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

MINERAL COMMODITY SUMMARIES 2009

Abrasives
Aluminum
Antimony
Arsenic
Asbestos
Barite
Bauxite
Beryllium
Bismuth
Boron
Bromine
Cadmium
Cement
Cesium
Chromium
Clays
Cobalt
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
Niobium
Nitrogen
Peat
Perlite
Phosphate Rock
Platinum
Potash
Pumice
Quartz Crystal
Rare Earths
Rhenium
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

USGS
science for a changing world

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

MINERAL COMMODITY SUMMARIES 2009

Abrasives
Aluminum
Antimony
Arsenic
Asbestos
Barite
Bauxite
Beryllium
Bismuth
Boron
Bromine
Cadmium
Cement
Cesium
Chromium
Clays
Cobalt
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
Niobium
Nitrogen
Peat
Perlite
Phosphate Rock
Platinum
Potash
Pumice
Quartz Crystal
Rare Earths
Rhenium
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

USGS
science for a changing world

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

United States Government Printing Office, Washington: 2009

Manuscript approved for publication January 29, 2009.

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1–888–ASK–USGS

Suggested citation:
U.S. Geological Survey, 2009, Mineral commodity summaries 2009: U.S. Geological Survey, 195 p.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512-1800; DC area (202) 512-1800
Fax: (202) 512-2104 Mail: P.O. Box 979050, St. Louis, MO 63197-9000
ISBN 978-1-4113-295-0

CONTENTS

INSTANT INFORMATION

Information about the U.S. Geological Survey, its programs, staff, and products is available from the Internet at <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 <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. Orders are accepted over the Internet at <http://bookstore.gpo.gov>, by telephone toll free (866) 512-1800; Washington, DC area (202) 512-1800, by fax (202) 512-2104, or through the mail (P.O. Box 979050, St. Louis, MO 63197-9000).

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

INTRODUCTION

Each chapter of the 2009 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 2008 mineral production data for the world. More than 90 individual minerals and materials are covered by two-page synopses.

For mineral commodities for which there is a Government stockpile, detailed information concerning the stockpile status is included in the two-page synopsis. Because specific information concerning committed inventory was no longer available from the Defense Logistics Agency, National Defense Stockpile Center, that information, which was included in earlier Mineral Commodity Summaries publications, has been deleted from Mineral Commodity Summaries 2009.

National reserves and reserve base information for most mineral commodities found in this report, including those for the United States, are derived from a variety of sources. The ideal source of such information would be comprehensive evaluations that apply the same criteria to deposits in different geographic areas and report the results by country. In the absence of such evaluations, national reserves and reserve base estimates compiled by countries for selected mineral commodities are a primary source of national reserves and reserve base information. Lacking national assessment information by governments, sources such as academic articles, company reports, common business practice, presentations by company representatives, and trade journal articles, or a combination of these, serve as the basis for national reserves and reserve base information reported in the mineral commodity sections of this publication.

A national estimate may be assembled from the following: historically reported reserves and reserve base information carried for years without alteration because no new information is available; historically reported reserves and reserve base reduced by the amount of historical production; and company reported reserves. International minerals availability studies conducted by the U.S. Bureau of Mines, before 1996, and estimates of identified resources by an international collaborative effort (the International Strategic Minerals Inventory) are the basis for some reserves and reserve base estimates.

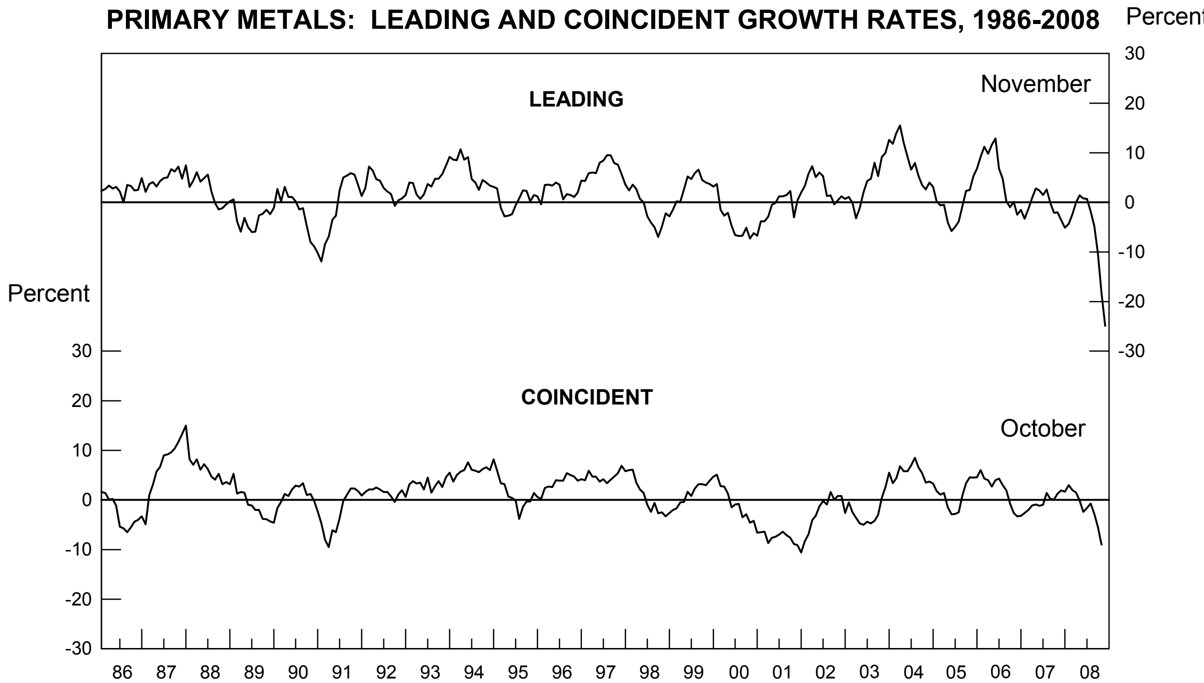
The USGS collects information about the quantity and quality of mineral resources but does not directly measure reserves, and companies or governments do not directly report reserves or reserve base to the USGS.

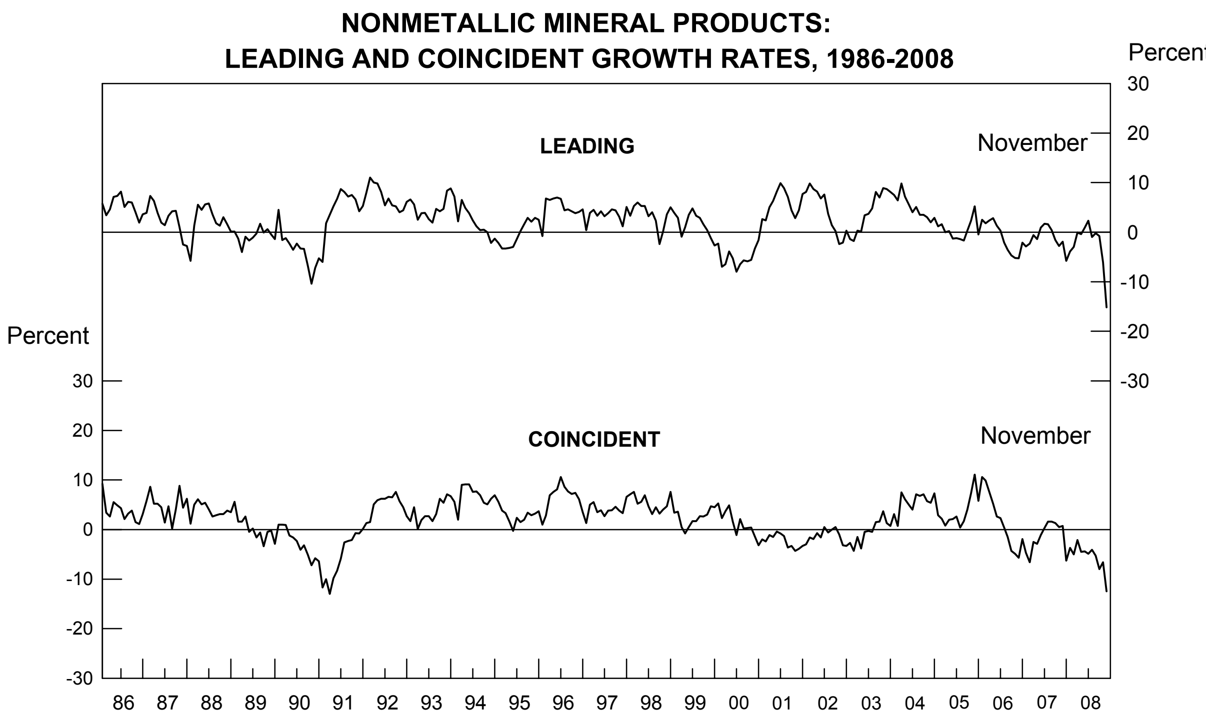
Reassessment of reserves and reserve base is a continuing process, and the intensity of this process differs for mineral commodities, countries, and time period.

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 2009 are welcomed.

GROWTH RATES OF LEADING AND COINCIDENT INDEXES FOR MINERAL PRODUCTS



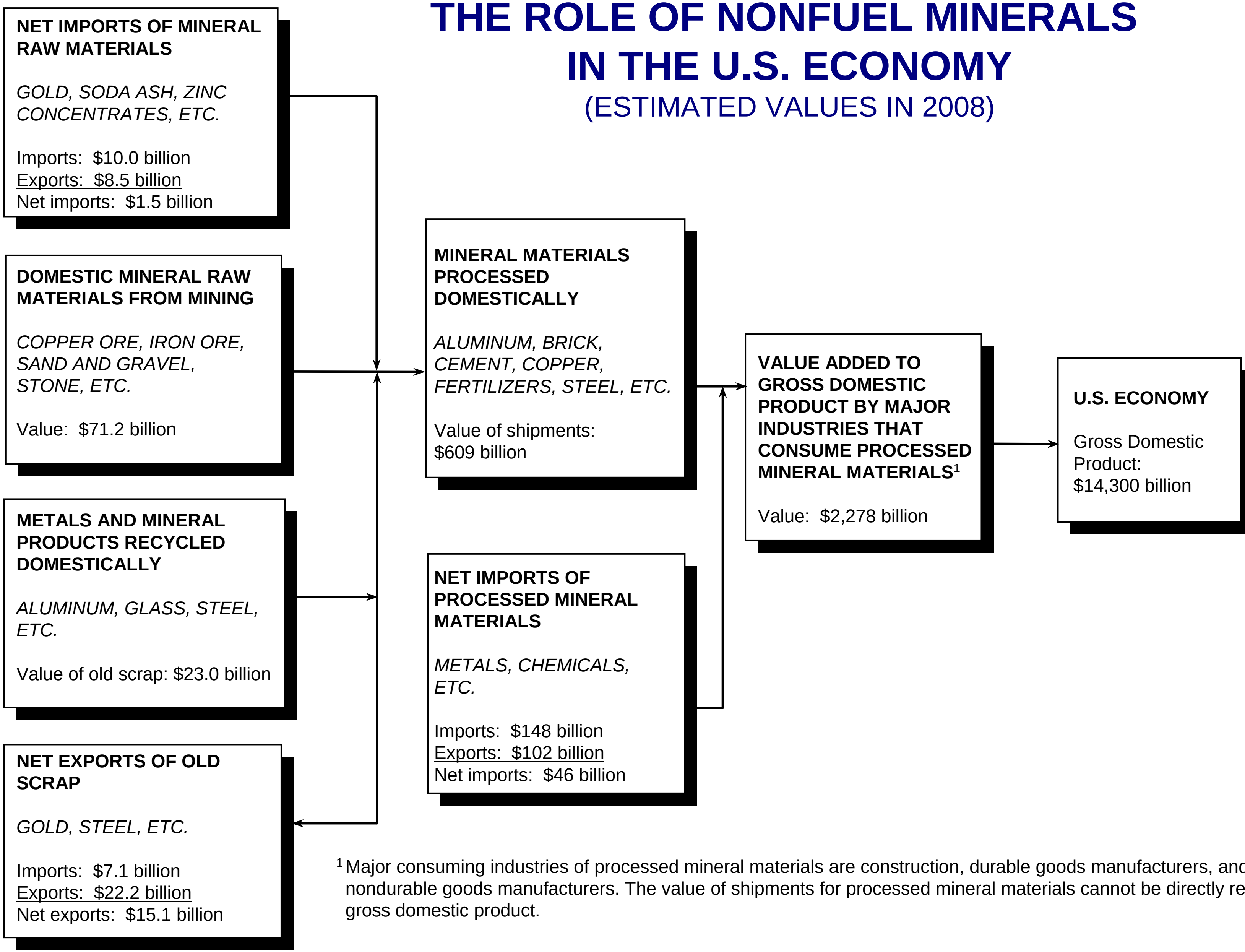


The leading indexes historically give signals several months in advance of major changes in the corresponding coincident index, which measures current industry activity. The growth rates, which can be viewed as trends, are expressed as compound annual rates based on the ratio of the current month's index 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 2008)

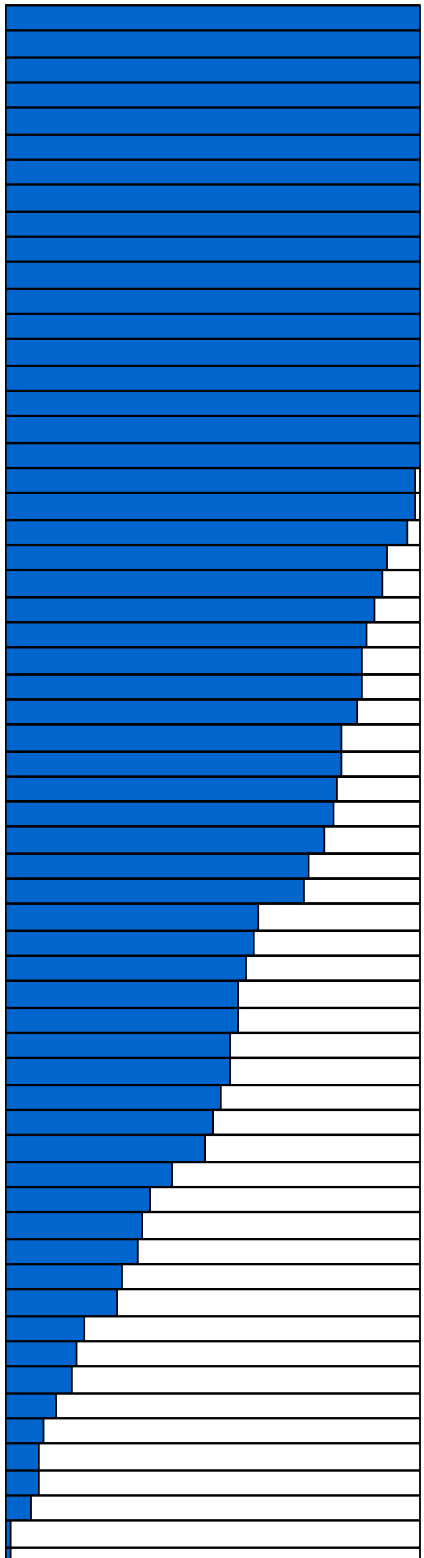


[1] Major consuming industries of processed mineral materials are construction, durable goods manufacturers, and some nondurable goods manufacturers. The value of shipments for processed mineral materials cannot be directly related to gross domestic product.

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

2008 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS

Commodity	Percent	Major Import Sources (2004-07)[1]
ARSENIC (trioxide)	100	China, Morocco, Hong Kong, Mexico
ASBESTOS	100	Canada
BAUXITE and ALUMINA	100	Jamaica, Guinea, Brazil, Australia
CESIUM	100	Canada
FLUORSPAR	100	China, Mexico, South Africa, Mongolia
GRAPHITE (natural)	100	China, Mexico, Canada, Brazil
INDIUM	100	China, Japan, Canada, Belgium
MANGANESE	100	South Africa, Gabon, China, Australia
NIOBIUM (columbium)	100	Brazil, Canada, Estonia
QUARTZ CRYSTAL (industrial)	100	China, Japan, Russia
RARE EARTHS	100	China, France, Japan, Russia
RUBIDIUM	100	Canada
STRONTIUM	100	Mexico, Germany
TANTALUM	100	Australia, China, Brazil, Japan
THALLIUM	100	Russia, Netherlands, Belgium
THORIUM	100	United Kingdom, France
VANADIUM	100	Czech Republic, Swaziland, Canada, Rep. of Korea
YTTRIUM	100	China, Japan, France
GALLIUM	99	China, Ukraine, Germany, Canada
GEMSTONES	99	Israel, India, Belgium, South Africa
BISMUTH	97	Belgium, Mexico, United Kingdom, China
DIAMOND (natural industrial stone)	92	Botswana, South Africa, Namibia, Ireland
PLATINUM	91	South Africa, Germany, United Kingdom, Canada
STONE (dimension)	89	Italy, Brazil, Turkey, China
RHENIUM	87	Chile, Germany, Netherlands
ANTIMONY	86	China, Mexico, Belgium
MICA, sheet (natural)	86	China, India, Belgium, Brazil
GERMANIUM	85	Belgium, Canada, Germany, China
COBALT	81	Norway, Russia, China, Canada
POTASH	81	Canada, Belarus, Russia, Germany
TIN	80	Peru, Bolivia, China, Indonesia
BARITE	79	China, India
TITANIUM MINERAL CONCENTRATES	77	South Africa, Australia, Canada, Ukraine
ZINC	73	Canada, Peru, Mexico, Ireland
PALLADIUM	72	Russia, South Africa, United Kingdom, Belgium
TUNGSTEN	61	China, Germany, Canada, Bolivia
SILVER	60	Mexico, Canada, Peru, Chile
PEAT	58	Canada
DIAMOND (dust, grit and powder)	56	China, Ireland, Russia, Rep. of Korea
SILICON (ferrosilicon)	56	China, Russia, Venezuela, Canada
CHROMIUM	54	South Africa, Kazakhstan, Russia, Zimbabwe
TITANIUM (sponge)	54	Kazakhstan, Japan, Russia, China
MAGNESIUM COMPOUNDS	52	China, Canada, Austria, Australia
MAGNESIUM METAL	50	Canada, Russia, Israel, China
NITROGEN (fixed), AMMONIA	48	Trinidad and Tobago, Canada, Russia, Ukraine
GARNET (industrial)	40	Australia, India, China, Canada
VERMICULITE	35	China, South Africa
NICKEL	33	Canada, Russia, Norway, Australia
COPPER	32	Chile, Canada, Peru, Mexico
SULFUR	28	Canada, Mexico, Venezuela
GYPSUM	27	Canada, Mexico, Spain, Dominican Republic
PERLITE	19	Greece
SALT	17	Canada, Chile, The Bahamas, Mexico
MICA, scrap and flake (natural)	16	Canada, China, India, Finland
CEMENT	12	Canada, China, Thailand, Rep. of Korea
PHOSPHATE ROCK	9	Morocco
IRON and STEEL	8	Canada, European Union, Mexico, China
IRON and STEEL SLAG	8	Canada, Japan, Italy, France
PUMICE	6	Greece, Italy, Turkey, Mexico
LIME	1	Canada, Mexico
STONE (crushed)	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. Trends in other sectors of the domestic economy are often reflected in mineral production and consumption rates. For instance, continued declines in the U.S. housing market during 2008 were reflected in further reductions in the production and consumption of cement, clays, construction sand and gravel, and crushed stone (commodities that are used almost exclusively in construction), and those associated with the related manufacture of goods, such as ceramic tile, paint, sanitaryware, roofing, and wallboard, used by the housing industry. The widespread effects of the slowing domestic economy became more apparent in the last 3 to 6 months of 2008 when prices for many other mineral commodities declined sharply after reaching record highs earlier in the year, indicating significantly lower demand for those materials or products containing them.

The figure on page 4 shows that the primary metals industry and the nonmetallic minerals products industry are intrinsically cyclical, and growth rates for leading and coincident indexes fell sharply in the second half of 2008. These growth rates are directly affected by the U.S. business cycle as well as by global economic conditions. The U.S. Geological Survey (USGS) generates composite indexes to measure economic activity in these industries. The coincident composite indexes describe the current situation using production, employment, and shipments data. The leading composite indexes forecast major changes in the industry's direction by such variables as stock prices, commodity prices, product new orders, and other indicators, which are combined into one gauge. For each of the indexes, a growth rate is calculated to measure its change relative to the previous 12 months.

As shown in the figure on page 5, the estimated value of mineral raw materials produced at mines in the United States in 2008 was $71 billion, a slight increase from $70 billion in 2007. Net exports of mineral raw materials and old scrap contributed an additional $14 billion to the U.S. economy. The domestic raw materials, along with domestically recycled materials, were used to process mineral materials worth $609 billion. These mineral materials, including aluminum, brick, copper, fertilizers, and steel, and imported processed materials (worth about $46 billion) were, in turn, consumed by downstream industries with a value added of an estimated $2.3 trillion in 2008, representing about 16% of the U.S. GDP.

The total quantity of minerals produced in the United States in 2008 decreased slightly from that of 2007, although their value increased slightly. The increased value was a result of increased unit prices for some metals and nonmetal minerals—particularly gold, magnesium, phosphate rock, and potash—partly owing to increased energy costs passed along to customers by producers of other nonmetal minerals.

The estimated value of U.S. metal mine production in 2008 was $27.6 billion, about 9% greater than that of 2007. Principal contributors to the total value of metal mine production in 2008 were copper (34%), gold (24%), iron ore and molybdenum (13% each), zinc (5%), and lead (4%). Metals with the largest increases in value of mine production were magnesium metal (200%), gold (24%), platinum (23%), iron ore (22%), and copper (11%).

The estimated value of U.S. nonmetal mine production in 2008 was $43.6 billion, slightly less than that of 2007. Principal contributors to the total value of nonmetal mine production in 2008 were crushed stone (28%), cement (21%), construction sand and gravel (17%), and phosphate rock (8%). Nonmetals that showed significantly increased value and represented more than 1% of total nonmetal production were phosphate rock (130% increase in value), potash (88%), and soda ash (11%).

Mine production of 14 mineral commodities was worth more than $1 billion each in the United States in 2008. These were crushed stone, copper, cement, construction sand and gravel, gold, iron ore (shipped), molybdenum concentrates, phosphate rock, lime, clays (all varieties), salt, zinc, soda ash, and lead, listed in decreasing order of value.

The figure on page 6 illustrates the reliance of the United States on foreign sources for raw and processed mineral materials. In 2008, the United States supplied more than one-half of its apparent consumption of 43 mineral commodities through imports and was 100% import reliant for 18 of those. U.S. import dependence has grown significantly during the past 30 years. In 1978, the United States was 100% import dependent for seven mineral commodities, and more than 50% import dependent for 25 mineral commodities. In 2008, the United States was a net exporter of 21 mineral commodities, meaning more of those domestically produced mineral commodities was exported than imported. That figure has remained relatively stable, with net exports of 18 mineral commodities in 1978.

In 2008, 11 States each produced more than $2 billion worth of nonfuel mineral commodities. These States were, in descending order of value, Arizona, Nevada, Florida, Utah, California, Texas, Minnesota, Alaska, Missouri, Colorado, and Michigan. The mineral production of these States accounted for 59% of the U.S. total output value (table 3).

In fiscal year 2008, the Defense Logistics Agency (DLA) sold $433 million of excess mineral materials from the 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

[1]Staff, U.S. Geological Survey

TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

	2004	2005	2006	2007	2008[e]
Total mine production:[1]					
Metals	12,500	16,500	23,300	25,300	27,600
Industrial minerals	33,500	38,900	43,500	44,200	43,600
Coal	22,200	26,700	29,300	30,000	31,200
Employment:[2]					
Coal mining	59	61	67	68	72
Metal mining	20	22	25	28	33
Industrial minerals, except fuels	81	84	82	82	81
Chemicals and allied products	520	510	508	505	518
Stone, clay, and glass products	388	387	391	386	373
Primary metal industries	364	363	363	358	351
Average weekly earnings of production workers:[3]					
Coal mining	1,029	1,071	1,093	1,050	1,132
Metal mining	1,034	1,002	974	1,074	1,197
Industrial minerals, except fuels	790	827	861	870	844
Chemicals and allied products	820	832	834	820	812
Stone, clay, and glass products	688	700	713	716	711
Primary metal industries	800	816	844	843	849

[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

	2004	2005	2006	2007	2008[e]
Gross domestic product (billion dollars)	11,686	12,422	13,178	13,808	14,300
Industrial production (2002=100):					
Total index	104	107	110	111	109
Manufacturing:	104	108	111	113	110
Nonmetallic mineral products	104	108	110	108	103
Primary metals:	110	108	112	110	105
Iron and steel	118	110	119	116	105
Aluminum	96	103	105	104	105
Nonferrous metals (except aluminum)	104	103	98	101	101
Chemicals	106	109	113	114	110
Mining:	100	98	101	101	103
Coal	101	103	105	104	106
Oil and gas extraction	96	92	93	95	97
Metals	98	106	110	109	117
Nonmetallic minerals	108	111	111	94	81
Capacity utilization (percent):					
Total industry:	78	80	81	81	78
Mining:	88	89	91	89	90
Metals	72	79	80	79	83
Nonmetallic minerals	86	88	88	75	66
Housing starts (thousands)	1,950	2,073	1,812	1,341	902
Light vehicle sales (thousands)[1]	13,500	13,500	12,700	12,200	9,710
Highway construction, value, put in place (billion dollars)	59	64	72	76	79

[e]Estimated.
[1]Excludes imports.

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

acquisition and disposals of NDS mineral materials. At the end of the fiscal year, mineral materials valued at $1.57 billion remained in the stockpile.

In August, the Defense National Stockpile Center announced plans to suspend competitive commercial offerings of six commodities and reduce the sale quantities of nine additional commodities for the remainder of fiscal year 2008. The actions were taken as a result of an ongoing study to address congressional concerns about Department of Defense needs for strategic and critical materials. Sales offerings for iridium, niobium metal ingot, platinum, tantalum carbide powder, tin, and zinc were suspended, and sales of beryllium, chromium metal, cobalt, high-carbon ferromanganese, high- and low-carbon ferrochromium, germanium, tungsten ores and concentrates, and tungsten metal powder were reduced. After the fiscal year 2009 Defense Authorization Bill was signed by the President in October 2008, sales of cobalt, germanium, and tungsten ores and concentrates restarted.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2008[p, 1]

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$1,220,000	18	1.72	Cement (portland), stone (crushed), lime, sand and gravel (construction), clays (common).
Alaska	2,740,000	8	3.85	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	7,840,000	1	11.02	Copper, molybdenum concentrates, sand and gravel (construction), cement (portland), stone (crushed).
Arkansas	843,000	27	1.18	Bromine, stone (crushed), cement (portland), sand and gravel (construction), lime.
California	4,000,000	5	5.63	Sand and gravel (construction), cement (portland), boron minerals, stone (crushed), soda ash.
Colorado	2,050,000	10	2.89	Molybdenum concentrates, sand and gravel (construction), gold, cement (portland), stone (crushed).
Connecticut	140,000	44	0.20	Stone (crushed), sand and gravel (construction), stone (dimension), clays (common), gemstones (natural).
Delaware[2]	21,500	50	0.03	Sand and gravel (construction), magnesium compounds, stone (crushed), gemstones (natural).
Florida	4,200,000	3	5.90	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), zirconium concentrates.
Georgia	1,850,000	13	2.60	Clays (kaolin), stone (crushed), cement (portland), clays (fuller's earth), sand and gravel (construction).
Hawaii	158,000	43	0.22	Stone (crushed), sand and gravel (construction), gemstones (natural).
Idaho	1,220,000	19	1.72	Phosphate rock, molybdenum concentrates, sand and gravel (construction), silver, lead.
Illinois	1,110,000	21	1.57	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime.
Indiana	932,000	24	1.31	Stone (crushed), cement (portland), sand and gravel (construction), lime, stone (dimension).
Iowa	782,000	28	1.10	Stone (crushed), cement (portland), sand and gravel (construction), lime, gypsum (crude).
Kansas	1,060,000	23	1.48	Helium (Grade-A), cement (portland), stone (crushed), salt, helium (crude).
Kentucky	772,000	29	1.08	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (common).
Louisiana	508,000	35	0.71	Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), clays (common).
Maine	229,000	41	0.32	Sand and gravel (construction), cement (portland), stone (crushed), stone (dimension), cement (masonry).
Maryland	548,000	34	0.77	Cement (portland), stone (crushed), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts	246,000	40	0.35	Stone (crushed), sand and gravel (construction), lime, stone (dimension), clays (common).
Michigan	2,050,000	11	2.88	Iron ore (usable shipped), cement (portland), sand and gravel (construction), salt, stone (crushed).
Minnesota	3,210,000	7	4.52	Iron ore (usable shipped), sand and gravel (construction), stone (crushed), sand and gravel (industrial), stone (dimension).

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2008[p, 1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Mississippi	$228,000	42	0.32	Stone (crushed), sand and gravel (construction), clays (fuller's earth), cement (portland), clays (ball).
Missouri	2,080,000	9	2.92	Stone (crushed), lead, cement (portland), lime, zinc.
Montana	1,380,000	17	1.94	Copper, molybdenum concentrates, platinum metal, gold, palladium metal.
Nebraska[2]	138,000	45	0.19	Cement (portland), stone (crushed), sand and gravel (construction), lime, clays (common).
Nevada	6,480,000	2	9.10	Gold, copper, sand and gravel (construction), magnesite, silver.
New Hampshire	119,000	46	0.17	Stone (crushed), sand and gravel (construction), stone (dimension), gemstones (natural).
New Jersey	326,000	37	0.46	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), greensand marl, peat.
New Mexico	1,810,000	14	2.54	Copper, potash, sand and gravel (construction), molybdenum concentrates, cement (portland).
New York	1,520,000	16	2.13	Salt, stone (crushed), sand and gravel (construction), cement (portland), zinc.
North Carolina[2]	876,000	25	1.23	Stone (crushed), phosphate rock, sand and gravel (industrial), sand and gravel (construction), stone (dimension).
North Dakota[2]	45,300	49	0.06	Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial).
Ohio	1,120,000	20	1.58	Stone (crushed), salt, sand and gravel (construction), lime, cement (portland).
Oklahoma	746,000	30	1.05	Stone (crushed), cement (portland), sand and gravel (construction), iodine (crude), sand and gravel (industrial).
Oregon	419,000	36	0.59	Stone (crushed), sand and gravel (construction), cement (portland), diatomite, perlite (crude).
Pennsylvania	1,680,000	15	2.37	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Rhode Island	55,700	48	0.08	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), gemstones (natural).
South Carolina	617,000	32	0.87	Cement (portland), stone (crushed), sand and gravel (construction), cement (masonry), sand and gravel (industrial).
South Dakota	270,000	39	0.38	Cement (portland), stone (crushed), gold, sand and gravel (construction), stone (dimension).
Tennessee	856,000	26	1.20	Stone (crushed), cement (portland), zinc, sand and gravel (construction), clays (ball).
Texas	3,300,000	6	4.64	Cement (portland), stone (crushed), sand and gravel (construction), salt, lime.
Utah	4,170,000	4	5.86	Copper, molybdenum concentrates, magnesium metal, gold, potash.
Vermont	98,800	47	0.14	Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural).
Virginia	1,090,000	22	1.53	Stone (crushed), cement (portland), sand and gravel (construction), lime, zirconium concentrates.
Washington	619,000	31	0.87	Sand and gravel (construction), stone (crushed), cement (portland), zinc, gold.
West Virginia	276,000	38	0.39	Stone (crushed), cement (portland), lime, sand and gravel (industrial), sand and gravel (construction).
Wisconsin	575,000	33	0.81	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime, stone (dimension).
Wyoming	1,890,000	12	2.65	Soda ash, clays (bentonite), helium (Grade-A), sand and gravel (construction), cement (portland).
Undistributed	623,000	XX	0.88	
Total	71,100,000	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

Soaring demand for steel products and ferrous raw materials in China and other countries caused record price increases and profits for steelmakers and raw material suppliers during 2008. According to World Steel Association data, world crude steel production for the first 8 months of 2008 was about 6% higher than that in the comparable period of 2007. The three leading steel-producing countries were China, with about 38%; Japan, 9%; and the United States, 7%. By the end of 2008, the global economic downturn adversely affected customers of steel used in construction, industrial equipment, and vehicles. Reduced consumption of steel led to rapidly declining steel prices, prompting steelmakers in Asia, Europe, and North America to slash output, delay mill-expansion plans, and furlough workers. The world's largest steel producer by volume of production announced plans to reduce production in Europe by 30% and in North America by 35%, including indefinite furloughs to more than 2,400 employees in its Burns Harbor, IN, plant. China's steelmakers are expected to collectively decrease active production capacity by 20% in 2009. Globally, lower revenues and additional layoffs are forecast into 2009. The world's leading iron ore producer announced cuts in iron-ore pellet production in Brazil by 65%, while the world's third-leading iron ore exporter also planned to cut production.

Although copper prices declined in September, average copper prices during the first 9 months of 2008 remained at or near record-high levels. The London Metal Exchange Ltd. (LME) copper price reached an all-time high of $4.08 per pound in April and averaged $3.61 per pound for the first 9 months of the year. Global commodity exchange inventories, which began the year at low levels, trended downward for the first 9 months of the year. Despite numerous announced expansions in mine capacity, estimated global copper mine production for the first 9 months of the year was slightly lower than that for the same period of 2007. Numerous factors, including labor unrest, lower ore grades, rapidly escalating production costs, technical problems, and utility and equipment shortages, contributed to lower than anticipated production. In October, concurrent with development of the global financial crisis, copper prices plummeted, and the LME price fell below $1.70 per pound. Though it cautioned that the economic crisis could significantly alter projections, the International Copper Study Group (2008) forecast a small annual production surplus to develop by yearend that could expand to about 300,000 tons in 2009.

Power generation problems, coupled with the continuing labor problems, caused several South African mines to curtail production and expansion projects—particularly ferroalloys, gold, and platinum-group metals (PGMs) producers. Other mines were closed owing to safety concerns, and some operations were temporarily closed in order to divert electricity to other facilities. Prices of platinum and rhodium reached all-time highs of $2,275 per troy ounce and $10,100 per troy ounce, respectively, and the palladium price reached a 7-year high of $585 per troy ounce. The global economic downturn resulted in lower automobile demand, which in turn resulted in falling consumption and plummeting prices of PGM in the second half of 2008.

Australian gold producers faced similar production declines and also had power problems; however, the main reasons for the drop in production were the lower average grades and rising costs. Indonesia saw drastic drops in gold production owing to lower grades and heavy rainfall. With the production decreases in the major gold-producing nations and China's increased gold production, China remained the leading gold-producing nation, followed by South Africa, the United States, and Australia.

The tightening of automobile emissions standards in China, Europe, Japan, and other parts of the world is expected to lead to higher average platinum loadings on catalysts, especially in light-duty diesel vehicles, as particulate matter emissions become more closely controlled. In the United States, cost-reduction efforts are continuing by most automakers and are likely to lead to a reduction in the use of platinum in auto catalysts. The large price differential between platinum and palladium has led to the assumption that automobile manufacturers will continue to change PGMs ratios in gasoline-engine vehicles in favor of palladium, as well as continue efforts to increase the proportion of palladium used in diesel vehicles. In May, new investment vehicles for PGMs, exchange traded notes (ETNs), were launched for platinum and palladium and are the first such PGM-trading products available to U.S. investors. Unlike exchange-traded funds, ETNs are based on futures contracts, and physical metal is not held.

In 2008, the global merger and acquisition (M&A) market fell by more than 33% from 2007 levels, including 44% in the 4th quarter, after 5 years of continuous growth. The M&A market shrunk in most regions of the world except Brazil and China. Merger volume dropped in Asia-Pacific, Europe, and the United States by 12%, 29%, and 38%, respectively, as a result of the global economic downturn (Vranceanu, 2008). The proposed merger between BHP Billiton Group and Rio Tinto Group was cancelled in November following the collapse in commodity prices and turmoil in the financial markets. The proposed hostile takeover by BHP, once worth $170 billion, had lost more than one-half of its value before BHP withdrew its offer. China and other global steelmakers opposed the merger arguing that the combined entity would control more than 33% of the world's seaborne trade in iron ore (Macalister, 2008; Matthews and others, 2008).

As of late October, many junior exploration and mining companies were cutting costs, laying off employees, cancelling exploration programs—even closing operating mines. The severe drop in share prices was likely to eliminate some junior miners. Commodity markets have seen a dramatic reduction in prices leading to reduced capacity expansions and mothballing of existing facilities. Lower fuel costs are expected to reduce development, and operating costs and equipment costs may decrease as reduced demand leads to increased availability. Analysts at Mineral Fields Group predicted recovery in copper, gold, and molybdenum in the short term and in other base metals, silver, and uranium in the long term. Analysts at J.P. Morgan forecast recovery in the second half of 2009 but cautioned that recovery would vary by commodity (Dickson, 2008).

References Cited

Dickson, Ellsworth, 2008, It’s an “L” of a question: Resource World, v. 6, no. 10, November, p. 7.

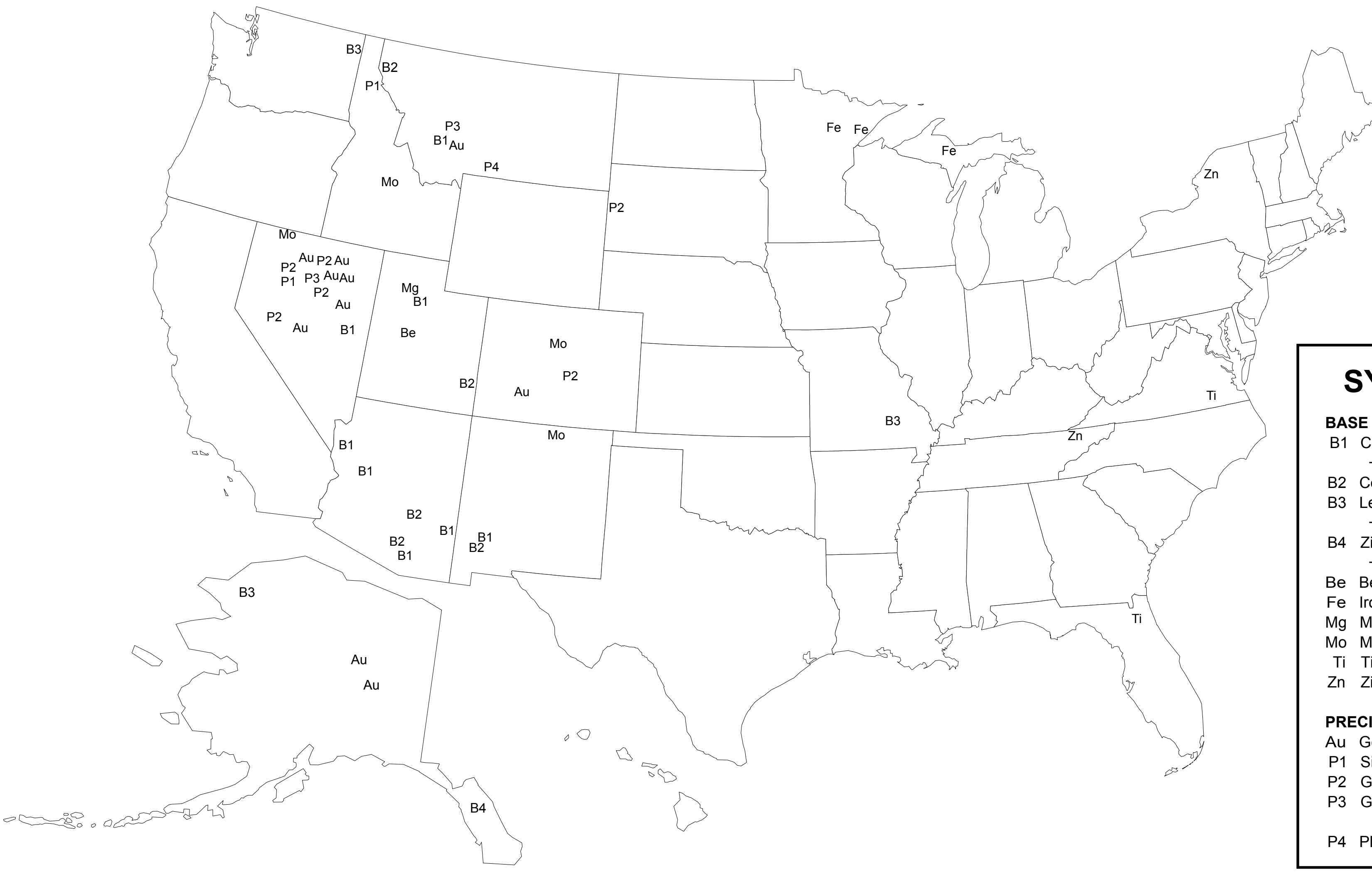
International Copper Study Group, 2008, Forecast 2008-2009: Lisbon, Portugal, International Copper Study Group press release, October 8, 1 p.

Macalister, Terry, 2008, BHP walks away from mining mega-merger: The Guardian, November 26. (Accessed January 12, 2009, at http://www.guardian.co.uk/business/2008/nov/26/bhp-rio-tinto-deal-collapse.)

Matthews, R.G., Cimilluca, Dana, and Barta, Patrick, 2008, Death of a megadeal—BHP ends its pursuit of Rio: Wall Street Journal, November 26, p. B1, B4.

Vranceanu, Claudiu, 2008, Biggest mergers and acquisitions in 2008: Wall Street, December 31. (Accessed January 11, 2009, at http://www.wall-street.ro/articol/English-Version/56433/Biggest-mergers-and-acquisitions-in-2008.html.)

MAJOR METAL-PRODUCING AREAS



SYMBOLS

BASE METALS

B1 Copper and molybdenum +/- gold, silver
B2 Copper +/- gold, silver
B3 Lead, zinc +/- copper +/- gold +/- silver
B4 Zinc and silver + lead and gold
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

SYMBOLS

Ba	Barite	Mica	Mica
B	Borates	O	Olivine
Br	Bromine	Peat	Peat
Dia	Diatomite	P	Phosphate
Gar	Garnet	K	Potash
Gyp	Gypsum	Pyrp	Pyrophyllite
He	Helium	Salt	Salt
Irz	Ilmenite, rutile, and zircon	NaC	Soda ash
		NaS	Sodium sulfate
I	Iodine	S	Sulfur
Ky	Kyanite	Talc	Talc
MgCp	Magnesium compounds	Vm	Vermiculite
		Wol	Wollastonite
		Zeo	Zeolites

MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART II

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 $1.92 million, and production of high-purity fused aluminum oxide was estimated to have a value of more than $4.79 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 $26.4 million. Bonded and coated abrasive products accounted for most abrasive uses of fused aluminum oxide and silicon carbide.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production,[1] United States and Canada (crude):					
Fused aluminum oxide, regular	20,000	10,000	10,000	10,000	10,000
Fused aluminum oxide, high-purity	5,000	5,000	5,000	5,000	5,000
Silicon carbide	35,000	35,000	35,000	35,000	35,000
Imports for consumption (U.S.):					
Fused aluminum oxide	232,000	244,000	209,000	237,000	289,000
Silicon carbide	209,000	201,000	186,000	164,000	136,000
Exports (U.S.):					
Fused aluminum oxide	13,900	13,900	15,300	18,200	24,600
Silicon carbide	13,900	15,600	20,300	19,300	16,000
Consumption, apparent (U.S.):					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	230,000	220,000	201,000	180,000	155,000
Price, dollars per ton, United States and Canada:					
Fused aluminum oxide, regular	323	144	152	165	165
Fused aluminum oxide, high-purity	544	656	652	671	671
Silicon carbide	614	603	693	744	739
Net import reliance[2] as a percentage of apparent consumption (U.S.):					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	85	84	83	81	77

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

Import Sources (2004-07): Fused aluminum oxide, crude: China, 80%; Canada, 13%; Venezuela, 5%; Germany, 1%; and other, 1%. Fused aluminum oxide, grain: Brazil, 23%; Germany, 23%; Austria, 15%; Italy, 9%; and other, 30%. Silicon carbide, crude: China, 74%; Venezuela, 8%; Romania, 6%; Netherlands, 6%; and other, 6%. Silicon carbide, grain: China, 36%; Brazil, 24%; Russia, 10%; Vietnam, 7%; and other, 23%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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 2007, the Department of Defense sold 4,095 tons of fused aluminum oxide abrasive grain from the National Defense Stockpile for $1.73 million. During fiscal year 2008, no sales of fused aluminum oxide abrasive grain from the National Defense Stockpile were held. Although 4,990 tons was authorized for disposal, and 178 tons was reported as remaining inventory, the sales in fiscal year 2007 actually depleted all remaining inventory of fused aluminum oxide abrasive grain.

Stockpile Status—9-30-08[3]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Fused aluminum oxide, grain	178	4,990	4,990	—

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7757]**

ABRASIVES (MANUFACTURED)

Events, Trends, and Issues: Imports and higher operating costs continued to challenge abrasives 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	
	2007	2008[e]	2007	2008[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, emery, 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 2008, 6 companies operated 14 primary aluminum smelters; 4 smelters were temporarily idled and 1 that had been idle since 2000 was demolished in 2007. Based upon published market prices, the value of primary metal production was $7.9 billion. Aluminum consumption was centered in the East Central United States. Transportation accounted for an estimated 37% of domestic consumption; the remainder was used in packaging, 23%; building, 13%; electrical, 8%; machinery, 8%; consumer durables, 7%; and other, 4%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Primary	2,516	2,481	2,284	2,554	2,640
Secondary (from old scrap)	1,160	1,080	1,260	1,600	1,400
Imports for consumption	4,720	5,330	5,180	4,490	4,300
Exports	1,820	2,370	2,820	2,840	3,800
Consumption, apparent[2]	6,060	5,990	5,980	5,110	3,700
Price, ingot, average U.S. market (spot), cents per pound	84.0	91.0	121.4	125.2	132.3
Stocks:					
Aluminum industry, yearend	1,470	1,430	1,410	1,400	1,300
LME, U.S. warehouses, yearend[3]	116	209	228	463	860
Employment, number[4]	57,500	58,400	57,300	56,600	55,000
Net import reliance[5] as a percentage of apparent consumption	39	41	31	19	E

Recycling: In 2008, aluminum recovered from purchased scrap was about 3.6 million tons, of which about 60% came from new (manufacturing) scrap and 40% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 30% of apparent consumption.

Import Sources (2004-07): Canada, 55%; Russia, 16%; Brazil, 4%; China, 4%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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.

Events, Trends, and Issues: During the first half of 2008, domestic primary aluminum production increased substantially owing to smelter restarts after new power contracts were obtained by producers in late 2006 and early 2007. However, in the second half of the year, production was curtailed at two smelters owing to high electricity prices, power supply issues, and a sharp drop in the price of aluminum that took place in August. Domestic smelters operated at about 72% of rated or engineered capacity.

Prepared by **E. Lee Bray [(703) 648-4979, lbray@usgs.gov, fax: (703) 648-7757]**

ALUMINUM

Net import reliance as a percent of apparent consumption continued a decline that began in 2005, as domestic primary production increased while imports for consumption decreased and exports increased, resulting in the United States becoming a net exporter of aluminum in 2008. Canada and Russia accounted for almost three-fourths of total imports. U.S. exports increased by 34% in 2008 compared with the amount exported in 2007. China, Canada, Mexico and Taiwan, in descending order, received approximately three-fourths of total U.S. exports.

The price of primary aluminum generally rose through July 2008 before declining significantly. In January, the average monthly U.S. market price for primary ingot quoted by Platts Metals Week was $1.136 per pound; it reached a high of $1.426 per pound in July, but in September, the price was $1.192 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 $1.138 per pound.

World primary aluminum production continued to increase as capacity expansions outside the United States were brought onstream. World inventories of metal held by producers, as reported by the International Aluminium Institute, increased through the end of August to about 3.0 million tons from 2.8 million tons at yearend 2007. Inventories of primary aluminum metal held by the LME worldwide increased during the year to 1,380,000 tons at the end of September from 930,000 tons at yearend 2007.

World Smelter Production and Capacity:

	Production		Yearend capacity	
	2007	2008[e]	2007	2008[e]
United States	2,554	2,640	3,620	3,620
Australia	1,960	1,960	1,950	1,950
Bahrain	873	870	830	830
Brazil	1,660	1,660	1,700	1,700
Canada	3,090	3,100	3,100	3,100
China	12,600	13,500	14,000	15,000
Germany	550	590	600	600
Iceland	398	790	790	790
India	1,220	1,300	1,500	1,800
Mozambique	564	550	570	570
Norway	1,300	1,100	1,350	1,200
Russia	3,960	4,200	4,400	4,400
South Africa	899	850	900	900
Tajikistan	419	420	515	515
United Arab Emirates, Dubai	890	920	890	950
Venezuela	610	550	625	625
Other countries	4,460	4,700	5,360	5,770
World total (rounded)	38,000	39,700	42,700	44,300

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: Composites can substitute for aluminum in aircraft fuselages and wings. Glass, paper, plastics, and steel can substitute for aluminum in packaging. Magnesium, titanium, and steel can substitute for aluminum in ground transportation and structural uses. Composites, steel, vinyl, and wood can substitute for aluminum in construction. Copper can replace aluminum in electrical applications.

[e]Estimated. E Net exporter.
[1]See also Bauxite and Alumina.
[2]Domestic primary metal production + recovery from old aluminum scrap + net import reliance. Series revised by removing imported scrap to avoid double counting.
[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: One mine in Nevada produced some antimony concentrate in 2008. 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 others, 13%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production:					
Mine (recoverable antimony)	—	—	—	W	W
Smelter:					
Primary	W	W	W	W	W
Secondary	3,650	3,030	3,520	3,480	3,350
Imports for consumption	33,500	22,700	23,200	21,900	22,400
Exports of metal, alloys, oxide, and waste and scrap[1]	3,810	2,140	2,140	1,950	2,050
Consumption, apparent[2]	36,800	31,400	24,300	23,700	23,800
Price, metal, average, cents per pound[3]	130	161	238	257	284
Stocks, yearend	2,830	2,110	2,120	1,900	1,850
Employment, plant, number[e]	30	10	10	10	10
Net import reliance[4] as a percentage of apparent consumption	90	88	86	85	86

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 (2004-07): Metal: China, 67%; Mexico, 11%; Peru, 8%; and other, 14%. Ore and concentrate: China, 66%; Bolivia, 2%; and other, 32%. Oxide: China, 47%; Mexico, 40%; Belgium, 7%; and other, 6%. Total: China, 51%; Mexico, 34%; Belgium, 6%; and other, 9%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
Ore and concentrates	2617.10.0000	Free.
Antimony oxide	2825.80.0000	Free.
Antimony and articles thereof, including waste and scrap	8110.00.0000	Free.

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

Government Stockpile: None.

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

ANTIMONY

Events, Trends, and Issues: In 2008, antimony production from domestic source materials was derived mostly from the recycling of lead-acid batteries. One mine in Nevada produced some antimony concentrate. 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 $2.66 per pound and generally rose during much of the year finishing August at $3.04 per pound.

During 2008, the world's leading antimony producer, China, continued experiencing sporadic production problems. Rivers in southern China have been dry because of droughts in late winter, impeding the transportation of antimony materials. Also, Government authorities implemented measures ahead of the Summer Olympic Games that affected antimony production; among the Government's initiatives has been a crackdown on pollution levels, which restricted production at some antimony plants.

Several new antimony mine projects were being developed in Australia, Canada, and Mexico.

World Mine Production Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	2007	2008[e]		
United States	W	W	—	90,000
Bolivia	5,500	3,500	310,000	320,000
China	150,000	150,000	790,000	2,400,000
Russia (recoverable)	3,500	2,000	350,000	370,000
South Africa	4,400	3,000	44,000	200,000
Tajikistan	2,000	2,000	50,000	150,000
Thailand	—	—	420,000	450,000
Other countries	4,000	4,000	150,000	330,000
World total (rounded)	170,000	165,000	2,100,000	4,300,000

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. 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: There has been no domestic production of arsenic trioxide or arsenic metal since 1985. Imports of arsenic trioxide averaged more than 20,000 tons annually during 2001-03 and were used mainly in the production of chromated copper arsenate (CCA) wood preservatives. The grids in lead-acid storage batteries were strengthened by the addition of arsenic metal, and small-arms ammunition used by the United States military was hardened by the addition of less than 1% arsenic metal. Other applications of arsenic metal include its use as an antifriction additive for bearings, in lead shot, and in clip-on wheel weights. Arsenic compounds were used in fertilizers, fireworks, herbicides, and insecticides. The electronics industry used high-purity arsenic (99.9999%) for gallium-arsenide semiconductors that are used for solar cells, space research, and telecommunication. Arsenic may be used for germanium-arsenide-selenide specialty optical materials. Indium-gallium-arsenide was used for short wave infrared technology. The value of arsenic compounds and metal consumed domestically in 2008 was estimated to be about $7 million.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Imports for consumption:					
Metal	872	812	1,070	759	500
Trioxide	6,150	8,330	9,430	7,010	8,000
Exports, metal	220	3,270	3,060	2,490	1,300
Estimated consumption[1]	6,800	5,870	7,340	5,280	7,200
Value, cents per pound, average:[2]					
Metal (China)	88	95	160	81	98
Trioxide (China)	49	18	22	42	41
Trioxide (Mexico)	32	67	NA	NA	NA
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: Electronic circuit boards, relays, and switches may contain arsenic and should be disposed of at sites that recycle arsenic-containing, end-of-service electronics or at hazardous waste sites. Arsenic contained in the process water at wood treatment plants where CCA was used was recycled. Arsenic was also recovered from gallium-arsenide scrap from semiconductor manufacturing. There was no recovery or recycling of arsenic from arsenic-containing residues and dusts at nonferrous smelters in the United States.

Import Sources (2004-07): Metal: China, 86%; Japan, 10%; and other, 4%. Trioxide: China, 49%; Morocco, 37%; Hong Kong, 5%; Mexico, 3%; and other, 6%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
Metal	2804.80.0000	Free.
Acid	2811.19.1000	2.3% ad val.
Trioxide	2811.29.1000	Free.
Sulfide	2813.90.1000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **William E. Brooks [(703) 648-7791, wbrooks@usgs.gov, fax: (703) 648-7757]**

ARSENIC

Events, Trends, and Issues: Exposure to arsenic may affect breathing, heart rhythm, and possibly increase the risk for bladder cancer. Therefore, in response to these human health issues, the wood-preserving industry made a voluntary decision to stop using CCA to treat wood used for decks and outdoor residential use by yearend 2003. Because of known performance and lower cost, CCA may still be used to treat wood used for nonresidential applications. Human health concerns, regulation, use of alternative wood preservation material, and the substitution of concrete or plasticized wood products will affect the long-term demand for arsenic.

Exports of arsenic metal have increased dramatically since 2004. Exports classified as arsenic metal may include arsenic-containing “e-waste” such as computers and other electronics destined for reclamation and recycling. The exported arsenic may also have been used directly in electronics applications or in the production of small-arms ammunition. Export destinations for arsenic metal were Germany (35%), Japan (34%), and China (31%).

The U.S. Food and Drug Administration (FDA) issued a warning to consumers and recalled certain brands of mineral water that were found to contain from 454 to 674 micrograms per liter (µg/l) arsenic; FDA’s standard of quality for bottled water allows no more than 10 µg/l. Geologic sources of arsenic and the effects of high levels of arsenic on humans are the focus of global government and university research.

Rice grown in the United States may contain from one to five times the arsenic contained in rice from Bangladesh, Europe, and India. Arsenic was added to chicken feed in order to promote growth, kill parasites, and improve pigmentation of chicken meat; therefore, chicken manure may introduce arsenic to agricultural fields and ultimately to ground water. Arsenic may also be released from coal-burning powerplant emissions and from buried World War I ammunition. Researchers estimated that 1,740 tons of arsenic may be contained in CCA-treated wood and construction debris left by Hurricane Katrina in August 2005. Arsenic trioxide may be used to treat leukemia.

World Production, Reserves, and Reserve Base:

	Production (arsenic trioxide)		Reserves and reserve base[4] (arsenic content)
	2007	2008[e]	
Belgium	1,000	1,000	
Chile	11,400	11,500	World reserves and reserve base are thought to be about 20 and 30 times, respectively, annual world production. The reserve base for the United States is estimated to be 80,000 tons.
China	25,000	25,000	
Kazakhstan	1,500	1,500	
Mexico	1,600	1,500	
Morocco	8,950	7,000	
Peru	4,320	4,000	
Russia	1,500	1,500	
Other countries	630	500	
World total (rounded)	55,900	53,500	

World Resources: Arsenic may be obtained from roasting arsenopyrite, the most abundant ore mineral of arsenic, as well as from copper, gold, and lead smelter dust. Arsenic may be recovered from enargite, a copper mineral; realgar and orpiment in China, Peru, and the Philippines; copper-gold ores in Chile; and associated with gold occurrences in Canada. In Sichuan Province, China, orpiment and realgar from gold mines are stockpiled for later recovery of arsenic. Global resources of copper and lead contain approximately 11 million tons of arsenic.

Substitutes: Wood-treatment substitutes include alkaline copper quaternary, ammoniacal copper quaternary, ammoniacal copper zinc arsenate, copper azole, and copper citrate. In humid areas, silver-containing biocides are being considered as an alternative wood preservative. Other CCA-treated wood substitutes include concrete, steel, plasticized wood scrap, or plastic composites.

[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 metric tons unless otherwise noted)

Domestic Production and Use: Asbestos has not been mined in the United States since 2002, so the United States is dependent on imports to meet manufacturing needs. Asbestos consumption in the United States was estimated to be 1,880 t, based on asbestos imports through July 2008. Roofing products were estimated to account for 76% of U.S. consumption and other applications, 24%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production (sales), mine	—	—	—	—	—
Imports for consumption	3,450	2,530	2,230	1,730	1,880
Exports[1]	1,580	1,510	3,410	815	451
Consumption, estimated	3,450	2,530	2,230	1,730	1,880
Price, average value, dollars per ton[2]	234	561	451	473	868
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2004-07): Canada, 82%; and other, 18%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
Asbestos other than crocidolite	2524.90.0000	Free.
Crocidolite	2524.10.0000	Free.

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

Government Stockpile: None.

Prepared by **Robert L. Virta [(703) 648-7726, rvirta@usgs.gov, fax: (703) 648-7757]**

ASBESTOS

Events, Trends, and Issues: There was no production of asbestos in the United States. U.S. exports decreased to an estimated 451 tons in 2008 from 815 tons in 2007. Exports are likely to include some nonasbestos materials and reexports, as U.S. production of asbestos ceased in 2002. Imports increased to 1,880 t in 2008 from 1,730 tons in 2007. Domestic use of asbestos increased to 1,880 tons in 2008 from 1,730 tons in 2007. 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 reduced the permissible asbestos exposure limit to 0.1 fiber per cubic centimeter (f/cc) from 2 f/cc for an 8-hour time-weighted average. The 15-minute excursion limit for metal and nonmetal mines was reduced to 1 f/cc from 10 fibers per milliliter, and the 1-hour excursion limit for coal mines was reduced to 1 f/cc from 10 f/cc during each 8-hour day.

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.

South Africa enacted a ban on the use, processing, manufacturing, and trade of asbestos or asbestos-containing materials, with some exemptions.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States	—	—	Small	Large
Brazil	230,000	220,000	Moderate	Moderate
Canada	185,000	175,000	Large	Large
China	380,000	380,000	Large	Large
Kazakhstan	300,000	300,000	Large	Large
Russia	925,000	925,000	Large	Large
Zimbabwe	100,000	100,000	Moderate	Moderate
Other countries	80,000	75,000	Moderate	Large
World total (rounded)	2,200,000	2,180,000	Large	Large

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

Substitutes: Numerous materials substitute for asbestos in products. 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.

[e]Estimated. — Zero.
[1]Probably includes nonasbestos materials and reexports.
[2]Average value for U.S. chrysotile imports, all grades combined. Prices for individual commercial products are no longer published.
[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: Domestic producers of crude barite sold or used for grinding about 615,000 tons in 2008 valued at about $30 million, an increase in production of about 35% from that of 2007. Most of the production came from four major mines in Nevada followed by a significantly smaller sales volume from a single mine in Georgia. In 2008, about 2.9 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. The majority of Nevada crude barite was ground in Nevada and then sold to gas drilling customers in Colorado, Utah, and Wyoming. Crude barite was shipped to a Canadian grinding mill in Lethbridge, Alberta, which supplies the Western Canadian drilling mud market. A new producer shipped crude barite from its mine in Nevada to its grinding mill in Wyoming. The barite imports to the Louisiana and Texas ports went primarily to offshore drilling operations in the Gulf of Mexico and to onshore operations in Louisiana, New Mexico, Oklahoma, and Texas. 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 also used as a filler, extender, or weighting agent in products such as paints, plastics, and rubber. Some specific applications include its use in automobile brake and clutch pads and 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:	2004	2005	2006	2007	2008[e]
Sold or used, mine	532	489	589	455	615
Imports for consumption	2,000	2,690	2,550	2,600	2,400
Exports	70	93	72	15	52
Consumption, apparent[1] (crude and ground)	2,460	3,080	3,070	3,040	2,960
Consumption[2] (ground and crushed)	2,440	2,720	3,040	2,980	2,950
Price, average value, dollars per ton, f.o.b. mine	35.10	35.90	40.00	45.30	49.00
Employment, mine and mill, number[e]	340	340	330	330	350
Net import reliance[3] as a percentage of apparent consumption	78	84	81	85	79

Recycling: None.

Import Sources (2004-07): China, 92%; India, 7%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Crude barite	2511.10.5000	$1.25 per metric ton.
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.
Carbonate	2836.60.0000	2.3% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **M. Michael Miller [(703) 648-7716, mmiller1@usgs.gov, fax: (703) 648-7757]**

BARITE

Events, Trends, and Issues: A new open pit mine and jig mill started barite production in Elko County, NV; crude barite was shipped to the company's grinding plant in Evanston, WY. The operation planned to mill 75,000 tons of stockpiled barite ore mined in the 1980s while stripping overburden to access the ore body.

There is a tariff on U.S. imports of crude barite equal to $1.25 per ton, but there is no tariff on imports of ground barite. As a result, some of the major importers of crude barite have applied for and received foreign trade zone status for their grinding mills. Two such applications were approved in 2007 (Amelia, LA, and Galveston, TX), and another two were approved in 2008 (Morgan City, LA, and Corpus Christi, TX). This means that the ground barite produced by these mills will be reported as imports for consumption and not as crude barite received from foreign suppliers.

World Mine Production, Reserves, and Reserve Base: Barite production from Brazil and Thailand has decreased to the point where they are currently minor producers; data on mine production, reserves, and reserve base have been moved to the "other countries" category. France's sole barite producer ceased production in 2006; data on reserves have been revised to zero and reserve base data have been included in other countries.

	Mine production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States	455	615	15,000	45,000
Algeria	63	65	9,000	15,000
Bulgaria	51	50	NA	NA
China	4,400	4,400	62,000	360,000
Germany	88	85	1,000	1,500
India	1,000	1,000	53,000	80,000
Iran	240	250	NA	NA
Kazakhstan	[5]95	[5]95	NA	150,000
Mexico	186	160	7,000	8,500
Morocco	[6]485	[6]500	10,000	11,000
Pakistan	44	44	1,000	2,000
Russia	63	65	2,000	3,000
Turkey	150	150	4,000	20,000
United Kingdom	55	55	100	600
Vietnam	120	100	NA	NA
Other countries	135	140	24,000	180,000
World total (rounded)	7,630	7,770	190,000	880,000

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[4] 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]Sold or used by domestic mines + imports – exports.
[2]Domestic and imported crude barite sold or used by domestic grinding establishments.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.
[5]Estimated marketable barite; however, reported production figures are significantly higher.
[6]Estimated marketable production based on export data.

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 three Bayer refineries operating throughout the year and one temporarily idled. Domestic bauxite was used in the production of nonmetallurgical products, such as abrasives, chemicals, and refractories.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, bauxite, mine	NA	NA	NA	NA	NA
Imports of bauxite for consumption[2]	10,600	13,200	12,900	11,200	11,600
Imports of alumina[3]	1,650	1,860	1,860	2,440	2,600
Exports of bauxite[2]	75	62	43	30	17
Exports of alumina[3]	1,230	1,210	1,540	1,160	1,300
Shipments of bauxite from Government stockpile excesses[2]	66	—	—	—	—
Consumption, apparent, bauxite and alumina (in aluminum equivalents)[4]	2,830	3,540	3,290	3,630	3,600
Price, bauxite, average value U.S. imports (f.a.s.) dollars per ton	23	25	28	31	31
Stocks, bauxite, industry, yearend[2, 5]	3,120	W	W	W	W
Net import reliance,[6] bauxite and alumina, as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2004-07):[7] Bauxite: Jamaica, 31%; Guinea, 22%; Brazil, 19%; Guyana, 12%; and other, 16%. Alumina: Australia, 45%; Suriname, 23%; Jamaica, 12%; Brazil, 7%; and other, 13%. Total: Jamaica, 26%; Guinea, 16%; Brazil, 16%; Australia, 15%; 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 2008 had normal-trade-relations status.

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

Government Stockpile:

Stockpile Status—9-30-08[8]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Bauxite, metal grade Jamaica-type	—	—	2,030	—

Prepared by **E. Lee Bray [(703) 648-4979, lbray@usgs.gov, fax: (703) 648-7757]**

BAUXITE AND ALUMINA

Events, Trends, and Issues: The published price range for metallurgical-grade alumina began the year at $350 to $370 per ton, as published by Metal Bulletin. By the end of February, the price range had reached $390 to $420 per ton, where it remained until the end of June. The price range increased to $420 to $450 per ton at the beginning of July until mid-August, when it began to decline. The price range was $360 to $390 per ton at the end of September.

World production of alumina increased slightly compared with that of 2007. Based on production data from the International Aluminium Institute, world alumina production during the first 2 quarters of 2008 increased by 4% compared with that for the same period in 2007. Expansions of bauxite mines in Australia, Brazil, China, and India accounted for most of the slight increase in worldwide production of bauxite in 2008 compared with that of 2007.

World Bauxite Mine Production, Reserves, and Reserve Base: Estimates of reserves and the reserve base for Vietnam were added based on new information from the state mining company.

	Mine production		Reserves[9]	Reserve base[9]
	2007	2008[e]		
United States	NA	NA	20,000	40,000
Australia	62,400	63,000	5,800,000	7,900,000
Brazil	24,800	25,000	1,900,000	2,500,000
China	30,000	32,000	700,000	2,300,000
Greece	2,220	2,200	600,000	650,000
Guinea	18,000	18,000	7,400,000	8,600,000
Guyana	1,600	1,600	700,000	900,000
India	19,200	20,000	770,000	1,400,000
Jamaica	14,600	15,000	2,000,000	2,500,000
Kazakhstan	4,800	4,800	360,000	450,000
Russia	6,400	6,400	200,000	250,000
Suriname	4,900	4,500	580,000	600,000
Venezuela	5,900	5,900	320,000	350,000
Vietnam	30	30	2,100,000	5,400,000
Other countries	7,150	6,800	3,200,000	3,800,000
World total (rounded)	202,000	205,000	27,000,000	38,000,000

World Resources: Bauxite resources are estimated to be 55 to 75 billion tons, located in Africa (33%), Oceania (24%), South America and the Caribbean (22%), Asia (15%), and elsewhere (6%). 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 alunite, anorthosite, coal wastes, and oil shales, offer additional potential alumina sources. Although it would require new plants using different technology, alumina from these nonbauxitic materials could satisfy the demand for primary metal, refractories, aluminum chemicals, and abrasives. Synthetic mullite, produced from kyanite and sillimanite, substitutes for bauxite-based refractories. Although more costly, silicon carbide and alumina-zirconia can substitute for bauxite-based abrasives.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — 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. Data revised based on new information from the Jamaica Bauxite Institute.

[3]Calcined equivalent weights.

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

[5]A company acquisition in 2007 resulted in the withholding of data, including revisions to data from 2005.

[6]Defined as imports – exports + adjustments for Government and industry stock changes (all in aluminum equivalents). Treated as separate commodities, the net import reliance equaled 100% for bauxite and 26% for alumina in 2008. For the years 2004-07, the net import reliance was 100% for bauxite and ranged from 5% to 31% for alumina.

[7]Based on aluminum equivalents.

[8]See Appendix B for definitions.

[9]See Appendix C for definitions.

BERYLLIUM

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

Domestic Production and Use: One 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—some of which was sold. Estimated beryllium consumption of 141 tons was valued at about $50 million, based on the estimated unit value for beryllium in imported beryllium-copper master alloy. Based on sales revenues, nearly one-half of beryllium use was estimated to be used 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:	2004	2005	2006	2007	2008[e]
Production, mine shipmentse	90	110	155	152	155
Imports for consumption[1]	85	93	62	72	80
Exports[2]	217	201	135	101	130
Government stockpile releases[3]	106	79	158	36	36
Consumption:					
Apparent[4]	69	84	226	109	141
Reported, ore	130	160	180	192	NA
Unit value, average annual, beryllium-copper master alloy, dollars per pound contained beryllium[5]	125	99	128	144	162
Stocks, ore, consumer, yearend	40	35	50	100	NA
Net import reliance[6] as a percentage of apparent consumption	E	E	[7]31	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 (2004-07):[1] Kazakhstan, 58%; United Kingdom, 10%; Ireland, 9%; Japan, 7%; and other, 16%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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, including 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 fiscal year 2009 Annual Materials Plan are as follows: beryl ore, 36 tons of contained beryllium; beryllium-copper master alloy, 11 tons of contained beryllium; and beryllium metal, 36 tons.

Stockpile Status—9-30-08[8]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Beryl ore (11% BeO)	1	1	[9]109	—
Beryllium-copper master alloy	—	—	11	3
Beryllium metal:				
Hot-pressed powder	133	88	—	21
Vacuum-cast	31	31	36	9

Prepared by **Brian W. Jaskula [(703) 648-4908, bjaskula@usgs.gov, fax: (703) 648-7757]**

BERYLLIUM

Events, Trends, and Issues: During the first three quarters of 2008, the leading U.S. beryllium producer had greater sales of bulk and strip beryllium-copper alloy products than during the first three quarters of 2007. Sales of beryllium products for defense applications and medical and industrial x-ray equipment were lower than those during the first three quarters of 2007; sales of beryllium to an experimental nuclear fusion reactor in Europe and to the National Aeronautics and Space Administration for the James Webb Space Telescope effectively ended in 2007. Sales of beryllium oxide ceramics were lower than those during the first three quarters of 2007.

In 2008, the leading U.S. beryllium producer opened a new bertrandite mine in Utah. The company also began construction of a new primary beryllium facility at its operations in Ohio. The engineering and design of the new facility was funded by the U.S. Department of Defense under the Defense Production Act, Title III. Construction and startup of the facility was expected to take 2 to 3 years; funding would require additional Title III approval. Primary beryllium facilities, the last of which closed in the United States in 2000, produce the feedstock used to make beryllium metal products.

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]	
	2007	2008
United States	152	155
China	20	20
Mozambique	6	6
Other countries	([11])	([11])
World total (rounded)	180	180

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 15,900 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 Gold Hill and Spor Mountain 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. In some applications, certain metal matrix or organic composites, high-strength grades of aluminum, pyrolytic graphite, silicon carbide, steel, or titanium may be substituted for beryllium metal or beryllium composites. Copper alloys containing nickel and silicon, tin, 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. Aluminum nitride or boron nitride may be substituted for beryllium oxide in some applications.

[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.
[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]Significant releases of beryl from the National Defense Stockpile resulted in a positive net import reliance as a percentage of apparent consumption in 2006.
[8]See Appendix B for definitions.
[9]Actual quantity will be limited to remaining inventory.
[10]See Appendix C for definitions.
[11]Less than ½ unit.

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 $80 million. About 43% of the bismuth was used for metallurgical additives; 24% in fusible alloys, solders, and ammunition cartridges; 31% in pharmaceuticals and chemicals; and 2% 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Refinery	—	—	—	—	—
Secondary (old scrap)	70	80	80	100	100
Imports for consumption, metal	1,990	2,530	2,300	3,070	3,480
Exports, metal, alloys, and scrap	109	142	311	421	566
Consumption:					
Reported	2,420	2,340	1,980	1,570	1,080
Apparent	2,130	2,490	2,070	2,750	3,000
Price, average, domestic dealer, dollars per pound	3.35	3.91	5.04	14.07	12.13
Stocks, yearend, consumer	134	136	158	156	163
Net import reliance[1] as a percentage of apparent consumption	95	96	95	96	97

Recycling: All types of bismuth-containing new and old alloy scrap were recycled and contributed about 10% of U.S. bismuth consumption, or 300 tons.

Import Sources (2004-07): Belgium, 29%; Mexico, 20%; United Kingdom, 19%; China, 16%; and other, 16%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
Bismuth and articles thereof, including waste and scrap	8106.00.0000	Free.

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

Government Stockpile: None.

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

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 a nontoxic replacement 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 the possibilities of using bismuth in lead-free solders. Researchers are examining liquid lead-bismuth coolants for use in nuclear reactors. Work is proceeding toward developing a bismuth-containing metal polymer bullet.

The price of bismuth started 2008 at $13.25 per pound and remained in a narrow range through the end of June. In July, the price fell to $12.50 per pound and generally declined through the end of October, where it finished at $9.75 per pound. The estimated average price of bismuth for 2008 was about 14% below that for 2007. Industry analysts attributed the lower price to slackened world demand in view of a world economic slowdown.

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 a European bismuth refiner. 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:

	Mine production		Reserves[2]	Reserve base[2]
	2007	2008[e]		
United States	—	—	—	14,000
Bolivia	150	150	10,000	20,000
Canada	190	190	5,000	30,000
China	3,500	3,000	240,000	470,000
Kazakhstan	140	140	5,000	10,000
Mexico	1,200	1,200	10,000	20,000
Peru	950	960	11,000	42,000
Other countries	170	160	39,000	74,000
World total (rounded)	6,300	5,800	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 and sustained 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: Data for boron production and consumption in 2008 in the United States were withheld to avoid disclosure of individual company proprietary data. Boron minerals, primarily as sodium borates, were produced domestically by two companies in southern California. The leading producer operated an open pit tincal and kernite mine and associated compound plants. A second company produced borax and boric acid using saline brines as the raw material. A third company that previously processed calcium and calcium sodium borates became a trader and sold from inventory and imported products in 2005 but continues to be idle in 2008. 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 2008 was glass and ceramics, 74%; soaps, detergents, and bleaches, 6%; agriculture, 3%; enamels and glazes, 3%; and other, 14%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production[1]	637	612	W	W	W
Imports for consumption, gross weight:					
Borax	([2])	1	2	1	1
Boric acid	49	52	85	67	65
Colemanite	21	31	25	26	27
Ulexite	110	103	131	92	90
Exports, gross weight:					
Boric acid	61	183	221	248	260
Colemanite	18	—	—	—	—
Refined sodium borates	135	308	393	446	470
Consumption:					
Apparent	509	439	W	W	W
Reported	385	W	W	W	W
Price, dollars per ton, granular pentahydrate borax[3]	577-673	587-685	587-685	599-699	599-699
Employment, number	1,390	1,360	1,320	1,350	1,420
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2004-07): Boric acid: Turkey, 55%; Chile, 24%; Bolivia, 8%; Peru, 5%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Natural borates:		
Sodium	2528.10.0000	Free.
Calcium	2528.90.0010	Free.
Other	2528.90.0050	Free.
Boric acids	2810.00.0000	1.5% ad val.
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.

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

Government Stockpile: None.

Prepared by **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

BORON

Events, Trends, and Issues: Although production data were withheld, the United States was a major world producer of refined boron compounds during 2008. U.S. processed products had fewer impurities and were produced with lower emissions than in other countries. The U.S. industry continues to produce boron minerals with a higher productivity per worker hour than those produced in other countries.

Growth in fiberglass and borosilicate production has driven a global demand for boron. A rapid increase in the manufacture of reinforcement-grade fiberglass in Asia, with subsequent increase in demand for borates, offset the development of boron-free reinforcement-grade fiberglass in Europe and the United States. The continued rise in energy prices can be expected to lead to greater use of insulation-grade fiberglass, with consequent growth in the use of boron.

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. China, Eastern Europe, and India are favorable areas for increased borates consumption because of their growing economies. Turkey launched a promotional campaign by seeking out new areas of use for the mineral. Significant strides in foreign investment, free trade, industrialization, and urbanization would continue to increase the demand for borates over the next several years.

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

	Production—All forms		Reserves[6]	Reserve base[6]
	2007	2008[e]		
United States	W	W	40,000	80,000
Argentina	550	670	2,000	9,000
Bolivia	50	65	NA	NA
Chile	528	540	NA	NA
China	145	150	25,000	47,000
Iran	2	2	1,000	1,000
Kazakhstan	30	30	NA	NA
Peru	10	10	4,000	22,000
Russia	400	400	40,000	100,000
Turkey	2,130	2,250	60,000	150,000
World total (rounded)	3,840	4,100	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. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Minerals and compounds sold or used by producers; includes both actual mine production and marketable products.
[2]Less than ½ unit.
[3]Source: Industrial Minerals, no. 446, December 2004, p. 71; no. 459, December 2005, p. 70; no. 471, December 2006, p. 74; no. 483, December 2007, p. 76. In Mineral Commodity Summaries 2008 and earlier, price of granulated pentahydrate borax in bulk, carload, works was used.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]Gross weight of ore in thousand metric tons.
[6]See Appendix C for definitions.

BROMINE

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

Domestic Production and Use: Bromine was recovered from underground brines by two companies in Arkansas. Bromine was the leading mineral commodity, in terms of value, produced in Arkansas. The two bromine companies in the United States accounted for about one-third of world production.

Primary uses of bromine compounds are in flame retardants, drilling fluids, brominated pesticides (mostly methyl bromide), and water treatment. Bromine is also used in the manufacture of dyes, insect repellents, perfumes, pharmaceuticals, and photographic chemicals. Other products containing bromine included intermediate chemicals for the manufacture of chemical products and bromide solutions used alone or in combination with other chemicals.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production[1]	222,000	226,000	243,000	W	W
Imports for consumption, elemental bromine and compounds[2]	62,000	60,000	44,000	30,000	38,000
Exports, elemental bromine and compounds	9,000	10,000	12,000	11,000	11,000
Consumption, apparent[3]	274,000	277,000	275,000	W	W
Price, cents per kilogram, bulk, purified bromine	86.0	74.0	139.2	NA	NA
Employment, number	1,500	1,200	1,100	1,000	1,000
Net import reliance[4] as a percentage of apparent consumption	19	18	12	<25	<25

Recycling: Some bromide solutions were recycled to obtain elemental bromine and to prevent the solutions from being disposed of as hazardous waste. Hydrogen bromide is emitted as a byproduct in many organic reactions. This byproduct waste is recycled with virgin bromine brines and is a major source of bromine production. Plastics containing bromine flame retardants can be incinerated as solid organic waste, and the bromine can be recovered. 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 (2004-07): Israel, 93%; China, 4%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Bromine	2801.30.2000	5.5% ad val.
Hydrobromic acid	2811.19.3000	Free.
Potassium or sodium bromide	2827.51.0000	Free.
Ammonium, calcium, or zinc bromide	2827.59.2500	Free.
Other bromides and bromide oxides	2827.59.5100	3.6% ad val.
Potassium bromate	2829.90.0500	Free.
Sodium bromate	2829.90.2500	Free.
Ethylene dibromide	2903.31.0000	5.4% ad val.
Methyl bromide	2903.39.1520	Free.
Bromochloromethane	2903.49.1000	Free.
Tetrabromobisphenol A	2908.19.2500	5.5% ad val.
Decabromodiphenyl and octabromodiphenyl oxide	2909.30.0700	5.5% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: Although still the leading bromine producer in the world, the U.S. dominance has decreased as other countries, such as China, Israel, Japan, and Jordan, have strengthened their positions as world producers of elemental bromine.

Prepared by **Lori E. Apodaca [(703) 648-7724, lapodaca@usgs.gov, fax: (703) 648-7757]**

BROMINE

Albemarle Corp., Baton Rouge, LA, acquired Sorbent Technologies Corp., Twinsburg, OH, for $22.5 million in cash. The acquisition will broaden Albermarle's bromine-based solutions for removing mercury emissions from coal-fired powerplants.[5] Gulf Resources Inc., Shandong, China, acquired its fifth bromine production facility in China, increasing the company's annual bromine production capacity to about 4,700 tons.[6]

The largest use of bromine is in flame retardants; however, bromine use in flame retardants is of concern because of persistence of some bromine compounds in the environment and their potential health effects. The European Court of Justice ruled that Deca-BDE (decabromodiphenyl ether), a flame retardant, can no longer be used in electronics and electrical applications. The European Union approved the use of tetrabromobisphenol-A, a flame retardant used in more than 70% of the world's electrical and electronic appliances.

Bromine and bromine compound prices increased in 2008, reflecting the expanding markets of bromine and 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]
	2007	2008[e]		
United States[1]	W	W	11,000,000	11,000,000
Azerbaijan	2,000	2,000	300,000	300,000
China	130,000	135,000	130,000	3,500,000
Germany	1,600	1,600	([8])	([8])
India	1,500	1,500	([9])	([9])
Israel	159,000	165,000	([10])	([10])
Japan	20,000	20,000	([11])	([11])
Jordan	69,000	70,000	([10])	([10])
Spain	([12])	([12])	1,400,000	1,400,000
Turkmenistan	([12])	([12])	700,000	700,000
Ukraine	3,000	3,000	400,000	400,000
World total (rounded)	[13]387,000	[13]398,000	Large	Large

World Resources: Bromine is found principally in seawater, evaporitic (salt) lakes, and underground brines associated with petroleum deposits. In the Middle East, the Dead Sea 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 phosphorus 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. NA Not available. W Withheld to avoid disclosing company proprietary data.
[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]Albemarle Corp., 2008, Albemarle Corporation acquires Sorbent Technologies: Albemarle Corp. press release, October 10, 1 p.
[6]Gulf Resources, Inc., 2008, Gulf Resources, Inc. announces first quarter 2008 financial results: Gulf Resources Inc. press release, May 8, 1 p.
[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.
[12]Less than ½ unit.
[13]Excludes U.S. production.

CADMIUM

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

Domestic Production and Use: Three companies in the United States were thought to have produced cadmium metal in 2008. One company, operating in Tennessee, recovered cadmium as a byproduct of zinc leaching from roasted sulfide concentrates. The other two companies, with facilities located in Ohio and Pennsylvania, thermally recovered cadmium metal from spent nickel-cadmium (NiCd) batteries and other cadmium-bearing scrap. Based on the average New York dealer price, U.S. cadmium metal consumption was valued at about $3.87 million in 2008.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, refinery[1]	1,480	1,470	723	735	745
Imports for consumption, metal only	102	207	179	315	182
Imports for consumption, metal, alloys, scrap	263	288	180	316	221
Exports, metal only	22	([2])	18	270	362
Exports, metal, alloys, scrap	154	686	483	424	440
Consumption of metal, apparent	1,840	699	568	585	564
Price, metal, average annual:[3]					
Dollars per kilogram	1.20	3.30	2.98	7.61	6.86
Dollars per pound	0.55	1.50	1.35	3.45	3.11
Stocks, yearend, producer and distributor	1,170	1,540	1,400	1,440	1,400
Net import reliance[4] as a percentage of apparent consumption	20	E	E	E	E

Recycling: Cadmium is mainly recovered from spent consumer and industrial NiCd batteries. Other waste and scrap from which cadmium can be recovered includes 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.

Import Sources (2004-07): Metal:[5] Australia, 31%; Mexico, 27%; Canada, 14%; Peru, 9%; and other, 19%.

Tariff: Item	Number	Normal Trade Relations[6] 12-31-08
Cadmium oxide	2825.90.7500	Free.
Cadmium sulfide	2830.90.2000	3.1% ad val.
Pigments and preparations based on cadmium compounds	3206.49.6010	3.1% ad val.
Unwrought cadmium and powders	8107.20.0000	Free.
Cadmium waste and scrap	8107.30.0000	Free.
Wrought cadmium and other articles	8107.90.0000	4.4% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: Most of the world's primary cadmium (approximately 51%) was being produced in Asia and the Pacific—specifically China, Japan, and the Republic of Korea—followed by North America (22%), Central Europe and Eurasia (18%), and Western Europe (6%). Global secondary cadmium production accounted for approximately 20% of all cadmium metal production, and this percentage was expected to increase in the future.

Cadmium use in batteries amounted to an estimated 83% of global consumption. The remaining 17% was distributed as follows: pigments, 8%; coatings and plating, 7%; stabilizers for plastics, 1.2%; and nonferrous alloys, photovoltaic devices, and other, 0.8%. The percentage of cadmium consumed globally for NiCd battery production has been increasing, while the percentages for the other traditional end uses of cadmium—specifically coatings, pigments, and stabilizers—have gradually decreased, owing to environmental and health concerns. A large percentage of the global NiCd battery market was concentrated in Asia.

Prepared by **Amy C. Tolcin [(703) 648-4940, atolcin@usgs.gov, fax: (703) 648-7757]**

CADMIUM

NiCd battery use in consumer electronics was thought to be declining owing partly to the preference for other rechargeable battery chemistries—particularly lithium ion (Li-ion) batteries, which have already replaced NiCd batteries to a large degree in laptops and cell phones. Li-ion batteries are used in lightweight electronic devices because of their greater energy density (power-to-weight ratio). However, demand for cadmium may increase owing to several new market opportunities for NiCd batteries, particularly in industrial applications. NiCd batteries currently power a large percentage of battery electric vehicles. Industrial-sized NiCd batteries could also be used to store energy produced by certain on-grid photovoltaic systems. Peak energy produced during the midday would be stored in a NiCd battery and later dispatched during periods of high electricity demand.

Concern over cadmium's toxicity has spurred various recent legislative efforts, especially in the European Union, to restrict the use of cadmium in most of its end-use applications. The final effect of this legislation on global cadmium consumption has yet to be seen. If recent legislation involving cadmium dramatically reduces long-term demand, a situation could arise, such as has been recently seen with mercury, where an accumulating oversupply of byproduct cadmium will need to be permanently stockpiled.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[7]	Reserve base[7]
	2007	2008[e]		
United States	735	745	43,000	67,000
Australia	350	350	66,000	260,000
Canada	2,100	2,100	23,000	84,000
China	4,000	4,100	99,000	280,000
Germany	640	640	—	8,000
India	580	620	21,000	49,000
Japan	1,930	2,000	—	—
Kazakhstan	2,100	2,100	41,000	89,000
Korea, Republic of	3,400	3,500	—	—
Mexico	1,620	1,620	21,000	39,000
Netherlands	500	500	—	—
Peru	420	420	54,000	87,000
Russia	810	850	12,000	37,000
Other countries	1,205	1,250	110,000	200,000
World total (rounded)	20,400	20,800	490,000	1,200,000

World Resources: Cadmium is generally recovered as a byproduct from zinc concentrates. Zinc-to-cadmium ratios in typical zinc ores range from 200:1 to 400:1. Sphalerite (ZnS), the most economically significant zinc mineral, commonly contains minor amounts of other elements; cadmium, which shares certain similar chemical properties with zinc, will often substitute for zinc in the sphalerite crystal lattice. The cadmium mineral greenockite (CdS) is frequently associated with weathered sphalerites and wurtzites [(Zn, Fe)S] but usually at microscopic levels. 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. Barium/zinc or calcium/zinc stabilizers can replace barium/cadmium stabilizers in flexible polyvinylchloride applications.

[e]Estimated. E Net exporter. — Zero.

[1]Cadmium metal and oxide produced as a byproduct of lead-zinc refining plus metal from recycling.

[2]Less than ½ unit.

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

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

[5]Imports for consumption of unwrought metal and metal powders (Tariff no. 8107.20.0000).

[6]No tariff for Australia, Canada, and Mexico for items shown.

[7]See Appendix C for definitions.

CEMENT

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2008, about 85 million tons of portland cement and about 3 million tons of masonry cement were produced at 113 plants in 37 States; total cement production capacity was about 130 million tons. Cement also was produced at two plants in Puerto Rico. Notwithstanding a significant decline in sales volumes, sales prices rose modestly in 2008 and implied a value of cement production, excluding that of Puerto Rico, of about $10.5 billion. Most of the cement was used to make concrete, worth at least $50 billion. As in 2007, the bulk of the sales decline was of imported cement. About 75% of cement sales went to ready-mixed concrete producers, 13% to concrete product manufacturers, 6% to contractors (mainly road paving), 3% to building materials dealers, and 3% to other users. Texas, California, Florida, Pennsylvania, 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]	2004	2005	2006	2007	2008[e]
Production:					
Portland and masonry cement[2]	97,434	99,319	98,167	95,464	87,700
Clinker	86,658	87,405	88,555	86,106	80,200
Shipments to final customers, includes exports	120,731	129,791	129,240	115,426	99,000
Imports of hydraulic cement for consumption	25,396	30,403	32,141	21,496	11,000
Imports of clinker for consumption	1,630	2,858	3,425	972	610
Exports of hydraulic cement and clinker	749	766	723	885	950
Consumption, apparent[3]	121,950	128,250	127,660	116,700	98,600
Price, average mill value, dollars per ton	79.50	91.00	101.50	105.00	107.00
Stocks, cement, yearend	6,740	7,450	9,380	8,760	7,900
Employment, mine and mill, number[e]	16,200	16,300	16,300	16,000	15,000
Net import reliance[4] as a percentage of apparent consumption	21	25	26	19	12

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 significant recycling of concrete for use as aggregate.

Import Sources (2004-07):[5] China, 19%; Canada, 18%; Thailand, 9%; Republic of Korea, 8%; and other, 46%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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: The dominant issue in 2008 was the continuation of a trend, begun in 2006, of declines in overall construction spending related to the combined effects of the severe decline in the housing market (especially in speculative purchasing of homes, which more or less ceased in 2006), escalating mortgage rates on subprime loans and related increases in foreclosures, and tighter credit overall. In 2008, the construction declines broadened significantly into nonhousing sectors, spurred by widespread financial difficulties in the private sector, and, in the public sector, by shortfalls in State funding related to reduced property tax revenues. Whereas the lower levels of cement sales had largely been accommodated in 2007 by sharp drops in cement imports and only slightly by decreased domestic cement production, both fell significantly in 2008. Although two new cement plants came online in 2008, three others closed, and announcements were made of additional plant closures (mostly of older wet kiln facilities) planned for 2009. Likewise, a number of ongoing capacity expansion projects were postponed or halted.

Prepared by **Hendrik G. van Oss [(703) 648-7712, hvanoss@usgs.gov, fax: (703) 648-7757]**

CEMENT

A number of environmental issues, especially carbon dioxide emissions, affect the cement industry. Carbon dioxide reduction strategies by the cement industry largely aim at reducing emissions per ton of cement product rather than by plant. These strategies include 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), such as pozzolans, for portland cement in the finished cement products and in concrete. Because SCM do not require the energy-intensive clinker manufacturing (kiln) phase of cement production, their use, or the use of inert additives or extenders, reduces the unit monetary and environmental costs of the cement component of concrete. Recent revisions to the major portland cement standard ASTM-C150 and the similar AASHTO M85 allow for the incorporation of up to 5% ground limestone as an inert extender, but it was as yet unclear how many plants would be able to adopt this practice. Research was ongoing toward developing cements that require less energy to manufacture than portland cement, and/or that utilize more benign raw materials.

Fossil fuel cost increases continued to be of concern to the cement industry. 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		Clinker capacity[e]	
	2007	**2008[e]**	**2007**	**2008**
United States (includes Puerto Rico)	96,500	89,100	102,000	104,000
Brazil	46,400	48,000	45,000	45,000
China	1,350,000	1,450,000	1,300,000	1,400,000
Egypt	38,400	40,000	37,000	38,000
France	[e]22,300	22,000	22,000	22,000
Germany	33,400	33,000	31,000	31,000
India	[e]170,000	175,000	160,000	170,000
Indonesia	[e]36,000	36,000	42,000	42,000
Iran	[e]36,000	35,000	35,000	36,000
Italy	47,500	47,000	46,000	46,000
Japan	67,700	67,000	70,000	70,000
Korea, Republic of	57,000	56,000	62,000	62,000
Mexico	40,700	40,000	40,000	40,000
Pakistan	[e]26,000	30,000	35,000	36,000
Russia	59,900	61,000	65,000	65,000
Saudi Arabia	30,400	30,000	29,000	29,000
Spain	[e]54,500	55,000	42,000	42,000
Thailand	35,700	35,000	50,000	50,000
Turkey	49,500	48,000	45,000	45,000
Vietnam	[e]36,400	37,000	32,000	35,000
Other countries (rounded)	[e]437,000	466,000	420,000	430,000
World total (rounded)	[e]2,770,000	2,900,000	2,700,000	2,800,000

World Resources: Although individual plant 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 many 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 + adjustments for stock changes.

[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: Pollucite, the ore mineral of cesium, may be found in zoned pegmatites worldwide. There are occurrences of cesium-bearing pollucite in pegmatites in Maine and South Dakota; however, these occurrences are not mined. Canada is the leading producer and supplier of pollucite concentrate, which is imported for processing by one corporation in the United States. The most widespread use of cesium is in cesium formate brines, a specialty, high-density drilling fluid used for completing high-temperature, high-pressure oil and gas wells in Argentina and in the North Sea. Cesium formate is especially useful for this application because of its density; it has a specific gravity of 2.3, which is more than twice the specific gravity of water.

Vibrations of cesium are used to maintain the accuracy of the atomic clocks at the U.S. Naval Observatory, Washington, DC. The master clock there provides a reference time, available to the public at (202) 762-1401. Atomic clocks that use cesium are accurate to a few hundred trillionths of a second and help synchronize the positions of the jets that track returning U.S. space shuttles. Global positioning satellites, Internet and cell phone transmissions, and missile guidance systems are all dependent on the accuracy of cesium atomic clocks.

Other applications of cesium include DNA separation techniques, infrared detectors, night vision devices, photoelectric cells, and traffic controls. Cesium-131 and cesium-137 are nuclear reactor-produced isotopes of cesium. These may be used, respectively, to treat prostate cancer or as brachytherapy where the radioactive source is placed within the cancerous area. Cesium chloride is also used in pill form to increase the pH level of tumor cells back to a normal level, which can slow the cancer's growth. This is usually used as an alternative cancer treatment for patients. Cesium-137 in the form of radioactive cesium chloride in stainless steel capsules is used in self-contained irradiators at hospitals and universities for blood irradiation and in biomedical and radiation research, as well as other industrial uses. Cesium-137 is also widely used in industrial gauges, in mining and geophysical instruments, and for sterilization of food, sewage, and surgical equipment.

Salient Statistics—United States: Production, consumption, import, and export data for cesium have not been available since the late 1980s. U.S. consumption and world mine production are unavailable. There is no trading of cesium, and therefore no market price is available. Consumption of cesium in the United States is small and is estimated to amount to only a few thousand kilograms per year. In 2008, one company offered 1-gram ampoules of 99.8% (metals basis) cesium for $44.40 each and 99.98% (metals basis) cesium for $58.40. The price for 50 grams of 99.8% (metals basis) cesium was $583.00, and 100 grams of 99.98% (metals basis) cesium was priced at $1,603.00. This is a 4.5% increase for the 99.8% (metals basis) cesium and a 5% increase for the 99.8% (metals basis) cesium from that of 2007.

Recycling: Cesium formate fluids are rented to oil and gas clients, and after completion of the well, the used cesium formate fluids are returned and reprocessed for subsequent drilling operations. Approximately 15% of the cesium formate may be lost in the well. There are no data available on the amounts used or recovered.

Import Sources (2004-07): Canada is the chief source of pollucite concentrate imported by the United States, and the United States is 100% import reliant.

Tariff:

Item	Number	Normal Trade Relations 12-31-08
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.

Prepared by **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

CESIUM

Events, Trends, and Issues: Domestic cesium occurrences will remain uneconomic unless there is a change in the market, such as new or increased end uses. The United States is reliant on imports of pollucite concentrate from Canada for its cesium supply. Cost and reactivity of the metal point to continued limited applications. Commercially useful quantities of inexpensive cesium are available as a byproduct of the production of lithium metal. There are no known human health issues associated with cesium, and its use has minimal environmental impact.

Cesium formate brine usage is increasing in the oil and gas exploration industry. Cesium formate brine does not contain solids or oil, which dramatically improves well control, well integrity, as well as increases the speed of drilling. Aside from its use in drilling fluid, cesium formate brine also has an application as a fast-acting liquid pill for releasing drill pipes differentially stuck in oil-based mud (OBM) filter cakes. The pill of formate brine rapidly destroys the OBM filter cake and allows the pipe to be jarred free. Cesium-137 is being used to monitor oil flow in pipelines. Cesium-137 is added to a new batch of oil to let the receiving station know if there is new oil being sent. The radiation that is given off by cesium-137 can be easily detected by holding a detector at the end of the pipeline.

The International Atomic Energy Agency has indicated that cesium-137 is one of several radioactive materials that may be used in radiological dispersion devices or “dirty bombs.” As of February 2008, the National Research Council (NRC) has mandated that the U.S. government take steps to promote the replacement of cesium-137, with lower risk alternatives. The NRC suggested that alternatives could lower the potential for theft and misuse. For most applications, radioactive cesium chloride can be replaced by lower-hazard alternatives that will not change the performance of the equipment. Such options include using less hazardous forms of radioactive cesium, radioactive cobalt, and x-ray generators.

World Mine Production, Reserves, and Reserve Base: Pollucite is a hydrated aluminosilicate mineral that may form in association with lithium-rich, lepidolite-bearing or petalite-bearing zoned pegmatites, which are a type of granite with exceptionally large crystals. Cesium reserves and reserve base are therefore estimated based on the occurrence of pollucite, which is mined as a byproduct with the lithium mineral lepidolite. Concentrates of pollucite may contain about 20% cesium by weight; however, cesium resource and mine production data are either limited or not available. The deposit at Lac du Bonnet, Manitoba, Canada, contains approximately 300,000 tons of pollucite that grades 24% Cs_2O and also contains tantalum. The next largest occurrence that may 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: Because of similar physical properties, proximity on the periodic table, and similar atomic radii, cesium and rubidium may be used interchangeably in many applications.

NA Not available. — Zero.
[1]See Appendix C for definitions.

CHROMIUM

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

Domestic Production and Use: In 2008, the United States consumed about 10% of world chromite ore production in various forms of imported materials, such as chromite ore, chromium chemicals, chromium ferroalloys, chromium metal, and stainless steel. One U.S. company mined chromite ore in Oregon. Imported chromite was consumed by one chemical firm to produce chromium chemicals. One company produced ferrochromium and chromium metal. Stainless- and heat-resisting-steel producers were the leading consumers of ferrochromium. Superalloys require chromium. The value of chromium material consumption in 2007 was $548 million as measured by the value of net imports, excluding stainless steel, and was expected to be about $1,800 million in 2008.

Salient Statistics—United States:[1]	2004	2005	2006	2007	2008[e]
Production:					
Primary	—	—	W	W	W
Secondary	233	255	234	292	290
Imports for consumption	489	503	520	464	500
Exports	171	220	212	284	250
Government stockpile releases	94	91	103	156	90
Consumption:					
Reported (includes scrap)	444	431	437	442	400
Apparent[2] (includes scrap)	647	628	645	629	630
Unit value, average annual import (dollars per metric ton):					
Chromite ore (gross mass)	114	140	141	156	250
Ferrochromium (chromium content)	1,322	1,425	1,290	1,951	3,500
Chromium metal (gross mass)	5,823	8,007	8,181	8,331	10,000
Stocks, yearend, held by U.S consumers	8	9	10	10	10
Net import reliance[3] as a percentage of apparent consumption	64	59	64	54	54

Recycling: In 2008, recycled chromium (contained in reported stainless steel scrap receipts adjusted for stainless steel and chromium metal scrap trade) accounted for 32% of apparent consumption.

Import Sources (2004-07): Chromium contained in chromite ore, chromium ferroalloys and metal, and stainless steel mill products: South Africa, 35%; Kazakhstan, 19%; Russia, 6%; Zimbabwe, 5%; and other, 35%.

Tariff:[4] Item	Number	Normal Trade Relations 12-31-08
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:[5] 22% (Domestic), 14% (Foreign).

Government Stockpile: In fiscal year (FY) 2008, which ended on September 30, 2008, the Defense Logistics Agency, Defense National Stockpile Center (DNSC), reported sales of 29,357 tons of high-carbon ferrochromium, 22,710 tons of low-carbon ferrochromium, and 327 tons of chromium metal. As a result of a July 2008 change in DNSC's method of computing inventory, the FY 2008 change in reported inventory does not accurately reflect the change in physical inventory. Disposals in the following table are based on DNSC's reported sales. Metallurgical-grade chromite ore and ferrochromium silicon stocks were exhausted in FY 2002; chemical- and refractory-grade chromite ore stocks were exhausted in FY 2004. The DNSC announced maximum disposal limits for FY 2009 of about 136,000 tons of ferrochromium (high- and low-carbon combined) and 907 tons of chromium metal. At the current maximum disposal rate, ferrochromium stocks will be exhausted in FY 2011; chromium metal, in FY 2014.

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

CHROMIUM

Stockpile Status—9-30-08[5]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008	Average chromium content
Ferrochromium:					
High-carbon	139	139	[6]136	29.4	71.4%
Low-carbon	66.7	66.7	([6])	22.7	71.4%
Chromium metal	4.82	4.82	0.907	0.327	100%

<u>Events, Trends, and Issues</u>: The price of ferrochromium reached historically high levels in 2008. China's role as a chromium consumer grew along with its stainless steel production industry. China's importance as a consumer of raw materials used in stainless steel production increased owing to its strong economic growth and the expansion of its stainless steel production. China's stainless steel production exceeded that of the United States beginning in 2004 and by 2008 was 335% greater than that of the United States. The U.S. financial problems and the subsequent economic slowdown were expected to result in reduced chromium material consumption and production, factors that could cause prices to decrease.

<u>World Mine Production, Reserves, and Reserve Base</u>: The Indian reserves and reserve base were revised based on information reported by the Government of India. The reserves and reserve base of Kazakhstan were revised based on new information published by mining companies. The reserves and reserve base of South Africa were recalculated to be consistent with those of India and Kazakhstan.

	Mine production[7] 2007	Mine production[7] 2008[e]	Reserves[8] (shipping grade)[9]	Reserve base[8] (shipping grade)[9]
United States	W	W	110	120
India	3,320	3,300	21,000	44,000
Kazakhstan	3,690	3,700	6,100	180,000
South Africa	9,650	9,600	77,000	150,000
Other countries	4,850	4,900	NA	NA
World total (rounded)	21,500	21,500	NA	NA

<u>World Resources</u>: 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.

<u>Substitutes</u>: 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. W Withheld to avoid disclosing company proprietary data.
[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 26 U.S.C. sec. 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.
[9]Reserves and reserve base units are thousand metric tons of shipping-grade chromite ore, which 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 2008, clay and shale production was reported in 41 States. About 190 companies operated approximately 830 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 2008, sales or use was estimated to be 33.2 million tons valued at $1.73 billion. Major uses for specific clays were estimated to be as follows: ball clay—38% floor and wall tile, 24% sanitaryware, and 38% other uses; bentonite—26% absorbents, 23% drilling mud, 17% foundry sand bond, 14% iron ore pelletizing, and 20% other uses; common clay—57% brick, 19% lightweight aggregate, 14% cement, and 10% other uses; fire clay—58% heavy clay products, 42% refractory products and other uses; fuller's earth—66% absorbent uses and 34% other uses; and kaolin—62% paper and 38% other uses.

Salient Statistics—United States:[1]	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production, mine:					
Ball clay	1,220	1,210	1,190	1,070	964
Bentonite	4,550	4,710	4,940	4,820	4,870
Common clay	24,600	24,300	24,200	20,600	17,500
Fire clay	307	353	848	565	508
Fuller's earth	3,260	2,730	2,540	2,660	2,630
Kaolin	7,760	7,800	7,470	7,110	6,750
Total[2]	41,700	41,200	41,200	36,800	33,200
Imports for consumption:					
Artificially activated clay and earth	25	17	21	23	22
Kaolin	205	262	303	194	70
Other	21	22	22	14	19
Total[2]	251	301	346	231	111
Exports:					
Ball clay	107	141	140	83	70
Bentonite	915	847	1,270	1,430	1,200
Fire clay[3]	332	368	348	425	390
Fuller's earth	49	55	69	134	140
Kaolin	3,640	3,580	3,540	3,300	3,000
Clays, not elsewhere classified	586	634	607	279	400
Total[2]	5,630	5,620	5,980	5,650	5,200
Consumption, apparent	36,300	35,900	35,600	31,400	28,100
Price, average, dollars per ton:					
Ball clay	44	44	44	46	47
Bentonite	45	46	48	52	53
Common clay	7	7	10	11	11
Fire clay	28	30	22	42	43
Fuller's earth	101	100	96	97	100
Kaolin	121	110	131	135	142
Employment, number:[e]					
Mine	1,080	990	1,250	1,150	900
Mill	4,910	4,940	5,130	5,080	4,850
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2004-07): Brazil, 80%; Mexico, 5%; United Kingdom, 4%; Canada, 3%; and other, 8%.

Prepared by **Robert L. Virta [(703) 648-7726, rvirta@usgs.gov, fax: (703) 648-7757]**

CLAYS

Tariff: Item	Number	Normal Trade Relations 12-31-08
Kaolin and other kaolinitic clays, whether or not calcined	2507.00.0000	Free.
Bentonite	2508.10.0000	Free.
Fire clay	2508.30.0000	Free.
Common blue clay and other ball clays	2508.40.0110	Free.
Decolorizing and fuller's earths	2508.40.0120	Free.
Other clays	2508.40.0150	Free.
Chamotte or dina's earth	2508.70.0000	Free.
Activated clays and earths	3802.90.2000	2.5% ad val.
Expanded clays and other 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); and clay used for alumina and aluminum compounds, 22% (Domestic).

Government Stockpile: None.

Events, Trends, and Issues: Slowing U.S. construction markets resulted in a decline in production of ball clay, common clay, and fire clay. Bentonite production increased slightly, largely on the strength of the market for drilling mud. Kaolin production declined because of competition with kaolin from Brazil, a lower demand in world paper markets, and lower U.S. construction activity. Fuller's earth markets remained strong, so production was almost unchanged from that of 2007.

World Mine Production, Reserves, and Reserve Base:[5] Reserves and reserve base are large in major producing countries, but data are not available.

	Mine production					
	Bentonite		Fuller's earth		Kaolin	
	2007	2008[e]	2007	2008[e]	2007	2008[e]
United States (sales)	4,820	4,870	2,660	2,630	7,110	6,750
Brazil (beneficiated)	240	240	—	—	2,500	2,490
Commonwealth of Independent States (crude)	750	750	—	—	6,170	6,200
Czech Republic (crude)	220	220	—	—	3,800	3,800
Germany (sales)	365	385	—	—	3,800	3,850
Greece (crude)	950	950	—	—	60	60
Italy (kaolinitic earth)	600	600	3	3	584	580
Korea, Republic of (crude)	—	—	—	—	2,630	2,600
Mexico	435	435	102	100	962	960
Spain	105	105	870	870	450	450
Turkey	930	930	—	—	580	580
United Kingdom	—	—	—	—	1,800	1,750
Other countries	2,490	2,520	255	297	8,550	8,630
World total (rounded)	11,900	12,000	3,890	3,900	39,000	38,700

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. — Zero.
[1]Excludes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Also includes some refractory-grade kaolin.
[4]Defined as imports – exports.
[5]See Appendix C for definitions.

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 2008; 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. The sole U.S. producer of extra-fine cobalt powder used cemented carbide scrap as feed. Seven companies were known to produce cobalt compounds. More than 60 industrial consumers were surveyed on a monthly or annual basis. Data reported by these consumers indicate that 46% of the cobalt consumed in the United States was used in superalloys, mainly in aircraft gas turbine engines; 8% in cemented carbides for cutting and wear-resistant applications; 15% in various other metallic applications; and 31% in a variety of chemical applications. The total estimated value of cobalt consumed in 2008 was $850 million.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Mine	—	—	—	—	—
Secondary	2,300	2,030	2,010	1,930	1,900
Imports for consumption	8,720	11,100	11,600	10,300	11,000
Exports	2,500	2,440	2,850	3,100	2,900
Shipments from Government stockpile excesses	1,630	1,110	260	617	200
Consumption:					
Reported (includes secondary)	8,990	9,150	9,280	9,340	9,300
Apparent[1] (includes secondary)	9,950	11,800	11,000	9,600	10,200
Price, average annual spot for cathodes, dollars per pound	23.93	15.96	17.22	30.55	40.40
Stocks, industry, yearend	1,210	1,190	1,180	1,340	1,300
Net import reliance[2] as a percentage of apparent consumption	77	83	82	80	81

Recycling: In 2008, cobalt contained in purchased scrap represented an estimated 20% of cobalt reported consumption.

Import Sources (2004-07): Cobalt contained in metal, oxide, and salts: Norway, 20%; Russia, 18%; China, 11%; Canada, 10%; and other, 41%.

Tariff: Item	Number	Normal Trade Relations[3] 12-31-08
Cobalt ores and concentrates	2605.00.0000	Free.
Chemical compounds:		
Cobalt oxides and hydroxides	2822.00.0000	0.1% ad val.
Cobalt chlorides	2827.39.6000	4.2% ad val.
Cobalt sulfates	2833.29.1000	1.4% ad val.
Cobalt carbonates	2836.99.1000	4.2% ad val.
Cobalt acetates	2915.29.3000	4.2% ad val.
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.

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

Government Stockpile: The disposal limit for cobalt in the fiscal year 2009 Annual Materials Plan was unchanged from that of fiscal year 2008.

Stockpile Status—9-30-08[4]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Cobalt	497	497	1,590	481

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

COBALT

Events, Trends, and Issues: During the first half of 2008, the worldwide demand for cobalt reportedly was slightly higher than that of the first half of 2007, and world availability of refined cobalt (as measured by production and U.S. Government shipments) was 5% higher than that of the first half of 2007. During 2008, production from new operations or expansions of existing operations began in Australia, Canada, Congo (Kinshasa), Cuba, Finland, and Zambia. Numerous additional brownfield and greenfield projects that would add to future world cobalt supply were in the planning and development stages. The overall trend in the price of cobalt cathode was downward during the first 11 months of 2008. Low cobalt, copper, and nickel prices and the serious downturn in the global financial markets in late 2008 were expected, however, to delay financing, construction, and startup of some new production.

The London Metal Exchange announced a plan to launch a cobalt contract during the second half of 2009. The global contract would include delivery to warehouses in Baltimore, Rotterdam, and Singapore; would trade in 1-metric-ton lots of minimum 99.3% cobalt; and be priced in dollars per kilogram.

China was the world’s leading producer of refined cobalt, and much of its production was from cobalt-rich ore and partially refined cobalt imported from Congo (Kinshasa). As a result of restrictions on exports of unprocessed cobalt from Congo (Kinshasa), the Chinese cobalt industry was expected to develop more domestic and foreign sources of cobalt supply, to invest in African cobalt projects, to increase the recycling of cobalt scrap, to continue to shift its consumption towards more downstream materials, and to consolidate into fewer larger companies. Since 2005, China has been the third- or fourth-ranked supplier of cobalt imports to the United States.

World Mine Production, Reserves, and Reserve Base: Reserves and reserve base estimates for Australia were revised based on new information reported by the Australian Government.

	Mine production		Reserves[5]	Reserve base[5]
	2007	2008[e]		
United States	—	—	33,000	860,000
Australia	5,900	6,300	1,500,000	1,800,000
Brazil	1,400	1,200	29,000	40,000
Canada	8,300	8,300	120,000	350,000
China	2,000	2,000	72,000	470,000
Congo (Kinshasa)	25,300	32,000	3,400,000	4,700,000
Cuba	3,800	3,900	1,000,000	1,800,000
Morocco	1,500	1,600	20,000	NA
New Caledonia[6]	1,600	1,000	230,000	860,000
Russia	6,300	5,800	250,000	350,000
Zambia	7,600	7,800	270,000	680,000
Other countries	1,900	1,900	180,000	1,100,000
World total (rounded)	65,500	71,800	7,100,000	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, as much as 1 billion tons of hypothetical and speculative cobalt resources may 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; iron-cobalt-nickel, nickel, cermets, or ceramics in cutting and wear-resistant materials; nickel-based 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. net import reliance and secondary production, as estimated from consumption of purchased scrap.
[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.

COPPER

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

Domestic Production and Use: Domestic mine production in 2008 increased by about 12% to 1.3 million tons and its value rose to about $9.4 billion. The principal mining States, in descending order of production—Arizona, Utah, New Mexico, Nevada, and Montana—accounted for more than 99% of domestic production; copper also was recovered at mines in Idaho and Missouri. Although copper was recovered at 27 mines operating in the United States, 17 mines accounted for about 99% of production. Three primary smelters, 4 electrolytic and 3 fire refineries, and 15 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, 21%; transportation equipment, 10%; consumer and general products, 11%; and industrial machinery and equipment, 9%.[1]

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Mine	1,160	1,140	1,200	1,170	1,310
Refinery:					
Primary	1,260	1,210	1,210	1,280	1,250
Secondary	51	47	45	42	50
Copper from all old scrap	191	183	150	150	140
Imports for consumption:					
Ores and concentrates	23	([2])	([2])	([2])	([2])
Refined	807	1,000	1,070	829	730
Unmanufactured	1,060	1,230	1,320	1,100	1,000
General imports, refined	704	977	1,070	832	730
Exports:					
Ores and concentrates	24	137	108	90	100
Refined	118	40	106	51	45
Unmanufactured	789	815	990	835	870
Consumption:					
Reported, refined	2,410	2,270	2,110	2,140	2,000
Apparent, unmanufactured[3]	2,550	2,400	2,190	2,280	2,090
Price, average, cents per pound:					
Domestic producer, cathode	133.9	173.5	314.8	328.0	324
London Metal Exchange, high-grade	130.0	166.8	304.9	322.8	320
Stocks, yearend, refined, held by U.S. producers, consumers, and metal exchanges	134	66	196	130	120
Employment, mine and mill, thousands	6.4	7.0	8.4	9.7	11.2
Net import reliance[4] as a percentage of apparent consumption	43	42	38	37	33

Recycling: Old scrap, converted to refined metal and alloys, provided 140,000 tons of copper, equivalent to 6% of apparent consumption. Purchased new scrap, derived from fabricating operations, yielded 750,000 tons of contained copper; about 89% 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-based scrap), brass mills recovered 72%; miscellaneous manufacturers, foundries, and chemical plants, 14%; ingot makers, 9%; and copper smelters and refiners, 5%. Copper in all old and new, refined or remelted scrap contributed about 31% of the U.S. copper supply.

Import Sources (2004-07): Unmanufactured: Chile, 40%; Canada, 33%; Peru, 13%; Mexico, 6%; and other, 8%. Refined copper accounted for 79% of unwrought copper imports.

Tariff: Item	Number	Normal Trade Relations[5] 12-31-08
Copper ores and concentrates	2603.00.0000	1.7¢/kg on 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 stockpiles of refined copper and brass were liquidated in 1993 and 1994, respectively. Details on inventories of beryllium-copper master alloys (4% beryllium) can be found in the section on beryllium.

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

COPPER

Events, Trends, and Issues: Although copper prices began to weaken in September, on average copper prices during the first 9 months of 2008 remained at or near record-high levels. The London Metal Exchange Ltd. (LME) price reached an alltime high of $4.08 per pound in April and averaged $3.61 per pound for the first 9 months of the year. Global commodity exchange inventories, which began the year at low levels, trended downward for the first 9 months of the year. Despite numerous announced expansions in mine capacity, estimated global copper mine production for the first 9 months of the year was slightly lower than that for the same period of 2007. Numerous factors, including labor unrest, lower ore grades, rapidly escalating production costs, technical problems, and utility and equipment shortages, contributed to lower than anticipated production. In October, concurrent with development of the global financial crisis, copper prices plummeted, the LME price falling below $1.70 per pound. Though it cautioned that the economic crisis could significantly alter projections, the International Copper Study Group[6] forecast a small annual production surplus to develop by yearend that would expand to about 300,000 tons in 2009.

In the United States, mine production rose owing to the startup of two major mining projects and expanded output of existing operations. In October, however, the leading U.S. producer announced that the drop in copper prices and rising production costs would lead to revaluation of its planned global expansions. Owing to lower ore grades and increases in energy, labor, mining rates, and other input costs, the company's U.S. production costs had risen by 48% to $1.24 per pound of copper in the first 9 months of 2008 from the comparative period in 2007. Domestic consumption of refined copper continued to trend lower owing to weaker housing and automotive demand and brass mill closings. Domestic mine production was expected to rise by more than 200,000 tons in 2009 owing to the startup of new production and increased capacity utilization, while consumption was expected to decline further.

World Mine Production, Reserves, and Reserve Base: Official reserves reported by China may include small and low-grade deposits not currently economic to develop. Significant upward revisions to reserves for Chile, Kazakhstan, Mexico, and Peru are based on tabulated data from individual company reports.

	Mine production		Reserves[7]	Reserve base[7]
	2007	2008[e]		
United States	1,170	1,310	35,000	70,000
Australia	870	850	24,000	43,000
Canada	589	590	10,000	20,000
Chile	5,560	5,600	160,000	360,000
China	946	1,000	30,000	63,000
Indonesia	797	650	36,000	38,000
Kazakhstan	407	460	18,000	22,000
Mexico	347	270	38,000	40,000
Peru	1,190	1,220	60,000	120,000
Poland	452	430	30,000	48,000
Russia	740	750	20,000	30,000
Zambia	520	560	19,000	35,000
Other countries	1,840	2,030	70,000	110,000
World total (rounded)	15,400	15,700	550,000	1,000,000

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).[8] A preliminary assessment indicates that global land-based resources exceed 3 billion tons. 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 and 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 2007 by the Copper Development Association, Inc., 2008.
[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. General imports 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, 2008, Forecast 2008-2009: Lisbon, Portugal, International Copper Study Group press release, October 8, 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 2008, domestic production of industrial diamond was estimated to be approximately 261 million carats, and the United States remained the world's leading market. All domestic output was synthetic grit and powder. Two firms, one in Pennsylvania and another 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 and polishing, and transportation systems (infrastructure and vehicles). Stone cutting and highway building and repair consumed most of the industrial stone. About 94% 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:	2004	2005	2006	2007	2008[e]
Bort, grit, and dust and powder; natural and synthetic:					
Production:					
Manufactured diamond[e]	252	256	258	260	261
Secondary	4.6	4.6	34.2	34.4	34.4
Imports for consumption	240	284	371	411	493
Exports[1]	86	92	90	107	122
Sales from Government stockpile excesses	—	—	—	—	—
Consumption, apparent	411	453	573	598	666
Price, value of imports, dollars per carat	0.25	0.27	0.22	0.19	0.12
Net import reliance[2] as a percentage of apparent consumption	38	42	49	51	56
Stones, natural:					
Production:					
Mine	—	—	—	—	—
Secondary	([3])	0.53	0.56	0.38	0.38
Imports for consumption[4]	1.8	2.1	2.2	3.1	3.8
Exports[1]	0.5	([3])	([3])	—	([3])
Sales from Government stockpile excesses	0.4	—	([3])	([3])	0.5
Consumption, apparent	2.1	2.2	2.8	3.5	4.6
Price, value of imports, dollars per carat	7.77	13.91	12.61	11.54	10.41
Net import reliance[2] as a percentage of apparent consumption	80	77	80	89	92

Recycling: In 2008, the amount of diamond bort, grit, and dust and powder recycled was estimated to be 34.4 million carats. Lower prices of newly produced industrial diamond appear to be reducing the number and scale of diamond stone recycling operations. In 2008, it was estimated that 383,000 carats of diamond stone was recycled.

Import Sources (2004-07): Bort, grit, and dust and powder; natural and synthetic: China, 40%; Ireland, 26%; Russia, 6%; Republic of Korea, 5%; and other, 23%. Stones, primarily natural: Botswana, 32%; South Africa, 21%; Namibia, 11%; Ireland, 7%; and other, 29%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Industrial Miners' diamonds, carbonados	7102.21.1010	Free.
Industrial Miners' diamonds, other	7102.21.1020	Free.
Industrial diamonds, simply sawn, cleaved, or bruted	7102.21.3000	Free.
Industrial diamonds, not worked	7102.21.4000	Free.
Industrial diamonds, other	7102.29.0000	Free.
Grit or dust and powder of natural or synthetic diamonds	7105.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7757]**

DIAMOND (INDUSTRIAL)

Government Stockpile: During fiscal year 2008, the Department of Defense sold 473,406 carats of industrial diamond stone from the National Defense Stockpile for $8.22 million. Although 520,000 carats were authorized for disposal, this depleted all remaining inventory of industrial diamond stone.

Stockpile Status—9-30-08[5]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Industrial stones	—	0.520	0.520	0.473

Events, Trends, and Issues: The United States is likely to continue to be the world's leading market for industrial diamond into the next decade and likely will remain a significant producer and exporter of synthetic industrial diamond as well. Increase in U.S. demand for industrial diamond is likely to continue in the construction sector as the United States continues building and repairing 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. research group has developed a fast chemical vapor deposition (CVD) method of growing nearly 100%-pure diamond using microwave plasma technology. The greatest potential for CVD diamond will be in computer applications, 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. 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]
	2007	2008[e]		
United States	—	—	NA	NA
Australia	19	18	90	230
Botswana	8	8	130	230
China	1	1	10	20
Congo (Kinshasa)	22	23	150	350
Russia	15	15	40	65
South Africa	9	9	70	150
Other countries	3	3	85	210
World total (rounded)	77	77	580	1,300

World Resources: Natural diamond resources have been discovered in more than 35 countries. Natural diamond accounts for about 12% 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 88% 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 568 million carats in 2008; 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 2008, domestic production of diatomite was estimated at 653,000 tons with an estimated processed value of $163 million, f.o.b. plant. Production occurred at 7 diatomite-producing companies with 12 mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Diatomite is frequently used in filter aids, 52%; cement additives, 26%; absorbents, 12%; fillers, 9%; and other applications (specialized pharmaceutical or biomedical uses), 1%. The unit value of diatomite varied widely in 2008, from less than $9.00 per ton for cement manufacture to approximately $1,000 per ton for limited specialty markets, including art supplies, cosmetics, and DNA extraction. The average unit value for filter-grade diatomite was $373 per ton.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production[1]	620	653	799	687	653
Imports for consumption	2	4	7	4	3
Exports	143	142	150	143	152
Consumption, apparent	479	515	656	548	504
Price, average value, dollars per ton, f.o.b. plant	285	274	220	237	249
Stocks, producer, yearend[e]	36	40	40	40	40
Employment, mine and plant, number[e]	1,000	1,000	1,020	1,020	1,020
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (2004-07): Mexico, 31%; Spain, 19%; Italy, 18%; France, 17%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Siliceous fossil meals, including diatomite	2512.00.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert D. Crangle, Jr. [(703) 648-6410, rcrangle@usgs.gov, fax: (703) 648-7757]**

DIATOMITE

Events, Trends, and Issues: The amount of domestically produced diatomite sold or used in 2008 decreased by about 5% compared with that of 2007. 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. Domestically, production of diatomite used as an ingredient in portland cement decreased. An important application for diatomite is the removal of microbial contaminants, such as bacteria, protozoa, and viruses in public water systems. Other applications for diatomite include filtration of human blood plasma, pharmaceutical processing, and use as a nontoxic insecticide.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2007	2008[e]		
United States[1]	687	653	250,000	500,000
Chile	29	25	NA	NA
China	420	440	110,000	410,000
Commonwealth of Independent States	80	76	NA	13,000
Costa Rica	25	24	NA	NA
Czech Republic	55	52	4,500	4,800
Denmark[4] (processed)	230	220	NA	NA
France	75	71	NA	2,000
Germany	54	51	NA	NA
Iceland	28	27	NA	NA
Italy	25	24	NA	NA
Japan	120	110	NA	NA
Mexico	63	60	NA	2,000
Peru	35	33	2,000	5,000
Spain	34	32	NA	NA
Other countries	136	130	550,000	NA
World total (rounded)[5]	2,100	2,000	Large	Large

World Resources: World resources of crude diatomite are adequate for the foreseeable future. Transportation costs will continue to determine the maximum economic distance most forms of diatomite may be shipped and still remain competitive with alternative materials.

Substitutes: Many materials can be substituted for diatomite. However, the unique properties of diatomite assure its continuing 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 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]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.
[4]Includes sales of moler production.
[5]Data are rounded to no more than three significant digits; may not add to totals shown.

FELDSPAR

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: U.S. feldspar production in 2008 had an estimated value of about $36 million. The three leading producers accounted for about 75% of the production, with five other companies supplying the remainder. Producing states were North Carolina, Virginia, California, Oklahoma, Georgia, Idaho, and South Dakota, in descending order of estimated tonnage. 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 2008 end-use distribution of domestic feldspar was glass, 65%, and pottery and other uses, 35%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, marketable[e]	770	750	760	730	600
Imports for consumption	21	26	5	4	2
Exports	10	15	10	10	11
Consumption, apparent[e]	781	761	755	724	591
Price, average value, marketable production, dollars per ton[e]	57	57	59	59	60
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	1	1	E	E	E

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

Import Sources (2004-07): Turkey, 62%; Mexico, 35%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Feldspar	2529.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Michael J. Potter [(703) 648-7723, mpotter@usgs.gov, fax: (703) 648-7757]**

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 9 months of 2008 were slightly lower than in the comparable period of 2007, according to the U.S. Census Bureau.

Feldspar use in tile and vitreous sanitaryware reflected trends in housing construction. U.S. housing starts for the first 9 months were about 31% lower than in the same period of 2007, according to the U.S Census Bureau. Reduced construction activity resulted in reduced feldspar usage in ceramic tiles, glass fiber insulation, and plumbing fixtures. In 2007 (latest data), U.S. tile consumption decreased by about 19% from that of 2006, according to the Tile Council of North America, Inc. U.S. imports decreased by 20%. This reflected the trend of the declining housing market. In 2007, about 82% of tiles consumed in the United States was imported. The leading sources of imports, in descending order of volume, were Italy, Mexico, China, Brazil, and Spain.

Brazil is the world's third largest ceramic tiles manufacturer and has the second largest tile consumer market. The country's ceramic tile sector consists of 94 companies with 117 processing facilities located in 18 States.[3]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States[e]	730	600	NA	NA
Argentina	170	290	NA	NA
Brazil	125	130	NA	NA
China	2,000	2,000	NA	NA
Colombia	100	100	NA	NA
Czech Republic	490	490	25,000	68,000
Egypt	350	350	NA	NA
France	650	650	NA	NA
Germany	171	170	NA	NA
India	160	160	NA	NA
Iran	260	260	NA	21,000
Italy	4,200	4,200	NA	NA
Japan	750	700	NA	NA
Korea, Republic of	399	400	NA	NA
Malaysia	150	250	NA	NA
Mexico	460	440	NA	NA
Poland	350	350	11,000	87,000
Portugal	130	130	NA	NA
Spain	600	600	NA	NA
Thailand	1,000	800	NA	NA
Turkey	3,800	3,800	NA	NA
Venezuela	200	200	NA	NA
Other countries	850	1,200	NA	NA
World total (rounded)	18,100	18,300	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]Chuecco, Fátima, 2008, Brazil's tile industry begins domestic shift: Industrial Minerals, no. 493, October, p. 30.
[4]See Appendix C for definitions.

FLUORSPAR

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In Illinois, fluorspar was processed and sold from stockpiles produced as a byproduct of limestone quarrying. Byproduct calcium fluoride was recovered from industrial waste streams, although data are not available on exact quantities. 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 casting, primary aluminum production, glass manufacture, enamels, welding rod coatings, cement production, and other uses or products. An estimated 52,000 tons of fluorosilicic acid (equivalent to about 92,000 tons of 92% fluorspar) was recovered from phosphoric acid plants processing phosphate rock. Fluorosilicic acid was used primarily in water fluoridation.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Finished, all grades	—	—	—	—	NA
Fluorspar equivalent from phosphate rock	90	86	70	94	92
Imports for consumption:					
Acid grade	546	586	490	577	465
Metallurgical grade	53	43	62	43	75
Total fluorspar imports	599	629	553	620	540
Fluorspar equivalent from hydrofluoric acid plus cryolite	197	209	233	233	230
Exports[1]	21	36	13	14	15
Shipments from Government stockpile	62	28	66	17	—
Consumption:					
Apparent[2]	691	616	608	613	460
Reported	618	582	523	539	550
Price, average value, dollars per ton, c.i.f. U.S. port					
Acid grade	167	202	217	NA	NA
Metallurgical grade	83	93	101	111	104
Stocks, yearend, consumer and dealer[3]	105	131	90	90	80
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 recycle HF and fluorides from smelting operations. HF is recycled in the petroleum alkylation process.

Import Sources (2004-07): China, 58%; Mexico, 26%; South Africa, 10%; and Mongolia, 6%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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: There were no sales of fluorspar during fiscal year 2008. The Defense National Stockpile Center, Defense Logistics Agency, reported that 206 tons of unspecified acid-grade and metallurgical-grade fluorspar remained in the stockpile as of September 30, 2008.

Prepared by **M. Michael Miller [(703) 648-7716, mmiller1@usgs.gov, fax: (703) 648-7757]**

FLUORSPAR

Events, Trends, and Issues: In 2008, Hastie Mining Co. and Moodie Mineral Co. completed their drilling program for fluorspar in Livingston County, KY, and barring permitting problems expected to break ground on the Klondike II Fluorspar Mine before the end of the year. The company installed a heavy-media plant to process stockpiled fluorspar ore produced as a byproduct at its limestone quarry in Hardin County, IL. The flotation mill at Salem, KY, was vandalized while it sat idle; as a result, it will require significant time and expense to bring the plant back into operating condition.[5]

Acid-grade fluorspar prices increased dramatically and reached historic highs in 2008. A reduction in Chinese exports of fluorspar was the leading cause, but other factors such as increasing costs in China (production, domestic transport, and taxes), high ocean shipping rates, and inflationary pressures contributed to the rise in prices. Published prices for Chinese acid-grade fluorspar delivered to the U.S. Gulf of Mexico increased from a range of $300 to $305 per metric ton at the beginning of the year to $530 to $550 per ton in early October. These steep price increases were reflected, although to a lesser degree, in prices for Mexican and South African acid-grade fluorspar. During the same time period, Mexican prices (for low-arsenic product) increased from a range of $270 to $280 per ton to $400 to $420, while South African prices (free on board Durban) increased from $175 to $204 per ton to $250 per ton.[6, 7]

World Mine Production, Reserves, and Reserve Base: Estimates for reserves and reserve base for France were revised to zero. France's sole producer ceased production in 2006, citing insufficient reserves for further production.

	Mine production		Reserves[8, 9]	Reserve base[8, 9]
	2007	2008[e]		
United States	—	NA	NA	6,000
China	3,200	3,200	21,000	110,000
Kenya	82	100	2,000	3,000
Mexico	933	980	32,000	40,000
Mongolia	380	400	12,000	16,000
Morocco	90	90	NA	NA
Namibia	[10]118	[10]120	3,000	5,000
Russia	180	200	NA	18,000
South Africa	285	340	41,000	80,000
Spain	150	140	6,000	8,000
Other countries	270	270	110,000	180,000
World total (rounded)	5,690	5,840	230,000	470,000

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: Aluminum smelting dross, borax, calcium chloride, iron oxides, manganese ore, silica sand, and titanium dioxide have been used as substitutes for fluorspar fluxes. 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 and fluorspar distributors.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]B. Moodie, Moodie Mineral Co., oral commun., September 2008.
[6]Industrial Minerals, 2008, Prices: Industrial Minerals, no. 484, January, p. 64.
[7]Industrial Minerals, 2008, Prices: Industrial Minerals, no. 493, October, p. 88.
[8]See Appendix C for definitions.
[9]Measured as 100% calcium fluoride.
[10]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 2008. 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 $23 million. Gallium arsenide (GaAs) and gallium nitride (GaN) electronic components represented about 98% of domestic gallium consumption. About 65% of the gallium consumed was used in integrated circuits (ICs). Optoelectronic devices, which include laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells, represented 29% of gallium demand. The remaining 6% 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. ICs were used in defense applications, high-performance computers, and telecommunications.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, primary	—	—	—	—	—
Imports for consumption	19,400	15,800	26,900	37,100	48,400
Exports	NA	NA	NA	NA	NA
Consumption:					
Reported	21,500	18,700	20,300	25,100	30,000
Apparent	NA	NA	NA	NA	NA
Price, yearend, dollars per kilogram, 99.99999%-pure[1]	550	538	443	530	560
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 (2004-07): China, 17%; Ukraine, 17%; Germany, 16%; Canada, 14%; and other, 36%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Gallium arsenide wafers, undoped	2853.00.0010	2.8% ad val.
Gallium arsenide wafers, doped	3818.00.0010	Free.
Gallium metal	8112.92.1000	3.0% ad val.

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 2007. Prices for low-grade (99.99%-pure) gallium decreased in Asia and Europe in the first half of 2008, from $550 to $600 per kilogram at the beginning of the year to about $475 to $525 per kilogram by midyear. Some producers in China claimed that prices are lower owing to a seasonal slowdown. Prices in the United States remained stable at $550 to $600 per kilogram.

Prepared by **Brian W. Jaskula [(703) 648-4908, bjaskula@usgs.gov, fax: (703) 648-7757]**

GALLIUM

The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) set a world record in solar cell efficiency with a photovoltaic device that converts 40.8% percent of the light that hits it into electricity. The solar cell uses compositions of gallium indium phosphide and gallium indium arsenide to split the solar spectrum into three equal parts that are absorbed by each of the cell's three junctions for higher potential efficiencies.

A Canadian-based firm completed drilling on its property in Humboldt County, NV. Based on an updated, independent gallium resource estimate, indicated resources were 714 metric tons of gallium and inferred resources were 335 tons. The firm plans to collect a bulk sample for metallurgical testing in preparation for a prefeasibility study.

Market conditions remained strong for GaAs-based products in 2008. Demand was driven mainly by high-speed, feature-rich, third-generation, cellular handsets and other high-speed wireless applications, which require greater numbers of GaAs components per unit than previously used. Analysts estimated that the market for GaAs components exceeded $3.6 billion in 2007, and exhibited year-on-year growth of 17%.

Companies continued to try to improve the quality of GaN by improving growth and fabrication techniques. In addition to improvements in traditional substrate materials, such as sapphire and silicon carbide, companies are developing GaN grown on diamond and glass substrates.

Analysts estimated that the LED market would increase by 12% in 2008 as a result of product expansion outside of the mobile phone market. New applications included LED backlighting for liquid crystal displays, notebook PC backlighting, digital cameras, DVD players, and automotive lighting. The market for packaged LEDs reached $4.6 billion in 2007.

World Production, Reserves, and Reserve Base:[3] In 2008, world primary production was estimated to be about 95 metric tons, about 19% higher than that in 2007. China, Germany, Kazakhstan, and Ukraine were the leading producers; countries with smaller output were Hungary, Japan, Russia, and Slovakia. Refined gallium production was estimated to be about 135 metric tons; this figure includes some scrap refining. China, Japan, and the United States were the principal producers of refined gallium. Gallium was recycled from new scrap in Germany, Japan, the United Kingdom, and the United States. World primary gallium production capacity in 2008 was estimated to be 184 metric tons; refinery capacity, 167 tons; and recycling capacity, 78 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-based LEDs that may compete with GaAs in the future. Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific-wavelength applications, and GaAs competes with helium-neon lasers in visible laser diode applications. Silicon is the principal competitor with GaAs in solar cell applications. GaAs-based ICs 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 based on the 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 2008 by four firms—one in Idaho, one in Montana, and two in New York. The estimated value of crude garnet production was about $11 million, while refined material sold or used had an estimated value of $5.8 million. Major end uses for garnet were waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 15%; abrasive powders, 10%; and other end uses, 10%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production (crude)	28,400	40,100	34,100	61,400	61,000
Sold by producers	30,400	23,100	16,800	20,700	21,000
Imports for consumption[e]	36,500	41,800	50,800	52,300	54,600
Exports[e]	10,900	13,400	13,300	12,000	13,900
Consumption, apparent[e, 2]	54,000	68,600	71,600	102,000	102,000
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]	160	160	160	160	160
Net import reliance[4] as a percentage of apparent consumption	47	41	52	40	40

Recycling: Small amounts of garnet reportedly are recycled.

Import Sources (2004-07):[e] Australia, 37%; India, 30%; China, 21%; Canada, 11%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Emery, natural corundum, natural garnet, and other natural abrasives, crude	2513.20.1000	Free.
Emery, natural corundum, natural garnet, and other natural abrasives, other than crude	2513.20.9000	Free.
Natural abrasives on woven textile	6805.10.0000	Free.
Natural abrasives on paper or paperboard	6805.20.0000	Free.
Natural abrasives sheets, strips, disks, belts, sleeves, or similar form	6805.30.1000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7757]**

GARNET (INDUSTRIAL)

Events, Trends, and Issues: During 2008, U.S. garnet consumption decreased slightly, while domestic production of crude garnet concentrates remained about the same compared with the production of 2007. In 2007, domestic U.S. production of crude garnet concentrates increased about 80% compared with the production of 2006, owing to the purchase and startup of production by the Ruby Valley Garnet Mine in Montana. In 2008, imports were estimated to have increased 4% compared with those of 2007, and exports were estimated to have increased 16% from those of 2007. The 2008 estimated domestic sales of garnet remained at about the same level as sales of 2007. In 2008, the United States was a net importer. Garnet imports have supplemented 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 mineral products that occur with garnet, such as kyanite, marble, mica minerals, sillimanite, staurolite, wollastonite, or metallic ores, may be produced.

World Mine Production, Reserves, and Reserve Base: The reserve base for India was revised based on information reported by the Government of India.

	Mine production		Reserves[5]	Reserve base[5]
	2007	2008[e]		
United States	61,400	61,000	5,000,000	25,000,000
Australia	160,000	160,000	1,000,000	7,000,000
China	30,000	30,000	Moderate to Large	Moderate to Large
India	65,000	65,000	90,000	6,500,000
Other countries	35,500	36,000	6,500,000	20,000,000
World total (rounded)	352,000	352,000	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 those in 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 – exports + 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 35% in 2008 from that of 2007. The natural gemstone production value increased about 10% from that of 2007. Domestic gemstone production included agate, beryl, coral, garnet, jade, jasper, opal, pearl, quartz, sapphire, shell, topaz, tourmaline, turquoise, and many other gem materials. In decreasing order, Oregon, Tennessee, Arizona, California, North Carolina, Arkansas, Alabama, Montana, Idaho, and Maine produced 87% of U.S. natural gemstones. The production value of laboratory-created (synthetic) gemstones decreased 42% from that of the previous year. This drop in production resulted from a large decrease in Moissanite production value. Laboratory-created gemstones were manufactured by four firms in North Carolina, Florida, Massachusetts, and Arizona, in decreasing order of production. Major gemstone uses were carvings, gem and mineral collections, and jewelry.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:[2]					
Natural[3]	14.5	13.4	11.3	11.9	13.0
Laboratory-created (synthetic)	30.7	51.1	52.1	73.5	42.8
Imports for consumption	15,500	17,200	18,300	20,100	22,700
Exports, including reexports[4]	7,230	8,850	9,930	12,300	16,400
Consumption, apparent[5]	8,220	8,410	8,430	7,880	6,420
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 (2004-07 by value): Israel, 47%; India, 19%; Belgium, 16%; South Africa, 5%; and other, 13%. Diamond imports accounted for 95% of the total value of gem imports.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
Imitation precious stones	7018.10.2000	Free.
Pearls, imitation, not strung	7018.10.1000	4.0% ad val.
Pearls, natural	7101.10.0000	Free.
Pearls, cultured	7101.21.0000	Free.
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.
Synthetic, cut but not set	7104.90.1000	Free.

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.

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7757]**

GEMSTONES

Events, Trends, and Issues: In 2008, the U.S. market for unset gem-quality diamonds was estimated to have exceeded $19.0 billion, accounting for more than an estimated 35% of world demand. The domestic market for natural, unset nondiamond gemstones was estimated to be about $1.15 billion. The United States is expected to continue dominating global gemstone consumption.

Canadian diamond production continued increasing in 2008 to about 18 million carats. Diamond exploration also continued in Canada, and many new deposits have been found. Canada produced more than 19% of the world's natural gemstone diamonds in 2008. The success of the Canadian gem diamond industry has stimulated interest in exploration for commercially feasible diamond deposits in the United States; however, at present, there are no operating commercial diamond mines in the United States.

Mine production of diamond in 2008 increased for Angola, the Central African Republic, Guinea, and Sierra Leone, while production decreased for Brazil, and production in Australia, Botswana, Canada, China, Congo (Kinshasa), Côte d'Ivoire, Ghana, Guyana, Namibia, Russia, South Africa, and Tanzania remained the same compared with that of 2007, based on submissions from country sources.

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

	Mine production	
	2007	2008[e]
Angola	8,700	10,000
Australia	231	230
Botswana	25,000	25,000
Brazil	300	200
Canada	18,000	18,000
Central African Republic	370	470
China	100	100
Congo (Kinshasa)	5,400	5,400
Côte d'Ivoire	210	210
Ghana	720	720
Guinea	815	1,100
Guyana	350	350
Namibia	2,200	2,200
Russia	23,300	23,300
Sierra Leone	360	600
South Africa	6,100	6,100
Tanzania	230	230
Other countries[9]	210	210
World total (rounded)	93,000	94,000

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]Reexports excluded from apparent consumption calculation.
[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]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 2008 producer price, was $7.4 million. Germanium production in the United States comes from either the refining of imported germanium compounds or industry-generated scrap. Germanium for domestic consumption also was obtained from materials imported in chemical form and either 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. These concentrates were exported to Canada for processing. Another mine in Tennessee had begun producing germanium-rich zinc concentrates in the first half of 2008.

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. The major end uses for germanium, worldwide, were estimated to be fiber-optic systems, 30%; infrared optics, 25%; polymerization catalysts, 25%; electronics and solar electric applications, 15%; and other (phosphors, metallurgy, and chemotherapy), 5%. Domestically, these end uses varied and were estimated to be infrared optics, 50%; fiber-optic systems, 30%; electronics and solar electric applications, 15%; and other (phosphors, metallurgy, and chemotherapy), 5%. Germanium is not used in polymerization catalysts in the United States.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, refinery[e]	4,400	4,500	4,600	4,600	4,600
Total imports[1]	23,800	23,500	50,000	52,400	65,500
Total exports[1]	13,800	10,100	12,400	11,700	18,200
Shipments from Government stockpile excesses	7,190	4,510	4,580	6,900	—
Consumption, estimated	25,000	27,000	55,000	60,000	55,000
Price, producer, yearend, dollars per kilogram:					
Zone refined	600	660	950	1,240	1,600
Dioxide, electronic grade	400	405	660	800	975
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant[2] number[e]	65	65	65	65	70
Net import reliance[3] as a percentage of estimated consumption	70	65	85	80	85

Recycling: Worldwide, about 30% of the total germanium consumed is produced from recycled materials. During the manufacture of most optical devices, more than 60% of the germanium metal used is routinely recycled as new scrap. Germanium scrap was also recovered from the window blanks in decommissioned tanks and other military vehicles. In the European Union, recent technological advancements in the production of optical fibers has reduced, somewhat, the available supply of germanium scrap.

Import Sources (2004-07):[4] Belgium, 37%; Canada, 22%; Germany, 19%; China, 12%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Germanium oxides	2825.60.0000	3.7% ad val.
Metal, unwrought	8112.92.6000	2.6% ad val.
Metal, powder	8112.92.6500	4.4% ad val.
Metal, wrought	8112.99.1000	4.4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: The Defense National Stockpile Center (DNSC), Defense Logistics Agency, suspended sales of germanium metal in November 2007 while it awaited the passage of the National Defense Authorization Act for fiscal year 2008. The sale of germanium is limited by a revenue cap that is adjusted by legislation each fiscal year.

Stockpile Status—9-30-08[5]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Germanium	16,531	16,531	8,000	714

Prepared by **David E. Guberman [(703) 648-4977, dguberman@usgs.gov, fax: (703) 648-7757]**

GERMANIUM

Events, Trends, and Issues: Consumption of germanium continued to grow in 2008 as fiber-optic network construction occurred in many parts of the world. Accelerated construction was particularly evident in North America and Japan. As of September 2008, fiber-to-the-home network connections were available to nearly 13.8 million homes in North America, up about 45% from those in 2007. Recent technological advancements in fiber-optic cable design have allowed for more installations of fiber-optic networks in multiple-dwelling buildings such as apartment and condominium buildings. Unlike the typical fiber-optic cable used in the past, this new cable design can be bent around tight corners and routed through buildings with virtually no signal loss. Significant domestic growth also was seen in the infrared optics sector owing to its continued military use in navigation systems, detection and search devices, and optical imaging and target evaluation systems. Commercial use of germanium in night-vision lenses for automobiles continued to be offered by select manufacturers. Germanium-based nuclear radiation detection equipment was used by the military, as well as by law enforcement agencies, for national security purposes. Use in solar energy conversion systems was seen as an expanding market for germanium, in view of technological advancements utilizing germanium substrates as the building blocks of multilayer solar cells. In 2008, demand for the germanium substrates as key components of the solar cells commonly used in satellites and earth-based applications continued to be strong. On a global scale, several new projects that utilized germanium substrates in terrestrial solar power generation systems were either operational or under construction in 2008. Recently, a university in Utah announced that it had developed a new technique for slicing germanium into the wafers that act as the substrate in the production of solar cells. The new process was more efficient than current slicing methods and had the potential to reduce the overall costs associated with germanium-based solar cells.

Germanium prices continued to move upward in 2008 as demand grew and supplies remained tight. The availability of germanium metal in North America was further limited in 2008 owing to the suspension of sales from the Government stockpile. In June, a major producer of infrared optical devices and germanium substrates announced plans to expand capacity at its location in Oklahoma. The new facility, scheduled to open in 2010, was expected to eventually double the firm's germanium substrate production capabilities and support anticipated growth in the terrestrial solar cell market. In July, an Australian company reported that surface sampling had identified widespread germanium occurrences in a coal seam at an existing uranium project site in North Dakota.

Silicon-germanium (SiGe) continued to gain interest as a viable semiconductor material. Research and development efforts have resulted in the capability to produce smaller integrated circuits that exhibit reduced electronic noise pollution, thereby prolonging the life of cells while ensuring steady operation in an ultra high-frequency environment.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production[e]		Reserves[6]	Reserve base[6]
	2007	2008		
United States	4,600	4,600	450,000	500,000
Other countries	95,000	100,000	NA	NA
World total	100,000	105,000	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 sintered zinc sulfide lens has been developed for use in far-infrared-ray cameras, and is reported to be competitive with germanium lenses. Silicon can be a less expensive substitute for germanium in certain electronic applications. Although some metallic compounds that contain gallium, indium, selenium, and tellurium can be substituted for germanium, germanium is more reliable than these materials in many high-frequency electronics applications, and is a more economical substrate for some light-emitting-diode applications. Zinc selenide and germanium glass substitute for germanium metal in infrared applications systems but often at the expense of performance. Titanium has the potential to be a substitute for germanium as a polymerization catalyst.

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

[1]In addition to the gross weight of wrought and unwrought germanium and waste and scrap that comprise these figures, this series includes 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 stock changes; rounded to nearest 5%.

[4]Imports are based on the gross weight of wrought and unwrought germanium and waste and scrap; includes estimated germanium dioxide, metal content but 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 few large placer mines (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 operations yielded more than 99% of the gold produced in the United States. In 2008, the value of mine production was about $6.7 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, 80%; electrical and electronics, 8%; dental and other, 12%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Mine	258	256	252	238	230
Refinery:					
Primary	222	195	181	176	170
Secondary (new and old scrap)	92	81	89	135	120
Imports[2]	283	341	263	170	230
Exports[2]	257	324	389	519	595
Consumption, reported	185	183	185	180	180
Stocks, yearend, Treasury[3]	8,140	8,140	8,140	8,140	8,140
Price, dollars per ounce[4]	411	446	606	699	900
Employment, mine and mill, number[5]	7,550	7,910	8,350	9,130	9,200
Net import reliance[6] as a percentage of apparent consumption	8	4	E	E	E

Recycling: 120 tons of new and old scrap, equal to about 67% of reported consumption, was recycled in 2008.

Import Sources (2004-07):[2] Peru, 35%; Canada, 30%; Mexico, 9%; Chile, 8; and other, 18%.

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 Governmentwide secondary precious-metals recovery program.

Events, Trends, and Issues: Domestic gold mine production in 2008 was estimated to be 3% less than the level of 2007. Reduced production from several mines in Nevada and one mine in Colorado accounted for much of the decrease. These decreases were partially offset by increases in production from one mine in Alaska, one in California, and a few in Nevada. Despite the decrease in production, the United States rose to the third leading gold-producing nation and was a net exporter of gold.

Power generation problems, coupled with the continuing increase in costs at South African gold mines and continuing labor problems, has caused several mines to curtail production and expansion projects. Other mines were closed owing to safety concerns, and some operations were temporarily closed in order to divert electricity to other facilities. Australian gold producers faced similar production declines and also had power problems; however, the main reasons for the drop in production were the lower average grades and rising costs. Indonesia saw drastic drops in production owing to lower grades and heavy rainfall. With the production decreases in the major gold-producing nations and China's increased gold production, China remained the leading gold-producing nation, followed by South Africa, the United States, and Australia.

Jewelry consumption continued to drop as the price of gold continued to increase. The estimated price in 2008 was 29% higher than the price in 2007. During the first 9 months of 2008, Engelhard Corp.'s daily price of gold ranged from an alltime high of $1,011 per troy ounce on March 17 to a low of about $741 per troy ounce in early September.

Prepared by **Micheal W. George [(703) 648-4962, mgeorge@usgs.gov, fax: (703) 648-7757]**

GOLD

With the increase in price and the worldwide economic slowdown, investment in gold has increased. Gold Exchange-Traded Funds (ETFs) have gained popularity with investors. According to some industry analysts, investing in gold in the traditional manner is not as accessible and carries higher costs owing to insurance, storage, and higher markups. 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.

World Mine Production, Reserves, and Reserve Base: Reserves and reserve base estimates were revised, excluding Australia and China, based on a commercially available database of reserves and resources of mines and potential mines.

	Mine production		Reserves[7]	Reserve base[7]
	2007	2008[e]		
United States	238	230	3,000	5,500
Australia	246	225	5,000	6,000
Brazil	40	40	2,000	2,500
Canada	101	100	2,000	4,200
China	275	295	1,200	4,100
Chile	42	42	2,000	3,400
Ghana	84	84	1,600	2,700
Indonesia	118	90	3,000	6,000
Mexico	39	41	1,400	3,400
Peru	170	175	1,400	2,300
Papua New Guinea	65	65	1,300	2,300
Russia	157	165	5,000	7,000
South Africa	252	250	6,000	31,000
Uzbekistan	85	85	1,700	1,900
Other countries	471	440	[8]10,000	[8]22,000
World total (rounded)	2,380	2,330	47,000	100,000

World Resources: An assessment of U.S. gold resources indicated 33,000 tons of gold in identified (15,000 tons) and undiscovered (18,000 tons) resources.[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 and electronic products, and in 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]One 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: 3 (2004), 0 (2005), 0 (2006), 189 (2007), and 250 (2008 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 2008, 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 2008 were refractory applications, 28%; steelmaking and foundry operations, 23%; brake linings, 12%; batteries and lubricants, 4%; and other applications, 33%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production, mine	—	—	—	—	—
Imports for consumption	64	65	53	59	55
Exports	46	22	22	16	16
Consumption, apparent[1]	18	43	30	43	39
Price, imports (average dollars per ton at foreign ports):					
Flake	485	512	528	499	669
Lump and chip (Sri Lankan)	2,420	2,550	2,320	2,219	3,026
Amorphous	177	170	188	150	200
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. The abundance of graphite in the world market inhibits increased recycling efforts. Information on the quantity and value of recycled graphite is not available.

Import Sources (2004-07): China, 46%; Mexico, 24%; Canada, 20%; Brazil, 5%; and other, 5%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
Crystalline flake (not including flake dust)	2504.10.1000	Free.
Powder	2504.10.5000	Free.
Other	2504.90.0000	Free.

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

Government Stockpile: All stockpiled graphite inventories have been sold, and as of December 31, 2006, the National Defense Stockpile contained no graphite inventories.

Prepared by **Donald W. Olson [(703) 648-7721, dolson@usgs.gov, fax: (703) 648-7757]**

GRAPHITE (NATURAL)

Events, Trends, and Issues: Graphite was in near supply-demand balance worldwide in 2008. Leading sources for graphite imports were: flake graphite from China, Canada, Mexico, 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). China produced the majority of the world's graphite from deposits clustered in the Shandong and Heilongjiang producing regions, and China's graphite production is expected to continue growing as producers there collaborate with western graphite producers. In the past few years, Canada has had a number of new graphite mines begin production, and this trend is expected to continue through the next few years. 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: The reserve base for India was revised based on information reported by the Government of India.

	Mine production		Reserves[3]	Reserve base[3]
	2007	2008[e]		
United States	—	—	—	1,000
Brazil	76	76	360	1,000
Canada	28	28	([4])	([4])
China	800	800	74,000	140,000
Czech Republic	3	3	1,300	14,000
India	130	130	5,200	11,000
Korea, North	30	30	([4])	([4])
Madagascar	15	5	940	960
Mexico	13	13	3,100	3,100
Norway	2	2	([4])	([4])
Sri Lanka	3	3	([4])	([4])
Turkey	2	2	([4])	([4])
Ukraine	8	8	([4])	([4])
Other countries	4	6	5,100	44,000
World total (rounded)	1,110	1,110	90,000	220,000

World Resources: Domestic resources of graphite 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 C for definitions.
[4]Included with "Other countries."

GYPSUM

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2008, domestic production of crude gypsum was estimated to be 12.7 million tons with a value of about $95 million. The leading crude gypsum-producing States were, in descending order, Oklahoma, Arkansas, Iowa, California, Nevada, Texas, Indiana, and Michigan, which together accounted for 77% of total output. Overall, 46 companies produced gypsum in the United States at 51 mines in 29 States, and 9 companies calcined gypsum at 52 plants in 28 States. Approximately 85% of domestic consumption, which totaled approximately 23.8 million tons, was accounted for by manufacturers of wallboard and plaster products. Approximately 3 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 2008, the capacity of operating wallboard plants in the United States was about 26.8 billion square feet[1] per year.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Crude	17,200	21,100	21,100	17,900	12,700
Synthetic[2]	8,400	8,690	9,290	8,500	8,000
Calcined[3]	23,200	21,000	26,100	16,700	18,700
Wallboard products sold (million square feet[1])	30,500	28,700	35,000	27,800	26,400
Imports, crude, including anhydrite	10,100	11,200	11,400	9,400	7,800
Exports, crude, not ground or calcined	149	148	143	147	159
Consumption, apparent[4]	35,600	40,800	41,600	35,700	28,000
Price:					
Average crude, f.o.b. mine, dollars per metric ton	7.21	7.48	8.83	7.50	7.25
Average calcined, f.o.b. plant, dollars per metric ton	21.07	20.26	19.80	17.37	17.00
Employment, mine and calcining plant, number[e]	5,900	5,900	5,900	6,000	5,400
Net import reliance[5] as a percentage of apparent consumption	28	27	27	26	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 primarily for agricultural purposes and for the manufacture of new wallboard. Other potential markets for recycled gypsum include athletic field marking, cement production as a stucco additive, grease absorption, sludge drying, and water treatment.

Import Sources (2004-07): Canada, 67%; Mexico, 24%; Spain, 7%; Dominican Republic, 1%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Gypsum; anhydrite	2520.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: China was the world's leading producer of gypsum in 2008, evidence of that country's continued and dramatic economic growth. U.S. gypsum production declined as the housing and construction markets continued to falter, with apparent consumption decreasing by about 20%. The construction of new wallboard plants and the expansion of existing plants that began in 2005 slowed in 2008. Recently expanded or renovated facilities will consume synthetic gypsum produced through scrubbed emissions from coal-fired electric power plants. 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 building plasters, the manufacture of portland cement, and wallboard products. Road building and repair are expected to continue to drive gypsum consumption in the cement industry. The construction of large wallboard plants designed to use synthetic gypsum as feedstock will result in less use of natural gypsum as these new plants become operational. In 2008, regional shortages of wallboard supplies, as a result of higher transportation costs from producing States, were met by imports. Imports decreased by approximately 20%. Exports, although very low compared with imports, increased by approximately 8%.

Prepared by **Robert D. Crangle, Jr. [(703) 648-6410, rcrangle@usgs.gov, fax: (703) 648-7757]**

GYPSUM

World Mine Production, Reserves, and Reserve Base:

	Mine production 2007	Mine production 2008[e]	Reserves[6]	Reserve base[6]
United States	17,900	12,700	700,000	Large
Algeria	1,200	1,300		
Australia	4,200	4,100		
Austria	1,000	1,000		
Brazil	1,800	1,700	1,300,000	Large
Canada	7,700	7,300	450,000	Large
China	37,000	40,700		
Egypt	2,000	2,000		
France	4,800	4,700		
Germany	1,800	1,700		
India	2,500	2,800		
Iran	12,000	12,000		
Italy	5,500	5,500	Reserves and reserve base are large in major producing countries, but data are not available.	
Japan	5,900	5,700		
Mexico	6,100	5,800		
Poland	1,600	1,700		
Russia	2,300	2,400		
Spain	11,500	11,300		
Thailand	8,600	8,800		
United Kingdom	1,700	1,700		
Uruguay	1,200	1,100		
Other countries	15,300	14,900		
World total (rounded)	154,000	151,000	Large	Large

World Resources: Domestic gypsum resources are adequate but unevenly distributed. Large imports from Canada augment domestic supplies for wallboard manufacturing in the United States, particularly in the eastern and southern coastal regions. 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; 89 countries produce gypsum. China is the leading producer, producing more than twice the annual amount of the United States, the world's second ranked producer. Iran ranks third in world production and supplies much of the gypsum needed for construction in the Middle East. Spain, the leading European producer, ranked fourth in the world, and supplies both crude gypsum and gypsum products to much of Western Europe. An increased use of wallboard in Asia, coupled with new gypsum product plants, amplified production in that region. As more cultures recognize the economics and efficiency of wallboard, worldwide production of gypsum is expected to 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 2008, synthetic gypsum accounted for 39% 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 2008 by private industry was about $640 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. Ten industry plants (four in Kansas, and one each in Colorado, New Mexico, 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 2008 domestic consumption of 64.9 million cubic meters (2.34 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:	2004	2005	2006	2007	2008[e]
Helium extracted from natural gas[2]	86	76	79	77	78
Withdrawn from storage[3]	44	57	58	61	53
Grade-A helium sales	130	133	137	138	131
Imports for consumption	—	—	—	—	—
Exports[4]	44.9	51.4	61.9	64.2	66.1
Consumption, apparent[4]	85.1	81.6	75.2	73.5	64.9
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Price: The Government price for crude helium was $2.18 per cubic meter ($60.50 per thousand cubic feet) in fiscal year (FY) 2008. 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 $4.15 to $4.87 per cubic meter ($115 to $135 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 (2004-07): None.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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 Public Law 104-273, the BLM manages the Federal Helium Program, which includes all operations of the Cliffside Field helium storage reservoir, in Potter County, TX, 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 (in-kind) crude helium from the BLM.

In FY 2008, privately owned companies purchased about 5.7 million cubic meters (207 million cubic feet) of in-kind crude helium. In addition to this, privately owned companies also purchased 46.2 million cubic meters (1,664 million cubic feet) of open market sales helium. During FY 2008, BLM's Amarillo Field Office, Helium Operations (AMFO), accepted about 19.9 million cubic meters (717 million cubic feet) of private helium for storage and redelivered nearly 72.6 million cubic meters (2,617 million cubic feet). As of September 30, 2008, about 31.3 million cubic meters (1,129 million cubic feet) of privately owned helium remained in storage at Cliffside Field.

Stockpile Status—9-30-08[6]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Helium	541.6	541.6	63.8	51.9

Prepared by **Norbert Pacheco[7] [(806) 356-1031, Norbert_Pacheco@blm.gov, fax: (806) 356-1041]**

HELIUM

Events, Trends, and Issues: During FY 2008, most helium suppliers announced price increases that averaged about 30%. These increases were in response to continued increased raw material, energy, and distribution costs. Some companies increased high-pressure cylinder rental charges, and others continued cost-recovery efforts through various charges and surcharges. The price of pure helium is expected to continue to increase as production costs, including the price of crude helium, increase and helium reserves are depleted. Helium demand is expected to continue to grow at about 2.5% to 3.5% per year. Helium exports are expected to increase by about 3% from 2007 exports. During FY 2008, the AMFO conducted four open market helium sales. Sales totaled 46.2 million cubic meters (1,664 million cubic feet). During 2008, the Skikda, Algeria, and Qatar helium plants, which came onstream in late 2005, operated and produced helium at much better rates than during 2007. These two plants are expected to produce about 40% to 75% of their nameplate capacities during 2008. Worldwide, nine new helium plant projects are scheduled for startup sometime between 2009 and 2015. Two projects are scheduled for startup in the U.S. during 2011-12 in the Riley Ridge, WY, and St. Johns, AZ, areas. The other plants will be in Algeria, Australia, China, India, Indonesia, Qatar, and Russia.

World Production, Reserves, and Reserve Base: Reserves and reserve base numbers were revised based on estimated production for 2008.

	Production		Reserves[8]	Reserve base[8]
	2007	2008[e]		
United States (extracted from natural gas)	77	78	4,000	[9]20,000
United States (from Cliffside Field)	61	53	([10])	([10])
Algeria	16	16	1,800	8,200
Canada	NA	NA	NA	2,000
China	NA	NA	NA	1,100
Poland	2.5	2.5	24	280
Qatar	7.1	12.5	NA	10,000
Russia	7.1	6.9	1,700	6,800
Other countries	NA	NA	NA	800
World total (rounded)	171	169	NA	49,000

World Resources: As of December 31, 2006, the total helium reserves and resources of the United States were estimated to be 20.6 billion cubic meters (744 billion cubic feet). This includes 4.25 billion cubic meters (153.2 billion cubic feet) of measured reserves, 5.33 billion cubic meters (192.2 billion cubic feet) of probable resources, 5.93 billion cubic meters (213.8 billion cubic feet) of possible resources, and 5.11 billion cubic meters (184.4 billion cubic feet) of speculative resources. Included in the measured reserves are 0.67 billion cubic meters (24.2 billion cubic feet) of helium stored in the Cliffside Field Government Reserve, and 0.065 billion cubic meters (2.3 billion cubic feet) of helium contained in Cliffside Field native gas. The Hugoton (Kansas, Oklahoma, and Texas), Panhandle West, Panoma, Riley Ridge, and Cliffside Fields are the depleting fields from which most U.S.-produced helium is being extracted. These fields contain an estimated 2.7 billion cubic meters (96 billion cubic feet) of helium.

Helium resources of the world exclusive of the United States were estimated to be about 31.3 billion cubic meters (1.13 trillion cubic feet). The locations and volumes of the major deposits, in billion cubic meters, are Qatar, 10.1; Algeria, 8.2; Russia, 6.8; Canada, 2.0; and China, 1.1. As of December 31, 2008, AMFO had analyzed over 21,900 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, probable, possible, and speculative 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 2008. 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. Production of indium tin oxide (ITO) continued to be the leading end use of indium and accounted for most global indium consumption. ITO thin-film coatings were primarily used for electrically conductive purposes in a variety of flat-panel devices—most commonly liquid crystal displays (LCDs). Other end uses included solders and alloys, compounds, electrical components and semiconductors, and research. The estimated value of primary indium metal consumed in 2008, based upon the annual average U.S. producer price, was about $89 million.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, refinery	—	—	—	—	—
Imports for consumption[1]	143	142	100	147	160
Exports	NA	NA	NA	NA	NA
Consumption, estimated	100	115	125	125	130
Price, average annual, dollars per kilogram[2]	643	946	918	795	685
Stocks, producer, yearend	NA	NA	NA	NA	NA
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: Data on the quantity of secondary indium recovered from scrap were not available. Indium is most commonly recovered from ITO. Sputtering, the process in which ITO is deposited as a thin-film coating onto a substrate, is highly inefficient; approximately 30% of an ITO target is deposited onto the substrate. The remaining 70% consists of the spent ITO target, the grinding sludge, and the after-processing residue left on the walls of the sputtering chamber. It was estimated that 60% to 65% of the indium in a new ITO target will be recovered, and research was underway to improve this rate further. A short recycling process time for used ITO targets is critical as a recycler may have millions of dollars worth of indium in the recycling loop at any one time, and a large increase in ITO scrap could be problematic owing to large capital costs, environmental restrictions, and limited storage space. It was reported that the ITO recycling loop—from collection of scrap to production of secondary materials—now takes less than 30 days. ITO recycling is concentrated in China, Japan, and the Republic of Korea—the countries where ITO production and sputtering take place.

An LCD manufacturer has developed a process to reclaim indium directly from scrap LCD panels. The panels are crushed into millimeter-sized particles then soaked in an acid solution to dissolve the ITO, from which the indium is recovered. Indium recovery from tailings was thought to have been insignificant, as these wastes contain low amounts of the metal and can be difficult to process. However, recent improvements to the process technology have made indium recovery from tailings viable when the price of indium is high.

Import Sources (2004-07):[1] China, 43%; Japan, 18%; Canada, 17%; Belgium, 7%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Unwrought indium, including powders	8112.92.3000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2008, global consumption of indium was estimated to have increased from that of 2007, and the indium market was forecast to remain in a supply deficit for at least another year. Japanese ITO manufacturers predicted that their ITO production would increase in 2008 compared with that of 2007, as demand for the material was projected to increase 10% to 15% along with rising flat-panel shipments. Secondary indium production, which accounted for a larger share of production than primary, was expected to rise significantly. Primary production was expected to increase as well, but not considerably. Several refineries have added or expanded capacity, but primary production will continue to be limited by the availability of indium-bearing concentrates. A few indium-bearing deposits located in Argentina, Australia, Bolivia, Brazil, Canada, and China were either being actively explored or developed.

Prepared by **Amy C. Tolcin [(703) 648-4940, atolcin@usgs.gov, fax: (703) 648-7757]**

INDIUM

Photovoltaic (PV) applications could become another large market opportunity for indium. Thin-film PV technologies—including copper-indium-gallium-diselenide (CIGS)—accounted for less than 6% of the global solar cell market. Silicon-based technologies continued to dominate with a 94% share. However, a shortage of high-purity polysilicon has prompted the development of thin films, which are less efficient but more economical than the silicon-based counterparts. Flexible CIGS solar cells could be used in roofing materials and in various applications in the aerospace, military, and recreational industries.

The U.S. producer price for indium began 2008 at $685 per kilogram and remained at that level for most of the year.

World Refinery Production, Reserves, and Reserve Base: World indium reserves and reserve base are not sufficiently well delineated to report consistent figures.

	Refinery production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States	—	—	NA	NA
Belgium	30	30	NA	NA
Canada	50	50	NA	NA
China	320	330	NA	NA
France	10	—	NA	NA
Japan	60	60	—	—
Korea, Republic of	50	50	—	—
Peru	6	6	NA	NA
Russia	12	12	NA	NA
Other countries	25	30	NA	NA
World total (rounded)	563	568	NA	NA

World Resources: Indium's abundance in the continental crust is estimated to be approximately 0.05 part per million. Trace amounts of indium occur in base metal sulfides—particularly chalcopyrite, sphalerite, and stannite—by ionic substitution. Indium is most commonly recovered from 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's recent price volatility and various supply concerns associated with the metal have accelerated the development of ITO substitutes. Antimony tin oxide (ATO) coatings, which are deposited by an ink-jetting process, have been developed as an alternative to ITO coatings in LCDs and have been successfully annealed to LCD glass. Carbon nanotube coatings, applied by wet-processing techniques, have been developed as an alternative to ITO coatings in flexible displays, solar cells, and touch screens. Poly(3,4-ethylene dioxythiophene) (PEDOT) has also been developed as a substitute for ITO in flexible displays and organic light-emitting diodes. PEDOT can be applied in a variety of ways, including spin coating, dip coating, and printing techniques. Graphene quantum dots have been developed to replace ITO electrodes in solar cells and also have been explored as a replacement for ITO in LCDs. Researchers have recently developed a more adhesive zinc oxide nanopowder to replace ITO in LCDs. The technology was estimated to be commercially available within the next 3 years. Indium phosphide can be substituted by gallium arsenide in solar cells and in many semiconductor applications. Hafnium can replace indium in nuclear reactor control rod alloys.

[e]Estimated. NA Not available. — Zero.
[1]Imports for consumption of unwrought indium and indium powders (Tariff no. 8112.92.3000).
[2]Indium Corp.'s price for 99.97% purity metal; 1-kilogram bar in lots of 10,000 troy ounces. Source: Platts Metals Week.
[3]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.
[4]See Appendix C for definitions.

IODINE

(Data in metric tons elemental iodine unless otherwise noted)

Domestic Production and Use: Iodine was produced in 2008 by three companies operating in Oklahoma. Production increased slightly in 2008 compared with that of 2007. 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. Prices for iodine have increased in recent years owing to high demand, which has led to high-capacity utilization. The average c.i.f. value of iodine imports in 2008 was estimated to be $22.20 per kilogram.

Establishing an accurate end-use pattern for iodine was difficult because intermediate iodine compounds were marketed before reaching their final end uses. Of the consumers that participate in an annual U.S. Geological Survey canvass, 17 plants reported consumption of iodine in 2007. Iodine compounds reported used were unspecified organic compounds, including ethyl and methyl iodide, 45%; crude iodine, 13%; potassium iodide, 10%; sodium iodide, 9%; povidine-iodine (iodophors), 7%; ethylenediamine dihydroiodide, 4%; and other, 12%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production	1,130	1,570	W	W	W
Imports for consumption, crude content	5,700	6,250	5,640	6,060	6,660
Exports[1]	1,060	2,430	1,580	1,060	1,200
Shipments from Government stockpile excesses	245	444	467	93	—
Consumption:					
Apparent	5,810	5,600	W	W	W
Reported	4,070	4,680	4,570	4,730	4,900
Price, average c.i.f. value, dollars per kilogram, crude	13.38	16.75	19.34	21.12	22.20
Employment, number	30	30	30	30	30
Net import reliance[2] as a percentage of apparent consumption	81	72	W	W	W

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

Import Sources (2004-07): Chile, 76%; Japan, 23%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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	2827.60.5100	4.2% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: The National Defense Stockpile Center announced that all iodine (94,100 kilograms) in the stockpile had been sold.

Events, Trends, and Issues: Chile was the largest iodine producing country, with Chilean producers accounting for more than 50% of world production. Two of the leading iodine companies in the world were located in Chile. Iodine was a coproduct of surface mineral deposits used to produce nitrate fertilizer. Japan was the second leading producer; its production was associated with gas brines. The Turkmenistan Government continues to invest significantly in repairing and upgrading its production facilities to achieve its anticipated goal of 1,800 tons of iodine per year by 2010. A company in Azerbaijan announced its intent to build a $70 million iodine production facility in Azerbaijan during the next 3 years that will have the capacity to produce 10,000 tons of iodine per year. The output of the plant would be exported to Russian and European markets.

Prepared by **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

IODINE

During the second quarter of 2008, a leading producer of iodine in Chile finished construction of a new mechanically agitated leach plant. The commissioning process, which consists of testing and optimizing plant components, was experiencing some unanticipated challenges in the crushing and grinding section, which may delay full startup until late in the fourth quarter of 2008 or early in the first quarter of 2009. The company anticipated these improvements would result in an extended mine life, lower production costs, and reduced working-capital requirements. Another leading Chilean producer announced plans to increase production capacity of iodine from its northern Chile deposits by approximately 25% by 2012.

U.S. consumption growth is strongest in the pharmaceuticals and sanitation end-use market. Use of x-ray contrast media in medical diagnostics is increasing. This has offset iodine's waning consumption in photographic film, an end-use application that has declined recently owing to the increasing popularity of digital-imaging systems.

Global iodine consumption patterns continue to increase owing to the growing levels of awareness among health-conscious consumers about the importance of iodine as a dietary ingredient in a well-balanced diet. Use of iodine in food products is gaining in momentum as governments resort to iodine fortification as a means to eradicate diseases caused by iodine deficiency. In the Middle East, consumption of iodine in the animal feed sector is projected to increase. The water-treatment market is also expected to increase, with more growth anticipated in Asian areas such as China, India, and Pakistan.

Application breakthroughs are expected to give rise to new end uses and result in increases in demand for crude iodine. Replacement of chlorofluorocarbons (CFCs) with fluoroiodocarbons offers an opportunity for iodine as a potential substitute for chlorine in CFCs. With bromine-based herbicides increasingly coming under environmental pressure, opportunities exist for increased use of iodine in herbicides.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2007	2008[e]		
United States	W	W	250,000	550,000
Azerbaijan	300	300	170,000	340,000
Chile	15,500	16,000	9,000,000	18,000,000
China	570	580	4,000	120,000
Indonesia	75	75	100,000	200,000
Japan	8,700	8,800	4,900,000	7,000,000
Russia	300	300	120,000	240,000
Turkmenistan	270	500	170,000	350,000
Uzbekistan	2	2	NA	NA
World total (rounded)	[4]25,700	[4]27,000	15,000,000	27,000,000

World Resources: In addition to the reserve base shown above, seawater contains 0.05 parts 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. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Export data for the years 2004-2006 revised by the U.S. Census Bureau.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for definitions.
[4]Excludes U.S. production.

IRON ORE[1]

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

Domestic Production and Use: In 2008, mines in Michigan and Minnesota shipped 98% of the usable ore produced in the United States, with an estimated value of greater than $3.0 billion. Twelve iron ore mines (11 open pits and 1 dredging operation), 8 concentration plants, and 8 pelletizing plants operated during the year. Almost all ore was concentrated before shipment. Eight of the mines operated by three companies accounted for virtually all of the production. The United States produced and consumed about 3% of the world's iron ore output.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, usable	54.7	54.3	52.7	52.5	54
Shipments	54.9	53.2	52.7	50.9	56
Imports for consumption	11.8	13.0	11.5	9.4	9
Exports	8.4	11.8	8.3	9.3	11
Consumption:					
Reported (ore and total agglomerate)[3]	64.5	60.1	58.2	54.8	55
Apparent[e]	57.9	56.6	57.1	51.3	52
Price,[4] U.S. dollars per metric ton	37.92	44.50	53.88	59.64	66.00
Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore[e, 5]	17.6	16.5	15.3	16.6	16.6
Employment, mine, concentrating and pelletizing plant, quarterly average, number	4,410	4,450	4,470	4,450	4,450
Net import reliance[6] as a percentage of apparent consumption (iron in ore)	6	4	8	E	E

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

Import Sources (2004-07): Canada, 55%; Brazil, 37%; Chile, 2%; Trinidad and Tobago, 2%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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 an almost 20% increase in worldwide price for lump and fines in 2006 and almost 10% in 2007, the 2008 iron ore price showed an even steeper increase of greater than 65% for lump and fines and almost 87% for pellets from the Americas. For the first time, Australian producers were successful in obtaining a price margin for shorter transport distances into the Asian market with an almost 80% increase in price for fines and an increase of greater than 96% for lump ores.

Major iron-ore-mining companies continue to reinvest profits in mine development, but increases in capacity may outstrip expected consumption in 2009, as growth dominated by China slows. In 2007, it was estimated that China increased production of mostly lower grade ores by about 20% from that of the previous year—significantly lower than the 40% increase seen between 2005 and 2006. Estimates of Chinese imports of higher grade ores in 2007, mostly from Australia and Brazil, showed an increase of about 18% compared with those of 2006.

International iron ore trade and production of iron ore and pig iron—key indicators of iron ore consumption—clearly show that iron ore consumption in China is the major factor upon which the expansion of the international iron ore industry depends. China continued to be active in pursuing overseas joint ventures, increasing iron ore imports, and expanding domestic production of low-grade ores—all of which indicate continued growth of iron ore consumption.

Throughout 2008, BHP Billiton continued its effort to merge with Rio Tinto plc. This is one of the most significant merger attempts over the past several years in the world iron and steel industry and would represent a major consolidation within the iron ore industry.[7]

Prepared by **John D. Jorgenson [(703) 648-4912, jjorgenson@usgs.gov, fax: (703) 648-7757]**

IRON ORE

Owing to increased prices and interest by Chinese importers, a previously operated iron ore mine reopened in Utah. The opening or reopening of several lower grade iron ore deposits has been investigated by small capitalization miners in Alaska, Arizona, Missouri, Nevada, and New Mexico.

Construction activities for a direct-reduced iron nugget plant—the Mesabi Nugget project—progressed during 2008. A plant to produce these 96%-to-98% iron-content nuggets in Minnesota was expected to be completed in the third quarter of 2009, with the reopening of an iron ore mine planned for 2010.

Increased operating costs have been offset by operational improvements in the U.S. iron ore industry. Fuel costs at the beginning of 2008 were substantially higher than originally projected. Other production costs, such as transportation, also increased, and the availability of capital equipment and skilled labor has remained a major challenge, although the worldwide mining boom appeared to come to an abrupt halt in the latter part of 2008 as capital markets tightened.

World Mine Production, Reserves, and Reserve Base: The mine production estimates for China are based on crude ore, rather than usable ore, which is reported for the other countries. The iron ore reserve base estimate for Brazil has been revised based on new information from that country.

	Mine production		Crude ore		Iron content	
	2007	2008[e]	Reserves[8]	Reserve base[8]	Reserves[8]	Reserve base[8]
United States	52	54	6,900	15,000	2,100	4,600
Australia	299	330	16,000	45,000	10,000	28,000
Brazil	355	390	16,000	33,000	8,900	17,000
Canada	33	35	1,700	3,900	1,100	2,500
China	707	770	21,000	46,000	7,000	15,000
India	180	200	6,600	9,800	4,200	6,200
Iran	32	32	1,800	2,500	1,000	1,500
Kazakhstan	24	26	8,300	19,000	3,300	7,400
Mauritania	12	12	700	1,500	400	1,000
Mexico	12	12	700	1,500	400	900
Russia	105	110	25,000	56,000	14,000	31,000
South Africa	42	42	1,000	2,300	650	1,500
Sweden	25	27	3,500	7,800	2,200	5,000
Ukraine	78	80	30,000	68,000	9,000	20,000
Venezuela	23	20	4,000	6,000	2,400	3,600
Other countries	47	50	11,000	30,000	6,200	17,000
World total (rounded)	2,000	2,200	150,000	350,000	73,000	160,000

World Resources: United States resources are estimated to be about 110 billion tons of ore containing 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 prior to commercial use. World resources are estimated to exceed 800 billion tons of crude ore containing more than 230 billion tons of iron.

Substitutes: Iron ore, used directly, as lump ore, or converted to briquettes, concentrates, pellets, or sinter, is the only source of primary iron. In some operations, ferrous scrap may constitute as much as 7% of the blast furnace feedstock. Scrap is extensively used in steelmaking in electric arc furnaces and in iron and steel foundries, but scrap availability can be an issue in any given year. In general, large price increases for lump and fine iron ores and iron ore pellets during 2008 were offset by price increases in the alternative—scrap. The margin between iron ore and scrap import prices decreased between 2004 and 2006, but remained level for 2007 and 2008; therefore, the relative attractiveness of scrap compared to iron ore has changed little since 2006.

[e]Estimated. E Net exporter.
[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]Estimated from reported value of ore at mines.
[5]Information regarding consumer stocks at receiving docks and plants has not been available since 2003 (these stock changes were estimated).
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]Jorgenson, J.D., 2008, Iron ore in February 2008: U.S. Geological Survey Mineral Industry Surveys, August, 5 p.
[8]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 2008 that were valued at about $117 billion. Pig iron was produced by 8 companies operating integrated steel mills in about 18 locations. About 57 companies, producing raw steel at about 116 plants, had combined production capability of about 113 million tons. Indiana accounted for 25% of total raw steel production, followed by Ohio, 14%, Pennsylvania, 6%, and Michigan, 5%. The distribution of steel shipments was estimated to be: warehouses and steel service centers, 19%; construction, 16%; transportation (predominantly automotive), 13%; cans and containers, 3%; and other, 49%. About 564 iron foundries and 239 steel foundries operated in the United States in 2008.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Pig iron production[2]	42.3	37.2	37.9	36.3	35.6
Steel production:	99.7	94.9	98.2	98.1	93.7
Basic oxygen furnaces, percent	47.9	45.0	57.1	58.2	58
Electric arc furnaces, percent	52.1	55.0	42.9	41.8	42
Continuously cast steel, percent	97.1	96.8	96.7	96.7	97.1
Shipments:					
Steel mill products	101	95.2	99.3	96.5	97.9
Steel castings[3]	0.7	0.7	[e]0.7	[e]0.7	0.7
Iron castings[3]	7.5	7.4	[e]7.4	[e]7.4	7.4
Imports of steel mill products	32.5	29.1	41.1	30.2	29.4
Exports of steel mill products	7.2	8.5	8.8	10.1	12.8
Apparent steel consumption[4]	117	113	120	114	107
Producer price index for steel mill products (1982=100)[5]	147.2	159.7	174.1	182.9	225
Steel mill product stocks at service centers yearend[6]	14.4	11.7	15.0	11.1	13.0
Total employment, average, number[7]					
Blast furnaces and steel mills	123,000	122,000	122,000	121,000	121,000
Iron and steel foundries[e]	116,000	115,000	115,000	115,000	115,000
Net import reliance[8] as a percentage of apparent consumption	14	15	17	16	8

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

Import Sources (2004-07): Canada, 16%; European Union, 16%; Mexico, 10%; China, 10%; and other, 48%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Pig iron	7201.10.0000	Free.
Carbon steel:		
Semifinished	7207.12.0050	Free.
Hot-rolled, pickled	7208.27.0060	Free.
Sheets, hot-rolled	7208.39.0030	Free.
Cold-rolled	7209.18.2550	Free.
Galvanized	7210.49.0090	Free.
Bars, hot-rolled	7213.20.0000	Free.
Structural shapes	7216.33.0090	Free.
Stainless steel:		
Semifinished	7218.91.0015	Free.
Do.	7218.99.0015	Free.
Cold-rolled sheets	7219.33.0035	Free.
Bars, cold-finished	7222.20.0075	Free.
Pipe and tube	7304.41.3045	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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

IRON AND STEEL

Events, Trends and Issues: Gross domestic product (GDP) growth may be considered a predictor of the health of the steelmaking and steel manufacturing industries worldwide and domestically. The World Bank forecasts world GDP growth in 2008 to be 2.7%, down from its earlier forecast of 3.3%, and down from 3.7% in 2007. GDP forecasts for 2009 and 2010 are 3.0% and 3.4%, respectively. The U.S. GDP growth is expected to be 1.1% in 2008, down from an earlier 1.9% forecast. GDP growth forecasts for 2008 for the European euro zone, Japan, and China were also revised downward to 1.7%, 1.4%, and 9.4%, respectively. For 2009, the International Monetary Fund predicted GDP growth for Canada, Japan, the United Kingdom, and the United States to be 1.2%, 0.5%, 0.1%, and 0.1%, respectively.

Soaring demand for steel products and ferrous raw materials in China and other countries caused record price increases and profits for steelmakers and raw material suppliers during 2008. The global economy, which may have entered a recession by the end of 2008 and which has been characterized by major problems in the commodity, credit, and financial sectors, adversely affected customers of steel used in construction, industrial equipment, and vehicles. Reduced consumption of steel led to rapidly declining steel prices, prompting steelmakers in Asia, Europe, and North America to slash output, delay mill-expansion plans, and furlough workers. Before the end of 2008, the world's leading iron ore miners saw spot iron ore prices fall as global steel output declined. The world's leading iron ore producer announced cuts in iron-ore pellet production in Brazil by 65%, while the world's third-leading iron ore exporter also planned to cut production.

In addition, the coking coal market began to deteriorate before yearend 2008. The world's largest steel producer by volume of production announced plans to reduce production in North America by 35% and in Europe by 30%, and to lay off indefinitely as many as 2,444 employees in its Burns Harbor, IN, plant. China's steelmakers are expected to collectively decrease active production capacity by 20% in 2009. Globally, lower revenues and additional layoffs are forecast into 2009. A general economic recovery is not anticipated until at least the latter part of 2009. U.S. steel production and revenues are likely to decline in 2009.

World Production:

	Pig iron		Raw steel	
	2007	2008[e]	2007	2008[e]
United States	36	36	98	94
Brazil	36	37	32	36
China	469	478	489	513
France	12	12	19	19
Germany	31	30	49	48
Italy	11	11	32	32
Japan	87	88	120	123
Korea, Republic of	29	31	52	55
Russia	52	52	72	74
Ukraine	36	34	43	40
United Kingdom	11	11	14	14
Other countries	137	138	320	312
World total (rounded)	947	958	1,340	1,360

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.
[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 + adjustments for industry stock changes - semifinished steel product imports.
[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 $32.8 billion in 2008, up by about 60% from that of 2007. U.S. apparent steel consumption, an indicator of economic growth, decreased to about 106 million metric tons in 2008. Manufacturers of pig iron, raw steel, and steel castings accounted for about 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 machinery parts, motor blocks, and pipe. 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 2008, raw steel production was an estimated 99 million tons, slightly more than that of 2007; annual steel mill capability utilization was about the same as that of 2007. Net shipments of steel mill products were estimated to have been about 98 million tons compared with 96 million tons for 2007. The domestic ferrous castings industry shipped less than 11 million tons of all types of iron castings in 2008 and less than 1.0 million tons of steel castings.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Home scrap	14	15	13	12	12
Purchased scrap[2]	59	58	58	65	65
Imports for consumption[3]	5	4	5	4	4
Exports[3]	12	13	15	17	17
Consumption, reported	67	66	65	65	65
Price, average, dollars per metric ton delivered, No. 1 Heavy Melting composite price, Iron Age Average, Pittsburgh, Philadelphia, Chicago	210	192	219	253	235
Stocks, consumer, yearend	5.4	5.0	4.6	4.4	4.4
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. In the United States alone, an estimated 65 million tons of steel was recycled in steel mills and foundries in 2008.

In the United States, the primary source of old steel scrap was the automobile. The recycling rate for automobiles in 2007, the latest year for which statistics were available, was about 110%. 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 automotive recycling industry recycled through more than 200 car shredders more than 14 million tons of steel from end-of-life vehicles, the equivalent of nearly 13.5 million automobiles. More than 12,000 vehicle dismantlers throughout North America resell parts.

The recycling rates for appliances and steel cans in 2007 were 90% and 63%, respectively. Recycling rates for construction materials in 2007 were about 98% for plates and beams and 65% 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 at an even greater rate. Public interest in recycling continues to increase as the number of environmental regulations increase, and recycling is becoming more profitable and convenient.

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 avoids the accumulation of abandoned steel products in the environment. Recycled scrap consists of approximately 48% post-consumer (old, obsolete) scrap, 29% prompt scrap (produced in steel-product manufacturing plants), and 23% home scrap (recirculating scrap within current operations).

Import Sources (2004-07): Canada, 67%; United Kingdom, 13%; Sweden, 5%; Netherlands, 5%; and other, 10%.

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

IRON AND STEEL SCRAP

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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.

Events, Trends, and Issues: Hot-rolled steel prices increased steadily during 2008 to a peak in July, after which they decreased to early 2008 levels. Prices during 2008 were higher than those in 2007. The producer price index for steel mill products increased to 258.3 in August 2008 from 98.3 in February 2002. Steel mill capability utilization peaked at 97.3% in September 2004, decreased to 75% in December 2006, fluctuated between 81% and 91% during June to August 2008, and then decreased dramatically to 71% in October 2008.

Scrap prices fluctuated widely between about $217 and $285 per metric ton in 2007. Composite prices published by Iron Age Scrap Price Bulletin for No. 1 Heavy Melting steel scrap delivered to purchasers in Chicago, IL, and Philadelphia and Pittsburgh, PA, averaged about $402 per metric ton during the first 10 months of 2008. As reported by Iron Age Scrap Price Bulletin, the average price for nickel-bearing stainless steel scrap delivered to purchasers in Pittsburgh was about $2,522 per ton in 2008, which was lower than the 2007 average price of $2,913 per ton. The prices fluctuated widely between $3,388 per ton in March and April 2008 and a low of $638 before yearend. Exports of ferrous scrap decreased in 2008 to an estimated 12.8 million tons from 16.7 million tons during 2007, mainly to Turkey, China, Canada, and Taiwan, in descending order. Export scrap value increased from $6.9 billion in 2007 to an estimated $9.4 billion in 2008.

Worldwide annual production of ferrous scrap is about 300 million metric tons per year. Until mid-2008, global steel production and prices were at historic highs, after which demand and prices for steel products began to decline, followed by declining demand for scrap. As the global economy retracted, scrap steel buyers in Asia and Europe began cancelling orders, which may lead to a steel scrap oversupply of more than 5 million tons in ports, ships, and yards. Profit margins have dropped in the steel scrap industry from $200 to $20 per ton. Steel production and scrap consumption are not expected to revive until at least late 2009.

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

World Resources: Not applicable.

Substitutes: About 1.8 million tons of direct-reduced iron was used in the United States in 2008 as a substitute for iron and steel scrap, down from 2.1 million tons in 2007.

[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 2002 Census of Wholesale Trade.
[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: Iron and steel slags are marketable coproducts of iron- and steelmaking. Actual production data are unavailable but may be estimated as being in the range of 17 to 23 million tons in 2008. About 15 million tons of domestic iron and steel slag, valued at about $380 million[1] (f.o.b.), was sold during the year. Iron or blast furnace slag accounted for about 60% of the tonnage sold and had a value of about $340 million; nearly 90% of this value was granulated slag. Steel slag produced from basic oxygen and electric arc furnaces accounted for the remainder.[2] Slag processing was 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 ranged widely in 2008 from about $0.50 for steel slags in areas having abundant competing natural aggregates to almost $110 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, almost all GGBFS is 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 only over short distances, but 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, marketed[1, 3]	21.2	21.6	20.3	17.0	15.0
Imports for consumption[4]	1.0	1.6	1.6	1.9	1.3
Exports	0.1	([5])	0.1	0.1	0.1
Consumption, apparent[4, 6]	21.1	21.6	20.2	17.0	15.0
Price average value, dollars per ton, f.o.b. plant	15.50	17.60	20.00	25.00	25.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, number[e]	2,700	2,600	2,500	2,500	2,400
Net import reliance[7] as a percentage of apparent consumption	4	7	8	11	8

Recycling: Some slags are returned to the blast and steel 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 (2004-07): Year-to-year import data for ferrous slags show that the dominant form is granulated blast furnace slag (mostly unground), but show significant variations in both tonnage and unit value. Many past data contain discrepancies; and the official data in recent years appear to significantly underreport imports of granulated blast furnace slag. Principal country sources for 2004-07 were Canada, 45%; Japan, 20%; Italy, 19%; France, 9%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Granulated slag	2618.00.0000	Free.
Slag, dross, scale, from manufacture of iron and steel	2619.00.3000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Prepared by **Hendrik G. van Oss [(703) 648-7712, hvanoss@usgs.gov, fax: (703) 648-7757]**

IRON AND STEEL SLAG

Events, Trends, and Issues: Domestic supplies of air-cooled blast furnace slag have been declining in recent years because of the depletion of old slag piles and the closure of many blast furnaces for economic and/or environmental reasons. No new blast furnaces are under construction or are planned. Granulation cooling is currently installed at only four active blast furnaces, but others are under evaluation as candidates for this type of cooling. Pelletized blast furnace slag, used mainly as a lightweight aggregate, remains in limited supply, but it is unclear if any additional pelletizing capacity is being planned. Steel slag from integrated iron and steel works is in decline, but that from electric arc furnaces (largely fed with steel scrap) remains abundant. Slags compete with natural aggregates in various construction applications. For performance and environmental reasons, demand has been growing for GGBFS as a cementitious ingredient in concrete, and GGBFS prices have increased significantly in recent years. In both aggregate and cementitious applications, however, the market for slag is constrained by overall levels of construction, and as a result, slag sales declined significantly in 2007-08 and were expected to decline further in 2009. The decline in sales of GGBFS in 2007-08 contributed (along with a depreciating dollar and higher shipping costs) to the closure in 2008 of one import-fed grinding plant. Notwithstanding this closure, long-term growth in the supply of GGBFS is likely to hinge on imports, either of the ground or unground material.

World Mine Production, Reserves, and Reserve Base: Slag is not a mined material and thus the concept of reserves does not apply to this mineral commodity. Slag production data for the world are unavailable, but it is estimated that annual world iron slag output in 2008 was on the order of 240 to 290 million tons, and steel slag about 115 to 170 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 2004-08.
[3]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.
[4]Comparison of official (U.S. Census Bureau) with unofficial import data suggest that the official data understate the true imports of granulated slag by nearly 2 million tons per year. Of these apparently missing imports, the USGS canvass appears to capture only about 0.6 million tons within its sales data. Thus the apparent consumption statistics are likely too low by about 1.0 to 1.3 million tons per year.
[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.

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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Mine[e]	90	90	90	90	90
Synthetic mullite[e]	40	40	40	40	40
Imports for consumption (andalusite)	4	6	4	2	5
Exports[e]	35	35	35	35	35
Shipments from Government stockpile excesses	0.1	—	—	—	—
Consumption, apparent[e]	99	101	99	97	100
Price, average, dollars per metric ton:					
U.S. kyanite, raw[1]	NA	NA	NA	224	229
U.S. kyanite, calcined[1]	272	272	313	333	357
Andalusite, Transvaal, South Africa[1]	238	238	248	235	263
Stocks, producer	NA	NA	NA	NA	NA
Employment, kyanite mine, office, and plant, number[e]	120	130	135	130	125
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2004-07): South Africa, 97%, France, 3%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
Andalusite, kyanite, and sillimanite	2508.50.0000	Free.
Mullite	2508.60.0000	Free.

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

Government Stockpile: None.

Prepared by **Michael J. Potter [(703) 648-7723, mpotter@usgs.gov, fax: (703) 648-7757]**

KYANITE AND RELATED MINERALS

Events, Trends, and Issues: The steel industry worldwide continued to be the leading consumer of refractories. According to World Steel Association data, world crude steel production for the first 8 months of 2008 was about 6% higher than in the comparable period of 2007. The three leading steel-producing countries were China with about 38%; Japan, 9%; and the United States, 7%.

According to the Freedonia Group, U.S. demand for refractory products is forecast to grow at the modest rate of 1.8% per year to $2.5 billion in 2011. Shipments of refractories are projected to rise 1.3% per year. Demand for bricks and shapes may increase more rapidly than for monolithics (unshaped refractories) because of certain performance characteristics, such as reduced heat-up time.[3]

The global refractories market is being especially driven by the rapid industrialization of regions such as Asia-Pacific, Eastern Europe, and Latin America. Russia and Ukraine are major steel producers in Eastern Europe. Ukraine's refractories industry has developed actively and has invested in modernization and worked on reducing energy consumption.[4]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2007	2008[e]	
United States[e]	90	90	Large in the United States. South Africa reports a reserve base of about 51 million tons of aluminosilicates ore (andalusite and sillimanite).
France	65	65	
India	22	23	
South Africa	220	220	
Other countries	5	5	
World total (rounded)	400	400	

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 journal.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]Industrial Minerals, 2008, U.S. refractory demand growth 1.8% to 2011: Industrial Minerals, no. 488, May, p. 31.
[4]Backus, Rachel, 2008, Eastern Europe cashing in: Industrial Minerals, no. 484, January, p. 26-33.
[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 2008, based on the average U.S. producer price, was $1.23 billion. Five 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 21 plants that produced secondary lead, 12 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 2008. 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 systems; and as traction batteries used in airline ground equipment, golf carts, industrial forklifts, mining vehicles, etc. About 10% of lead was used in ammunition; casting material; pipes, sheets (including radiation shielding), traps and extruded products; building construction, cable covering, and caulking lead; solder; and oxides for ceramics, chemicals, glass, and pigments. 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:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production:					
Mine, lead in concentrates	445	437	429	444	440
Primary refinery	148	143	153	123	136
Secondary refinery, old scrap	1,130	1,150	1,160	1,180	1,210
Imports for consumption:					
Lead in concentrates	—	—	([1])	([1])	([1])
Refined metal, wrought and unwrought	208	310	343	267	300
Exports:					
Lead in concentrates	292	390	298	300	300
Refined metal, wrought and unwrought	83	65	68	56	50
Shipments from Government stockpile excesses, metal	42	29	24	—	—
Consumption:					
Reported	1,480	1,490	1,560	1,570	1,620
Apparent[2]	1,470	1,480	1,580	1,540	1,600
Price, average, cents per pound:					
North American Producer	55.1	61.0	77.4	124	131
London Metal Exchange	40.2	44.2	58.0	117	107
Stocks, metal, producers, consumers, yearend	59	47	54	49	54
Employment:					
Mine and mill (peak), number[3]	1,020	1,100	1,070	1,100	1,200
Primary smelter, refineries	240	240	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	E

Recycling: About 1.20 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 (2004-07): Metal, wrought and unwrought: Canada, 69%; Mexico, 8%; Peru, 7%; China, 6%; and other, 10%.

Tariff: Item	**Number**	**Normal Trade Relations**[5] **12-31-08**
Unwrought (refined)	7801.10.0000	2.5% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: Prices for refined lead began to drop in the second half of 2008 and continued to decline until yearend, reflective of global demand that weakened during the same period. The average North American Producer and London Metal Exchange cash prices in September were nearly 30% lower than they were at the beginning of 2008. Use of lead worldwide was estimated to have increased by about 5% in 2008, driven primarily

Prepared by **David E. Guberman [(703) 648-4977, dguberman@usgs.gov, fax: (703) 648-7757]**

by strong economic growth in the information technology, telecommunications, and transportation sectors in China.

Global mine production of lead concentrate increased by about 7% in 2008. Mine production rose in Bolivia, Canada, China, India, Mexico, and Russia owing to new projects coming online, along with expansions at some existing operations. Global production of refined lead in 2008 was expected to be 7% higher than that of the previous year, owing to production increases in Australia, Canada, China, Kazakhstan, the Republic of Korea, Malaysia, the United Kingdom, and the United States. China continued to be both the largest producer and consumer of refined lead in the world. The Chinese trade balance for refined lead has shifted during the past year as a result of export tax increases that were implemented in 2007. Chinese exports of refined lead declined by more than 20% during the first half of 2008 compared with those of the same period of the previous year. Conversely, Chinese exports of lead-acid batteries, which are not subject to the higher export taxes, have increased in 2008 compared with those of the previous year.

According to Battery Council International statistics, demand for replacement SLI batteries in 2008 was expected to be up slightly from that of 2007, whereas original equipment SLI demand was down, the latter being consistent with lower new vehicle sales figures.

In October, the Environmental Protection Agency (EPA) issued a final rule that substantially strengthened the national ambient air quality standards (NAAQS) for lead. The revised standards, which must be attained no later than January 2017, are significantly tighter than previous standards and are intended to improve health protection for at-risk groups. In conjunction with the strengthening of the NAAQS, the EPA was planning to expand the existing lead monitoring network to ensure monitors are assessing air quality in areas that might violate the new standard.

World Mine Production, Reserves, and Reserve Base: Reserves estimates for Australia, Canada, and the United States were revised based on information released by producers in the respective countries.

	Mine production		Reserves[6]	Reserve base[6]
	2007	2008[e]		
United States	444	440	7,700	19,000
Australia	641	576	24,000	59,000
Canada	82	95	400	5,000
China	1,500	1,540	11,000	36,000
India	78	85	NA	NA
Ireland	54	56	NA	NA
Kazakhstan	40	47	5,000	7,000
Mexico	120	145	1,500	2,000
Morocco	45	35	500	1,000
Peru	329	335	3,500	4,000
Poland	85	53	NA	5,400
South Africa	42	48	400	700
Sweden	62	69	500	1,000
Other countries	248	300	24,000	30,000
World total (rounded)	3,770	3,800	79,000	170,000

World Resources: In recent years, significant lead resources have been demonstrated in association with zinc and/or silver or copper deposits in Australia, 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, cans, containers, and electrical cable covering. 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 bismuth, copper, silver, and tin.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Less than ½ unit.
[2]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 lead and zinc-lead mines for which lead was either a principal or significant product.
[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 C for definitions.

LIME[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2008, 19.8 million tons (21.8 million short tons) of quicklime and hydrate was produced (excluding commercial hydrators) at a value of about $1.8 billion. At yearend, there were 32 companies producing lime, which included 22 companies with commercial sales and 10 companies that produced lime strictly for internal use (for example, sugar companies). These companies had 81 primary lime plants (plants operating lime kilns) in 30 States and Puerto Rico. The 4 leading U.S. lime companies produced quicklime or hydrate in 24 States from 36 lime plants and 12 separate hydrating plants. Combined, these plants accounted for about 70% of U.S. lime production. Principal producing States, each with production of more than 1 million tons, were Alabama, Kentucky, Missouri, Nevada, Ohio, Pennsylvania, and Texas. Major markets for lime were, in descending order of consumption, steelmaking, flue gas desulfurization (fgd), construction, water treatment, mining, precipitated calcium carbonate, and pulp and paper.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production[2]	20,000	20,000	21,000	20,200	19,800
Imports for consumption	232	310	298	375	325
Exports	100	133	116	144	175
Consumption, apparent	20,100	20,200	21,200	20,400	20,000
Quicklime average value, dollars per ton at plant	64.80	72.10	78.10	84.60	89.20
Hydrate average value, dollars per ton at plant	89.80	91.10	98.30	102.40	106.30
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and plant, number	5,350	5,300	5,300	5,300	5,400
Net import reliance[3] as a percentage of apparent consumption	1	1	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 (2004-07): Canada, 80%; Mexico, 19%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Calcined dolomite	2518.20.0000	3% ad. val.
Quicklime	2522.10.0000	Free.
Slaked lime	2522.20.0000	Free.
Hydraulic lime	2522.30.0000	Free.

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

Government Stockpile: None.

Events, Trends, and Issues: In 2008, lime sales were steady through most of the year, but suffered a downturn when the economy slowed in the second half of the year and especially when steel production decreased in the fourth quarter. Prices continued to increase, with quicklime prices increasing about $5 per metric ton and hydrate prices increasing about $4 per ton. These price increases do not include the fuel surcharges applied by many of the companies. In some cases, these surcharges were calculated based on the price per barrel of crude oil. With the dramatic decrease in oil prices, these surcharges would have been reduced or eliminated in the latter part of the year. Evidence of future price increases was indicated by one major lime supplier announcing across-the-board price increases of $30 per short ton (where contracts allowed) effective January 1, 2009.

In February, Carmeuse North America (Pittsburgh, PA) and Oglebay Norton Co. (Cleveland, OH) finalized the agreement under which Carmeuse acquired Oglebay Norton. The new combined company was renamed Carmeuse Lime and Stone. The acquisition will allow Carmeuse to expand into the limestone reagent fgd market, and to diversify into filler materials and industrial sands.[4]

Prepared by **M. Michael Miller [(703) 648-7716, mmiller1@usgs.gov, fax: (703) 648-7757]**

LIME

In October, Mississippi Lime Company (St. Louis, MO) acquired from Alpha Natural Resources, Inc. (Abingdon, VA) its majority interest in Gallatin Materials LLC. Gallatin Materials is a new lime producer that started up its plant near Verona, KY, in early 2008. Mississippi Lime also acquired the remaining shares from minority shareholders to assume full control of the company.[5] This acquisition dovetailed nicely with Mississippi Lime's recent expansion into hydrate markets in the Midwest and Southeast. In 2008, the company built a new hydrating plant in Weirton, WV, and acquired a second hydrating plant in Chester, SC.[6, 7]

World Lime Production and Limestone Reserves and Reserve Base:

	Production		Reserves and reserve base[8]
	2007	**2008[e]**	
United States	20,200	19,800	Adequate for all countries listed.
Austria	2,000	2,000	
Belgium	2,200	2,100	
Brazil	7,000	7,000	
Canada	2,200	2,100	
China	170,000	175,000	
France	4,000	4,000	
Germany	7,120	7,000	
Iran	2,600	2,600	
Italy[9]	6,000	6,000	
Japan (quicklime only)	9,150	9,000	
Mexico	6,500	6,500	
Poland	2,000	2,000	
Russia	8,200	8,000	
South Africa (sales)	1,599	1,600	
Turkey (sales)	3,600	3,500	
United Kingdom	2,000	2,000	
Vietnam	2,120	2,100	
Other countries	24,500	23,000	
World total (rounded)	283,000	290,000	

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, cement kiln dust, fly ash, and lime kiln dust 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]Carmeuse Lime & Stone, 2008, Carmeuse closes acquisition of Oglebay-Norton: Pittsburgh, PA, Carmeuse Lime & Stone press release, February 13, 1 p.
[5]Industrial Specialties News, 2008, Mississippi Lime buys fledgling lime producer: Industrial Specialties News, v. 22, no. 20, October 20, p. 1.
[6]Mississippi Lime Company, 2008, Mississippi Lime Company commissions hydrate expansion: St. Louis, MO, Mississippi Lime Company press release, April 3, 1 p.
[7]Mississippi Lime Company, 2008, Mississippi Lime Company acquires hydrated lime plant in Chester, SC: St. Louis, MO, Mississippi Lime Company press release, April 16, 1 p.
[8]See Appendix C for definitions.
[9]Includes hydraulic lime.

LITHIUM

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

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

Although lithium markets vary by location, global end-use markets are estimated as follows: batteries, 25%; ceramics and glass, 18%; lubricating greases, 12%; pharmaceuticals and polymers, 7%; air conditioning, 6%; primary aluminum production, 4%; continuous casting, 3%; chemical processing 3%; and other uses, 22%. 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production	W	W	W	W	W
Imports for consumption	2,910	3,580	3,260	3,140	3,000
Exports	1,690	1,720	1,500	1,760	1,900
Consumption:					
Apparent	W	W	W	W	W
Estimated	1,900	2,500	2,500	2,100	1,700
Employment, mine and mill, number	57	59	61	68	68
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 (2004-07): Chile, 61%; Argentina, 36%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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.

Prepared by **Brian W. Jaskula [(703) 648-4908, bjaskula@usgs.gov, fax: (703) 648-7757]**

LITHIUM

Events, Trends, and Issues: The only active lithium carbonate plant in the United States was 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. A second brine operation was under development in Argentina. 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. Based on new information, lithium production was apparently discontinued in Russia during the early 1990s.

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 cordless tools, portable computers and telephones, and video cameras. Several major automobile companies were pursuing the development of 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 generations of these vehicles 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: Reserves and reserve base estimates for Australia have been revised based on new information.

	Mine production		Reserves[2]	Reserve base[2]
	2007	2008[e]		
United States	W	W	38,000	410,000
Argentina[e]	3,000	3,200	NA	NA
Australia[e]	6,910	6,900	170,000	220,000
Bolivia	—	—	—	5,400,000
Brazil	180	180	190,000	910,000
Canada	707	710	180,000	360,000
Chile	11,100	12,000	3,000,000	3,000,000
China	3,010	3,500	540,000	1,100,000
Portugal	570	570	NA	NA
Zimbabwe	300	300	23,000	27,000
World total (rounded)	[3]25,800	[3]27,400	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 batteries, ceramics, greases, and manufactured glass. Examples are calcium and aluminum soaps as substitutes for stearates in greases; calcium, magnesium, mercury, and zinc as anode material in primary batteries; and sodic and potassic fluxes in ceramics and glass manufacture. 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 43% of U.S. magnesium compounds production in 2008. 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 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:	2004	2005	2006	2007	2008[e]
Production	292	301	282	342	340
Imports for consumption	356	391	371	357	390
Exports	35	31	28	26	26
Consumption, apparent	613	661	624	673	704
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant, number[e]	370	370	370	370	370
Net import reliance[2] as a percentage of apparent consumption	52	54	55	49	52

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

Import Sources (2004-07): China, 78%; Canada, 6%; Austria, 5%; Australia, 3%; and other, 8%.

Tariff:[3] **Item**	**Number**	**Normal Trade Relations 12-31-08**
Crude magnesite	2519.10.0000	Free.
Dead-burned and fused magnesia	2519.90.1000	Free.
Caustic-calcined magnesia	2519.90.2000	Free.
Kieserite	2530.20.1000	Free.
Epsom salts	2530.20.2000	Free.
Magnesium hydroxide	2816.10.0000	3.1% ad val.
Magnesium chloride	2827.31.0000	1.5% ad val.
Magnesium sulfate (synthetic)	2833.21.0000	3.7% ad val.

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

Government Stockpile: None.

Prepared by **Deborah A. Kramer [(703) 648-7719, dkramer@usgs.gov, fax: (703) 648-7757]**

MAGNESIUM COMPOUNDS

Events, Trends, and Issues: Production capacity at the caustic-calcined magnesia plant in Queensland, Australia, was set to increase by 100,000 tons per year from its current capacity of 80,000 tons per year in response to growth in the world steel, nickel, cobalt, copper, and agricultural markets. Installation of a third multiple-hearth furnace was scheduled to be completed by September 2009. The company also has the capacity to produce 110,000 tons per year of dead-burned magnesia and 30,000 tons per year of fused magnesia. In Canada, the magnesite producer announced that it would double the production capacity for caustic-calcined magnesia at its Exshaw, Alberta, plant to 50,000 tons per year by adding another furnace and was considering restarting production at its 14,000-ton-per-year fused magnesia plant.

After being purchased by a private equity firm in 2007, Brazil's leading magnesite producer announced plans to triple its dead-burned magnesia production and double its refractories production. Based on first quarter 2008 production data, the company would increase dead-burned magnesia production to 360,000 tons per year, a small increase from the plant's current production capacity of 320,000 tons per year. However, the company planned to increase its refractories production capacity to 580,000 tons per year by 2009 from its current level of 335,000 tons per year. Most of the company's refractory products are used by Brazil's steel industry. The company also acquired a German refractories company in September 2008; the combination of the two refractories groups would create the world's third ranked refractories company in terms of revenue.

The leading magnesite producer in Turkey planned to start production of fused magnesia and increase production capacity for dead-burned magnesia and magnesia-base refractories by yearend. A smaller producer in Turkey planned to increase production capacity for dead-burned magnesia to 35,000 tons per year from the current level of 12,000 tons per year and begin producing fused magnesia by 2009. In February, Russia's leading magnesite producer acquired one of two magnesite producers in Slovakia and, later in 2008, announced plans to acquire the other producer.

World Mine Production, Reserves, and Reserve Base:

	Magnesite production		Magnesite reserves and reserve base[4]	
	2007	2008[e]	Reserves	Reserve base
United States	W	W	10,000	15,000
Australia	130	140	100,000	120,000
Austria	202	200	15,000	20,000
Brazil	93	100	45,000	65,000
China	1,960	2,000	380,000	860,000
Greece	144	150	30,000	30,000
India	103	105	14,000	55,000
Korea, North	346	350	450,000	750,000
Russia	346	350	650,000	730,000
Slovakia	173	170	45,000	320,000
Spain	144	150	10,000	30,000
Turkey	605	600	65,000	160,000
Other countries	145	140	390,000	440,000
World total (rounded)	[5]4,390	[5]4,460	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 2008, magnesium was produced by one company in Utah by an electrolytic process that recovered magnesium from brines from the Great Salt Lake. Magnesium used as a constituent of aluminum-based alloys that were used for packaging, transportation, and other applications was the leading use for primary magnesium, accounting for 41% of primary metal use. Structural uses of magnesium (castings and wrought products) accounted for 32% of apparent consumption. Desulfurization of iron and steel accounted for 13% of U.S. consumption of primary metal, and other uses were 14%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Primary	W	W	W	W	W
Secondary (new and old scrap)	72	73	82	84	85
Imports for consumption	99	85	76	72	82
Exports	12	10	12	15	13
Consumption:					
Reported, primary	101	82	75	72	75
Apparent[2]	140	130	120	130	140
Price, yearend:					
Metals Week, U.S. spot Western, dollars per pound, average	1.58	1.23	1.40	2.25	3.50
Metal Bulletin, European free market, dollars per metric ton, average	1,875	1,595	2,100	4,300	4,400
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	61	60	53	47	50

Recycling: In 2008, about 23,000 tons of secondary production was recovered from old scrap.

Import Sources (2004-07): Canada, 43%; Russia, 17%; Israel, 17%; China, 8%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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: From yearend of 2007 to the end of the first quarter of 2008, the average U.S. spot Western price increased by nearly $1.00 per pound. Prices in China and Europe also increased significantly. Several factors contributed to these price escalations. In the United States, a decline in imports from Russia and Canada, two of the leading import sources, caused a supply shortage on the spot market. In China, increased prices for ferrosilicon, power, and transportation were cited as causes for the rapid price increase. In addition, enforcement of environmental regulations by the Government may have led to shutdowns at some smaller plants, but the larger plants in Shanxi Province were still operating. The magnesium price range reached a high of $5,950 to $6,250 per metric ton at the end of May, but began falling rapidly after that. Consumption in China and in Europe had fallen, and consumers were working off some of their stocks rather than purchasing magnesium on the spot market at the high prices.

Softness in the North American auto industry coupled with high magnesium prices has affected several magnesium diecasting companies. Two firms with diecasting operations in Missouri filed for bankruptcy, and one firm with diecasting operations in Ohio closed in 2008.

Prepared by **Deborah A. Kramer [(703) 648-7719, dkramer@usgs.gov, fax: (703) 648-7757]**

MAGNESIUM METAL

A Malaysian firm announced that it was constructing a 15,000-ton-per-year magnesium plant in Taiping, Perak State, Malaysia, at a cost of about $54.4 million. A groundbreaking ceremony was held on February 26, and the plant was expected to be completed by the first half of 2009. A Bahrain-based firm announced that it would establish a $1 billion company to construct magnesium smelters in the Middle East and North Africa region. Bankable feasibility studies have already been completed to construct and operate a magnesium plant in the region with an initial production capacity of 30,000 to 60,000 tons per year. Preliminary discussions also were underway with international partners that have been identified to subsidize the equipment for the plant. The company eventually planned to build multiple magnesium smelters in several locations in the region. A new company, formed by former employees of the Norwegian magnesium producer, announced that it would restart production at the shuttered magnesium plant in Porsgrunn. The firm planned to produce primary and recycled magnesium, using locally produced olivine as a raw material, and to refurbish the recycling facilities by late 2008 or early 2009, the latter with a capacity of 15,000 tons per year. The primary magnesium plant was expected to take about 2 years to complete, and was projected to be completed by 2011, with a capacity of 35,000 t/yr, slightly less than the capacity at the plant when it closed.

In China, companies continued to implement expansion plans for magnesium metal and alloy production. More than 50 projects were announced to add magnesium metal, alloy, and/or diecasting capacities in China. Some were upgrades of existing capacity that had been shut down, but most were new projects that could increase production capacity significantly. Additional proposed primary production capacity totaled more than 3 million metric tons, although many of these plants most likely will not be constructed.

In June, the remaining Canadian magnesium producer announced that it would close its manufacturing facility in Haley, Ontario. The Haley facility supplied the cast magnesium billet used in the company's magnesium extrusion operations in Aurora, CO. All of these supplies will be provided by outsource partners. The Haley plant also produced specialty magnesium granules and turnings, which will be produced at the firm's facility in Nuevo Laredo, Mexico.

In September, the U.S. Environmental Protection Agency (EPA) announced that it planned to include the Rowley, UT, magnesium plant on its Superfund list. According to EPA, hazards at the site included heavy metals, acidic wastewater, polychlorinated biphenyls, dioxins and furans, hexachlorobenzene, and polycyclic aromatic hydrocarbons. The public had until November 3 to provide comments on the inclusion of the site on the Superfund list.

World Primary Production, Reserves, and Reserve Base:

	Primary production	
	2007	2008[e]
United States	W	W
Brazil	18	18
Canada	16	—
China	627	700
Israel	25	30
Kazakhstan	21	20
Russia	37	35
Serbia	2	2
Ukraine	3	3
World total[5] (rounded)	749	808

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. — Zero.
[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 2008. 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, in plant fertilizers and animal feed, and as a brick colorant. Manganese ferroalloys were produced at two smelters, although one operated sporadically throughout the year. Construction, machinery, and transportation end uses accounted for about 29%, 10%, and 10%, 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 $3 billion.

Salient Statistics—United States:[1]	2004	2005	2006	2007	2008[e]
Production, mine[2]	—	—	—	—	—
Imports for consumption:					
Manganese ore	451	656	572	602	564
Ferromanganese	429	255	358	315	481
Silicomanganese[3]	422	327	400	414	369
Exports:					
Manganese ore	123	13	2	29	42
Ferromanganese	9	14	22	29	25
Shipments from Government stockpile excesses:[4]					
Manganese ore	172	34	73	101	147
Ferromanganese	37	36	56	68	115
Consumption, reported:[5]					
Manganese ore[6]	441	368	365	300	298
Ferromanganese	315	286	297	272	292
Consumption, apparent, manganese[7]	1,030	773	1,050	1,030	1,000
Price, average, 46% to 48% Mn metallurgical ore, dollars per metric ton unit, contained Mn:					
Cost, insurance, and freight (c.i.f.), U.S. ports[e]	2.89	4.39	3.51	3.48	12.97
CNF[8] China, Ryan's Notes	NA	3.21	2.33	6.05	[9]15.92
Stocks, producer and consumer, yearend:					
Manganese ore[6]	159	337	159	100	100
Ferromanganese	16	30	31	20	25
Net import reliance[10] 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 (2004-07): Manganese ore: Gabon, 61%; South Africa, 18%; Australia, 8%; China, 3%; and other, 10%. Ferromanganese: South Africa, 53%; China, 18%; Republic of Korea, 6%; Mexico, 6%, and other, 17%. Manganese contained in all manganese imports: South Africa, 34%; Gabon, 21%; China, 9%; Australia, 7%; and other, 29%.

Tariff:

Item	Number	Normal Trade Relations 12-31-08
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: 22% (Domestic), 14% (Foreign).

Government Stockpile: The uncommitted inventory of metallurgical ore was no longer differentiated between stockpile and nonstockpile grades.

Prepared by **Lisa A. Corathers [(703) 648-4973, lcorathers@usgs.gov, fax: (703) 648-7757]**

MANGANESE

Stockpile Status—9-30-08[11]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Manganese ore:				
Battery grade	—	—	18	16
Chemical grade	—	—	—	—
Metallurgical grade	3	3	227	—
Ferromanganese, high-carbon	436	436	91	37
Synthetic dioxide	—	—	3	1

Events, Trends, and Issues: Apparent consumption in 2008 was slightly lower than that of 2007 owing to moderate demand by the domestic steel industry, as reflected in lower manganese imports (content basis) and a reduction in producer and consumer stock releases. Through September 2008, domestic steel production was 4% higher than that of the same period in 2007. By the end of October 2008, the U.S. weekly average spot price for high-carbon ferromanganese was double that at the start of the year, and medium-carbon ferromanganese and silicomanganese weekly average spot prices were more than 30% higher over the same period. The annual average domestic manganese ore contract price followed the 314% to 413% increase in the international price for metallurgical-grade ore set between Japanese consumers and major suppliers in February 2008. The average weekly spot market price for 48% manganese ore, CNF China, had increased by 35% to $15.92 per metric ton unit through October 2008, owing to increased global demand for manganese ore, particularly in China and India. However, U.S. spot market prices for manganese ferroalloys and Chinese spot market prices for 48% manganese ore declined in October because of decreasing demand caused by global financial problems that began during the third quarter of 2008.

World Mine Production, Reserves, and Reserve Base (metal content): Reserve and reserve base estimates have been revised from those previously published for Gabon (reserves, upward; reserve base, downward), Mexico (reserve base, downward), and South Africa (reserves, downward), as reported by the major manganese producers in Gabon, Mexico, and South Africa. Reserves are based on estimates of demonstrated resources.

	Mine production		Reserves[12]	Reserve base[12]
	2007	2008[e]		
United States	—	—	—	—
Australia	2,540	2,200	68,000	160,000
Brazil	933	1,300	35,000	57,000
China	[e]2,000	2,800	40,000	100,000
Gabon	1,490	1,600	52,000	[13]90,000
India	[e]900	940	56,000	[13]150,000
Mexico	125	130	4,000	8,000
South Africa	2,600	3,000	95,000	[13]4,000,000
Ukraine	[e]580	480	140,000	520,000
Other countries	1,420	1,400	Small	Small
World total (rounded)	[e]12,600	14,000	500,000	5,200,000

World Resources: Land-based manganese 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 manganese resources, and Ukraine accounts for 10%.

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 estimated average content for all components except imports, for which content is reported.
[8]Cost and freight (CNF) represents the costs paid by a seller to ship manganese ore by sea to a Chinese port; excludes insurance.
[9]Average weekly price through October 2008.
[10]Defined as imports – exports + adjustments for Government and industry stock changes.
[11]See Appendix B for definitions.
[12]See Appendix C for definitions.
[13]Includes inferred resources.

MERCURY

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

Domestic Production and Use: Mercury has not been produced as a primary mineral commodity in the United States since 1992, when the McDermitt Mine, Humboldt County, NV, closed; however, mercury was produced as a byproduct from several gold-silver mines in Nevada. Byproduct mercury production data were not reported. Secondary mercury was also recovered by retorting end-of-use mercury-containing products, such as batteries, compact and traditional fluorescent lamps, dental amalgam, medical devices, and thermostats, as well as mercury contaminated soils. Secondary mercury production data were not reported. The domestic chlorine-caustic soda industry was the leading end user of mercury. Some of the mercury used at these facilities was recycled in-plant; however, approximately 100 tons of replacement mercury is purchased yearly. Some mercury-containing chlor-alkali waste, as “amalgam” (not chemically defined), was exported to Canada and landfilled. Mercury use has declined in the United States because of mercury toxicity and concerns for human health. Mercury has been released to the environment from mercury-containing car switches when the automobile is scrapped for recycling, coal-fired power plants, and from incinerated mercury-containing medical devices. Mercury is no longer used in batteries and paints manufactured in the United States. Mercury was imported, refined, and then exported for global use in chlorine-caustic soda production, dental amalgam, fluorescent lights, and small-scale gold mining. Some button-type batteries, cleansers, fireworks, folk medicines, grandfather clocks, pesticides, and skin-lightening creams and soaps may contain mercury.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Mine (byproduct)	NA	NA	NA	NA	NA
Secondary	NA	NA	NA	NA	NA
Imports for consumption (gross weight), metal[2]	92	212	94	67	150
Exports (gross weight), metal	278	319	390	84	900
Price, average value, dollars per flask, free market[3]	365.00	555.00	670.00	530.00	600.00
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: In 2008, six companies in the United States accounted for the majority of secondary mercury reclamation and production. More than 50 smaller companies collected barometers, computers, dental amalgam, gym flooring, medical devices, thermostats, and some mercury-containing toys and shipped them on to larger companies for retorting. The reservoir of mercury-containing products for recycling is shrinking because of increased use of nonmercury materials and devices that substitute for mercury.

Import Sources (2004-07): Peru, 39%; Chile, 20%; Germany, 13%; Russia, 11%; and other, 17%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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 1,329 tons of mercury was held by the U.S. Department of Energy, Oak Ridge, TN.

Stockpile Status—9-30-08[5]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Mercury	4,436	4,436	—	—

Events, Trends, and Issues: The United States is a leading exporter of mercury. In 2008, the principal export destinations of U.S. mercury were the Netherlands, Vietnam, and India. According to trade journals, the average cost of a flask of domestic mercury was $550 to $650 in 2008. Global consumption for mercury was estimated to be approximately 2,000 tons per year and approximately 50% of this consumption comes from the use of mercury compounds used to make vinyl monomer in China and Eastern Europe. Mercury is also widely used for small-scale

Prepared by **William E. Brooks [(703) 648-7791, wbrooks@usgs.gov, fax: (703) 648-7757]**

MERCURY

gold mining in many parts of the world, and the rising price of gold, to as high as $1,000 per troy ounce in 2008, has also influenced the global demand for mercury. Diminishing supplies of mercury that can be recycled from end-of-use, mercury-containing products, and availability of mercury from China, Kyrgyzstan, and Spain, also affect the mercury price. Nonmercury technology for the production of chlorine and caustic soda and the ultimate closure of the world's mercury-cell chlor-alkali plants will put tons of mercury on the global market for recycling, sale, or storage. The U.S. Department of State, the U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), and other Government agencies participated in interagency meetings to address management of commodity-grade mercury. The EPA provided estimates of costs for permanent mercury storage. The Energy Independence and Security Act of 2007 was signed by the President and will phase out general service incandescent bulbs in favor of mercury-containing compact fluorescent bulbs in Federal buildings. The Mercury Market Minimization Act of 2008, a bill to prohibit the sale, distribution, and export of elemental mercury (S. 906), was signed by the President. All exports of the substance will be banned as of January 1, 2013. The USGS completed an inventory of mercury use in Peru, an important source of imported mercury and user of mercury for small-scale gold mining. Governmental regulations and environmental standards are likely to continue as major factors in domestic mercury recycling, supply, and demand. Byproduct mercury production is expected to continue from gold-silver mining and processing, as is secondary production of mercury from a diminishing supply of mercury-containing products. Mercury may also be recovered and recycled from compact and traditional fluorescent lamps. Domestic mercury consumption will continue to decline as nonmercury-containing products, such as digital thermometers, are substituted.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	2007	2008[e]		
United States	NA	NA	—	7,000
Algeria	—	—	—	3,000
China	800	600	NA	NA
Italy	—	—	—	69,000
Kyrgyzstan	250	250	7,500	13,000
Spain	—	—	—	90,000
Other countries	120	100	38,000	61,000
World total (rounded)	1,170	950	46,000	240,000

World Resources: 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 production is from stockpiled material. In the United States, there are mercury occurrences in Alaska, Arkansas, California, Nevada, and Texas; however, mercury has not been mined as a primary metal commodity since 1992. The declining consumption of mercury, except for small-scale gold mining, indicates that these resources are sufficient for another century or more of use.

Substitutes: For aesthetic or human health concerns, natural-appearing ceramic composites substitute for the dark-gray mercury-containing dental amalgam. "Galistan," an alloy of gallium, indium, and tin, or alternatively, digital thermometers, now replaces the mercury used in thermometers. Mercury-cell technology is being replaced by newer diaphragm and membrane cell technology at chlor-alkali plants. Light-emitting diodes that contain indium substitute for mercury-containing fluorescent lamps. 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]Import totals decreased compared with those in Mineral Commodity Summaries 2008 because previously calomel, a mercury chloride and a potential source of mercury, reportedly was imported from Chile; however, a review of Chilean customs data indicated that the material was cuprous chloride and not mercury chloride.

[3]Platts Metals Week average mercury price quotation for the year. Actual prices may vary significantly from quoted prices.

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

[5]See Appendix B for definitions.

[6]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 98,700 tons in 2008. North Carolina accounted for about 37% 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 2008 scrap mica production was estimated to be $14 million. Ground mica sales in 2007 were valued at about $50 million and were expected to increase in value in 2008. There were 10 domestic producers of scrap and flake mica.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:[2, 3]					
Mine	99	78	110	97	99
Ground	98	120	123	85	104
Imports, mica powder and mica waste	42	36	45	41	29
Exports, mica powder and mica waste	10	9	7	8	9
Consumption, apparent[4]	132	105	148	130	118
Price, average, dollars per metric ton, reported:					
Scrap and flake	155	248	204	149	213
Ground:					
Wet	NA	776	784	794	790
Dry	269	226	237	246	240
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine, number	NA	NA	NA	NA	NA
Net import reliance[5] as a percentage of apparent consumption	25	26	26	26	16

Recycling: None.

Import Sources (2004-07): Canada, 34%; China, 31%; India, 26%; Finland, 5%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
Mica powder	2525.20.0000	Free.
Mica waste	2525.30.0000	Free.

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

Government Stockpile: None.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7757]**

MICA (NATURAL), SCRAP AND FLAKE

Events, Trends, and Issues: Domestic production of ground mica increased in 2008, based on data through August. The increase primarily resulted from the restart of mica production in Alabama and stable mine production in the other producing States. Canada remained the main source of imported phlogopite mica for the United States. Canada and China were the leading sources of imported mica powder, and India and Canada were the principal sources of mica waste. India, China, and Finland were the major sources of imported crude and rifted mica valued at under $1.00 per kilogram. Finland, Russia, and the United States were major world producers of scrap and flake mica in 2008. 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[6]	Reserve base[6]
	2007	2008[e]		
United States[2]	97	99	Large	Large
Brazil	4	4	Large	Large
Canada	18	18	Large	Large
Finland	68	70	Large	Large
France	20	20	Large	Large
India	4	4	Large	Large
Korea, Republic of	37	37	Large	Large
Norway	3	3	Large	Large
Russia	100	100	Large	Large
Other countries	32	30	Large	Large
World total (rounded)	380	390	Large	Large

World Resources: Resources of scrap and flake mica are available in clay deposits, granite, pegmatite, and schist, 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 scrap and flake mica production.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]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 2008 at a gemstone-bearing pegmatite in Amelia, Virginia. The domestic consuming industry was dependent upon imports and shipments of U.S. Government stockpile excesses to meet demand for sheet mica. During 2008, an estimated 397 tons of imported, unworked mica split block and mica splittings valued at $357,000 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 1,680 tons of imported worked mica valued at $17.9 million also was consumed.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, mine[e]	([2])	([2])	([2])	([2])	([2])
Imports, plates, sheets, strips; worked mica; split block; splittings; other >$1.00/kg	1,400	1,390	1,770	1,950	2,070
Exports, plates, sheets, strips; worked mica; crude and rifted into sheet or splittings >$1.00/kg	1,090	1,430	1,400	1,300	2,070
Shipments from Government stockpile excesses	18	38	6	7	([2])
Consumption, apparent	328	[3]3	[3]380	[3]683	3
Price, average value, dollars per kilogram, muscovite and phlogopite mica, reported:					
Block	67	125	130	135	132
Splittings	1.73	1.56	1.53	1.60	1.53
Stocks, fabricator and trader, yearend	NA	NA	NA	NA	NA
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	86

Recycling: None.

Import Sources (2004-07): China, 21%; India, 20%; Belgium, 20%; Brazil, 18%; and other, 21%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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—9-30-08[5]

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2008**	**Disposals FY 2008**
Block:				
Muscovite (stained and better)	—	([6])	([6])	0.315
Splittings:				
Muscovite	—	([6])	([6])	—

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7757]**

MICA (NATURAL), SHEET

Events, Trends, and Issues: Demand for sheet mica in 2008 decreased; however, imports increased for the third year in a row, following a 10% increase in imports in 2007. Changes in imports in different categories were mixed in 2008 compared with those of 2007. Imports of worked sheet decreased 9% for "plates, sheets, and strips of agglomerated or reconstituted mica," and "mica, worked, and articles of mica not classified elsewhere." U.S. imports of unworked sheet mica (based on data through August) increased 250%, primarily the result of large increases in the categories "mica, worked, and articles of mica not classified elsewhere" and "split block mica." Imports of "mica splittings" declined.

Shipments from the National Defense Stockpile (NDS) declined in 2008 to 315 kilograms, and all remaining uncommitted stocks of mica (239 kilograms of muscovite block) were sold on April 29, 2008. Stocks of muscovite film in the NDS were depleted by the end of fiscal year (FY) 2004. Stocks of phlogopite splittings were sold out in FY 2005. The remaining stocks of muscovite splittings were sold out in FY 2007. The remaining stocks of mica in the NDS (muscovite block) were sold and shipped in FY 2008.

Imports were the principal source of the domestic supply of sheet mica in 2008. 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 a small apparent consumption in 2005 and possibly resulting in understating apparent consumption in 2006 and 2007. Future supplies were expected to come increasingly from imports, primarily from China, India, and Russia. Prices for imported sheet mica also were expected to increase, and 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]
	2007	2008		
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®, Nomex®, Noryl®, nylon, nylatron, phenolics, Plexiglass®, polycarbonate, polyester, styrene, Teflon®, vinyl-PVC, and vulcanized fiber. Mica paper made from scrap mica can be substituted for sheet mica in electrical and insulation applications.

[e]Estimated. NA Not available. — 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 disposal plan for all categories of mica in the National Defense Stockpile is all remaining stocks. No stocks of mica remained in the NDS at the end of fiscal year 2008.
[7]See Appendix C for definitions.

MOLYBDENUM

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

Domestic Production and Use: In 2008, molybdenum, valued at about $4.5 billion (based on average oxide price), was produced by 12 mines. Molybdenum ore was produced as a primary product at four mines—one each in Colorado, Idaho, Nevada, and New Mexico—whereas eight copper mines (four 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 83% of the molybdenum consumed.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, mine	41,500	58,000	59,800	57,000	61,400
Imports for consumption	17,300	20,700	16,700	18,300	13,300
Exports	34,500	42,100	34,500	33,700	32,300
Consumption:					
Reported	17,400	18,900	19,000	20,500	22,900
Apparent	24,100	34,700	44,300	41,000	43,500
Price, average value, dollars per kilogram[1]	36.73	70.11	54.62	66.79	73.30
Stocks, mine and plant concentrates, product, and consumer materials	7,500	9,400	7,000	7,600	6,500
Employment, mine and plant, number	630	880	910	940	940
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 (2004-07): Ferromolybdenum: China, 71%; Chile 15%; Canada, 7%; United Kingdom, 4%; and other, 3%. Molybdenum ores and concentrates: Chile, 39%; Mexico, 25%; Canada, 24%; Peru, 10%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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.

Prepared by **Michael J. Magyar [(703) 648-4964, mmagyar@usgs.gov, fax: (703) 648-7757]**

MOLYBDENUM

Events, Trends, and Issues: U.S. mine output of molybdenum in concentrate in 2008 increased about 8% from that of 2007. U.S. imports for consumption decreased an estimated 27% from those of 2007, while the U.S. exports decreased about 4% from those of 2007. Domestic roasters operated at full production levels in 2007 and 2008. U.S. reported consumption increased almost 12% from that of 2007 while apparent consumption increased about 6%, owing to increased destocking offsetting reduced imports. Mine capacity utilization in 2008 was about 83%.

China's high level of steel production and consumption continued to generate strong internal consumption of molybdenum. This consumption, coupled with reduced Chinese exports in 2007 and 2008 owing to export quotas and duties imposed in July 2007, continued to support historically high molybdenum prices. Most byproduct and primary molybdenum mines in the United States maintained high production levels in 2008. Production capacity at the Henderson Mine, Empire, CO, was expanded to about 18,100 tons per year of contained molybdenum in 2006, and mine production approached that level in 2007 and 2008. The Ashdown Mine, near Denio, NV, started molybdenum operations in 2007, and the byproduct molybdenum circuits at the Morenci Mine in Greenlee County, AZ, and the Mission Mine in Pima County, AZ, also restarted in 2007.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2007	2008[e]	(thousand metric tons)	
United States	57,000	61,400	2,700	5,400
Armenia	4,080	4,100	200	400
Canada	12,000	12,000	450	910
Chile	44,912	45,000	1,100	2,500
China	59,800	59,800	3,300	8,300
Iran	2,600	2,600	50	140
Kazakhstan	400	400	130	200
Kyrgyzstan	250	250	100	180
Mexico	2,500	4,000	135	230
Mongolia	1,300	1,300	30	50
Peru	16,737	17,000	140	230
Russia[e]	3,300	3,500	240	360
Uzbekistan[e]	600	600	60	150
World total (rounded)	205,000	212,000	8,600	19,000

World Resources: Identified resources amount to about 5.4 million tons of molybdenum in the United States and about 14 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, niobium (columbium), 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 2008. Limited amounts of byproduct nickel were recovered from copper and palladium-platinum ores mined in the Western United States. On a monthly or annual basis, 110 facilities reported nickel consumption. The principal consuming State was Pennsylvania, followed by Kentucky, West Virginia, and North Carolina. Approximately 52% of the primary nickel consumed went into stainless and alloy steel production, 34% into nonferrous alloys and superalloys, 10% into electroplating, and 4% into other uses. End uses were as follows: transportation, 30%; chemical industry, 15%; electrical equipment, 10%; construction, 9%; fabricated metal products, 8%; household appliances, 8%; petroleum industry, 7%; machinery, 6%; and other, 7%. The estimated value of apparent primary consumption was $2.70 billion.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, refinery byproduct	W	W	W	W	W
Shipments of purchased scrap[1]	133,000	141,000	147,000	180,000	165,000
Imports: Primary	136,000	143,000	153,000	125,000	141,000
Imports: Secondary	18,800	15,500	20,300	16,200	22,200
Exports: Primary	8,000	7,630	8,050	13,100	14,000
Exports: Secondary	48,300	55,600	59,300	103,000	110,000
Consumption: Reported, primary	102,000	100,000	124,000	98,400	85,000
Consumption: Reported, secondary	103,000	101,000	108,000	93,600	77,300
Consumption: Apparent, primary	128,000	135,000	144,000	111,000	127,000
Consumption: Total[2]	232,000	237,000	252,000	205,000	204,000
Price, average annual, London Metal Exchange:					
Cash, dollars per metric ton	13,823	14,738	24,244	37,216	21,360
Cash, dollars per pound	6.270	6.685	10.997	16.881	9.689
Stocks: Consumer, yearend	11,900	13,500	14,100	14,100	14,300
Stocks: Producer, yearend[3]	6,580	5,940	6,450	6,600	6,700
Net import reliance[4] as a percentage of apparent consumption	49	48	49	21	33

Recycling: About 77,300 tons of nickel was recovered from purchased scrap in 2008. This represented about 38% of reported secondary plus apparent primary consumption for the year.

Import Sources (2004-07): Canada, 43%; Russia, 15%; Norway, 10%; Australia, 8%; and other, 24%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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 8,800 tons of nickel ingot contaminated by low-level radioactivity plus 5,100 tons of contaminated shredded nickel scrap. Planned decommissioning activities at former nuclear defense sites are expected to generate an additional 20,000 tons of nickel in shredded scrap.

Events, Trends, and Issues: Although slightly lower than that of 2007, world nickel mine production was at a relatively high level in 2008 despite the global financial crisis. Stainless steel accounted for two-thirds of primary nickel use, with more than one-half of the steel going into the construction, food processing, and transportation sectors. U.S. production of austenitic (nickel-bearing) stainless steel slipped to 1.35 million tons in 2007, 21% less than the record-high 1.71 million tons in 2006. China was the leading consumer of nickel, with an estimated apparent consumption of 348,000 tons in 2007. China produced 5.52 million tons of austenitic stainless steel in 2007, exceeding the combined output of Japan and the United States. Nickel prices peaked at unprecedented levels in mid-2007, but gradually declined during the next 18 months as the world economy weakened. In October 2008, the London Metal Exchange cash mean for 99.8%-pure nickel averaged $12,133 per metric ton ($5.50 per pound), down 61% from the mean in October 2007.

Prepared by **Peter H. Kuck [(703) 648-4965, pkuck@usgs.gov, fax: (703) 648-7757]**

NICKEL

Declining metal prices, fears of recession, and the tightening of credit forced nickel producers to halt mining at less profitable operations and delay early stage development projects. Three world-class laterite mining complexes were in the final stages of commissioning. In early 2008, Australia's leading nickel producer began ramping up production at its new $2.2 billion Ravensthorpe Mine, which is northwest of Esperance. Nickel and cobalt were being leached from the ore and converted onsite to a mixed hydroxide intermediate, which was then shipped to Yabulu, Queensland, for refining. The $3.2 billion laterite mining complex at Goro, New Caledonia, was scheduled to begin production of mixed hydroxide in early 2009. The New Caledonian nickel was being recovered onsite as an oxide using advanced pressure-acid-leach technology. Work was also underway on two traditional ferronickel plants in the Brazilian States of Goias and Para. The Onca Puma mining complex in Para State was scheduled to begin production of ferronickel in January 2009. The credit crisis put severe financial pressures on motor vehicle manufacturers, causing them to reassess the post-2010 marketplace. Nickel-metal hydride (NiMH) batteries continue to be widely used in hybrid motor vehicles, despite inroads made by lithium-ion batteries. Sales in the United States of hybrid electric passenger vehicles have risen steadily to 350,000 in 2007 from 9,370 in 2000. Several automobile manufacturers were readying prototype plug-in hybrids or fully electric vehicles for commercial production. High prices for jet fuel encouraged major air carriers to order more fuel-efficient aircraft, increasing the demand for superalloys. The nuclear power industry was in the early stages of a renaissance because of high prices for natural gas. U.S. utilities were considering constructing 15 to 33 additional nuclear powerplants—facilities that would require sizeable amounts of austenitic stainless steel and other nickel-bearing alloys. Construction of new wind farms could require significant numbers of nickel-based batteries for energy storage and load leveling.

World Mine Production, Reserves, and Reserve Base: Estimates of the reserves and reserve base for Australia and Colombia, and for Spain (included in "Other countries"), were revised based on new mining industry information.

	Mine production		Reserves[5]	Reserve base[5]
	2007	2008[e]		
United States	—	—	—	150,000
Australia	161,000	180,000	26,000,000	29,000,000
Botswana	38,000	36,000	490,000	920,000
Brazil	75,300	75,600	4,500,000	8,300,000
Canada	255,000	250,000	4,900,000	15,000,000
China	85,000	85,000	1,100,000	7,600,000
Colombia	101,000	74,900	1,400,000	2,700,000
Cuba	75,000	77,000	5,600,000	23,000,000
Dominican Republic	47,100	47,000	720,000	1,000,000
Greece	21,200	20,100	490,000	900,000
Indonesia	229,000	211,000	3,200,000	13,000,000
New Caledonia[6]	125,000	92,600	7,100,000	15,000,000
Philippines	79,500	88,400	940,000	5,200,000
Russia	280,000	276,000	6,600,000	9,200,000
South Africa	37,900	38,000	3,700,000	12,000,000
Venezuela	20,000	20,000	560,000	630,000
Zimbabwe	7,120	6,530	15,000	260,000
Other countries	27,700	28,600	2,200,000	6,100,000
World total (rounded)	1,660,000	1,610,000	70,000,000	150,000,000

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% is 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: To offset high nickel prices, engineers have begun substituting low-nickel, duplex, or ultrahigh-chromium stainless steels for austenitic grades in a few construction applications. Nickel-free specialty steels are sometimes used in place of stainless steel within the power generating and petrochemical industries. Titanium alloys or specialty plastics can substitute for nickel metal or nickel-based alloys in highly corrosive chemical environments. 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]Scrap receipts – shipments by consumers + exports – imports + adjustments for consumer stock changes.
[2]Apparent primary consumption + reported secondary consumption.
[3]Stocks of producers, agents, and dealers held only in the United States.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for definitions.
[6]Overseas territory of France.

NIOBIUM (COLUMBIUM)

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

Domestic Production and Use: Significant U.S. niobium mine production has not been reported since 1959. Domestic niobium resources are of low grade, some are mineralogically complex, and most are not commercially recoverable. Companies in the United States produced ferroniobium and niobium compounds, metal, and other alloys from imported niobium minerals, oxides, and ferroniobium. Niobium was consumed mostly in the form of ferroniobium by the steel industry and as niobium alloys and metal by the aerospace industry. Major end-use distribution of reported niobium consumption was as follows: steels, 78%; and superalloys, 22%. In 2007, the estimated value of niobium consumption was $229 million and was expected to be about $370 million in 2008, as measured by the value of imports.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Mine	—	—	—	—	—
Recycling	NA	NA	NA	NA	NA
Imports for consumption[e, 1]	6,910	7,610	10,500	10,120	10,500
Exports[e, 1]	276	337	561	1,100	600
Government stockpile releases[e, 2]	90	152	156	—	10
Consumption:[e]					
Apparent	6,730	7,430	10,100	9,020	9,910
Reported[3]	4,220	4, 600	5,050	6,510	6,500
Price, ferroniobium, dollars per pound[4]	6.57	6.58	NA	NA	NA
Unit value, ferroniobium, dollars per metric ton[5]	13,355	13,197	14,022	21,918	14,000
Net import reliance[6] as a percentage of apparent consumption	100	100	100	100	100

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

Import Sources (2004-07): Niobium contained in niobium and tantalum ore and concentrate; ferroniobium; and niobium metal and oxide: Brazil, 82%; Canada, 9%; Estonia, 2%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Synthetic tantalum-niobium concentrates	2615.90.3000	Free.
Niobium ores and concentrates	2615.90.6030	Free.
Niobium oxide	2825.90.1500	3.7% ad val.
Ferroniobium:		
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.
Niobium, unwrought:		
Waste and scrap[7]	8112.92.0600	Free.
Alloys, metal, powders	8112.92.4000	4.9% ad val.
Niobium, other[7]	8112.99.9000	4.0% ad val.

Depletion Allowance:[8] 22% (Domestic), 14% (Foreign).

Government Stockpile: For fiscal year (FY) 2008 (October 1, 2007, through September 30, 2008), the Defense National Stockpile Center (DNSC), Defense Logistics Agency, disposed of no niobium materials. The DNSC's niobium mineral concentrate inventory was exhausted in FY 2007; niobium carbide powder, in FY 2002; and ferroniobium, in FY 2001. The DNSC announced maximum disposal limits for FY 2009 of about 9 tons[9] of niobium metal ingots.

Stockpile Status—9-30-08[8]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Niobium metal	10.1	10.1	[9]9	—

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

NIOBIUM (COLUMBIUM)

Events, Trends, and Issues: Niobium was imported principally in the form of ferroniobium and niobium unwrought metal, alloy, and powder. Niobium import dependence was expected to be the same as it was in 2007 when Brazil was the leading supplier of niobium. By weight, Brazil supplied 87% of niobium comprising 91% of ferroniobium, 87% of niobium metal, and 63% of niobium oxide. The leading suppliers of niobium in ore and concentrate were Australia (73%) and Canada (22%). Niobium apparent consumption is believed to have increased in 2008 compared with that of 2007. Capital market problems and the subsequent economic slowdown were expected to result in reduced niobium material consumption, price, and production.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[10]	Reserve base[10]
	2007	2008[e]		
United States	—	—	—	NA
Australia	NA	NA	21,000	320,000
Brazil	57,300	57,000	2,600,000	2,600,000
Canada	3,020	3,000	62,000	92,000
Other countries	119	150	NA	NA
World total (rounded)	60,400	60,000	2,700,000	3,000,000

World Resources: World resources are more than adequate to supply projected needs. Most of the world's identified resources of niobium occur mainly as pyrochlore in carbonatite [igneous rocks that contain more than 50% by volume carbonate (CO_3) minerals] deposits and are outside the United States. The United States has approximately 150,000 tons of niobium resources in identified deposits, all of which were considered uneconomic at 2008 prices for niobium.

Substitutes: The following materials can be substituted for niobium, 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]Imports and exports include the estimated niobium content of niobium and tantalum ores and concentrates, niobium oxide, ferroniobium, niobium unwrought alloys, metal, and powder.
[2]Government stockpile releases are the uncommitted inventory change as reported by the Defense National Stockpile Center.
[3]Includes ferroniobium and nickel niobium.
[4]Price is time-weighted (by week) average of trade journal reported ferroniobium price per pound of contained niobium, standard (steelmaking) grade. Ferroniobium price was discontinued in 2005; columbite price was discontinued in 2000; and pyrochlore price was discontinued in 1993.
[5]Unit value is mass-weighted average U.S. import value of ferroniobium assuming 65% niobium content. To convert dollars per metric ton to dollars per pound, divide by 2,205.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]This category includes other than niobium-containing material.
[8]See Appendix B for definitions.
[9]Actual quantity limited to remaining sales authority; additional legislative authority is required.
[10]See Appendix C for definitions.

NITROGEN (FIXED)—AMMONIA

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

Domestic Production and Use: Ammonia was produced by 13 companies at 22 plants in 16 States in the United States during 2008; 5 additional plants were idle for the entire year. Sixty 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 2008, 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 89% of apparent domestic ammonia consumption was for fertilizer use, including anhydrous ammonia for direct application, urea, ammonium nitrates, ammonium phosphates, and other nitrogen compounds. Ammonia also was used to produce plastics, synthetic fibers and resins, explosives, and numerous other chemical compounds.

Salient Statistics—United States:[1]	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production[2]	8,990	8,340	8,190	8,840	8,240
Imports for consumption	5,900	6,520	5,920	6,530	7,720
Exports	381	525	194	145	166
Consumption, apparent	14,400	14,400	14,000	15,200	15,800
Stocks, producer, yearend	298	254	170	155	188
Price, dollars per ton, average, f.o.b. Gulf Coast[3]	274	304	302	309	500
Employment, plant, number[e]	1,300	1,150	1,150	1,050	1,100
Net import reliance[4] as a percentage of apparent consumption	38	42	41	42	48

Recycling: None.

Import Sources (2004-07): Trinidad and Tobago, 56%; Canada, 15%; Russia, 12%; Ukraine, 10%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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: The Henry Hub spot natural gas price ranged between $7 and $13 per million British thermal units for most of the year. The natural gas prices started to decrease in July as a result of mild temperatures, increase in natural gas production, and lower crude oil prices. The average Gulf Coast ammonia price continued to increase from $438 per short ton at the beginning of 2008 to a high of around $880 per short ton in September. The average ammonia price for the year likely will be above $500 per short ton. The U.S. Department of Energy, Energy Information Administration, projected that Henry Hub natural gas spot prices would average $8.74 per million British thermal units in 2009.

Increased demand for fertilizers in the United States allowed Terra Industries Inc. of Sioux City, IA, to restart annual production of 363,000 tons of ammonia in a $10 million expansion at its Donaldsonville, LA, plant. Terra will make ammonia fertilizer at this plant for the first time since late 2004.[5]

Rising natural gas prices in developed countries are causing a shift of gas-based industries, such as nitrogen production, to developing countries. Several companies have announced plans to build new ammonia plants in Algeria, China, Libya, and Peru, which would add 5.6 million tons of annual capacity within the next 2 to 3 years. A series of coal gasification projects in China were brought online, including three plants with ammonia capacities of 500,000 tons per year.

Prepared by **Lori E. Apodaca [(703) 648-7724, lapodaca@usgs.gov, fax: (703) 648-7757]**

NITROGEN (FIXED)—AMMONIA

According to the U.S. Department of Agriculture, U.S. corn growers planted 35.2 million hectares of corn in the 2008 crop year (July 1, 2007, through June 30, 2008), which was a 7% decrease from hectares planted in 2007. The decrease in plantings was principally in response to favorable prices for other crops, high input costs for corn, and crop rotation considerations that motivated some farmers to plant fewer acres of corn. Corn plantings for the 2009 crop year, however, were expected to increase to 36.8 million hectares. Corn acreage is expected to remain at historically high levels owing to the continued expansion of U.S. ethanol production.

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 occurs in the Gulf of Mexico during the summer. Scientists continue to study the effects of fertilization on the Nation's environmental health.

World Ammonia Production, Reserves, and Reserve Base:

	Plant production		Reserves and reserve base[6]
	2007	2008[e]	
United States	8,840	8,240	Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries.
Bangladesh	1,300	1,300	
Canada	4,100	4,100	
China	42,480	44,600	
Egypt	1,750	1,900	
Germany	2,746	2,800	
India	11,000	11,000	
Indonesia	4,400	4,400	
Iran	2,000	2,000	
Japan	1,090	1,360	
Netherlands	1,800	1,800	
Pakistan	2,250	2,250	
Poland	1,900	1,900	
Qatar	1,800	1,800	
Romania	1,300	1,300	
Russia	10,500	11,000	
Saudi Arabia	2,600	2,500	
Trinidad and Tobago	5,100	5,100	
Ukraine	4,200	4,200	
Other countries	20,300	22,000	
World total (rounded)	131,000	136,000	

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]Green Markets, 2008, Terra Donaldsonville plant in startup mode: Green Markets, v. 32, no. 31, August 4, p. 10-11.
[6]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 $17.0 million in 2008. Peat was harvested and processed by about 38 companies in 14 of the conterminous States. The Alaska Department of Commerce, Office of Minerals Development, which conducted its own canvass of producers, reported 51,000 cubic meters of peat was produced in 2007; output was reported only by volume.[2] A production estimate was unavailable for Alaska for 2008. Florida, New York, Minnesota, and Michigan were the leading producing States, in order of quantity harvested. Reed-sedge peat accounted for approximately 82% of the total volume produced, followed by sphagnum moss, 8%, humus, 7%, and hypnum moss, 3%. More than 94% of domestic peat was sold for horticultural use, including general soil improvement, golf course construction, nurseries, and potting soils. Other applications included earthworm culture medium, mixed fertilizers, mushroom culture, packing for flowers and plants, seed inoculants, and vegetable cultivation. In the industrial sector, peat was used as an oil absorbent and as an efficient filtration medium for the removal of waterborne contaminants in mine waste streams, municipal storm drainage, and septic systems.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production	696	685	551	635	650
Commercial sales	741	751	734	694	700
Imports for consumption	786	891	924	977	995
Exports	29	36	41	56	79
Consumption, apparent[3]	1,380	1,600	1,500	1,590	1,560
Price, average value, f.o.b. mine, dollars per ton	28.64	27.76	27.34	25.59	26.10
Stocks, producer, yearend	251	195	128	98	100
Employment, mine and plant, number[e]	700	700	650	625	620
Net import reliance[4] as a percentage of apparent consumption	50	57	63	60	58

Recycling: None.

Import Sources (2004-07): Canada, 98%; and other, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
Peat	2703.00.0000	Free.

Depletion Allowance: 5% (Domestic).

Government Stockpile: None.

Prepared by **Lori E. Apodaca [(703) 648-7724, lapodaca@usgs.gov, fax: (703) 648-7757]**

PEAT

Events, Trends, and Issues: 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 production to average about 600,000 tons per year and imported peat from Canada to account for more than 60% of domestic consumption.

The Canadian Spagnum Peat Moss Association was concerned with the level of harvest for the 2008 season. Abnormal and persistently wet conditions throughout all Canadian peat harvest regions have affected the ability of the industry to harvest expected volumes (about a 20% decrease in harvest and inventory in comparison with those of the past 5 years). The area most affected was Eastern Canada, with New Brunswick and Quebec accounting for about 66% of Canada's peat production.

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]
	2007	2008[e]		
United States	635	650	150,000	10,000,000
Belarus	2,500	2,500	400,000	4,000,000
Canada	1,250	1,000	720,000	30,000,000
Estonia	1,900	2,000	60,000	2,000,000
Finland	9,100	9,100	6,000,000	6,400,000
Ireland	4,300	4,300	([6])	([6])
Latvia	1,000	1,000	76,000	1,300,000
Lithuania	307	300	190,000	300,000
Moldova	475	475	([6])	([6])
Russia	1,300	1,300	1,000,000	60,000,000
Sweden	1,280	1,300	([6])	([6])
Ukraine	395	400	([6])	([6])
Other countries	1,260	1,300	1,400,000	6,000,000
World total (rounded)	25,700	25,600	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 country. Reserve and reserve base data were estimated based on data from International Peat Society publications and 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 and straw are 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., 2008, Alaska's mineral industry 2007—A summary: Alaska Department of Natural Resources Information Circular 57, 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 crude perlite produced in 2008 was $21.4 million. Crude ore production came from eight mines operated by seven companies in six Western States. New Mexico continued to be the major producing State. Processed crude perlite was expanded at 58 plants in 29 States. The principal end uses were building construction products, 60%; fillers, 13%; horticultural aggregate, 13%; filter aid, 7%; and other, 7%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production[1]	508	508	454	409	449
Imports for consumption[e]	238	196	245	229	135
Exports[e]	37	32	30	28	28
Consumption, apparent	709	672	669	610	556
Price, average value, dollars per ton, f.o.b. mine	41.81	40.68	42.90	45.25	49.93
Employment, mine and mill	133	128	113	110	103
Net import reliance[2] as a percentage of apparent consumption	28	24	32	33	19

Recycling: Not available.

Import Sources (2004-07): Greece, 100%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Vermiculite, perlite and chlorites, unexpanded	2530.10.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Wallace P. Bolen [(703) 648-7727, wbolen@usgs.gov, fax: (703) 648-7757]**

PERLITE

Events, Trends, and Issues: The amount of processed crude perlite sold or used from U.S. mines increased about 10% compared with the historically low levels reported for 2007. Domestic miners increased market share, as imports dropped dramatically. Imports were estimated to have decreased to about 135,000 tons, as consumption dropped to its lowest levels since 1991.

Rising fuel prices and strong competition for ocean freight have increased the cost of shipping perlite. In response, some consumers have returned to purchasing domestic perlite instead of imported product. Between 1999 and 2007, perlite imports were increasingly replacing domestic perlite, but this trend was halted in 2008.

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]
	2007	2008[e]		
United States	409	449	50,000	200,000
Greece	525	500	50,000	300,000
Hungary	71	70	3,000	([4])
Japan	240	240	([4])	([4])
Mexico	41	45	([4])	([4])
Turkey	270	270	([4])	5,700,000
Other countries	204	200	600,000	1,500,000
World total (rounded)	1,760	1,770	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.
[1]Processed perlite sold and used by producers.
[2]Defined as imports - exports + adjustments for Government and industry stock changes; changes in stocks were 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 30.9 million tons of marketable product valued at $3.5 billion, 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 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, marketable	35,800	36,100	30,100	29,700	30,900
Sold or used by producers	36,500	35,200	30,200	31,100	31,000
Imports for consumption	2,500	2,630	2,420	2,670	3,000
Consumption[1]	39,000	37,800	32,600	33,800	34,000
Price, average value, dollars per ton, f.o.b. mine[2]	27.79	29.61	30.49	51.10	113.00
Stocks, producer, yearend	7,220	6,970	7,070	4,970	4,900
Employment, mine and beneficiation plant, number[e]	2,700	2,700	2,500	2,350	2,350
Net import reliance[3] as a percentage of apparent consumption	7	7	7	14	9

Recycling: None.

Import Sources (2004-07): Morocco, 100%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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: Beginning in late 2007 and continuing into 2008, the price of phosphate rock jumped dramatically worldwide owing to increased agricultural demand and tight supplies of phosphate rock. The average U.S. price was more than double that of 2007. Average spot prices from North Africa and other exporting regions approached $500 per ton, which was more than five times the average price in 2007. Prices for nitrogen, potash, and sulfur also increased, thus causing the price of fertilizers to reach record highs.

Prepared by **Stephen M. Jasinski [(703) 648-7711, sjasinsk@usgs.gov, fax: (703) 648-7757]**

PHOSPHATE ROCK

In 2008, domestic phosphate rock production increased slightly compared with that of 2007 and consumption and sales remained about the same. Three new phosphate rock mines are planned for development over the next decade in Florida to replace existing mines. The permitting process, however, has been delayed by opposition from local governments concerned about environmental and water use issues. In Idaho, one company received approval from the U.S. Forest Service to expand its mine and another company was developing a new mine to replace its existing mine that is near depletion. Worldwide phosphate rock production was estimated to have increased, primarily in China and North Africa.

Domestic phosphoric acid and MAP production was lower in 2008 and DAP production was higher than that of 2007. Overall exports of phosphoric acid and phosphate fertilizers were higher, led by sales of DAP to India. The United States remained the leading exporter of DAP and MAP, but China is now the leading producer of phosphate rock, phosphoric acid, DAP, and MAP. Most of the Chinese production supplies the growing demand for fertilizers within the country. China raised the export tariffs on phosphate rock and fertilizer products in 2008 to ensure its domestic requirements.

World Mine Production, Reserves, and Reserve Base: Reserves data for Australia were revised based on information provided by an Australian Government agency. Reserves data for China were revised based on a comprehensive study of Chinese phosphate rock reserves conducted by a major university in China.

	Mine production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States	29,700	30,900	1,200,000	3,400,000
Australia	2,200	2,300	82,000	1,200,000
Brazil	6,000	6,000	260,000	370,000
Canada	700	800	25,000	200,000
China	45,400	50,000	4,100,000	10,000,000
Egypt	2,200	3,000	100,000	760,000
Israel	3,100	3,100	180,000	800,000
Jordan	5,540	5,500	900,000	1,700,000
Morocco and Western Sahara	27,000	28,000	5,700,000	21,000,000
Russia	11,000	11,000	200,000	1,000,000
Senegal	600	600	50,000	160,000
South Africa	2,560	2,400	1,500,000	2,500,000
Syria	3,700	3,700	100,000	800,000
Togo	800	800	30,000	60,000
Tunisia	7,800	7,800	100,000	600,000
Other countries	8,110	10,800	890,000	2,200,000
World total (rounded)	156,000	167,000	15,000,000	47,000,000

World Resources: Foreign reserve data were derived from information received from Government sources, individual companies, and independent sources. Reserve data for China were based on official government sources and other Chinese data. Production data for China do 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. High phosphate rock prices have renewed interest in exploiting offshore resources of Mexico and Namibia.

Substitutes: There are no substitutes for phosphorus in agriculture.

[e]Estimated.
[1]Defined as phosphate rock sold or used + imports.
[2]Marketable phosphate rock, weighted value, all grades.
[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. The leading demand sector for PGMs continued to be catalysts for air-pollution abatement in both light- and heavy-duty vehicles. PGMs are also used in the chemical sector as catalysts for manufacturing bulk chemicals such as nitric acid; in the petroleum refining sector; and in the fabrication of laboratory equipment. In the electronics sector, PGMs are used in computer hard disks, multilayer ceramic capacitors, and hybridized integrated circuits. PGMs are used by the glass manufacturing sector in the production of fiberglass, liquid crystal displays, and flat-panel displays. 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. Platinum and palladium can be used as investment tools in the form of exchange traded notes (ETNs).

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Mine production:[1]					
Platinum	4,040	3,920	4,290	3,860	3,700
Palladium	13,700	13,300	14,400	12,800	12,400
Imports for consumption:					
Platinum	86,400	106,000	114,000	181,000	195,000
Palladium	127,000	139,000	119,000	113,000	107,000
Rhodium	13,200	13,600	15,900	16,600	16,000
Ruthenium	18,800	23,200	36,000	48,700	57,000
Iridium	3,230	3,010	2,800	3,400	2,800
Osmium	75	39	56	23	24
Exports:					
Platinum	20,000	20,700	45,500	28,900	27,000
Palladium	31,500	27,000	53,100	41,800	40,000
Rhodium	311	615	1,600	2,200	3,500
Other PGMs	1,086	1,080	3,390	8,190	6,700
Price,[2] dollars per troy ounce:					
Platinum	848.76	899.51	1,144.42	1,308.44	1,680.00
Palladium	232.93	203.54	322.93	357.34	370.00
Rhodium	983.24	2,059.73	4,561.06	6,203.09	7,260.00
Ruthenium	64.22	74.41	193.09	573.74	340.00
Iridium	185.33	169.51	349.45	444.43	450.00
Employment, mine, number[1]	1,580	1,620	1,720	1,630	1,700
Net import reliance as a percentage of apparent consumption[e]					
Platinum	92	93	90	91	91
Palladium	83	84	75	73	72

Recycling: An estimated 26,000 kilograms of PGMs was recovered from new and old scrap in 2008.

Import Sources (2004-07): Platinum: South Africa, 35%; Germany, 17%; United Kingdom, 11%; Canada, 5%; and other, 32%. Palladium: Russia, 41%; South Africa, 22%; United Kingdom, 18%; Belgium, 5%; and other, 14%.

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

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

Government Stockpile:

Stockpile Status—9-30-08[3]

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2008**	**Disposals FY 2008**
Platinum	261	261	778	—
Palladium	—	—	3,110	—
Iridium	18	18	186	—

Prepared by **Patricia J. Loferski [(703) 648-7708, ploferski@usgs.gov, fax: (703) 648-7757]**

PLATINUM-GROUP METALS

Events, Trends, and Issues: A power crisis in South Africa, the world's leading supplier of PGM, resulted in the shutdown of all platinum mines for 5 days in January, which caused production loss, supply fears, and record-high prices in the first half of 2008. Prices of platinum and rhodium reached alltime highs of $2,275 per troy ounce and $10,100 per troy ounce, respectively, and the palladium price reached a 7-year high of $585 per troy ounce. The global economic downturn resulted in lower automobile demand, which in turn resulted in falling consumption and prices of PGM in the second half of the year. The desire for an alternative fuel, both for automobiles and to power homes, has led to a large global public and private effort to develop fuel cell technology. Platinum is the catalyst used in fuel cells to convert hydrogen and oxygen to electricity. A decrease in car sales in Europe and North America can be expected to cause a decrease in use of platinum and palladium in the regions in 2008 and beyond. The tightening of emissions standards in China, Europe, Japan, and other parts of the world is expected to lead to higher average platinum loadings on catalysts, especially in 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 large price differential between platinum and palladium has led to the assumption that automobile manufacturers will continue to change PGMs ratios in gasoline-engine vehicles in favor of palladium, as well as continue efforts to increase the proportion of palladium used in diesel vehicles. 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 May, new investment vehicles for PGMs, ETNs, were launched for platinum and palladium and are the first such PGM-trading product available to U.S. investors. Unlike exchange-traded funds, ETNs are based on futures contracts, and physical metal is not held.

World Mine Production, Reserves, and Reserve Base:

	Mine production				PGMs	
	Platinum		Palladium		Reserves[4]	Reserve base[4]
	2007	2008[e]	2007	2008[e]		
United States	3,860	3,700	12,800	12,400	900,000	2,000,000
Canada	6,200	7,200	10,500	12,500	310,000	390,000
Colombia	1,400	1,700	NA	NA	([5])	([5])
Russia	27,000	25,000	96,800	88,000	6,200,000	6,600,000
South Africa	166,000	153,000	86,500	80,000	63,000,000	70,000,000
Zimbabwe	5,300	5,600	4,200	4,400	([5])	([5])
Other countries	3,490	3,500	8,120	8,300	800,000	850,000
World total (rounded)	213,000	200,000	219,000	206,000	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 as much as 25% 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]See Appendix C for definitions.
[5]Included with "Other countries."

POTASH

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

Domestic Production and Use: In 2008, the production value of marketable potash, f.o.b. mine, was about $895 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, one 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:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production, marketable[1]	1,200	1,200	1,100	1,100	1,200
Imports for consumption	4,920	4,920	4,470	4,970	5,250
Exports	233	200	332	199	275
Consumption, apparent[1]	6,000	5,900	5,200	5,900	6,200
Price, dollars per metric ton of K_2O, average, muriate, f.o.b. mine[2]	200	280	290	400	717
Employment, number:					
Mine	520	500	500	500	500
Mill	620	630	630	630	630
Net import reliance[3] as a percentage of apparent consumption	80	80	79	81	81

Recycling: None.

Import Sources (2004-07): Canada, 90%; Belarus, 6%; Russia, 2%; Germany, 1%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Potassium nitrate	2834.21.0000	Free.
Potassium chloride	3104.20.0000	Free.
Potassium sulfate	3104.30.0000	Free.
Potassic fertilizers, other	3104.90.0100	Free.
Potassium-sodium nitrate mixtures	3105.90.0010	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Stephen M. Jasinski [(703) 648-7711, sjasinsk@usgs.gov, fax: (703) 648-7757]**

POTASH

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. Other potassium fertilizers include potassium nitrate, potassium magnesium sulfate, and potassium sulfate. Potash demand and prices increased throughout the year domestically and worldwide as a result of more crop acres that required potash fertilizer being planted, owing in part to high grain prices and tight world supplies. Initiatives promoting the production of biofuels (transportation fuels made from agricultural products) have spurred increased plantings and increased fertilizer consumption; however, this use is not likely to increase in the United States, as future emphasis will be on other technologies such as biodiesel and cellulosic ethanol.

U.S. production has been relatively stable for several years, but the increased demand has prompted some producers in New Mexico and Utah to begin expanding their production capacity, with work expected to be completed by 2010. Canada continued to lead the world in potash production, and output reached record levels despite a strike by miners at three mines in Saskatchewan that began in August 2008. In addition to restarting idled operations, plans were announced to expand current facilities in Saskatchewan and explore for potash in Manitoba.

Production in 2008 was estimated to have increased slightly. From 2009 to 2012, world potash production capacity was anticipated to increase by 20% owing to expansions to existing facilities in Belarus, Canada, China, Israel, Russia, and the United States, and from a new mine in Argentina.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States	[1]1,100	[1]1,200	90,000	300,000
Belarus	4,970	5,100	750,000	1,000,000
Brazil	405	430	300,000	600,000
Canada	11,100	11,000	4,400,000	11,000,000
Chile	500	580	10,000	50,000
China	2,000	2,100	8,000	450,000
Germany	3,600	3,600	710,000	850,000
Israel	2,200	2,400	[5]40,000	[5]580,000
Jordan	1,090	1,200	[5]40,000	[5]580,000
Russia	6,600	6,900	1,800,000	2,200,000
Spain	580	590	20,000	35,000
Ukraine	12	12	25,000	30,000
United Kingdom	427	480	22,000	30,000
Other countries	—	—	50,000	140,000
World total (rounded)	34,600	36,000	8,300,000	18,000,000

World Resources: Estimated domestic potash resources total about 7 billion tons. Most of these lie 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. The Holbrook Basin of Arizona contains resources of about 1 billion tons. A large potash resource lies about 2,100 meters under central Michigan. The U.S. reserve figure above includes approximately 40 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 profitably mined.

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]Data are rounded to no more than two significant digits to avoid disclosing company proprietary data.
[2]Average prices based on actual sales; excludes soluble and chemical muriates.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.
[5]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 2008 was about $29 million. Domestic output came from 21 producers in 7 States. Pumice and pumicite were mined in California, Arizona, New Mexico, Idaho, Oregon, Nevada, and Kansas, in descending order of production. Approximately 50% of all production came from Arizona and California. About 58% of mined pumice was used toward the production of construction building block. Horticulture consumed nearly 14%; concrete admixture and aggregate, 7%; abrasives, 7%; and the remaining 14% was used for absorbent, filtration, landscaping, laundry stone washing, and other applications.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, mine[1]	1,490	1,270	1,540	1,270	1,140
Imports for consumption[2]	402	240	109	37	86
Exports[e, 2]	20	15	18	9	17
Consumption, apparent	1,870	1,500	1,630	1,300	1,210
Price, average value, dollars per ton, f.o.b. mine or mill	16.80	31.00	28.85	22.85	25.00
Employment, mine and mill, number	100	110	110	110	110
Net import reliance[3] as a percentage of apparent consumption	20	15	6	2	6

Recycling: Not available.

Import Sources (2004-07): Greece, 74%; Italy, 20%; Turkey, 3%; Mexico, 2%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Pumice, crude or in irregular pieces, including crushed	2513.10.0010	Free.
Pumice, except crude or crushed	2513.10.0080	Free.

Depletion Allowance: 5% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Robert D. Crangle, Jr. [(703) 648-6410, rcrangle@usgs.gov, fax: (703) 648-7757]**

PUMICE AND PUMICITE

Events, Trends, and Issues: The amount of domestically produced pumice and pumicite sold or used in 2008 decreased by 10% to 1.14 million tons, compared with 1.27 million tons in 2007. Imports were approximately double those of 2007. Approximately 98% of pumice imports originated from Greece and Mexico to supply markets in the Eastern United States and Gulf Coast regions. Imports of pumice from Italy, which decreased from 47,000 tons in 2006 to less than 500 tons in 2007, remained low in 2008. The dramatic decrease resulted from the closure of a large pumice mining operation in Lipari. Apparent consumption fell by approximately 7% in 2008 compared with that of 2007.

In 2008, a continued slowdown in the construction industry led to decreases in pumice and pumicite domestic mine production, as well as apparent consumption. Although pumice and pumicite are plentiful in the Western United States, legal challenges and public land designations could limit access to known deposits. Pumice and pumicite production is sensitive to mining and transportation costs. As higher fuel prices lead to increases in production expenditures, imports and competing materials could become more attractive than domestic products.

All domestic pumice and pumicite mining in 2008 was accomplished through open pit methods, 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 local dust issues at some operations, the environmental impact was restricted to a relatively small geographic area.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States[1]	1,270	1,140	Large	Large
Algeria	450	400		
Cameroon	600	600		
Chile	1,400	1,100		
Ecuador	710	740	Quantitative estimates of reserves and reserve base for most countries are not available.	
France	250	230		
Greece	2,250	2,000		
Iran	1,500	1,400		
Italy	4,020	1,000		
Spain	600	540		
Syria	650	650		
Turkey	700	630		
Other countries	2,400	2,280		
World total (rounded)	16,800	12,700	NA	NA

World Resources: The identified United States resources of pumice and pumicite are concentrated in the West, and 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. Greece and Iran are the leading producers of pumice and pumicite, followed by Chile, the United States, Ecuador, and Turkey. There are large resources of pumice and pumicite on all continents.

Substitutes: The costs of transportation determine the maximum economic distance for which pumice and pumicite can be shipped, while still remaining competitive with alternative materials. Competitive resources that may be substituted for pumice and pumicite include crushed aggregates, diatomite, expanded shale and clay, and vermiculite.

[e]Estimated. NA Not available.
[1]Quantity sold and used by producers.
[2]The data for the 2006 imports for consumption and the 2004-07 exports are based on revised U.S. Census Bureau information.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]See Appendix C for definitions.

QUARTZ CRYSTAL (INDUSTRIAL)

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Cultured quartz crystal production capacity still exists in the United States but would require considerable refurbishment to be brought online. 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. Lascas[1] mining and processing in Arkansas ended in 1997 and, in 2008, no U.S. firms reported the production of cultured quartz crystals.

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: The U.S. Census Bureau, which is the primary Government source of U.S. trade data, does not provide specific import or export statistics on lascas. The U.S. Census Bureau 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 was estimated to be $120 per kilogram in 2008. Lumbered quartz, which is as-grown quartz that has been processed by sawing and grinding, was estimated to be $297 per kilogram in 2008. Other salient statistics were not available.

Recycling: None.

Import Sources (2004-07): The United States is 100% import reliant on cultured quartz crystal. Although no definitive data exists listing import sources for cultured quartz crystal, imported material is thought to be mostly from Asian countries, probably China, Japan, and Russia.

Tariff:

Item	Number	Normal Trade Relations 12-31-08
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: As of September 30, 2008, the National Defense Stockpile (NDS) contained 7,134 kilograms of natural quartz crystal. The stockpile has 11 weight classes for natural quartz crystal that range from 0.2 kilograms to more than 10 kilograms. The stockpiled crystals, however, are primarily in the larger weight classes. The larger pieces are suitable as seed crystals, which are very thin crystals cut to exact dimensions, to produce cultured quartz crystal. In addition, many of the stockpiled crystals could be of interest to the specimen and gemstone industry. Little, if any, of the stockpiled material is likely to be used in the same applications as cultured quartz crystal. No natural quartz crystal was sold from the NDS in 2008, and the Federal Government does not intend to dispose of or sell any of the remaining material. Previously, only individual crystals in the NDS inventory that weighed 10 kilograms or more and could be used as seed material were sold.

Stockpile Status—9-30-08[2]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Quartz crystal	7	—	—	—

Prepared by **Thomas P. Dolley [(703) 648-7710, tdolley@usgs.gov, fax: (703) 648-7757]**

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 drive 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 (the very rare mineral berlinite), langasite, lithium niobate, and lithium tantalate, which have larger piezoelectric coupling constants, have been studied and used. The cost competitiveness of these materials as opposed to cultured quartz crystal is dependent on the type of application the material is used for and the processing required.

— Zero.
[1]Lascas is a nonelectronic-grade quartz used as a feedstock for growing cultured quartz crystal and for production of fused quartz.
[2]See Appendix B for definitions.
[3]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: In 2008, rare earths were not mined in the United States; however, rare-earth concentrates previously produced at Mountain Pass, CA, were processed into lanthanum concentrate and didymium (75% neodymium, 25% praseodymium) products. Rare-earth concentrates, intermediate compounds, and individual oxides were available from stocks. The United States continued to be a major consumer, exporter, and importer of rare-earth products in 2008. The estimated value of refined rare earths imported by the United States was more than $127 million. Based on final 2007 reported data, the estimated 2007 distribution of rare earths by end use, in decreasing order, was as follows: glass polishing and ceramics, 34%; automotive catalytic converters, 30%; rare-earth phosphors for computer monitors, lighting, radar, televisions, and x-ray-intensifying film, 14%; chemicals and petroleum refining catalysts, 11%; ceramics, 3%; pharmaceuticals and pharmaceutical equipment, 3%; permanent magnets, 2%; metallurgical applications and alloys, 1%; laser and scintillator crystals, 1%; and other, 1%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, bastnäsite concentrates[e]	—	—	—	—	—
Imports:[2]					
Thorium ore (monazite or various thorium materials)	—	—	—	—	—
Rare-earth metals, alloy	804	880	867	784	807
Cerium compounds	1,880	2,170	2,590	2,680	2,180
Mixed REOs	1,660	640	1,570	2,570	2,750
Rare-earth chlorides	1,310	2,670	2,750	1,610	1,570
Rare-earth oxides, compounds	11,400	8,550	10,600	9,900	9,050
Ferrocerium, alloys	105	130	127	123	143
Exports:[2]					
Thorium ore (monazite or various thorium materials)	—	—	—	1	56
Rare-earth metals, alloys	1,010	636	733	1,470	1,580
Cerium compounds	2,280	2,210	2,010	1,470	1,620
Other rare-earth compounds	4,800	2,070	2,700	1,300	642
Ferrocerium, alloys	3,720	4,320	3,710	3,210	2,170
Consumption, apparent	5,480	6,030	9,530	10,200	10,500
Price, dollars per kilogram, yearend:					
Bastnäsite concentrate, REO basis[e]	4.08	5.51	5.51	5.51	8.82
Monazite concentrate, REO basis[3]	0.59	0.54	0.87	0.87	0.87
Mischmetal, metal basis, metric ton quantity[4]	5-6	5-6	5-6	7-8	8-9
Stocks, producer and processor, yearend	W	W	W	W	W
Employment, mine and mill, number at yearend	68	70	55	91	99
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Small quantities, mostly permanent magnet scrap.

Import Sources (2004-07): Rare-earth metals, compounds, etc.: China, 87%; France, 5%; Japan, 4%; Russia, 2%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7757]**

RARE EARTHS

Events, Trends, and Issues: Domestic consumption for rare earths in 2008 increased slightly, based on apparent consumption (derived from 9 months of trade data), although rare-earth imports and exports were estimated to be lower than in 2007. Prices were higher in 2008 than in 2007 for most rare-earth products amid increased consumption and a stable supply. Consumption increased for cerium compounds used in automotive catalytic converters and in glass additives and glass polishing compounds; rare-earth compounds used in automotive catalytic converters and many other applications; yttrium compounds used in color televisions and flat-panel displays, electronic thermometers, fiber optics, lasers, and oxygen sensors; and phosphors for color televisions, electronic thermometers, fluorescent lighting, pigments, superconductors, x-ray-intensifying screens, and other applications. Consumption was also higher for mixed rare-earth compounds and for rare-earth metals and their alloys used in armaments, base-metal alloys, lighter flints, permanent magnets, pyrophoric alloys, and superalloys. U.S. consumption, however, was substantially lower for rare-earth chlorides used in the production of fluid cracking catalysts used in oil refining. 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 for electric and hybrid vehicles.

The rare-earth separation plant at Mountain Pass, CA, resumed operations in 2007 and continued to operate in 2008. Bastnäsite concentrates and other rare-earth intermediates and refined products continued to be sold from mine stocks at Mountain Pass. Exploration for rare earths continued strong in 2008, and economic assessments continued at Nolans in Australia, Hoidas Lake and Thor Lake in Canada, and Kangankunde in Malawi, Africa. Removal of overburden at the Mt. Weld rare-earth deposit in Australia commenced in early 2008, and initial mining of the open pit was completed in June, recovering 773,300 t of ore at an average grade of 15.4% REO.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves[6]	Reserve base[6]
	2007	2008		
United States	—	—	13,000,000	14,000,000
Australia	—	—	5,200,000	5,800,000
Brazil	650	650	48,000	84,000
China	120,000	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	380	380	30,000	35,000
Other countries	NA	NA	22,000,000	23,000,000
World total (rounded)	124,000	124,000	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, loparite, phosphorites, rare-earth-bearing (ion adsorption) clays, secondary monazite, 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 2004, and estimated for 2005 through 2008.
[4]Price range from Elements—Rare Earths, Specialty Metals and Applied Technology, Trade Tech, Denver, CO, and Web-based High Tech Materials, Longmont, CO, and Hefa Rare Earth Canada Co. Ltd., Richmond, British Columbia, Canada.
[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 2008, ores containing rhenium were mined at eight operations (four in Arizona, and 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 (APR), metal powder, and perrhenic acid. 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 70%, respectively, of the end use. Bimetallic platinum-rhenium catalysts were used in petroleum-reforming for the production of high-octane hydrocarbons, which are used in the production of lead-free gasoline. Rhenium improves the high-temperature (1,000° C) strength properties of some nickel-based 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 2008 was about $91 million.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production[1]	6,500	7,900	8,100	7,100	7,700
Imports for consumption	19,200	28,900	38,800	41,000	50,200
Exports	NA	NA	NA	NA	NA
Consumption, apparent	25,700	36,900	46,900	48,100	57,900
Price,[2] average value, dollars per kilogram, gross weight:					
Metal powder, 99.99% pure	1,090	1,070	1,260	1,620	1,770
Ammonium perrhenate	710	680	840	2,730	2,860
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	75	78	83	85	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 (2004-07): Rhenium metal powder: Chile, 85%; Germany, 7%; Netherlands, 4%; and other, 4%. Ammonium perrhenate: Kazakhstan, 62%; Germany, 10%; Netherlands, 8%; Chile, 6%; and other, 14%.

Tariff:

Item	Number	Normal Trade Relations 12-31-08
Salts of peroxometallic acids, other—ammonium perrhenate	2841.90.2000	3.1% ad val.
Rhenium, etc., (metals) waste and scrap	8112.92.0600	Free.
Rhenium, (metals) unwrought; powders	8112.92.5000	3% ad val.
Rhenium, etc., (metals) wrought; etc.	8112.99.9000	4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Michael J. Magyar [(703) 648-4964, mmagyar@usgs.gov, fax: (703) 648-7757]**

RHENIUM

Events, Trends, and Issues: During 2008, average rhenium metal price, based on U.S. Census Bureau customs value, was about $1,770 per kilogram, about 9% more than that of 2007. Rhenium imports for consumption increased by about 22% owing to continued strong demand for superalloys in the gas turbine engine market and improved demand in the catalyst market. Rhenium production in the United States increased by about 8% owing to increased production of byproduct molybdenum concentrates in the United States. The four larger working copper-molybdenum mines maintained byproduct molybdenum production levels near capacity in 2008, while the four smaller operations made incremental increases in production in 2008.

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. Imports of rhenium from Kazakhstan were reduced in 2008 to more normal levels after the influx of stockpiled material in late 2006 and early 2007. Stockpiled quantities of low-grade APR imported into the United States from Kazakhstan in 2007 slowly came into the market after the material was reprocessed. Owing to strong demand, both APR and metal powder spot prices rose sharply in 2007. Basic-grade APR rose from about $4,600 per kilogram in January to about $8,200 per kilogram in December. Metal powder rose from about $5,950 per kilogram in January to about $9,700 per kilogram in December. These trends continued in 2008 with APR rising from $8,200 per kilogram in January to $9,700 in August before retreating to about $8,500 per kilogram in November. Metal powder rose from about $9,000 per kilogram in January to about $11,900 per kilogram in October before retreating to about $9,900 per kilogram in November.

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:

	Mine production[4]		Reserves[5]	Reserve base[5]
	2007	2008		
United States	7,100	7,700	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[6]	22,900	27,600	1,300,000	2,500,000
Kazakhstan	7,700	8,000	190,000	250,000
Peru	5,000	5,000	45,000	550,000
Russia	1,500	1,500	310,000	400,000
Other countries	4,000	4,000	91,000	360,000
World total (rounded)	51,000	57,000	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 80% recovery of estimated rhenium contained in MoS_2 concentrates. Roasted MoS_2 concentrate data revised for 2004 and 2005.
[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]See Appendix C for definitions.
[6]Estimated rhenium recovered from roaster residues from Belgium, Chile, and Mexico.

RUBIDIUM

(Data in kilograms of rubidium content unless otherwise noted)

Domestic Production and Use: Worldwide, rubidium occurrences may be associated with zoned pegmatites in the minerals pollucite, a source of cesium, or lepidolite, a source of lithium. Rubidium is not mined in the United States; however, rubidium concentrate is imported from Canada for processing in the United States. There are rubidium occurrences in Maine and South Dakota, and rubidium may also be found with some evaporite minerals in other States. Applications for rubidium and its compounds include photoelectrics, specialty glass, pyrotechnics, and as standards for atomic absorption analysis. Rubidium-rich feldspars are used in ceramic applications for spark plugs and electrical insulators because of their high dielectric capacity. Other applications include the use of high-purity rubidium (>98%) in vapor cells as a wavelength reference, and use as a substitute for cesium as a frequency standard in atomic clocks. Rubidium-82, an isotope of rubidium, is used to trace blood flow in the heart. Rubidium-87, a natural decay product of strontium-82, may be extracted from potassium-bearing minerals, such as micas, and used for dating episodes of heating and deformation in rocks.

Salient Statistics—United States: One mine in Canada produced byproduct rubidium concentrate, which was then imported into the United States for processing. Production data from the Canadian mine, and U.S. consumption, export, and import data, are not available. In the United States, consumption of rubidium may amount to only a few thousand kilograms per year. No market price is available because the metal is not traded. In 2008, one company offered 1-gram ampoules of 99.75%-grade rubidium (metals basis) at $60.80 each, and the price for 100 grams of the same material was $1,168.00. This is a 4.5% increase from that of 2007.

Recycling: None.

Import Sources (2004-07): The United States is 100% import reliant on byproduct rubidium concentrate imported from Canada.

Tariff:

Item	Number	Normal Trade Relations 12-31-08
Alkali metals, other	2805.19.9000	5.5% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

RUBIDIUM

Events, Trends, and Issues: Rubidium has been available commercially as a byproduct of lithium chemicals production for 40 years. Demand is limited by the lack of supply, but discovery of new resources of rubidium, increases in lithium exploration, as well as higher grade rubidium discoveries, may create new supplies leading to expanded commercial applications. The use of rubidium as an atomic clock for global positioning satellites continues to increase. The stability of the rubidium clock is so great that it would lose only 3 seconds in 1 million years. Rubidium carbonate glass has been extensively tested for use in anticollision devices for motor vehicles. The role of rubidium-82 and positron emission tomography (PET) in the evaluation and care of patients with suspected coronary artery disease is evolving in conjunction with advances in PET instrumentation, data analysis, and clinical research. Rubidium forms interesting amalgams with mercury and alloys with gold, properties that may expand usage. Small amounts of rubidium are released into the atmosphere during coal combustion; however, there have been no adverse environmental or human health issues associated with the processing or use of rubidium.

World Mine Production, Reserves, and Reserve Base:[1] There are no minerals in which rubidium is the predominant metallic element; however, rubidium may be taken up in trace amounts in the lattices of potassium feldspars and micas during the crystallization of some pegmatites. The rubidium-bearing minerals lepidolite and pollucite may be found in some zoned pegmatites, which are exceptionally coarse-grained plutonic rocks that form late in the crystallization of a silicic magma. Lepidolite, a lithium-bearing mica, is the principal ore mineral of rubidium and may contain up to 3.15% rubidium. Pollucite, a cesium aluminosilicate mineral, may contain up to 1.35% rubidium.

World Resources: Rubidium-bearing zoned pegmatites are known in several locations in Canada, and there are also pegmatite occurrences in Afghanistan, Namibia, Peru, Zambia, and other countries. Minor amounts of rubidium are reported in brines in northern Chile and China and in evaporites in France, Germany, and the United States (New Mexico and Utah). World resources of rubidium are unknown.

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 many applications.

[1]See Appendix C for definitions.

SALT

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Domestic production of salt increased an estimated 3% in 2008. The total value was estimated to be more than $1.6 billion. Thirty-one companies operated 64 plants in 16 States. The estimated percentage of salt sold or used, by type, was salt in brine, 44%; rock salt, 38%; vacuum pan, 10%; and solar salt, 8%.

The chemical industry consumed about 40% 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 39% of U.S. demand. The remaining markets for salt, in declining order, were distributors, 8%; agricultural, 3%; food, 3%; general industrial, 3%; water treatment, 2%; and other combined with exports, 2%.

Salient Statistics—United States:[1]	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production	46,500	45,100	44,400	44,500	46,000
Sold or used by producers[2]	45,000	45,000	40,600	45,400	46,000
Imports for consumption	11,900	12,100	9,490	8,640	10,000
Exports	1,100	879	973	833	800
Consumption:					
Reported	50,700	53,100	42,400	53,200	55,200
Apparent[2]	55,800	56,200	49,100	53,200	55,200
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant:					
Vacuum and open pan salt	128.39	130.75	145.90	154.95	155.00
Solar salt	49.25	58.14	65.06	61.65	65.00
Rock salt	25.83	25.84	24.98	27.84	40.00
Salt in brine	7.01	7.03	6.99	7.11	8.00
Employment, mine and plant, number[e]	4,100	4,100	4,100	4,100	4,100
Net import reliance[3] as a percentage of apparent consumption	23	20	17	15	17

Recycling: None.

Import Sources (2004-07): Canada, 39%; Chile, 28%; The Bahamas, 9%; Mexico, 9%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Salt (sodium chloride)	2501.00.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: A vacuum pan salt producer in Schuyler County, NY, was purchased by a large energy company. The company will utilize the subsurface empty salt caverns to store natural gas for regional energy consumers. The salt company will continue to produce and sell salt while developing new caverns.

A Canadian oilfield waste company, with operations in Alberta, British Columbia, and Saskatchewan, applied for permits to pump a slurry of crude oil, crude oil components, drill cuttings, drilling mud, and hydrocarbons into the Weeks Island salt dome in Louisiana. The brine-filled salt cavern was a storage site for the Strategic Petroleum Reserve (SPR) but was closed in 1992 because of a fault that was discovered near the surface that could have leached oil into the local bay. The proposed project will develop new caverns 300 meters to 1,000 meters below and nearly 800 meters laterally from the SPR caverns.

Prepared by **Dennis S. Kostick [(703) 648-7715, dkostick@usgs.gov, fax: (703) 648-7757]**

SALT

Weather forecasters predict that the winter weather of yearend 2008 and early 2009 will be more severe than the previous few seasons. Many municipal stockpiles of salt were depleted in early 2008. However, in the late summer and early fall when orders were placed for the upcoming winter, the salt purchasers in many municipalities and local and State transportation departments were notified by most of the salt producers that salt supplies were short and that the prices would be double or triple compared with the previous year's prices. This large increase was because of higher energy costs and transportation delays from flooding in the Midwest that hampered barge shipments.

Budget constraints for local and State governments may affect the availability and consumption of rock salt for highway deicing in 2009. It is anticipated that the domestic salt industry will strive to have adequate salt available from domestic and foreign sources for emergency use if adverse winter weather develops.

World Production, Reserves, and Reserve Base:

	Production		Reserves and reserve base[4]
	2007	**2008[e]**	
United States[1]	44,500	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	11,400	12,000	
Brazil	6,900	7,000	
Canada	11,800	12,000	
Chile	4,400	5,000	
China	59,800	60,000	
Egypt	2,400	2,400	
France	6,100	6,000	
Germany	19,800	19,000	
India	16,000	15,800	
Iran	2,000	2,000	
Italy	2,200	2,200	
Mexico	8,400	8,400	
Netherlands	5,000	5,000	
Poland	4,400	4,400	
Romania	2,470	2,500	
Russia	2,200	2,200	
Spain	4,600	4,600	
Turkey	2,700	2,700	
Ukraine	5,500	5,500	
United Kingdom	5,800	5,800	
Other countries	28,600	29,500	
World total (rounded)	257,000	260,000	

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 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.
[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 $7.6 billion was produced by an estimated 4,100 companies from about 6,700 operations in 50 States. Leading producing States, in order of decreasing tonnage, were California, Texas, Arizona, Michigan, Colorado, Wisconsin, Washington, New York, Ohio, and Utah, which together accounted for about 52% of the total output. It is estimated that about 44% of construction sand and gravel was used as concrete aggregates; 23% for road base and coverings and road stabilization; 14% as construction fill; 12% as asphaltic concrete aggregates and other bituminous mixtures; 3% for plaster and gunite sands; 1% for concrete products, such as blocks, bricks, and pipes; and the remaining 3% for filtration, golf courses, 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 2008, was about 769 million tons, a decrease of 19% compared with the revised total for the same period in 2007. 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production	1,240	1,280	1,320	1,230	1,040
Imports for consumption	5	7	5	4	4
Exports	1	1	1	([3])	1
Consumption, apparent	1,240	1,290	1,320	1,240	1,050
Price, average value, dollars per ton	5.32	5.86	6.47	7.01	7.23
Employment, mines, mills, and shops, number	37,000	37,700	38,500	38,000	34,100
Net import reliance[4] as a percentage of apparent consumption	([3])	([3])	1	([3])	([3])

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

Import Sources (2004-07): Canada, 73%; Mexico, 19%; The Bahamas, 5%; and other, 3%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
Sand, silica and quartz, less than 95% silica	2505.10.5000	Free.
Sand, other	2505.90.0000	Free.
Pebbles and gravel	2517.10.0015	Free.

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

Government Stockpile: None.

Prepared by **Wallace P. Bolen [(703) 648-7727, wbolen@usgs.gov, fax: (703) 648-7757]**

SAND AND GRAVEL (CONSTRUCTION)

Events, Trends, and Issues: As the U.S. economy continued to falter, construction sand and gravel output dropped for the second straight year, down by more than 15%, or nearly 200 million tons, compared with that of 2007. Demand for construction aggregate fell because total U.S. construction declined in 2008, led by a double-digit decline in housing construction. It is estimated that 2009 domestic production will decrease to about 1 billion tons as housing construction and home prices remain at historically low levels, and revenues to governments are affected by lower home values and associated revenues. Decreased revenues could curtail publicly funded construction projects, which in turn would lower demand for construction sand and gravel.

Crushed stone, the other major construction aggregate, continues to replace 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, permitting, safety, and zoning 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 would support higher-than-average price increases in industrialized and urban areas.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	2007	2008[e]	
United States	1,230	1,040	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 2008.

[e]Estimated. NA Not available.
[1]See also Sand and Gravel (Industrial).
[2]See Appendix A for conversion to short tons.
[3]Less than ½ unit.
[4]Defined as imports – exports + adjustments for Government and industry stock changes; changes in stocks are not available and assumed to be zero.
[5]See Appendix C for definitions.
[6]No reliable production information for most 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 $832 million was produced by 68 companies from 136 operations in 34 States. Leading States, in order of tonnage produced, were Illinois, Texas, Wisconsin, Oklahoma, Minnesota, North Carolina, California, and Michigan. Combined production from these States represented 63% of the domestic total. About 33% of the U.S. tonnage was used as glassmaking sand, 21% as hydraulic fracturing sand and well-packing and cementing sand, 14% as foundry sand, 8% as whole-grain fillers and building products, 5% as ground silica and whole-grain silica, 4% as golf course sand, and 15% for other uses.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production	29,700	30,600	28,800	30,000	30,000
Imports for consumption	490	711	855	511	323
Exports	1,790	2,910	3,830	3,000	3,070
Consumption, apparent	28,400	28,400	25,800	27,500	27,300
Price, average value, dollars per ton	23.06	24.57	26.58	28.60	27.73
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 (2004-07): Mexico, 60%; Canada, 36%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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 2008 remained unchanged compared with those of 2007, but were sufficient to fulfill demand for many uses, which included ceramics, chemicals, fillers (ground and whole-grain), container, filtration, flat and specialty glass, hydraulic fracturing, and recreational uses. U.S. apparent consumption was 27.3 million tons in 2008, down slightly from that of the previous year. Imports of industrial sand and gravel in 2008 decreased to 323,000 tons from 511,000 tons in 2007. 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 2008 remained essentially unchanged compared with those of 2007.

Prepared by **Thomas P. Dolley [(703) 648-7710, tdolley@usgs.gov, fax: (703) 648-7757]**

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 data 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. The high level of exports was attributed to the high quality and advanced processing techniques used in the United States 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 2008. 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]		Reserves and reserve base[3]
	2007	2008	
United States	30,000	30,000	
Australia	5,300	5,300	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	1,500	1,500	
Canada	1,900	1,900	
Chile	1,200	1,200	
Czech Republic	1,000	1,000	
France	5,000	5,000	
Gambia	1,400	1,400	
Germany	7,700	8,400	
Hungary	3,800	3,800	
India	1,600	1,600	
Iran	2,000	2,000	
Italy	14,000	14,000	
Japan	4,300	4,300	
Korea, Republic of	2,200	2,200	
Mexico	2,700	2,700	
Norway	1,500	1,500	
Poland	4,000	4,000	
Romania	1,500	1,500	
Slovakia	2,000	2,000	
Slovenia	200	200	
South Africa	3,300	3,300	
Spain	5,000	5,000	
Turkey	1,200	1,200	
United Kingdom	5,600	5,600	
Other countries	7,300	7,300	
World total (rounded)	126,000	127,000	

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.

[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 decreased slightly in 2008. Although scandium was not mined domestically in 2008, 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 2008 were aluminum alloys for sporting equipment (baseball and softball bats, bicycle frames, crosse handles (lacrosse stick handles), golf clubs, gun frames, and tent poles), metallurgical research, high-intensity metal halide lamps, analytical standards, electronics, oil well tracers, and lasers.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Price, yearend, dollars:					
Per kilogram, oxide, 99.0% purity	500	500	700	700	900
Per kilogram, oxide, 99.9% purity	1,300	1,300	1,400	1,400	1,400
Per kilogram, oxide, 99.99% purity[2]	2,500	2,500	1,450	1,620	1,620
Per kilogram, oxide, 99.999% purity[2]	3,200	3,000	1,500	2,540	2,540
Per kilogram, oxide, 99.9995% purity[2]	NA	NA	2,100	3,260	3,260
Per gram, dendritic, metal[3]	193.60	162.50	208.00	208.00	188.00
Per gram, metal, ingot[4]	124.00	131.00	131.00	131.00	152.00
Per gram, scandium acetate, 99.99% purity[5]	68.70	70.30	74.00	74.00	NA
Per gram, scandium chloride, 99.9% purity[5]	44.30	48.70	48.70	48.70	57.40
Per gram, scandium fluoride, 99.9% purity[5]	188.20	193.80	193.80	193.80	224.20
Per gram, scandium iodide, 99.999% purity[5]	169.00	174.00	174.00	174.00	201.00
Per metric ton, scandium-aluminum alloy[2]	NA	NA	NA	74.00	74.00
Net import reliance[6] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2004-07): Not available.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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 remained stable for the lower grades and increased for the higher purities from those of the previous year. The supply of domestic and foreign scandium remained strong to meet increased demand. Although demand decreased in 2008, the total market remained very small. Domestic decreases in scandium demand were primarily related to recently developed applications in carbon fiber and carbon nanotube technology for baseball and softball bats; however, scandium-aluminum baseball and softball bats remained popular high-end sports equipment, and sports equipment remained the leading use of scandium. New demand is expected to come from future fuel-cell markets and aerospace applications.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7757]**

SCANDIUM

Scandium's use in metal halide lighting continued. 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. 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:[7] Scandium was produced as byproduct material in China, Kazakhstan, Russia, and Ukraine. Foreign mine production data were not available. No scandium was mined in the United States in 2008. 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 are in apatites and eudialytes in the Kola Peninsula and in uranium-bearing deposits in Kazakhstan. 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. Titanium and aluminum high-strength alloys, as well as carbon fiber and carbon nanotube material, may substitute in sporting goods, especially baseball and softball bats and bicycle frames. Light-emitting diodes, also known as LEDs, are beginning to displace halides in industrial lighting, residential safety and street lighting, and buoys and maritime lamp applications.

[e]Estimated. NA Not available.
[1]See also Rare Earths.
[2]Scandium oxide as a white powder and scandium-aluminum master alloy with a 2% scandium metal content in metric quantities from Stanford Materials Corporation.
[3]Scandium pieces, 99.9% purity, distilled dendritic; 2004-07 prices converted from 0.5-gram price, and 2008 price from 2-gram price, from Alfa Aesar, a Johnson Matthey company.
[4]Metal ingot pieces, 99.9% purity, 2004-08, from Alfa Aesar, a Johnson Matthey company.
[5]Acetate, chloride, and fluoride, in crystalline or crystalline aggregate form and scandium iodide as ultradry powder from Alfa Aesar, a Johnson Matthey company. Fluoride price converted from 5-gram quantity.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]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, and glass 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. Historically, the primary electronic use was 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. Selenium is also used in thin-film photovoltaic copper indium gallium diselenide (CIGS) solar cells.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, refinery	W	W	W	W	W
Imports for consumption, metal and dioxide	412	589	409	544	585
Exports, metal, waste and scrap	160	254	191	562	640
Consumption, apparent	W	W	W	W	W
Price, dealers, average, dollars per pound, 100-pound lots, refined	24.86	51.44	24.57	32.90	33.00
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 estimated to be very small because most scrap xerographic and electronic materials were exported for recovery of the contained selenium.

Import Sources (2004-07): Belgium, 45%; Canada, 15%; Germany, 10%; Philippines, 10%; and other, 20%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
Selenium metal	2804.90.0000	Free.
Selenium dioxide	2811.29.2000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Micheal W. George [(703) 648-4962, mgeorge@usgs.gov, fax: (703) 648-7757]**

SELENIUM

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. Estimated domestic selenium production increased in 2008 compared with that of 2007.

China, which remains the leading consumer of selenium, 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 increased in 2007 and in the first half of 2008 owing to increases in consumption from the manganese refining industry.

Domestic use of selenium in glass and 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. An increased interest in solar cell technologies has increased the consumption of selenium in CIGS solar cells.

World Refinery Production, Reserves, and Reserve Base: Reserve and reserve base estimates for Chile were revised upward based on new information from company reports.

	Refinery production		Reserves[2]	Reserve base[2]
	2007	2008[e]		
United States	W	W	10,000	19,000
Belgium	200	200	—	—
Canada	120	120	6,000	10,000
Chile	75	75	20,000	40,000
Finland	60	60	—	—
India	14	15	—	—
Japan	806	840	—	—
Peru	75	75	5,000	8,000
Philippines	65	65	2,000	3,000
Sweden	20	20	—	—
Other countries[3]	123	120	43,000	92,000
World total (rounded)	[4]1,560	[4]1,590	86,000	172,000

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. An assessment of U.S. copper resources indicated that total copper resources in identified and undiscovered resources totals about 550 million metric tons, almost eight 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. 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 2008 was about $87 billion. Four companies produced silicon materials in six plants. Of those companies, three produced ferrosilicon in four plants. Silicon metal was produced by two companies in four plants. Two of the four companies in the industry produced both products at two plants. All of the 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 part 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 small percentage of silicon demand.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Ferrosilicon, all grades[1]	128	125	146	155	166
Silicon metal	147	145	W	W	W
Imports for consumption:					
Ferrosilicon, all grades[1]	173	197	223	208	220
Silicon metal	165	152	146	147	175
Exports:					
Ferrosilicon, all grades[1]	6	8	5	7	11
Silicon metal	18	23	27	28	35
Consumption, apparent:					
Ferrosilicon, all grades[1]	297	317	360	359	374
Silicon metal	291	275	W	W	W
Price,[2] average, cents per pound Si:					
Ferrosilicon, 50% Si	58.2	55.0	62.9	74.0	118
Ferrosilicon, 75% Si	55.4	48.0	54.9	65.6	110
Silicon metal	81.9	76.2	79.3	113	119
Stocks, producer, yearend:					
Ferrosilicon, all grades[1]	15	13	16	14	14
Silicon metal	7	6	W	W	W
Net import reliance[3] as a percentage of apparent consumption:					
Ferrosilicon, all grades[1]	57	61	59	58	56
Silicon metal	50	47	<50	<50	<50

Recycling: Insignificant.

Import Sources (2004-07): Ferrosilicon: China, 42%; Russia, 18%; Venezuela, 17%; Canada, 8%; and other, 15%. Silicon metal: Brazil, 38%; South Africa, 25%; Canada, 17%; Norway, 6%; and other, 14%. Total: China, 24%; Brazil, 18%; Canada, 12%, South Africa, 11%; and other, 35%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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.
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.

Depletion Allowance: Quartzite, 14% (Domestic and foreign); gravel, 5% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Lisa A. Corathers [(703) 648-4973, lcorathers@usgs.gov, fax: (703) 648-7757]**

SILICON

Events, Trends, and Issues: Domestic ferrosilicon production in 2008, expressed in terms of contained silicon, was expected to increase by 7% from that of 2007. Through the first 8 months of 2008, spot market prices trended upward in the U.S. market for silicon materials, owing to increased demand for ferrosilicon in steelmaking, increased Chinese ferrosilicon export prices, increased demand for silicon metal production, and decreased silicon metal imports from Brazil and South Africa—the largest foreign suppliers of silicon metal to the United States. However, U.S. spot market prices for silicon materials declined in September and October, primarily because of decreasing demand caused by global financial problems that began during the third quarter of 2008.

Demand for silicon metal comes primarily from the aluminum and chemical industries. Domestic secondary aluminum production—the primary materials source for aluminum-silicon alloys—was projected to decrease by 13% in 2008. In the first 7 months of 2008, domestic chemical production was nearly unchanged compared with that in 2007. Domestic apparent consumption of ferrosilicon in 2008 was projected to increase by 4% compared with that of 2007. 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, and through the first nine months of 2008, domestic steel production was 4% higher than that of the same period in 2007.

Two major developments affected the global supply of silicon materials. Production of silicon materials in Norway increased to an estimated 340,000 tons in 2008 from 221,000 tons in 2007, owing primarily to high ferrosilicon production levels. This was offset somewhat by the significant decrease (22%) in Ukraine’s ferrosilicon and silicon metal production compared with that of 2007.

World Production, Reserves, and Reserve Base:

	Production[e, 4]		Reserves and reserve base[5]
	2007	2008	
United States[6]	155	166	The reserves and reserve base in most major producing countries are ample in relation to demand. Quantitative estimates are not available.
Brazil	265	270	
Canada	66	66	
China	3,300	3,300	
France	164	160	
Iceland	74	74	
India	39	39	
Kazakhstan	68	68	
Macedonia	39	39	
Norway	221	340	
Russia	635	640	
South Africa	149	140	
Spain	78	78	
Ukraine	109	85	
Venezuela	61	60	
Other countries	180	180	
World total (rounded)	5,590	5,700	

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, the United States, and South Africa, and for silicon metal, China, Brazil, France, and Norway. China was by far the leading producer of both ferrosilicon (2,700,000 tons) and silicon metal (560,000 tons) in 2008.

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 2008, approximately 1,120 tons of silver with an estimated value of $570 million was produced in the United States. Silver was produced as a byproduct from 31 base- and precious-metal mines. Alaska continued as the country's leading silver-producing State, followed by Nevada; however, company production data are proprietary and were withheld. There were 21 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. Silver's traditional use categories include coins and medals, industrial applications, jewelry and silverware, and photography. The physical properties of silver include ductility, electrical conductivity, malleability, and reflectivity. The demand for silver in industrial applications continues to increase and includes use of silver in bandages for wound care, batteries, brazing and soldering, in catalytic converters in automobiles, in cell phone covers to reduce the spread of bacteria, in clothing to minimize odor, electronics and circuit boards, electroplating, hardening bearings, inks, mirrors, solar cells, water purification, and wood treatment to resist mold. Silver was used for miniature antennas in Radio Frequency Identification Devices (RFIDs) that were used in casino chips, freeway toll transponders, gasoline speed purchase devices, passports, and on packages to keep track of inventory shipments. Mercury and silver, the main components of dental amalgam, are biocides and their use in amalgam inhibits recurrent decay.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Mine	1,250	1,230	1,140	1,260	1,120
Refinery:					
Primary	1,140	2,530	3,150	4,110	2,500
Secondary (old scrap)	1,920	980	1,500	1,540	1,550
Imports for consumption[2]	4,100	4,540	4,820	4,980	4,550
Exports[2]	422	319	1,670	780	520
Consumption, apparent[e]	6,700	7,560	7,550	6,880	6,740
Price, dollars per troy ounce[3]	6.69	7.34	11.61	13.38	15.85
Stocks, yearend:					
Treasury Department[4]	220	220	220	220	220
COMEX, CBT[5]	3,580	3,750	4,000	4,125	4,090
Exchange Traded Fund[6]	—	—	3,330	3,890	5,290
Employment, mine and mill,[7] number	900	900	900	900	850
Net import reliance[8] as a percentage of apparent consumption[e]	54	54	38	59	60

Recycling: In 2008, approximately 1,600 tons of silver was recovered from old and new scrap. This includes 60 to 90 tons of silver that is reclaimed and recycled annually from photographic wastewater.

Import Sources (2004-07):[2] Mexico, 50%; Canada, 31%; Peru, 13%; Chile, 2%; and other, 4%.

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.

Prepared by **William E. Brooks [(703) 648-7791, wbrooks@usgs.gov, fax: (703) 648-7757]**

SILVER

Events, Trends, and Issues: In 2008, silver prices averaged $15.85 per troy ounce and rose to the highest average annual price since 1980. Prices rose to $20.92 in March, which was more than 20% higher than the previous year's high of $15.82 per troy ounce established in November 2007. The overall rise in silver prices corresponded to investment interest in several new silver exchange traded funds (ETF) that have opened since the first silver ETF was established in April 2006. At the end of 2007, silver ETF inventories totaled approximately 5,290 tons of silver and rose to more than 6,000 tons by July 2008. Consumption of silver also continued to rise for industrial applications. In the United States, demand for photography fell to 1,120 tons since peaking in 1999 at 2,290 tons. Silver is still used in x-ray films; however, many hospitals have begun to use digital systems. Approximately 99% of the silver in photographic wastewater may be recycled. Silver demand for industrial applications increased while demand for silver in photography, jewelry, silverware, and coins and metals decreased. Use of silver increased to help regulate body heat and to control odor in shoes and sports and everyday clothing. The use of trace amounts of silver in bandages for wound care and minor skin infections is also increasing. World silver mine production increased to 20,900 tons in response to increased production at new and existing polymetallic mines, such as Greens Creek in Alaska, the San Cristobal Mine in Bolivia, and the Uchucchacua Mine in Peru.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[9]	Reserve base[9]
	2007	2008[e]		
United States	1,260	1,120	25,000	80,000
Australia	1,880	1,800	31,000	37,000
Canada	800	800	16,000	35,000
Chile	1,900	2,000	NA	NA
China	2,560	2,600	26,000	120,000
Mexico	3,000	3,000	37,000	40,000
Peru	3,500	3,600	36,000	37,000
Poland	1,200	1,300	51,000	140,000
South Africa	70	70	NA	NA
Other countries	4,630	4,600	50,000	80,000
World total (rounded)	20,800	20,900	270,000	570,000

World Resources: Silver was obtained as a byproduct from processing and smelting copper, gold, and lead-zinc ores. Ores from these polymetallic deposits account for more than two-thirds of U.S. and world resources of silver; the remaining silver resources are associated with veins and submicroscopic gold deposits in which gold is the primary commodity. Most recent silver discoveries have been associated with gold occurrences; however, base-metal occurrences that contain byproduct silver will continue to account for a significant share of future reserves and resources. Peru, Mexico, and China are the world's leading producers of silver, in descending order of production.

Substitutes: Digital imaging, film with reduced silver content, silverless black-and-white film, and xerography substitute for silver that has traditionally been used in black-and-white as well as color printing applications. Surgical pins and plates may be made with tantalum and titanium in place of silver. Stainless steel may be substituted for silver flatware, and germanium added to silver flatware will make it tarnish resistant. Nonsilver batteries may replace silver batteries in some applications. Aluminum and rhodium may be used to replace silver that was traditionally used in mirrors and other reflecting surfaces. Silver may be used to replace more costly metals in catalytic converters for off-road vehicles.

[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]Held in United Kingdom by ETF Securities and iShares Silver Trust and in Switzerland by Zürcher Kantonalbank.
[7]Source: U.S. Department of Labor, Mine Safety and Health Administration.
[8]Defined as imports – exports + adjustments for Government and industry stock changes.
[9]Includes silver recoverable from base-metal ores. See Appendix C for definitions.

SODA ASH

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: The total value of domestic soda ash (sodium carbonate) produced in 2008 was estimated to be about $1.4 billion.[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 2007 reported data, the estimated 2008 distribution of soda ash by end use was glass, 49%; chemicals, 30%; soap and detergents, 8%; distributors, 5%; miscellaneous uses, 3%; flue gas desulfurization and water treatment, 2% each; and pulp and paper, 1%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production[2]	11,000	11,000	11,000	11,100	11,200
Imports for consumption	6	8	7	9	15
Exports	4,670	4,680	4,820	5,130	5,200
Consumption:					
Reported	6,260	6,200	6,110	5,940	6,000
Apparent	6,290	6,380	6,100	6,030	6,000
Price:					
Quoted, yearend, soda ash, dense, bulk:					
F.o.b. Green River, WY, dollars per short ton	105.00	155.00	155.00	155.00	260.00
F.o.b. Searles Valley, CA, same basis	130.00	180.00	180.00	180.00	285.00
Average sales value (natural source), f.o.b. mine or plant, dollars per short ton	63.75	80.19	96.64	103.53	115.00
Stocks, producer, yearend	338	243	290	206	200
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 (2004-07): United Kingdom, 36%; Mexico, 27%; China, 17%; Germany, 8%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Disodium carbonate	2836.20.0000	1.2% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: A major soda ash manufacturer in India purchased a United States chemical company for $1.05 billion that included a 75% interest in the company's Wyoming soda ash operation. The Indian company also had soda ash production facilities in India, Kenya, the Netherlands, and the United Kingdom. As a result of the acquisition, the U.S. soda ash industry for the first time was no longer a U.S. majority-owned industry, with foreign ownership now accounting for 60% of total domestic nameplate capacity. The same Indian soda ash company proposed to develop the natural soda ash deposit at Lake Natron in Tanzania, which is the breeding ground for 75% of the world's Lesser Flamingo bird population. The proposed project would produce 500,000 tons of soda ash; however, there were concerns about the plant's environmental impact on the flamingos.

The leading U.S. soda ash producer in Wyoming announced it would restart the remaining 700,000 tons of mothballed capacity at its Granger facility by 2012. U.S. export sales have risen as world market conditions have improved for soda ash. Global energy consumption has increased, and that caused soda ash production costs and transportation costs to rise accordingly for all soda ash producers. In the United States, the industry announced an increase of $50 per short ton in May 2008 for the list and off-list price of bulk soda ash, and a $40-per-short-ton increase in August.

Prepared by **Dennis S. Kostick [(703) 648-7715, dkostick@usgs.gov, fax: (703) 648-7757]**

SODA ASH

A joint venture between a major United States soda ash producer and Saudi Arabia's largest glass container manufacturer was formed in February 2008. A synthetic soda ash plant with an annual production capacity of 900,000 tons was to be built in Saudi Arabia with the first phase of construction to be completed by 2010. Salt, limestone, and energy would be supplied from local sources.

The adverse economic conditions in domestic automobile production and housing starts that affected soda ash consumption in the flat glass and fiberglass sectors in 2007 continued through 2008. 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 2009.

World Production, Reserves, and Reserve Base:

	Production		Reserves[4, 5]	Reserve base[5]
Natural:	2007	2008[e]		
United States	11,100	11,200	[6]23,000,000	[6]39,000,000
Botswana	250	250	400,000	NA
Kenya	370	380	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)	11,700	11,800	24,000,000	40,000,000
World total, synthetic (rounded)	33,300	34,200	XX	XX
World total (rounded)	45,000	46,000	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. This 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, only 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. Nine companies operating 11 plants in 9 States recovered byproduct sodium sulfate from various manufacturing processes or products, including battery reclamation, cellulose, resorcinol, silica pigments, and sodium dichromate. About one-half of the total output was a byproduct of these plants in 2008. The total value of natural and synthetic sodium sulfate sold was an estimated $40 million. Estimates of U.S. sodium sulfate consumption by end use were soap and detergents, 35%; glass, 18%; pulp and paper, 15%; carpet fresheners and textiles, 4% each; and miscellaneous, 24%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, total (natural and synthetic)[1]	467	309	290	312	320
Imports for consumption	49	75	61	43	70
Exports	138	149	158	101	120
Consumption, apparent (natural and synthetic)	378	235	193	254	270
Price, quoted, sodium sulfate (100% Na_2SO_4), bulk, f.o.b. works, East, dollars per short ton	114	134	134	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 (2004-07): Canada, 75%; Mexico, 17%; China, 3%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
Disodium sulfate:		
Saltcake (crude)	2833.11.1000	Free.
Other:	2833.11.5000	0.4% ad val.
Anhydrous	2833.11.5010	0.4% ad val.
Other	2833.11.5050	0.4% ad val.

Depletion Allowance: Natural, 14% (Domestic and foreign); synthetic, none.

Government Stockpile: None.

Prepared by **Dennis S. Kostick [(703) 648-7715, dkostick@usgs.gov, fax: (703) 648-7757]**

SODIUM SULFATE

Events, Trends, and Issues: In late 2007, a major detergent manufacturer in India purchased the California natural sodium sulfate producer. The domestic ascorbic acid producer, including its byproduct sodium sulfate facility, ceased production in New Jersey. A rayon plant in Tennessee also closed, reducing byproduct sodium sulfate availability. Both facilities had a combined sodium sulfate production capacity of about 71,000 tons per year.

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 2009 is expected to be comparable with that of 2008, with detergents remaining the leading sodium-sulfate-consuming sector. If the winter of 2008-09 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 Bureau 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 $12 billion was produced by 1,450 companies operating 3,620 quarries, 86 underground mines, and 193 sales/distribution yards in 50 States. Leading States, in descending order of production, were Texas, Pennsylvania, Missouri, Georgia, Illinois, Virginia, North Carolina, Florida, Indiana, and Ohio, together accounting for 51% of the total crushed stone output. Of the total crushed stone produced in 2008, about 69% was limestone and dolomite; 15%, granite; 7%, traprock; and the remaining 9% was shared, in descending order of tonnage, by miscellaneous stone, sandstone and quartzite, marble, volcanic cinder and scoria, slate, shell, and calcareous marl. It is estimated that of the 1.36 billion tons of crushed stone consumed in the United States in 2008, 49% was reported by use, 31% was reported for unspecified uses, and 20% of the total consumed was estimated for nonrespondents to the U.S. Geological Survey (USGS) canvasses. Of the 666 million tons reported by use, 83% was used as construction aggregates, mostly for highway and road construction and maintenance; 11%, for cement manufacturing; 2%, for lime manufacturing; 2%, 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 2008 was 926 million tons, a 16% decrease compared with that of the same period of 2007. Third quarter shipments for consumption decreased 18% compared with those of the same period of 2007. 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production	1,630	1,700	1,770	1,600	1,340
Imports for consumption	19	21	20	20	19
Exports	1	1	1	1	1
Consumption, apparent[3]	1,650	1,730	1,790	1,620	1,360
Price, average value, dollars per metric ton	6.08	7.26	8.04	8.66	8.98
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e, 4]	79,600	81,000	82,600	81,900	81,000
Net import reliance[5] as a percentage of apparent consumption	1	1	1	1	1

Recycling: Road surfaces made of asphalt and crushed stone and, to a lesser extent, cement concrete surface layers and structures, were recycled on a limited but increasing basis in most States. Asphalt road surfaces were recycled by 58 companies in 29 States, and concrete was recycled by 50 companies in 22 States. The amount of material recycled increased 25% compared with that in 2007.

Import Sources (2004-07): Canada, 43%; Mexico, 38%; The Bahamas, 17%; and other, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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.

Prepared by **Jason Christopher Willett [(703) 648-6473, jwillett@usgs.gov, fax: (703) 648-7757]**

STONE (CRUSHED)

Events, Trends, and Issues: Crushed stone production was 1.34 billion tons in 2008, a decrease of 16% compared with that of 2007. It is estimated that in 2008, apparent consumption will also decrease by 16% to about 1.36 billion tons. Demand for construction aggregates is anticipated to decrease slightly for 2009 based on the slowdown in activity that some of the principal construction markets have experienced over the last 3 years. Long-term projected increases in construction aggregates demand 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. The underlying factors that would support a rise in f.o.b. and delivered prices of crushed stone are expected to be present in 2009, 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[6]
	2007	2008[e]	
United States	1,600	1,340	Adequate except where special
Other countries[7]	NA	NA	types are needed or where
World total	NA	NA	local shortages exist.

World Resources: Stone resources of the world are very large. Supply of high-purity limestone and dolomite suitable for specialty uses is 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]Includes recycled material.
[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]See Appendix C for definitions.
[7]Reliable production information is not available for other countries 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 1.45 million tons of dimension stone, valued at $288 million, was sold or used by U.S. producers in 2008. Dimension stone was produced by 124 companies, operating 165 quarries, in 35 States. Leading producer States, in descending order by tonnage and value, were Wisconsin, Indiana, Georgia, Vermont, and Massachusetts. These five States accounted for about 59% of the production and contributed about 50% of the value of domestic production. Approximately 35%, by tonnage, of dimension stone sold or used was limestone, followed by granite (32%), miscellaneous stone (17%), sandstone (12%), marble (3%), and slate (1%). By value, the leading sales or uses were for granite (38%), followed by limestone (34%), miscellaneous stone (11%), sandstone (8%), marble (5%), and slate (4%). Dressed stone represented 57% of the tonnage and 66% of the value of all the dimension stone sold or used by domestic producers, including exports. The leading uses and distribution of dressed stone, by tonnage, were in panels and veneer, tile, blackboards, exports, and unlisted and unspecified uses (28%), ashlars and partially squared pieces (21%), and flagging (18%). Rough stone mainly was sold for building and construction (50%) and monuments (18%), by tonnage.

Salient Statistics—United States:[2]	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Sold or used by producers:					
Tonnage	1,460	1,360	1,330	1,390	1,450
Value, million dollars	281	269	265	275	288
Imports for consumption, value, million dollars	1,790	2,180	2,500	2,540	2,500
Exports, value, million dollars	64	66	76	74	74
Consumption, apparent, value, million dollars	2,010	2,380	2,690	2,740	2,710
Price	Variable, depending on type of product				
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)	86	89	90	90	89
Granite only:					
Production	429	416	428	453	450
Exports (rough and finished)	143	135	108	112	112
Price	Variable, depending on type of product				
Employment, quarry and mill, number[3]	1,500	1,500	1,500	1,500	1,500

Recycling: Small amounts of dimension stone were recycled principally by restorers of old stone work.

Import Sources (2004-07 by value): Dimension stone: Italy, 22%; Brazil, 21%; Turkey, 20%; China, 17%; and other, 20%. Granite only: Brazil, 35%; China, 21%; Italy, 19%; India, 15%; and other, 10%.

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 2008. Most crude or rough trimmed stone was imported at 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.

Prepared by **Thomas P. Dolley [(703) 648-7710, tdolley@usgs.gov, fax: (703) 648-7757]**

STONE (DIMENSION)

<u>Events, Trends, and Issues</u>: The United States is the world's largest market for dimension stone. Imports of dimension stone decreased slightly in value to about $2.5 billion compared with those of 2007. Dimension stone exports remained level at about $74 million. Apparent consumption, by value, was $2.71 billion in 2008—a $30 million, or 1%, decrease from that of 2007. Dimension stone for construction and refurbishment is being used commonly in both commercial and residential markets. The global economic downturn will pose a challenge to increased demand, domestic production, and imports of dimension stone in the near term.

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

	Mine production		Reserves and reserve base[5]
	2007	2008[e]	
United States	1,390	1,450	Adequate except for certain
Other countries	NA	NA	special types and local
World total	NA	NA	shortages.

<u>World Resources</u>: 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.

<u>Substitutes</u>: In certain 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. Estimates of primary strontium compound end uses in the United States were pyrotechnics and signals, 30%; ferrite ceramic magnets, 30%; master alloys, 10%; pigments and fillers, 10%; electrolytic production of zinc, 10%; and other applications, 10%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production	—	—	—	—	—
Imports for consumption:					
Strontium minerals	2,760	799	671	541	445
Strontium compounds	14,500	11,700	8,860	8,550	8,250
Exports, compounds	552	255	716	720	725
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, apparent, celestite and compounds	16,700	12,200	8,820	8,370	7,750
Price, average value of mineral imports at port of exportation, dollars per ton	53	56	64	67	70
Net import reliance[2] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2004-07): Strontium minerals: Mexico, 100%. Strontium compounds: Mexico, 78%; Germany, 11%; and other, 11%. Total imports: Mexico, 79%; Germany, 10%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Celestite	2530.90.8010	Free.
Strontium metal	2805.19.1000	3.7% ad val.
Compounds:		
Strontium oxide, hydroxide, peroxide	2816.40.1000	4.2% ad val.
Strontium nitrate	2834.29.2000	4.2% ad val.
Strontium carbonate	2836.92.0000	4.2% ad val.

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

Government Stockpile: None.

Prepared by **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

STRONTIUM

Events, Trends, and Issues: China is the world's leading producer of strontium carbonate, with plant capacity of 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 and Spain, 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. Turkey had been another leading celestite producer, but continues to experience significant decline in production.

Strontium demand for cathode ray tubes (CRTs) continues to be strong in Asia and Mexico, but newer television technology is likely to eventually replace CRTs in those markets as well. Although CRTs are still available, 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. Even without strontium carbonate consumption in television glass, estimated strontium consumption in ceramics and glass manufacture remained one of the top end-use industries through its use in ceramic ferrite magnets and other ceramic and glass applications. The use of strontium nitrate in pyrotechnics was estimated to equal the use of strontium carbonate in ferrite magnets.

World Mine Production, Reserves, and Reserve Base:[3]

	Mine production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States	—	—	—	1,400,000
Argentina	20,000	5,000	All other:	All other:
China[e]	190,000	200,000	6,800,000	11,000,000
Iran	—	—		
Mexico	96,900	96,900		
Morocco	2,700	2,700		
Pakistan	2,000	2,100		
Spain	190,000	200,000		
Turkey	9,000	5,000		
World total (rounded)	511,000	512,000	6,800,000	12,000,000

World Resources: Resources of strontium in the United States are several times the reserve base. 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 CRT 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. — 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 2008, elemental sulfur and byproduct sulfuric acid were produced at 114 operations in 29 States and the U.S. Virgin Islands. As a result of dramatically increased prices during the year, total shipments were valued at nearly $1 billion. Elemental sulfur production was 8.4 million tons; Louisiana and Texas accounted for about 45% of domestic production. Elemental sulfur was recovered, in descending order of tonnage, at petroleum refineries, natural-gas-processing plants, and coking plants by 40 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 seven nonferrous smelters in five States by six companies. Domestic elemental sulfur provided 60% of domestic consumption, and byproduct acid accounted for 6%. The remaining 34% 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 about 60% of reported sulfur demand; petroleum refining, 25%; and metal mining, 3%. Other uses, accounting for 12% 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Recovered elemental	9,380	8,790	8,390	8,280	8,400
Other forms	739	711	674	803	800
Total (may be rounded)	10,100	9,500	9,050	9,090	9,200
Shipments, all forms	10,100	9,480	8,960	9,120	9,200
Imports for consumption:					
Recovered, elemental[e]	2,850	2,820	2,950	2,930	3,400
Sulfuric acid, sulfur content	784	877	793	851	1,000
Exports:					
Recovered, elemental	949	684	635	922	740
Sulfuric acid, sulfur content	67	110	79	110	80
Consumption, apparent, all forms	12,800	12,400	12,000	11,900	12,800
Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and/or plant	32.62	30.88	32.85	36.29	100.00
Stocks, producer, yearend	185	160	221	187	200
Employment, mine and/or plant, number	2,700	2,700	2,600	2,600	2,600
Net import reliance[1] as a percentage of apparent consumption	21	24	25	23	28

Recycling: Between 3 million and 5 million tons of spent sulfuric acid was reclaimed from petroleum refining and chemical processes.

Import Sources (2004-07): Elemental: Canada, 71%; Mexico, 16%; Venezuela, 11%; and other, 2%. Sulfuric acid: Canada, 83%; Mexico, 11%; and other, 6%. Total sulfur imports: Canada, 73%; Mexico, 15%; Venezuela, 8%; and other, 4%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
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.

Events, Trends, and Issues: Total U.S. sulfur production and shipments increased slightly compared with those of 2007. Increased domestic production of elemental sulfur from petroleum refineries offset a decline in recovery from natural gas operations. Sulfur recovery from refineries is expected to continue on an upward trend. Recovered sulfur from domestic natural gas processing is expected to continue to decline. Byproduct sulfuric acid production is expected to remain relatively stable, unless one or more of the remaining nonferrous smelters closes. World sulfur production increased slightly and is likely to steadily increase for the foreseeable future. Significantly increased production is expected from sulfur recovery at liquefied natural gas operations in the Middle East and expanded oil sands operations in Canada, unless a downturn in the world economy limits investments in those arenas.

Prepared by **Joyce A. Ober [(703) 648-7717, jober@usgs.gov, fax: (703) 648-7757]**

SULFUR

Elemental sulfur prices reached record highs during the year, skyrocketing to more than 10 times what they had been during much of 2007. High prices were driven by tight supplies that resulted from lower than expected production in the United States, owing to the processing of more lower sulfur crude oil than normal and unplanned outages at refineries. In other parts of the world, slow progress at new petroleum and natural gas developments and increased consumption at phosphate fertilizer operations, because of the increased emphasis placed on agriculture for biofuels production, contributed to high prices. Prices, however, peaked in August and began to decline in October; the downturn was expected to be steeper than the increases. In August, the Tampa, FL, sulfur price reached about $600 per ton and remained at that level throughout September. By the end of November, spot prices in Tampa had declined to about $70 per ton, and further decreases were likely.

Domestic phosphate rock consumption was slightly higher in 2008 than in 2007, which resulted in increased demand for sulfur to process the phosphate rock into phosphate fertilizers; however, demand for sulfur for fertilizers in the rest of the world was higher than that in the United States. High sulfur demand continued in China and India, but decreased sharply in the third quarter, precipitating the price crash. Some Canadian sulfur stocks were remelted to meet increased demand for overseas trade, and high prices made it possible for material in remote areas to be marketed successfully until the market collapsed.

World Production, Reserves, and Reserve Base:

	Production—All forms	
	2007	2008[e]
United States	9,090	9,200
Australia	950	950
Canada	8,967	8,800
Chile	1,573	1,600
China	8,460	8,500
Finland	615	615
France	1,306	1,300
Germany	2,300	2,500
India	1,152	1,200
Iran	1,570	1,600
Italy	740	740
Japan	3,200	3,200
Kazakhstan	2,600	2,600
Korea, Republic of	1,690	1,700
Kuwait	700	700
Mexico	1,770	1,800
Netherlands	530	530
Poland	1,324	1,300
Russia	7,050	7,100
Saudi Arabia	3,100	3,200
South Africa	641	650
Spain	601	600
United Arab Emirates	1,950	2,000
Uzbekistan	520	520
Venezuela	800	800
Other countries	5,230	5,200
World total (rounded)	68,400	69,000

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 of sulfur 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 sulfur 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: Domestic talc production in 2008 was estimated to be 645,000 tons valued at $21 million. There were nine talc-producing mines in five States in 2008. Montana was the leading producer, followed by Texas, Vermont, New York, and California. Sales of talc were estimated to be 619,000 tons valued at $75 million. About 36% of the talc produced domestically was exported in 2008. Talc produced in the United States was used for ceramics, 31%; paper, 21%; paint, 19%; roofing, 8%; plastics, 5%; rubber, 4%; cosmetics, 2%; and other, 10%. About 190,000 tons of talc was imported with more than 75% of the imported talc being used for plastics, cosmetics, and paint applications, in decreasing order by tonnage. Other uses for imported talc included ceramics, paper, and refractory applications. Two companies in North Carolina mined pyrophyllite. Production of pyrophyllite decreased from that of 2007. Consumption was, in decreasing order by tonnage, in refractory products, ceramics, and paint.

Salient Statistics—United States:[1]	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production, mine	833	856	895	769	645
Sold by producers	854	826	900	720	619
Imports for consumption	226	237	314	221	190
Exports	202	198	163	183	220
Shipments from Government stockpile excesses	([2])	—	—	—	([2])
Consumption, apparent	857	895	1,050	807	615
Price, average, processed, dollars per ton	88	86	90	114	121
Employment, mine and mill	404	440	435	430	440
Net import reliance[3] as a percentage of apparent consumption	3	4	14	5	E

Recycling: Insignificant.

Import Sources (2004-07): China, 47%; Canada, 34%; Japan, 7%; France, 5%; and other, 7%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
Not crushed, not powdered	2526.10.0000	Free.
Crushed or 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—9-30-08[4]
(Metric tons)

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2008**	**Disposals FY 2008**
Talc, block and lump	867	867	[5]907	—
Talc, ground	622	622	([6])	430

Prepared by **Robert L. Virta [(703) 648-7726, rvirta@usgs.gov, fax: (703) 648-7757]**

TALC AND PYROPHYLLITE

Events, Trends, and Issues: Production of talc declined 16% and sales decreased 14% from those of 2007. U.S. exports of talc increased 20% from those of 2007. Canada remained the major destination for U.S. talc exports, accounting for 48% of the tonnage. Mexico was another significant importer of U.S. talc, accounting for 12% of the export tonnage. The lower value of the U.S. dollar with respect to other currencies has helped to boost export sales in 2007 and 2008. U.S. imports decreased 14% from those of 2007. In 2008, Canada and China supplied approximately 83% of the imported talc. Apparent consumption decreased by 24% in 2008. The declines in the housing market resulted in lower sales to construction-related applications such as adhesives, caulks, ceramic tile, joint compounds, paint, roofing, rubber, and sealants. These are markets on which talc producers are strongly dependent for domestic sales. The continued slowdown of the U.S. and world economies and tightening of the credit market may exacerbate the situation. U.S. talc production, sales, and apparent consumption may experience slight additional declines until the housing market improves. In 2008, U.S. apparent consumption declined below 700,000 tons for the first time since 1976.

A major talc producer in New York announced that it would stop production by the end of 2008. The company cited declines in sales as the reason for its departure from the talc market after about 60 years of mining in the State.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	2007	2008[e]		
United States[1]	769	645	140,000	540,000
Brazil	400	405	180,000	250,000
China	2,400	2,400	Large	Large
Finland	550	550	Large	Large
India	642	660	4,000	9,000
Japan	275	375	100,000	160,000
Korea, Republic of	744	740	14,000	18,000
Other countries	1,840	1,800	Large	Large
World total (rounded)	7,620	7,580	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. E Net exporter. — 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 block and lump talc and ground talc.
[6]Included in block and lump talc.
[7]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. Companies in the United States 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 2007 was estimated at about $162 million and was expected to be about $190 million in 2008 as measured by the value of imports.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production:					
Mine	—	—	—	—	—
Recycling	NA	NA	NA	NA	NA
Imports for consumption[e, 1]	1,540	1,630	1,160	1,160	1,200
Exports[e, 1]	984	984	949	511	600
Government stockpile releases[e, 2]	127	210	289	—	—
Consumption, apparent	679	852	498	644	600
Price, tantalite, dollars per pound of Ta_2O_5 content[3]	30	35	32	36	36
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	100

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.

Import Sources (2004-07): Tantalum contained in niobium (columbium) and tantalum ore and concentrate; tantalum metal; and tantalum waste and scrap—Australia, 18%; China, 14%; Brazil, 12%; Japan, 10%; and other, 46%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Synthetic tantalum-niobium concentrates	2615.90.3000	Free.
Tantalum ores and concentrates	2615.90.6060	Free.
Tantalum oxide[5]	2825.90.9000	3.7% ad val.
Potassium fluotantalate[5]	2826.90.9000	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:[6] 22% (Domestic), 14% (Foreign).

Government Stockpile: In fiscal year (FY) 2008 (October 1, 2007, through September 30, 2008), the Defense National Stockpile Center (DNSC), Defense Logistics Agency, sold no tantalum materials. DNSC announced maximum disposal limits for FY 2009 of about 3.63 tons[7] of tantalum contained in tantalum carbide powder. DNSC exhausted stocks of tantalum minerals in FY 2007; metal powder in FY 2006; metal oxide in FY 2006; and metal ingots in FY 2005.

Stockpile Status—9-30-08[6]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Tantalum carbide powder	1.73	1.73	[7]3.63	—

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

TANTALUM

Events, Trends, and Issues: U.S. tantalum apparent consumption in 2008 was estimated to decrease about 7% from that of 2007. Tantalum ore and concentrate, metals, and waste and scrap were the leading imported tantalum materials, with each accounting for approximately equal amounts of tantalum. By weight, tantalum mineral concentrate imports for consumption were supplied 77% by Australia and 20% by Canada; metal, 24% by Brazil and 13% each by China and Japan; and waste and scrap, 18% by Australia, 14% by China, and 12% by Brazil. Capital market problems and the subsequent economic slowdown were expected to result in reduced tantalum material consumption, price, and production.

World Mine Production, Reserves, and Reserve Base:

	Mine production[8]		Reserves[9]	Reserve base[9]
	2007	2008[e]		
United States	—	—	—	Negligible
Australia	435	435	40,000	84,000
Brazil	180	180	88,000	90,000
Canada	45	45	3,000	3,000
Ethiopia	77	77	NA	NA
Rwanda	42	42	NA	NA
Other countries[10]	36	36	NA	NA
World total (rounded)	815	815	130,000	180,000

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 2008 prices.

Substitutes: The following materials can be substituted for tantalum, but usually with less effectiveness: niobium in carbides; aluminum and ceramics in electronic capacitors; glass, niobium, platinum, titanium, and zirconium in corrosion-resistant equipment; and hafnium, iridium, molybdenum, niobium, rhenium, and tungsten in high-temperature applications.

[e]Estimated. NA Not available. — Zero.
[1]Imports and exports include the estimated tantalum content of niobium and tantalum ores and concentratres, unwrought tantalum alloys and powder, tantalum waste and scrap, and other tantalum articles.
[2]Disposals reported by DNSC, net quantity (uncommitted inventory).
[3]Price is an average based on trade journal reported prices.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]This category includes other than tantalum-containing material.
[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]Includes Burundi, Congo (Kinshasa), Nigeria, Uganda, and Zimbabwe.

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 in Texas, 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 was increasingly used in the production of cadmium-tellurium-based solar cells. 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:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, refinery	W	W	W	W	W
Imports for consumption, unwrought, waste and scrap	63	42	31	44	90
Exports	6	51	4	15	50
Consumption, apparent	W	W	W	W	W
Price, dollars per kilogram, 99.95% minimum[1]	13	96	89	82	215
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 very small amount is recovered from scrapped selenium-tellurium photoreceptors employed in older plain paper copiers in Europe.

Import Sources (2004-07): Belgium, 35%; Canada, 25%; China, 13%; Philippines, 10%; and other, 17%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Tellurium	2804.50.0020	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Micheal W. George [(703) 648-4962, mgeorge@usgs.gov, fax: (703) 648-7757]**

TELLURIUM

Events, Trends, and Issues: Estimated domestic tellurium production increased in 2008 as compared with that of 2007. Though detailed information on the world tellurium market was not available, world tellurium consumption was estimated to have increased significantly in 2008. There was a sharp increase in demand for high-purity tellurium for cadmium telluride solar cells. Tellurium consumption also increased in thermal cooling applications. The price of tellurium increased in 2008 because growth in consumption worldwide, partially in solar cell manufacturing, was not matched by growth in production. World production of tellurium, a byproduct of copper refining, was believed to have increased owing to an increase in world copper production. Production in Japan was solely from scraped photocopier drums, and in 2007 and 2008 there was no production. Selenium, a coproduct that was in strong demand, experienced a slight increase in production from waste and anode slimes that also contained tellurium.

World Refinery Production, Reserves, and Reserve Base: Reserve and reserve base estimates for Peru were revised upward based on new information from company reports.

	Refinery production		Reserves[3]	Reserve base[3]
	2007	2008[e]		
United States	W	W	3,000	6,000
Canada	8	8	700	1,500
Peru	33	30	2,300	3,700
Other countries[4]	NA	NA	16,000	37,000
World total (rounded)	NA	NA	22,000	48,000

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. With increased concern for supply of tellurium, companies are investigating other potential resources, such as gold telluride and lead-zinc ores with higher concentrations of tellurium, which are not included in estimated world resources.

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 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.

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:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production, mine	([1])	([1])	([1])	([1])	([1])
Imports for consumption (gross weight)					
Unwrought powders	117	23	—	—	470
Formed and articles	98	212	530	901	450
Waste and scrap	110	—	—	—	—
Total	325	235	530	901	920
Exports (gross weight)					
Unwrought powders	224	209	—	155	60
Formed and articles	965	43	229	258	280
Waste and scrap	—	—	—	190	200
Total	1,190	252	229	603	540
Consumption[e]	900	300	300	300	380
Price, metal, dollars per kilogram[2]	1,600	1,900	4,650	4,560	4,900
Net import reliance[e, 3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2004-07): Russia, 72%; Netherlands, 14%; Belgium, 9%, and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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 price for thallium metal remained high in 2008 as the supply worldwide continued to be relatively tight. The average price for high-purity granules and rod increased by about 7% in 2008 and has tripled during the past 4 years. China continued its policy of eliminating toll trading tax benefits on exports of thallium that began in 2006, thus contributing to the shortage on the world market. Higher internal demand for many metals, including thallium, has prompted China to begin importing greater quantities of thallium. Kazakhstan recently proposed a new tax code for all metals that included a 6% mineral extraction tax on thallium. In 2008, a Polish zinc producer announced that it was in the process of building a new thallium sulfide plant, which was expected to be commissioned in early 2009.

Research and development activities of both a basic and applied nature that could expand the use of thallium were conducted during 2008. Researchers invented a new thermoelectric material that has the potential to make automobiles more efficient by converting heat wasted through engine exhaust into electricity. It is estimated that nearly 60% of the energy produced by a typical gasoline engine is lost through waste heat that escapes in engine exhaust. The new material, thallium-doped lead telluride, is more than twice as effective at converting heat energy

Prepared by **David E. Guberman [(703) 648-4977, dguberman@usgs.gov, fax: (703) 648-7757]**

THALLIUM

into electrical energy than the leading thermoelectric material currently used commercially, sodium-doped lead telluride. The material also has potential uses in power generators and heat pumps. Other activities included the development of HTS materials for such applications as magnetic resonance imaging, storage of magnetic energy, and magnetic propulsion. In other research, thallium sulfide thin films of several different compositions were formed on both glass and polyethylene plastic. The photoconductive properties of these thin films may find use in solar batteries and other devices.

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 database. Under its national primary drinking water regulations, the EPA has set an enforceable Maximum Contaminant Level for thallium at 2 parts per billion. All public water supplies must abide by these regulations. The EPA continues to conduct studies at its National Risk Management Research Laboratory (NRMRL) to develop and promote technologies that protect and improve human health and the environment. Studies were conducted recently at NRMRL on methods to remove thallium from mine wastewaters.

World Mine Production, Reserves, and Reserve Base:[4]

	Mine production		Reserves[5]	Reserve base[5]
	2007	2008[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.

Although 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.

Nonpoisonous substitutes like tungsten compounds are being marketed as substitutes for thallium in high-density liquids for sink-float separation of minerals.

[e]Estimated. — Zero.
[1]No reported mine production; flue dust and residues from base-metal smelters, from which thallium metal and compounds may be recovered, are 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 2008, 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 catalysts, high-temperature ceramics, and welding electrodes. Thorium's use in most products has generally decreased because of its naturally occurring radioactivity. The value of thorium alloys, compounds, and metal used by the domestic industry was estimated to have decreased to about $155,000 from $318,000 in 2007.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production, refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	—	—	10.0	—	—
Thorium ore and concentrates (monazite), ThO_2 content	—	—	0.70	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	5.32	4.93	48.6	6.37	9.77
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	3.94	3.65	36.0	4.71	7.23
Exports:					
Thorium ore and concentrates (monazite), gross weight	18	—	—	1	68
Thorium ore and concentrates (monazite), ThO_2 content	0.72	—	—	0.04	3.36
Thorium compounds (oxide, nitrate, etc.), gross weight	0.73	0.74	1.09	1.63	0.98
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	0.54	0.55	0.81	1.21	0.72
Shipments from Government stockpile excesses ($ThNO_3$)	—	—	—	—	—
Consumption:					
Reported, (ThO_2 content)	NA	NA	NA	NA	NA
Apparent	3.40	3.10	35.2	3.50	6.51
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	175.00	NA	NA
99.99% purity[4]	107.25	107.25	107.25	200.00	300.00
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2004-07): Monazite: Canada, 100%. Thorium compounds: United Kingdom, 67%; France, 31%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Thorium ores and concentrates (monazite)	2612.20.0000	Free.
Thorium compounds	2844.30.1000	5.5% ad val.

Depletion Allowance: Monazite, 22% on thorium content, 14% on rare-earth and yttrium content (Domestic); 14% (Foreign).

Government Stockpile: None.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7757]**

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 2008. 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 2007, according to the U.S. Geological Survey's canvass of mines and processors. In 2008, thorium consumption was believed to be primarily in catalysts, microwave tubes, and optical equipment and was estimated to have increased.

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.

On the basis of data through August 2008, the average value of imported thorium compounds increased to $158.82 per kilogram from the 2007 average of $50.43 per kilogram (gross weight). The average value of exported thorium compounds decreased to $214.82 per kilogram based on data through August 2008, compared with the 2007 average value of $249.74.

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

	Refinery production 2007	Refinery production 2008	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, yttrium, and zirconium 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 in 1997.
[3]Source: Rhodia Canada, Inc., and Rhodia Electronics and Catalysis, Inc., f.o.b. port of entry, duty paid, ThO_2 basis, 2004 to 2008.
[4]Source: Rhodia Electronics and Catalysis, Inc., 1- to 950-kilogram quantities, f.o.b. port of entry, duty paid. In 2007, Rhodia ceased sales of its 99.9% purity thorium oxide.
[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 86% of the primary tin consumed domestically in 2008. The major uses were as follows: cans and containers, 26%; electrical, 24%; construction, 11%; transportation, 11%; and other, 28%. On the basis of the average New York composite price, the estimated values of some critical items in 2008 were as follows: primary metal consumed, $1.3 billion; imports for consumption, refined tin, $1.4 billion; and secondary production (old scrap), $301 million.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production:					
Secondary (old scrap)	5,240	11,800	11,600	11,200	12,000
Secondary (new scrap)	3,590	2,280	2,340	2,800	2,600
Imports for consumption, refined tin	47,600	37,500	43,300	46,600	51,600
Exports, refined tin	3,650	4,330	5,490	5,100	4,700
Shipments from Government stockpile excesses	10,600	8,368	8,409	4,540	60
Consumption, reported:					
Primary	36,700	32,200	42,600	43,000	46,000
Secondary	7,990	9,170	11,900	11,000	10,000
Consumption, apparent	58,800	54,700	57,500	57,500	59,500
Price, average, cents per pound:					
New York market	409	361	419	680	951
New York composite	547	483	565	899	1,240
London	385	334	398	692	924
Kuala Lumpur	385	334	398	692	924
Stocks, consumer and dealer, yearend	8,980	8,270	9,000	8,700	8,200
Net import reliance[1] as a percentage of apparent consumption	92	78	79	81	80

Recycling: About 15,000 tons of tin from old and new scrap was recycled in 2008. Of this, about 12,000 tons was recovered from old scrap at 2 detinning plants and 84 secondary nonferrous metal processing plants.

Import Sources (2004-07): Peru, 46%; Bolivia, 14%; China, 14%; 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), Defense Logistics Agency, 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 2008 (October 1, 2007, through September 30, 2008) remained at 12,000 tons, although inventory levels were approximately 3,800 tons. DNSC planned one long-term negotiated “contract” sale for fiscal year 2008 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. Tin is held in the Federal depot in Hammond, IN. In August 2008, DNSC suspended the sales of several commodities, including tin, until further notice as a result of an ongoing study to address congressional concerns about Department of Defense needs for strategic and critical materials.

Stockpile Status—9-30-08[2]

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2008**	**Disposals FY 2008**
Pig tin	3,850	3,850	12,000	4,320

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

TIN

Events, Trends, and Issues: Apparent consumption of tin in the United States increased an estimated 3% in 2008 compared with that of 2007. The average monthly composite price of tin rose steadily during the first 5 months of 2008, rising from $10.04 per pound in January and reaching $14.54 in May; then the average composite price declined steadily through much of the rest of the year, reaching $12.21 per pound in August. These represented substantially higher prices than those that prevailed in 2007. Higher prices in 2008 were attributed to a combination of increased demand worldwide and erratic supply situations in some countries.

Developments continued in major tin-consuming countries to move to new lead-free solders that usually contain greater amounts of tin then do leaded solders.

Tin producers responded to the higher tin prices in 2008 with tin mine and tin smelter openings and expansions, including ones in Australia, Bolivia, Canada, and Thailand. Tin exploration activity increased, especially in Australia and Canada.

China continued as the world's leading tin producer from both mine and smelter sources, but experienced sporadic difficulty in obtaining feedstock for its smelters. Indonesia, the world's second leading tin producer from both mine and smelter sources, continued to experience some production difficulties, some related to a Government shutdown of possibly illegal production sites.

World Mine Production, Reserves, and Reserve Base: Reserves and reserve base numbers for Malaysia were decreased, after consultation with Malaysian Government sources, to reflect a longtime downward trend in tin mining and exploration.

	Mine production		Reserves[3]	Reserve base[3]
	2007	2008[e]		
United States	—	—	—	40,000
Australia	2,100	2,000	150,000	300,000
Bolivia	16,000	16,000	450,000	900,000
Brazil	10,000	12,000	540,000	2,500,000
China	135,000	150,000	1,700,000	3,500,000
Congo (Kinshasa)	3,500	3,000	NA	NA
Indonesia	102,000	100,000	800,000	900,000
Malaysia	2,500	2,000	500,000	600,000
Peru	39,000	38,000	710,000	1,000,000
Portugal	100	100	70,000	80,000
Russia	2,500	2,000	300,000	350,000
Thailand	100	100	170,000	200,000
Vietnam	3,500	3,500	NA	NA
Other countries	4,000	4,000	180,000	200,000
World total (rounded)	320,000	333,000	5,600,000	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. The value of titanium mineral concentrates consumed in the United States in 2008 was about $600 million. Zircon was a coproduct of mining from ilmenite and rutile deposits. About 94% of titanium mineral concentrates was consumed by domestic titanium dioxide (TiO_2) pigment producers. The remaining 6% was used in welding rod coatings and for manufacturing carbides, chemicals, and metal.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production[2] (rounded)	300	300	300	300	200
Imports for consumption	872	1,000	1,030	1,220	1,210
Exports,[e] all forms	6	14	21	6	10
Consumption, reported[3]	1,494	[e]1,390	[e]1,510	[e]1,600	1,550
Price, dollars per metric ton, yearend:					
Ilmenite, bulk, minimum 54% TiO_2, f.o.b. Australia	81	80	80	107	99
Rutile, bulk, minimum 95% TiO_2, f.o.b. Australia	455	470	475	594	500
Slag, 80%-95% TiO_2[4]	347-466	390-555	402-454	418-457	404-505
Stocks, mine, consumer, yearend	369	NA	NA	NA	NA
Employment, mine and mill, number[e]	300	286	246	220	194
Net import reliance[5] as a percentage of reported consumption	58	71	67	76	77

Recycling: None.

Import Sources (2004-07): South Africa, 52%; Australia, 27%; Canada, 15%; Ukraine, 3%; and other, 3%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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 decreased moderately. While mining continued at Starke, FL, and Stony Creek, VA, mining operations at Green Cove Springs, FL, were limited to reprocessing of tailings to recover zircon. At the Stony Creek mining operation, development of the Brink deposit, located 48 kilometers south of the Old Hickory Mine, was proceeding, and production was expected to begin in the second quarter of 2009.

Prepared by **Joseph Gambogi [(703) 648-7718, jgambogi@usgs.gov, fax: (703) 648-7757]**

TITANIUM MINERAL CONCENTRATES

Global production of titanium mineral concentrates was estimated to have decreased slightly compared with that of 2007. In Vietnam, new government policies were being implemented to cease ilmenite exports, control illegal mining, and promote the development of upgraded products. In Sierra Leone, a dredge capsized, removing about 100,000 tons per year of natural rutile production capacity. In South Africa, production was hindered by mineral processing difficulties, power supply issues, and a water ingress at a slag furnace. New mining projects were being developed in Australia, Canada, Chile, India, Kenya, Madagascar, Mozambique, Senegal, and South Africa.

World Mine Production, Reserves, and Reserve Base: Reserve base estimate for Australia was revised based on new information derived from government and industry reports.

	Mine production		Reserves[6]	Reserve base[6]
	2007	2008[e]		
Ilmenite:				
United States[2]	[7]300	[7]200	6,000	59,000
Australia	1,400	1,250	130,000	150,000
Brazil	127	130	43,000	84,000
Canada[8]	816	900	31,000	36,000
China	550	550	200,000	350,000
India	378	378	85,000	210,000
Mozambique	14	133	16,000	21,000
Norway[8]	377	380	37,000	60,000
South Africa[8]	1,100	1,090	63,000	220,000
Ukraine	290	302	5,900	13,000
Vietnam	254	215	1,600	14,000
Other countries	115	109	66,000	150,000
World total (ilmenite, rounded)	5,720	5,640	680,000	1,400,000
Rutile:				
United States	([9])	([9])	400	1,800
Australia	297	309	22,000	31,000
Brazil	3	3	1,200	2,500
India	20	20	7,400	20,000
Mozambique	—	3	480	570
Sierra Leone	79	95	2,500	3,600
South Africa	108	121	8,300	24,000
Ukraine	57	57	2,500	2,500
Other countries	—	—	400	1,000
World total (rutile, rounded)	[9]564	[9]608	45,000	87,000
World total (ilmenite and rutile, rounded)	6,290	6,250	730,000	1,500,000

World Resources: Ilmenite supplies about 92% 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 10 operations in 10 States. Numerous firms consumed ingot to produce wrought products and castings. In 2008, an estimated 79% of the titanium metal was used in aerospace applications. The remaining 21% was used in armor, chemical processing, marine, medical, power generation, sporting goods, and other nonaerospace applications. The value of sponge metal consumed was about $542 million, assuming an average selling price of $15.93 per kilogram.

In 2008, titanium dioxide (TiO_2) pigment, which was valued at about $3.7 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), 59%; plastic, 24%; paper, 12%; and other, 5%. Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Titanium sponge metal:					
Production	W	W	W	W	W
Imports for consumption	11,900	15,800	24,400	25,900	24,000
Exports	2,410	1,910	1,380	2,000	2,400
Shipments from Government stockpile excesses	3,910	2,510	—	—	—
Consumption, reported	21,200	26,100	28,400	33,700	34,000
Price, dollars per kilogram, yearend	7.88	11.78	13.58	15.75	15.93
Stocks, industry yearend[e]	7,660	4,330	8,240	7,820	11,000
Employment, number[e]	300	300	350	400	400
Net import reliance[2] as a percentage of reported consumption	66	73	67	72	54
Titanium dioxide:					
Production	1,540,000	1,310,000	1,370,000	1,440,000	1,500,000
Imports for consumption	264,000	341,000	288,000	221,000	200,000
Exports	635,000	524,000	581,000	682,000	770,000
Consumption, apparent	1,170,000	1,130,000	1,080,000	979,000	930,000
Producer price index, yearend	158	172	165	162	178
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number[e]	4,400	4,300	4,300	4,300	4,200
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 33,000 tons in 2008. Estimated use of titanium as scrap and ferrotitanium by the steel industry was about 10,500 tons; by the superalloy industry, 1,200 tons; and, in other industries, 1,400 tons. Old scrap reclaimed totaled about 600 tons.

Import Sources (2004-07): Sponge metal: Kazakhstan, 52%; Japan, 35%; Russia, 6%; China, 4%; and other, 3%. Titanium dioxide pigment: Canada, 32%; China, 13%; Germany, 8%; France, 6%; and other, 41%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-08**
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.
Unwrought titanium metal	8108.20.0000	15.0% ad val.
Titanium waste and scrap metal	8108.30.0000	Free.
Other titanium metal articles	8108.90.3000	5.5% ad val.
Wrought titanium metal	8108.90.6000	15.0% ad val.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Prepared by **Joseph Gambogi [(703) 648-7718, jgambogi@usgs.gov, fax: (703) 648-7757]**

TITANIUM AND TITANIUM DIOXIDE

Events, Trends, and Issues: Domestic production of TiO_2 pigment was an estimated 1.5 million tons, a moderate increase compared with that of 2007. Global production of TiO_2 was estimated to have increased 2% compared with that of 2007. TiO_2 pigment capacity expansions that were underway included those in Kwinana, Australia (50,000 tons per year, 2010), Orissa, India (40,000 tons per year, 2013), Yanbu, Saudi Arabia (92,000 tons per year, 2009), and Greatham, United Kingdom (50,000 tons per year, 2009). China's TiO_2 pigment production capacity was expected to rise to 1,500,000 tons per year by 2012. In France, the 65,000-ton-per-year Le Havre TiO_2 pigment plant was shut down owing to its high cost to operate. Rising prices for chlorine, energy, and sulfur increased manufacturing costs for TiO_2 pigment producers.

Almost all titanium metal producers were in the process of expanding sponge capacity to meet rising demand from aerospace and industrial uses. However, delays in two major aircraft programs resulted in lower prices for titanium metal products and delays in some capacity expansion programs. In Albany, OR, sponge capacity was increased to 9,980 tons per year. In Hamilton, MS, commissioning of a 9,070-ton-per-year sponge plant was delayed from 2010 to 2011. In Henderson, NV, sponge capacity was increased to 12,600 tons per year. In Rowley, UT, a new 10,900-ton-per-year sponge plant was expected to begin producing in 2009. In New Johnsonville, TN, capacity to produce titanium tetrachloride—the chemical intermediate used to produce titanium metal, TiO_2 pigment, and other compounds—was expanded by 45,000 tons per year. China's sponge capacity was expected to rise to 150,000 tons per year by 2012. In India, plans were underway to construct a 10,000-ton-per-year titanium sponge plant by 2009. Japan's sponge capacity was expected to rise to 66,000 tons per year by 2011. Russian production capacity was expected to increase to 46,500 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 2008[3]	
	2007	2008[e]	Sponge	Pigment
United States	W	W	23,100	1,580,000
Australia	—	—	—	241,000
Belgium	—	—	—	74,000
Canada	—	—	—	90,000
China[e]	45,200	55,000	78,000	900,000
Finland	—	—	—	130,000
France	—	—	—	125,000
Germany	—	—	—	440,000
Italy	—	—	—	80,000
Japan	38,900	39,000	40,000	317,000
Kazakhstan[e]	25,400	26,000	26,000	1,000
Mexico	—	—	—	125,000
Russia[e]	34,200	36,000	36,000	20,000
Spain	—	—	—	80,000
Ukraine[e]	9,200	10,000	10,000	120,000
United Kingdom	—	—	—	290,000
Other countries	—	—	—	670,000
World total (rounded)	[4]153,000	[4]166,000	213,000	5,280,000

World Resources:[5] 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. Aluminum, nickel, specialty steels, and zirconium alloys may be substituted for titanium for applications that require corrosion resistance. 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]Operating capacity.
[4]Excludes U.S. production.
[5]See Appendix C for definitions.

TUNGSTEN

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

Domestic Production and Use: Limited shipments of tungsten concentrates were made from a California mine in 2008. Approximately eight companies in the United States processed tungsten concentrates, ammonium paratungstate, tungsten oxide, and/or scrap to make tungsten powder, tungsten carbide powder, and/or tungsten chemicals. One of these companies announced that it planned to expand its tungsten processing plant in Pennsylvania. Nearly 60 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 construction, metalworking, mining, and oil- and gas-drilling 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 2008 was $560 million.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production:					
Mine	—	—	—	W	W
Secondary	4,000	4,650	4,450	4,310	5,000
Imports for consumption:					
Concentrate	2,310	2,080	2,290	3,880	3,800
Other forms	8,240	9,070	9,700	9,050	8,900
Exports:					
Concentrate	43	52	130	109	75
Other forms	3,730	5,890	6,310	5,950	5,600
Government stockpile shipments:					
Concentrate	979	2,310	3,120	1,740	1,600
Other forms	80	404	16	31	51
Consumption:					
Reported, concentrate	W	W	W	W	W
Apparent,[1] all forms	12,600	11,600	13,200	13,300	14,200
Price, concentrate, dollars per mtu WO_3,[2] average:					
U.S. spot market, Platts Metals Week	49	146	200	189	185
European market, Metal Bulletin	55	123	166	165	165
Stocks, industry, yearend:					
Concentrate	W	W	W	W	W
Other forms	1,780	2,300	2,130	1,980	1,980
Net import reliance[3] as a percentage of apparent consumption	73	68	68	68	61

Recycling: In 2008, the tungsten contained in scrap consumed by processors and end users represented approximately 35% of apparent consumption of tungsten in all forms.

Import Sources (2004-07): Tungsten contained in ores and concentrates, intermediate and primary products, wrought and unwrought tungsten, and waste and scrap: China, 43%; Germany, 11%; Canada, 10%; Bolivia, 7%; and other, 29%.

Tariff: **Item**	**Number**	**Normal Trade Relations[4] 12-31-08**
Ore	2611.00.3000	Free.
Concentrate	2611.00.6000	37.5¢/kg tungsten content.
Tungsten oxide	2825.90.3000	5.5% ad val.
Ammonium tungstate	2841.80.0010	5.5% ad val.
Tungsten carbide	2849.90.3000	5.5% ad val.
Ferrotungsten	7202.80.0000	5.6% ad val.
Tungsten powders	8101.10.0000	7.0% ad val.

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

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

TUNGSTEN

Government Stockpile:

Stockpile Status—9-30-08[5]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Metal powder	183	183	136	51
Ores and concentrates	19,800	19,800	3,630	1,450

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, imposed constraints on mining and processing tungsten ores, continued to shift the balance of export quotas towards value-added downstream tungsten materials and products, and imposed or increased export duties on many tungsten materials. The growth in China's economy during the past decade has resulted in China becoming the world's largest tungsten consumer. To conserve its resources and meet increasing domestic demand, the Chinese Government was expected to continue to limit tungsten production and exports and to increase imports of tungsten. In addition, the Chinese tungsten industry was investing in mine development projects outside China and developing technologies to increase the use of tungsten scrap and the processing of both low-grade ores and mixed scheelite-wolframite concentrates.

Numerous companies worked towards developing tungsten deposits or reopening inactive tungsten mines in Asia, Australia, Europe, and North America. In 2007-08, new production of tungsten concentrates began in Australia, China, Peru, Spain, the United States, and Uzbekistan. The serious downturn in the global financial markets in late 2008 could delay the startup of additional proposed production, however.

Health, safety, and environmental issues have been significant to the production and use of tungsten in recent years.

World Mine Production, Reserves, and Reserve Base: Production estimates for China were revised downward to represent tungsten content of concentrates; production estimates for Russia were revised downward based on new information from that country.

	Mine production		Reserves[6]	Reserve base[6]
	2007	2008[e]		
United States	W	W	140,000	200,000
Austria	1,200	1,200	10,000	15,000
Bolivia	1,100	1,100	53,000	100,000
Canada	2,700	2,600	260,000	490,000
China	41,000	41,000	1,800,000	4,200,000
Korea, North	600	600	NA	35,000
Portugal	850	900	4,700	62,000
Russia	3,200	3,200	250,000	420,000
Other countries	3,880	4,000	440,000	750,000
World total (rounded)	54,500	54,600	3,000,000	6,300,000

World Resources: World tungsten resources are geographically widespread. China ranks first 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 for cemented tungsten carbides include cemented carbides based on molybdenum carbide and titanium carbide, ceramics, ceramic-metallic composites (cermets), diamond tools, and tool steels. Potential substitutes for other applications are as follows: 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. net import reliance and secondary production, as estimated from scrap consumption.
[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]No tariff for Canada and Mexico. Tariffs for other countries for some items may be eliminated under special trade agreements.
[5]See Appendix B for definitions.
[6]See Appendix C for definitions.

VANADIUM

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

Domestic Production and Use: Seven U.S. firms that comprise the majority of 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 92% of the domestic vanadium consumption in 2008. 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:	2004	2005	2006	2007	2008[e]
Production, mine, mill[1]	—	—	—	—	—
Imports for consumption:					
Ash, ore, residues, slag	2,350	1,690	1,000	920	720
Vanadium pentoxide, anhydride	1,040	1,370	1,920	2,390	4,100
Oxides and hydroxides, other	120	186	129	42	183
Aluminum-vanadium master alloys (gross weight)	19	1	102	1,110	547
Ferrovanadium	3,020	11,900	2,140	2,220	3,320
Exports:					
Vanadium pentoxide, anhydride	240	254	341	327	243
Oxides and hydroxides, other	584	899	832	626	953
Aluminum-vanadium master alloys (gross weight)	887	1,500	1,930	1,700	1,357
Ferrovanadium	285	504	389	154	265
Consumption, reported	4,050	3,910	4,030	4,130	5,190
Price, average, dollars per pound V_2O_5	5.99	16.28	7.86	7.40	14.75
Stocks, consumer, yearend	336	371	330	295	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 consumed. The vanadium content of other recycled steels was lost to slag during processing and was not recovered.

Import Sources (2004-07): Ferrovanadium: Czech Republic, 76%; Swaziland, 7%; Canada, 6%; Republic of Korea, 6%; and other, 5%. Vanadium pentoxide: South Africa, 59%; China, 20%; Russia, 18%; and other, 3%.

Tariff: Ash, residues, slag, and waste and scrap enter duty-free.

Item	Number	Normal Trade Relations 12-31-08
Vanadium pentoxide anhydride	2825.30.0010	5.5% ad val.
Vanadium oxides and hydroxides, other	2825.30.0050	5.5% ad val.
Vanadates	2841.90.1000	5.5% ad val.
Ferrovanadium	7202.92.0000	4.2% ad val.
Aluminum-vanadium master alloys	7601.20.9030	Free.

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

Government Stockpile: None.

Prepared by **Michael J. Magyar [(703) 648-4964, mmagyar@usgs.gov, fax: (703) 648-7757]**

VANADIUM

Events, Trends, and Issues: Preliminary data indicate that U.S. vanadium consumption in 2008 increased about 24% from that of the previous year; however, that increase is partially attributable to expanded reporting by large consumers in 2008. Among the major uses for vanadium, production of carbon, full-alloy, and high-strength, low-alloy steels accounted for 16%, 40%, and 30% of domestic consumption, respectively. In 2008, U.S. steel production was expected to be about the same as that of 2007.

Vanadium pentoxide prices ranged from $7.30 to $18.40 per pound of V_2O_5 and averaged $14.75 for the year, about 100% higher than that of 2007. Ferrovanadium prices ranged from $18.00 to $46.00 per pound of ferrovanadium and averaged an estimated $35.18 for the year, about 80% higher than that of 2007. The sharp rise in prices in 2008 occurred in the first quarter of the year when power shortages in South Africa and bad weather in China sharply reduced vanadium production. Supply disruption in a tight market, coupled with stable demand in the steel and aerospace industries, kept prices high for most of 2008.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	2007	2008[e]		
United States	—	—	45,000	4,000,000
China	19,000	20,000	5,000,000	14,000,000
Russia	14,500	16,000	5,000,000	7,000,000
South Africa	24,000	23,000	3,000,000	12,000,000
Other countries	1,000	1,000	NA	1,000,000
World total (rounded)	58,500	60,000	13,000,000	38,000,000

World Resources: World resources of vanadium exceed 63 million tons. Vanadium occurs in deposits of phosphate rock, titaniferous magnetite, 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 coal, crude oil, 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. Certain metals, such as manganese, molybdenum, niobium (columbium), 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 and mill 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 lightweight concrete aggregates (including cement premixes, concrete, and plaster), 35%; horticulture, 30%; insulation, 5%; and other, 30%.

Salient Statistics—United States:	2004	2005	2006	2007	2008[e]
Production[e, 1]	[2]100	100	100	100	100
Imports for consumption[e]	69	91	65	51	60
Exports[e]	10	[3]5	[3]5	[3]5	[3]5
Consumption, apparent, concentrate[e]	[4]160	[4]185	160	146	155
Consumption, exfoliated[e]	90	85	90	85	90
Price, average, concentrate, dollars per ton, ex-plant	[5]143	[6]143	[7]138	140	140
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number[e, 8]	100	90	95	100	100
Net import reliance[9] as a percentage of apparent consumption[e]	35	45	40	32	35

Recycling: Insignificant.

Import Sources (2004-07): China, 51%; South Africa, 48%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Vermiculite, perlite and chlorites, unexpanded	2530.10.0000	Free.
Exfoliated vermiculite, expanded clays, foamed slag, and similar expanded materials	6806.20.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Michael J. Potter [(703) 648-7723, mpotter@usgs.gov, fax: (703) 648-7757]**

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 any material from Canada and Mexico, were about 54,000 tons for the first 8 months of 2008. China provided 70% and South Africa, 25%.[10]

Rio Tinto plc concluded the acquisition of the Namekara vermiculite mine in Uganda from IBI Corp. of Toronto, Ontario, Canada. However, the terms of the initial sales agreement were modified because of a *force majeure* circumstance that did not allow Rio Tinto to complete a review of transportation costs. Subsequently, Rio Tinto indicated that it would be selling the Namekara Mine.[11]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[12]	Reserve base[12]
	2007	2008[e]		
United States[e]	100	100	25,000	100,000
Australia	13	15	NA	NA
Brazil	19	20	NA	NA
China	110	110	NA	NA
Russia	25	25	NA	NA
South Africa	199	200	14,000	80,000
Zimbabwe	15	15	NA	NA
Other countries	27	25	NA	NA
World total	508	510	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 overburden.[13]

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 http://www.mining-journal.com.)
[3]Excludes Canada and Mexico.
[4]Rounded.
[5]Industrial Minerals, 2004, Prices: Industrial Minerals, no. 442, July, p. 64-65.
[6]Moeller, Eric, 2006, Vermiculite: Mining Engineering, v. 58, no. 6, June, p. 61. (Average of prices from range of sized grades.)
[7]Moeller, Eric, 2007, Vermiculite: Mining Engineering, v. 59, no. 6, June, p. 61-62. (Average of prices from range of sized grades.)
[8]Mine, mill, and office.
[9]Defined as imports – exports + adjustments for Government and industry stock changes.
[10]Commonwealth Business Media, Inc., 2008, Port Import/Export Reporting Service. (Accessed November 17, 2008, at http://www.piers.com.)
[11]Industrial Minerals, 2008, Rio Tinto closes Ugandan vermiculite buy...to sell it: Industrial Minerals, no. 488, May, p. 21.
[12]See Appendix C for definitions.
[13]Roskill Information Services, Ltd., 2004, The economics of vermiculite (8th ed.): London, United Kingdom, Roskill Information Services Ltd., 126 p. plus appendixes.

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 2008. All yttrium metal and compounds used in the United States were imported. Principal uses were in phosphors for color televisions and computer monitors, temperature sensors, trichromatic fluorescent lights, and x-ray-intensifying screens. Yttrium also was used as a stabilizer in zirconia in alumina-zirconia abrasives, bearings and seals, high-temperature refractories for continuous-casting nozzles, jet-engine coatings, oxygen sensors in automobile engines, simulant gemstones, and wear-resistant and corrosion-resistant cutting tools. 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 dental and medical surgical procedures, digital communications, distance and temperature sensing, industrial cutting and welding, nonlinear optics, photochemistry, and photoluminescence. Yttrium also was used in heating-element alloys, high-temperature superconductors, and superalloys. The approximate distribution in 2007 by end use was as follows: phosphors (all types), 89%; ceramics, 10%; and metallurgy, 1%.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, mine	—	—	—	—	—
Imports for consumption:					
In monazite	—	—	—	—	—
Yttrium, alloys, compounds, and metal[e, 2]	619	582	742	676	600
Exports, in ore and concentrate	NA	NA	NA	NA	NA
Consumption, estimated[3]	619	582	742	676	600
Price, dollars:					
Monazite concentrate, per metric ton[4]	326	300	300	300	300
Yttrium oxide, per kilogram, 99.0% to 99.99% purity[5]	22-85	10-85	10-85	10-85	10-85
Yttrium metal, per kilogram, 99.9% purity[5]	96	96	68-155	68-155	68-155
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 (2004-07):[e] Yttrium compounds, greater than 19% to less than 85% weight percent yttrium oxide equivalent: China, 95.7%; Japan, 3.7%; and France, 0.6%. Import sources based on Journal of Commerce data (2007 only): China, 86.2%; Austria, 7.9%; Japan, 2.4%; Hong Kong, 2.0%; and other, 1.5%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-08**
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.

Prepared by **James B. Hedrick [(703) 648-7725, jhedrick@usgs.gov, fax: (703) 648-7757]**

YTTRIUM

Events, Trends, and Issues: Estimated yttrium consumption in the United States decreased in 2007 and was expected to decrease again in 2008. The United States required yttrium for use in various phosphors and in electronics, especially those used in defense applications.

Yttrium production and marketing within China continued to be competitive; however, prices for yttrium have been increasing. China was the source of most of the world's supply of yttrium, from its weathered clay ion-adsorption ore deposits in the southern Provinces, primarily in Fujian, Guangdong, and Jiangxi, with a lesser number of deposits in Guangxi and Hunan. Processing was primarily at facilities in Guangdong, Jiangsu, and Jiangxi Provinces. Yttrium was consumed mainly 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]
	2007	2008		
United States	—	—	120,000	130,000
Australia	—	—	100,000	110,000
Brazil	15	15	2,200	6,200
China	8,800	8,800	220,000	240,000
India	55	55	72,000	80,000
Malaysia	4	4	13,000	21,000
Sri Lanka	—	—	240	260
Other countries	—	—	17,000	20,000
World total (rounded)	8,900	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, carbonatites, uranium ores, and weathered clay deposits (ion-adsorption ore). Additional large subeconomic resources of yttrium occur in apatite-magnetite rocks, deposits of niobium-tantalum minerals, non-placer monazite-bearing deposits, sedimentary phosphate deposits, and uranium ores, especially those of the Blind River District near Elliot Lake, Ontario, Canada, which contain yttrium in brannerite, monazite, and uraninite. Additional resources in Canada are contained in allanite, apatite, and britholite at Eden Lake, Manitoba; allanite and apatite at Hoidas Lake, Saskatchewan; and fergusonite and xenotime at Thor Lake, Northwest Territories. The world's resources of yttrium 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 impart 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 2004 and estimated for 2005 through 2008.
[5]Yttrium oxide and metal prices for 5-kilogram to 1-metric-ton quantities from 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 2008, based on zinc contained in concentrate, was about $1.51 billion. It was produced in 7 States at 16 mines operated by 9 companies. Two facilities—one primary and the other secondary—produced the bulk of refined zinc metal of commercial grade in 2008. Of the total zinc consumed, about 55% was used in galvanizing, 21% in zinc-based 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:	2004	2005	2006	2007	2008[e]
Production:					
Mine, zinc in ore and concentrate	739	748	727	803	770
Primary slab zinc[1]	194	195	113	121	122
Secondary slab zinc[1]	156	156	156	157	150
Imports for consumption:					
Zinc in ore and concentrate	231	156	383	271	44
Refined zinc[2]	868	700	895	758	744
Exports:					
Zinc in ore and concentrate	745	786	825	816	851
Refined zinc	3	1	3	8	4
Shipments from Government stockpile	32	27	30	10	([3])
Consumption, apparent, refined zinc	1,250	1,080	1,200	1,050	1,010
Price, average, cents per pound:					
North American[4]	52.5	67.1	158.9	154.4	89.0
London Metal Exchange (LME), cash	47.5	62.7	148.5	147.0	85.0
Producer and consumer stocks, slab zinc, yearend	63	61	47	35	40
Employment:					
Mine and mill, number[5]	910	980	1,130	1,560	1,870
Smelter primary, number[e]	600	600	246	264	264
Net import reliance[6] as a percentage of apparent consumption (refined zinc)	72	67	78	74	73

Recycling: In 2008, an estimated 102,000 metric tons of zinc waste and scrap was exported, mainly to China (90%), and 17,000 metric tons was imported for consumption, most of which came from Canada (60%).

Import Sources (2004-07): Ore and concentrate: Peru, 69%; Ireland, 14%; Mexico, 12%; Australia, 4%; and other, 1%. Metal: Canada, 66%; Mexico, 16%; Republic of Korea, 4%; Australia, 3%; and other, 11%. Waste and scrap: Canada, 75%; Mexico, 15%; and other, 10%. Combined total: Canada, 50%; Peru, 17%; Mexico, 15%; Ireland, 3%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations[7] 12-31-08
Zinc ores and concentrates, Zn content	2608.00.0030	Free.
Hard zinc spelter	2620.11.0000	Free.
Zinc oxide and zinc peroxide	2817.00.0000	Free.
Unwrought zinc, not alloyed:		
Containing 99.99% or more zinc	7901.11.0000	1.5% ad val.
Containing less than 99.99% zinc:		
Casting-grade	7901.12.1000	3% ad val.
Other	7901.12.5000	1.5% ad val.
Zinc alloys	7901.20.0000	3% ad val.
Zinc waste and scrap	7902.00.0000	Free.

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

Prepared by **Amy C. Tolcin [(703) 648-4940, atolcin@usgs.gov, fax: (703) 648-7757]**

ZINC

Government Stockpile:

Stockpile Status—9-30-08[8, 9]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2008	Disposals FY 2008
Zinc	7	7	[10]27	([3])

Events, Trends, and Issues: According to an October forecast from the International Lead and Zinc Study Group, in 2008, global zinc mine production increased by 3.9% to 11.6 million tons, refined metal production by 5.1% to 11.9 million tons, and consumption by 3.8% to 11.8 million tons. This leaves an excess of 150,000 tons of metal on the market, with a larger surplus anticipated in 2009.

Increased mine production was driven by expansions in Latin America and increased output in China, India, Iran, and Kazakhstan. Metal production rose as a result of increased output in China and India. A decline in zinc consumption in Europe and the United States during the year was offset by increased consumption in countries with emerging markets, particularly China, as well as Brazil and India. China's continued growth in demand was supported by the increased production of galvanized products—especially those used in transportation (highway barriers) and communication (galvanized iron towers) infrastructure.

Zinc prices continued to decline during 2008 as the metal market remained in surplus over the year. The LME cash price for zinc in October 2008 averaged $1,301 per metric ton, an approximate 70% decline in value from its peak reached in 2006. A wave of zinc mine closings and cutbacks (particularly in Australia, Canada, and the United States) began around midyear as prices began to fall below operating costs, and a few smelters announced production cutbacks towards the end of the year in order to prevent an accumulation of stocks. Mines in New York and Tennessee closed in 2008 because of low zinc prices.

World Mine Production, Reserves, and Reserve Base:

	Mine production[11] 2007	Mine production[11] 2008[e]	Reserves[12]	Reserve base[12]
United States	803	770	14,000	90,000
Australia	1,520	1,510	42,000	100,000
Canada	620	660	5,000	30,000
China	2,900	3,200	33,000	92,000
Kazakhstan	390	420	14,000	35,000
Mexico	430	460	7,000	25,000
Peru	1,440	1,450	18,000	23,000
Other countries	2,800	2,840	49,000	87,000
World total (rounded)	10,900	11,300	180,000	480,000

World Resources: Identified zinc resources of the world are about 1.9 billion metric tons.

Substitutes: Aluminum, plastics, and steel substitute for galvanized sheet. Aluminum, magnesium, and plastics are major competitors as diecasting materials. Aluminum alloy, cadmium, paint, and plastic coatings replace zinc for corrosion protection; aluminum alloys substitute for brass. Many elements are substitutes for zinc in chemical, electronic, and pigment uses.

[e]Estimated.
[1]Production estimate increases resulted from reanalysis of and revisions to data.
[2]Revised to include casting-grade zinc (Tariff no. 7901.12.1000).
[3]Less than ½ unit.
[4]Platts Metals Week price for North American Special High Grade zinc.
[5]Includes mine and mill employment at lead-zinc, zinc, and zinc-lead producing mines only. Source: Mine Safety and Health Administration.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]No tariff for Canada and Mexico for items shown.
[8]See Appendix B for definitions.
[9]Sales of zinc under Basic Ordering Agreement DLA-ZINC-004 were suspended on August 6, 2008.
[10]Actual quantity will be limited to remaining inventory.
[11]Zinc content of concentrate and direct shipping ore.
[12]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 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 are in the ore in a zirconium-to-hafnium ratio of about 50:1. Zirconium chemicals were produced by the metal producer in Oregon and by at least 11 other companies. Zirconia (ZrO_2) was produced from zircon at plants in Alabama, New Hampshire, New Jersey, New York, Ohio, Tennessee, 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, welding rod coatings, and sandblasting. The leading consumers of zirconium and hafnium metal are the nuclear energy and chemical process industries.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008[e]**
Production, zircon (ZrO_2 content)	W	W	W	W	W
Imports:					
Zirconium, ores and concentrates (ZrO_2 content)	22,900	24,800	23,500	13,000	23,000
Zirconium, unwrought, powder, and waste and scrap	89	283	256	299	352
Zirconium, wrought	708	741	492	485	431
Zirconium oxide[1]	3,960	3,160	2,820	3,740	5,240
Hafnium, unwrought, waste and scrap	4	4	4	4	10
Exports:					
Zirconium ores and concentrates (ZrO_2 content)	44,700	65,600	49,600	43,000	34,100
Zirconium, unwrought, powder, and waste and scrap	233	321	271	328	687
Zirconium, wrought	1,470	1,650	1,610	1,830	1,910
Zirconium oxide[1]	1,600	2,260	3,340	2,400	3,310
Consumption, zirconium ores and concentrates, apparent (ZrO_2 content)	W	W	W	W	W
Prices:					
Zircon, dollars per metric ton (gross weight):					
Domestic[2]	502	570	785	763	790
Imported, f.o.b.[3]	477	674	791	872	890
Zirconium, unwrought, dollars per kilogram[3]	31	22	23	24	32
Hafnium, unwrought, dollars per kilogram[3]	223	235	194	250	289
Net import reliance[4] 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 were 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 (2004-07): Zirconium ores and concentrates: Australia, 57%; South Africa, 37%; China, 3%; Canada, 1%; and other, 2%. Zirconium, unwrought, including powder: France, 60%; Germany, 26%; China, 9%; and other, 5%. Hafnium, unwrought: France, 65%; Canada, 21%; United Kingdom, 5%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
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.

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

Prepared by **Joseph Gambogi [(703) 648-7718, jgambogi@usgs.gov, fax: (703) 648-7757]**

ZIRCONIUM AND HAFNIUM

Government Stockpile: None.

Events, Trends, and Issues: Domestic consumption of zirconium mineral concentrates decreased slightly compared with that of 2007. The reprocessing of tailings to recover zircon continued in Green Cove Springs, FL, despite the cessation of mining in 2007. Domestic mining of heavy minerals continued in Stony Creek, VA, and Starke, FL.

In 2008, global production of zirconium concentrates decreased about 5% compared with that of 2007. Production difficulties in Australia, Indonesia, and Mozambique limited the availability of zirconium mineral concentrates. Owing to constrained supply, prices for zircon concentrate increased to record-high levels. Global consumption of zircon was forecast to increase an average of 3% per year through 2015; however, the global financial instabilities in 2008 increased the uncertainty of this forecast. Consumption growth in China was expected to continue to lead the global average.

Heavy mineral exploration and mining projects were underway in Australia, Canada, India, Kenya, Madagascar, Mozambique, Russia, Senegal, and South Africa. The availability of hafnium, 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. The reserves and reserve base estimates for Australia and "Other countries" have been revised based on new information from government and company reports.

	Zirconium				Hafnium	
	Mine production (thousand metric tons)		Reserves[5] (million metric tons, ZrO_2)	Reserve base[5]	Reserves[5] (thousand metric tons, HfO_2)	Reserve base[5]
	2007	2008[e]				
United States	W	W	3.4	5.7	68	97
Australia	605	575	20	35	180	600
Brazil	31	31	2.2	4.6	44	91
China	180	160	0.5	3.7	NA	NA
India	29	29	3.4	3.8	42	46
South Africa	400	405	14	14	280	290
Ukraine	35	35	4.0	6.0	NA	NA
Other countries	145	120	3.5	4.2	NA	NA
World total (rounded)	1,430	1,360	51	77	610	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. Niobium (columbium), stainless steel, and tantalum provide limited substitution in nuclear applications, while titanium and synthetic materials may substitute in some chemical plant uses.

Silver-cadmium-indium control rods are used in lieu of hafnium at numerous nuclear powerplants. Zirconium can be used interchangeably with hafnium in certain superalloys; in others, only hafnium produces the desired or required grain boundary refinement.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Includes germanium oxides and zirconium oxides.
[2]Yearend average price.
[3]Unit value based on U.S. imports for consumption.
[4]Defined as imports – exports.
[5]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.

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 2008 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. FY 2008 (fiscal year 2008) is the period October 1, 2007, through September 30, 2008. 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 2008 refers to material sold or traded from the stockpile in FY 2008.

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*

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical (or)	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUBECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		
Other Occurrences	Includes nonconventional and low-grade materials				

FIGURE 2.—*Reserve Base* and *Inferred Reserve Base* Classification Categories

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical (or)	Speculative
ECONOMIC	Reserve Base		Inferred Reserve Base		
MARGINALLY ECONOMIC					
SUBECONOMIC					
Other Occurrences	Includes nonconventional and low-grade materials				

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	Mowafa Taib
Angola	Omayra Bermúdez-Lugo
Bahrain	Mowafa Taib
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	Harold R. Newman
Congo (Brazzaville)	Philip M. Mobbs
Congo (Kinshasa)	Thomas R. Yager
Côte d'Ivoire	Omayra Bermúdez-Lugo
Djibouti	Thomas R. Yager
Egypt	Mowafa Taib
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	Mowafa Taib
Israel	Thomas R. Yager
Jordan	Mowafa Taib
Kenya	Thomas R. Yager
Kuwait	Philip M. Mobbs
Lebanon	Mowafa Taib
Lesotho	Harold R. Newman
Liberia	Omayra Bermúdez-Lugo
Libya	Mowafa Taib
Madagascar	Thomas R. Yager
Malawi	Thomas R. Yager
Mali	Omayra Bermúdez-Lugo
Mauritania	Mowafa Taib
Mauritius	Harold R. Newman
Morocco & Western Sahara	Harold R. Newman
Mozambique	Thomas R. Yager
Namibia	Omayra Bermúdez-Lugo
Niger	Omayra Bermúdez-Lugo
Nigeria	Philip M. Mobbs
Oman	Mowafa Taib
Qatar	Mowafa Taib
Reunion	Harold R. Newman
Rwanda	Thomas R. Yager
São Tomé & Principe	Omayra Bermúdez-Lugo
Saudi Arabia	Philip M. Mobbs
Senegal	Omayra Bermúdez-Lugo
Seychelles	Harold R. Newman
Sierra Leone	Omayra Bermúdez-Lugo
Somalia	Thomas R. Yager
South Africa	Thomas R. Yager
Sudan	Thomas R. Yager
Swaziland	Harold R. Newman
Syria	Mowafa Taib
Tanzania	Thomas R. Yager
Togo	Harold R. Newman
Tunisia	Mowafa Taib
Turkey	Philip M. Mobbs
Uganda	Harold R. Newman
United Arab Emirates	Mowafa Taib
Yemen	Mowafa Taib
Zambia	Philip M. Mobbs
Zimbabwe	Philip M. Mobbs

Asia and the Pacific

Afghanistan	Chin S. Kuo
Australia	Pui-Kwan Tse
Bangladesh	Yolanda Fong-Sam
Bhutan	Lin Shi
Brunei	Pui-Kwan Tse
Burma	Yolanda Fong-Sam
Cambodia	Yolanda Fong-Sam
China	Pui-Kwan Tse
Fiji	Lin Shi
India	Chin S. Kuo
Indonesia	Chin S. Kuo
Japan	Chin S. Kuo
Korea, North	Lin Shi
Korea, Republic of	Lin Shi
Laos	Yolanda Fong-Sam
Malaysia	Pui-Kwan Tse
Mongolia	Susan G. Wacaster
Nauru	Pui-Kwan Tse
Nepal	Lin Shi
New Caledonia	Susan G. Wacaster
New Zealand	Pui-Kwan Tse
Pakistan	Chin S. Kuo
Papua New Guinea	Susan G. Wacaster
Philippines	Yolanda Fong-Sam
Singapore	Pui-Kwan Tse
Solomon Islands	Chin S. Kuo
Sri Lanka	Chin S. Kuo
Taiwan	Pui-Kwan Tse
Thailand	Lin Shi
Timor, East	Pui-Kwan Tse
Tonga	Chin S. Kuo
Vanuatu	Chin S. Kuo
Vietnam	Yolanda Fong-Sam

Europe and Central Eurasia

Albania	Mark Brininstool
Armenia[1]	Richard M. Levine
Austria[2]	Steven T. Anderson
Azerbaijan[1]	Richard M. Levine
Belarus[1]	Richard M. Levine

Europe and Central Eurasia—continued

Belgium[2]	Alberto A. Perez
Bosnia and Herzegovina	Mark Brininstool
Bulgaria[2]	Mark Brininstool
Croatia	Mark Brininstool
Cyprus[2]	Harold R. Newman
Czech Republic[2]	Mark Brininstool
Denmark, Faroe Islands, and Greenland[2]	Harold R. Newman
Estonia[2]	Richard M. Levine
Finland[2]	Harold R. Newman
France[2]	Alberto A. Perez
Georgia[1]	Richard M. Levine
Germany[2]	Steven T. Anderson
Greece[2]	Harold R. Newman
Hungary[2]	Richard M. Levine
Iceland	Harold R. Newman
Ireland[2]	Harold R. Newman
Italy[2]	Alberto A. Perez
Kazakhstan[1]	Richard M. Levine
Kyrgyzstan[1]	Richard M. Levine
Latvia[2]	Richard M. Levine
Lithuania[2]	Richard M. Levine
Luxembourg[2]	Alberto A. Perez
Macedonia	Mark Brininstool
Malta[2]	Harold R. Newman
Moldova[1]	Richard M. Levine
Montenegro	Mark Brininstool
Netherlands[2]	Alberto A. Perez
Norway	Harold R. Newman
Poland[2]	Mark Brininstool
Portugal[2]	Alfredo C. Gurmendi
Romania[2]	Richard M. Levine
Russia[1]	Richard M. Levine
Serbia	Mark Brininstool
Slovakia[2]	Mark Brininstool
Slovenia[2]	Mark Brininstool
Spain[2]	Alfredo C. Gurmendi
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]	Alberto A. Perez
Uzbekistan[1]	Richard M. Levine

North America, Central America, and the Caribbean

Belize	Susan G. Wacaster
Canada	Philip M. Mobbs
Costa Rica	Susan G. Wacaster
Cuba	Omayra Bermúdez-Lugo
Dominican Republic	Susan G. Wacaster
El Salvador	Susan G. Wacaster
Guatemala	Steven T. Anderson
Haiti	Susan G. Wacaster
Honduras	Susan G. Wacaster
Jamaica	Susan G. Wacaster
Mexico	Alberto A. Perez
Nicaragua	Susan G. Wacaster
Panama	Susan G. Wacaster
Trinidad and Tobago	Susan G. Wacaster

South America

Argentina	Steven T. Anderson
Bolivia	Steven T. Anderson
Brazil	Alfredo C. Gurmendi
Chile	Steven T. Anderson
Colombia	Susan G. Wacaster
Ecuador	Susan G. Wacaster
French Guiana	Alfredo C. Gurmendi
Guyana	Alfredo C. Gurmendi
Paraguay	Alfredo C. Gurmendi
Peru	Alfredo C. Gurmendi
Suriname	Alfredo C. Gurmendi
Uruguay	Alfredo C. Gurmendi
Venezuela	Alfredo C. Gurmendi

[1]Member of Commonwealth of Independent States.
[2]Member of European Union.

Country specialist	Telephone	E-mail
Steven T. Anderson	(703) 648-7744	sanderson@usgs.gov
Omayra Bermúdez-Lugo	(703) 648-4946	obermude@usgs.gov
Mark Brininstool	(703) 648-7798	mbrininstool@usgs.gov
Yolanda Fong-Sam	(703) 648-7756	yfong-sam@usgs.gov
Alfredo C. Gurmendi	(703) 648-7745	agurmend@usgs.gov
Chin S. Kuo	(703) 648-7748	ckuo@usgs.gov
Richard M. Levine	(703) 648-7741	rlevine@usgs.gov
Philip M. Mobbs	(703) 648-7740	pmobbs@usgs.gov
Harold R. Newman	(703) 648-7742	hnewman@usgs.gov
Alberto A. Perez	(703) 648-7749	aperez@usgs.gov
Lin Shi	(703) 648-7994	lshi@usgs.gov
Mowafa Taib	(703) 648-4986	mtaib@usgs.gov
Pui-Kwan Tse	(703) 648-7750	ptse@usgs.gov
Susan G. Wacaster	(703) 648-7785	swacaster@usgs.gov
Thomas R. Yager	(703) 648-7739	tyager@usgs.gov