicon and silicon metal, as applicable, except as noted.
[5]See Appendix C for definitions.
[6]Ferrosilicon only.

SILVER

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

Domestic Production and Use: In 2006, approximately 1,100 tons of silver with an estimated value of nearly $400 million were produced in the United States. Alaska continued as the country's leading silver-producing State, followed by Nevada; however, company production data are proprietary and were withheld. Domestic silver was produced as a byproduct from 36 base- and precious-metal mines. There were 21 principal refiners of commercial-grade silver, with an estimated total output of 3,000 tons from domestic and foreign ores and concentrates, and from old and new scrap. The physical properties of silver include ductility, electrical conductivity, malleability, and reflectivity. Silver's traditional use categories include coins and medals, industrial applications, jewelry and silverware, and photography. However, in April 2006, an important new category, the silver exchange traded fund (ETF), which was modeled after the gold ETF that was started in 2003, was established. Under the ETF, physical silver is held by an investment agency. At the same time, the demand for silver in industrial applications is increasing and includes use of silver in bandages for wound care, batteries, brazing and soldering, in cell phone covers to reduce the spread of bacteria, in clothing to minimize odor, in catalytic converters in automobiles, electronics and circuit boards, electroplating, hardening bearings, mirrors, solar cells, wood treatment to resist mold, and water purification. Silver and mercury, the main components of dental amalgam, are biocides and their use in amalgam inhibits recurrent decay. Silver was widely used for miniature antennas in Radio Frequency Identification Devices (RFIDs) that were used in passports and on packages to keep track of inventory shipments.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Mine	1,350	1,240	1,250	1,230	1,100
Refinery:					
Primary	2,580	2,580	1,140	2,530	1,000
Secondary	1,030	1,010	1,920	980	1,050
Imports for consumption[2]	4,300	4,510	4,100	3,880	4,000
Exports[2]	680	181	422	166	500
Consumption, apparent[e]	5,980	6,440	6,700	5,750	6110
Price, dollars per troy ounce[3]	4.62	4.91	6.69	7.34	11.20
Stocks, yearend:					
Treasury Department[4]	220	220	220	220	220
COMEX, CBT[5]	3,290	3,430	3,580	3,750	3,290
Exchange Traded Fund	—	—	—	—	3,330
Employment, mine and mill,[6] number	910	840	900	900	800
Net import reliance[7] as a percentage of apparent consumption[e]	60	65	53	61	65

Recycling: Approximately 1,000 tons of silver was recovered from old and new scrap in 2006. This includes 60 to 90 tons of silver that are reclaimed and recycled annually from photographic wastewater.

Import Sources (2002-05):[2] Mexico, 51%; Canada, 34%; Peru, 12%; Chile, 2%; and other, 1%.

Tariff: No duties are imposed on imports of unrefined silver or refined bullion.

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

Government Stockpile: All of the remaining silver in the National Defense Stockpile was transferred to the U.S. Mint by the Defense Logistics Agency for use in the manufacture of numismatic and bullion coins by yearend 2004. This transfer marked the end of silver requirements for the National Defense Stockpile.

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SILVER

Events, Trends, and Issues: In 2006, silver prices continued to rise and averaged $11.20 per troy ounce, surpassing 2005's high of $7.34, 2004's 17-year high of $6.69, and 1987's high of $6.99. Prices rose to more than $14.00 per troy ounce in April and May in response to investment interest in the silver ETF, which was established in late April. Demand also rose for the use of silver in fabrication and industrial applications. Photographic use of silver was relatively stable, and losses to digital photography because of weak film sales were offset by the use of high-purity silver for color paper. Silver is still used in X-ray films, and 99% of the silver in photographic wastewater may be recovered. The use of trace amounts of silver in bandages for wound care and minor skin infections is increasing. Sports and everyday clothing may be embedded with silver, which will help regulate body heat and control odor. The deficit in world silver production as compared with world silver demand was about 700 t in 2006.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	2005	2006[e]		
United States	1,230	1,100	25,000	80,000
Australia	2,050	2,150	31,000	37,000
Canada	1,120	1,310	16,000	35,000
Chile	1,400	1,400	NA	NA
China	2,500	2,550	26,000	120,000
Mexico	2,890	3,000	37,000	40,000
Peru	3,190	3,200	36,000	37,000
Poland	1,300	1,300	51,000	140,000
South Africa	89	90	NA	NA
Other countries	3,500	3,400	50,000	80,000
World total (rounded)	19,300	19,500	270,000	570,000

World Resources: Silver was obtained as a byproduct from processing copper, gold, and lead-zinc ores. More than two-thirds of U.S. and world resources of silver are contained in such polymetallic deposits. The remaining silver resources are in veins in which gold is the primary commodity, and most recent silver discoveries have been associated with gold occurrences. However, base-metal discoveries that contain byproduct silver will account for a significant share of future reserves and resources.

Substitutes: Aluminum and rhodium may be used to replace silver used in mirrors and other reflecting surfaces. Tantalum and titanium may be used for surgical plates and pins in place of silver. Stainless steel may be substituted for silver flatware, and germanium added to silver will help keep tableware from tarnishing. Nonsilver batteries may replace silver batteries in some applications. Alternatives to silver use in traditional photographic applications include digital imaging, film with reduced silver content, silverless black and white film, and xerography.

[e]Estimated. NA Not available. — Zero.
[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Refined bullion, doré, and other unwrought silver; 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: U.S. Department of Labor, Mine Safety and Health Administration.
[7]Defined as imports – exports + adjustments for Government and industry stock changes.
[8]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: The total value of domestic soda ash (sodium carbonate) produced in 2006 was estimated to be about $928 million.[1] The U.S. soda ash industry comprised four companies in Wyoming operating five plants, one company in California with one plant, and one company with one mothballed plant in Colorado that owns one of the Wyoming plants. The five producers have a combined annual nameplate capacity of 14.5 million tons. Salt, sodium sulfate, and borax were produced as coproducts of sodium carbonate production in California. Sodium bicarbonate, sodium sulfite, and chemical caustic soda were manufactured as coproducts at several of the Wyoming soda ash plants. Sodium bicarbonate was produced at the Colorado operation using soda ash feedstock shipped from the company's Wyoming facility.

Based on final 2005 reported data, the estimated 2006 distribution of soda ash by end use was glass, 49%; chemicals, 27%; soap and detergents, 10%; distributors, 5%; miscellaneous uses, 4%; flue gas desulfurization and pulp and paper, 2% each, and water treatment, 1%.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production[2]	10,500	10,600	11,000	11,000	10,900
Imports for consumption	9	5	6	8	6
Exports	4,250	4,450	4,670	4,680	4,800
Consumption:					
Reported	6,430	6,270	6,260	6,200	6,000
Apparent	6,250	6,090	6,290	6,380	6,000
Price:					
Quoted, yearend, soda ash, dense, bulk:					
F.o.b. Green River, WY, dollars per short ton	105.00	105.00	105.00	155.00	170.00
F.o.b. Searles Valley, CA, same basis	130.00	130.00	130.00	180.00	195.00
Average sales value (natural source), f.o.b. mine or plant, dollars per short ton	68.00	65.21	63.75	80.19	85.00
Stocks, producer, yearend	222	330	338	243	300
Employment, mine and plant, number	2,600	2,600	2,600	2,600	2,500
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 (2002-05): Canada, 98%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Disodium carbonate	2836.20.0000	1.2% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: In late 2005, a major synthetic soda ash producer in India acquired the soda ash operations in England, Kenya, and the Netherlands from the only soda ash producer based in England. A second Indian soda ash manufacturer purchased one of the soda ash plants in Romania for $24 million during the same time period. In 2006, this same manufacturer bought the second soda ash plant in Romania and intended to purchase all or part of one of the U.S. soda ash companies. These transactions, combined with plants in its own country, established India as the third leading soda ash-producing nation in the world.

A Chinese investment group based in Beijing built a soda ash plant for $100 million in Kungrad, in the area of western Uzbekistan locally known as the Republic of Karakalpakstan. The facility was scheduled to produce 100,000 tons of soda ash annually using salt from Barsakelmes and limestone from Jamansay. Uzbekistan will consume about 60,000 tons to 70,000 tons each year and export the remainder.

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SODA ASH

Although the U.S. soda ash industry posted higher average annual values in 2005, most of the increases included energy and transportation surcharges. Because of China's increased soda ash production posing a barrier to U.S. export sales in the Far East markets, the U.S. Congress passed legislation to aid the Wyoming soda ash industry's global competitiveness by reducing the federal royalty rate from 6% to 2% for a 5-year period.

In May 2006, a major domestic soda ash producer announced a $15 per short ton increase in the list and off-list price of soda ash effective July 1 or as contracts permit. Other producers soon followed this price move. The same company made a second price increase announcement in September that would raise the off-list price another $10 per short ton. One other company followed this move, but other companies remained uncommitted by yearend.

The economic slowdowns in the domestic automobile construction and the building construction industries affected soda ash consumption in 2006. Notwithstanding the continuing economic and energy problems in certain areas of the world, overall global demand for soda ash is expected to grow from 1.5% to 2% annually for the next several years. If the domestic economy improves, U.S. demand may be slightly higher in 2007.

World Production, Reserves, and Reserve Base:

	Production		Reserves[4, 5]	Reserve base[5]
Natural:	2005	2006[e]		
United States	11,000	10,900	[6]23,000,000	[6]39,000,000
Botswana	250	280	400,000	NA
Kenya	360	360	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 (rounded)	11,600	11,500	24,000,000	40,000,000
World total, synthetic (rounded)	30,400	31,500	XX	XX
World total (rounded)	42,000	43,000	XX	XX

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 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 conventional and continuous mining, is the primary method of mining Wyoming trona ore. The method has an average 45% mining recovery, whereas average recovery from solution mining is 30%. Improved solution-mining techniques, such as horizontal drilling to establish communication between well pairs, could increase this extraction rate and entice companies to develop some of the deeper trona beds. 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. XX Not applicable. — 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, one each in California and Texas. Fourteen companies operating 17 plants in 14 States recovered byproduct sodium sulfate from various manufacturing processes or products, including ascorbic acid, battery reclamation, cellulose, rayon, and silica pigments. About one-half of the total output was a byproduct of these plants in 2006. The total value of natural and synthetic sodium sulfate sold was an estimated $70 million. Estimates of U.S. sodium sulfate consumption by end use were soap and detergents, 46%; pulp and paper, 13%; textiles, 12%; glass, 11%; carpet fresheners, 7%; and miscellaneous, 11%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, total (natural and synthetic)[1]	500	466	469	467	480
Imports for consumption	51	45	49	75	65
Exports	139	154	138	149	140
Consumption, apparent (natural and synthetic)	412	357	380	393	405
Price, quoted, sodium sulfate (100% Na_2SO_4), bulk, f.o.b. works, East, dollars per short ton	114	114	114	134	134
Employment, well and plant, number[e]	225	225	225	225	225
Net import reliance[2] as a percentage of apparent consumption	E	E	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 (2002-05): Canada, 90%; Mexico, 6%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

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SODIUM SULFATE

Events, Trends, and Issues: Both U.S. and Canadian natural sodium sulfate producers implemented energy surcharges on all shipments of sodium sulfate because escalating energy costs affected operating economics. Domestic producers used the New York Mercantile Exchange Henry Hub to base surcharges on the fifteenth day of the month preceding the beginning of each quarter, whereas Canadian natural sodium sulfate operators used the Natural Gas Exchange (AECO) that based quarterly surcharges on the AECO monthly index average for the previous quarter.

The primary use of sodium sulfate worldwide is in powdered detergents. Sodium sulfate is a low-cost, inert, white filler in home laundry detergents. 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 increase. Asia and Latin America are major markets for sodium sulfate consumption because of the increasing demand for packaged powder detergents. Sodium sulfate consumption in the domestic textile industry also has been declining because of imports of less expensive textile products.

The outlook for sodium sulfate in 2007 is expected to be comparable with that of 2006, with detergents remaining the leading sodium-sulfate-consuming sector. If the winter of 2006-07 is relatively mild, byproduct recovery of sodium sulfate from automobile batteries may decline because fewer battery failures during mild winter weather reduce recycling. World production and consumption of sodium sulfate have been stagnant but are expected to increase 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 to be between 1.5 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 with reserves listed above, the following countries also possess 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's 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 also can be obtained as a byproduct from the production of ascorbic acid, battery recycling, 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 $13.1 billion was produced by 1,200 companies operating 3,200 quarries, 85 underground mines, and 190 sales/distribution yards in 50 States. Leading States, in descending order of production, were Texas, Florida, Pennsylvania, Missouri, Virginia, Georgia, Illinois, Ohio, North Carolina, and Tennessee, together accounting for 54% of the total crushed stone output. Of the total crushed stone produced in 2006, about 70% was limestone and dolomite; 16%, granite; 8%, traprock; and the remaining 6% was shared, in descending order of tonnage, by sandstone and quartzite, miscellaneous stone, marble, volcanic cinder and scoria, calcareous marl, shell, and slate. It is estimated that of the 1.69 billion tons of crushed stone consumed in 2006, 32% was for unspecified uses, and 18% was estimated for nonrespondents to the U.S. Geological Survey (USGS) canvasses. Of the remaining 850 million tons reported by use, 85% was used as construction aggregates, mostly for highway and road construction and maintenance; 13% for chemical and metallurgical uses, including cement and lime manufacture; 1% for agricultural uses; and 2% for special and miscellaneous uses and products. To provide a more accurate estimate of the consumption patterns for crushed stone, the “unspecified uses—reported and estimated,” as defined in the USGS Minerals Yearbook, are not included in the above percentages.

The estimated output of crushed stone in the 48 conterminous States shipped for consumption in the first 9 months of 2006 was 1.3 billion tons, a 1.3% decrease compared with that of the same period of 2005. Third quarter shipments for consumption decreased 3.5% compared with those of the same period of 2005. Additional production information, by quarter for each State, geographic division, and the United States, is reported in the USGS quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production	1,510	1,530	1,630	1,690	1,670
Imports for consumption	14	15	19	21	24
Exports	3	1	1	1	1
Consumption, apparent[3]	1,530	1,540	1,640	1,710	1,690
Price, average value, dollars per metric ton	5.71	5.98	6.08	7.18	7.75
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e, 4]	79,000	78,500	79,600	79,600	79,700
Net import reliance[5] as a percentage of apparent consumption	([6])	([6])	([6])	([6])	([6])

Recycling: Road surfaces made of asphalt and crushed stone and, to a lesser extent, cement concrete surface layers and structures, were recycled on a limited but increasing basis in most States. Asphalt road surfaces were recycled by 46 companies in 21 States, and concrete was recycled by 40 companies in 19 States. The amount of material recycled increased 13% compared with the amount in 2005.

Import Sources (2002-05): Mexico, 40%; Canada, 35%; The Bahamas, 23%; and other, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Crushed stone	2517.10.00	Free.

Depletion Allowance: (Domestic) 14% for some special uses; 5% if used as ballast, concrete aggregate, riprap, road material, and similar purposes.

Government Stockpile: None.

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STONE (CRUSHED)

Events, Trends, and Issues: Crushed stone output was 1.67 billion tons in 2006, a decrease of 1.2% compared with that of 2005. It is estimated that in 2007, domestic production and apparent consumption will be about 1.73 billion tons, a 2% increase. Gradual increases in demand for construction aggregates are anticipated after 2007 based on the expected volume of work on the infrastructure and an expanding U.S. economy. Long-term projected increases will be influenced by activity in the public and private construction sectors, as well as by construction work related to security measures being implemented around the Nation. Crushed stone f.o.b. prices are expected to increase, and the delivered prices of crushed stone are expected to increase, especially in and near metropolitan areas.

The crushed stone industry continued to be concerned with environmental, health, and safety regulations. Shortages in some urban and industrialized areas are expected to continue to increase owing to local zoning regulations and land-development alternatives. These issues are expected to continue and to cause new crushed stone quarries to locate away from large population centers.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[7]
	2005	2006[e]	
United States	1,690	1,670	Adequate except where special
Other countries[8]	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 crushed stone used as construction aggregates include sand and gravel, iron and steel 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]Data rounded to no more than three significant digits.
[4]Including office staff.
[5]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.
[6]Less than ½ unit.
[7]See Appendix C for definitions.
[8]No reliable production information for other countries is available owing to a wide variety of ways in which countries report their crushed stone production. Some countries do not report production for this mineral commodity. Production information for some countries is available in the country chapters of the USGS Minerals Yearbook.

STONE (DIMENSION)[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Approximately 1.5 million tons of dimension stone, valued at $275 million, was sold or used in 2006. Dimension stone was produced by 100 companies, operating 136 quarries, in 35 States. Leading producer States, in descending order by tonnage, were Wisconsin, Georgia, Indiana, Vermont, and Massachusetts. These five States accounted for about 62% of the production. Leading producer States, in descending order by value, were Indiana, Wisconsin, Vermont, Georgia, and South Dakota. These States contributed about 53% of the value of domestic production. Approximately 38%, by tonnage, of dimension stone sold or used was limestone, followed by granite (27%), marble (14%), sandstone (13%), miscellaneous stone (7%), and slate (1%). By value, the leading sales or uses were for granite (39%), followed by limestone (35%), sandstone (9%), marble (7%), miscellaneous stone (6%), and slate (4%). Rough block represented 64% of the tonnage and 54% of the value of all the dimension stone sold or used by domestic producers, including exports. The leading uses and distribution of rough block, by tonnage, were in flagging, exports, and unlisted and unspecified applications (36%) and construction (34%). Dressed stone mainly was sold for flagging (27%), curbing (24%), and ashlars and partially squared pieces (17%), by tonnage.

Salient Statistics—United States:[2]	**2002**	**2003**	**2004**	**2005**	**2006**[e]
Production:					
Tonnage	1,260	1,340	1,460	1,510	1,530
Value, million dollars	254	268	281	269	275
Imports for consumption, value, million dollars	1,190	1,390	1,790	2,180	2,500
Exports, value, million dollars	64	64	64	66	68
Consumption, apparent, value, million dollars	1,380	1,590	2,010	2,380	2,710
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)	82	83	86	88	89
Granite only:					
Production	431	463	429	416	416
Imports for consumption	NA	NA	NA	NA	NA
Exports (rough and finished)	140	144	143	135	135
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 (2002-05 by value): Dimension stone: Italy, 25%; Turkey, 20%; China, 9%; Mexico, 9%; and other, 37%. Granite only: Brazil, 26%; Italy, 17%; India, 16%; Canada, 13%; and other, 28%.

Tariff: Dimension stone tariffs ranged from free to 6.5% ad valorem, according to type, degree of preparation, shape, and size, for countries with normal trade relations in 2006. 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 aggregate, 7.5% (Domestic and foreign); dimension stone used for rubble and other nonbuilding purposes, 5% (Domestic and foreign).

Government Stockpile: None.

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STONE (DIMENSION)

Events, Trends, and Issues: The United States is the world's largest market for dimension stone. Domestic production tonnage remained steady at about 1.5 million tons; value increased to $275 million in 2006 from $269 million in 2005. Imports of dimension stone continued to increase. Imports increased by 15% in value to about $2.5 billion. Dimension stone exports increased to about $68 million. Apparent consumption, by value, was $2.7 billion in 2006—a $328 million increase from that of 2005. Dimension stone for new construction and refurbishment is being used more commonly in both commercial and residential markets. Increased domestic production and imports, along with improved quarrying, finishing, handling technology, greater varieties of stone, and the rising costs of alternative construction materials, are among the factors that suggest the demand for dimension stone will continue to increase during the next 5 years.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2005	2006[e]	
United States	1,510	1,530	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 aluminum, brick, ceramic tile, concrete, glass, plastics, resin-agglomerated stone, and steel.

[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, and analysis of celestite import data indicates that production at this operation has decreased substantially since 2001. Primary strontium compounds were used in the faceplate glass of color television picture tubes, 55%; pyrotechnics and signals, 22%; ferrite ceramic magnets, 13%; and other applications, 10%.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production	—	—	—	—	—
Imports for consumption:					
Strontium minerals	1,150	1,020	2,760	799	900
Strontium compounds	25,400	23,300	14,500	11,700	9,700
Exports, compounds	340	693	552	255	500
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, apparent, celestite and compounds	26,200	23,600	16,700	12,200	10,100
Price, average value of mineral imports at port of exportation, dollars per ton	60	57	53	57	64
Net import reliance[2] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2002-05): Strontium minerals: Mexico, 100%. Strontium compounds: Mexico, 90%; Germany, 6%; and other, 4%. Total imports: Mexico, 91%; Germany, 5%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
Celestite	2530.90.8010	Free.
Strontium metal	2805.19.1000	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	2816.40.1000	4.2% ad val.

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

Government Stockpile: Celestite was held in the National Defense Stockpile for decades. In recent years, its total value was listed as zero because the material that remained in the stockpile was low-quality material that was not stockpile-grade and did not meet the specifications required by strontium compound producers. None had been sold since 1979. In the Strategic and Critical Materials Report to the Congress for October 2004 through September 2005, the Defense Logistics Agency, National Defense Stockpile Center, reported that the remaining 11,600 tons of celestite had been disposed of at the site where it had been stored.

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STRONTIUM

Events, Trends, and Issues: China is the world's leading producer of strontium carbonate with the plant capacity to produce 200,000 tons per year, followed by Germany and Mexico with 70,000 and 127,000 tons per year, respectively. China uses mostly domestic and some imported celestite to supply its strontium carbonate plants, the German producer uses imported celestite, and Mexican producers use domestic ore to supply their plants. Major markets for Chinese strontium carbonate are in Asia and Europe. Chinese celestite reserves are smaller and of lower quality than the ores in other major producing countries, including Mexico, Spain, and Turkey, raising the question of whether Chinese celestite producers will be able to maintain high enough production levels to meet the demand at strontium carbonate plants for an extended period of time, or if additional imports will be required.

The demand for strontium carbonate for television faceplate glass continues, but appears to be decreasing as the popularity of flat-panel television monitors grows. Domestic consumption of strontium carbonate decreased in the past 5 years as a result of a shift in production facilities for color televisions to other countries that has resulted in the closure of all but one television glass plant in the United States. China, Europe, and North America are the most important markets for televisions. Southeast Asia and Latin America have higher growth rates, potentially representing huge markets for television manufacturers and thus the strontium carbonate industry. Growth continues in flat-panel technology, which requires much smaller quantities of strontium carbonate, resulting in steadily decreasing demand for strontium carbonate for television displays, especially in North America and Europe.

World Mine Production, Reserves, and Reserve Base:[3]

	Mine production		Reserves[4]	Reserve base[4]
	2005	2006[e]		
United States	—	—	—	1,400,000
Argentina	6,700	7,500	All other:	All other:
China[e]	140,000	160,000	6,800,000	11,000,000
Iran	7,500	7,500		
Mexico	115,214	110,000		
Morocco	2,700	2,700		
Pakistan	2,000	2,000		
Spain	160,000	150,000		
Tajikistan	NA	NA		
Turkey	60,000	60,000		
World total (rounded)	494,000	500,000	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 factor 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 2006, elemental sulfur and byproduct sulfuric acid were produced at 113 operations in 29 States and the U.S. Virgin Islands. Total shipments were valued at about $320 million. Elemental sulfur production was 8.5 million tons; Louisiana and Texas accounted for about 45% of domestic production. Elemental sulfur was recovered at petroleum refineries, natural-gas-processing plants, and coking plants by 42 companies at 107 plants in 26 States and the U.S. Virgin Islands. Byproduct sulfuric acid, representing about 8% of production of sulfur in all forms, was recovered at six nonferrous smelters in five States by six companies. Domestic elemental sulfur provided 62% of domestic consumption, and byproduct acid accounted for 5%. The remaining 33% 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 62% of reported sulfur demand; petroleum refining, 26%; and metal mining, 3%. Other uses, accounting for 9% 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:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Recovered elemental	8,500	8,920	9,380	8,750	8,500
Other forms	772	683	739	711	740
Total (may be rounded)	9,270	9,600	10,100	9,460	9,240
Shipments, all forms	9,260	9,600	10,100	9,430	9,200
Imports for consumption:					
Recovered, elemental[e]	2,560	2,870	2,850	2,820	3,100
Sulfuric acid, sulfur content	346	297	784	877	900
Exports:					
Recovered, elemental	709	840	949	684	700
Sulfuric acid, sulfur content	48	67	67	110	100
Consumption, apparent, all forms	11,400	12,000	12,800	12,300	12,400
Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and/or plant	11.84	28.71	32.50	30.92	28.00
Stocks, producer, yearend	181	206	185	160	180
Employment, mine and/or plant, number	2,700	2,700	2,700	2,700	2,700
Net import reliance[1] as a percentage of apparent consumption	19	20	21	24	26

Recycling: Between 3 million and 5 million tons of spent sulfuric acid was reclaimed from petroleum refining and chemical processes.

Import Sources (2002-05): Elemental: Canada, 72%; Mexico, 18%; Venezuela, 7%; and other, 3%. Sulfuric acid: Canada, 71%; Mexico, 13%; Germany, 4%; and other, 12%. Total sulfur imports: Canada, 72%; Mexico, 17%; Venezuela, 6%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

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SULFUR

Events, Trends, and Issues: Total U.S. sulfur production was slightly lower in 2006 than it was in 2005 because of slow recovery from the two hurricanes that hit the Gulf Coast region in 2005 and complete implementation of an acid-gas reinjection project at a major natural-gas-processing plant in Wyoming. Decreased production of elemental sulfur from petroleum refineries is not expected to establish a new trend, but rather a temporary downturn. Recovery from refineries is expected to return to normal early in 2006 and to resume its upward trend, supported by new facilities being installed to increase refining capacity and the capability of current operations to handle higher sulfur crude oil. Recovered sulfur from domestic natural gas processing is expected to decline as a result of the natural depletion of some large natural gas deposits and projects to reinject acid gas. Byproduct sulfuric acid production is expected to remain relatively stable unless one or more of the remaining nonferrous smelters closes. World sulfur production did not change because the decreased production in the United States countered increases in other parts of the world.

Domestic phosphate rock consumption was 15% lower in 2006 than in 2005, which resulted in decreased demand for sulfur to process the phosphate rock into phosphate fertilizers. Worldwide sulfur prices decreased from the high levels seen in 2005, although they remained relatively strong compared to recent history. Some Canadian sulfur stocks were remelted to meet increased demand for overseas trade, while material in areas less accessible to markets was stockpiled.

World Production, Reserves, and Reserve Base:

	Production—All forms 2005	Production—All forms 2006[e]
United States	9,460	9,240
Australia	1,010	1,000
Canada	8,973	9,000
Chile	1,660	1,700
China	7,710	7,800
Finland	720	750
France	945	930
Germany	2,520	2,500
India	1,130	1,200
Iran	1,460	1,500
Italy	685	680
Japan	3,260	3,300
Kazakhstan	2,030	2,500
Korea, Republic of	1,690	1,700
Kuwait	700	700
Mexico	1,717	1,600
Netherlands	535	550
Poland	1,220	800
Russia	6,950	7,000
Saudi Arabia	2,300	2,300
South Africa	793	650
Spain	616	600
United Arab Emirates	1,950	2,000
Uzbekistan	520	500
Venezuela	800	800
Other countries	4,660	4,800
World total (rounded)	66,000	66,000

Reserves and reserve base[2]

Previously published reserves and reserve base data are outdated and inadequate for this tabulation because of changes in the world sulfur industry. For this reason, specific country data have been omitted from this report.

Reserves of sulfur in crude oil, natural gas, and sulfide ores are large. Because most sulfur production is a result of the processing of fossil fuels, supplies should be adequate for the foreseeable future. Because petroleum and sulfide ores can be processed long distances from where they are produced, actual sulfur production may not be in the country for which the reserves were attributed. For instance, sulfur from Saudi Arabian oil actually may be recovered at refineries in the United States.

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 is 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.

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.
[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 2006 domestic talc production was $24.9 million. There were 11 talc-producing mines in 7 States in 2006. Companies in Montana, New York, Texas, and Vermont accounted for most of the domestic production. Domestically produced ground talc was used in ceramics, 32%; paint, 20%; paper, 16%; roofing, 8%; plastics, 5%; rubber, 3%; cosmetics, 1%; and other, 15%. Two companies in North Carolina mined pyrophyllite. Production of pyrophyllite increased slightly from that of 2005. Consumption was, in decreasing order by tonnage, in refractory products, ceramics, and paint.

Salient Statistics—United States:[1]	**2002**	**2003**	**2004**	**2005**	**2006**[e]
Production, mine	828	840	833	856	880
Sold by producers	764	845	854	826	861
Imports for consumption	232	237	226	237	290
Exports	166	192	202	198	185
Shipments from Government stockpile excesses	—	—	([2])	—	—
Consumption, apparent	894	885	857	895	985
Price, average, processed, dollars per ton	98	89	88	86	85
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill	510	460	404	440	435
Net import reliance[3] as a percentage of apparent consumption	7	5	3	4	11

Recycling: Insignificant.

Import Sources (2002-05): China, 45%; Canada, 35%; France, 6%; Japan, 3%; and other, 11%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-06**
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—9-30-06[4]
(Metric tons)

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 2006**	**Disposals FY 2006**
Talc, block and lump	867	—	867	[5]907	—
Talc, ground	1,050	—	1,050	—	—

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TALC AND PYROPHYLLITE

Events, Trends, and Issues: Production and sales of talc increased from those of 2005. Exports decreased by 7% compared with those of 2005. Canada remained the major destination for U.S. talc exports, accounting for about 45% of the tonnage. U.S. imports of talc increased by an estimated 14% compared with those of 2005. In 2006, Canada and China supplied approximately 65% of the imported talc. Calculated apparent consumption increased by 10% in 2006. Actual consumption probably increased only 2% to 3% because a significant portion of the increase in talc imports in 2006 probably was stockpiled rather than entered into commerce.

Overall sales into the U.S. talc markets have declined during the past 20 years. Apparent consumption reached a high of 1.05 million tons in 1990 and declined to 857,000 tons in 2004. There has been a mild rebound in U.S. apparent consumption during the past 2 years. Based on current markets, U.S. consumption probably will be in the range of 875,000 to 925,000 tons for the next several years. No major changes in market trends are evident in world markets so world production also is expected to remain relatively stable.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	2005	2006[e]		
United States[1]	856	880	140,000	540,000
Brazil	607	601	180,000	250,000
China	3,000	3,000	Large	Large
Finland	542	550	Large	Large
India	630	640	4,000	9,000
Japan	431	380	100,000	160,000
Korea, Republic of	900	960	14,000	18,000
Other countries	1,280	1,260	Large	Large
World total (rounded)	8,250	8,300	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: Substitutes for talc include bentonite, chlorite, kaolin, and pyrophyllite in ceramics; chlorite, kaolin, and mica in paint; calcium carbonate and kaolin in paper; bentonite, kaolin, mica, and wollastonite in plastics; and kaolin and mica in rubber.

[e]Estimated. 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]Includes lump and block talc and ground talc.
[6]See Appendix C for definitions.

TANTALUM

(Data in metric tons of tantalum content unless otherwise noted)

Domestic Production and Use: No significant U.S. tantalum mine production has been reported since 1959. Domestic tantalum resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Three companies produced tantalum alloys, compounds, and metal from imported concentrates; and metal and alloys were recovered from foreign and domestic scrap. Tantalum was consumed mostly in the form of alloys, compounds, fabricated forms, ingot, and metal powder. Tantalum capacitors were estimated to account for more than 60% of tantalum use. Major end uses for tantalum capacitors include automotive electronics, pagers, personal computers, and portable telephones. The value of tantalum consumed in 2006 was estimated at about $164 million.

Salient Statistics—United States:[1]	**2002**	**2003**	**2004**	**2005**	**2006**[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
Mineral concentrates[e]	730	480	450	380	300
Tantalum metal, alloys, waste, scrap[e]	308	283	659	599	578
Exports, concentrate, metal, alloys, waste, scrap[e]	511	581	717	613	530
Government stockpile releases[e, 2]	18	218	205	245	254
Consumption, apparent	657	513	673	682	695
Price, tantalite, dollars per pound[3]	31.00	28.00	30.80	34.50	32.40
Net import reliance[4] as a percentage of apparent consumption	83	79	89	90	87

Recycling: Tantalum was recycled mostly from new scrap that was generated during the manufacture of tantalum-containing electronic components and from tantalum-containing cemented carbide and superalloy scrap. Tantalum in this scrap was estimated to be about 20% of apparent consumption. Tantalum recycled from old scrap was estimated to be about 13% of apparent consumption in 2006.

Import Sources (2002-05): Australia, 54%; Canada, 11%; China, 8%; Japan, 6%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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:		
Powders	8103.20.0030	2.5% ad val.
Alloys and metal	8103.20.0090	2.5% ad val.
Tantalum, waste and scrap	8103.30.0000	Free.
Tantalum, other	8103.90.0000	4.4% ad val.

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

Government Stockpile: For fiscal year 2006, the Defense National Stockpile Center (DNSC), Defense Logistics Agency, sold about 2 tons of tantalum carbide powder, about 9 tons of tantalum metal ingots, about 254 tons of tantalum contained in tantalum-columbium minerals, and about 9 tons of tantalum contained in tantalum oxide from the National Defense Stockpile. There were no sales of tantalum capacitor-grade metal in fiscal year 2006. The DNSC announced maximum disposal limits for fiscal year 2007 of about 2 tons[5] of tantalum contained in tantalum carbide powder, about 5 tons[5] of tantalum contained in tantalum metal powder, about 227 tons[5] of tantalum contained in tantalum minerals, and about 9 tons[5] of tantalum contained in tantalum oxide.

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TANTALUM

Stockpile Status—9-30-06[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Tantalum:					
Carbide powder	3.6	—	3.6	[7]2	2
Metal:					
Powder	—	—	—	[7]18	—
Ingots	—	1	—	[7]18	9
Minerals	63	—	63	227	254
Oxide	—	—	—	9	9

Events, Trends, and Issues: U.S. apparent consumption of tantalum in 2006 was estimated to be about 2% greater than that in 2005. Australia supplied about 77% of tantalum mineral concentrate imports for consumption, by weight, and about 84% of the value. Belgium, Brazil, China, and the Netherlands were the major destinations for the tantalum exports in 2006. In September, quoted spot price ranges for tantalum minerals (per pound tantalum pentoxide content), in three published sources, were $30 to $35, $23.50 to $35, and $34 to $38. Public information on current prices for tantalum products was not available. According to industry sources, the pricing for tantalum products is mostly established by negotiation between buyer and seller; product specifications, volume, and processing requirements influence the negotiated price.

World Mine Production, Reserves, and Reserve Base:

	Mine production[8] 2005	Mine production[8] 2006[e]	Reserves[9]	Reserve base[9]
United States	—	—	—	Negligible
Australia	730	730	40,000	80,000
Brazil	250	260	NA	73,000
Burundi	6	9	NA	NA
Canada	70	70	3,000	NA
Congo (Kinshasa)	25	10	NA	NA
Ethiopia	45	70	NA	NA
Mozambique	81	81	NA	NA
Namibia	3	3	NA	NA
Nigeria	5	5	NA	NA
Rwanda	40	50	NA	NA
Uganda	0.1	—	NA	NA
Zimbabwe	NA	0.2	NA	NA
Other countries[10]	NA	NA	NA	NA
World total (rounded)	1,260	1,290	43,000	150,000

World Resources: Identified resources of tantalum, most of which are in Australia, Brazil, and Canada, are considered adequate to meet projected needs. The United States has about 1,500 tons of tantalum resources in identified deposits, all of which are considered uneconomic at 2006 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]Revisions principally based on reevaluation of import and export data.
[2]Disposals reported by DNSC, net quantity (uncommitted inventory).
[3]Yearend average price from trade journals, per pound of contained pentoxides.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]Actual quantity limited to remaining sales authority; additional legislative authority is required.
[6]See Appendix B for definitions.
[7]Actual quantity limited to remaining sales authority or inventory.
[8]Excludes production of tantalum contained in tin slags.
[9]See Appendix C for definitions.
[10]Bolivia, China, Russia, and Zambia also produce (or are believed to produce) tantalum mineral concentrates, 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: In the United States, one firm produced commercial-grade tellurium at its refinery complex, mainly from copper anode slimes but also from lead refinery skimmings, both of domestic origin. Primary and intermediate producers further refined domestic and imported commercial-grade metal and tellurium dioxide, producing tellurium and tellurium compounds in high-purity form for specialty applications.

Tellurium's major use is as an alloying additive in steel to improve machining characteristics. It is also used as a minor additive in copper alloys to improve machinability without reducing conductivity; in lead alloys to improve resistance to vibration and fatigue; in cast iron to help control the depth of chill; and in malleable iron as a carbide stabilizer. It is used in the chemical industry as a vulcanizing agent and accelerator in the processing of rubber and as a component of catalysts for synthetic fiber production. Tellurium's other uses include those in photoreceptor and thermoelectric electronic devices, thermal cooling devices, as an ingredient in blasting caps, and as a pigment to produce various colors in glass and ceramics.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, refinery	W	W	W	W	W
Imports for consumption, unwrought, waste and scrap	34	55	75	46	40
Exports	3	10	6	51	4
Consumption, apparent	W	W	W	W	W
Price, dollars per pound, 99.95% minimum[1]	7	10	13	96	100
Stocks, producer, refined, yearend	W	W	W	W	W
Net import reliance[2] as a percentage of apparent consumption	W	W	W	W	W

Recycling: There is little or no scrap from which to extract secondary tellurium because the uses of tellurium are nearly all dissipative in nature. Currently, none is recovered in the United States, but a small amount may be recovered in Europe or elsewhere from scrapped selenium-tellurium photoreceptors employed in older plain paper copiers.

Import Sources (2002-05): Belgium, 29%; Germany, 21%; Canada, 18%; China, 9%; and other, 23%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Tellurium	2804.50.0020	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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TELLURIUM

Events, Trends, and Issues: Estimated domestic tellurium production increased in 2006 as compared with that of 2005 owing to a resolution of a labor strike at the one domestic producer. Though detailed information on the world tellurium market was not available, world tellurium consumption was estimated to have increased significantly in 2006. World production of tellurium, a byproduct of copper refining, was believed to have increased owing to an increase in world copper production. Russian tellurium production in 2006 reportedly was higher than in 2005. Selenium, a coproduct which was in strong demand, experienced a surge in production from waste and anode slimes that contained tellurium. With the sole U.S. producer of tellurium in bankruptcy protection, the future of American production is uncertain.

Global consumption was estimated to have increased in 2006. There was an increase in demand for high-purity tellurium for cadmium telluride solar cells. Tellurium consumption also increased in thermal cooling applications.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[3]	Reserve base[3]
	2005	2006[e]		
United States	W	W	3,000	6,000
Canada	75	75	700	1,500
Japan	22	20	NA	NA
Peru	22	33	1,600	2,800
Other countries[4]	NA	NA	16,000	37,000
World total (rounded)	[5]119	[5]128	21,000	47,000

World Resources: The figures shown for reserves and reserve base include only tellurium contained in economic copper deposits. These estimates assume that less than one-half of the tellurium contained in unrefined copper anodes is actually recovered.

More than 90% of tellurium is produced from anode slimes collected from electrolytic copper refining, and the remainder is derived from skimmings at lead refineries and from flue dusts and gases generated during the smelting of bismuth, copper, and lead ores. In copper production, tellurium is recovered only from the electrolytic refining of smelted copper. Growth in the global use of the leaching solvent extraction-electrowinning processes for copper extraction has limited the growth of tellurium supply.

Substitutes: Several materials can replace tellurium in most of its uses, but usually with losses in production efficiency or product characteristics. Bismuth, calcium, lead, phosphorus, selenium, and sulfur can be used in place of tellurium in many free-machining steels. Several of the chemical process reactions catalyzed by tellurium can be carried out with other catalysts or by means of noncatalyzed processes. In rubber compounding, sulfur and/or selenium can act as vulcanization agents in place of tellurium. The selenides of the refractory metals can function as high-temperature, high-vacuum lubricants in place of tellurides. The selenides and sulfides of niobium and tantalum can serve as electrically conducting solid lubricants in place of tellurides of those metals.

The selenium-tellurium photoreceptors used in some xerographic copiers and laser printers have been replaced by organic photoreceptors in newer machines. Amorphous silicon and copper indium diselenide are the two principal competitors to cadmium telluride in photovoltaic power cells.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Average yearend price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions. Estimates include tellurium contained in copper resources only.
[4]In addition to the countries listed, Australia, Belgium, China, Germany, Kazakhstan, the Philippines, and Russia produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable production estimates.
[5]Excludes refinery production from the United States.

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 has not been recovered domestically since 1981. Consumption of thallium metal and thallium compounds continued for most of its established end uses. These included the use of radioactive thallium isotope 201 for medical purposes in cardiovascular imaging; thallium as an activator (sodium iodide crystal doped with thallium) in gamma radiation detection equipment (scintillometer); thallium-barium-calcium-copper oxide high-temperature superconductor (HTS) used in filters for wireless communications; thallium in lenses, prisms and windows for infrared detection and transmission equipment; thallium-arsenic-selenium crystal filters for light diffraction in acousto-optical measuring devices; and thallium as an alloying component with mercury for low-temperature measurements. Other uses included an additive in glass to increase its refractive index and density, a catalyst for organic compound synthesis, and a component in high-density liquids for sink-float separation of minerals.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, mine	([1])	([1])	([1])	([1])	([1])
Imports for consumption (gross weight)					
Unwrought powders	49	36	117	23	30
Formed and articles	258	45	98	212	279
Waste and scrap	—	—	110	—	—
Total	307	81	325	235	309
Exports (gross weight)					
Unwrought powders	—	490	224	209	200
Formed and articles	463	1,560	965	43	1,090
Waste and scrap	188	39	—	—	—
Total	651	2,090	1,190	252	1,290
Consumption[e]	500	NA	900	300	NA
Price, metal, dollars per kilogram[2]	1,250	1,300	1,600	1,900	5,170
Net import reliance[e, 3] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2002-05): Russia, 90%; and Belgium, 10%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-06**
Unwrought and powders	8112.51.0000	4.0% ad val.
Waste and scrap	8112.52.0000	Free.
Other	8112.59.0000	4.0% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The annual thallium consumption and trade numbers found in the "Salient Statistics—United States" table are relatively low in comparison with other mineral commodities, and their changes do not conform to the normal supply-demand economic model. A telephone survey of several chemical and specialty metal providers determined that there was a scarcity of thallium metal in stock and relatively high prices in 2006. The lowest price found was $1,164 for 225-gram rods or $5,173.33 per kilogram, and most prices were significantly higher—some more than $6,000 per kilogram.

Research and development activities of both a basic and applied nature were conducted during 2006 that could expand the use of thallium. Atomic property research of thallium has potential to make this element important in elementary particle physics. Other activities included the development of HTS materials for such applications as magnetic resonance imaging, storage of magnetic energy, magnetic propulsion, more efficient electrical motors, and electric power generation and transmission. Materials are considered HTS if they have a critical transition (to superconductivity) temperature (Tc) above 77 Kelvin (K), the boiling temperature of liquid nitrogen. Presently, the HTS material attaining the highest Tc, 138 K, is a mercury-thallium-barium-calcium-copper oxide mix. Improved methods for manufacturing high-temperature superconductor tapes and films were under development. Tapes and films could be significant energy savers if used in ultrafast computers and power transmission systems.

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THALLIUM

A broad range of commercial applications would become available if HTS materials could be fabricated on a large scale into wires having a certain degree of flexibility and strength. Currently, HTS materials are relatively brittle metal-oxide ceramics. There are now more than 50 known HTS materials, but only a few (nonthallium) have been used successfully to form long-length wires.

In medical applications, dipyridamole-thallium imaging continued to be a useful preoperative procedure for assessing long-term cardiac risks in patients with coronary artery disease or diabetes who are undergoing peripheral vascular surgery. Further uses of radioactive thallium in clinical diagnostic applications include cardiovascular and oncological imaging.

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. Further information on thallium toxicity can be found in the U.S. Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) database. The EPA initiated studies at its National Risk Management Research Laboratory on thallium removal from mine wastewaters. The U.S. Department of Health and Human Services, Food and Drug Administration, issued a guidance document announcing an approved drug for treatment of internal bodily contamination by radioactive or nonradioactive thallium. The drug, a form of industrial and artists' pigment (Prussian blue), effectively increases the rate of elimination of thallium from the body by interrupting readsorption in the intestine by fixing the metal through ion exchange with the drug.

World Mine Production, Reserves, and Reserve Base:[4]

	Mine production		Reserves[5]	Reserve base[5]
	2005	2006[e]		
United States	([1])	([1])	32,000	120,000
Other countries	10,000	10,000	350,000	530,000
World total (rounded)	10,000	10,000	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 to be 0.7 part per million.

Substitutes: The apparent leading potential demand for thallium could be in the area of HTS materials but demand will be based on which HTS formulation has a combination of favorable electric and physical qualities and is best suited for fabrication. A firm presently using a thallium HTS material in filters for wireless communications is considering using a nonthallium HTS. While research in HTS continues, and thallium is part of that research effort, it is not guaranteed that HTS products will be a large user of thallium in the future.

While other materials and formulations can substitute for thallium in gamma radiation detection equipment and optics used for infrared detection and transmission, thallium materials are presently superior and more cost effective for these very specialized uses.

While thallium is still used in high-density liquids for sink-float separation of minerals, nonpoisonous substitutes like tungsten compounds are being marketed.

[e]Estimated. NA Not available. — Zero.
[1]No reported mine production; flue dust and residues from base-metal smelters, from which thallium metal and compounds may be recovered, are being exported to Canada, France, the United Kingdom, and other countries.
[2]Estimated price of 99.999%-pure granules or rods in 100- to 250-gram or larger lots.
[3]Defined as imports – exports + adjustments for Government and industry stock changes. Consumption and exports of unwrought thallium were from imported material or from a drawdown in unreported inventories.
[4]Estimates are based on thallium content of zinc ores.
[5]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. In the United States, thorium has been a byproduct of refining monazite for its rare-earth content. Monazite itself is recovered as a byproduct of processing heavy-mineral sands for titanium and zirconium minerals. In 2006, monazite was not recovered domestically as a salable product. Essentially all thorium compounds and alloys consumed by the domestic industry were derived from imports, stocks of previously imported materials, or materials previously 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. Thorium's use in most products has decreased because of its naturally occurring radioactivity. The value of thorium alloys, compounds, and metal used by the domestic industry was estimated to have increased to about $1.1 million.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	—	—	—	—	—
Thorium ore and concentrates (monazite), ThO_2 content	—	—	—	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	0.65	4.10	5.32	4.93	38.0
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	0.48	3.03	3.94	3.65	28.0
Exports:					
Thorium ore and concentrates (monazite), gross weight	—	—	—	—	—
Thorium ore and concentrates (monazite), ThO_2 content	—	—	—	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	0.88	0.59	0.73	0.74	1.00
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	0.65	0.44	0.54	0.55	0.74
Shipments from Government stockpile excesses ($ThNO_3$)	—	—	—	—	—
Consumption:					
Reported, (ThO_2 content[e])	NA	NA	NA	NA	NA
Apparent	NA	NA	NA	NA	NA
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
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2002-05): Monazite: None. Thorium compounds: France, 99.7%; and other, 0.3%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-06**
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: None.

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THORIUM

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 2006. Domestic demand for thorium ores, compounds, metals, and alloys has exhibited a long-term declining trend. No thorium consumption was reported in the United States in 2005, according to the U.S. Geological Survey's canvass of mines and processors. In 2006, consumption was believed to be primarily by catalyst manufacturers and was estimated to have increased. On the basis of data through August 2006, the average value of imported thorium compounds increased to $30.28 per kilogram from the 2005 average of $29.35 per kilogram (gross weight). The average value of exported thorium compounds was $456.89 per kilogram based on data through August 2006. 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 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 likely that thorium's use will continue to decline unless a low-cost disposal process is developed or new technology, such as a nonproliferative nuclear fuel, creates renewed demand.

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

	Refinery production 2005	Refinery production 2006	Reserves[7]	Reserve base[7]
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	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 geologic provinces similar to those that contain reserves. The leading share is 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 (Denmark), India, South Africa, and the United States.

Substitutes: Nonradioactive substitutes have been developed for many applications of 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. 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. and Rhodia Electronics and Catalysis, Inc., f.o.b. port of entry, duty paid, ThO_2 basis.
[4]Source: Rhodia Electronics and Catalysis, 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]Estimates, based on thorium contents of rare-earth ores.
[7]See Appendix C for definitions.

TIN

(Data in metric tons of tin content unless otherwise noted)

Domestic Production and Use: Tin has not been mined or smelted in the United States since 1993 and 1989, respectively. Twenty-five firms used about 81% of the primary tin consumed domestically in 2006. The major uses were as follows: cans and containers, 27%; electrical, 23%; construction, 10%; transportation, 10%; and other, 30%. On the basis of the average New York composite price, the estimated values of some critical items were as follows: primary metal consumed, $397 million; imports for consumption, refined tin, $496 million; and secondary production (old scrap), $138 million. Estimated secondary (old scrap) tonnage for 2005 and 2006 (see below) show significant increases for those 2 years owing to more complete coverage of the secondary tin industry; the years 2005 and 2006 are more reflective of the actual tonnage.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Secondary (old scrap)	6,760	5,500	5,240	11,800	12,000
Secondary (new scrap)	3,790	3,570	3,590	2,280	3,000
Imports for consumption, refined tin	42,200	37,100	47,600	37,500	43,300
Exports, refined tin	2,940	3,690	3,650	4,330	5,500
Shipments from Government stockpile excesses	8,960	8,880	10,600	8,368	9,000
Consumption, reported:					
Primary	34,000	32,900	36,700	32,200	34,600
Secondary	5,830	4,510	7,990	9,170	10,000
Consumption, apparent	55,700	48,700	58,770	54,730	58,100
Price, average, cents per pound:					
New York market	195	232	409	360	415
New York composite	292	340	547	483	520
London	184	222	385	334	362
Kuala Lumpur	184	222	385	333	363
Stocks, consumer and dealer, yearend	8,930	7,960	8,975	8,270	9,000
Net import reliance[1] as a percentage of apparent consumption	88	89	92	78	79

Recycling: About 15,000 tons of tin from old and new scrap was recycled in 2006. Of this, about 12,000 tons was recovered from old scrap at 2 detinning plants and 91 secondary nonferrous metal processing plants.

Import Sources (2002-05): Peru, 47%; Bolivia, 14%; China, 13%; Indonesia, 10%; and other, 16%.

Tariff: Most major imports of tin, including unwrought metal, waste and scrap, and unwrought tin alloys, enter the United States duty free.

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

Government Stockpile: The Defense National Stockpile Center (DNSC) continued its tin sales program by offering material for sale under the Negotiated format (long-term sales) and the Basic Ordering Agreement (BOA) format (spot market sales). The DNSC Annual Materials Plan for tin sales for fiscal year 2007 (October 1, 2006, through September 30, 2007) remained at 12,000 tons, although current inventory levels are approximately 8,900 tons. DNSC plans one long-term negotiated "contract" sale for fiscal year 2007 and weekly offerings under the DNSC BOA. Under the BOA approach, DNSC posts the amount of tin that it wants to sell on its Web site every Tuesday. Interested parties submit a quote, and DNSC makes a sales determination by the end of the business day. In fiscal year 2006, DNSC sold 8,000 tons under negotiated and 368 tons under BOA. Tin is held in Federal depots at two locations: Hammond, IN; and New Haven, IN.

Stockpile Status—9-30-06[2]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 2006**	**Disposals FY 2006**
Pig tin	8,932	—	8,932	12,000	8,368

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TIN

Events, Trends, and Issues: Apparent consumption of tin in the United States increased an estimated 6% in 2006 compared with that of 2005. The average monthly dealer price of tin rose steadily during the first 5 months of 2006, rising from $3.40 per pound in January to $4.21 per pound in May. The price declined to $3.81 per pound in June, and rose to $4.01 per pound in July. These represented generally higher prices than prevailed in 2005.

Developments accelerated in major tin-consuming countries in moving to new lead-free solders that usually contain greater amounts of tin than do leaded solders.

Tin producers responded to the higher tin prices and strong demand of the past several years with tin mine and tin smelter openings and expansions. Several closed or partially disabled tin mines were reopened. A large tin smelter started production in Singapore. China continued to be the leading tin producer, from both mines and smelters.

The world tinplate industry continued to experience major mergers and consolidations. The dominant one resulted in the combination of two of the world's largest steel producers and tinplate manufacturers. The Steel Recycling Institute announced that the steel can (usually tinplated) recycling rate in the United States was 63% for 2005, compared with 62% in 2004. Tin, as well as steel, is recovered in can recycling.

Two leading tin information organizations, ITRI Ltd. and CRU International Ltd., both based in the United Kingdom, jointly released new data regarding world tin consumption. Solder and tinplate have long been considered the "big two" applications for tin, but their new data indicate that the global solder market is now more than twice the size of the tinplate market.

World Mine Production, Reserves, and Reserve Base: Reserve estimates for the United States were revised to zero because there has been no reported mine production of tin in the United States since 1993.

	Mine production		Reserves[3]	Reserve base[3]
	2005	2006[e]		
United States	—	—	—	40,000
Australia	2,800	2,000	150,000	300,000
Bolivia	18,700	18,400	450,000	900,000
Brazil	12,500	11,800	540,000	2,500,000
China	120,000	100,000	1,700,000	3,500,000
Congo (Kinshasa)	80	2,100	NA	NA
Indonesia	80,000	85,000	800,000	900,000
Malaysia	3,000	3,100	1,000,000	1,200,000
Peru	42,100	42,200	710,000	1,000,000
Portugal	200	100	70,000	80,000
Russia	3,000	3,400	300,000	350,000
Thailand	600	250	170,000	200,000
Vietnam	3,500	1,000	NA	NA
Other countries	4,000	4,000	180,000	200,000
World total (rounded)	290,000	273,000	6,100,000	11,000,000

World Resources: U.S. resources of tin, primarily in Alaska, were insignificant compared with those of the rest of the world. World resources, principally in western Africa, southeastern Asia, Australia, Bolivia, Brazil, China, and Russia, are sufficient to sustain recent annual production rates well into the future.

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. NA Not available. — 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 surface mining operations in Florida and Virginia. In Georgia, one operation produced heavy mineral concentrate that was used by one of the Florida operations to produce ilmenite and rutile concentrates. The value of titanium mineral concentrates consumed in the United States in 2006 was about $500 million. The major coproduct of mining from ilmenite and rutile deposits was zircon. About 95% of titanium mineral concentrates was consumed by domestic titanium dioxide (TiO_2) pigment producers. The remaining 5% of consumption was used in welding rod coatings and for manufacturing carbides, chemicals, and metal.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production[2] (ilmenite and rutile, rounded)	300	300	300	300	300
Imports for consumption:					
Ilmenite and slag	599	569	535	660	660
Rutile, natural and synthetic	368	397	337	342	350
Exports,[e] all forms	2	7	6	14	16
Consumption, reported:					
Ilmenite and slag[3]	951	959	1,080	[e]994	1,000
Rutile, natural and synthetic	452	453	414	[e]394	400
Price, dollars per metric ton, yearend:					
Ilmenite, bulk, minimum 54% TiO_2, f.o.b. Australia	93	90	81	80	80
Rutile, bulk, minimum 95% TiO_2, f.o.b. Australia	450	430	455	470	465
Slag, 80%-95% TiO_2[4]	340-527	385-444	347-466	390-555	413-550
Stocks, mine, consumer, yearend:					
Ilmenite	197	200	299	NA	NA
Rutile	75	74	70	NA	NA
Employment, mine and mill, number[e]	349	344	300	286	248
Net import reliance[5] as a percentage of reported consumption	74	68	58	71	71

Recycling: None.

Import Sources (2002-05): South Africa, 48%; Australia, 34%; Canada, 10%; Ukraine, 4%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Synthetic rutile	2614.00.3000	Free.
Ilmenite and ilmenite sand	2614.00.6020	Free.
Rutile concentrate	2614.00.6040	Free.
Titanium slag	2620.99.5000	Free.

Depletion Allowance: Ilmenite and rutile; 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic consumption of titanium mineral concentrates was estimated to have increased moderately. Cost-cutting measures were expected to idle mining operations in Green Cove Springs, FL, and Lulaton, GA, by yearend. The Green Cove Springs operation had been in production since 1972, while the Lulaton operation was started in 2004. The closures will leave the United States with mining operations in Stony Creek, VA, and Starke, FL.

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TITANIUM MINERAL CONCENTRATES

The global supply of titanium mineral concentrates was estimated to have increased 5% compared with that of 2005. In the Murray Basin, Australia, several mineral sands projects were under development, and the Douglas and Mindari mineral sands projects neared completion. In Canada, upgraded slag capacity was expected to be raised to 375,000 tons per year from 325,000 tons per year by yearend. In China, a 100,000-ton-per-year slag operation was expected to be operational by 2008. In Madagascar, construction at the Fort Dauphin minerals sands project was underway with 750,000 tons per year of mineral sands capacity expected in 2008. Mine production at the Moma mineral sands project in Mozambique was expected to begin in January 2007. Moma's production capacity is expected to reach 800,000 tons per year of ilmenite, 56,000 tons per year of zircon, and 21,000 tons per year of rutile. The first of two dredges was refurbished and commissioned at the Sierra Rutile mine in Sierra Leone. The second dredge is scheduled for start-up in 2007 and is expected to raise capacity to 200,000 tons of heavy minerals per year. The Sierra Rutile mine has been idle since 1995.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	2005	2006[e]		
Ilmenite:				
United States[2]	[7]300	[7]300	6,000	59,000
Australia	1,180	1,210	130,000	160,000
Brazil	130	130	12,000	12,000
Canada[8]	731	780	31,000	36,000
China	450	475	200,000	350,000
India	297	297	85,000	210,000
Mozambique	—	—	16,000	21,000
Norway[8]	381	381	37,000	60,000
South Africa[8]	867	893	63,000	220,000
Ukraine	218	273	5,900	13,000
Vietnam	95	64	5,200	7,500
Other countries	136	144	15,000	78,000
World total (ilmenite, rounded)	4,800	5,000	610,000	1,200,000
Rutile:				
United States	([9])	([9])	400	1,800
Australia	163	171	19,000	31,000
Brazil	3	3	3,500	3,500
India	18	20	7,400	20,000
Mozambique	—	—	480	570
Sierra Leone	—	80	2,500	3,600
South Africa	105	108	8,300	24,000
Ukraine	57	62	2,500	2,500
Other countries	—	—	8,100	17,000
World total (rutile, rounded)	[9]351	[9]444	52,000	100,000
World total (ilmenite and rutile, rounded)	5,200	5,400	660,000	1,300,000

World Resources: Ilmenite supplies about 90% of the world's demand for titanium minerals. World resources of anatase, ilmenite, and rutile total more than 2 billion tons.

Substitutes: Ilmenite, leucoxene, rutile, slag, and synthetic rutile compete as feedstock sources for producing TiO_2 pigment, titanium metal, and welding rod coatings.

[e]Estimated. NA Not available. — Zero.
[1]See also Titanium and Titanium Dioxide.
[2]Rounded to nearest 0.1 million tons to avoid disclosing company proprietary data.
[3]Excludes ilmenite used to produce synthetic rutile.
[4]Landed duty-paid value based on U.S. imports for consumption.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]See Appendix C for definitions.
[7]Includes rutile.
[8]Mine production is primarily used to produce titaniferous slag.
[9]U.S. rutile production is included with ilmenite to avoid disclosing 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 three operations in Nevada, Oregon, and Utah. Ingot was produced by eight operations in eight States. Numerous firms consumed ingot to produce wrought products and castings. In 2006, an estimated 72% of the titanium metal was used in aerospace applications. The remaining 28% was used in armor, chemical processing, marine, medical, power generation, sporting goods, and other nonaerospace applications. The value of sponge metal consumed was about $315 million, assuming an average selling price of $10.50 per kilogram.

In 2006, titanium dioxide (TiO_2) pigment, which was valued at about $3.5 billion, was produced by four companies at eight facilities in seven States. The estimated use of TiO_2 pigment by end use was paint (includes lacquers and varnishes), 54%; plastic, 27%; paper, 16%; and other, 3%. Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Titanium sponge metal:					
Production	W	W	W	W	W
Imports for consumption	10,700	9,590	11,900	15,800	25,100
Exports	2,810	5,000	2,410	1,910	1,210
Shipments from Government stockpile excesses	5,400	6,820	3,910	2,510	—
Consumption, reported	17,300	17,100	21,200	27,000	30,000
Price, dollars per kilogram, yearend	8.02	6.50	8.50	9.23	13.50
Stocks, industry yearend[e]	11,700	8,180	7,660	4,330	6,520
Employment, number[e]	300	300	300	300	300
Net import reliance[2] as a percentage of reported consumption	46	87	66	73	72
Titanium dioxide:					
Production	1,410,000	1,420,000	1,540,000	1,310,000	1,360,000
Imports for consumption	231,000	240,000	264,000	341,000	380,000
Exports	540,000	584,000	635,000	524,000	600,000
Consumption, apparent	1,110,000	1,070,000	1,170,000	1,130,000	1,140,000
Price, rutile, list, dollars per pound, yearend	0.90	0.88	1.00	1.15	1.17
Stocks, producer, yearend	145,000	156,000	NA	NA	NA
Employment, number[e]	4,500	4,500	4,400	4,300	4,300
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 600 tons in 2006. Estimated use of titanium as scrap and ferrotitanium by the steel industry was about 8,000 tons; by the superalloy industry, 1,300 tons; and, in other industries, 1,500 tons. Old scrap reclaimed totaled about 600 tons.

Import Sources (2002-05): Sponge metal: Kazakhstan, 52%; Japan, 40%; Russia, 7%; and other, 1%. Titanium dioxide pigment: Canada, 29%; Germany, 10%; China, 9%; France, 8%; and other, 44%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Titanium oxides (unfinished TiO_2 pigments)	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	8108.30.0000	Free.
Unwrought titanium metal	8108.20.0000	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.

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TITANIUM AND TITANIUM DIOXIDE

Government Stockpile: The Defense National Stockpile Center continued the sale of titanium sponge held in the Government stockpile. In fiscal year 2006, the remaining inventory of sponge was exhausted.

Stockpile Status—9-30-06[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Titanium sponge	—	—	—	—	679

Events, Trends, and Issues: Domestic production of TiO_2 pigment was an estimated 1.4 million tons, a slight increase compared with that of 2005. Global production of TiO_2 was estimated to have increased 3% compared with that of 2005. In January, the hurricane-damaged DeLisle, MS, TiO_2 plant resumed operation. In Saudi Arabia, production capacity at the Yanbu TiO_2 pigment plant was raised to 120,000 tons per year and was expected to increase to 180,000 tons per year by 2008. TiO_2 pigment capacity at Greatham, United Kingdom, was expected to increase to150,000 tons per year in 2007. In 2006, rising demand from commercial aircraft and military markets significantly increased the production and consumption of titanium metal. Domestic and international titanium metal producers were adding capacity to keep pace with rising demand. In Albany, OR, an idle sponge plant was restarted in 2006 and was expected to reach a capacity of 7,260 tons per year by yearend 2007. In Rowley, UT, a new 10,900-ton-per-year sponge plant was expected to begin producing in 2008. In Henderson, NV, sponge capacity was expected to increase to 12,600 tons per year by yearend. China's sponge capacity is expected to rise to 47,500 tons per year by 2008. Japan's sponge capacity is expected to rise to 52,000 tons per year by 2009. Russian production capacity is expected to increase to 44,000 tons per year by 2008 and 56,000 tons per year by 2012. Several concerted efforts to develop a low-cost method for producing titanium metal were ongoing.

World Sponge Metal Production and Sponge and Pigment Capacity:

	Sponge production		Capacity 2006[4]	
	2005	2006[e]	Sponge	Pigment
United States	W	W	12,300	1,580,000
Australia	—	—	—	241,000
Belgium	—	—	—	74,000
Canada	—	—	—	90,000
China[e]	9,510	14,500	15,000	500,000
Finland	—	—	—	130,000
France	—	—	—	225,000
Germany	—	—	—	440,000
Italy	—	—	—	80,000
Japan	30,800	35,000	39,000	317,000
Kazakhstan[e]	19,000	23,000	23,000	1,000
Mexico	—	—	—	125,000
Russia[e]	29,000	32,000	32,000	20,000
Spain	—	—	—	80,000
Ukraine[e]	8,100	8,100	10,000	120,000
United Kingdom	—	—	—	290,000
Other countries	—	—	—	670,000
World total (rounded)	[5]96,000	[5]110,000	130,000	5,000,000

World Resources:[6] Resources and reserves of titanium minerals are discussed in Titanium Mineral Concentrates. The commercial feedstock sources for titanium are ilmenite, leucoxene, rutile, slag, and synthetic rutile.

Substitutes: There are few materials that possess titanium metal's strength-to-weight ratio and corrosion resistance. In high-strength applications, titanium competes with aluminum, composites, intermetallics, steel, and superalloys. For applications that require corrosion resistance, aluminum, nickel, specialty steels, and zirconium alloys may be substituted for titanium. Ground calcium carbonate, precipitated calcium carbonate, kaolin, and talc compete with titanium dioxide as a white pigment.

[e]Estimated. E Net exporter. NA Not available. 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 reported U.S. production of tungsten concentrates was in 1994. In 2006, approximately nine 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. Approximately 65 industrial consumers were surveyed on a monthly or annual basis. Data reported by these consumers indicate that more than one-half of the tungsten consumed in the United States was used in cemented carbide parts for cutting and wear-resistant materials primarily in the metalworking, mining, oil- and gas-drilling, and construction industries. The remaining tungsten was consumed to make tungsten heavy alloys for applications requiring high density; electrodes, filaments, wires, and other components for electrical, electronic, heating, lighting, and welding applications; steels, superalloys, and wear-resistant alloys; and chemicals for various applications. The estimated value of apparent consumption in 2006 was $470 million.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production:					
Mine	—	—	—	—	—
Secondary	4,380	4,130	4,000	4,640	4,500
Imports for consumption:					
Concentrate	4,090	4,690	2,310	2,080	2,100
Other forms	6,510	7,620	8,240	9,070	10,200
Exports:					
Concentrate	94	20	43	52	190
Other forms	3,220	5,070	3,730	5,890	7,100
Government stockpile shipments:					
Concentrate	1,140	710	979	2,310	3,500
Other forms	177	182	80	404	16
Consumption:					
Reported, concentrate	W	W	W	W	W
Apparent,[1] all forms	11,900	10,100	12,600	11,600	13,200
Price, concentrate, dollars per mtu WO_3,[2] average:					
U.S. spot market, Platts Metals Week	55	50	49	146	205
European market, Metal Bulletin	38	45	55	123	165
Stocks, industry, yearend:					
Concentrate	W	W	W	W	W
Other forms	1,610	1,820	1,780	2,300	2,100
Net import reliance[3] as a percentage of apparent consumption	69	63	73	68	66

Recycling: In 2006, the tungsten contained in scrap consumed by processors and end users represented approximately 34% of apparent consumption of tungsten in all forms.

Import Sources (2002-05): Tungsten contained in ores and concentrates, intermediate and primary products, wrought and unwrought tungsten, and waste and scrap: China, 42%; Canada, 21%; Germany, 8%; Portugal, 5%; and other, 24%.

Tariff: Item	**Number**	**Normal Trade Relations[4] 12-31-06**
Ore	2611.00.3000	Free.
Concentrate	2611.00.6000	Free.[5]
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	5.5% 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. Included in the data listed in the following table, as of September 30, 2006, are 4,690 tons of tungsten contained in uncommitted nonstockpile-grade ores and concentrates authorized for disposal.

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TUNGSTEN

Stockpile Status—9-30-06[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Ferrotungsten	—	—	—	[7]136	133
Metal powder	266	—	266	[7]136	—
Ores and concentrates	22,500	252	22,500	[7]3,630	3,630

Events, Trends, and Issues: World tungsten supply was dominated by Chinese production and exports. China's Government restricted the amounts of tungsten that could be produced and exported, continued to shift the balance of export quotas towards value-added downstream tungsten materials and products, eliminated export tax rebates on all tungsten materials, and imposed export duties on ferrotungsten and tungsten scrap. The growth in China's economy during the past decade has resulted in China becoming the world's largest tungsten consumer. Tungsten prices remained high as a result of inadequate supplies of tungsten concentrates within China combined with increased demand for tungsten materials in China and elsewhere. To meet its needs for tungsten raw materials, China imported higher amounts of tungsten concentrates and scrap.

The sole Canadian producer of tungsten concentrates signed a memorandum of understanding with a U.S. company to form a joint venture to build a processing plant in Minnesota that would use new technology to produce sodium tungstate, ammonium paratungstate, and tungsten metal powder. Tungsten concentrate production began in Peru, and various companies worked towards developing tungsten deposits or reopening inactive tungsten mines in Australia, Canada, China, Spain, Thailand, the United States, Uzbekistan, and Vietnam.

Health, safety, and environmental issues are becoming increasingly significant to the production and use of metals such as tungsten.

World Mine Production, Reserves, and Reserve Base: Reserves and reserve base estimates for Portugal were revised downward based on new information from that country.

	Mine production		Reserves[8]	Reserve base[8]
	2005	2006[e]		
United States	—	—	140,000	200,000
Austria	1,350	1,350	10,000	15,000
Bolivia	520	530	53,000	100,000
Canada	700	2,500	260,000	490,000
China	61,000	62,000	1,800,000	4,200,000
Korea, North	600	600	NA	35,000
Portugal	820	900	2,600	7,500
Russia	4,400	4,500	250,000	420,000
Other countries	710	950	350,000	700,000
World total (rounded)	70,100	73,300	2,900,000	6,200,000

World Resources: World tungsten resources are geographically widespread. China ranks number one in the world in terms of tungsten resources and reserves and has some of the largest deposits. Canada, Kazakhstan, Russia, and the United States also have significant tungsten resources.

Substitutes: Potential substitutes include cemented carbides based on molybdenum carbide and titanium carbide, ceramics, ceramic-metallic composites (cermets), diamond tools, and tool steels for cemented tungsten carbides; molybdenum for certain tungsten mill products; molybdenum steels for tungsten steels; lighting based on carbon nanotube filaments, induction technology, and light-emitting diodes (LEDs) for lighting based on tungsten electrodes or filaments; depleted uranium for tungsten alloys or unalloyed tungsten in weights and counterweights; and depleted uranium alloys for cemented tungsten carbides or tungsten alloys in armor-piercing projectiles. In some applications, substitution would result in increased cost or a loss in product performance.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]The sum of U.S. secondary production, as estimated from scrap consumption, and net import reliance.
[2]A metric ton unit (mtu) of tungsten trioxide (WO_3) contains 7.93 kilograms of tungsten.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]Special tariff rates apply for Canada and Mexico. Tariffs for other countries for some items may be eliminated under special trade agreements.
[5]Special tariff rate effective on or before December 31, 2003, under number 9902.26.1100.
[6]See Appendix B for definitions.
[7]Actual quantity limited to remaining sales authority.
[8]See Appendix C for definitions.

VANADIUM

(Data in metric tons of vanadium content unless otherwise noted)

Domestic Production and Use: Eight U.S. firms that make up the domestic vanadium industry produced 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 pig iron slag. Metallurgical use, primarily as an alloying agent for iron and steel, accounted for about 90% of the domestic vanadium consumption in 2006. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts for the production of maleic anhydride and sulfuric acid.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, mine, mill[1]	—	—	—	—	—
Imports for consumption:					
Ash, ore, residues, slag	1,870	3,060	2,350	1,690	700
Vanadium pentoxide, anhydride	406	474	1,040	1,370	2,370
Oxides and hydroxides, other	66	74	120	186	231
Aluminum-vanadium master alloys (gross weight)	98	232	19	1	153
Ferrovanadium	2,520	1,360	3,020	11,900	2,220
Exports:					
Vanadium pentoxide, anhydride	91	185	240	254	334
Oxides and hydroxides, other	203	284	584	899	998
Aluminum-vanadium master alloys (gross weight)	529	677	887	1,850	2,700
Ferrovanadium	142	397	285	504	437
Consumption, reported	3,080	3,240	4,050	3,910	3,810
Price, average, dollars per pound V_2O_5	1.34	2.21	5.99	16.28	8.08
Stocks, consumer, yearend	221	250	336	371	340
Employment, mine and mill, number[1]	—	—	—	—	—
Net import reliance[2] as a percentage of apparent consumption	100	100	100	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. The vanadium content of other recycled steels was lost to slag during processing and was not recovered.

Import Sources (2002-05): Ferrovanadium: Czech Republic, 74%; Swaziland, 9%; Canada, 8%; Austria, 4%; and other, 5%. Vanadium pentoxide: South Africa, 82%; China, 9%; Mexico, 5%; and other, 4%.

Tariff: Ash, residues, slag, and waste and scrap enter duty-free.

Item	Number	Normal Trade Relations 12-31-06
Vanadium pentoxide anhydride	2825.30.0010	6.6% ad val.
Vanadium oxides and hydroxides, other	2825.30.0050	6.6% ad val.
Vanadates	2841.90.1000	6.1% 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.

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VANADIUM

Events, Trends, and Issues: Preliminary data indicate that U.S. vanadium consumption in 2006 decreased about 2% from that of the previous year. Among the major uses for vanadium, production of carbon, full-alloy, and high-strength low-alloy steels accounted for 25%, 27%, and 27% of domestic consumption, respectively. Steel production in 2006 was expected to be 1% to 2% higher than that of 2005.

Both ferrovanadium and vanadium pentoxide prices decreased significantly in 2006 from 2005 levels. Prices that had spiked in the second quarter of 2005 dropped by about 50% by the end of the year, and the trend continued into 2006 with prices stabilizing at about one-half of their 2005 levels for ferrovanadium and vanadium pentoxide, respectively. Stable demand in the steel and aerospace industries and increased production of vanadium in Russia and China kept world supply and demand in balance in 2006.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2005	2006[e]		
United States	—	—	45,000	4,000,000
China	17,000	17,500	5,000,000	14,000,000
Russia	15,100	18,800	5,000,000	7,000,000
South Africa	25,000	25,000	3,000,000	12,000,000
Other countries	1,100	1,100	NA	1,000,000
World total (rounded)	58,200	62,400	13,000,000	38,000,000

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 and secondary recovery are adequate to supply a large portion of domestic needs, a substantial part of U.S. demand is currently met by foreign material because it is currently uneconomic to mine vanadium in the United States.

Substitutes: Steels containing various combinations of other alloying elements can be substituted for steels containing vanadium. Metals, such as columbium (niobium), 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. — Zero.
[1]Domestic vanadium mine production stopped in 1999.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]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 in South Carolina and Virginia produced vermiculite concentrate. Most of the vermiculite concentrate was shipped to 17 exfoliating plants in 11 States. The end uses for exfoliated vermiculite were estimated to be agricultural, insulation, and other, 74%; and lightweight concrete aggregates (including cement premixes, concrete, and plaster), 26%.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production[e, 1]	100	110	[2]100	100	100
Imports for consumption[e]	56	37	69	91	50
Exports[e]	10	15	10	5	5
Consumption, apparent, concentrate[e]	150	130	160	186	145
Consumption, exfoliated[e]	115	95	90	85	90
Price, average, concentrate, dollars per ton, ex-plant	143	143	[3]143	[4]143	143
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number[e]	90	90	[5]100	[5]100	[5]100
Net import reliance[6] as a percentage of apparent consumption[e]	30	20	35	46	31

Recycling: Insignificant.

Import Sources (2002-05): South Africa, 63%; China, 35%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
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.

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VERMICULITE

Events, Trends, and Issues: U.S. imports of vermiculite are not collected as a separate category by the U.S. Census Bureau. However, according to a nongovernmental source, U.S. imports, excluding those from Canada and Mexico, were about 31,000 tons for the first 8 months of 2006. Two countries supplied most of this material: China provided 76% and South Africa, 23%.[7]

IBI Corporation (based in Ontario, Canada) and its wholly owned subsidiary North American Vermiculite Inc. announced in early April an agreement with Rio Tinto America Industrial Minerals Inc. The agreement was to grant Rio Tinto an option to acquire 100% interest in the Mica Peak/Gold Butte vermiculite property located about 80 kilometers east of Las Vegas, NV. IBI Corp. produces vermiculite from its Namekara vermiculite mine in Uganda. Rio Tinto owns a 49% interest in Palabora Mining Co. in South Africa, which produces vermiculite from an open pit mine and recovery plant.[8]

South Africa continued to be the leading producer of vermiculite with an estimated 200,000 tons in 2006. Major export markets were Europe and North America. Chinese production of vermiculite may be 100,000 tons per year or more, although official data were not available. Much of the Chinese output was exported to Asia and North America.[4]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[9]	Reserve base[9]
	2005	2006[e]		
United States[e]	100	100	25,000	100,000
Brazil	30	30	NA	NA
China	100	100	NA	NA
Russia	25	25	NA	NA
South Africa	210	200	14,000	80,000
Zimbabwe	23	22	NA	NA
Other countries	39	39	NA	NA
World total (rounded)	530	520	NA	NA

World Resources: Marginal reserves of vermiculite that occur in Colorado, Nevada, North Carolina, Texas, and Wyoming are estimated to be 2 million to 3 million tons. Reserves have been reported in Australia, Brazil, China, Russia, South Africa, Uganda, the United States, Zimbabwe, and some other countries. However, reserve information comes from many sources, and in most cases it is not clear whether the numbers refer to vermiculite alone or vermiculite plus host rock and/or overburden.[9]

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, slag, and slate. 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.
[1]Concentrate sold and used by producers.
[2]Dickson, Ted, 2006, Vermiculite, Countries and Commodities Reports, accessed March 17, 2006, via URL http://www.mining-journal.com.
[3]Industrial Minerals, 2004, Prices: Industrial Minerals, no. 442, July, p. 64-65.
[4]Moeller, Eric, 2006, Vermiculite: Mining Engineering, v. 58, no. 6, June, p. 61. (Average of prices from range of sized grades.)
[5]Mine, mill, and office.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]Commonwealth Business Media, Inc., 2006, Port Import/Export Reporting Service, accessed October 24, 2006, at URL http://www.piers.com.
[8]Industrial Minerals, 2006, Mica Peak vermiculite option to Rio Tinto: Industrial Minerals, no. 464, May, p. 13.
[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 not mined in the United States in 2006. All yttrium metal and compounds used in the United States were imported. Principal uses were in phosphors for color televisions and computer monitors, trichromatic fluorescent lights, temperature sensors, and X-ray-intensifying screens. Yttrium also was used as a stabilizer in zirconia, in alumina-zirconia 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 also was used in heating-element alloys, superalloys, and high-temperature superconductors. The approximate distribution in 2005 by end use was as follows: lamp and cathode-ray-tube phosphors, 94%; alloys, 6%; and miscellaneous, <1%.

Salient Statistics—United States:	**2002**	**2003**	**2004**	**2005**	**2006[e]**
Production, mine	—	—	—	—	—
Imports for consumption:					
In monazite	—	—	—	—	—
Yttrium, alloys, compounds, and metal[e, 2]	330	380	619	582	600
Exports, in ore and concentrate	NA	NA	NA	NA	NA
Consumption, estimated[3]	330	380	619	582	600
Price, dollars:					
Monazite concentrate, per metric ton[4]	298	275	326	300	300
Yttrium oxide, per kilogram, 99.0% to 99.99% purity[5]	22-88	22-88	22-85	10-85	10-89
Yttrium metal, per kilogram, 99.0% to 99.9% purity[5]	95-115	95-115	96	96	94
Stocks, processor, yearend	NA	NA	NA	NA	NA
Net import reliance[e, 6] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Small quantities, primarily from laser crystals and synthetic garnets.

Import Sources (2002-05):[e] Yttrium compounds, >19% to < 85% weight percent yttrium oxide equivalent: China, 91%; Japan, 6%; France, 2%; Austria, 1%; and other, 0.1%. Import sources based on Journal of Commerce data (2005 only): China, 91%; Japan, 3%; Belgium, 3%; Austria, 2%; and other, 1%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-06**
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.
Other rare-earth compounds, including yttrium oxide $\geq$ 85% Y_2O_3, 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.

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YTTRIUM

Events, Trends, and Issues: Yttrium demand in the United States decreased in 2005 and increased in 2006. The United States required increased amounts for use in various phosphors and in electronics, especially those used in defense applications. Yttrium production and marketing within China continued to be competitive, keeping international prices low, although China was the source of most of the world's supply. Yttrium was consumed primarily in the form of high-purity oxide and nitrate compounds.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e, 7]		Reserves[8]	Reserve base[8]
	2005	2006		
United States	—	—	120,000	130,000
Australia	—	—	100,000	110,000
Brazil	8	8	2,200	6,200
China	6,000	8,800	220,000	240,000
India	55	55	72,000	80,000
Malaysia	15	4	13,000	21,000
Sri Lanka	—	—	240	260
Other	—	—	17,000	20,000
World total (rounded)	6,080	8,900	540,000	610,000

World Resources: Large resources of yttrium in monazite and xenotime are available worldwide in ancient and recent placer deposits, 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 near Elliot Lake, Ontario, Canada. The world's resources are probably very large.

Substitutes: Substitutes for yttrium are available for some applications but generally are much less effective. In most uses, especially in electronics, lasers, and phosphors, 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 have lower toughness.

[e]Estimated. NA Not available. — Zero.
[1]See also Rare Earths.
[2]Imports based on data from the Port Import/Export Reporting Service (PIERS).
[3]Essentially all yttrium consumed domestically was imported or refined from imported ores and concentrates.
[4]Monazite price based on monazite exports from Malaysia for 2002 to 2004 and estimated for 2005 and 2006.
[5]Yttrium oxide and metal prices from Elements—Rare Earths, Specialty Metals and Applied Technology (a High Tech Materials online publication at www.rareearthsmarketplace.com), Rhodia Rare Earths, Inc., Shelton, CT; the China Rare Earth Information Center, Baotou, China; Hefa Rare Earth Canada Co., Ltd., Vancouver, Canada; and Stanford Materials Corp., Aliso Viejo, CA.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]Includes yttrium contained in rare-earth ores.
[8]See Appendix C for definitions.

ZINC

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

Domestic Production and Use: The value of zinc mined in 2006, based on contained zinc recoverable from concentrate, was about $2.32 billion. It was produced in 6 States at 11 mines operated by 7 companies. Alaska, Missouri, Montana, and Washington accounted for about 99% of domestic mine output; the Red Dog Mine in Alaska accounted for about 80% of total U.S. production. Two primary and 12 large- and medium-sized secondary smelters refined zinc metal of commercial grade in 2006. 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, 21% in zinc-base alloys, 16% in brass and bronze, and 8% 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, sulfuric acid, cadmium, silver, gold, and germanium.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production:					
Mine, zinc in ore[1]	780	768	739	748	725
Primary slab zinc	182	187	188	191	120
Secondary slab zinc	113	116	117	118	150
Imports for consumption:					
Ore and concentrate	122	164	231	156	115
Refined zinc	874	758	812	668	810
Exports:					
Ore and concentrate	822	841	745	786	760
Refined zinc	1	2	3	1	1
Shipments from Government stockpile	11	14	29	20	38
Consumption:					
Apparent, refined zinc	1,180	1,080	1,160	999	1,120
Apparent, all forms	1,420	1,340	1,400	1,230	1,350
Price, average, cents per pound:					
Domestic producers[2]	38.6	40.6	52.5	67.1	145.0
London Metal Exchange (LME), cash	35.3	37.5	47.5	62.7	140.0
Stocks, slab zinc, yearend	78	73	73	71	71
Employment:					
Mine and mill, number[e]	1,500	1,000	600	600	650
Smelter primary, number[e]	600	600	600	600	250
Net import reliance[3] as a percentage of apparent consumption:					
Refined zinc	75	72	73	69	76
All forms of zinc	62	58	60	56	63

Recycling: In 2006, an estimated 350,000 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, 305,000 tons was derived from new scrap, and 45,000 tons was derived from old scrap. About 55,000 tons of scrap was exported, mainly to China, and 14,000 tons was imported, most of which came from Canada (85%).

Import Sources (2002-05): Ore and concentrate: Peru, 62%; Australia, 18%; Ireland, 11%; Mexico, 8%; and other, 1%. Metal: Canada, 63%; Mexico, 18%; Kazakhstan, 4%; Brazil, 4%; and other, 11%. Waste and scrap: Canada, 88%; Mexico, 10%; and other, 2%. Combined total: Canada, 53%; Mexico, 16%; Peru, 13%; Australia, 5%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations[4] 12-31-06
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).

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ZINC

Government Stockpile:

Stockpile Status—9-30-06[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 2006	Disposals FY 2006
Zinc	13	2	13	45	36

Events, Trends, and Issues: The LME cash settlement price of zinc increased substantially in 2006, exceeding $4,000 per ton for several days in September. The rapid price increase was the result of several factors: a 15-year low in LME stocks of zinc, increased world demand, tight world supply, and investment buying. World mine and refinery production both increased in 2006, driven primarily by China and India. Exclusive of China, world refined zinc consumption outpaced supply. The high prices have resulted in the reopening and expansion of zinc mines worldwide in 2006 with more planned in 2007.

One of the two primary zinc smelters in the United States closed in late January 2006, removing 100,000 tons per year of production capacity. The smelter was sold later in the year, and the new company plans to reopen the facility to recover zinc from electric arc furnace (EAF) dust from steel mills in addition to zinc concentrates. Initial annual production capacity of zinc from EAF dust was projected to be 30,000 tons. One zinc mine in New York was restarted in 2006, after a 5-year closure. The ore from the mine was processed in Canada. Three zinc mines in Tennessee, which have been closed since 2001, were scheduled to reopen in the second quarter of 2007, according to the new owner.

The United States remained one of the leading 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 domestically. Canada and Mexico are the leading sources of zinc for the United States because of their geographical proximity and because of trade agreements. 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]
	2005	2006[e]		
United States	748	725	30,000	90,000
Australia	1,330	1,400	33,000	80,000
Canada	755	725	11,000	31,000
China	2,450	2,500	33,000	92,000
Kazakhstan	400	450	30,000	35,000
Mexico	470	450	8,000	25,000
Peru	1,200	1,210	16,000	20,000
Other countries	2,400	2,500	59,000	87,000
World total (rounded)	9,800	10,000	220,000	460,000

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: The zirconium-silicate mineral zircon is produced as a coproduct from the mining and processing of heavy minerals. Two firms produced zircon from surface mining operations in Florida, Georgia, and Virginia. Zirconium and hafnium metal were produced from zircon by two domestic producers, one in Oregon and the other in Utah. Typically, both elements occur in the ore in a zirconium-to-hafnium ratio of about 50:1. Primary zirconium chemicals were produced by the metal producer in Oregon and at a plant in New Jersey. Secondary zirconium chemicals were produced by 10 other companies. Zirconia (ZrO_2) was produced from zircon at plants in Alabama, New Hampshire, New York, Ohio, and by the metal producer in Oregon. Ceramics, foundry applications, opacifiers, and refractories are the leading end uses for zircon. Other end uses of zircon include abrasives, chemicals, metal alloys, sandblasting media, and welding rod coatings. The leading consumers of zirconium and hafnium metal are the nuclear energy and chemical process industries.

Salient Statistics—United States:	2002	2003	2004	2005	2006[e]
Production, zircon (ZrO_2 content)	W	W	W	W	W
Imports:					
Zirconium, ores and concentrates (ZrO_2 content)	22,900	24,300	22,900	24,800	17,500
Zirconium, unwrought, powder, and waste and scrap	82	75	89	283	249
Zirconium, wrought	474	468	708	741	490
Zirconium oxide[1]	2,900	2,350	3,960	3,160	2,610
Hafnium, unwrought, waste and scrap	5	5	4	4	4
Exports:					
Zirconium ores and concentrates (ZrO_2 content)	30,600	45,900	44,700	65,600	56,200
Zirconium, unwrought, powder, and waste and and scrap	208	204	233	321	249
Zirconium, wrought	1,430	1,490	1,470	1,650	1,650
Zirconium oxide[1]	1,950	1,520	1,600	2,260	3,460
Consumption, zirconium ores and concentrates, apparent (ZrO_2 content)	W	W	W	W	W
Prices:					
Zircon, dollars per metric ton (gross weight):					
Domestic[2]	350	360	557	570	710
Imported, f.o.b.[3]	397	396	477	673	802
Zirconium, unwrought, dollars per kilogram[4]	39	44	31	22	25
Hafnium, unwrought, dollars per kilogram[4]	137	195	223	235	187
Net import reliance[5] as a percentage of apparent consumption:					
Zirconium	E	E	E	E	E
Hafnium	NA	NA	NA	NA	NA

Recycling: In-plant recycled zirconium came from scrap generated during metal production and fabrication and was recycled by companies in Oregon and Utah. Scrap zirconium metal and alloys was recycled by companies in California and Oregon. Zircon foundry mold cores and spent or rejected zirconia refractories are often recycled. Recycling of hafnium metal was insignificant.

Import Sources (2002-05): Zirconium ores and concentrates: Australia, 57%; South Africa, 35%; China, 4%; Canada, 2%; and other, 2%. Zirconium, unwrought, including powder: France, 53%; Germany, 23%; China, 10%; Japan, 7%; and other, 7%. Hafnium, unwrought, including powder: France, 66%; Canada, 22%; China, 6%; Japan, 4%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-06
Zirconium ores and concentrates	2615.10.0000	Free.
Germanium oxides and zirconium dioxide	2825.60.0000	3.7% ad val.
Ferrozirconium	7202.99.1000	4.2% ad val.
Zirconium, unwrought, zirconium powders	8109.20.0000	4.2% ad val.
Zirconium waste and scrap	8109.30.0000	Free.
Other zirconium articles	8109.90.0000	3.7% ad val.
Hafnium, unwrought, hafnium powders	8112.92.2000	Free.

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ZIRCONIUM AND HAFNIUM

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

Government Stockpile: None.

Events, Trends, and Issues: Global production of zirconium concentrates increased to 920,000 tons in 2006, which was a moderate increase compared with that of 2005. Global demand for zircon by the ceramics and chemicals industries helped to increase the demand by 3% compared with that of 2005. Meanwhile, prices for zircon concentrate increased to record-high levels. In 2006, U.S. imports of zirconium ores and concentrates decreased by about 18%, and exports increased by 3%. Cost-cutting measures were expected to idle mining operations in Green Cove Springs, FL, and Lulaton, GA, by yearend. The Green Cove Springs operation has been in production since 1972, and the Lulaton operation was started in 2004. The closures will leave the United States with mining operations in Stony Creek, VA, and Starke, FL. Mine production at the Moma mineral sands project in Mozambique was expected to begin in January 2007. By 2008, Moma's production capacity was expected to reach 800,000 tons per year of ilmenite, 56,000 tons per year of zircon and 21,000 tons per year of rutile. New production from Australia (Douglas, Mindari, Pooncarie, Tiwi Islands), The Gambia (Sanyang), Madagascar (Fort Dauphin), and Malawi (Lake Malawi) are expected to bring the supply of and demand for zirconium concentrates into balance. The availability of hafnium, which is produced as a byproduct during zirconium metal processing, continued to exceed demand.

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. Russia was the sole producer of baddeleyite in 2006; Russian data are included in the "Other countries" category.

	Mine production Zircon and baddeleyite		Reserves[6] (thousand metric tons)		Reserve base[6] (thousand metric tons)	
	2005	2006[e]	ZrO_2 content	HfO_2 content	ZrO_2 content	HfO_2 content
United States	W	W	3,400	68	5,700	97
Australia	445	480	9,100	180	30,000	600
Brazil	35	35	2,200	44	4,600	91
China	17	20	500	NA	3,700	NA
India	20	20	3,400	42	3,800	46
South Africa	305	310	14,000	280	14,000	290
Ukraine	35	37	4,000	NA	6,000	NA
Other countries	20	20	900	NA	4,100	NA
World total (rounded)	880	920	38,000	610	72,000	1,100

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), tantalum, and stainless steel provide limited substitution in for zirconium alloys nuclear applications. Titanium alloys and synthetic materials may substitute for zirconium alloys in some chemical plant uses.

Silver-cadmium-indium control rods are used in lieu of hafnium at many 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. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Includes germanium oxides and zirconium oxides.
[2]E.I. du Pont de Nemours & Co. and Iluka Resources, Inc., average price.
[3]U.S. Census Bureau trade data.
[4]Unit value based on U.S. imports for consumption.
[5]Defined as imports – exports.
[6]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 the quantity of mineral materials held in the National Defense Stockpile. Nonstockpile-grade materials may be included in the table; where significant, the quantities of these stockpiled materials will be specified in the text accompanying the table.

Committed inventory refers to materials that have been sold or traded from the stockpile, either in fiscal year 2006 (FY 2006) or in prior years, but not yet removed from stockpile facilities as of September 30, 2006. FY 2006 is the period October 1, 2005, through September 30, 2006.

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 financial loss to the United States.

Disposal plan FY 2006 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. For mineral commodities that have a disposal plan greater than the inventory, actual quantity will be limited to remaining disposal authority or inventory. 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 2006 refers to material sold or traded from the stockpile in FY 2006.

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 (USGS) collects information about the quantity and quality of all mineral resources. In 1976, the USGS and the U.S. Bureau of Mines developed a common classification and nomenclature, which was published as USGS 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 USGS and the U.S. Bureau of Mines collaborated to revise Bulletin 1450-A. Their work was published in 1980 as USGS 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 system, designed generally for all mineral materials, is shown graphically in figures 1 and 2; its components and their 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 or 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, and 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; it is not a part of this classification system.

[1]Based on U.S. Geological Survey Circular 831, 1980.

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 in order to understand 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 figures 1 and 2. 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*

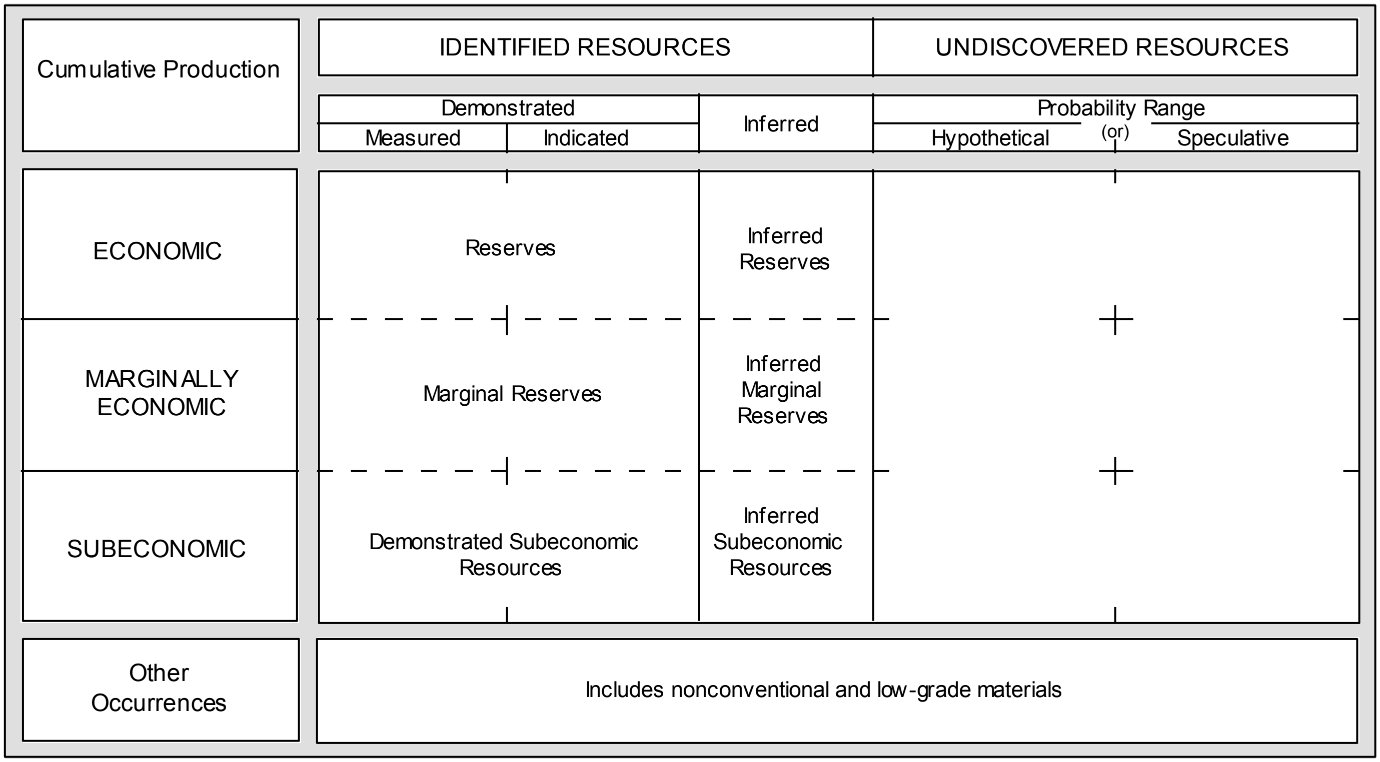
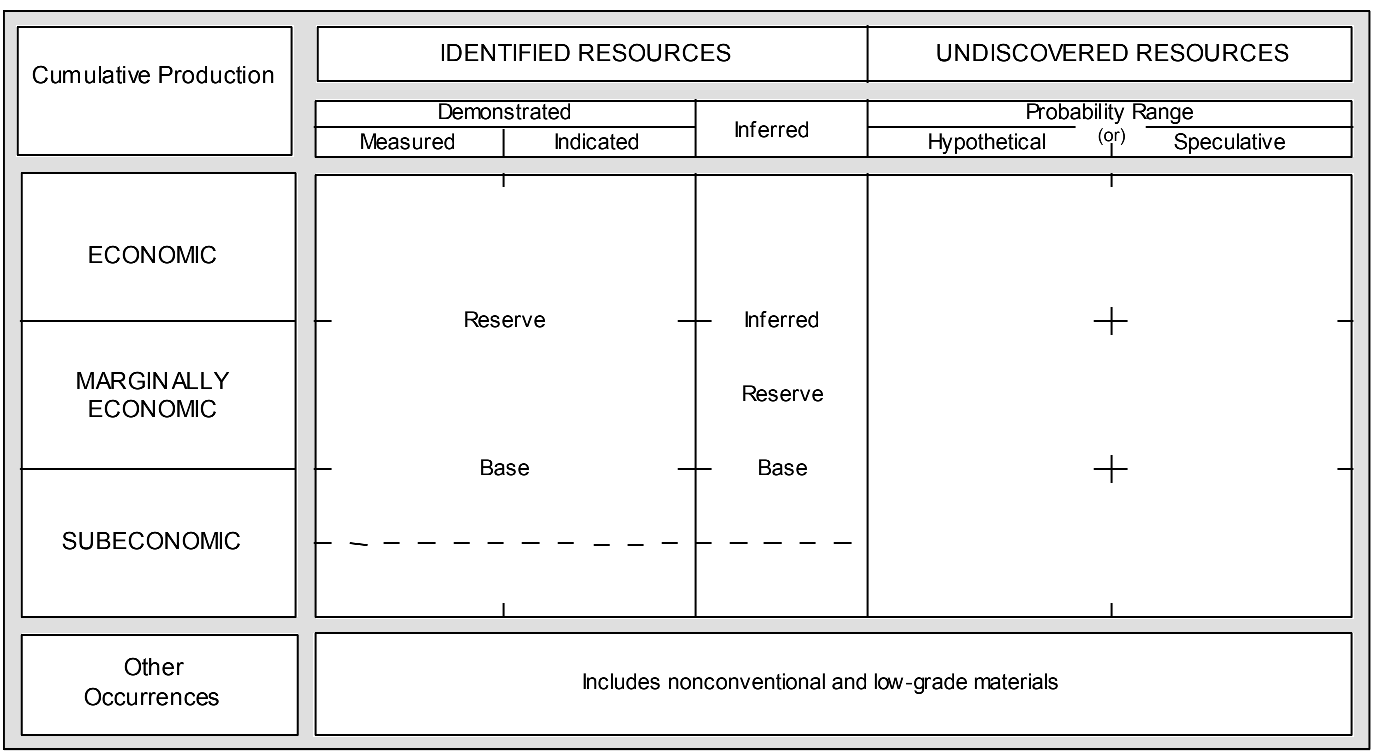


FIGURE 2.—*Reserve Base* and *Inferred Reserve Base* Classification Categories



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	Omayra Bermúdez-Lugo
Bahrain	Philip M. Mobbs
Benin	Omayra Bermúdez-Lugo
Botswana	Harold R. Newman
Burkina Faso	Omayra Bermúdez-Lugo
Burundi	Thomas R. Yager
Cameroon	Omayra Bermúdez-Lugo
Cape Verde	Harold R. Newman
Central African Republic	Omayra Bermúdez-Lugo
Chad	Philip M. Mobbs
Comoros	Thomas R. Yager
Congo (Brazzaville)	Philip M. Mobbs
Congo (Kinshasa)	Thomas R. Yager
Côte d'Ivoire	Omayra Bermúdez-Lugo
Djibouti	Thomas R. Yager
Egypt	Harold R. Newman
Equatorial Guinea	Philip M. Mobbs
Eritrea	Harold R. Newman
Ethiopia	Thomas R. Yager
Gabon	Omayra Bermúdez-Lugo
The Gambia	Omayra Bermúdez-Lugo
Ghana	Omayra Bermúdez-Lugo
Guinea	Omayra Bermúdez-Lugo
Guinea-Bissau	Omayra Bermúdez-Lugo
Iran	Philip M. Mobbs
Iraq	Philip M. Mobbs
Israel	Thomas R. Yager
Jordan	Thomas R. Yager
Kenya	Thomas R. Yager
Kuwait	Philip M. Mobbs
Lebanon	Thomas R. Yager
Lesotho	Harold R. Newman
Liberia	Omayra Bermúdez-Lugo
Libya	Philip M. Mobbs
Madagascar	Thomas R. Yager
Malawi	Thomas R. Yager
Mali	Omayra Bermúdez-Lugo
Mauritania	Omayra Bermúdez-Lugo
Mauritius	Thomas R. Yager
Morocco & Western Sahara	Harold R. Newman
Mozambique	Thomas R. Yager
Namibia	Philip M. Mobbs
Niger	Omayra Bermúdez-Lugo
Nigeria	Philip M. Mobbs
Oman	Philip M. Mobbs
Qatar	Philip M. Mobbs
Reunion	Thomas R. Yager
Rwanda	Thomas R. Yager
São Tomé & Principe	Harold R. Newman
Saudi Arabia	Philip M. Mobbs
Senegal	Omayra Bermúdez-Lugo
Seychelles	Thomas R. Yager
Sierra Leone	Omayra Bermúdez-Lugo
Somalia	Thomas R. Yager
South Africa	Thomas R. Yager
Sudan	Thomas R. Yager
Swaziland	Harold R. Newman
Syria	Thomas R. Yager
Tanzania	Thomas R. Yager
Togo	Harold R. Newman
Tunisia	Philip M. Mobbs
Turkey	Philip M. Mobbs
Uganda	Harold R. Newman
United Arab Emirates	Philip M. Mobbs
Yemen	Philip M. Mobbs
Zambia	Philip M. Mobbs
Zimbabwe	Philip M. Mobbs

Asia and the Pacific

Afghanistan	Chin S. Kuo
Australia	Pui-Kwan Tse
Bangladesh	Chin S. Kuo
Bhutan	Chin S. Kuo
Brunei	Pui-Kwan Tse
Burma	Yolanda Fong-Sam
Cambodia	John C. Wu
China	Pui-Kwan Tse
Christmas Island	Pui-Kwan Tse
Fiji	John C. Wu
India	Chin S. Kuo
Indonesia	Chin S. Kuo
Japan	John C. Wu
Korea, North	John C. Wu
Korea, Republic of	John C. Wu
Laos	John C. Wu
Malaysia	Pui-Kwan Tse
Mongolia	Pui-Kwan Tse
Nepal	Chin S. Kuo
New Caledonia	John C. Wu
New Zealand	Pui-Kwan Tse
Pakistan	Chin S. Kuo
Papua New Guinea	John C. Wu
Philippines	Yolanda Fong-Sam
Singapore	Pui-Kwan Tse
Solomon Islands	Chin S. Kuo
Sri Lanka	Chin S. Kuo
Taiwan	Pui-Kwan Tse
Thailand	John C. Wu
Timor, East	Pui-Kwan Tse
Tonga	Chin S. Kuo
Vanuatu	Chin S. Kuo
Vietnam	John C. Wu

Europe and Central Eurasia

Albania	Walter G. Steblez
Armenia[1]	Richard M. Levine
Austria[2]	Harold R. Newman
Azerbaijan[1]	Richard M. Levine
Belarus[1]	Richard M. Levine

Europe and Central Eurasia—continued

Belgium[2]	Harold R. Newman
Bosnia and Herzegovina	Walter G. Steblez
Bulgaria[2]	Walter G. Steblez
Croatia	Walter G. Steblez
Cyprus[2]	Harold R. Newman
Czech Republic[2]	Walter G. Steblez
Denmark, Faroe Islands, and Greenland[2]	Harold R. Newman
Estonia[2]	Richard M. Levine
Finland[2]	Harold R. Newman
France[2]	Walter G. Steblez
Georgia[1]	Richard M. Levine
Germany[2]	Steven T. Anderson
Greece[2]	Harold R. Newman
Hungary[2]	Walter G. Steblez
Iceland	Harold R. Newman
Ireland[2]	Harold R. Newman
Italy[2]	Walter G. Steblez
Kazakhstan[1]	Richard M. Levine
Kyrgyzstan[1]	Richard M. Levine
Latvia[2]	Richard M. Levine
Lithuania[2]	Richard M. Levine
Luxembourg[2]	Harold R. Newman
Macedonia	Walter G. Steblez
Malta[2]	Harold R. Newman
Moldova[1]	Richard M. Levine
Montenegro	Walter G. Steblez
Netherlands[2]	Harold R. Newman
Norway	Harold R. Newman
Poland[2]	Walter G. Steblez
Portugal[2]	Alfredo C. Gurmendi
Romania[2]	Walter G. Steblez
Russia[1]	Richard M. Levine
Serbia	Walter G. Steblez
Slovakia[2]	Walter G. Steblez
Slovenia[2]	Walter G. Steblez
Spain[2]	Ivette E. Torres
Sweden[2]	Harold R. Newman
Switzerland	Harold R. Newman
Tajikistan[1]	Richard M. Levine
Turkmenistan[1]	Richard M. Levine
Ukraine[1]	Richard M. Levine
United Kingdom[2]	Walter G. Steblez
Uzbekistan[1]	Richard M. Levine

[1]Member of Commonwealth of Independent States.
[2]Member of European Union.

North America, Central America, and the Caribbean

Antigua and Barbuda	Omayra Bermúdez-Lugo
Aruba	Omayra Bermúdez-Lugo
The Bahamas	Omayra Bermúdez-Lugo
Barbados	Omayra Bermúdez-Lugo
Belize	Steven T. Anderson
Bermuda	Omayra Bermúdez-Lugo
Canada	Alfredo C. Gurmendi
Costa Rica	Steven T. Anderson
Cuba	Omayra Bermúdez-Lugo
Dominica	Omayra Bermúdez-Lugo
Dominican Republic	Omayra Bermúdez-Lugo
El Salvador	Steven T. Anderson
Grenada	Omayra Bermúdez-Lugo
Guadeloupe	Omayra Bermúdez-Lugo
Guatemala	Steven T. Anderson
Haiti	Omayra Bermúdez-Lugo
Honduras	Steven T. Anderson
Jamaica	Omayra Bermúdez-Lugo
Martinique	Omayra Bermúdez-Lugo
Mexico	Ivette E. Torres
Montserrat	Omayra Bermúdez-Lugo
Netherlands Antilles	Omayra Bermúdez-Lugo
Nicaragua	Steven T. Anderson
Panama	Steven T. Anderson
St. Kitts and Nevis	Omayra Bermúdez-Lugo
St. Lucia	Omayra Bermúdez-Lugo
St. Vincent & the Grenadines	Omayra Bermúdez-Lugo
Trinidad and Tobago	Omayra Bermúdez-Lugo

South America

Argentina	Ivette E. Torres
Bolivia	Steven T. Anderson
Brazil	Alfredo C. Gurmendi
Chile	Steven T. Anderson
Colombia	Ivette E. Torres
Ecuador	Steven T. Anderson
French Guiana	Yolanda Fong-Sam
Guyana	Yolanda Fong-Sam
Paraguay	Alfredo C. Gurmendi
Peru	Alfredo C. Gurmendi
Suriname	Yolanda Fong-Sam
Uruguay	Alfredo C. Gurmendi
Venezuela	Ivette E. Torres

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Ivette E. Torres	(703) 648-7746	itorres@usgs.gov
Pui-Kwan Tse	(703) 648-7750	ptse@usgs.gov
John C. Wu	(703) 648-7751	jwu@usgs.gov
Thomas R. Yager	(703) 648-7739	tyager@usgs.gov