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

MINERAL COMMODITY SUMMARIES 2011

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 and Steel
Iron Ore
Iron Oxide Pigments
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
Wollastonite
Yttrium
Zeolites
Zinc
Zirconium

USGS
science for a changing world

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

MINERAL COMMODITY SUMMARIES 2011

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 and Steel
Iron Ore
Iron Oxide Pigments
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
Wollastonite
Yttrium
Zeolites
Zinc
Zirconium

USGS
science for a changing world

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

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

Manuscript approved for publication January 21, 2011.

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

For an overview of USGS information products, including maps, imagery, and publications,
visit http://www.usgs.gov/pubprod

For sale by the Superintendent of Documents, U.S. Government Printing Office
Mail: Stop IDCC; Washington, DC 20402–0001
Phone: (866) 512–1800 (toll-free); (202) 512–1800 (DC area)
Fax: (202) 512–2104
Internet: bookstore.gpo.gov

Suggested citation:
U.S. Geological Survey, 2011, Mineral commodity summaries 2011: U.S. Geological Survey, 198 p.

ISBN 978–1–4113–3083–2

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 (888) ASK-USGS [(888) 275-8747].

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

KEY PUBLICATIONS

Minerals Yearbook—These annual publications review the mineral industries of the United States and of more than 180 other 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 2011 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 2010 mineral production data for the world. More than 90 individual minerals and materials are covered by two-page synopses.

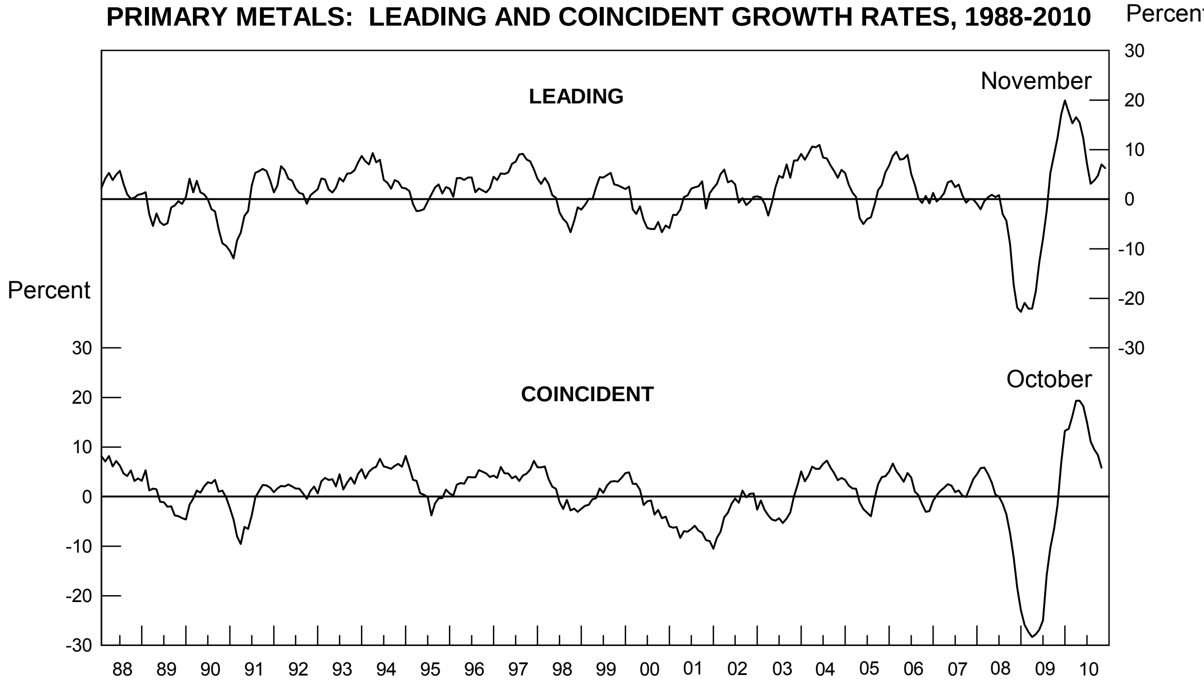
For mineral commodities for which there is a Government stockpile, detailed information concerning the stockpile status is included in the two-page synopsis.

Mineral Commodity Summaries 2011 contains new chapters on iron oxide pigments, wollastonite, and zeolites. The chapters on mica (natural), scrap and flake and mica (natural), sheet have been combined into a single chapter—mica (natural). Abbreviations and units of measure, and definitions of selected terms used in the report, are in Appendix A and Appendix B, respectively. “Appendix C—Reserves and Resources” has been divided into “Part A—Resource/Reserve Classification for Minerals” and “Part B—Sources of Reserves Data,” including some information that was previously in this introduction. A directory of USGS minerals information country specialists and their responsibilities is Appendix D.

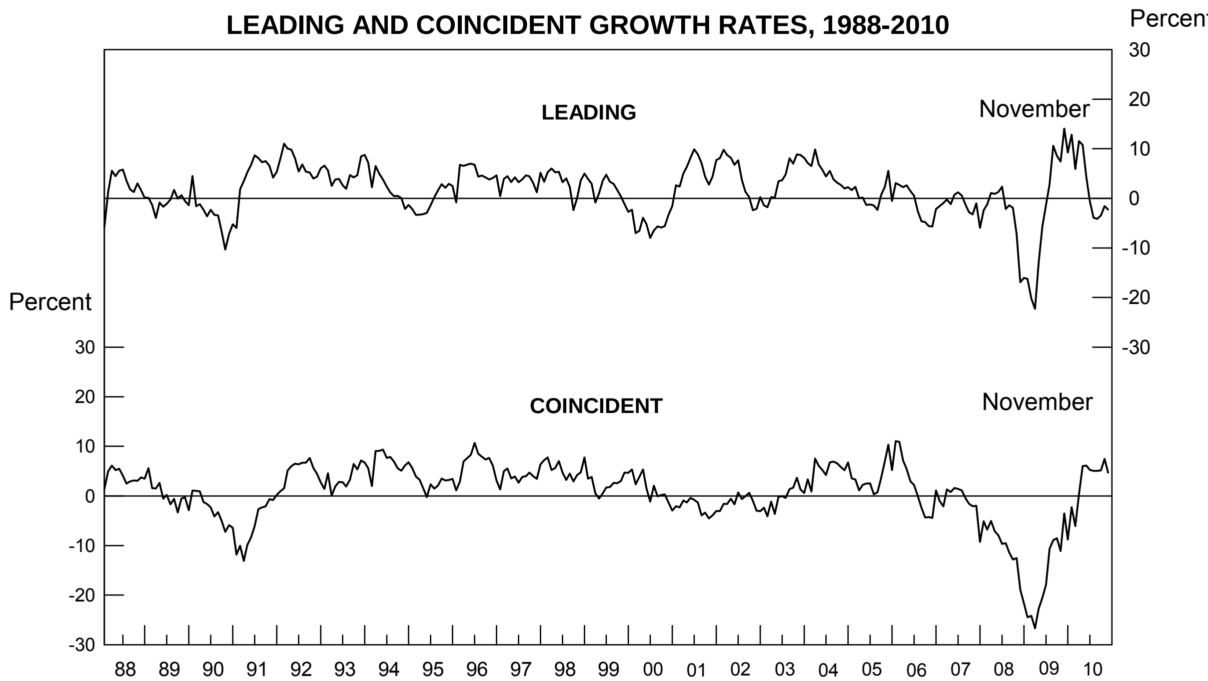
The USGS continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the MCS 2011 are welcomed.

GROWTH RATES OF LEADING AND COINCIDENT INDEXES FOR MINERAL PRODUCTS

PRIMARY METALS: LEADING AND COINCIDENT GROWTH RATES, 1988-2010



NONMETALLIC MINERAL PRODUCTS:
LEADING AND COINCIDENT GROWTH RATES, 1988-2010

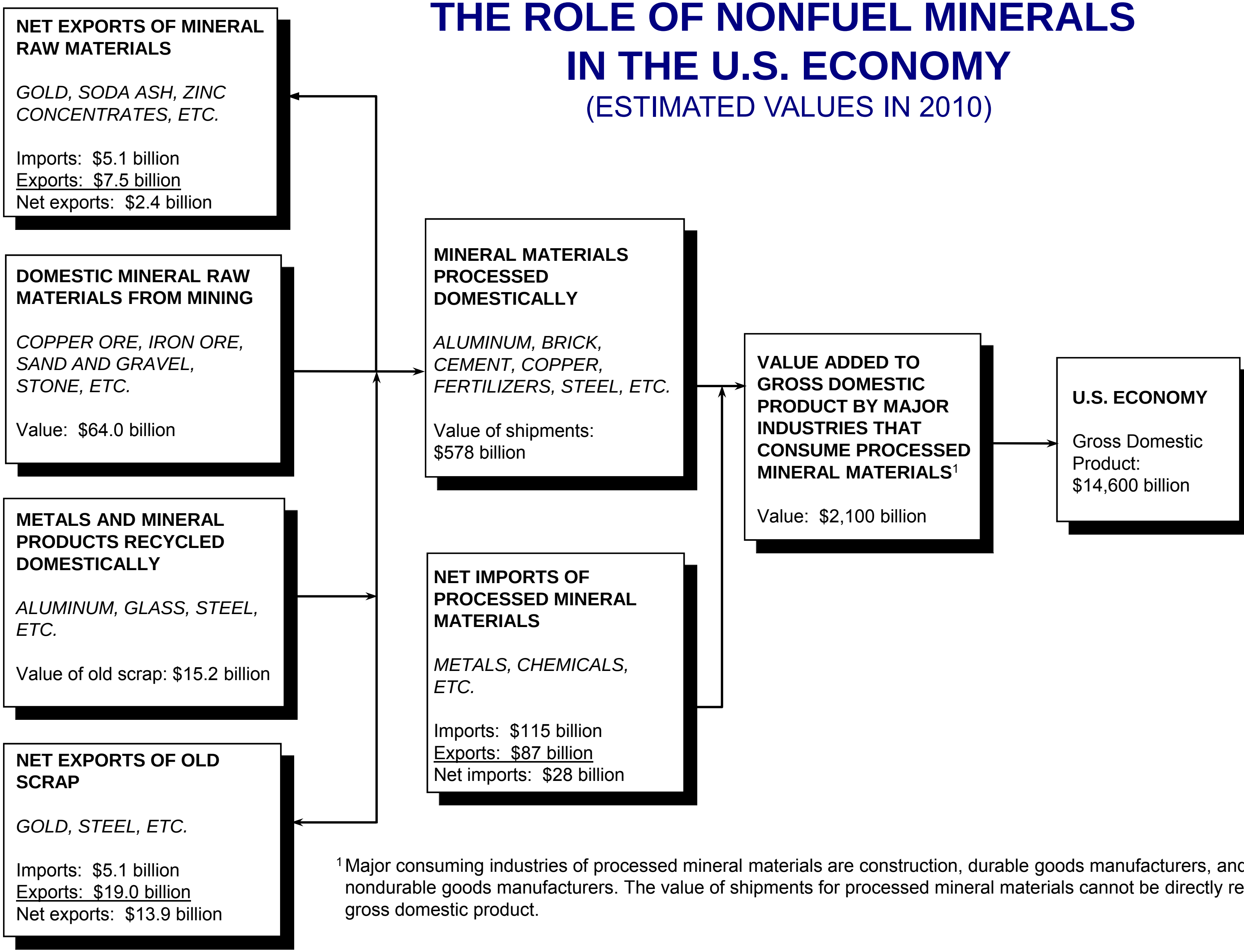


The leading indexes historically give signals several months in advance of major changes in the corresponding coincident index, which measures current industry activity. The growth rates, which can be viewed as trends, are expressed as compound annual rates based on the ratio of the current month's index 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 2010)

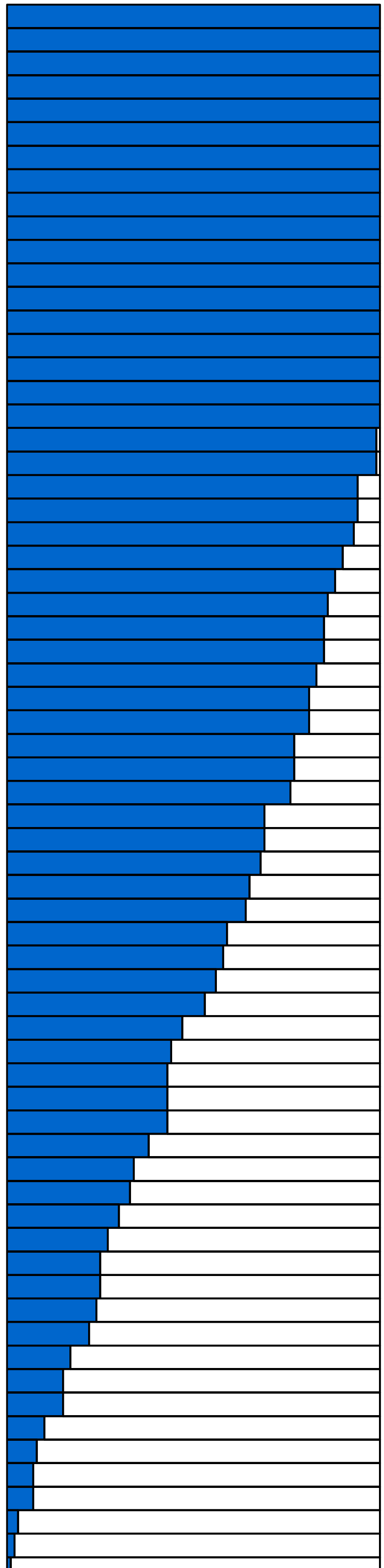


[1] Major consuming industries of processed mineral materials are construction, durable goods manufacturers, and some nondurable goods manufacturers. The value of shipments for processed mineral materials cannot be directly related to gross domestic product.

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

2010 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS

Commodity	Percent	Major Import Sources (2006-09)[1]
ARSENIC (trioxide)	100	Morocco, China, Belgium
ASBESTOS	100	Canada
BAUXITE and ALUMINA	100	Jamaica, Brazil, Guinea, Australia
CESIUM	100	Canada
FLUORSPAR	100	Mexico, China, South Africa, Mongolia
GRAPHITE (natural)	100	China, Mexico, Canada, Brazil
INDIUM	100	China, Canada, Japan, Belgium
MANGANESE	100	South Africa, Gabon, China, Australia
MICA, sheet (natural)	100	China, Brazil, Belgium, India
NIOBIUM (columbium)	100	Brazil, Canada, Germany, Estonia
QUARTZ CRYSTAL (industrial)	100	China, Japan, Russia
RARE EARTHS	100	China, France, Japan, Austria
RUBIDIUM	100	Canada
STRONTIUM	100	Mexico, Germany
TANTALUM	100	Australia, China, Kazakhstan, Germany
THALLIUM	100	Russia, Germany, Netherlands
THORIUM	100	United Kingdom, France, India, Canada
YTTRIUM	100	China, Japan, France
GALLIUM	99	Germany, Canada, China, Ukraine
GEMSTONES	99	Israel, India, Belgium, South Africa
BISMUTH	94	Belgium, China, United Kingdom, Mexico
PLATINUM	94	South Africa, Germany, United Kingdom, Canada
ANTIMONY	93	China, Mexico, Belgium
GERMANIUM	90	Belgium, China, Russia, Germany
IODINE	88	Chile, Japan
RHENIUM	86	Chile, Netherlands
DIAMOND (dust, grit and powder)	85	China, Ireland, Russia, Republic of Korea
STONE (dimension)	85	Brazil, China, Italy, Turkey
POTASH	83	Canada, Belarus, Russia
COBALT	81	Norway, Russia, China, Canada
TITANIUM MINERAL CONCENTRATES	81	South Africa, Australia, Canada, Mozambique
SILICON CARBIDE	77	China, Venezuela, Netherlands, Romania
ZINC	77	Canada, Peru, Mexico, Ireland
BARITE	76	China, India
TIN	69	Peru, Bolivia, China, Indonesia
VANADIUM	69	Rep. of Korea, Czech Republic, Canada, Austria
TUNGSTEN	68	China, Canada, Germany, Bolivia
SILVER	65	Mexico, Canada, Peru, Chile
TITANIUM (sponge)	64	Kazakhstan, Japan, Ukraine, Russia
PEAT	59	Canada
PALLADIUM	58	Russia, South Africa, United Kingdom, Belgium
CHROMIUM	56	South Africa, Kazakhstan, Russia, China
MAGNESIUM COMPOUNDS	53	China, Austria, Canada, Brazil
BERYLLIUM	47	Kazakhstan, Kenya, Germany, Ireland
SILICON (ferrosilicon)	44	China, Russia, Venezuela, Canada
LITHIUM	43	Chile, Argentina, China
NICKEL	43	Canada, Russia, Australia, Norway
NITROGEN (fixed), AMMONIA	43	Trinidad and Tobago, Russia, Canada, Ukraine
ALUMINUM	38	Canada, Russia, China, Mexico
MAGNESIUM METAL	34	Canada, Israel, China, Russia
GOLD	33	Canada, Mexico, Peru, Chile
COPPER	30	Chile, Canada, Peru, Mexico
MICA, scrap and flake (natural)	27	Canada, China, India, Finland
GARNET (industrial)	25	India, Australia, China, Canada
PERLITE	25	Greece
SALT	24	Canada, Chile, Mexico, The Bahamas
VERMICULITE	22	China, South Africa
SULFUR	17	Canada, Mexico, Venezuela
GYPSUM	15	Canada, Mexico, Spain
PHOSPHATE ROCK	15	Morocco
IRON and STEEL SLAG	10	Japan, Canada, Italy, South Africa
CEMENT	8	China, Canada, Republic of Korea, Taiwan
IRON and STEEL	7	Canada, European Union, China, Mexico
PUMICE	7	Greece, Turkey, Iceland, Mexico
DIAMOND (natural industrial stone)	3	Botswana, South Africa, Namibia, India
LIME	2	Canada, Mexico
STONE (crushed)	1	Canada, Mexico, The Bahamas



[1]In descending order of import share.

SIGNIFICANT EVENTS, TRENDS, AND ISSUES

In 2010, the value of mineral production increased in the United States, suggesting that the domestic nonfuel minerals industries, especially the metallic minerals industries, were beginning to feel the effects of recovery from the economic recession that began in December 2007 and lasted well into 2009. Some major mining sectors continued to struggle, however, with no increases in production or value of production. Minerals remained fundamental to the U.S. economy, nevertheless, contributing to the real gross domestic product (GDP) at several levels, including mining, processing, and manufacturing finished products. Minerals' contribution to the GDP was more than that of 2009, but below that of 2008. Trends in other sectors of the domestic economy were reflected in mineral production and consumption rates. For instance, continued declines in the construction industry during 2010 were reflected in further reductions in the production and consumption of cement, construction sand and gravel, crushed stone, and gypsum, which are used almost exclusively in construction. Performances in other sectors were mixed and less easily characterized.

The figure on page 4 shows that the primary metals industry and the nonmetallic minerals products industry are intrinsically cyclical. 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, new product 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. In 2010, the U.S. primary metals industry was still in the recovery that began in 2009. Although industry activity slowed in 2010, the relatively high leading index growth rate suggested that the recovery in primary metals activity is likely to continue into 2011. The recovery in the nonmetallic mineral products industry is also likely to continue in 2011, although activity growth likely will be slower than in the primary metals industry.

As shown in the figure on page 5, the estimated value of mineral raw materials produced at mines in the United States in 2010 was $64 billion, a 9% increase from $59 billion in 2009. Net exports of mineral raw materials and old scrap contributed an additional $16 billion to the U.S. economy. The domestic raw materials, along with domestically recycled materials, were used to process mineral materials worth $578 billion. These mineral materials, including aluminum, brick, copper, fertilizers, and steel, and net imports of processed materials (worth about $28 billion) were, in turn, consumed by downstream industries with a value added of an estimated $2.1 trillion in 2010, representing about 14% of the U.S. GDP, the same as in 2009.

The estimated value of U.S. metal mine production in 2010 was $29.1 billion, about 34% more than that of 2009. Principal contributors to the total value of metal mine production in 2010 were gold (30%), copper (29%), iron ore (15%), molybdenum (12%), and zinc (6%). The value of metal production increased by 34%. With few exceptions, metal prices increased in 2010. Gold continued its upward trajectory, reaching an alltime high of $1,424.07 per troy ounce in mid-November 2010. The estimated value of U.S. industrial minerals mine production in 2010 was $34.9 billion, 6% less than that of 2009, and was dominated by crushed stone (33%), construction sand and gravel (17%), and cement (16%). Although more types of industrial minerals showed increased mine production and value than decreased, the dominant materials continued to decline, but at a slower pace than in 2009. In general, industrial minerals prices were relatively stable, with modest price variations.

Mine production of 13 mineral commodities was worth more than $1 billion each in the United States in 2010. These were crushed stone, gold, copper, construction sand and gravel, cement, iron ore (shipped), molybdenum concentrates, salt, lime, clays (all varieties), zinc, soda ash, and phosphate rock, 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 2010, imports accounted for the supply of more than one-half of U.S. apparent consumption of 43 mineral commodities, and the United States 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 7 mineral commodities, and more than 50% import dependent for 25 mineral commodities. In 2010, the United States was a net exporter of 19 mineral commodities, meaning more of those domestically produced mineral commodities were exported than imported. That figure has remained relatively stable, with net exports of 18 mineral commodities in 1978.

In 2010, nine States each produced more than $2 billion worth of nonfuel mineral commodities. These States were, in descending order of value—Nevada, Arizona, Utah, Minnesota, Alaska, California, Texas, Missouri, and Florida. The mineral production of these States accounted for 55% of the U.S. total output value (table 3).

In fiscal year 2010, the Defense Logistics Agency, DLA Strategic Materials (DLA) (formerly Defense National Stockpile Center) sold $165 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 acquisition and disposals of NDS mineral materials. At the end of the fiscal year,

TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

	2006	2007	2008	2009	2010[e]
Total mine production:[1]					
Metals	23,100	25,200	27,200	21,800	29,100
Industrial minerals	38,900	40,000	44,100	37,100	34,900
Coal	29,300	29,600	36,600	35,600	36,300
Employment:[2]					
Coal mining	67	68	71	71	72
Metal mining	25	28	32	28	29
Industrial minerals, except fuels	82	82	79	73	71
Chemicals and allied products	508	504	513	478	470
Stone, clay, and glass products	391	384	363	305	294
Primary metal industries	363	358	348	275	281
Average weekly earnings of production workers:[3]					
Coal mining	1,093	1,052	1,138	1,250	1,359
Metal mining	974	1,074	1,195	1,096	1,161
Industrial minerals, except fuels	861	870	838	807	843
Chemicals and allied products	834	820	809	842	888
Stone, clay, and glass products	712	716	711	706	726
Primary metal industries	844	843	851	818	872

[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

	2006	2007	2008	2009	2010[e]
Gross domestic product (billion dollars)	13,399	14,062	14,369	14,119	14,600
Industrial production (2007=100):					
Total index	97	100	97	88	93
Manufacturing:	97	100	96	85	90
Nonmetallic mineral products	101	100	89	74	75
Primary metals:	98	100	98	67	85
Iron and steel	98	100	104	62	91
Aluminum	106	100	93	72	75
Nonferrous metals (except aluminum)	85	100	100	88	89
Chemicals	95	100	94	91	94
Mining:	99	100	101	96	101
Coal	102	100	102	94	94
Oil and gas extraction	98	100	101	106	110
Metals	102	100	104	90	99
Nonmetallic minerals	108	100	87	71	73
Capacity utilization (percent):					
Total industry:	81	81	78	70	74
Mining:	90	89	89	82	86
Metals	80	78	81	70	78
Nonmetallic minerals	88	83	74	65	69
Housing starts (thousands)	1,810	1,340	900	554	588
Light vehicle sales (thousands)[1]	12,700	12,200	9,720	7,520	8,590
Highway construction, value, put in place (billion dollars)	72	77	81	82	82

[e]Estimated.

[1]Excludes imports.

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

mineral materials valued at $1.30 billion remained in the stockpile.

In August 2008, DLA had announced plans to suspend competitive commercial offerings of six mineral commodities and reduce the sale quantities of nine additional mineral commodities for the remainder of fiscal year 2008. During fiscal year 2010, sales of iridium, niobium metal ingot, platinum, tantalum carbide powder, tin, and zinc remained suspended.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2010[p, 1]

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$1,010,000	21	1.58	Stone (crushed), cement (portland), lime, salt, sand and gravel (construction).
Alaska	3,240,000	5	5.07	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	6,700,000	2	10.46	Copper, molybdenum concentrates, sand and gravel (construction), cement (portland), stone (crushed).
Arkansas	630,000	31	0.98	Bromine, stone (crushed), sand and gravel (construction), cement (portland), lime.
California	2,710,000	6	4.23	Sand and gravel (construction), boron minerals, cement (portland), stone (crushed), gold.
Colorado	1,930,000	11	3.01	Molybdenum concentrates, gold, sand and gravel (construction), cement (portland), stone (crushed).
Connecticut[2]	141,000	42	0.22	Stone (crushed), sand and gravel (construction), clays (common), stone (dimension), gemstones (natural).
Delaware[2]	12,700	50	0.02	Magnesium compounds, sand and gravel (construction), stone (crushed), gemstones (natural).
Florida	2,080,000	9	3.25	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), zirconium concentrates.
Georgia	1,500,000	14	2.35	Clays (kaolin), stone (crushed), clays (fuller's earth), sand and gravel (construction), cement (portland).
Hawaii	112,000	46	0.17	Stone (crushed), sand and gravel (construction), gemstones (natural).
Idaho	1,200,000	16	1.88	Molybdenum concentrates, phosphate rock, silver, sand and gravel (construction), lead.
Illinois	910,000	23	1.42	Stone (crushed), sand and gravel (construction), cement (portland), sand and gravel (industrial), tripoli.
Indiana	837,000	25	1.31	Stone (crushed), cement (portland), sand and gravel (construction), lime, stone (dimension).
Iowa	542,000	32	0.85	Stone (crushed), cement (portland), sand and gravel (construction), lime, gypsum (crude).
Kansas	1,040,000	19	1.63	Helium (Grade–A), salt, cement (portland), stone (crushed), helium (crude).
Kentucky	742,000	27	1.16	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (common).
Louisiana	492,000	33	0.77	Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), clays (common).
Maine	114,000	45	0.18	Sand and gravel (construction), stone (crushed), cement (portland), stone (dimension), peat.
Maryland	438,000	37	0.68	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts[2]	194,000	40	0.30	Stone (crushed), sand and gravel (construction), lime, stone (dimension), clays (common).
Michigan	1,960,000	10	3.07	Iron ore (usable shipped), cement (portland), sand and gravel (construction), salt, stone (crushed).
Minnesota[2]	3,860,000	4	6.03	Iron ore (usable shipped), sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime.
Mississippi	183,000	43	0.29	Sand and gravel (construction), stone (crushed), clays (fuller’s earth), clays (ball), clays (bentonite).
Missouri	2,140,000	8	3.35	Cement (portland), stone (crushed), lead, lime, sand and gravel (construction).
Montana	1,120,000	17	1.74	Copper, molybdenum concentrates, palladium metal, platinum metal, sand and gravel (construction).

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2010[p, 1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Nebraska[2]	$181,000	41	0.28	Sand and gravel (construction), cement (portland), stone (crushed), sand and gravel (industrial), lime.
Nevada	7,550,000	1	11.79	Gold, copper, sand and gravel (construction), lime, silver.
New Hampshire	100,000	47	0.16	Sand and gravel (construction), stone (crushed), stone (dimension), gemstones (natural).
New Jersey[2]	232,000	38	0.36	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.
New Mexico	1,010,000	20	1.57	Copper, potash, sand and gravel (construction), stone (crushed), cement (portland).
New York	1,290,000	15	2.01	Salt, stone (crushed), sand and gravel (construction), cement (portland), clays (common).
North Carolina	908,000	24	1.42	Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), stone (dimension).
North Dakota[2]	88,000	48	0.14	Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial).
Ohio	1,080,000	18	1.69	Stone (crushed), salt, sand and gravel (construction), lime, cement (portland).
Oklahoma	646,000	30	1.01	Stone (crushed), cement (portland), sand and gravel (construction), iodine, helium (Grade-A).
Oregon	292,000	36	0.46	Stone (crushed), sand and gravel (construction), cement (portland), diatomite, perlite (crude).
Pennsylvania[2]	1,530,000	13	2.39	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Rhode Island[2]	34,400	49	0.05	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), gemstones (natural).
South Carolina[2]	440,000	34	0.69	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), sand and gravel (industrial).
South Dakota	298,000	35	0.46	Gold, sand and gravel (construction), cement (portland), stone (crushed), stone (dimension).
Tennessee	814,000	26	1.27	Stone (crushed), zinc, cement (portland), sand and gravel (industrial), sand and gravel (construction).
Texas	2,560,000	7	4.00	Stone (crushed), cement (portland), sand and gravel (construction), salt, lime.
Utah	4,420,000	3	6.90	Copper, molybdenum concentrates, gold, magnesium metal, potash.
Vermont[2]	119,000	44	0.19	Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural).
Virginia	952,000	22	1.49	Stone (crushed), cement (portland), sand and gravel (construction), lime, zirconium concentrates.
Washington	665,000	28	1.04	Gold, sand and gravel (construction), stone (crushed), cement (portland), lime.
West Virginia	230,000	39	0.36	Stone (crushed), cement (portland), lime, sand and gravel (industrial), cement (masonry).
Wisconsin	651,000	29	1.02	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime, stone (dimension).
Wyoming	1,860,000	12	2.90	Soda ash, helium (Grade–A), clays (bentonite), sand and gravel (construction), stone (crushed).
Undistributed	237,000	XX	0.37	
Total	64,000,000	XX	100.00	

[p]Preliminary. XX Not applicable.

[1]Data are rounded to no more than 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."

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

MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART II

SYMBOLS

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

ABRASIVES (MANUFACTURED)

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

Domestic Production and Use: Fused aluminum oxide was produced by two companies at three plants in the United States and Canada. Production of regular-grade fused aluminum oxide had an estimated value of $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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production,[1] United States and Canada (crude):					
Fused aluminum oxide, regular	10,000	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	209,000	237,000	285,000	64,200	170,000
Silicon carbide	186,000	164,000	127,000	78,000	140,000
Exports (U.S.):					
Fused aluminum oxide	15,300	18,200	21,900	12,300	19,000
Silicon carbide	20,300	19,300	17,000	20,700	24,000
Consumption, apparent (U.S.):					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	201,000	180,000	145,000	92,300	150,000
Price, value of imports, dollars per ton (U.S.):					
Fused aluminum oxide, regular	310	361	512	608	547
Fused aluminum oxide, high-purity	1,170	1,110	1,230	1,170	1,410
Silicon carbide	477	550	835	557	609
Net import reliance[2] as a percentage of apparent consumption (U.S.):					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	83	81	76	62	77

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

Import Sources (2006–09): Fused aluminum oxide, crude: China, 81%; Canada, 11%; Venezuela, 5%; Brazil, 1%; and other, 2%. Fused aluminum oxide, grain: Brazil, 30%; Germany, 25%; Austria, 17%; Italy, 7%; and other, 21%. Silicon carbide, crude: China, 84%; Venezuela, 5%; Netherlands, 4%; Romania, 3%; and other, 4%. Silicon carbide, grain: China, 42%; Brazil, 23%; Vietnam, 9%; Norway, 6%; and other, 20%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Fused aluminum oxide, crude	2818.10.1000	Free.
White, pink, ruby artificial corundum, greater that 97.5% fused aluminum oxide, grain	2818.10.2010	1.3% ad val.
Artificial corundum, not elsewhere specified or included, fused aluminum oxide, grain	2818.10.2090	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: None.

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. Abrasives markets are greatly influenced by activity in the manufacturing sector in the United States. During 2009, downturns in the U.S. manufacturing sector, owing to the impacts of the global economic recession, caused modest decreases in U.S. manufactured abrasives production, but significant decreases in consumption. This was particularly true of manufacturing activities in the aerospace, automotive, furniture, housing, and steel industries. The U.S. abrasive markets also are influenced by economic and technological trends. As the world and the United States slowly began to recover from the global economic recession during 2010, U.S. manufactured abrasives production and consumption also slowly began to show signs of improvement. After large drops in the imports of aluminum oxide and silicon carbide in 2009, imports began to increase during 2010. Global prices of abrasive aluminum oxide and silicon carbide, which had leveled out or dropped during the first three quarters of 2009, began moving steadily higher in the last quarter of 2009. This price trend continued through 2010.

World Production Capacity:

	Fused aluminum oxide		Silicon carbide	
	2009	2010	2009	2010
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.

ALUMINUM[1]

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

Domestic Production and Use: In 2010, five companies operated nine primary aluminum smelters; six smelters were closed the entire year. Demolition of two smelters that had been idle for several years was started in 2010. Based on published market prices, the value of primary metal production was $3.99 billion. Aluminum consumption was centered in the East Central United States. Packaging accounted for an estimated 31% of domestic consumption; the remainder was used in transportation, 28%; building, 14%; electrical, 9%; machinery, 7%; consumer durables, 7%; and other, 4%.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Primary	2,284	2,554	2,658	1,727	1,720
Secondary (from old scrap)	1,260	1,540	1,370	1,190	1,120
Imports for consumption	4,660	4,020	3,710	3,680	3,800
Exports	2,820	2,840	3,280	2,710	1,900
Consumption, apparent[2]	5,370	5,040	3,810	3,250	4,610
Price, ingot, average U.S. market (spot), cents per pound	121.4	125.2	120.5	79.4	101.7
Stocks:					
Aluminum industry, yearend	1,410	1,400	1,220	937	937
LME, U.S. warehouses, yearend[3]	228	463	1,290	2,200	2,340
Employment, number[4]	41,400	39,600	38,000	33,800	33,500
Net import reliance[5] as a percentage of apparent consumption	34	19	E	10	38

Recycling: In 2010, aluminum recovered from purchased scrap was about 2.7 million tons, of which about 59% came from new (manufacturing) scrap and 41% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 24% of apparent consumption.

Import Sources (2006–09): Canada, 60%; Russia, 11%; China, 5%; Mexico, 3%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010, production from domestic primary aluminum smelters had stabilized after cutbacks made during 2008 and 2009 in response to price drops in the second half of 2008. Production from a smelter in New Madrid, MO, reached full capacity in the second quarter of 2010 after partially closing as a result of an electrical failure in January 2009. Work on an expansion project resumed at the smelter in New Madrid that would increase capacity to 266,000 tons per year from 250,000 tons per year by yearend 2013. Work continued on an expansion project at a smelter in Massena, NY, which would increase production capacity to 148,000 tons per year from 125,000 tons per year. Demolition of smelters in Frederick, MD, and Badin, NC, were announced after the owner of both smelters was unable to obtain favorable power contracts. By the beginning of the fourth quarter of 2010, domestic smelters operated at about 55% of rated or engineered capacity.

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

ALUMINUM

The United States continued to be reliant upon imports in 2010, as domestic primary production remained at significantly lower levels than in 2008, and exports continued to decline. Canada, China, and Russia accounted for about 40% of total U.S. imports. U.S. exports decreased by 30% in 2010 compared with the amount exported in 2009. China, Canada, and Mexico, in descending order, received approximately 40% of total U.S. exports.

The monthly average U.S. market price for primary ingot quoted by Platts Metals Week ranged between $0.934 per pound and $1.109 per pound throughout 2010. Prices on the London Metal Exchange (LME) followed the trend of U.S. market prices.

World primary aluminum production increased in 2010 compared with production in 2009, mainly as a result of starting new smelters and restarting smelters that had been shut down in 2008 and early in 2009. New smelters and restarted smelters were mainly in China, Qatar, and the United Arab Emirates. Smelters in Norway that shut down production during midyear 2009 remained closed in 2010. World inventories of metal held by producers, as reported by the International Aluminium Institute, increased through the end of August to about 2.4 million tons from 2.2 million tons at yearend 2009. Inventories of primary aluminum metal held by the LME worldwide decreased during the year to 4.4 million tons at the end of September from 4.6 million tons at yearend 2009.

World Smelter Production and Capacity:

	Production		Yearend capacity	
	2009	**2010[e]**	**2009**	**2010[e]**
United States	1,727	1,720	3,500	3,190
Australia	1,940	1,950	2,050	2,050
Bahrain	870	870	880	880
Brazil	1,540	1,550	1,700	1,700
Canada	3,030	2,920	3,090	3,020
China	12,900	16,800	19,000	18,400
Germany	292	370	620	620
Iceland	785	780	790	790
India	1,400	1,400	1,700	2,300
Mozambique	545	550	570	570
Norway	1,130	800	1,230	1,230
Russia	3,820	3,850	4,280	4,280
South Africa	809	800	900	900
United Arab Emirates, Dubai	1,010	1,400	1,120	1,650
Venezuela	610	440	625	590
Other countries	4,900	5,200	6,750	6,800
World total (rounded)	37,300	41,400	48,800	49,000

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 reserves for bauxite are 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; excludes imported scrap.
[3]Includes aluminum alloy.
[4]Alumina and aluminum production workers (North American Industry Classification System—3313). Source: U.S. Department of Labor, Bureau of Labor Statistics.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.

ANTIMONY

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

Domestic Production and Use: There was no antimony mine production in the United States in 2010. 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, 35%; transportation, including batteries, 23%; chemicals, 16%; ceramics and glass, 12%; and others, 14%.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Mine (recoverable antimony)	—	W	—	—	—
Smelter:					
Primary	W	W	W	W	W
Secondary	3,520	3,480	3,180	3,020	3,100
Imports for consumption	23,200	21,900	29,000	20,200	22,000
Exports of metal, alloys, oxide, and waste and scrap[1]	2,140	1,950	2,200	2,100	1,900
Consumption, apparent[2]	24,300	23,700	28,800	19,800	21,600
Price, metal, average, cents per pound[3]	238	257	280	236	370
Stocks, yearend	2,120	1,900	1,490	1,420	1,500
Employment, plant, number[e]	10	10	10	15	15
Net import reliance[4] as a percentage of apparent consumption	86	85	94	92	93

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 (2006–09): Metal: China, 68%; Mexico, 14%; Peru, 8%; and other, 10%. Ore and concentrate: Bolivia, 59%; China, 28%; and other, 13%. Oxide: China, 53%; Mexico, 32%; Belgium, 8%; and other, 7%. Total: China, 56%; Mexico, 28%; Belgium, 7%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010, antimony production from domestic source materials was derived mostly from the recycling of lead-acid batteries. Recycling supplied only a minor portion of estimated domestic consumption, and the remainder came from imports. 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 continued to make antimony products. This domestic smelter, through its wholly owned Mexican subsidiary, received approval to build an ore-processing plant near its antimony-silver deposit in Mexico. The antimony materials produced there would provide feedstock for the Montana facility.

Two actions caused production reductions in China, the world's leading antimony producer. In March, the Government stated it would not approve any new projects for antimony before June 30, 2011; also in March, the Government shut down about 100 antimony smelters in China's dominant antimony-producing region, an action aimed at closing illegal mines and curbing pollution.

The price of antimony rose substantially during 2010. The price started the year at about $2.90 per pound and finished October at about $5.25 per pound. Industry observers attributed the strong price increase to production interruptions in China.

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

World Mine Production and Reserves: Reserves for China, Russia, and Thailand (in "Other countries") were changed based on new information from Government and other sources.

	Mine production		Reserves[5]
	2009	2010[e]	
Bolivia	3,000	3,000	310,000
China	140,000	120,000	950,000
Russia (recoverable)	3,500	3,000	350,000
South Africa	2,800	3,000	21,000
Tajikistan	2,000	2,000	50,000
Other countries	3,300	4,000	150,000
World total (rounded)	155,000	135,000	1,800,000

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 resource/reserve definitions and information concerning data sources.

ARSENIC

(Data in metric tons of arsenic unless otherwise noted)

Domestic Production and Use: Arsenic trioxide and arsenic metal have not been produced in the United States since 1985. Owing to environmental concerns and a voluntary ban on the use of arsenic trioxide for the production of chromated copper arsenate (CCA) wood preservatives at yearend 2003, imports of arsenic trioxide averaged 6,900 tons annually during 2004–09 compared with imports of arsenic trioxide that averaged more than 20,000 tons annually during 2001–03. Ammunition used by the United States military was hardened by the addition of less than 1% arsenic metal, and the grids in lead-acid storage batteries were strengthened by the addition of arsenic metal. Arsenic metal was also used 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. High-purity arsenic (99.9999%) was used by the electronics industry for gallium-arsenide semiconductors that are used for solar cells, space research, and telecommunication. Arsenic was also 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 2010 was estimated to be about $4 million.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Imports for consumption:					
Metal	1,070	759	376	438	980
Trioxide	9,430	7,010	4,810	4,660	4,900
Exports, metal	3,060	2,490	1,050	354	390
Estimated consumption[1]	7,450	5,280	4,130	4,740	5,500
Value, cents per pound, average:[2]					
Metal (China)	62	122	125	121	120
Trioxide (China)	21	23	23	18	20
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. These scrap materials 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 (2006–09): Metal: China, 85%; Japan, 12%; and other, 3%. Trioxide: Morocco, 52%; China, 40%; Belgium, 5%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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.

Events, Trends, and Issues: Apparent exports of arsenic metal have increased and, arsenic-containing “e-waste” such as computers and other electronics, destined for reclamation and recycling, may have been included in this export category. The exported arsenic metal may also have been intended for use in electronics applications. In 2010, the main export destinations for this category were Honduras (43%), Chile (28%), and Canada (21%).

In 1975, the Safe Drinking Water Act mandated that the U.S. Environmental Protection Agency (EPA) identify and regulate drinking water contaminants, such as arsenic, that may have adverse effects on human health. Ongoing applied research technology showed that 60% of total arsenic in source water at test sites in California, Minnesota, Nevada, New Hampshire, and Wisconsin, was removed.

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

ARSENIC

According to university medical research scientists, the ability to have an immune response to H1N1 (Swine Flu) infection was compromised by low levels of arsenic exposure from contaminated well water. Researchers noted that Mexico has areas of high arsenic in well water that include locations where H1N1 was first identified. Laboratory experiments on mice showed that morbidity for arsenic-exposed mice was significantly higher than for lab mice similarly exposed to H1N1, and researchers concluded that arsenic exposure disrupts the immune system and the endocrine system.

Nanotechnology may help alleviate water-pollution problems by removing contaminants such as arsenic, mercury, and pesticides. University researchers have used nanoparticles of iron or “nanorust” to remove arsenic from drinking water. The large surface area of nanorust and the magnetic interaction means that 100 times more arsenic can be captured using nanorust filtration than with filtration systems using larger particles. A chemical-free method to remove arsenic from well water was used in India. The treatment system contains a nozzle that sprays oxygen into water from arsenic-bearing aquifers. The oxygenated water oxidizes iron adsorbed from the groundwater into an iron compound that removes the arsenic as a coprecipitate.

In response to 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. However, because of known performance and lower cost, CCA may still be used to treat wood used for nonresidential applications. Arsenic may also be released from coal-burning powerplant emissions. Human health concerns, environmental regulation, use of alternative wood preservation material, and the substitution of concrete or plasticized wood products will affect the long-term demand for arsenic.

World Production and Reserves:

	Production (arsenic trioxide)		Reserves[4]
	2009	2010[e]	
Belgium	1,000	1,000	World reserves are thought to be about 20 times annual world production.
Chile	11,000	11,500	
China	25,000	25,000	
Kazakhstan	1,500	1,500	
Mexico	500	1,000	
Morocco	8,500	8,000	
Peru	4,850	4,500	
Russia	1,500	1,500	
Other countries	505	500	
World total (rounded)	54,400	54,500	

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

Substitutes: Substitutes for CCA in wood treatment include alkaline copper quaternary, ammoniacal copper quaternary, ammoniacal copper zinc arsenate, copper azole, and copper citrate. CCA-treated wood substitutes include concrete, steel, plasticized wood scrap, or plastic composite material. The use of silver-containing biocides is being considered as an alternative wood preservative in some humid areas.

[e]Estimated.
[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 resource/reserve definitions and information concerning data sources.

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 820 tons, based on asbestos imports through July 2010. Roofing products were estimated to account for about 72% of U.S. consumption and other applications, 28%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production (sales), mine	—	—	—	—	—
Imports for consumption	2,230	1,730	1,460	869	820
Exports[1]	3,410	815	368	59	180
Consumption, estimated	2,230	1,730	1,460	869	820
Price, average value, dollars per ton[2]	451	473	746	787	656
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2006–09): Canada, 90%; and other, 10%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
Crocidolite	2524.10.0000	Free.
Amosite	2524.90.0010	Free.
Chrysotile:		
Crudes	2524.90.0030	Free.
Milled fibers, group 3 grades	2524.90.0040	Free.
Milled fibers, group 4 and 5 grades	2524.90.0045	Free.
Other, chrysotile	2524.90.0055	Free.
Other	2524.90.0060	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: Health and liability issues continue to result in a decline in asbestos use by manufacturers of asbestos products. U.S. apparent consumption has declined to 820 tons in 2010 from 803,000 tons in 1973. In the past 2 years, some of the decline in imports and asbestos consumption probably can be attributed to reduced commercial building construction where asbestos-based roofing compounds may be used. Based on current trends, asbestos consumption is likely to continue to decline in the future. All the asbestos used in the United States was chrysotile, which was imported from Brazil and Canada.

World Mine Production and Reserves:

	Mine production		Reserves[4]
	2009	**2010[e]**	
United States	—	—	Small
Brazil	288,000	270,000	Moderate
Canada	150,000	100,000	Large
China	380,000	350,000	Large
Kazakhstan	230,000	230,000	Large
Russia	1,000,000	1,000,000	Large
Other countries	19,000	20,000	Moderate
World total (rounded)	2,070,000	1,970,000	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 Customs value for U.S. chrysotile imports, all grades combined. Prices for individual commercial products are no longer published.
[3]Defined as imports – exports.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.

BARITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Domestic producers of crude barite sold or used for grinding an estimated 670,000 tons in 2010 valued at about $36 million, an increase in production of 75% from that of 2009. 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 2010, an estimated 2.7 million tons of barite (from domestic production and imports) was sold by crushers and grinders in 10 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 Wyoming and then sold primarily to gas-drilling customers in Colorado, New Mexico, North Dakota, Utah, and Wyoming. Crude barite was shipped to a Canadian grinding mill in Lethbridge, Alberta, which supplies the Western Canada drilling mud market. The barite imports to Louisiana and Texas ports mostly went to offshore drilling operations in the Gulf of Mexico and to onshore operations in Louisiana, Oklahoma, and Texas.

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 underwater petroleum pipelines. 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.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Sold or used, mine	589	455	648	383	670
Imports for consumption	2,550	2,600	2,620	1,430	2,100
Exports	72	15	62	49	20
Consumption, apparent[1] (crude and ground)	3,070	3,040	3,210	1,770	2,800
Consumption[2] (ground and crushed)	3,040	2,980	2,840	2,080	2,700
Price, average value, dollars per ton, f.o.b. mine	40.00	45.30	47.60	51.90	54.00
Employment, mine and mill, number[e]	330	330	350	330	350
Net import reliance[3] as a percentage of apparent consumption	81	85	80	78	76

Recycling: None.

Import Sources (2006–09): China, 95%; India, 3%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 of barium	2833.27.0000	0.6% ad val.
Carbonate	2836.60.0000	2.3% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In April 2010, the explosion of the Deepwater Horizon drilling rig and subsea blowout of the Macondo oil well in the Gulf of Mexico resulted in the largest offshore oil spill in U.S. history. A 6-month moratorium on deepwater drilling was declared by the Government in late May and lifted in October after the U.S. Department of the Interior introduced new safety standards for operators drilling in water depths greater than 152 meters (500 feet). The drilling moratorium and more stringent regulatory reviews of shallow-water drilling applications reduced offshore drilling operations in the Gulf of Mexico, which resulted in a decrease in barite sales and consumption in the Gulf of Mexico. In mid-April (before the moratorium) there were 55 drilling rigs operating in the Gulf of Mexico, but by mid-July the number had dropped to 12. Deepwater wells require much larger amounts of barite than most onshore wells because of deeper drilling depths and higher pressures, so this small decrease in operating rigs had a significant impact on Gulf of Mexico barite sales. Some experts estimate it could take 2 years for oil and gas production in the Gulf of Mexico to return to pre-spill levels.

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

BARITE

Nationally, the rig count of operating drill rigs increased during 2010 as the oil and gas industry increased exploration activities after oil and gas prices recovered from their lows during the 2008–09 recession. The monthly rig count of operating drill rigs increased by nearly 500 between December 2009 and October 2010, and was led by Texas, with an additional 250 rigs operating; North Dakota, with an additional 66; and Oklahoma, with an additional 45.

Bad weather in China (drought conditions in the winter and early spring, and flooding in the summer and fall) hampered production and shipment of barite during 2010. Much of China's barite resources are in the provinces of Fujian, Guangdong, Guangxi, Guizhou, and Hunan in southern China, which was the region hit hardest by the adverse weather. India, the world's second leading barite producer, also experienced weather-related problems in its barite mining industry as its major barite mine in Andhra Pradesh was flooded by late summer monsoon rains. The lower part of the mine that produced higher quality 4.2 specific gravity product was flooded. China and India normally account for about 70% of world barite supplies, and weather-derived problems were expected to adversely affect world supplies of barite in the latter part of 2010 and apply upward pressure on prices.

World Mine Production and Reserves: The barite reserves estimates for Algeria, China, and Russia have been revised based on new information from those countries.

	Mine production		Reserves[4]
	2009	2010[e]	
United States	383	670	15,000
Algeria	60	60	29,000
China	3,000	3,600	100,000
Germany	75	75	1,000
India	1,200	1,000	34,000
Iran	200	250	NA
Kazakhstan	[5]95	[5]100	NA
Mexico	152	140	7,000
Morocco	[6]430	[6]460	10,000
Pakistan	42	45	1,000
Russia	63	65	12,000
Turkey	150	150	4,000
United Kingdom	50	50	100
Vietnam	70	90	NA
Other countries	160	160	24,000
World total (rounded)	6,130	6,900	240,000

World Resources: In the United States, identified resources of barite are estimated to be 150 million tons, and undiscovered 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]Imported and domestic barite, crushed and ground, sold or used by domestic grinding establishments.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[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 production 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, bauxite, mine	NA	NA	NA	NA	NA
Imports of bauxite for consumption[2]	12,900	11,200	12,400	7,770	9,050
Imports of alumina[3]	1,860	2,440	2,530	1,860	1,670
Exports of bauxite[2]	43	30	31	23	43
Exports of alumina[3]	1,540	1,160	1,150	946	1,700
Shipments of bauxite from Government stockpile excesses[2]	—	—	—	—	—
Consumption, apparent, bauxite and alumina (in aluminum equivalents)[4]	3,290	3,630	3,410	2,510	2,070
Price, bauxite, average value U.S. imports (f.a.s.) dollars per ton	28	31	26	30	27
Stocks, bauxite, industry, yearend[2]	W	W	W	W	W
Net import reliance,[5] bauxite and alumina, as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2006–09):[6] Bauxite: Jamaica, 35%; Guinea, 24%; Brazil, 17%; Guyana, 8%; and other, 16%. Alumina: Australia, 39%; Jamaica, 17%; Brazil, 16%; Suriname, 16%; and other, 12%. Total: Jamaica, 29%; Brazil, 17%; Guinea, 16%; Australia, 14%; and other, 24%.

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 9 months of 2010 had normal-trade-relations status.

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

Government Stockpile:

Stockpile Status—9-30-10[7]

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2010**	**Disposals FY 2010**
Bauxite, metal grade Jamaica-type	—	—	—	—

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

BAUXITE AND ALUMINA

Events, Trends, and Issues: The monthly average price (f.a.s.) for U.S. imports of metallurgical-grade alumina began the year at $343 per ton. By April, the price had peaked at $465 per ton, then declined to $323 per ton by August.

World production of alumina increased compared with that of 2009. Based on production data from the International Aluminium Institute and industry sources in China, world alumina production during 2010 increased by 14% compared with that in 2009. Increases in production from reopened, new, and expanded mines in Australia, Brazil, Guinea, India, and Jamaica accounted for most of the 6% increase in worldwide production of bauxite in 2010 compared with that of 2009.

World Bauxite Mine Production and Reserves: Reserves estimates for Australia, Brazil, Guyana, and India have been revised based on new information available through company and government reports.

	Mine production		Reserves[8]
	2009	2010[e]	
United States	NA	NA	20,000
Australia	65,200	70,000	5,400,000
Brazil	28,200	32,100	3,400,000
China	40,000	40,000	750,000
Greece	2,100	2,000	600,000
Guinea	15,600	17,400	7,400,000
Guyana	1,760	1,800	850,000
India	16,000	18,000	900,000
Jamaica	7,820	9,200	2,000,000
Kazakhstan	5,130	5,300	360,000
Russia	5,780	4,700	200,000
Suriname	4,000	3,100	580,000
Venezuela	2,500	2,500	320,000
Vietnam	30	30	2,100,000
Other countries	4,740	4,440	3,300,000
World total (rounded)	199,000	211,000	28,000,000

World Resources: Bauxite resources are estimated to be 55 to 75 billion tons, in Africa (32%), Oceania (23%), South America and the Caribbean (21%), Asia (18%), 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.

[3]Calcined equivalent weights.

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

[5]Defined as imports – exports + adjustments for Government and industry stock changes (all in aluminum equivalents). Treated as separate commodities, the U.S. net import reliance as a percentage of apparent consumption equaled 100% for bauxite, but the United States was a net exporter of alumina in 2010. For 2006–09, the U.S. net import reliance as a percentage of apparent consumption was 100% for bauxite and ranged from being a net exporter to 31% for alumina.

[6]Based on aluminum equivalents.

[7]See Appendix B for definitions.

[8]See Appendix C for resource/reserve definitions and information concerning data sources.

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 320 tons was valued at about $160 million, based on the estimated unit value for beryllium in imported beryllium-copper master alloy. Based on sales revenues, more than one-half of beryllium use was estimated to be in computer and telecommunications products, and the remainder was used in aerospace and defense applications, appliances, automotive electronics, industrial components, medical devices, and other applications.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, mine shipments[e]	155	150	175	120	170
Imports for consumption[1]	62	72	70	21	200
Exports[2]	135	101	112	23	40
Government stockpile releases[3]	158	36	39	19	29
Consumption:					
Apparent[4]	226	107	211	167	320
Reported, ore	180	190	220	150	290
Unit value, average annual, beryllium-copper master alloy, dollars per pound contained beryllium[5]	128	144	159	154	230
Stocks, ore, consumer, yearend	50	100	60	30	70
Net import reliance[6] as a percentage of apparent consumption	[7]31	E	17	28	47

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 (2006–09):[1] Kazakhstan, 57%; Kenya, 10%; Germany, 9%; Ireland, 8%; and other, 16%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010 Annual Materials Plan are as follows: beryl ore, 1 ton, and beryllium metal, 54 tons of contained beryllium. The 2011 Annual Materials Plan's publishing date was delayed by the Defense Logistics Agency.

Stockpile Status—9-30-10[8]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Beryl ore (11% BeO)	—	—	([9])	—
Beryllium-copper master alloy	—	—	—	—
Beryllium metal:				
Hot-pressed powder	97	52	—	36
Vacuum-cast	14	14	54	2

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

BERYLLIUM

Events, Trends, and Issues: Market conditions improved considerably for beryllium-based products in 2010. During the first half of 2010, the leading U.S. beryllium producer reported volume shipments of strip and bulk beryllium-copper alloy products to be 100% and 62% higher, respectively, than those during the first half of 2009. Sales of beryllium products for key markets, including aerospace, automotive electronics, ceramics, computer and telecommunications, medical and industrial x-ray equipment, and oil and gas, were substantially higher than those during the first half of 2009. Sales of beryllium products for defense-related applications were slightly higher in the first half of 2010 compared with those of the first half of 2009. The strong sales growth in 2010 was also due in part to higher beryllium prices and replenishment of supply chain inventories that were drawn down in 2009.

In an effort to ensure current and future availability of high-quality domestic beryllium to meet critical defense and commercial needs, the U.S. Department of Defense in 2005, under the Defense Production Act, Title III, invested in a public-private partnership with the leading U.S. beryllium producer to build a new $90.4 million primary beryllium facility in Ohio. Construction of the facility was completed in 2010. Approximately two-thirds of the facility's output was to be allocated for defense and government-related end uses; the remaining output going to the private sector. Plant capacity was reported at 160,000 pounds per year of high-purity beryllium metal to meet Defense requirements. Primary beryllium facilities, the last of which closed in the United States in 2000, traditionally produced 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 is required to carefully control the quantity of beryllium dust, fumes, and mists in the workplace, which adds to the final cost of beryllium products.

World Mine Production and Reserves:

	Mine production[e] 2009	Mine production[e] 2010
United States	120	170
China	20	20
Mozambique	2	2
Other countries	1	1
World total (rounded)	144	190

Reserves[10]

The United States has very little beryl that can be economically handsorted from pegmatite deposits. The Spor Mountain area in Utah, an epithermal deposit, contains a large bertrandite resource, which was being mined. Proven bertrandite reserves in Utah total about 15,900 tons of contained beryllium. World beryllium reserves 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. — 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]Less than ½ unit.
[10]See Appendix C for resource/reserve definitions and information concerning data sources.

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 reported consumption of bismuth was approximately $19 million. About 60% of the bismuth was used in pharmaceuticals and chemicals, 36% in metallurgical additives, and 4% in fusible alloys, solders, and ammunition cartridges.

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. As a result, that opened a wider market for bismuth as a metallurgical additive to lead-free pipes. 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Refinery	—	—	—	—	—
Secondary (old scrap)	80	100	100	60	50
Imports for consumption, metal	2,300	3,070	1,930	1,250	1,200
Exports, metal, alloys, and scrap	311	421	375	397	350
Consumption:					
Reported	1,960	2,630	1,090	1,180	1,050
Apparent	2,120	2,740	1,560	1,010	910
Price, average, domestic dealer, dollars per pound	5.04	14.07	12.73	7.84	8.22
Stocks, yearend, consumer	120	139	228	134	125
Net import reliance[1] as a percentage of apparent consumption	96	96	94	94	94

Recycling: All types of bismuth-containing new and old alloy scrap were recycled and contributed about 10% of U.S. bismuth consumption, or 100 tons.

Import Sources (2006–09): Belgium, 33%; China, 31%; United Kingdom, 17%; Mexico, 11%; and other, 8%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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 2010 at $7.65 per pound and rose slightly throughout the year, ending August at $8.40 per pound. The estimated average price of bismuth for 2010 was about 7% above that for 2009. Industry analysts attributed the higher price to increased world demand.

In Canada, an exploration firm announced further progress with the analysis and development of its cobalt-gold-bismuth deposit in Northwest Territories. Another Canadian exploration company reported additional advancements to develop its bismuth-fluorspar-tungsten property in Vietnam.

World Mine Production and Reserves:

	Mine production		Reserves[2]
	2009	2010[e]	
United States	—	—	—
Bolivia	50	150	10,000
Canada	90	100	5,000
China	6,000	5,100	240,000
Kazakhstan	150	140	5,000
Mexico	900	1,000	10,000
Peru	1,000	1,100	11,000
Other countries	10	10	39,000
World total (rounded)	8,200	7,600	320,000

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 had been on standby status since the mid-1990s awaiting a significant and sustained rise in the metal price, and in late 2008 there were reports that it had reopened. 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 resource/reserve definitions and information concerning data sources.

BORON

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

Domestic Production and Use: Two companies in southern California produced boron minerals, mostly sodium borates. Most of the boron products consumed in the United States are manufactured domestically. To avoid disclosing company proprietary data, U.S. boron production and consumption in 2010 were withheld. The leading boron producer mined borate ores containing kernite and tincal by open pit methods and operated associated compound plants. The kernite was used for boric acid production and the tincal was used as a feedstock for sodium borate production. A second company produced borates from brines extracted through solution mining techniques. 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 2010 was glass and ceramics, 78%; soaps, detergents, and bleaches, 4%; agriculture, 4%; enamels and glazes, 3%; and other, 11%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production[1]	W	W	W	W	W
Imports for consumption, gross weight:					
Borax	2	1	1	([2])	([2])
Boric acid	85	67	50	36	39
Colemanite	25	26	30	31	35
Ulexite	131	92	75	28	30
Exports, gross weight:					
Boric acid	221	248	303	171	250
Refined sodium borates	393	446	519	417	650
Consumption:					
Apparent	W	W	W	W	W
Reported	W	W	W	W	W
Price, average value of mineral imports at port of exportation, dollars per ton	298	302	302	339	360
Employment, number	1,320	1,320	1,310	1,220	1,240
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2006–09): Boric acid: Turkey, 59%; Chile, 22%; Bolivia, 8%; Peru, 5%; and other, 6%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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 **Marc A. Angulo [(703) 648-7945, mangulo@usgs.gov, fax: (703) 648-7757]**

BORON

Events, Trends, and Issues: The global economic downturn in the last quarter of 2008 and through most of 2009 negatively affected sectors vital for boron consumption, such as the construction and automotive industries. The moderate economic recovery in 2010 created steady growth in boron production and consumption. Demand for fiberglass, the principle use of boron, was expected to increase 2.3% annually through 2012. Consumption of boron used in high-technical fiberglass sectors, such as in electronic products and wind turbines, was expected to increase by 10% in North America and by 13% in Europe by 2012. Demand for borates was expected to shift slightly away from detergents and soaps towards glass and ceramics.

Although borate consumption in China decreased in 2009 owing to the economic downturn, consumption was projected to increase driven by demand from its domestic ceramic and glass industries. With low-grade domestic boron reserves and the anticipated rise in demand, Chinese imports from Chile, Russia, Turkey, and the United States were expected to increase over the next several years. Europe and emerging markets were requiring more stringent building standards with respect to heat conservation, which directly correlates to higher consumption of borates for insulation fiberglass. Continued investment in new refineries and technologies and the continued rise in demand were expected to fuel growth in world production over the next several years.

World Production and Reserves: Revisions to reserves estimates for Chile and China are based on new information from those countries.

	Production—All forms[4]		Reserves[5]
	2009	2010[e]	
United States	W	W	40,000
Argentina	750	800	2,000
Bolivia	83	92	NA
Chile	608	650	35,000
China	145	150	32,000
Iran	2	2	1,000
Kazakhstan	30	30	NA
Peru	187	170	4,000
Russia	400	400	40,000
Turkey	1,300	1,200	60,000
World total (rounded)	[6]3,510	[6]3,500	210,000

World Resources: Large deposits of boron resources containing high B_2O_3 content occur in southern California and in Turkey. U.S. deposits consist primarily of tincal, kernite, and borates contained in brines, and to a lesser extent ulexite and colemanite. About 70% of all Turkish deposits are colemanite. Small deposits are being mined in South America. At current levels of consumption, world resources are adequate for the foreseeable future.

Substitutes: The substitution of other materials for boron is possible in detergents, enamel, insulation, and soaps. Sodium percarbonate can replace borates in detergents and requires lower temperatures to undergo hydrolysis, which is an environmental consideration. Some enamels can use other glass-producing substances, such as phosphates. Insulation substitutes include cellulose, foams, and mineral wools. In soaps, sodium and potassium salts of fatty acids can act as cleaning and emulsifying agents.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Minerals and compounds sold or used by producers; includes both actual mine production and marketable products.
[2]Less than ½ unit.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]Gross weight of ore in thousand metric tons.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Excludes U.S. production.

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 capacity, although one company closed one of its plants early in the year.

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:	2006	2007	2008	2009	2010[e]
Production	[1]243,000	W	W	W	W
Imports for consumption, elemental bromine and compounds[2]	43,100	32,200	41,200	34,200	45,000
Exports, elemental bromine and compounds	12,400	8,560	9,640	6,120	8,000
Consumption, apparent	[3]275,000	W	W	W	W
Price, cents per kilogram, bulk, purified bromine	139.2	NA	NA	NA	NA
Employment, number[e]	1,100	1,000	1,000	1,000	950
Net import reliance[4] as a percentage of apparent consumption	12	<25	<25	<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 to the U.S. Geological Survey by companies but is included in data collected by the U.S. Census Bureau.

Import Sources (2006–09): Israel, 86%; China, 7%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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.

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

BROMINE

Events, Trends, and Issues: Although still the leading bromine producer in the world, the United States' dominance has decreased as other countries, such as Israel, Japan, and Jordan, strengthened their positions as world producers of elemental bromine. China also is a significant bromine producer, although environmental restrictions to protect farmland, limits to plant expansions, and shutdowns of unlicensed bromine operations have resulted in tight supplies in China and driven up prices globally.

The leading use of bromine is in flame retardants; however, this use is in decline because of the environmental considerations and potential health effects related to specific bromine flame-retardant compounds. In the United States in 2010, bromine chemical producers and importers reached an agreement with the U.S. Environmental Protection Agency to voluntarily phase out the production, importation, and use of decabromodiphenyl ether (Deca-BDE), a widely used flame retardant, in all consumer products by December 2012, and in all products by the end of 2013. Legislation with similar requirements was introduced in the U.S. House of Representatives. Canada and the European Union already had banned the use of Deca-BDE in computers, televisions, and textiles.

Several companies were pursuing new markets for bromine to mitigate mercury emissions at powerplants. Bromine compounds bond with mercury in flue gases from coal-fired powerplants creating mercuric bromide, a substance that is more easily captured in flue-gas scrubbers than the mercuric chloride that is produced at many facilities. Wide acceptance of the new technology would likely increase demand for bromine, counteracting, at least in part, the decline expected from the ban on Deca-BDE.

Bromine and bromine compound prices increased in 2010, reflecting the expanding markets of bromine, especially in China, and increases in the costs of energy, raw materials, regulatory compliance, and transportation.

World Production and Reserves:

	Production		Reserves[5]
	2009	2010[e]	
United States	W	W	11,000,000
Azerbaijan	3,500	3,500	300,000
China	140,000	140,000	NA
Germany	1,400	1,400	NA
India	1,500	1,500	NA
Israel	128,000	130,000	NA
Japan	20,000	20,000	NA
Jordan	80,000	80,000	NA
Spain	100	100	1,400,000
Turkmenistan	150	150	700,000
Ukraine	700	700	400,000
World total (rounded)	[6]375,000	[6]380,000	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 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]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]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 refined cadmium in 2010. One company, operating in Tennessee, recovered primary cadmium as a byproduct of zinc leaching from roasted sulfide concentrates. The other two companies, with facilities in Ohio and Pennsylvania, thermally recovered secondary 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 $2.2 million in 2010.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, refinery[1]	723	735	777	633	650
Imports for consumption:					
Metal only	179	315	153	117	210
Metal, alloys, scrap	180	316	197	122	215
Exports:					
Metal only	18	270	295	276	40
Metal, alloys, scrap	483	424	421	661	230
Consumption of metal, apparent	530	594	528	199	572
Price, metal, annual average,[2] dollars per kilogram	2.98	7.61	5.92	2.87	3.90
Stocks, yearend, producer and distributor[3]	74	107	132	27	90
Net import reliance[4] as a percentage of apparent consumption	E	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 (2006–09): Metal:[5] Mexico, 32%; Australia, 25%; Canada, 18%; Peru, 7%; and other, 18%.

Tariff: **Item**	**Number**	**Normal Trade Relations[6] 12-31-10**
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: Global refinery production of cadmium was estimated to increase in 2010 as a result of production increases at zinc smelters that also recovered byproduct cadmium. Domestic apparent consumption of cadmium recovered in 2010 from its relatively low level in 2009; apparent consumption of cadmium declined dramatically in 2009 from that of 2008 as the recession in the United States deepened. The increase in domestic consumption in 2010 may have been affected by the economic stimulus package, which allocated approximately $2 billion for advanced battery manufacturing. Global consumption of refined cadmium was expected to increase as the market for NiCd-containing portable electronics rises.

Most of the world's primary cadmium metal was produced in Asia and the Pacific—specifically China, Japan, and the Republic of Korea—followed by North America, Central Europe and Eurasia, and Western Europe. Secondary cadmium production takes place mainly at NiCd battery recycling facilities.

Cadmium use in batteries accounted for the majority of global consumption. The remainder was distributed as follows, in order of descending consumption: pigments, coatings and plating, stabilizers for plastics, nonferrous alloys, and other specialized uses (including photovoltaic devices). 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. 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 released 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 and Reserves: Cadmium reserves were calculated as a percentage of zinc reserves. Changes to cadmium reserves data from the prior year reflect a reevaluation of zinc reserves globally and by country.

	Refinery production		Reserves[7]
	2009	2010[e]	
United States	633	650	39,000
Australia	370	360	61,000
Canada	1,300	1,500	18,000
China	4,300	5,600	92,000
Germany	400	440	—
India	610	660	130,000
Japan	1,820	1,900	—
Kazakhstan	1,800	1,700	51,000
Korea, Republic of	3,000	3,200	—
Mexico	1,210	1,300	48,000
Netherlands	490	600	—
Peru	375	400	45,000
Poland	600	670	22,000
Russia	700	750	21,000
Other countries	1,190	2,300	130,000
World total (rounded)	18,800	22,000	660,000

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 sphalerite and wurtzite but usually at microscopic levels. 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 produced as a byproduct of lead-zinc refining plus metal from recycling.
[2]Average New York dealer price for 99.95% purity in 5-short-ton lots. Source: Platts Metals Week.
[3]Data were revised based on new information regarding producer stock levels.
[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, Mexico, and Peru for items shown.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.

CEMENT

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2010, about 61 million tons of portland cement and 1.8 million tons of masonry cement were produced at 102 plants in 36 States. Cement also was produced at two plants in Puerto Rico. Overall production was the lowest since 1982 and reflected continued plant closures and indefinite idlings. Although the rate of decline abated significantly, sales volumes in 2010 were the lowest in 27 years and were nearly 59 million tons or 45% below the record level of 2005. The overall value of sales was about $6.5 billion. Most of the cement was used to make concrete, worth at least $35 billion. About 73% of cement sales went to ready-mixed concrete producers, 12% to concrete product manufacturers, 10% to contractors (mainly road paving), 2% to building materials dealers, and 3% to other users. In descending order, Texas, California, Missouri, Pennsylvania, Alabama, and Michigan were the six leading cement-producing States and accounted for about 50% of U.S. production.

Salient Statistics—United States:[1]	2006	2007	2008	2009	2010[e]
Production:					
Portland and masonry cement[2]	98,167	95,464	86,310	63,929	62,800
Clinker	88,555	86,130	78,382	56,116	59,000
Shipments to final customers, includes exports	129,240	115,426	97,322	71,489	71,100
Imports of hydraulic cement for consumption	32,141	21,496	10,744	6,211	6,300
Imports of clinker for consumption	3,425	972	621	556	590
Exports of hydraulic cement and clinker	723	886	823	884	1,000
Consumption, apparent[3]	127,660	116,600	96,800	71,500	69,500
Price, average mill value, dollars per ton	101.50	104.00	103.50	99.00	92.00
Stocks, cement, yearend	9,380	8,890	8,360	6,130	4,700
Employment, mine and mill, number[e]	16,300	16,000	15,000	13,000	12,000
Net import reliance[4] as a percentage of apparent consumption	27	19	11	8	8

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 (2006–09):[5] China, 24%; Canada, 23%; Republic of Korea, 10%; Taiwan, 7%; and other, 36%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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: Construction spending levels remained low because of the combined effects of the ongoing depressed housing market, high numbers of housing foreclosures, reduced tax revenues to the States, credit tightening, and high levels of unemployment. In the construction sectors requiring significant amounts of concrete (hence cement), stimulus spending had little impact in 2009 and through the first half of 2010. Cement production began to pick up modestly after the first quarter in 2010 but still registered a decline for the year. The spate of announced plant closures and idlings begun in 2008 abated somewhat in 2010, although it was uncertain if some of the still idle plants would ever reopen. From 2008 through 2010, at least six plants were closed permanently, another plant permanently shut its only kiln, and nine plants were placed into indefinite idle status. Many multiple-kiln plants reduced the number of kilns in operation, and plants overall idled kilns temporarily for slow sales and extended the periods of maintenance downtime on the kilns. One new plant was expected to open toward yearend 2010.

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

CEMENT

The manufacture of clinker for cement releases a great deal of carbon dioxide, and plant-level reporting of these emissions to the U.S. Environmental Protection Agency (EPA) became mandatory in 2010. Carbon dioxide reduction strategies by the cement industry largely aim at reducing emissions per ton of cement product rather than by plant overall. These strategies include installation of more fuel-efficient kiln technologies, partial substitution of noncarbonated 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. Research was ongoing toward developing cements that require less energy to manufacture than portland cement, and/or that utilize more benign raw materials.

A new emissions limitation protocol for cement plants was finalized in 2010 by the EPA after initial release in 2009 and revisions in the interim. The protocol would significantly lower the acceptable emissions levels of mercury and certain other pollutants. It was unclear how many plants would be able to comply with the new limits; the mercury limits were further expected to make it difficult for cement plants to continue to burn fly ash as a raw material for clinker manufacture.

World Production and Capacity:

	Cement production		Clinker capacity[e]	
	2009	2010[e]	2009	2010
United States (includes Puerto Rico)	64,900	63,500	[6]114,000	[6]109,000
Brazil	51,700	59,000	50,000	55,000
China	1,629,000	1,800,000	1,300,000	1,500,000
Egypt	46,500	48,000	45,000	46,000
Germany	30,400	31,000	31,000	31,000
India	[e]205,000	220,000	250,000	260,000
Indonesia	[e]40,000	42,000	42,000	42,000
Iran	[e]50,000	55,000	50,000	57,000
Italy	36,300	35,000	46,000	46,000
Japan	54,800	56,000	63,000	63,000
Korea, Republic of	50,100	46,000	50,000	50,000
Mexico	35,200	34,000	42,000	42,000
Pakistan	[e]32,000	30,000	42,000	45,000
Russia	44,300	49,000	65,000	65,000
Saudi Arabia	[e]40,000	45,000	40,000	50,000
Spain	[e]50,000	50,000	42,000	42,000
Thailand	31,200	31,000	50,000	50,000
Turkey	54,000	60,000	63,000	65,000
Vietnam	47,900	50,000	50,000	55,000
Other countries (rounded)	[e]466,000	520,000	460,000	470,000
World total (rounded)	[e]3,060,000	3,300,000	2,900,000	3,100,000

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 (cement and clinker) – exports.

[5]Hydraulic cement and clinker.

[6]Capacity includes at least 7 million tons (2009) and nearly 6 million tons (2010) classified as indefinite idle status rather than closed.

CESIUM

(Data in kilograms of cesium content unless otherwise noted)

<u>Domestic Production and Use</u>: Pollucite, the principal ore mineral of cesium, is not mined in the United States; however, occurrences of cesium-bearing pollucite in pegmatites have been discovered in Maine and were mined in the past. Pollucite occurs in zoned pegmatites worldwide, associated with lepidolite, petalite, and spodumene; the largest deposit is at Bernic Lake in Canada. Canada is the leading producer and supplier of pollucite concentrate, which is imported for processing by one company in the United States. The principal end use of cesium is in formate brines, a high-density, low-viscosity fluid used for high-pressure/high-temperature (HPHT) oil and gas drilling and exploration. Cesium formate possesses anti-oxidant and water-structuring properties that protect drilling polymers from thermal degradation and has the required density needed to maintain well control. Other significant end uses are in biomedical, chemical, and electronic applications.

Cesium is used as an atomic resonance frequency standard in atomic clocks, playing a vital role in global positioning satellite, Internet, and cell phone transmissions and aircraft guidance systems. Cesium clocks monitor the cycles of microwave radiation emitted by cesium's electrons and use these cycles as a time reference. Owing to the high accuracy of the cesium atomic clock, the international definition of a second is based on the cesium atom. The U.S. primary time and frequency standard is based on a cesium fountain clock at the National Institute of Standards and Technology in Boulder, CO.

Cesium-131 and cesium-137 are used primarily to treat cancer. Both have been used in brachytherapy, where the radioactive source is placed within the cancerous area. With a shorter half-life and higher energy, cesium-131 is used as an alternative to iodine-125 and palladium-103 in the treatment of prostate cancer. Cesium-137 is also widely used in industrial gauges, in mining and geophysical instruments, and for sterilization of food, sewage, and surgical equipment. Cesium can be used in ferrous and nonferrous metallurgy to remove gases and other impurities.

<u>Salient Statistics—United States</u>: Consumption, import, and export data for cesium have not been available since the late 1980s. Because cesium is not traded, no market price is available. Consumption of cesium in the United States is estimated to be only a few thousand kilograms per year. In 2010, one company offered 1-gram ampoules of 99.8% (metals basis) cesium for $52.00 each and 99.98% (metals basis) cesium for $64.00, an increase of 2.6% and 1.9% from that of 2009, respectively. The price for 50 grams of 99.8% (metals basis) cesium was $642.00, and 100 grams of 99.98% (metals basis) cesium was priced at $1,760.00, an increase of 2.1% and 2.0% from that of 2009, respectively.

<u>Recycling</u>: Cesium formate brines are normally used by oil and gas exploration clients on a rental basis. After completion of the well, the used cesium formate is returned and reprocessed for subsequent drilling operations. Approximately 85% of the cesium formate can be retrieved and recycled for further use. There are no data available on the amounts used or recovered.

<u>Import Sources (2006–09)</u>: Canada is the chief source of pollucite concentrate imported by the United States, and the United States is 100% import reliant.

<u>Tariff</u>:

Item	Number	Normal Trade Relations 12-31-10
Alkali metals, other	2805.19.9000	5.5% ad val.
Chlorides, other	2827.39.9000	3.7% ad val.

<u>Depletion Allowance</u>: 14% (Domestic and foreign).

<u>Government Stockpile</u>: None.

Prepared by **Marc A. Angulo [(703) 648-7945, mangulo@usgs.gov, fax: (703) 648-7757]**

CESIUM

Events, Trends, and Issues: Domestic cesium occurrences will remain uneconomic unless market conditions change, such as the discovery of new end uses or increased consumption for existing end uses. Commercially useful quantities of inexpensive cesium are available as a byproduct of the production of lithium. Increases in lithium exploration are expected to yield discoveries of additional cesium resources, which may lead to expanded commercial applications. There are no known human health issues associated with cesium, and its use has minimal environmental impact.

Cesium's cost and reactivity limit its viability in many applications; however, its use in cesium formate brines and nuclear medicine is showing steady growth. Cesium formate drilling operations are being undertaken in the Thar Desert in Pakistan, in the North Sea off the coast of Norway, and in Argentina. In addition to its use in drilling fluid, cesium formate brine is used 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.

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." Cesium-137 is now regulated in the United States by the U.S. Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA). The NRC monitors devices containing cesium-137, requiring material holders to obtain specific licenses for these devices. The EPA places a maximum allowance of cesium-137 that can be released into the air by nuclear facilities and requires the cleanup of contaminated soil and groundwater. The NRC agreed to encourage research into finding and implementing alternatives, but deemed that a near-term replacement was not practical and would be detrimental to current emergency medical capabilities.

World Mine Production and Reserves: Pollucite, mainly formed in association with lithium-rich, lepidolite-bearing or petalite-bearing zoned granite pegmatites, is the principal cesium ore mineral. Cesium reserves are therefore estimated based on the occurrence of pollucite, which is mined as a byproduct of the lithium mineral lepidolite. Most pollucite contains 5% to 32% Cs_2O. Data on cesium resources and mine production are either limited or not available. The main pollucite zone at Bernic Lake in Canada contains approximately 400,000 metric tons of pollucite with an average Cs_2O content of 24%, and a secondary zone of approximately 100,000 metric tons of pollucite contains an average of 5% Cs_2O. The next largest occurrence that may become economic is in Zimbabwe.

	Reserves[1]
Canada	70,000,000
Other countries	NA
World total (rounded)	70,000,000

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

Substitutes: Cesium and rubidium can be used interchangeably in many applications because they have similar physical properties and atomic radii. Cesium, however, is more electropositive than rubidium, making it a preferred material in many applications.

NA Not available.
[1]See Appendix C for resource/reserve definitions and information concerning data sources.

CHROMIUM

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

Domestic Production and Use: In 2010, the United States was expected to consume about 2% 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 chromium metal. Stainless- and heat-resisting-steel producers were the leading consumers of ferrochromium. Superalloys require chromium. The value of chromium material consumption in 2009 was $358 million as measured by the value of net imports, excluding stainless steel, and was expected to be about $420 million in 2010.

Salient Statistics—United States:[1]	2006	2007	2008	2009	2010[e]
Production:					
Mine	—	—	—	—	—
Recycling[2]	179	162	146	141	160
Imports for consumption	520	485	559	273	400
Exports	212	291	287	280	200
Government stockpile releases	103	137	11	25	1
Consumption:					
Reported (includes recycling)	437	442	401	376	400
Apparent[3] (includes recycling)	589	493	432	159	360
Unit value, average annual import (dollars per metric ton):					
Chromite ore (gross mass)	141	156	227	227	230
Ferrochromium (chromium content)	1,290	1,951	3,728	2,085	2,400
Chromium metal (gross mass)	8,181	8,331	11,078	9,896	10,000
Stocks, yearend, held by U.S consumers	10	10	7	7	5
Net import reliance[4] as a percentage of apparent consumption	70	67	66	12	56

Recycling: In 2010, recycled chromium (contained in reported stainless steel scrap receipts) accounted for 44% of apparent consumption.

Import Sources (2006–09): Chromium contained in chromite ore, chromium ferroalloys and metal, and stainless steel mill products and scrap: South Africa, 33%; Kazakhstan, 16%; Russia, 9%; China, 6%; and other, 36%.

Tariff:[5] Item	Number	Normal Trade Relations 12-31-10
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:[6] 22% (Domestic), 14% (Foreign).

Government Stockpile: In fiscal year (FY) 2010, which ended on September 30, 2010, the Defense Logistics Agency, DLA Strategic Materials (formerly the Defense National Stockpile Center), reported disposals of 25,819 tons of high-carbon ferrochromium, 9,405 tons of low-carbon ferrochromium, and 151 tons of chromium metal. Disposals in the following table are estimated as the change in DLA Strategic Materials' reported current year minus previous year physical inventory, with adjustments for accounting changes when appropriate. 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 DLA Strategic Materials announced that maximum disposal limits for FY 2011 had not been approved.

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

CHROMIUM

Stockpile Status—9-30-10[6]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010	Average chromium content
Ferrochromium:					
High-carbon	95.4	—	[7]90.7	25.8	71.4%
Low-carbon	59.6	—	([7])	9.40	71.4%
Chromium metal	4.43	—	0.907	0.151	100%

Events, Trends, and Issues: Most chromite ore is converted into ferrochromium that is consumed by the metallurgical industry and most of that is consumed to make stainless and heat-resisting steel. World ingot and slab equivalent stainless and heat-resisting steel production at the end of the first half of 2010 was on track to reach 28 to 34 million tons for the year. At 28 million tons, production would be about the same as that of 2006, a year of peak production. At 34 million tons, an historically high stainless and heat-resisting steel world production would be reached.

World Mine Production and Reserves:

	Mine production[8] 2009	Mine production[8] 2010[e]	Reserves[9] (shipping grade)[10]
United States	—	—	620
India	3,760	3,800	44,000
Kazakhstan	3,330	3,400	180,000
South Africa	6,870	8,500	130,000
Other countries	5,340	6,300	NA
World total (rounded)	19,300	22,000	>350,000

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

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

[e]Estimated. NA Not available. — Zero.
[1]Data in thousand metric tons of contained chromium unless otherwise noted.
[2]Recycling production is based on reported stainless steel scrap receipts.
[3]Calculated consumption of chromium; equal to production (from mines and recycling) + imports – exports + stock adjustments.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]In addition to the tariff items listed, certain imported chromium materials (see 26 U.S.C. sec. 4661, 4662, and 4672) are subject to excise tax.
[6]See Appendix B for definitions.
[7]Disposal plan for ferrochromium without distinction between high-carbon and low-carbon ferrochromium; total included in high-carbon.
[8]Mine production units are thousand metric tons, gross weight, of marketable chromite ore.
[9]See Appendix C for resource/reserve definitions and information concerning data sources.
[10]Reserves 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 2010, clay and shale production was reported in 39 States. About 180 companies operated approximately 820 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 2010, sales or use was estimated to be 27 million tons valued at $1.5 billion. Major uses for specific clays were estimated to be as follows: ball clay—36% floor and wall tile, 22% sanitaryware, and 42% other uses; bentonite—25% absorbents, 19% drilling mud, 17% foundry sand bond, 12% iron ore pelletizing, and 27% other uses; common clay—50% brick, 25% lightweight aggregate, 16% cement, and 9% other uses; fire clay—38% heavy clay products, 62% refractory products and other uses; fuller's earth—74% absorbent uses and 26% other uses; and kaolin—58% paper and 42% other uses.

Salient Statistics—United States:[1]	2006	2007	2008	2009	2010[e]
Production, mine:					
Ball clay	1,190	1,070	967	831	910
Bentonite	4,940	4,820	5,030	3,650	4,000
Common clay	24,200	20,600	17,500	12,500	13,500
Fire clay	848	565	447	320	270
Fuller's earth	2,540	2,660	[2]2,350	[2]2,010	[2]2,300
Kaolin	7,470	7,110	6,740	5,290	5,700
Total[3]	41,200	36,700	[2]33,200	[2]24,500	[2]27,000
Imports for consumption:					
Artificially activated clay and earth	21	23	25	20	18
Kaolin	303	194	330	281	250
Other	22	14	20	26	34
Total[3]	346	231	375	327	300
Exports:					
Ball clay	140	83	65	35	41
Bentonite	1,270	1,430	1,090	710	960
Fire clay[4]	348	425	393	328	395
Fuller's earth	69	134	127	90	330
Kaolin	3,540	3,300	2,960	2,290	2,600
Clays, not elsewhere classified	607	279	153	374	365
Total[3]	5,980	5,650	4,790	3,830	4,700
Consumption, apparent	35,600	31,400	28,600	21,000	23,000
Price, average, dollars per ton:					
Ball clay	44	46	46	45	47
Bentonite	48	52	49	57	59
Common clay	10	11	12	13	13
Fire clay	22	42	40	30	31
Fuller's earth	96	97	[2]98	[2]102	[2]107
Kaolin	131	135	134	135	140
Employment, number:[e]					
Mine	1,250	1,150	1,060	875	770
Mill	5,130	5,080	5,020	4,540	4,100
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2006–09): Brazil, 81%; Mexico, 6%; Canada, 4%; United Kingdom, 3%; and other, 6%.

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

CLAYS

Tariff: Item	Number	Normal Trade Relations 12-31-10
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); clay from which alumina and aluminum compounds are extracted, 22% (Domestic); and ball clay, bentonite, china clay, sagger clay, and clay used or sold for use dependent on its refractory properties, 14% (Domestic).

Government Stockpile: None.

Events, Trends, and Issues: Many markets for clays improved in 2010 as the U.S. economy began to recover from the recession, which began in 2008. A slight improvement in commercial and private housing construction resulted in increased sales of ball clay and common clay. Bentonite sales increased with greater demand from the oil drilling, foundry, and iron ore industries. Kaolin production improved because of a slight recovery in world paper markets and greater construction activity. Fuller's earth and kaolin sales increased mainly on the strength of increased exports.

World Mine Production and Reserves:[6] Reserves are large in major producing countries, but data are not available.

	Mine production					
	Bentonite		Fuller's earth		Kaolin	
	2009	2010e	2009	2010e	2009	2010e
United States (sales)	3,650	4,000	[2]2,010	[2]2,300	5,290	5,700
Brazil (beneficiated)	239	245	—	—	2,680	2,750
Czech Republic (crude)	116	120	—	—	2,890	2,950
Germany (sales)	350	380	—	—	3,200	3,250
Greece (crude)	845	860	—	—	—	—
Italy	146	150	3	3	1,070	1,000
Mexico	511	520	108	110	78	80
Spain	155	165	820	830	465	470
Turkey	1,000	1,050	—	—	800	850
Ukraine (crude)	300	320	—	—	1,120	1,150
United Kingdom	—	—	—	—	1,800	1,850
Uzbekistan (crude)	—	—	—	—	5,500	5,550
Other countries	2,350	2,400	259	285	8,140	8,400
World total (rounded)	9,660	10,000	3,200	3,500	33,000	34,000

World Resources: Resources of all clays are extremely large.

Substitutes: Clays compete with calcium carbonate in many filler and extender applications. For pet litter, clays compete with other mineral-based litters such as those manufactured using diatomite and zeolite; organic litters made from shredded corn stalks and paper, straw, and wood shavings; and litters made using silica gel. As an oil absorbent, clays compete mainly with diatomite, zeolite, and a variety of polymer and natural organic products.

[e]Estimated. E Net exporter. — Zero.
[1]Excludes Puerto Rico.
[2]Excludes attapulgite.
[3]Data may not add to totals shown because of independent rounding.
[4]Also includes some refractory-grade kaolin.
[5]Defined as imports – exports.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

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 2010; however, negligible amounts of byproduct cobalt were produced as intermediate products from some mining operations. U.S. supply comprised imports, stock releases, and secondary (scrap) materials. The sole U.S. producer of extra-fine cobalt powder, in Pennsylvania, used cemented carbide scrap as feed. Six 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 49% of the cobalt consumed in the United States was used in superalloys, mainly in aircraft gas turbine engines; 7% in cemented carbides for cutting and wear-resistant applications; 15% in various other metallic applications; and 29% in a variety of chemical applications. The total estimated value of cobalt consumed in 2010 was $440 million.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Mine	—	—	—	—	—
Secondary	2,010	1,930	1,930	1,790	2,000
Imports for consumption	11,600	10,300	10,700	7,680	11,000
Exports	2,850	3,100	2,850	2,440	2,800
Shipments from Government stockpile excesses	260	617	203	180	—
Consumption:					
Reported (includes secondary)	9,280	9,320	8,810	7,460	8,500
Apparent[1] (includes secondary)	11,000	9,630	10,100	7,520	10,000
Price, average annual spot for cathode, dollars per pound	17.22	30.55	39.01	17.86	21.00
Stocks, yearend:					
Industry	1,180	1,310	1,160	840	880
LME, U.S. warehouse	XX	XX	XX	XX	30
Net import reliance[2] as a percentage of apparent consumption	82	80	81	76	81

Recycling: In 2010, cobalt contained in purchased scrap represented an estimated 24% of cobalt reported consumption.

Import Sources (2006–09): Cobalt contained in metal, oxide, and salts: Norway, 18%; Russia, 16%; China, 15%; Canada, 11%; and other, 40%.

Tariff: **Item**	**Number**	**Normal Trade Relations[3] 12-31-10**
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:

Stockpile Status—9-30-10[4]

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2010**	**Disposals FY 2010**
Cobalt	301	301	454	6

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

COBALT

Events, Trends, and Issues: During 2009 and into 2010, global economic conditions began to improve, which resulted in increased demand for and supply of cobalt. During the first half of 2010, the world availability of refined cobalt (as measured by production and U.S. Government shipments) was 49% higher than that of the first half of 2009. China showed the largest increase in production; production from Congo (Kinshasa), Japan, and Zambia also increased significantly. In the next few years, global increases in supply from existing producers and new projects are forecast to outpace increases in consumption. If an oversupply of cobalt takes place, it could lead to a downward trend in prices.

The London Metal Exchange (LME) launched a cobalt contract in February 2010. The global contract traded in 1-metric-ton lots of minimum 99.3% cobalt metal with delivery to warehouses in Asia, Europe, and the United States. In early November, LME warehouses held approximately 200 tons of cobalt inventory worldwide.

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). China was a leading supplier of cobalt imports to the United States.

World Mine Production and Reserves: Reserves for Australia, Brazil, and China were revised based on information from those countries. Reserves for Canada, New Caledonia, and "Other countries" were revised based on company reports.

	Mine production		Reserves[5]
	2009	2010[e]	
United States	—	—	33,000
Australia	4,600	4,600	[6]1,400,000
Brazil	1,200	1,500	89,000
Canada	4,100	2,500	150,000
China	6,000	6,200	80,000
Congo (Kinshasa)	35,500	45,000	3,400,000
Cuba	3,500	3,500	500,000
Morocco	1,600	1,500	20,000
New Caledonia[7]	1,000	1,700	370,000
Russia	6,100	6,100	250,000
Zambia	5,000	11,000	270,000
Other countries	3,700	4,700	740,000
World total (rounded)	72,300	88,000	7,300,000

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 some applications, substitution for 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; cerium, iron, lead, manganese, or vanadium in paints; cobalt-iron-copper or iron-copper in diamond tools; iron-cobalt-nickel, nickel, cermets, or ceramics in cutting and wear-resistant materials; iron-phosphorous, manganese, nickel-cobalt-aluminum, or nickel-cobalt-manganese in lithium-ion batteries; nickel-based alloys or ceramics in jet engines; nickel in petroleum catalysts; and rhodium in hydroformylation catalysts.

[e]Estimated. XX Not applicable. — 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 resource/reserve definitions and information concerning data sources.
[6]Joint Ore Reserves Committee (JORC) compliant reserves for Australia were only about 290,000 tons.
[7]Overseas territory of France.

COPPER

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

Domestic Production and Use: Domestic mine production of copper in 2010 declined by about 5% to 1.12 million tons but its value rose to about $8.4 billion. The principal mining States, in descending order of production—Arizona, Utah, Nevada, New Mexico, 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 28 mines operating in the United States, 19 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; 15 rod mills; and 500 foundries, chemical plants, and miscellaneous consumers. Copper and copper alloy products were used in building construction, 49%; electric and electronic products, 20%; transportation equipment, 12%; consumer and general products, 10%; and industrial machinery and equipment, 9%.[1]

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Mine	1,200	1,170	1,310	1,180	1,120
Refinery:					
Primary	1,210	1,270	1,220	1,110	1,050
Secondary	45	46	54	46	45
Copper from all old scrap	151	158	155	172	160
Imports for consumption:					
Ores and concentrates	([2])	1	1	([2])	1
Refined	1,070	829	724	664	640
Unmanufactured	1,320	1,100	934	788	760
General imports, refined	1,070	832	721	645	620
Exports:					
Ores and concentrates	108	134	301	151	140
Refined	106	51	37	81	90
Unmanufactured	990	884	1,090	932	1,020
Consumption:					
Reported, refined	2,110	2,140	2,020	1,650	1,730
Apparent, unmanufactured[3]	2,200	2,270	2,000	1,600	1,730
Price, average, cents per pound:					
Domestic producer, cathode	314.8	328.0	319.2	241.2	342
London Metal Exchange, high-grade	304.9	322.8	315.0	233.6	335
Stocks, yearend, refined, held by U.S. producers, consumers, and metal exchanges	194	130	187	433	440
Employment, mine and mill, thousands	8.4	9.7	11.9	8.3	8.7
Net import reliance[4] as a percentage of apparent consumption	38	37	31	20	30

Recycling: Old scrap, converted to refined metal and alloys, provided 160,000 tons of copper, equivalent to 9% of apparent consumption. Purchased new scrap, derived from fabricating operations, yielded 670,000 tons of contained copper; about 82% 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 70%; miscellaneous manufacturers, foundries, and chemical plants, 14%; ingot makers, 11%; and copper smelters and refiners, 5%. Copper in all old and new, refined or remelted scrap contributed about 35% of the U.S. copper supply.

Import Sources (2006–09): Unmanufactured: Chile, 41%; Canada, 33%; Peru, 13%; Mexico, 6%; and other, 7%. Refined copper accounted for 82% of unwrought copper imports.

Tariff: Item	Number	Normal Trade Relations[5] 12-31-10
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: Refined copper prices, which began the year above $3.00 per pound, fluctuated sharply through several cycles during the first 9 months of the year, the London Metal Exchange Ltd. (LME) price ranging between $2.76 per pound (June 7) and $3.65 per pound (September 30), and averaging $3.25 during the period. While LME inventories of refined copper at the end of June were down slightly from those at yearend 2009, in September, the International Copper Study Group[6] projected that global refined copper production in 2010 would exceed refined copper demand by about 200,000 tons, about equal to that in 2009, as consumption and production of copper were projected to increase by 4% each. While consumption in 2010 was expected to increase significantly in North America and Europe, apparent consumption in the Asian market was expected to increase only slightly. China's apparent consumption of refined copper, which had increased by 38% in 2009, was expected to fall below that level in 2010. Substitution of refined copper for scrap and the assumed accumulation of significant quantities of unreported inventories had boosted apparent consumption in 2009 well above the growth in China's semimanufactures.

U.S. mine and refinery production continued to decline in 2010 owing to mine cutbacks instituted at yearend 2008 and lower ore grades. One electrolytic refinery in Michigan that treated imported anode closed in August. U.S. copper mine production was expected to rise by more than 100,000 tons in 2011 owing to expansions and restoration of cutbacks. Domestic consumption of refined copper rose by about 5% in 2010 but remained below the 2008 level.

World Mine Production and Reserves: Significant upward revisions to reserves for Australia and Peru are based on government reports. For Australia, Geoscience Australia's "Accessible Economically Demonstrated Resources" are reported; Joint Ore Reserves Committee (JORC) compliant reserves for Australia were only about 23 million tons. The Russian reserves estimate was revised and adjusted upward to include the Udokan deposit.

	Mine production		Reserves[7]
	2009	2010[e]	
United States	1,180	1,120	35,000
Australia	854	900	80,000
Canada	491	480	8,000
Chile	5,390	5,520	150,000
China	995	1,150	30,000
Indonesia	996	840	30,000
Kazakhstan	390	400	18,000
Mexico	238	230	38,000
Peru	1,275	1,285	90,000
Poland	439	430	26,000
Russia	725	750	30,000
Zambia	697	770	20,000
Other countries	2,190	2,300	80,000
World total (rounded)	15,900	16,200	630,000

World Resources: Recent assessments of copper resources indicated 550 million tons of copper remaining in identified and undiscovered resources in the United States[8] and 1.3 billion tons of copper in discovered, mined, and undiscovered resources in the Andes Mountains of South America.[9] A preliminary assessment indicates that global land-based resources exceed 3 billion tons. Deep-sea nodules and massive sulfides are potential copper resources.

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 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 2009 by the Copper Development Association, Inc., 2010.
[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, Chile, Mexico, and Peru for items shown. Tariffs for other countries may be eliminated under special trade agreements.
[6]International Copper Study Group, 2010, Forecast 2010–2011: Lisbon, Portugal, International Copper Study Group press release, October 1, 1 p.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.
[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.
[9]Cunningham, C.G., et al., 2008, Quantitative mineral resource assessment of copper, molybdenum, gold, and silver in undiscovered porphyry copper deposits in the Andes Mountains of South America: U.S. Geological Survey Open-file Report 2008–1253, 282 p.

DIAMOND (INDUSTRIAL)

(Data in million carats unless otherwise noted)

Domestic Production and Use: In 2010, total domestic production of industrial diamond was estimated to be approximately 93 million carats, and the United States was one of the world's leading markets. Domestic output was synthetic grit, powder, and stone. Two firms, one in Pennsylvania and another in Ohio, accounted for all of the production. Nine firms produced polycrystalline diamond from diamond powder. Three 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 93% 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Bort, grit, and dust and powder; natural and synthetic:					
Production:					
Manufactured diamond[e]	47	48	48.3	38.3	39
Secondary	34.2	34.4	33.9	33.5	33
Imports for consumption	371	411	492	246	520
Exports[1]	90	107	116	67	100
Consumption, apparent	362	386	458	271	490
Price, value of imports, dollars per carat	0.22	0.19	0.15	0.17	0.15
Net import reliance[2] as a percentage of apparent consumption	78	79	82	71	85
Stones, natural and synthetic:					
Production:					
Manufactured diamond[e]	81	82	83.1	52.7	54
Secondary	0.56	0.38	0.36	0.46	0.46
Imports for consumption[3]	2.2	3.1	3.22	1.4	1.7
Exports[1]	([4])	—	—	—	—
Sales from Government stockpile excesses	([4])	([4])	0.47	—	—
Consumption, apparent	83.8	85.5	87.1	54.6	56
Price, value of imports, dollars per carat	12.61	11.54	12.89	13.31	18.09
Net import reliance[2] as a percentage of apparent consumption	3	4	4	3	3

Recycling: In 2010, the amount of diamond bort, grit, and dust and powder recycled was estimated to be 33 million carats. Lower prices of newly produced industrial diamond appear to be reducing the number and scale of diamond stone recycling operations. In 2010, it was estimated that 458,000 carats of diamond stone was recycled.

Import Sources (2006–09): Bort, grit, and dust and powder; natural and synthetic: China, 63%; Ireland, 21%; Russia, 5%; Republic of Korea, 4%; and other, 7%. Stones, primarily natural: Botswana, 49%; South Africa, 29%; Namibia, 13%; India, 8%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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).

Government Stockpile: None.

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

DIAMOND (INDUSTRIAL)

Events, Trends, and Issues: In 2010, China was the world's leading producer of synthetic industrial diamond, with annual production exceeding 4 billion carats. The United States is likely to continue to be one of the world's leading markets for industrial diamond into the next decade and likely will remain a significant producer and exporter of synthetic industrial diamond as well. Owing to the negative impact of the economic recession on U.S. manufacturing sectors that utilize industrial diamond, U.S. imports in 2009 declined significantly compared with those of 2008, but they returned to prerecession levels in 2010. 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.

Demand for synthetic diamond grit and powder is expected to remain greater than that 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 to increase.

World Mine Production and Reserves:[5]

	Mine production		Reserves[6]
	2009	2010[e]	
United States	—	—	NA
Australia	11	11	95
Botswana	7	7	130
China	1	1	10
Congo (Kinshasa)	14	14	150
Russia	15	15	40
South Africa	3	3	70
Other countries	4	4	85
World total (rounded)	55	55	580

World Resources: Natural diamond resources have been discovered in more than 35 countries. Natural diamond accounts for about 1.2% 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 98.8% 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]May include synthetic miners' diamond.
[4]Less than ½ unit.
[5]Natural industrial diamond only. Note that synthetic diamond production far exceeds natural industrial diamond output. Worldwide production of manufactured industrial diamond totaled at least 4.38 billion carats in 2010; the leading producers included China, Ireland, Japan, Russia, South Africa, and the United States.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

DIATOMITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2010, domestic production of diatomite was estimated at 550,000 tons with an estimated processed value of $138 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, 55%; cement additives, 23%; absorbents, 10%; fillers, 9%; insulation, 2%; and less than 1% for other applications, including specialized pharmaceutical and biomedical uses. The unit value of diatomite varied widely in 2010, from less than $7.00 per ton for cement manufacture to more than $10,500 per ton for limited specialty markets, including art supplies, cosmetics, and DNA extraction. The average unit value for filter-grade diatomite was $380 per ton.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production[1]	799	687	764	575	550
Imports for consumption	7	4	3	1	1
Exports	150	143	151	88	90
Consumption, apparent	656	548	616	488	460
Price, average value, dollars per ton, f.o.b. plant	220	237	224	255	250
Stocks, producer, yearend[e]	40	40	40	40	40
Employment, mine and plant, number[e]	1,020	1,020	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 (2006–09): Spain, 31%; Italy, 25%; France, 16%; Mexico, 13%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010 decreased by about 4% compared with that of 2009. 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 was the next largest use. 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 and Reserves:

	Mine production		Reserves[3]
	2009	2010[e]	
United States[1]	575	550	250,000
Argentina	40	40	N/A
China	440	450	110,000
Commonwealth of Independent States	80	80	NA
Denmark[4] (processed)	225	225	NA
France	75	75	NA
Iceland	26	25	NA
Italy	25	25	NA
Japan	110	110	NA
Mexico	116	120	NA
Spain	50	50	NA
Turkey	30	30	NA
Other countries	50	50	NA
World total (rounded)	1,840	1,830	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 resource/reserve definitions and information concerning data sources.
[4]Includes sales of moler production.

FELDSPAR

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: U.S. feldspar production in 2010 was valued at about $36 million. The three leading producers accounted for about 88% of the production, with four other companies supplying the remainder. Producing states were North Carolina, Virginia, California, Idaho, Oklahoma, Georgia, 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 2010 end-use distribution of domestic feldspar was glass, 70%, and pottery and other uses, 30%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, marketable[e]	760	730	650	550	570
Imports for consumption	5	4	2	2	2
Exports	10	10	15	8	13
Consumption, apparent[e]	755	724	637	544	560
Price, average value, marketable production, dollars per ton	59	59	60	64	64
Employment, mine, preparation plant, and office, number[e]	400	400	700	570	570
Net import reliance[1] as a percentage of apparent consumption	E	E	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 (2006–09): Mexico, 82%; Germany, 9%; Canada, 7%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Feldspar	2529.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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. Most feldspar consumed by the glass industry is for the manufacture of container glass. The glass container industry was moderately stable, although competing materials in some market segments, such as baby food, fruit juices, mineral water, and wine, and a recent trend to import less expensive containers from China, presented challenges. While recovery for world economic markets from the economic recession in 2008 and 2009 was slow, slight improvement began in 2010. Residential and automotive flat glass markets continued to be somewhat depressed. Declines persisted in housing starts, and there was a continued sluggish increase in demand from commercial construction; however, partly owing to modestly increasing automobile sales and a modestly rejuvenated domestic automobile industry, general economic conditions improved.

Because of environmental initiatives, fiberglass consumption for thermal insulation was forecast to expand steadily in the United States through 2013. Domestic feldspar consumption has been shifting from ceramics toward glass markets. Another growing segment in the glass industry was solar glass. While only about 5% of glass manufactured in Europe was used to produce solar glass, that market was expected to increase as the solar cell market developed, potentially surpassing consumption in the automotive sector in Europe by 2025.

Prepared by **Arnold O. Tanner [(703) 648-4791, atanner@usgs.gov, fax: (703) 648-7757]**

FELDSPAR

Feldspar use in tile and sanitary ware continued to be sluggish because of the struggling housing market. At the request of European ceramic makers, the European Union (EU) began an antidumping probe of imported ceramic tiles from China to determine whether Chinese imports had caused injury to the EU's industry. Antidumping duties could be assessed against Chinese imports in the EU, depending on the results of the investigation.

World Mine Production and Reserves: Estimates of reserves were revised for the Czech Republic based on October 2008 Mineral Commodity Summaries of the Czech Republic; revisions for India were based on the Indian Minerals Yearbook.

	Mine production		Reserves[2]
	2009	2010[e]	
United States[e]	550	570	NA
Argentina	214	220	NA
Brazil	150	150	NA
China	2,000	2,000	NA
Czech Republic	431	440	29,000
Egypt	354	180	5,000
France	650	650	NA
Germany	140	150	NA
India	410	410	38,000
Iran	500	500	NA
Italy	4,700	4,700	NA
Japan	700	600	NA
Korea, Republic of	623	630	NA
Malaysia	357	450	NA
Mexico	383	440	NA
Poland	550	550	NA
Portugal	320	320	11,000
Saudi Arabia	500	500	NA
South Africa	100	100	NA
Spain	550	580	NA
Thailand	600	620	NA
Turkey	4,210	4,500	NA
Venezuela	200	170	NA
Other countries	760	750	NA
World total (rounded)	20,000	20,000	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. Ample geologic evidence indicates that resources are large, although not always conveniently accessible to the principal centers of consumption.

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

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

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

[2]See Appendix C for resource/reserve definitions and information concerning data sources.

FLUORSPAR

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In Illinois, fluorspar (calcium fluoride) 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, production of hydrofluoric acid (HF) in Louisiana and Texas was by far the leading use for acid-grade fluorspar. HF is the primary feedstock for the manufacture of virtually all fluorine-bearing chemicals and is also a key ingredient in the processing of aluminum and uranium. Other uses included 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 68,000 tons of fluorosilicic acid (equivalent to about 120,000 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Finished, all grades	—	—	NA	NA	NA
Fluorspar equivalent from phosphate rock	70	94	111	114	120
Imports for consumption:					
Acid grade	490	577	496	417	470
Metallurgical grade	62	43	76	58	70
Total fluorspar imports	553	620	572	475	540
Fluorspar equivalent from hydrofluoric acid plus cryolite	233	233	209	175	200
Exports	13	14	19	14	20
Shipments from Government stockpile	66	17	—	—	—
Consumption:					
Apparent[1]	608	613	528	473	520
Reported	523	539	506	400	480
Price, average value, dollars per ton, c.i.f. U.S. port					
Acid grade	217	NA	NA	NA	NA
Metallurgical grade	101	111	107	109	101
Stocks, yearend, consumer and dealer[2]	90	90	115	103	110
Net import reliance[3] 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 (2006–09): Mexico, 47%; China, 40%; South Africa, 9%; and Mongolia, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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: The last of the Government stocks of fluorspar officially were sold in fiscal year 2007.

Events, Trends, and Issues: World fluorspar demand showed some signs of recovery in 2010, but was still depressed compared with that of 2008. Prices were higher compared with those of 2009 but were still far below their peak in late 2008. Market conditions improved enough that some African fluorspar mines, which were forced to shut down in 2009 because of low demand and low prices, were able to resume production in 2010. With the dramatic decrease in fluorspar exports from China in recent years, companies outside of China were attempting to replace lost Chinese export supplies by expanding capacity at current mines or by developing new fluorspar mining projects. For example, Mexico's second leading fluorspar producer was developing new fluorspar mining concessions that were expected to be in production by the end of 2010. The new operations would increase the company's annual acidspar capacity by between 30,000 and 40,000 tons. Development work continued on the new U.S. fluorspar mine in western Kentucky, which was expected to begin production in early 2011 and produce about 50,000 tons of fluorspar per year. Work proceeded on reopening the St. Lawrence fluorspar mine in southeastern Newfoundland, Canada,

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

FLUORSPAR

with planned output of 120,000 to 180,000 tons of fluorspar per year. Some exploration activities were ongoing, particularly in Sweden, but development or exploration work on other projects was slowed by lagging demand and lack of investment capital.

Fluorspar was included in the list of 14 raw materials labeled as “critical” by an expert group chaired by the European Commission of the European Union (EU). The EU faces a potential shortage of these materials, which have high supply risks because a large share of the worldwide production comes from a handful of countries. This concentration of production is compounded by low substitutability and low recycling rates. The list was established in the framework of the 2008 EU Raw Materials Initiative, and the results of the report were expected to be used to help form strategies to ensure future access to critical raw materials. The expert group recommended updating the list of EU critical raw materials every 5 years and enlarging the scope for criticality assessment; policy actions improving access to primary resources; policy actions making recycling of raw materials or raw material-containing products more efficient; encouraging substitution of certain raw materials, notably by promoting research on substitutes for critical raw materials; and improving the overall material efficiency of critical raw materials.[4]

World Mine Production and Reserves: Production estimates for individual countries were made using country or company specific data where available; other estimates were made based on general knowledge of end-use markets. The reserve estimate for China has been revised based on new information.

	Mine production		Reserves[5, 6]
	2009	2010[e]	
United States	NA	NA	NA
Brazil	64	65	NA
China	2,900	3,000	24,000
Kazakhstan	67	65	NA
Kenya	16	30	2,000
Mexico	1,040	1,000	32,000
Mongolia	460	450	12,000
Morocco	75	80	NA
Namibia	74	110	3,000
Russia	240	220	NA
South Africa	204	130	41,000
Spain	140	120	6,000
Other countries	180	170	110,000
World total (rounded)	5,460	5,400	230,000

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 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]Excludes fluorspar equivalent of fluorosilicic acid, hydrofluoric acid, and cryolite.
[2]Industry stocks for two leading consumers and fluorspar distributors.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]Blamey, Andy, 2010, EU faces possible shortages of critical metals, minerals—report: Platts Metals Week, June 17. (Accessed September 24, 2010, at http://www.platts.com/RSSFeedDetailedNews/RSSFeed/HeadlineNews/Metals/8823248/.)
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Measured as 100% calcium fluoride.

GALLIUM

(Data in kilograms of gallium content unless otherwise noted)

Domestic Production and Use: No domestic primary gallium recovery was reported in 2010. 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 $35 million. Gallium arsenide (GaAs) and gallium nitride (GaN) electronic components represented about 99% of domestic gallium consumption. About 64% 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 35% of gallium demand. The remaining 1% 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:	2006	2007	2008	2009	2010[e]
Production, primary	—	—	—	—	—
Imports for consumption	26,900	37,100	41,100	35,900	59,000
Exports	NA	NA	NA	NA	NA
Consumption, reported	20,300	25,100	28,700	24,900	40,000
Price, yearend, dollars per kilogram, 99.99999%-pure[1]	443	530	579	449	670
Stocks, consumer, yearend	1,890	6,010	3,820	4,100	2,000
Employment, refinery, number	20	20	20	20	20
Net import reliance[2] as a percentage of reported consumption	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 (2006–09): Germany, 26%; Canada, 23%; China, 17%; Ukraine, 12%; and other, 22%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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. Gallium prices increased sharply throughout the second and third quarters of 2010 as end users restocked inventories depleted since the beginning of the global economic slowdown. Prices for low-grade (99.99%-pure) gallium increased in Asia and Europe in the first three quarters of 2010, from between $340 and $450 per kilogram at the beginning of the year to between $610 and $650 per kilogram by early October.

Market conditions improved significantly for GaAs- and GaN-based products in 2010. GaAs demand, while still being driven mainly by cellular handsets and other high-speed wireless applications, increased owing to rapid growth of feature-rich, application-intensive, third- and fourth-generation "smartphones," which employ considerably higher GaAs content than standard cellular handsets. Smartphones were estimated to account for 19% of all handset sales in 2010. Analysts estimated the smartphone market's sales volume will grow at an annual growth rate of 15% to 25% for the next several years.

The rapidly growing high-brightness LED industry was also a significant driver for GaAs- and GaN-based technologies. The backlighting of computer notebook screens, flat-screen computer monitors, and flat-screen televisions was the driving force for high-brightness LED consumption in 2010. The market share of LED-backlit computer notebooks was estimated by one analyst to have increased to 89% in 2010 from 46% in 2009, while LED-backlit computer monitors increased to 12% in 2010 from 2% in 2009, and LED-backlit flat-screen televisions increased to 22% in 2010 from 3% in 2009.The market for high-brightness LEDs reached $5.3 billion in 2009 and was expected to increase to $8.2 billion in 2010.

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

GALLIUM

In response to the unprecedented demand for high-brightness LEDs, several trimethylgallium (TMG) producers announced plans to expand their TMG capacities. TMGs are metalorganic precursors used in the production of LEDs. Two plants in the United States and one plant in the United Kingdom were expected to expand their TMG capacities to address short-term demand as quickly as possible, while a new plant was to be built in South Korea to create capacity for long-term demand.

As part of the American Recovery and Reinvestment Act, the U.S. Department of Energy (DOE) provided $13.4 million in funding to four GaN-based research projects to accelerate development in power electronics. The projects, funded through DOE’s Advanced Research Projects Agency-Energy, focus on accelerating innovation in green technology while increasing United States’ competitiveness in power electronics, grid-scale energy storage, and building efficiency.

Researchers at the University of Illinois announced the development of an efficient, lower cost method of manufacturing photovoltaic GaAs compound semiconductors that also allows versatility in the types of devices into which they could be incorporated. The manufacturing method allows creation of bulk quantities of flexible GaAs-based solar cells that can be incorporated onto surface areas much larger than conventional solar panels.

A German company achieved a record 20.3% efficiency for its copper-indium-gallium diselenide (CIGS) thin-film solar cell. The company’s CIGS material features a flexible substrate that allows it to be lightweight, flexible, and durable, unlike traditional solar panels that tend to be heavy, rigid, and fragile. The Fraunhofer Institute for Solar Energy Systems in Freiburg, Germany, confirmed the new results.

World Production and Reserves:[3] In 2010, world primary production was estimated to be 106 metric tons, 34% greater than the revised 2009 world primary production of 79 tons. China, Germany, Kazakhstan, and Ukraine were the leading producers; countries with lesser output were Hungary, Japan, Russia, and Slovakia. Refined gallium production was estimated to be about 161 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 Canada, Germany, Japan, the United Kingdom, and the United States. World primary gallium production capacity in 2010 was estimated to be 184 tons; refinery capacity, 177 tons; and recycling capacity, 141 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 comparable to the definition of reserves of other minerals cannot be made. The world bauxite reserves are so large that much of them will not be mined for many decades; hence, most of the gallium in the bauxite reserves 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 deposits, which are mainly subeconomic resources, 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 resource/reserve definitions and information concerning data sources.

GARNET (INDUSTRIAL)[1]

(Data in metric tons of garnet unless otherwise noted)

Domestic Production and Use: Garnet for industrial use was mined in 2010 by four firms—one in Idaho, one in Montana, and two in New York. The estimated value of crude garnet production was about \$8.31 million, while refined material sold or used had an estimated value of \$7.38 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:	2006	2007	2008	2009	2010[e]
Production (crude)	34,100	61,400	62,900	45,600	54,000
Sold by producers	16,800	20,700	49,800	22,100	26,100
Imports for consumption[e]	50,800	52,300	49,200	37,900	29,900
Exports[e]	13,300	12,000	12,500	13,200	12,300
Consumption, apparent[e, 2]	71,600	102,000	99,700	70,300	71,600
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	52	40	37	35	25

Recycling: Small amounts of garnet reportedly are recycled.

Import Sources (2006–09):[e] India, 38%; Australia, 37%; China, 16%; Canada, 8%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010, domestic U.S. production of crude garnet concentrates increased by 18% compared with the production of 2009. U.S. garnet consumption increased slightly compared with that of 2009. In 2010, imports were estimated to have decreased 21% compared with those of 2009, and exports were estimated to have decreased 7% from those of 2009. The 2010 estimated domestic sales of garnet increased by 18% compared with sales of 2009. In 2010, the United States remained 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, production may be restricted to only high-grade garnet ores or other salable mineral products that occur with garnet, such as kyanite, marble, mica minerals, sillimanite, staurolite, wollastonite, or metallic ores.

World Mine Production and Reserves:

	Mine production		Reserves[5]
	2009	2010[e]	
United States	45,600	54,000	5,000,000
Australia	160,000	150,000	1,000,000
China	450,000	470,000	Moderate to Large
India	700,000	700,000	6,500,000
Other countries	35,500	36,000	6,500,000
World total (rounded)	1,390,000	1,410,000	Moderate to Large

World Resources: World resources of garnet are large and occur in a wide variety of rocks, particularly gneisses and schists. Garnet also occurs in 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, Canada, 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 in 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 resource/reserve definitions and information concerning data sources.

GEMSTONES[1]

(Data in million dollars unless otherwise noted)

Domestic Production and Use: The combined value of U.S. natural and synthetic gemstone output increased by 7% in 2010 from that of 2009. The natural gemstone production value increased slightly from that of 2009, while synthetic gemstone production value increased 9% over the same period. 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, Arizona, Oregon, Utah, California, Idaho, Colorado, Arkansas, Montana, North Carolina, Maine, and Tennessee produced 84% of U.S. natural gemstones. The increase in total synthetic gemstone production value resulted from an increase in Moissanite production value. Laboratory-created gemstones were manufactured by five firms in Florida, New York, Massachusetts, North Carolina, and Arizona, in decreasing order of production. Major gemstone uses were carvings, gem and mineral collections, and jewelry.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:[2]					
Natural[3]	11.3	11.9	11.5	8.4	8.5
Laboratory-created (synthetic)	52.1	73.5	51.4	27.2	30.0
Imports for consumption	18,300	20,100	20,900	13,300	19,000
Exports, including reexports[4]	9,930	12,300	15,300	10,500	15,000
Consumption, apparent	8,430	7,880	5,670	2,820	4,400
Price	Variable, depending on size, type, and quality				
Employment, mine, number[e]	1,200	1,200	1,200	1,000	1,100
Net import reliance[5] as a percentage of apparent consumption	99	99	99	99	99

Recycling: Gemstones are often recycled by being resold as estate jewelry, reset, or recut, but this report does not account for those stones.

Import Sources (2006–09 by value): Israel, 48%; India, 20%; Belgium, 16%; South Africa, 5%; and other, 11%. Diamond imports accounted for 95% of the total value of gem imports.

Tariff:

Item	Number	Normal Trade Relations 12-31-10
Pearls, imitation, not strung	7018.10.1000	4.0% ad val.
Imitation precious stones	7018.10.2000	Free.
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: None.

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

GEMSTONES

Events, Trends, and Issues: In 2010, the U.S. market for gem-quality diamonds was estimated to be about $18 billion, accounting for more than 35% of world demand. This was an increase of about 42% compared with that of 2009. The domestic market for natural, nondiamond gemstones was estimated to be about $946 million, which was an increase of 21% from that of 2009. These increases in the U.S. gemstone markets are a reflection of improvements in the economy since the global recession, and its impact on luxury spending. The United States is expected to continue dominating global gemstone consumption.

World Gem Diamond Mine Production[6] and Reserves:

	Mine production		Reserves[7]
	2009	2010[e]	
Angola	8,100	8,100	World reserves of diamond-bearing deposits are substantial. No reserves data are available for other gemstones.
Australia	60	60	
Botswana	24,000	24,000	
Brazil	182	180	
Canada	10,900	11,000	
Central African Republic	300	300	
China	100	100	
Congo (Kinshasa)	3,600	3,600	
Côte d'Ivoire	210	210	
Ghana	500	500	
Guinea	2,400	2,400	
Guyana	179	180	
Lesotho	450	450	
Namibia	2,300	2,300	
Russia	17,800	18,000	
Sierra Leone	200	200	
South Africa	2,400	2,400	
Tanzania	150	150	
Other countries[8]	270	270	
World total (rounded)	74,100	74,000	

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]Defined as imports – exports and reexports + adjustments for Government and industry stock changes.
[6]Data in thousands of carats of gem diamond.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.
[8]In addition to countries listed, Cameroon, Congo (Brazzaville), Gabon, India, Indonesia, Liberia, Togo, Venezuela, and Zimbabwe are known to produce gem diamonds.

GERMANIUM

(Data in kilograms of germanium content unless otherwise noted)

Domestic Production and Use: Germanium production in the United States comes from either the refining of imported germanium compounds or domestic 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. The mine in Washington was placed on temporary care-and-maintenance status in February. A zinc mine complex in Tennessee, which had started producing germanium-rich zinc concentrates in early 2008 and was subsequently closed owing to declining market conditions, resumed operations under new ownership in 2010. There was no indication that any germanium had been recovered from these concentrates in 2010.

A germanium refinery in Utica, NY, produced germanium tetrachloride for optical fiber production. Another refinery in Quapaw, OK, 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. The estimated value of germanium metal consumed in 2009, based upon the annual average U.S. producer price, was about $43 million.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, refinery[e]	4,600	4,600	4,600	4,600	4,600
Total imports[1]	50,000	52,400	67,600	60,200	60,500
Total exports[1]	12,400	11,700	17,900	21,200	19,500
Shipments from Government stockpile excesses	4,580	6,900	102	68	—
Consumption, estimated	55,000	60,000	54,000	44,000	45,600
Price, producer, yearend, dollars per kilogram:					
Zone refined	950	1,240	1,490	940	940
Dioxide, electronic grade	660	800	960	580	580
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant,[2] number[e]	65	65	70	70	100
Net import reliance[3] as a percentage of estimated consumption	85	80	90	90	90

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.

Import Sources (2006–09):[4] Belgium, 36%; China, 34%; Russia, 17%; Germany, 10%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center) continued the Basic Ordering Agreement sales program for germanium using quarterly postings on the DLA Strategic Materials Web site. There were no sales of germanium metal reported during fiscal year 2010.

Stockpile Status—9-30-10[5]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Germanium	16,362	16,362	8,000	—

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

GERMANIUM

Events, Trends, and Issues: The global market for germanium metal and germanium dioxide had generally weakened in 2009 and remained relatively unchanged during the first 9 months of 2010. Following steep declines in 2009, the estimated market prices of germanium metal (99.99%) and germanium dioxide were flat during the year, at about $940 per kilogram and $580 per kilogram, respectively, by October 2010. Many of the germanium-related exploration and mining projects launched in North America from 2007 to 2008 were suspended or canceled owing to the global economic slowdown and the decline in the zinc market in 2009. Consumption of germanium substrates, used in light-emitting diodes and solar cells, increased during the first half of 2010 compared with that of the same period of 2009. In 2010, a leading domestic producer completed construction of a new germanium substrate manufacturing facility in Oklahoma that was expected to have the capacity to produce about 400,000 substrates per year. The use of germanium substrates in high-efficiency, multijunction solar cells for satellites continued to be a staple of consumption, and more germanium substrates were being used in terrestrial-based solar concentrator systems. Conversely, demand for germanium-based optical blanks for infrared devices declined during the first half of 2010 compared with that in the first half of 2009 owing to a decrease in government purchases. Military and law enforcement agencies continued to be leading consumers of germanium-based infrared devices.

Demand for germanium tetrachloride, used primarily in fiber optics, was relatively flat during the first half of the year. Consumption of germanium dioxide for use in catalysts for polyethylene terephthalate (PET) production, mainly in Japan, declined from that of the previous year owing to increased recycling of catalysts, increased use of substitute antinomy-based catalysts, and a reduction in the thickness of PET bottles. Germanium market conditions in China in 2010 were similar to those of the previous year when the economic slowdown reduced demand and prices. Producers were unwilling to drop prices below 2009 levels that had approached their production costs, and consumers were hesitant to agree to long-term purchase contracts. Stocks of germanium held by producers were thought to be elevated in 2010, and a potential impending increase in germanium supply, owing to the completion of a new production facility in Inner Mongolia within the next year, created uncertainty about future market stability. Yunnan Province added germanium to a list of materials that it planned to stockpile in 2010.

A report published by the European Union has identified germanium as 1 of 14 raw materials that are on a list of critical supply concerns for its member countries. The determination was based on each material's level of production, substitutability, and recycling rate, as well as risks associated with the location of supply sources.

A manufacturer developed a new type of phase-change memory chip, using an alloy of antimony, germanium, and titanium that could extend battery life in mobile devices by as much as 20%.

World Refinery Production and Reserves:

	Refinery production[e] 2009	Refinery production[e] 2010	Reserves[6]
United States	4,600	4,600	450,000
China	80,000	80,000	NA
Russia	5,000	5,000	NA
Other countries	30,000	30,000	NA
World total	120,000	120,000	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 exclude germanium contained in coal ash.

Substitutes: Silicon can be a less-expensive substitute for germanium in certain electronic applications. Some metallic compounds can be substituted in high-frequency electronics applications and in 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 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, but not germanium tetrachloride and other germanium compounds for which data are not available.

[5]See Appendix B for definitions.

[6]See Appendix C for resource/reserve definitions and information concerning data sources.

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 2010, the value of mine production was about $8.9 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, 69%; electrical and electronics, 9%; dental and other, 22%.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Mine	252	238	233	223	230
Refinery:					
Primary	181	176	168	170	180
Secondary (new and old scrap)	89	135	181	189	205
Imports for consumption[2]	263	170	231	320	540
Exports[2]	389	519	567	381	380
Consumption, reported	185	180	176	150	150
Stocks, yearend, Treasury[3]	8,140	8,140	8,140	8,140	8,140
Price, dollars per ounce[4]	606	699	874	975	1,200
Employment, mine and mill, number[5]	8,350	9,130	9,560	9,630	9,700
Net import reliance[6] as a percentage of apparent consumption	E	E	E	E	33

Recycling: In 2010, 205 tons of new and old scrap was recycled, more than the reported consumption.

Import Sources (2006–09):[2] Canada, 31%; Mexico, 30%; Peru, 13%; 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 2010 was estimated to be 3% more than the level of 2009. This marks the first increase in domestic production since 2000. Increased production from new mines in Alaska and Nevada, and from existing mines in Nevada, accounted for much of the increase. These increases were partially offset by decreases in production from mines in Montana and Utah. Because of the large increase in imports of gold products, the United States was not a net exporter of gold in 2010. The increases were mostly from imported ore and concentrates from Mexico, which were processed and refined in the United States.

Continued power generation problems, coupled with continuing labor problems and increase in costs in South Africa, caused several mines to continue to produce at reduced production levels. Australian gold producers have increased production because of new operations and additional production from several older mines. China increased gold production again and remained the leading gold-producing nation, followed by Australia, the United States, Russia, and South Africa.

Jewelry consumption continued to drop as the price of gold continued to increase. The estimated price in 2010 was 23% higher than the price in 2009. In 2010, Engelhard Corp.'s daily price of gold ranged from a low of $1,060.45 per troy ounce on February 5 to an alltime high of $1,424.07 per troy ounce in mid-November.

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

GOLD

With the increase in price of gold and the worldwide economic slowdown, investment in gold has increased, as investors seek safe-haven investments. 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. Demand for physical gold was also very high. There were local shortages of gold coins weighing 1 ounce or less.

World Mine Production and Reserves: Reserves estimates for Australia, Chile, and Peru were revised based on new information from government reports.

	Mine production		Reserves[7]
	2009	2010[e]	
United States	223	230	3,000
Australia	222	255	7,300
Brazil	60	65	2,400
Canada	97	90	990
Chile	41	40	3,400
China	320	345	1,900
Ghana	86	100	1,400
Indonesia	130	120	3,000
Mexico	51	60	1,400
Papua New Guinea	66	60	1,200
Peru	182	170	2,000
Russia	191	190	5,000
South Africa	198	190	6,000
Uzbekistan	90	90	1,700
Other countries	490	500	10,000
World total (rounded)	2,450	2,500	51,000

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.[8] 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.
e. Net bullion flow (in tons) to market from foreign stocks at the New York Federal Reserve Bank: 0 (2006), 189 (2007), 220 (2008), 0 (2009), and 0 (2010 estimate).

[3]Includes gold in Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.
[4]Engelhard's average gold price quotation for the year. In 2010, price was estimated by the USGS based on the first 9 months of data.
[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 resource/reserve definitions and information concerning data sources.
[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.

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 2010, approximately 90 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 2010 were estimated to be foundry operations and steelmaking combined, 32%; refractory applications and crucibles combined, 31%; brake linings, 8%; lubricants, 3%; and other applications, 26%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, mine	—	—	—	—	—
Imports for consumption	53	59	58	33	51
Exports	22	16	8	11	6
Consumption, apparent[1]	30	43	50	22	46
Price, imports (average dollars per ton at foreign ports):					
Flake	528	499	753	694	667
Lump and chip (Sri Lankan)	2,320	2,219	2,550	1,410	1,910
Amorphous	188	150	203	249	251
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 (2006–09): China, 46%; Mexico, 23%; Canada, 21%; Brazil, 6%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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: None.

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

GRAPHITE (NATURAL)

Events, Trends, and Issues: Worldwide demand for graphite was very weak during the last quarter of 2008 and in the first half of 2009, owing to the global recession's impact on the industrial sectors that use it. However, during the second half of 2009 worldwide demand for graphite began a slow increase, which continued steadily throughout 2010. Principal import sources of natural graphite were, in descending order of tonnage, China, Mexico, Canada, Brazil, and Madagascar, which combined, accounted for 98% of the tonnage and 90% of the value of total imports. Mexico provided all the amorphous graphite, and Sri Lanka provided all the lump and chippy dust variety. China and Canada were, in descending order of tonnage, the major suppliers of crystalline flake and flake dust graphite.

During 2010, China produced the majority of the world's graphite, and China's graphite production is expected to continue growing. In recent years, Canada has opened a number of new graphite mines, 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), are likely to 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 and Reserves:

	Mine production		Reserves[3]
	2009	2010[e]	
United States	—	—	—
Brazil	76	76	360
Canada	25	25	([4])
China	800	800	55,000
India	130	130	5,200
Korea, North	30	30	([4])
Madagascar	5	5	940
Mexico	5	5	3,100
Norway	2	2	([4])
Sri Lanka	11	11	([4])
Ukraine	6	6	([4])
Other countries	3	3	6,400
World total (rounded)	1,100	1,100	71,000

World Resources: Domestic resources of graphite are relatively small, but the rest of the world's inferred resources exceed 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.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.
[4]Included with "Other countries."

GYPSUM

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2010, domestic production of crude gypsum was estimated to be 9.0 million tons with a value of about $58.5 million. The leading crude gypsum-producing States were, in descending order, Nevada, Iowa, California, Oklahoma, Texas, Arkansas, New Mexico, Indiana, Michigan, and Arizona, which together accounted for 83% of total output. Overall, 46 companies produced gypsum in the United States at 55 mines in 18 States, and 9 companies calcined gypsum at 57 plants in 29 States. Approximately 90% of domestic consumption, which totaled approximately 19 million tons, was accounted for by manufacturers of wallboard and plaster products. Approximately 1 million tons for cement production and agricultural applications, and small amounts of high-purity gypsum for a wide range of industrial processes accounted for the remaining tonnage. At the beginning of 2010, the production capacity of operating wallboard plants in the United States was about 26.8 billion square feet[1] per year.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Crude	21,100	17,900	14,400	9,400	9,000
Synthetic[2]	9,290	8,500	7,740	7,700	7,500
Calcined[3]	26,100	16,700	18,000	14,000	13,000
Wallboard products sold (million square feet[1])	35,000	27,800	20,700	18,500	17,700
Imports, crude, including anhydrite	11,400	9,390	7,330	4,220	3,300
Exports, crude, not ground or calcined	143	147	149	156	360
Consumption, apparent[4]	41,600	35,600	29,300	21,200	19,400
Price:					
Average crude, f.o.b. mine, dollars per metric ton	8.83	7.50	8.70	8.50	6.50
Average calcined, f.o.b. plant, dollars per metric ton	41.79	38.30	42.64	35.00	33.00
Employment, mine and calcining plant, number[e]	5,900	6,000	5,400	4,500	4,500
Net import reliance[5] as a percentage of apparent consumption	27	26	24	19	15

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 feedstock 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 (2006–09): Canada, 66%; Mexico, 26%; Spain, 7%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Gypsum; anhydrite	2520.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: U.S. gypsum production declined as the housing and construction markets continued to falter, with apparent consumption decreasing by about 8% compared with that of 2009. China, the world's leading producer, produced approximately five times the amount produced in the United States, the world's fourth ranked producer. Iran ranked second in world production and supplied much of the gypsum needed for construction in the Middle East. Spain, the leading European producer, ranked third in the world, and supplied both crude gypsum and gypsum products to much of Western Europe. An increased use of wallboard in Asia, coupled with new gypsum product plants, spurred increased production in that region. As more cultures recognize the economy and efficiency of wallboard use, worldwide production of gypsum is expected to increase.

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. The construction of wallboard plants designed to use synthetic gypsum as feedstock will result in less use of natural gypsum as these new plants become operational. Imports decreased by approximately 21% compared with those of 2009. Exports, although very low compared with imports, more than doubled.

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

GYPSUM

Through 2010, more than 3,600 homeowner complaints from 39 States, the District of Columbia, American Samoa, and Puerto Rico were filed with the U.S. Consumer Product Safety Commission regarding reports of corrosive drywall. The problematic drywall, which was suspected of causing health ailments and the corrosion of metal components within an affected home, was thought to have been imported from China in 2006 and 2007. According to the U.S. International Trade Commission, more than 300 metric tons of Chinese drywall was imported into the United States in 2010, which represented less than 1% of total 2010 imports. For comparative purposes, Chinese drywall imports in 2006 were 218,000 metric tons and 12,400 metric tons in 2007.

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2009	2010[e]	
United States	9,400	9,000	700,000
Algeria	1,700	1,700	
Argentina	1,300	1,300	
Australia	3,500	3,500	
Brazil	1,920	1,900	1,300,000
Canada	3,540	3,500	450,000
China	45,000	45,000	
Egypt	2,500	2,500	
France	2,300	2,300	
Germany	1,898	1,900	
India	2,600	2,500	
Iran	13,000	13,000	
Italy	4,130	4,100	Reserves are large in major producing countries, but data for most are not available.
Japan	5,750	5,800	
Mexico	5,760	5,800	
Poland	1,500	1,500	
Russia	2,900	2,900	
Saudi Arabia	2,100	2,100	
Spain	11,500	11,500	
Thailand	8,500	8,500	
Turkey	3,100	3,100	
United Kingdom	1,700	1,700	
Other countries	11,400	11,000	
World total (rounded)	148,000	146,000	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 supplement 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; 88 countries produce gypsum.

Substitutes: In such applications as stucco and plaster, cement and lime may be substituted for gypsum; 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 2010, synthetic gypsum accounted for approximately 45% 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 and synthetic.
[4]Defined as crude production + total synthetic reported used + imports – exports.
[5]Defined as imports – exports.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

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 (99.997% or better) extracted domestically during 2010 by private industry was about $730 million. Nine 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 99% helium. Ten 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. Of these 10 plants, 6 (4 in Kansas, 1 in Oklahoma, and 1 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 2010 domestic consumption of 54 million cubic meters (1.9 billion cubic feet) was used for cryogenic applications, 32%; for pressurizing and purging, 18%; for welding cover gas, 13%; for controlled atmospheres, 18%; leak detection, 4%; breathing mixtures, 2%; and other, 13%.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Helium extracted from natural gas[2]	79	77	80	78	77
Withdrawn from storage[3]	58	61	50	40	48
Grade-A helium sales	137	138	130	118	125
Imports for consumption	—	—	—	—	—
Exports[4]	62	64	70	71	71
Consumption, apparent[4]	75	74	60	47	54
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Price: The Government price for crude helium was $2.33 per cubic meter ($64.75 per thousand cubic feet) in fiscal year (FY) 2010. 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 $5.05 to $5.77 per cubic meter ($140 to $160 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 (2006–09): None.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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. The Helium Privatization Act of 1996 mandated that all Federal Conservation helium stored in Bush Dome at the Cliffside Field be offered for sale, except 16.6 million cubic meters (600 million cubic feet).

In FY 2010, privately owned companies purchased about 4.8 million cubic meters (172 million cubic feet) of in-kind crude helium. In addition to this, privately owned companies also purchased 59.2 million cubic meters (2,130 million cubic feet) of open market sales helium. During FY 2010, the BLM's Amarillo Field Office, Helium Operations (AMFO), accepted about 13.3 million cubic meters (479 million cubic feet) of private helium for storage and redelivered nearly 60.5 million cubic meters (2,180 million cubic feet). As of September 30, 2010, about 12.9 million cubic meters (466 million cubic feet) of privately owned helium remained in storage at Cliffside Field.

Stockpile Status—9-30-10[6]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Helium	467.4	467.4	63.8	64.0

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

HELIUM

Events, Trends, and Issues: During 2010, some helium suppliers announced price increases of 5% to 10% in response to continued increased raw material, energy, and distribution costs. The price of pure helium is expected to continue to increase as production costs, including the price of crude helium, increase. The BLM raised the FY 2011 price of open-market crude helium to $2.70 per cubic meter ($75.00 per million cubic feet) based on recommendations from a report from the National Research Council of the National Academies. During 2010, helium consumption increased by about 15% compared with that of 2009. During FY 2010, the AMFO conducted four open market helium offerings, selling a total of 59.2 million cubic meters (2,133 million cubic feet). The Skikda, Algeria, helium plant continued to experience operational problems, and the plant in Arzew, Algeria, experienced production problems related to the liquefied natural gas trains. The Qatar helium plant experienced no major operational problems and maintained the same rates of production as in 2008 and 2009. A new helium plant in Australia started up in March. Worldwide, eight new helium plant projects were scheduled for startup between 2011 and 2017. Two projects were scheduled for startup in the United States during 2011–14 near Riley Ridge, WY, and St. Johns, AZ. The other plants were planned for Algeria, China, India, Indonesia, Qatar, and Russia.

World Production and Reserves: Reserves data were revised based on estimated production for 2009 and new information available from the Government of Poland.

	Production		Reserves[8]
	2009	2010[e]	
United States (extracted from natural gas)	78	77	4,000
United States (from Cliffside Field)	40	48	([9])
Algeria	20	18	1,800
Canada	NA	NA	NA
China	NA	NA	NA
Poland	3.3	2.6	33
Qatar	NA	NA	NA
Russia	5.3	5.5	1,700
Other countries	NA	NA	NA
World total (rounded)	147	150	NA

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 extracted. These fields contain an estimated 3.9 billion cubic meters (140 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, 2010, AMFO had analyzed about 22,000 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 and Evaluation Group, Bureau of Land Management, Amarillo Field Office, Helium Operations, Amarillo, TX.

[8]See Appendix C for resource/reserve definitions and information concerning data sources.

[9]Included in United States (extracted from natural gas) reserves.

INDIUM

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Indium was not recovered from ores in the United States in 2010. 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 2010, based upon the annual average New York dealer price, was about $66 million.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, refinery	—	—	—	—	—
Imports for consumption[1]	100	147	144	105	130
Exports	NA	NA	NA	NA	NA
Consumption, estimated	125	125	130	110	120
Price, average annual, dollars per kilogram					
U.S. producer[2]	918	795	685	500	565
New York dealer[3]	815	637	519	382	550
99.99% c.i.f. Japan[4]	NA	NA	479	348	560
Stocks, producer, yearend	NA	NA	NA	NA	NA
Net import reliance[5] 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 material is deposited onto the substrate. The remaining 70% consists of the spent ITO target material, the grinding sludge, and the after-processing residue left on the walls of the sputtering chamber. 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. 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 (2006–09):[1] China, 35%; Canada, 26%; Japan, 16%; Belgium, 8%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Unwrought indium, including powders	8112.92.3000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The price of indium recovered in 2010 after declining sharply during 2009. The U.S. producer price for indium began the year at $500 per kilogram and increased to $570 per kilogram in late January; the price remained at that level until mid-September. The New York dealer price range for indium began the year at $460 to $500 per kilogram, and increased through the end of May, reaching a high of $580 to $640 per kilogram. The price range then decreased and leveled off at $525 to $565 during June and most of July, after which it modestly increased to $550 to $575 per kilogram by mid-September.

Indium consumption in Japan (the leading global consumer of indium) was expected to increase by 20% in 2010 from that of 2009. Additionally, Chinese indium consumption was expected to continue to increase significantly, rising by 56% from that of 2009 to 75 tons owing to increased domestic demand for LCD-containing electronics. China planned to increase its domestic manufacturing of high-end LCD electronics rather than sell the raw materials to Japan and buy back the electronic products at high prices. As a result, the Chinese Government cut its second half 2010 indium export quotas by 30%.

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

INDIUM

China's 21 indium producers were allowed to export a combined total of 93 tons of indium in the latter half of 2010, compared with 140 tons during the first half of the year. Most of this material was exported to Japan for consumption.

In the downstream market, demand for ITO targets increased during the first half of 2010 from that of the second half of 2009 owing to a rise in LCD panel production. However, LCD panel inventories began to increase during the second half of 2010 owing to lower-than-expected LCD sales in the United States and global economic uncertainty. One LCD panel producer initiated a 30% production cut at one of its Japanese plants to control inventory. As a result of weakening LCD demand that occurred in the latter half of 2010, LCD panel producers lowered prices, resulting in an aggressive price competition among flat-screen LCD TV producers. However, ITO producers were not able to significantly lower their prices as higher indium prices in 2010 cut into profits.

World Refinery Production and Reserves:

	Refinery production		Reserves[6]
	2009	2010[e]	
United States	—	—	Quantitative estimates of reserves are not available.
Belgium	30	30	
Brazil	5	5	
Canada	40	35	
China	280	300	
Japan	67	70	
Korea, Republic of	70	80	
Peru	25	25	
Russia	4	4	
Other countries	25	25	
World total (rounded)	546	574	

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 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. Gallium arsenide can substitute for indium phosphide 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]Price is based on 99.99% minimum purity indium at warehouse (Rotterdam); cost, insurance, and freight (in minimum lots of 50 kilograms). Source: Platts Metals Week.
[4]Price is based on 99.99% purity indium, primary or secondary, shipped to Japan. Source: Platts Metals Week.
[5]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.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

IODINE

(Data in metric tons elemental iodine unless otherwise noted)

Domestic Production and Use: Iodine was produced in 2010 by three companies operating in Oklahoma, with a fourth company initializing iodine production in Montana in March 2010. Domestic iodine production decreased slightly in 2009 compared with that of 2008, owing to the economic downturn. Production in 2010 was estimated to increase from that of 2009. To avoid disclosing company proprietary data, U.S. iodine production in 2010 was withheld. The operation at Woodward, OK, continued production of iodine from subterranean brines. Another 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 2010 was estimated to be $24.18 per kilogram.

Domestic and imported iodine were used by downstream manufacturers to produce many intermediate iodine compounds, making it difficult to establish an accurate end-use pattern. Of the consumers that participate in an annual U.S. Geological Survey canvass, 17 plants reported consumption of iodine in 2009. Iodine and iodine compounds reported were unspecified organic compounds, including ethyl and methyl iodide, 51%; potassium iodide, 11%; crude iodine, 11%; povidine-iodine (iodophors), 7%; ethylenediamine dihydroiodide, 5%; sodium iodide, 4%; and other, 11%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production	W	W	W	W	W
Imports for consumption, crude content	5,640	6,060	6,300	5,190	5,200
Exports	1,580	1,060	950	1,160	1,000
Shipments from Government stockpile excesses	467	93	—	—	—
Consumption:					
Apparent	W	W	W	W	W
Reported	4,570	4,470	4,590	4,550	4,800
Price, average c.i.f. value, dollars per kilogram, crude	19.34	21.01	21.52	25.55	24
Employment, number[e]	30	30	30	30	30
Net import reliance[1] as a percentage of reported consumption	89	100	100	89	88

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

Import Sources (2006–09): Chile, 82%; Japan, 17%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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: None.

Prepared by **Marc A. Angulo [(703) 648-7945, mangulo@usgs.gov, fax: (703) 648-7757]**

IODINE

Events, Trends, and Issues: Demand for iodine has been driven in recent years by consumption for liquid crystal displays (LCD) and x-ray contrast media. With increased demand in these two sectors and global iodine production remaining constant, an imbalance between supply and demand was created and resulted in iodine prices increasing by 19% from 2008 to 2009. As consumption of iodine in biocides, LCDs, and nylon declined owing to the global economic downturn, prices remained relatively firm. The prices in 2010 were estimated to decrease slightly from those of 2009, but were projected to be more than 10% greater than those of 2008. With an economic recovery expected, demand for iodine used in biocides, iodine salts, LCDs, synthetic fabric treatments, and x-ray contrast media was expected to increase at a rate of between 3.5% and 4% per year during the next decade.

As in previous years, Chile was the world's leading producer of iodine, followed by Japan and the United States. Chile accounted for more than 50% of world production, having two of the leading iodine producers in the world. The largest Chilean producer reported a 20% decrease in sales from 2008 to 2009, which was attributed to the global economic downturn. In response to the downturn, the company announced the suspension of operations at one of its mining facilities. The third largest Chilean producer initiated a new project at Algorta, Chile, which was expected to replace its current operation at Lagunas, Chile.

Several governmental programs were expected to affect future iodine demand. The European Union prohibited its 27 member countries from using or selling iodine for the purpose of disinfecting drinking water. China's Ministry of Health announced the reduction of iodine content in salt owing to fears that iodized salt is causing a rise in thyroid disease. The U.S. Environmental Protection Agency approved the restricted use of the soil fumigant iodomethane (methyl iodide) as an alternative to ozone-depleting methyl bromide. Australia and Belgium required bread manufacturers to use iodized salt with the intent of limiting iodine deficiency in their populations.

World Mine Production and Reserves: The iodine reserves for Japan have been revised based on new information from the country.

	Mine production		Reserves[2]
	2009	2010[e]	
United States	W	W	250,000
Azerbaijan	300	300	170,000
Chile	17,400	18,000	9,000,000
China	580	590	4,000
Indonesia	75	75	100,000
Japan	9,600	9,800	5,000,000
Russia	300	300	120,000
Turkmenistan	270	270	170,000
Uzbekistan	2	2	NA
World total (rounded)	[3]28,500	[3]29,000	15,000,000

World Resources: In addition to the reserves 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: There are no comparable substitutes for iodine in many of its principal applications, such as in animal feed, catalytic, nutritional, pharmaceutical, and photographic uses. Bromine and chlorine could be substituted for iodine in biocide, colorant, and ink, although they are usually considered less desirable than iodine. Antibiotics can be used as a substitute for iodine biocides.

[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 resource/reserve definitions and information concerning data sources.
[3]Excludes U.S. production.

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 2009 and 2010 that were estimated to be valued at $74 billion and $139 billion, respectively. Pig iron was produced by 5 companies operating integrated steel mills in 15 locations. About 56 companies produce raw steel at about 114 minimills. Combined production capability was about 108 million tons. Indiana accounted for 24% of total raw steel production, followed by Ohio, 10%, Michigan, 7%, and Pennsylvania, 7%. The distribution of steel shipments was estimated to be: warehouses and steel service centers, 25%; construction, 22%; transportation (predominantly automotive), 13%; cans and containers, 3%; and other, 37%.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Pig iron production[2]	37.9	36.3	33.7	19.0	29
Steel production:	98.2	98.1	91.9	59.4	90
Basic oxygen furnaces, percent	42.9	41.8	42.6	38.2	39
Electric arc furnaces, percent	57.1	58.2	57.4	61.8	61
Continuously cast steel, percent	96.7	96.7	96.4	97	97
Shipments:					
Steel mill products	99.3	96.5	89.3	56.4	76
Steel castings[e, 3]	[e]0.7	[e]0.7	[e]0.7	[e]0.4	0.4
Iron castings[e, 3]	[e]7.4	[e]7.4	[e]7.4	[e]4.0	4.0
Imports of steel mill products	41.1	30.2	29.0	14.7	22
Exports of steel mill products	8.8	10.1	12.2	8.4	11
Apparent steel consumption[4]	120	116	102	63	82
Producer price index for steel mill products (1982=100)[5]	174.1	182.9	220.6	165.2	200
Steel mill product stocks at service centers yearend[6]	15.0	9.3	7.8	5.6	6.7
Total employment, average, number					
Blast furnaces and steel mills	102,000	102,000	107,000	[e]109,000	110,000
Iron and steel foundries[e]	95,000	95,000	86,000	86,000	86,000
Net import reliance[7] as a percentage of apparent consumption	17	16	13	11	7

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

Import Sources (2006–09): Canada, 19%; European Union, 15%; China, 13%; Mexico, 9%; and other, 44%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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: The expansion or contraction of gross domestic product (GDP) may be considered a predictor of the health of the steelmaking and steel manufacturing industries, worldwide and domestically. The World Bank's global GDP growth forecast for 2010 and 2011 was 2.7% and 3.2%, respectively, after 2.2% in 2009. The Federal Reserve Bank of Philadelphia survey of forecasters showed the economy expanding in 2010 and 2011 at rates of 4.2% and 4.3%, respectively, after contracting at a rate of 2.6% in 2009.

According to the Institute of Supply Management (ISM), economic activity in the manufacturing sector expanded in September 2010 for the 14th consecutive month and the overall economy grew for the 17th consecutive month. However, the ISM manufacturing index declined steadily during 2010 from its high in January 2010, suggesting weaker demand for steel products and slower growth in manufacturing activity during the remainder of 2010.

MEPS (International) Inc. forecast total world steel production in 2010 to be up 14% from that in 2009. MEPS also forecast increasing steel production in 2010 in the European Union, South America, Asia, the Commonwealth of Independent States (CIS), and Africa of 22%, 13%, 12%, 8%, and 6%, respectively.

According to the World Steel Association, world apparent steel consumption (ASC) was expected to increase by 5% in 2011, after increasing by 13% during 2010. China's ASC was expected to increase by 3.5% in 2011 and was expected to account for 46% of world steel consumption. ASC in India was expected to increase by 14% in 2011. ASC in the United States was expected to increase by 8% in 2011. European Union ASC was expected to increase by almost 6% in 2011 after increasing 19% in 2010.

World Production:

	Pig iron		Raw steel	
	2009	**2010[e]**	**2009**	**2010[e]**
United States	19	29	59	90
Brazil	35	32	34	33
China	544	600	568	630
France	8	10	13	16
Germany	20	29	33	44
India	30	39	57	67
Japan	86	82	88	110
Korea, Republic of	30	31	53	56
Russia	44	47	59	66
Ukraine	26	26	30	31
United Kingdom	8	7	10	10
Other countries	85	67	236	250
World total (rounded)	935	1,000	1,240	1,400

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. Do. Ditto.
[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]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 $22.5 billion in 2010, up by 40% from that of 2009. U.S. apparent steel consumption, an indicator of economic growth, increased to about 82 million tons in 2010. Manufacturers of pig iron, raw steel, and steel castings accounted for about 90% 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 10% to produce cast iron and steel products, such as motor blocks, pipe, and machinery parts. Relatively small quantities of scrap were used for producing ferroalloys, for the precipitation of copper, and by the chemical industry; these uses collectively totaled less than 1 million tons.

During 2010, raw steel production was an estimated 81.0 million tons, up about 36% from that of 2009; annual steel mill capability utilization was about 72% compared with 51% for 2009. Net shipments of steel mill products were estimated to have been about 76 million tons compared with 56 million tons for 2009.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Home scrap	12	12	12	10	9
Purchased scrap[2]	60	64	73	70	74
Imports for consumption[3]	5	4	4	3	4
Exports[3]	15	17	22	22	19
Consumption, reported	64	64	67	53	51
Price, average, dollars per metric ton delivered, No. 1 Heavy Melting composite price, Iron Age Average, Pittsburgh, Philadelphia, Chicago	214	249	349	208	335
Stocks, consumer, yearend	4.4	4.4	4.6	3.4	4.0
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, the primary source of old steel scrap was the automobile. The recycling rate for automobiles in 2009, the latest year for which statistics were available, was about 140%, indicating a significant shrinking of the country’s car and light car fleet from a high of 250 million vehicles down to 246 million vehicles. 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 more than 14 million tons of steel from end-of-life vehicles through more than 220 car shredders, the equivalent of more than 14 million automobiles. More than 12,000 vehicle dismantlers throughout North America resell parts.

The recycling rates for appliances and steel cans in 2009 were 90% and more than 66%, respectively. Recycling rates for construction materials in 2009 were, as in 2008, about 98% for plates and beams and 70% 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, and recycling is becoming more profitable and convenient as environmental regulations for primary production increase.

Recycling of scrap plays an important role in the conservation of energy because the remelting of scrap requires much less energy than the production of iron or steel products from iron ore. Also, consumption of iron and steel scrap by remelting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment. Recycled scrap consists of approximately 58% post-consumer (old, obsolete) scrap, 18% prompt scrap (produced in steel-product manufacturing plants), and 24% home scrap (recirculating scrap from current operations).

Import Sources (2006–09): Canada, 75%; United Kingdom, 8%; Mexico, 7%; Sweden, 4%; and other, 6%.

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 12-31-10
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 2010 to a high in April of about $754 per metric ton, after which they decreased to $626 per ton in August 2010. During the first 9 months of 2010, prices of hot-rolled steel were higher than those in 2009. The producer price index for steel mill products increased to 203 in May 2010 from 153 in May 2009. Steel mill production capability utilization peaked at 75.4% in June 2010 from a low of 40.8% in April 2009.

Scrap prices fluctuated widely between about $290 and $367 per ton in 2010. 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 $320 per ton during the first 8 months of 2010. As reported by Iron Age Scrap Price Bulletin, the average price for nickel-bearing stainless steel scrap delivered to purchasers in Pittsburgh was about $2,273 per ton during the first 10 months of 2010, which was 45% higher than the 2009 average price of $1,502 per ton. The prices fluctuated widely between a low of $1,711 per ton in January 2010 and a high of $2,724 per ton in April and May 2010. Exports of ferrous scrap decreased in 2010 to an estimated 19 million tons from 22 million tons during 2009, mainly to China, the Republic of Korea, Taiwan, Malaysia, Turkey, and Canada, in descending order of export tonnage. Export scrap value increased from $7.1 billion in 2009 to an estimated $8.0 billion in 2010.

North America has been experiencing a shortage of iron and steel scrap, owing to increased export demand, primarily from China, Turkey, and Canada. Even significantly increased prices for scrap have not led to an increase in scrap availability, because almost all old scrap had been collected from farms, ranches, and other sources, and recession-hit consumers have been keeping and repairing old appliances rather than disposing of them. Also, manufacturers were decreasing production, thus producing little new scrap for the scrap market.

World Mine Production and Reserves: Not applicable.

World Resources: Not applicable.

Substitutes: About 1.4 million tons of direct-reduced iron was used in the United States in 2009 as a substitute for iron and steel scrap, down from 2.0 million tons in 2008.

[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 for 2006 through 2010.
[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 coproducts of iron- and steelmaking and find a market primarily in the construction center. Although data on U.S. slag production are unavailable, the range of output is estimated as having increased by about 30% to about 11 to 15 million tons in 2010, owing to a restart of many of the iron and steel furnaces that had been idled at least part time in 2009. Better slag availability led to a modest increase in slag sales in 2010, although volumes remained constrained by continued low levels of construction spending. An estimated 15 million tons of iron and steel slag, valued at about $290 million[1] (f.o.b. plant), was sold in 2010. Iron or blast furnace slag accounted for about 60% of the tonnage sold and had a value of about $250 million; nearly 85% of this value was granulated slag. Steel slag produced from basic oxygen and electric arc furnaces accounted for the remainder.[2] Slag was processed by nearly 30 companies servicing active iron and/or steel facilities or reprocessing old slag piles at about 120 sites in 32 States; included in this tally are a number of 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, rounded averages for iron and steel slags sold for a variety of applications. Actual prices per ton ranged widely in 2010 from about $0.20 for steel slags for some uses to about $100 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. Nearly all GGBFS is used as a partial substitute for portland cement in concrete mixes or in blended cements. Pelletized slag is generally used for lightweight aggregate but can be ground into material similar to GGBFS. Owing to their low unit values, most slag types can be 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, marketed[1, 3]	20.3	19.6	18.8	12.5	15.0
Imports for consumption[4]	1.6	1.9	1.3	1.3	1.5
Exports	0.1	0.1	([5])	([5])	([5])
Consumption, apparent[4, 6]	20.2	19.6	18.8	12.5	15.0
Price average value, dollars per ton, f.o.b. plant	20.00	22.00	18.00	19.00	20.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, number[e]	2,500	2,200	2,100	2,000	2,100
Net import reliance[7] as a percentage of apparent consumption	8	9	7	10	10

Recycling: Slag may be returned to the blast and steel furnaces as ferrous and flux feed, but data on these returns are incomplete. Entrained metal, particularly in steel slag, is routinely recovered during slag processing for return to the furnaces, but data on metal returns are unavailable.

Import Sources (2006–09): Granulated blast furnace slag (mostly unground) is the dominant ferrous slag type imported, but official import data show significant year-to-year variations in tonnage and unit value and commonly include some shipments of industrial residues other than ferrous slags (such as fly ash, silica fume, cenospheres) or of slags of other metallurgical industries. Further, the official data in recent years appear to underrepresent true import levels of granulated slag. Based on official data, the principal country sources for 2006–09 were Japan, 44%; Canada, 38%; Italy, 13%; South Africa, 4%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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: The availability of blast furnace slag has been in general decline in recent years because of the closure or idling of a number of U.S. blast furnaces, the lack of construction of new furnaces, and the depletion of old slag piles. Granulation cooling is currently installed at only four active blast furnaces, but is being evaluated for installation at other sites, contingent on the sites remaining active. Pelletized blast furnace slag remains in limited supply, but it is unclear if any additional pelletizing capacity is being planned. Supplies of basic oxygen furnace steel slag from integrated iron and steel works have become constrained as plants have been idled and because of an increasing volume of slag that is being returned to the furnaces. Slag from electric arc steel furnaces (largely fed with steel scrap) remains relatively abundant. Where slag availability has not been a problem, slag (as aggregate) sales into the construction sector have tended to be less volatile than those of natural aggregates or of cement. Sales of granulated slag have trended more in line with those of cement, but, for both environmental and performance reasons, there has been a general growth in granulated slag's share of the cementitious material market in recent years, albeit still at a very small percentage of the total. Draft regulations were released in 2009–10 to restrict emissions (especially of mercury) by U.S. cement plants and to reclassify fly ash as a hazardous waste for disposal purposes; both regulations have the potential to reduce the supply of these cementitious materials to the U.S. market and, if so, then sales and the market share of GGBFS would be expected to increase. Long-term growth in the supply of GGBFS is likely to hinge on imports, either of ground or unground material.

World Mine Production and Reserves: 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 2010 was on the order of 230 to 270 million tons, and steel slag about 120 to 180 million tons, based on typical ratios of slag to crude iron and steel output.

World Resources: Not applicable.

Substitutes: Slag competes with crushed stone and sand and gravel as aggregates in the construction sector. Fly ash, natural pozzolans, 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 clinker (cement) manufacture. Some other metallurgical slags, such as copper slag, can compete with ferrous slags for some specialty markets, but are generally in much more restricted supply than ferrous slags.

[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, and are incomplete regarding slag returns to the furnaces.
[2]There were very minor sales of open hearth furnace steel slag from stockpiles but no domestic production of this slag type in 2006–10.
[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 significantly understate the true imports of granulated slag. The USGS canvass appears to capture only part of the imported slag. Thus the apparent consumption statistics are likely too low by about 0.3 to 1.3 million tons per year.
[5]Less than ½ unit.
[6]Defined as total sales of slag (includes that from imported feed) minus exports. Calculation is based on unrounded original data.
[7]Defined as total sales of imported slag minus exports of slag. Data are not available to allow adjustments for changes in stocks.

IRON ORE[1]

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

Domestic Production and Use: In 2010, mines in Michigan and Minnesota shipped 99% of the usable ore produced in the United States, with an estimated value of $2.0 billion. Thirteen iron ore mines (11 open pits, 1 reclamation operation, and 1 dredging operation), 9 concentration plants, and 9 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 was estimated to have produced and consumed 2% of the world's iron ore output.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, usable	52.7	52.5	53.6	26.7	49
Shipments	52.7	50.9	53.6	27.6	50
Imports for consumption	11.5	9.4	9.2	3.9	7
Exports	8.3	9.3	11.1	3.9	11
Consumption:					
Reported (ore and total agglomerate)[3]	58.2	54.7	51.9	31.0	50
Apparent[e]	57.1	52.1	49.7	25.7	47
Price,[4] U.S. dollars per metric ton	53.88	59.64	70.43	92.80	90.00
Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore[e, 5]	15.3	15.8	17.7	18.7	17
Employment, mine, concentrating and pelletizing plant, quarterly average, number	4,470	4,450	4,770	3,530	4,700
Net import reliance[6] as a percentage of apparent consumption (iron in ore)	8	E	E	E	E

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

Import Sources (2006–09): Canada, 61%; Brazil, 31%; Chile, 3%; Trinidad and Tobago, 1%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 70% increase in the worldwide price for iron ore fines into the European market and an almost 80% increase for fines from Australia into the Asian market in 2008, the global economic downturn resulted in a significant world price decrease in 2009. The price of fines into the European market decreased by almost 30% and the price of fines into the Asian market from Australia decreased by about one-third. Prices for lump ore, which had almost doubled in 2008, dropped back to where they had been in 2007. Pellet prices, which had risen almost 90% in 2008, were cut almost in half in the 2009 round of negotiations. April 2010 marked the end of the 40-year global benchmarking system for the sale of iron ore under an annual contract. Iron ore producers felt that they had been losing out when some customers reneged on contract tonnages when spot price fell below the contract price. The major producers reached agreements with several customers to move to shorter term or quarterly contracts.[7] U.S. prices in 2009 lagged world prices and actually increased corresponding to the increase seen in world prices in 2008.

Major iron-ore-mining companies continue to reinvest profits in mine development, but increases in production capacity may outstrip expected consumption within the next few years, as growth dominated by China slows. In 2009, it was estimated that China increased production (of mostly lower grade ores) by 7% from that of the previous year—significantly lower than the 17% increase seen between 2007 and 2008 and the greater-than-40% increase seen between 2005 and 2006. Estimates of Chinese imports of higher grade ores in 2009, mostly from Australia, Brazil, and India, showed an increase of more than 40% compared with those of 2008.

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

IRON ORE

In 2009, China imported almost two-thirds of the world's total iron ore exports and produced about 60% of the world's pig iron. Since international iron ore trade and production of iron ore and pig iron are key indicators of iron ore consumption, this demonstrates that iron ore consumption in China is the primary factor upon which the expansion of the international iron ore industry depends.

The Mesabi Nugget project—a direct-reduced iron nugget plant—was completed in Minnesota in the fourth quarter of 2009 and began production in 2010. The $270 million plant produces 96%-to-98% iron-content nuggets. Plans are being made to reopen an iron ore pit adjacent to the nugget plant. A $1.6-billion project to produce steel slab was also underway on the Mesabi Range in Minnesota. A taconite pellet plant is planned for operation in the latter part of 2012, as well as a direct-reduced iron plant and steelmaking facilities at the same site for 2015.

World Mine Production and Reserves: The mine production estimate for China is based on crude ore, rather than usable ore, which is reported for the other countries. The iron ore reserves estimates for Australia, Brazil, Canada, China, and Mauritania have been revised based on new information from those countries.

	Mine production		**Reserves[8]**	
	2009	**2010[e]**	**Crude ore**	**Iron content**
United States	27	49	6,900	2,100
Australia	394	420	24,000	15,000
Brazil	300	370	29,000	16,000
Canada	32	35	6,300	2,300
China	880	900	23,000	7,200
India	245	260	7,000	4,500
Iran	33	33	2,500	1,400
Kazakhstan	22	22	8,300	3,300
Mauritania	10	11	1,100	700
Mexico	12	12	700	400
Russia	92	100	25,000	14,000
South Africa	55	55	1,000	650
Sweden	18	25	3,500	2,200
Ukraine	66	72	30,000	9,000
Venezuela	15	16	4,000	2,400
Other countries	43	50	11,000	6,200
World total (rounded)	2,240	2,400	180,000	87,000

World Resources: U.S. resources are estimated to be about 27 billion tons of iron contained within 110 billion tons of ore. 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 230 billion tons of iron contained within greater than 800 billion tons of crude ore.

Substitutes: The only source of primary iron is iron ore, used directly, as lump ore, or converted to briquettes, concentrates, pellets, or sinter. At some blast furnace 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 through mid- 2009 were commensurate with price increases in the alternative—scrap. The ratio of scrap to iron ore import prices has greatly increased since the end of 2009, causing the relative attractiveness of scrap compared to iron ore to decrease to levels of 2008. The ratio of scrap to iron ore price still remains markedly below levels seen between 2003 and 2007.

[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 (stock changes for 2006–10 were estimated).
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]Jorgenson, J.D., 2010, Iron ore in April 2010: U.S. Geological Survey Mineral Industry Surveys, August, 7 p.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.

IRON OXIDE PIGMENTS

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Iron oxide pigments (IOPs) are mined by three companies in three States in the United States. Production data, which were withheld by the U.S. Geological Survey to protect company proprietary data, increased slightly in 2010. There were seven companies, including the three producers of natural IOPs, that processed and sold finished natural and synthetic IOPs. Sales by those companies increased 15% to 20% in 2010, although sales were still below the sales of 88,100 tons in 2007. About 50% of U.S. consumption was for colorizing construction materials such as concrete. Another 30% was used in coatings and paints, 18% in plastics and rubber, and 2% for unknown uses.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, mine	W	W	W	W	W
Production, finished natural and synthetic IOP	70,300	88,100	83,300	50,800	61,000
Imports for consumption	199,000	178,000	155,000	106,000	150,000
Exports, pigment grade	3,100	5,410	4,740	5,640	7,500
Consumption, apparent[1]	266,000	261,000	233,000	151,000	200,000
Price, average value, dollars per kilogram[2]	0.98	1.38	1.39	1.46	1.54
Employment, mine and mill	70	70	65	58	60
Net import reliance[3] as a percentage of apparent consumption	>50%	>50%	>50%	>50%	>50%

Recycling: None.

Import Sources (2006–09): Natural: Cyprus, 47%; Spain, 17%; France, 7%; and other, 29%. Synthetic: China, 60%; Germany, 22%; Italy, 5%; Brazil, 5%; and other, 8%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
Natural:		
Micaceous iron oxides	2530.90.2000	2.9% ad val.`
Earth colors	2530.90.8015	Free.
Iron oxides and hydroxides containing more than 70% Fe_2O_3:		
Synthetic:		
Black	2821.10.0010	3.7% ad val.
Red	2821.10.0020	3.7% ad val.
Yellow	2821.10.0030	3.7% ad val.
Other	2821.10.0050	3.7% ad val.
Earth colors	2821.20.0000	5.5% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Arnold O. Tanner [(703) 648-4791, atanner@usgs.gov, fax: (703) 648-7757]**

IRON OXIDE PIGMENTS

Events, Trends, and Issues: In 2010, natural IOP production and sales increased compared with those of 2009, reflecting a slight recovery of the U.S. and European economies and continued moderate to strong growth in Asia. Architectural and specialty paint markets improved in the United States in 2010 compared with those of 2009, as did brick markets. Commercial construction, a major market for IOP colorants in concrete, remained weak in 2010. Exports of pigment-grade IOPs increased significantly to Asian markets, where economic recovery was occurring at a faster pace than in other regions. Exports also increased moderately to Italy, Mexico, South America, Spain, and the United Kingdom. Exports of other grades of IOPs and hydroxides also increased to Asian and some European and South American markets. Imports of natural IOPs increased significantly from China, Cyprus, and France. Imports of synthetic IOPs increased from all major producing countries.

A study by a research firm revealed that a number of factors continued to influence the market for pigments in the coatings industry. These included the elimination of heavy metals and heavy-metal salts and an increase in competitively priced high-performance pigments from the Far East. Inorganic pigments, although losing some appeal owing to cadmium, chromium, or barium content, were seen, in general, to continue to be the preferred types where heat, light, and chemical resistance properties were required.

A leading world producer of natural and synthetic IOPs increased production and production capacity at all of its sites in Brazil, China, and Germany. In Jinshan, Shanghai, the company began operations at a new 10,000-ton-per-year plant to manufacture high-quality black IOPs. At its adjacent yellow IOPs plant, improvements in manufacturing technology increased the plant's ability to run at a full 28,000-ton-per-year capacity. Also at that plant, the company was making modifications to reduce emissions by at least 15% by 2011. Both plants served Asia-Pacific markets, including Australia and India.

A U.S.-based manufacturer of innovative inorganic pigments, in collaboration with a university in Italy with expertise in photocatalysis, introduced a new generation IOP with functional properties that respond to sunlight to enable surfaces to self-clean, reduce air pollutants, and inhibit microbial growth—the first colored pigment of its kind with photocatalytic properties. The manufacturing process merges the coloring power of IOP with the photo-catalytic properties of titanium dioxide, and the IOP was available in the complete range of yellow, red, and black IOP shades.

World Mine Production and Reserves:

	Mine production		Reserves[4]
	2009	2010[e]	
United States	W	W	Moderate
Cyprus	12,000	12,000	Moderate
Germany[5]	209,000	220,000	Moderate
Honduras	17,000	17,000	Moderate
India	385,000	390,000	Large
Pakistan	6,000	6,000	Moderate
Spain	140,000	150,000	Large
Other countries	21,200	21,000	Moderate
World total (rounded)	NA[6]	NA[6]	Large

World Resources: Domestic and world resources for production of IOPs are adequate. Adequate resources are available worldwide for the manufacture of synthetic IOPs.

Substitutes: IOPs are probably the most important of the natural minerals suitable for use as a pigment after milling. Because IOPs are low cost, color stable, and nontoxic, they can be economically used for imparting black, brown, yellow, and red coloring in large and relatively low-value applications. Other minerals may be used as colorants but they generally cannot compete with IOPs because of the limited tonnages available. Synthetic IOPs are widely used as colorants and compete with natural IOPs in many color applications. Organic colorants are used for some colorant applications but several of the organic compounds fade over time from exposure to sunlight.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Defined as production of natural and synthetic IOPs + imports – exports.
[2]Unit value for finished iron oxide pigments sold or used by U.S. producers.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]Includes natural and synthetic iron oxide pigment.
[6]A significant number of other countries undoubtedly produces iron oxide pigments, but output is not reported and no basis is available to formulate estimates of output levels. Such countries include Azerbaijan, China, Kazakhstan, Russia, and Ukraine. Unreported output likely is substantial.

KYANITE AND RELATED MATERIALS

(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. Commercially produced mullite is synthetic, produced from sintering or fusing such feedstock materials as kyanite or bauxitic kaolin; natural mullite occurrences typically are rare and uneconomic to mine. 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Mine[e]	100	118	97	71	70
Synthetic mullite[e]	40	40	40	40	40
Imports for consumption (andalusite)	4	2	6	5	6
Exports[e]	35	36	36	26	32
Consumption, apparent[e]	109	124	107	90	85
Price, average, dollars per metric ton:[1]					
U.S. kyanite, raw	NA	NA	229	283	283
U.S. kyanite, calcined	313	333	357	383	422
Andalusite, Transvaal, South Africa	248	235	263	352	352
Employment, kyanite mine, office, and plant, number[e]	135	130	120	120	120
Employment, mullite plant, office, and plant, number[e]	200	200	190	170	170
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2006–09): South Africa, 89%; France, 6%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
Andalusite, kyanite, and sillimanite	2508.50.0000	Free.
Mullite	2508.60.0000	Free.

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

Government Stockpile: None.

Prepared by **Arnold O. Tanner [(703) 648-4758, atanner@usgs.gov, fax: (703) 648-7757]**

KYANITE AND RELATED MATERIALS

Events, Trends, and Issues: Following the recession in 2008 and 2009, steel production in the United States, which ranked third in the world, rebounded with an increase of 56% in the first 8 months of 2010 compared with that of the same period in 2009. (In the same period of 2009, steel production had declined by 49% from the first 8 months of 2008.) Potentially increasing the demand for kyanite-mullite, crude steel production in the other three of the world's four leading steel-producing countries also increased in the first 8 months of 2010 compared with that of the same period in 2009—in China, the leading producer, by about 15%; in Japan (second) by 38%; and in Russia (fourth) by 15%. Total world production rose by 22% during the same period. Of the total world refractories market, estimated to be approximately 23 million tons, crude steel manufacturing consumed around 70% of production.

Global demand for refractory products grew significantly in the fourth quarter of 2009 and during 2010 as a result of the recovery of steel production and sharp reductions of refractory inventory implemented in 2009 across the supply chain. With the steel recovery continuing, mullite received increasing interest, as many refractory customers sought alternative aluminosilicate refractory minerals to refractory bauxite. Industry sources in the United States, Europe, and Southeast Asia expressed concern regarding the supply of 60% Al_2O_3 mullite grades from the United States. Such a potential shortage, along with the drive to reduce costs, resulted in a renewed interest in 60- and 70-grade mullite from China, although Chinese mullite prices were on the rise and the future availability there was uncertain. Because of increased demand, one company restarted all its kilns at Andersonville, GA, in late 2009, and in early 2010, brought onstream a new kiln, adding 75,000 tons annually to the company's existing production capacity.

World Mine Production and Reserves:

	Mine production		Reserves[3]
	2009	2010[e]	
United States[e]	71	70	Large in the United States.
France	65	65	
India	24	24	
South Africa	210	265	
Other countries	6	8	
World total (rounded)	375	430	

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.
[1]Source: Industrial Minerals.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.

LEAD

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

Domestic Production and Use: The value of recoverable mined lead in 2010, based on the average North American producer price, was $904 million. Five lead mines in Missouri, plus lead-producing mines in Alaska and Idaho, yielded all of the totals. Primary lead was processed at one smelter-refinery in Missouri. Of the 20 plants that produced secondary lead, 14 had annual capacities of 15,000 tons or more and accounted for more than 99% of secondary production. Lead was consumed at about 76 manufacturing plants. The lead-acid battery industry continued to be the principal user of lead, accounting for about 87% of the reported U.S. lead consumption for 2010. Lead-acid batteries were primarily used as starting-lighting-ignition batteries for automobiles and trucks and as industrial-type batteries for uninterruptible power-supply equipment for computer and telecommunications networks and for motive power.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Mine, lead in concentrates	429	444	410	406	400
Primary refinery	153	123	135	103	115
Secondary refinery, old scrap	1,160	1,180	1,140	1,110	1,150
Imports for consumption:					
Lead in concentrates	([1])	([1])	([1])	([1])	([1])
Refined metal, wrought and unwrought	343	267	314	253	275
Exports:					
Lead in concentrates	298	300	277	287	270
Refined metal, wrought and unwrought	68	56	75	82	65
Shipments from Government stockpile excesses, metal	24	—	—	—	—
Consumption:					
Reported	1,490	1,570	1,440	1,290	1,400
Apparent[2]	1,580	1,540	1,500	1,410	1,500
Price, average, cents per pound:					
North American Producer	77.4	124	120	86.9	106
London Metal Exchange	58.0	117	94.8	78.0	94
Stocks, metal, producers, consumers, yearend	54	39	73	63	58
Employment:					
Mine and mill (peak), number[3]	1,070	1,100	1,200	1,200	1,100
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: In 2010, about 1.15 million tons of secondary lead was produced, an amount equivalent to 82% of reported domestic lead consumption. Nearly all of it was recovered from old (post-consumer) scrap.

Import Sources (2006–09): Metal, wrought and unwrought: Canada, 74%; Mexico, 13%; Peru, 5%; China, 4%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations[5] 12-31-10
Unwrought (refined)	7801.10.0000	2.5% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: The global lead market was in surplus during 2010 owing to the continued economic slowdown and weakened demand for lead in many regions. Prices declined and stocks rose throughout the first half of the year. Monthly average London Metal Exchange (LME) lead prices began the year at $2,368 per metric ton in January 2010 and declined by 28% during the first half of 2010. Global stocks of refined lead held in LME warehouses increased by 21% to 190,475 tons during the first 6 months of 2010. Lead prices began to increase in the third quarter of 2010 and LME stock levels appeared to stabilize compared with those earlier in the year.

Domestic mine production in 2010 was expected to decline from that in the previous year partially owing to the early 2009 closures of two lead-producing mines in Washington and Montana. Lead-producing mines in Missouri were expected to produce less lead in concentrate in 2010 compared with that of 2009, owing to operational disruptions

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

LEAD

caused by underground fires and reduced ore head grade. At current production rates, a leading producer of zinc and lead in concentrate in Alaska will exhaust reserves at its open pit operations by early 2011. In mid-2010, the company began to develop an adjacent deposit at the site that might extend zinc and lead mining through 2031.

A leading domestic lead-acid battery manufacturer received necessary permits to begin constructing a new $100 million secondary lead smelter in Florence, SC. When completed in 2012, the facility would be the first new secondary lead smelter built in the United States in more than 20 years and would have the capacity to produce about 120,000 tons per year of secondary lead. Another producer planned to spend $117 million to expand secondary lead production capacity at an existing facility in Tampa, FL, by 400%, to 118,000 tons per year by 2012. In March, the operator of the only domestic primary lead smelter unveiled new primary lead processing technology that could reduce lead emissions by nearly 99% compared with traditional processing methods.

Global mine production of lead was expected to increase by 6% in 2010 from that in 2009, to 4.10 million tons owing to production increases in Australia, China, India, Mexico, and Russia. China was expected to account for more than 40% of global lead mine production. Global refined lead production was expected to increase by about 5% from that in 2009, to 9.10 million tons. Increased refined lead output was expected from Canada, China, Poland, and Thailand. Lead consumption was expected to increase by about 5% in 2010 from that in 2009 worldwide, partially owing to a 4% increase in Chinese lead consumption, driven by growth in the automobile and electric bicycle markets. During the first 8 months of 2010, 76.8 million lead-acid batteries were shipped in North America, a 9% increase from those in the same period of 2009. The International Lead and Zinc Study Group expected that global supply of refined lead would exceed demand by about 90,000 tons by yearend 2010.

World Mine Production and Reserves: Reserves estimates were revised based on information released by producers in the respective countries.

	Mine production		Reserves[6]
	2009	2010[e]	
United States	406	400	7,000
Australia	566	620	27,000
Bolivia	86	90	1,600
Canada	69	65	650
China	1,600	1,750	13,000
India	92	95	2,600
Ireland	50	45	600
Mexico	144	185	5,600
Peru	302	280	6,000
Poland	60	35	1,500
Russia	70	90	9,200
South Africa	49	50	300
Sweden	60	65	1,100
Other countries	306	330	4,000
World total (rounded)	3,860	4,100	80,000

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, Russia, 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 cable covering, cans, and containers. Aluminum, iron, plastics, and tin compete with lead in other packaging and coatings. Tin has replaced lead in solder for new or replacement potable water systems. In the electronics industry, there has been a move towards lead-free solders with compositions of bismuth, copper, silver, and tin. Steel and zinc were common substitutes for lead in wheel weights.

[e]Estimated. E Net exporter. — 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 Canada, Mexico, and Peru for item shown.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

LIME[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2010, an estimated 18.0 million tons (19.8 million short tons) of quicklime and hydrate was produced (excluding commercial hydrators) at a value of about $1.8 billion. At yearend, there were 31 companies producing lime, which included 21 companies with commercial sales and 10 companies that produced lime strictly for internal use (for example, sugar companies). These companies had 73 primary lime plants (plants operating lime kilns) in 29 States and Puerto Rico. The 4 leading U.S. lime companies produced quicklime or hydrate in 24 States and accounted for about 80% of U.S. lime production. Principal producing States were Alabama, Kentucky, and Missouri (each with production of more than 2 million tons), and Nevada, Ohio, Pennsylvania, and Texas (each with production of more than 1 million tons). 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production[2]	21,000	20,200	19,900	15,800	18,000
Imports for consumption	298	375	307	422	430
Exports	116	144	174	108	150
Consumption, apparent	21,200	20,400	20,000	16,100	18,000
Quicklime average value, dollars per ton at plant	78.10	84.60	89.90	102.00	105.00
Hydrate average value, dollars per ton at plant	98.30	102.40	107.20	126.40	130.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and plant, number	5,300	5,300	5,400	4,800	5,000
Net import reliance[3] as a percentage of apparent consumption	1	1	1	2	2

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 (2006–09): Canada, 86%; Mexico, 13%; and other, 1%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-10**
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 2010, the U.S. economy began a slow recovery from the longest recession since the 1930s. Production of raw steel, lime's largest end-use market, increased by about 35% in 2010 compared with that of 2009. This accounted for a significant portion of the increase in lime production and consumption in 2010. The flue gas desulfurization market benefitted from increased coal consumption for electricity generation as a result of the unusually long, hot summer experienced in the East and South. Regionally, lime sales were boosted by construction projects using lime for soil stabilization.

Although the lime industry reported significant production increases at many plants, a number of the plants idled in 2009 remained shut down during 2010. These included plants in Arizona, Idaho, Illinois, Utah, and Virginia.

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

LIME

The lime industry is facing possible future regulation of carbon dioxide emissions after the U.S. Environmental Agency (EPA) published findings that greenhouse gas emissions (GHG), including carbon dioxide, threaten the public health and welfare of current and future generations. These "endangerment" findings allow the EPA to require that any modification to a stationary source that increases GHG emissions above the significance threshold would need to go through "prevention of significant deterioration" (PSD) review and install the "best available control technology." In 2010, the EPA published its "PSD and title V greenhouse gas tailoring rule" to establish the applicability criteria that determine which stationary sources and modification projects become subject to permitting requirements for GHG emissions. The tailoring rule is designed to phase in regulation of GHG emissions from stationary sources by temporarily increasing the amount of GHG emissions that would trigger PSD, so that tens of thousands of sources are not immediately swept into the PSD program.

World Lime Production and Limestone Reserves:

	Production		Reserves[4]
	2009	2010[e]	
United States	15,800	18,000	Adequate for all countries listed.
Australia	2,000	2,200	
Belgium	2,000	2,000	
Brazil	7,450	7,700	
Canada	1,600	1,800	
China	185,000	190,000	
France	3,500	3,700	
Germany	6,000	6,800	
India	13,000	14,000	
Iran	2,700	2,800	
Italy[5]	6,000	6,400	
Japan (quicklime only)	8,400	9,400	
Korea, Republic of	3,600	4,000	
Mexico	5,500	5,700	
Poland	1,950	2,000	
Romania	2,000	2,200	
Russia	7,000	7,400	
South Africa (sales)	1,380	1,400	
Spain	2,000	2,200	
Turkey (sales)	3,800	4,000	
United Kingdom	1,500	1,600	
Vietnam	1,700	1,800	
Other countries	15,500	16,000	
World total (rounded)	299,000	310,000	

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]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]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 and Zimbabwe were major producers of lithium ore concentrates. The United States remained the leading importer 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 were withheld from publication to avoid disclosing company proprietary data. 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-ion batteries.

Although lithium markets vary by location, global end-use markets are estimated as follows: ceramics and glass, 31%; batteries, 23%; lubricating greases, 9%; air treatment, 6%; primary aluminum production, 6%; continuous casting, 4%; rubber and thermoplastics, 4%; pharmaceuticals, 2%; and other uses, 15%. 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production	W	W	W	W	W
Imports for consumption	3,260	3,140	3,160	1,890	2,000
Exports	1,500	1,440	1,450	920	1,600
Consumption:					
Apparent	W	W	W	W	W
Estimated	2,500	2,400	2,300	1,300	1,000
Employment, mine and mill, number	61	68	68	68	68
Net import reliance[1] as a percentage of apparent consumption	>50%	>50%	>50%	>50%	43%

Recycling: Recycled lithium content has been historically insignificant, but has increased steadily owing to the growth in consumption of lithium batteries. One U.S. company has recycled lithium metal and lithium-ion batteries since 1992 at its Canadian facility in British Columbia. In 2009, the U.S. Department of Energy awarded the company $9.5 million to construct the first U.S. recycling facility for lithium-ion batteries.

Import Sources (2006–09): Chile, 59%; Argentina, 38%; China, 1%; and other, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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.

Events, Trends, and Issues: Market conditions improved for lithium-based products in 2010. Sales volumes for the major lithium producers were reported to be up more than 30% by mid-2010. Consumption by lithium end-use markets for batteries, ceramics and glass, grease, and other industrial applications all increased. The leading lithium producer in Chile lowered its lithium prices by 20% in 2010. Many new companies continued exploring for lithium on claims worldwide. Numerous claims in Nevada, as well as Argentina, Australia, Bolivia, and Canada, have been leased or staked.

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 compared with the mining and processing costs for hard-rock ores. Two brine operations in Chile dominate the world

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

LITHIUM

market, and a facility at a brine deposit in Argentina produced lithium carbonate and lithium chloride. Two additional brine operations were under development in Argentina. Worldwide, most lithium minerals mined were used directly as ore concentrates in ceramics and glass applications rather than as feedstock for lithium carbonate and other lithium compounds.

In an effort to increase the quality of lithium suitable for advanced transportation batteries, the sole active lithium production company in United States began the expansion of its lithium operation in North Carolina to include battery-grade lithium hydroxide. Funding for the project was obtained in part from the U.S. Department of Energy. An emerging Australian lithium ore producer commenced lithium concentrate production in Western Australia. The lithium concentrate was to be converted to battery-grade lithium carbonate in China to supply the Asian market. Australia's leading lithium ore miner merged with an emerging lithium brine mining company to develop a lithium brine operation in Chile.

Batteries, especially rechargeable batteries, are the uses for lithium compounds with the largest growth potential. Demand for rechargeable lithium batteries continued to gain market share over rechargeable nonlithium batteries for use in cordless tools, portable computers and cellular telephones, and video cameras. 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.

Asian technology companies continued to invest in the development of lithium operations in other countries to ensure a stable supply of lithium for their battery industries. With lithium carbonate being one of the lowest cost components of a lithium-ion battery, the issue to be addressed was not cost difference or production efficiency but supply security attained by acquiring lithium from a number of different lithium sources.

World Mine Production and Reserves: Reserves estimates for Argentina, Brazil, Canada, China, and Portugal have been revised based on new information from Government and industry sources.

	Mine production		Reserves[2]
	2009	2010[e]	
United States	W	W	38,000
Argentina	2,220	2,900	850,000
Australia	6,280	8,500	580,000
Brazil	160	180	64,000
Canada	310	—	—
Chile	5,620	8,800	7,500,000
China	3,760	4,500	3,500,000
Portugal	—	—	10,000
Zimbabwe	400	470	23,000
World total (rounded)	[3]18,800	[3]25,300	13,000,000

World Resources: The identified lithium resources total 4 million tons in the United States and approximately 29 million tons in other countries. Among the other countries, identified lithium resources for Bolivia and Chile total 9 million tons and in excess of 7.5 million tons, respectively. China and Argentina total 5.4 million tons and 2.6 million tons of identified lithium resources, respectively, while Brazil, Congo, and Serbia each contain approximately 1 million tons. Identified lithium resources for Australia and Canada total 630,000 tons and 360,000 tons, respectively.

Substitutes: Substitution for lithium compounds is 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 in structural materials are composite materials consisting of boron, glass, or polymer fibers in engineering resins

[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 resource/reserve definitions and information concerning data sources.

[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 54% of U.S. magnesium compounds production in 2010. Magnesium oxide and other compounds were recovered from seawater by three companies in California, Delaware, and Florida; from well brines by one company in Michigan; and from lake brines by two companies in Utah. Magnesite was mined by one company in Nevada, 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 in agricultural, chemical, construction, environmental, and industrial applications. The remaining 40% was used for refractories.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production	282	342	274	239	243
Imports for consumption	371	357	342	173	295
Exports	28	26	25	13	16
Consumption, apparent	625	673	591	399	522
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant, number[e]	370	370	370	300	300
Net import reliance[2] as a percentage of apparent consumption	55	49	54	40	53

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

Import Sources (2006–09): China, 78%; Austria, 6%; Canada, 4%; Brazil, 3%; and other, 9%.

Tariff:[3] Item	Number	Normal Trade Relations 12-31-10
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.

Events, Trends, and Issues: Although still below 2008 production rates, U.S. steel production through July 2010 was 62% higher than that in 2009. Increased steel production and capacity utilization led to increased imports of dead-burned magnesia, compared with those in 2009. By July, dead-burned magnesia imports were almost 200,000 tons (gross weight), which was more than those for the full year 2009.

In August, the U.S. Department of Commerce, International Trade Administration (ITA) published its final determinations of its investigation of dumping of magnesia-carbon brick from China and Mexico into the United States. The ITA established a dumping margin of 128.10% ad valorem for 14 producing/exporting companies in China and 236% ad valorem as the China-wide rate. For Mexico, the ITA determined a dumping margin of 57.90% ad valorem. The ITA also found that subsidies existed for magnesia-carbon bricks exported from China, so it established countervailing duties of 24.24% ad valorem for most companies exporting from China, with one firm having a rate of 253.87% ad valorem.

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

MAGNESIUM COMPOUNDS

In Australia, the country's leading magnesia producer returned to full production capacity in June after running at about 25% of capacity since the beginning of 2009. The company also completed an expansion that increased its capacity by about 50% to bring the total to 175,000 tons per year of caustic-calcined magnesia, 135,000 tons per year of dead-burned magnesia, and 35,000 tons per year of fused magnesia. Another firm received State government approval to develop its magnesite property in Tasmania and, in the fourth quarter, began drilling to delineate the magnesite resource.

Several companies planned new magnesia plants. In Spain, the leading magnesite producer planned to open two new mines in 2011 with about 57 million tons of magnesite reserves to replace the company's operating mines that, at present mining rates, have a remaining life of 7 to 8 years. In May, a company in Turkey began production from a new 6,500-ton-per-year fused magnesia furnace, which doubled its fused magnesia production capacity. In India, a new joint venture planned to develop the Panthal magnesite deposit and build a 30,000-ton-per-year dead-burned magnesia plant at the site by 2012.

The world's second-ranked olivine producer planned to close its 1.1-million-ton-per-year mine in Greenland by yearend. The company cited lower olivine prices and unfavorable market conditions as reasons for the closure. The mine had been operating only since 2005.

World Magnesite Mine Production and Reserves: Reserves data for Australia, China, India, and Slovakia were revised based on new information from the respective country Governments.

	Mine production		Reserves[4]
	2009	2010[e]	
United States	W	W	10,000
Australia	58	70	95,000
Austria	231	230	15,000
Brazil	115	100	99,000
China	3,170	3,200	550,000
Greece	94	100	30,000
India	98	100	6,000
Korea, North	346	350	450,000
Russia	288	300	650,000
Slovakia	231	230	35,000
Spain	133	130	10,000
Turkey	576	600	49,000
Other countries	167	170	390,000
World total (rounded)	[5]5,510	[5]5,580	2,400,000

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 resource/reserve definitions and information concerning data sources.
[5]Excludes U.S. production.

MAGNESIUM METAL[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2010, magnesium was produced by one company at a plant 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 primary metal 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:	2006	2007	2008	2009	2010[e]
Production:					
Primary	W	W	W	W	W
Secondary (new and old scrap)	82	84	84	67	70
Imports for consumption	75	72	83	47	50
Exports	12	15	14	20	16
Consumption:					
Reported, primary	78	72	65	51	55
Apparent	[2]120	[2]130	[2]140	[3]90	[2]100
Price, yearend:					
Platts Metals Week, U.S. spot Western, dollars per pound, average	1.40	2.25	3.15	2.30	2.60
Metal Bulletin, China free market, dollars per metric ton, average	2,050	4,550	2,800	2,740	3,100
Stocks, producer and consumer, yearend	W	W	W	W	W
Employment, number[e]	400	400	400	400	400
Net import reliance[4] as a percentage of apparent consumption	53	47	50	33	34

Recycling: In 2010, about 20,000 tons of secondary production was recovered from old scrap.

Import Sources (2006–09): Canada, 36%; Israel, 25%; China, 11%; Russia, 8%; and other, 20%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Unwrought metal	8104.11.0000	8.0% ad val.
Unwrought alloys	8104.19.0000	6.5% ad val.
Wrought metal	8104.90.0000	14.8¢/kg on Mg content + 3.5% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: In October, the U.S. Department of Commerce, International Trade Administration (ITA), made a final determination of antidumping duties for imports of pure magnesium from China into the United States for May 1, 2008, through April 30, 2009. The ITA determined a duty of 0% ad valorem for one company and a China-wide duty of 111.73% ad valorem, the same as the China-wide rate had been since the 2007–08 review. In its final review of primary magnesium shipments to the United States from Russia from April 1, 2008, through March 31, 2009, the ITA determined that the dumping rate for one of the two Russian primary magnesium producers was 0% ad valorem. For the other, even though the company did not sell material into the United States during the period of review, the ITA determined that if any material from the company had entered the United States through another firm, it would be subject to the “all others” rate of duty established at the time that it was imported into the United States. Normally, if a company had not made any sales into the U.S. market, the antidumping duty would be rescinded. The ITA also completed an expedited 5-year sunset review of magnesium alloy imports from China and pure and alloy magnesium imports from Russia into the United States. Because no party in the original determination notified the ITA that it intended to participate in the reviews, the ITA determined that revocation of the antidumping orders would likely lead to a continuation of dumping. As a result, the ITA maintained the antidumping duty orders. For alloy magnesium from China, two companies had a duty of 49.66% ad valorem, and the China-wide duty was 141.49% ad valorem. For pure and alloy magnesium from Russia, one primary magnesium-producing firm had a duty of 21.71% ad valorem, the other had a duty of 18.65% ad valorem, and the Russia-wide rate was 21.01% ad valorem.

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

MAGNESIUM METAL

U.S. magnesium consumption increased in 2010 from the low level in 2009 as end-use markets that had been significantly affected by the global economic downturn began to recover slightly. Magnesium prices rose slightly in the United States because of tight supplies resulting from the antidumping duties assessed on magnesium imports from China and Russia. The duties also led to imports that were lower than historic levels, with Israel accounting for 62% of the total of U.S. imports of metal and alloy through the first 8 months of 2010. Magnesium supplies in the United States also were affected as a new titanium sponge plant in Rowley, UT, which began operating at the end of 2009, ramped up to full production. Significant quantities of magnesium used for titanium tetrachloride reduction were required for the initial startup period; the magnesium was supplied by the nearby U.S. producer.

In June, the U.S. Environmental Protection Agency (EPA) issued a final rule that requires annual greenhouse gas (GHG) emissions reporting from four source categories—one of which was magnesium production. Each facility must report total annual emissions for each of the following cover or carrier gases—sulfur hexafluoride, hydroflurocarbon HFC-134a, the fluorinated ketone FK 5-1-12, carbon dioxide, and any other fluorinated GHG as defined in the rule. Collection of the data was scheduled to begin on January 1, 2011, with the first report due on March 31, 2012.

In a ruling by the 10th Circuit Court of Appeals, a 2007 decision exempting the U.S. primary magnesium producer's waste streams from regulation by the EPA under the Resource Conservation and Recovery Act (RCRA) was thrown out. In the lawsuit originally begun in 2001, the company argued that the EPA exempted five wastes from regulation under subtitle C of RCRA and that the EPA could not change that interpretation, at least not without first complying with the notice and comment procedures of the Administrative Procedure Act. The district court had agreed with the company, but, according to the new appellate court ruling, because the EPA never previously adopted a definitive interpretation, it remained free to change its mind and issue a new interpretation of its own regulations. The appellate court remanded the decision to the district court.

The first production of magnesium from a new primary magnesium plant in Malaysia began in June, although the plant had not ramped up to commercial-scale production. The facility in Taiping in the state of Perak used locally mined dolomite feedstock for a Pidgeon-process plant using natural gas to fuel the process. The initial production capacity was 15,000 tons per year. The company planned to double the capacity in the future and to begin producing magnesium alloys.

World Primary Production and Reserves:

	Primary production	
	2009	**2010**[e]
United States	W	W
Brazil	16	16
China	501	650
Israel	29	30
Kazakhstan	21	20
Russia	37	40
Serbia	2	2
Ukraine	2	2
World total[6] (rounded)	608	760

Reserves[5]

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

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

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

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

MANGANESE

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

Domestic Production and Use: Manganese ore containing 35% or more manganese has not been produced domestically since 1970. 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. Construction, machinery, and transportation end uses accounted for about 28%, 9%, and 8%, 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 $1.1 billion.

Salient Statistics—United States:[1]	**2006**	**2007**	**2008**	**2009**	**2010**[e]
Production, mine[2]	—	—	—	—	—
Imports for consumption:					
Manganese ore	572	602	571	269	490
Ferromanganese	358	315	448	153	320
Silicomanganese[3]	400	414	365	130	310
Exports:					
Manganese ore	2	29	48	15	18
Ferromanganese	22	29	23	24	12
Silicomanganese	<1	3	7	7	19
Shipments from Government stockpile excesses:[4]					
Manganese ore	73	101	9	-3	—
Ferromanganese	56	68	18	25	30
Consumption, reported:[5]					
Manganese ore[6]	365	351	464	422	480
Ferromanganese	297	272	304	254	300
Consumption, apparent, manganese[7]	1,060	979	844	445	720
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]	3.22	3.10	12.15	6.61	8.00
CNF[8] China, Ryan's Notes	2.33	6.05	14.70	5.61	[9]6.70
Stocks, producer and consumer, yearend:					
Manganese ore[6]	153	190	255	115	170
Ferromanganese	31	31	27	31	16
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 (2006–09): Manganese ore: Gabon, 54%; South Africa, 17%; Australia, 12%; Brazil, 6%; and other, 11%. Ferromanganese: South Africa, 52%; China, 21%; Republic of Korea, 7%; Mexico, 5%; and other, 15%. Manganese contained in all manganese imports: South Africa, 35%; Gabon, 19%; China, 11%; Australia, 8%; and other, 27%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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).

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

MANGANESE

Government Stockpile:

Stockpile Status—9-30-10[11]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Manganese ore[12]	-9	-9	91	—
Ferromanganese, high-carbon	369	369	91	34

Events, Trends, and Issues: The global economic recovery, as measured by the expansion of global gross domestic product (estimated to increase by 2.7% from that of 2009 by the World Bank), coincided with the growth in the manganese market during 2010. U.S. steel production in 2010 was projected to be 38% more than that in 2009. Imports of manganese materials were significantly more in 2010 than in 2009—82%, 104%, and 139% more for manganese ore, ferromanganese, and silicomanganese, respectively. As a result, U.S. manganese apparent consumption increased by an estimated 66% to 720,000 metric tons in 2010. The annual average domestic manganese ore contract price followed the increase in the average international price for metallurgical-grade ore that was set between Japanese consumers and major suppliers in 2010. However, U.S. average weekly spot prices for high-carbon ferromanganese and silicomanganese through October 2010 were 16% lower than and about the same as, respectively, those at the start of the year, owing to higher inventory levels caused by domestic manganese material production increases and greater ferromanganese imports. Improved economic conditions led to planned expansions at five manganese mines and about 1,400,000 metric tons per year of additional manganese ferroalloy production capacity worldwide in 2010.

World Mine Production and Reserves (metal content): Reserves estimates have been revised from those previously published for Australia (upward), Brazil (upward), China (upward), and South Africa (downward), as reported by the Governments of Australia, Brazil, and China, and the major manganese producers in South Africa.

	Mine production		Reserves[13]
	2009	2010[e]	
United States	—	—	—
Australia	2,140	2,400	93,000
Brazil	730	830	110,000
China	[e]2,400	2,800	44,000
Gabon	881	1,400	52,000
India	[e]980	1,100	56,000
Mexico	169	210	4,000
South Africa	1,900	2,200	120,000
Ukraine	[e]375	580	140,000
Other countries	1,240	1,400	Small
World total (rounded)	10,800	13,000	630,000

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 75% 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, in manganese content, defined as stockpile shipments – receipts.
[5]Manganese consumption cannot 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 2010.
[10]Defined as imports – exports + adjustments for Government and industry stock changes.
[11]See Appendix B for definitions.
[12]Metallurgical grade. Negative inventory reflects adjustment in accounting by the Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center).
[13]See Appendix C for resource/reserve definitions and information concerning data sources.

MERCURY

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

Domestic Production and Use: Mercury has not been produced as a principal commodity in the United States since 1992, when the McDermitt Mine, in Humboldt County, NV, closed. In 2010, Mercury was produced as a byproduct from processing gold-silver ore at several mines in Nevada; however, these production data were not reported. Secondary, or recycled, mercury was recovered by retorting end-of-use mercury-containing products that included batteries, compact and traditional fluorescent lamps, dental amalgam, medical devices, and thermostats, as well as mercury-contaminated soils. The mercury was processed and refined for resale or exported. Secondary mercury production data were not reported. Mercury use is not carefully tracked in the United States; however, no more than 100 metric tons per year of mercury were consumed domestically. The leading domestic end user of mercury was the chlorine-caustic soda industry. However, owing to mercury toxicity and concerns for human health, overall mercury use has declined in the United States. Mercury has been released to the environment from mercury-containing car switches when the automobile is scrapped for recycling, from coal-fired powerplant emissions, 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, compact and traditional fluorescent lights, dental amalgam, neon lights, and small-scale gold mining. Some button-type batteries, cleansers, fireworks, folk medicines, grandfather clocks, pesticides, and some skin-lightening creams and soaps may contain mercury.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Mine (byproduct)	NA	NA	NA	NA	NA
Secondary	NA	NA	NA	NA	NA
Imports for consumption (gross weight), metal	94	67	155	206	200
Exports (gross weight), metal	390	84	732	753	500
Price, average value, dollars per flask, free market[2]	670.00	530.00	600.00	600.00	900.00
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Six companies in the United States accounted for the majority of secondary mercury recycling and production in 2010. Mercury-containing automobile convenience switches, barometers, computers, dental amalgam, fluorescent lamps, medical devices, thermostats, and some mercury-containing toys were collected by as many as 50 smaller companies and then the mercury-containing materials were shipped to larger companies for retorting and reclamation of the mercury. The increased use of nonmercury substitutes has resulted in a shrinking reservoir of mercury-containing products for recycling.

Import Sources (2006–09): Peru, 54%; Chile, 17%; Russia, 11%; Germany, 11%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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, DLA Strategic Materials (formerly Defense National Stockpile Center) has indicated that consolidated storage is preferred. An additional 1,329 tons of mercury was held by the U.S. Department of Energy, Oak Ridge, TN. Sales of mercury from the National Defense Stockpile remained suspended.

Stockpile Status—9-30-10[4]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Mercury	4,436	4,436	—	—

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

MERCURY

Events, Trends, and Issues: The United States was a leading exporter of mercury in 2010, and the principal export destinations included the Netherlands, Peru, and Vietnam. The average cost of a flask of domestic mercury was $900; however, by October the price had risen to $1,450 per flask. Impending mercury export bans in the European Union, in 2011, and in the United States, in 2013, in combination with rising gold prices, have affected the price of mercury. Mercury is used for small-scale gold mining in many parts of the world and the price of gold, rising to slightly more than $1,300 per troy ounce in October, has influenced the global demand for mercury. Global consumption of mercury was estimated to be 2,000 tons per year, and approximately 50% of this consumption came from the use of mercury compounds to make vinyl monomer in China and Eastern Europe. The price of mercury was also affected by diminishing supplies of mercury reclaimed from end-of-use, mercury-containing products, and availability of mercury from China and Kyrgyzstan. Use of nonmercury technology for chlor-alkali production 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. For example, at yearend 2008, five mercury cell facilities were operating in the United States, and one plant converted to membrane technology in 2009, thereby leaving four mercury-cell facilities in operation at yearend 2009. The Federal Government was trying to find storage sites for the Nation's excess mercury, and seven States—Colorado, Idaho, Missouri, Nevada, South Carolina, Texas, and Washington—were being considered. The EPA continued its efforts to provide mercury reduction technology to gold shops in Brazil, Peru, and other parts of South America where the gold-mercury amalgam is burned to eliminate the mercury before sale of the gold. Byproduct mercury production is expected to continue from domestic and foreign gold-silver mining and processing, as is secondary production of mercury from an ever-diminishing supply of mercury-containing products such as automobile convenience switches and thermostats. However, the volume of byproduct mercury that enters the global supply from foreign gold-silver processing may change dramatically from year to year; for example, mercury in Chile and Peru is typically stockpiled until there is sufficient material for export. Mercury may also be recycled from compact and traditional fluorescent lamps. Domestic mercury consumption will continue to decline as nonmercury-containing products, such as digital thermometers, are substituted for those containing mercury.

World Mine Production and Reserves:

	Mine production		Reserves[5]
	2009	2010[e]	
United States	NA	NA	—
Chile (byproduct)	NA	150	—
China	1,400	1,400	21,000
Kyrgyzstan	250	250	7,500
Peru (byproduct)	140	35	NA
Spain	NA	NA	NA
Other countries	130	130	38,000
World total (rounded)	1,920	1,960	67,000

World Resources: China, Kyrgyzstan, Russia, Slovenia, Spain, and Ukraine have most of the world's estimated 600,000 tons of mercury resources. Peru continues to be an important source of byproduct mercury imported into the United States. 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 principal 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 traditional mercury 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 0.035 ton.

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

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

[4]See Appendix B for definitions.

[5]See Appendix C for resource/reserve definitions and information concerning data sources.

MICA (NATURAL)

(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 53,000 tons in 2010. Mica was mined in Alabama, Georgia, North 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 2010 scrap mica production was estimated to be $7.5 million.

A minor amount of sheet mica was produced in 2010 as a byproduct at a gemstone mine in Amelia, VA, and as incidental production from feldspar mining in the Spruce Pine area of North Carolina. The domestic consuming industry was dependent upon imports to meet demand for sheet mica. Most sheet mica was fabricated into parts for electronic and electrical equipment.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Scrap and flake:					
Production:[1, 2]					
Mine	110	97	84	50	53
Ground	123	99	98	77	82
Imports, mica powder and mica waste	45	41	27	20	27
Exports, mica powder and mica waste	7	8	9	8	7
Consumption, apparent[3]	148	130	102	62	73
Price, average, dollars per metric ton, reported:					
Scrap and flake	204	149	143	140	140
Ground:					
Wet	784	683	651	651	650
Dry	237	243	251	284	290
Employment, mine, number	NA	NA	NA	NA	NA
Net import reliance[4] as a percentage of apparent consumption	26	26	18	19	27
Sheet:					
Production, mine[e]	([5])	([5])	([5])	([5])	([5])
Imports, plates, sheets, strips; worked mica; split block; splittings; other >$1.00/kg	1.77	1.95	1.90	1.51	2.10
Exports, plates, sheets, strips; worked mica; crude and rifted into sheet or splittings >$1.00/kg	1.40	1.30	2.02	1.11	0.95
Shipments from Government stockpile excesses	([5])	([5])	([5])	—	—
Consumption, apparent	[6]0.38	[6]0.68	([6, 7])	0.40	1.15
Price, average value, dollars per kilogram, muscovite and phlogopite mica, reported:					
Block	130	132	122	120	120
Splittings	1.53	1.57	[e]1.53	[e]1.60	1.60
Stocks, fabricator and trader, yearend	NA	NA	NA	NA	NA
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2006–09): Scrap and flake: Canada, 34%; China, 34%; India, 22%; Finland, 7%; and other, 3%. Sheet: China, 25%; Brazil, 21%; Belgium, 18%; India, 17%; and other, 19%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Split block mica	2525.10.0010	Free.
Mica splittings	2525.10.0020	Free.
Unworked—other	2525.10.0050	Free.
Mica powder	2525.20.0000	Free.
Mica waste	2525.30.0000	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.

Prepared by **Daniel J. Cordier [(703) 648-7723, dcordier@usgs.gov, fax: (703) 648-7757]**

MICA (NATURAL)

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

Government Stockpile: None.

Events, Trends, and Issues: Domestic production and consumption of scrap and flake mica were estimated to increase in 2010. The increase primarily resulted from increased production of minerals from which mica is a byproduct caused by a slight recovery in construction materials consumption. Apparent consumption of sheet mica increased in 2010 also. No environmental concerns are associated with the manufacture and use of mica products.

Significant stocks of sheet mica previously sold from the National Defense Stockpile (NDS) to domestic and foreign mica traders, brokers, and processors were exported, however, possibly resulting in understating apparent consumption in 2006 through 2009. The NDS has not held mica since 2008, when the last stocks of muscovite block were sold. Future supplies for U.S. consumption were expected to come increasingly from imports, primarily from Brazil, China, India, and Russia.

World Mine Production and Reserves:

	Scrap and flake			Sheet		
	Mine production[e]		Reserves[8]	Mine production[e]		Reserves[8]
	2009	2010		2009	2010	
All types:						
United States[1]	50	53	Large	([5])	([5])	Very small
Brazil	4	4	Large	—	—	NA
Canada	15	15	Large	—	—	NA
China	NA	NA	Large	—	—	NA
Finland:			Large			NA
Muscovite concentrate	8	8		—	—	
Biotite	60	60		—	—	
France	20	20	Large	—	—	NA
India	4	4	Large	3.5	3.5	Very large
Korea, Republic of	50	50	Large	—	—	NA
Norway	3	3	Large	—	—	NA
Russia	100	100	Large	1.5	1.5	Moderate
Other countries	26	30	Large	0.2	0.2	Moderate
World total (rounded)	340	350	Large	5.2	5.2	Very 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. World resources of sheet mica have not been formally evaluated 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. Domestic resources are uneconomic because of the high cost of hand labor required to mine and process sheet mica from pegmatites.

Substitutes: Some lightweight aggregates, such as diatomite, perlite, and vermiculite, may be substituted for ground mica when used as filler. Ground synthetic fluorophlogopite, a fluorine-rich mica, may replace natural ground mica for uses that require thermal and electrical properties of mica. Many materials can be substituted for mica in numerous electrical, electronic, and insulation uses. Substitutes include acrylic, cellulose acetate, fiberglass, fishpaper, nylon, nylatron, phenolics, polycarbonate, polyester, styrene, 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.
[1]Sold or used by producing companies.
[2]Excludes low-quality sericite used primarily for brick manufacturing.
[3]Based on scrap and flake mica mine production.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]Less than ½ unit.
[6]See explanation in the Events, Trends, and Issues section.
[7]Apparent consumption calculation in 2008 results in a negative number.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.

MOLYBDENUM

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

Domestic Production and Use: In 2010, molybdenum, valued at about $885 million (based on average oxide price), was produced by eight mines. Molybdenum ore was produced as a primary product at three mines—one each in Colorado, Idaho, and Nevada—whereas five copper mines (three in Arizona, one each in Montana 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 75% of the molybdenum consumed.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, mine	59,800	57,000	55,900	47,800	56,000
Imports for consumption	16,700	18,300	14,500	11,400	19,000
Exports	34,500	33,700	34,700	27,900	28,000
Consumption:					
Reported	19,000	21,000	21,100	18,100	18,000
Apparent	44,400	40,900	36,400	30,500	48,000
Price, average value, dollars per kilogram[1]	54.62	66.79	62.99	25.84	15.80
Stocks, mine and plant concentrates, product, and consumer materials	7,000	7,600	7,000	7,700	6,900
Employment, mine and plant, number	910	940	940	920	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 (2006–09): Ferromolybdenum: Chile, 48%; China, 36%; Canada, 9%; and other, 7%. Molybdenum ores and concentrates: Chile, 30%; Mexico, 30%; Canada, 22%; Peru, 17%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

MOLYBDENUM

Events, Trends, and Issues: U.S. mine output of molybdenum in concentrate in 2010 increased about 17% from that of 2009. U.S. imports for consumption increased 67% from those of 2009, while U.S. exports increased slightly from those of 2009. Domestic roasters operated at between 80% and 90% of full production capacity in 2009, but in 2010 operated close to full production levels. U.S. reported consumption decreased slightly from that of 2009 while apparent consumption increased 57%. Mine capacity utilization in 2009 was about 82%.

Molybdenum prices increased in the first half of 2010 but slowly started to decrease in the third quarter; however, molybdenum demand remained strong. Both byproduct and primary molybdenum production levels in the United States recovered in 2010 from their relatively low levels in 2009. The Henderson Mine in Empire, CO, increased molybdenum production by almost 50% in 2010 from that in 2009. Byproduct molybdenum production continued to be suspended at the Chino Mine in Grant County, NM, the Morenci Mine in Greenlee County, AZ, and the Mission Mine in Pima County, AZ. The Questa Mine, in Taos County, NM, suspended its primary molybdenum mine production as well.

World Mine Production and Reserves: Reserves for Canada, China, Mexico, Mongolia, Peru, and Russia were revised based on new information published in mining companies' annual reports.

	Mine production		Reserves[3]
	2009	2010[e]	(thousand metric tons)
United States	47,800	56,000	2,700
Armenia	4,150	4,200	200
Canada	8,840	9,100	200
Chile	34,900	39,000	1,100
China	93,500	94,000	4,300
Iran	3,700	3,700	50
Kazakhstan	380	400	130
Kyrgyzstan	250	250	100
Mexico	7,800	8,000	130
Mongolia	3,000	3,000	160
Peru	12,300	12,000	450
Russia[e]	3,800	3,800	250
Uzbekistan[e]	550	550	60
World total (rounded)	221,000	234,000	9,800

World Resources: Identified resources of molybdenum in the United States amount to about 5.4 million tons, and in the rest of the world, about 14 million tons. 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-weighted 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 resource/reserve definitions and information concerning data sources.

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 2010. Limited amounts of byproduct nickel were recovered from copper and palladium-platinum ores mined in the Western United States. Six sulfide mining projects were in varying stages of development in the Lake Superior region. On a monthly or annual basis, 105 facilities reported nickel consumption. The principal consuming State was Pennsylvania, followed by Kentucky, North Carolina, and Indiana. Approximately 44% of the primary nickel consumed went into stainless and alloy steel production, 42% into nonferrous alloys and superalloys, 9% into electroplating, and 5% into other uses. End uses were as follows: transportation, 32%; chemical industry, 14%; electrical equipment, 10%; construction, fabricated metal products, and petroleum industry, 8% each; household appliances and industrial machinery, 6% each; and other, 8%. The estimated value of apparent primary consumption was $2.81 billion.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, refinery byproduct	W	W	W	W	W
Shipments of purchased scrap[1]	142,000	186,000	160,000	152,000	152,000
Imports:					
Primary	153,000	125,000	129,000	99,900	144,000
Secondary	20,300	16,200	20,100	17,700	24,300
Exports:					
Primary	8,050	13,100	11,600	7,020	11,700
Secondary	59,300	103,000	94,600	90,000	75,300
Consumption:					
Reported, primary	105,000	101,000	102,000	81,200	116,000
Reported, secondary	103,000	98,900	85,200	79,400	100,000
Apparent, primary	143,000	112,000	115,000	94,500	129,000
Total[2]	247,000	211,000	200,000	174,000	229,000
Price, average annual, London Metal Exchange:					
Cash, dollars per metric ton	24,244	37,216	21,104	14,649	21,710
Cash, dollars per pound	10.997	16.881	9.572	6.645	9.847
Stocks:					
Consumer, yearend	14,000	19,100	19,200	16,600	22,200
Producer, yearend[3]	6,450	5,690	5,860	6,150	6,620
Net import reliance[4] as a percentage of apparent consumption	50	17	33	22	43

Recycling: About 100,000 tons of nickel was recovered from purchased scrap in 2010. This represented about 44% of reported secondary plus apparent primary consumption for the year.

Import Sources (2006–09): Canada, 44%; Russia, 16%; Australia, 10%; Norway, 8%; and other, 22%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 5,080 tons of contaminated shredded nickel scrap. Ongoing 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: In 2010, the U.S. economy began to recover from recessionary conditions, but the recovery remained weak. Prior to the recovery, U.S. production of austenitic (nickel-bearing) stainless steel had declined in 2009 to 1.16 million tons—10% less than the reduced output of 1.29 million tons in 2008. Stainless steel has traditionally accounted for two-thirds of primary nickel use worldwide, with more than one-half of the steel going into the construction, food processing, and transportation sectors. China produced 7.72 million tons of austenitic stainless steel in 2010, followed by the European Union with 5.41 million tons.

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

NICKEL

Nickel prices were adversely affected by the global economic recession in 2008 and 2009. In March 2009, the London Metal Exchange (LME) cash mean for 99.8%-pure nickel bottomed out at $9,693 per metric ton after a 22-month decline. The cash price gradually recovered and returned to above $19,000 per metric ton in March 2010. The average monthly LME cash price for November 2010 was $22,905 per ton. In July, a multinational joint venture began mining the large Ambatovy laterite deposit in east-central Madagascar. The ore was being slurried and piped to the venture's pressure leach plant and refinery near Toamasina. The Toamasina complex was designed to produce 60,000 tons per year of nickel and was expected to be in the early stages of commissioning at the beginning of 2011. New mines also were being developed at several locations in Brazil, Southeast Asia, and the Pacific. In August, the $4.5 billion Goro laterite project in New Caledonia began producing a nickel-cobalt intermediate for export. Goro was scheduled to reach full production in 2013 with a production capacity of 60,000 tons per year of nickel. The Onca Puma project in Brazil's Para State began producing ferronickel from laterite in December. Enhancement work continued at the new Ravensthorpe Mine in Western Australia at a cost of $190 million. The global automotive industry is using more and more nickel as the popularity and familiarity of electric and hybrid vehicles increase. Collaboration between battery manufacturers and the U.S. Department of Energy has enabled the startup of at least three facilities designed to mass produce advanced cathode materials, several of which contain nickel.

World Mine Production and Reserves: Estimates of reserves for Brazil, China, Indonesia, and 18 other countries were revised based on new mining industry information from published sources.

	Mine production		Reserves[5]
	2009	2010[e]	
United States	—	—	—
Australia	165,000	139,000	[6]24,000,000
Botswana	28,600	32,400	490,000
Brazil	54,100	66,200	8,700,000
Canada	137,000	155,000	3,800,000
China	79,400	77,000	3,000,000
Colombia	72,000	70,200	1,600,000
Cuba	67,300	74,000	5,500,000
Dominican Republic	—	3,100	960,000
Indonesia	203,000	232,000	3,900,000
Madagascar	—	7,500	1,300,000
New Caledonia[7]	92,800	138,000	7,100,000
Philippines	137,000	156,000	1,100,000
Russia	262,000	265,000	6,000,000
South Africa	34,600	41,800	3,700,000
Venezuela	13,200	14,300	490,000
Other countries	51,700	77,800	4,500,000
World total (rounded)	1,400,000	1,550,000	76,000,000

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. The long-term decline in discovery of new sulfide deposits in traditional mining districts has forced companies to shift exploration efforts to more challenging locations like the Arabian Peninsula, east-central Africa, and the Subarctic.

Substitutes: To offset high and fluctuating nickel prices, engineers have been substituting low-nickel, duplex, or ultrahigh-chromium stainless steels for austenitic grades in construction applications. Nickel-free specialty steels are sometimes used in place of stainless steel within the power-generating and petrochemical industries. Titanium alloys can substitute for nickel metal or nickel-based alloys in corrosive chemical environments. Cost savings in manufacturing lithium-ion batteries allow them to compete against nickel-metal hydride 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 resource/reserve definitions and information concerning data sources.
[6]For Australia, Joint Ore Reserves Committee (JORC) compliant reserves were only 4.7 million tons.
[7]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, 74%; and superalloys, 26%. In 2009, the estimated value of niobium consumption was $162 million and was expected to be about $330 million in 2010, as measured by the value of imports.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Mine	—	—	—	—	—
Secondary	NA	NA	NA	NA	NA
Imports for consumption[e, 1]	10,500	10,120	9,230	4,400	8,500
Exports[e, 1]	561	1,100	781	195	170
Government stockpile releases[e, 2]	156	—	—	—	—
Consumption:[e]					
Apparent	10,100	9,020	8,450	4,210	8,300
Reported[3]	5,050	6,510	5,380	4,350	4,000
Unit value, ferroniobium, dollars per metric ton[4]	14,022	21,918	34,398	37,298	37,500
Net import reliance[5] 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 (2006–09): Niobium contained in niobium and tantalum ore and concentrate; ferroniobium; and niobium metal and oxide: Brazil, 84%; Canada, 9%; Germany, 2%; Estonia, 2%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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[6]	8112.92.0600	Free.
Alloys, metal, powders	8112.92.4000	4.9% ad val.
Niobium, other[6]	8112.99.9000	4.0% ad val.

Depletion Allowance:[7] 22% (Domestic), 14% (Foreign).

Government Stockpile: For fiscal year (FY) 2010, which ended on September 30, 2010, the Defense Logistics Agency, DLA Strategic Materials (formerly the Defense National Stockpile Center), disposed of no niobium materials. DLA Strategic Materials announced that maximum disposal limits for FY 2011 had not been approved. The DLA Strategic Materials' niobium mineral concentrate inventory was exhausted in FY 2007; niobium carbide powder, in FY 2002; and ferroniobium, in FY 2001.

Stockpile Status—9-30-10[7]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Niobium metal	10.1	10.1	[8]9	—

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

NIOBIUM (COLUMBIUM)

Events, Trends, and Issues: Niobium principally was imported in the form of ferroniobium and niobium unwrought metal, alloy, and powder. United States niobium import dependence was expected to be the same as that of 2009, when Brazil was the leading niobium supplier. By weight in 2009, Brazil supplied 75% of total U.S. niobium imports, 69% of ferroniobium, 91% of niobium metal, and 86% of niobium oxide. The leading suppliers of niobium in ore and concentrate were Mozambique (48%) and Canada (32%). Financial market problems in 2008 and the subsequent economic slowdown resulted in reduced niobium material consumption in 2009. Niobium apparent consumption is believed to have increased significantly in 2010 compared with that of 2009.

World Mine Production and Reserves:

	Mine production		Reserves[9]
	2009	2010[e]	
United States	—	—	—
Brazil	58,000	58,000	2,900,000
Canada	4,330	4,400	46,000
Other countries	530	600	NA
World total (rounded)	62,900	63,000	2,900,000

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 2010 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 inventory reported by DLA Strategic Materials is the basis for estimating Government stockpile releases.

[3]Includes ferroniobium and nickel niobium.

[4]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.

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

[6]This category includes other than niobium-containing material.

[7]See Appendix B for definitions.

[8]Actual quantity limited to remaining sales authority; additional legislative authority is required.

[9]See Appendix C for resource/reserve definitions and information concerning data sources.

NITROGEN (FIXED)—AMMONIA

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

Domestic Production and Use: Ammonia was produced by 12 companies at 24 plants in 16 States in the United States during 2010; 4 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 2010, U.S. producers operated at about 85% 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 87% 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]	2006	2007	2008	2009	2010[e]
Production[2]	8,190	8,540	7,870	7,700	8,300
Imports for consumption	5,920	6,530	6,020	4,530	6,400
Exports	194	145	192	16	8
Consumption, apparent	14,000	15,000	13,600	12,300	14,700
Stocks, producer, yearend	201	157	302	167	151
Price, dollars per ton, average, f.o.b. Gulf Coast[3]	302	307	590	251	390
Employment, plant, number[e]	1,150	1,050	1,100	1,050	1,050
Net import reliance[4] as a percentage of apparent consumption	41	43	42	38	43

Recycling: None.

Import Sources (2006–09): Trinidad and Tobago, 57%; Russia, 15%; Canada, 13%; Ukraine, 7%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 $3.7 and $7.5 per million British thermal units for most of the year, with an average of around $4.5 per million British thermal units. Natural gas prices in 2010 were relatively stable; slightly higher prices were a result of increased demand for natural gas owing to colder temperatures. The average Gulf Coast ammonia price gradually increased from $275 per short ton at the beginning of 2010 to a high of around $420 per short ton in October. The average ammonia price for the year was estimated to be about $400 per short ton. The U.S. Department of Energy, Energy Information Administration, projected that Henry Hub natural gas spot prices would average $4.76 per million British thermal units in 2011.

In Minnesota, researchers began work on a $4 million project that uses wind power to produce anhydrous ammonia. However, industry analysts estimate that it is unlikely that commercial use of renewable energy to produce fertilizer can compete in the global market unless fertilizer prices are twice the current price.

Several companies have announced plans to build new ammonia plants in Argentina, Brazil, China, Cuba, Egypt, and India, which would add about 7.7 million tons of annual production capacity within the next 2 to 3 years. The largest growth in ammonia production is in China.

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 35.6 million hectares of corn in the 2010 crop year (July 1, 2009, through June 30, 2010), which was 2% higher than the area planted in 2009. Favorable planting conditions occurred through early May, but below average temperatures and wet conditions dominated much of the Midwest and portions of the Plains in the middle part of May, hampering the planting of the remaining acreage. Corn plantings for the 2011 crop year, however, were expected to increase to 36.0 million hectares. Corn acreage was expected to remain high owing in part to continued U.S. ethanol production and U.S. corn exports in response to a strong global demand for feed grains.

Nitrogen compounds also were an environmental concern. Overfertilization and the subsequent runoff of excess fertilizer may contribute to nitrogen accumulation in watersheds. Nitrogen in excess fertilizer runoff was suspected to be a cause of the hypoxic zone that arises in the Gulf of Mexico during the summer. Scientists continued to study the effects of fertilization on the Nation’s environmental health.

World Ammonia Production and Reserves:

	Plant production		Reserves[5]
	2009	2010[e]	
United States	7,700	8,300	Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries.
Australia	1,200	1,200	
Bangladesh	1,300	1,300	
Canada	4,000	4,000	
China	42,300	42,000	
Egypt	2,000	2,300	
Germany	2,360	2,500	
India	11,200	11,700	
Indonesia	4,600	4,600	
Iran	2,000	2,000	
Japan	1,100	1,000	
Netherlands	1,800	1,800	
Pakistan	2,300	2,300	
Poland	1,990	1,900	
Qatar	1,800	1,800	
Romania	1,300	1,300	
Russia	10,400	10,400	
Saudi Arabia	2,600	2,600	
Trinidad and Tobago	5,100	5,500	
Ukraine	4,200	3,300	
Uzbekistan	1,000	1,000	
Venezuela	1,160	1,160	
Other countries	17,000	17,000	
World total (rounded)	130,000	131,000	

World Resources: The availability of nitrogen from the atmosphere for fixed nitrogen production is unlimited. Mineralized occurrences of sodium and potassium nitrates, found in the Atacama Desert of Chile, contribute minimally to global nitrogen supply.

Substitutes: Nitrogen is an essential plant nutrient that has no substitute. Also, there are no known practical substitutes for nitrogen explosives and blasting agents.

[e]Estimated.

[1]U.S. Department of Commerce (DOC) data unless otherwise noted.

[2]Annual and preliminary data as reported in Current Industrial Reports MQ325B (DOC).

[3]Source: Green Markets.

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

[5]See Appendix C for resource/reserve definitions and information concerning data sources.

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 $16.0 million in 2010. Peat was harvested and processed by about 38 companies in 12 of the conterminous States. The Alaska Department of Commerce, Office of Minerals Development, which conducted its own canvass of producers, reported 182,000 cubic meters of peat was produced in 2009; output was reported only by volume.[2] A production estimate was unavailable for Alaska for 2010. Florida, Minnesota, and Maine were the leading producing States, in order of quantity harvested. Reed-sedge peat accounted for approximately 84% of the total volume produced, followed by sphagnum moss, 8%, hypnum moss, 6%, and humus, 2%. About 97% 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production	551	635	615	609	612
Commercial sales	734	694	648	644	646
Imports for consumption	924	977	936	906	960
Exports	41	56	[e]57	77	73
Consumption, apparent[3]	1,500	1,590	1,440	1,440	1,500
Price, average value, f.o.b. mine, dollars per ton	27.34	25.59	26.42	23.24	24.80
Stocks, producer, yearend	128	98	152	149	150
Employment, mine and plant, number[e]	650	625	620	610	610
Net import reliance[4] as a percentage of apparent consumption	63	60	57	58	59

Recycling: None.

Import Sources (2006–09): Canada, 97%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 peat industry had one of its best peat harvests in over the past 2 decades owing to the dry weather. The three major producing provinces—New Brunswick, Alberta, and Quebec—all had a strong production year. Indonesia announced plans for a 2-year moratorium on converting peatlands into palm oil plantations in an effort to reduce greenhouse gas emissions. The United Kingdom plans a phaseout by 2020 of peat-based composts that would be sold in garden centers as a means of preserving peatlands in that country.

World Mine Production and Reserves: 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]
	2009	2010[e]	
United States	609	612	150,000
Belarus	2,600	2,600	400,000
Canada	1,130	1,280	720,000
Estonia	828	830	60,000
Finland	9,100	6,700	6,000,000
Ireland	4,300	4,300	([6])
Latvia	1,000	1,000	76,000
Lithuania	536	530	190,000
Moldova	475	475	([6])
Russia	1,300	1,300	1,000,000
Sweden	1,280	1,280	([6])
Ukraine	360	450	([6])
Other countries	1,460	1,460	1,400,000
World total (rounded)	25,000	23,000	10,000,000

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. Reserves 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. peatlands are located in undisturbed areas of Alaska. Total world resources of peat were estimated to be between 5 trillion and 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]Hughes, R.A., Szumigala, D.J., and Harbo, L.A., 2010, Alaska's mineral industry 2009—A summary: Alaska Department of Natural Resources Information Circular 60, 15 p.
[3]Defined as production + imports – exports + adjustments for industry stock changes.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[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 2010 was $19.6 million. Crude ore production came from nine mines operated by seven companies in six Western States. New Mexico continued to be the major producing State. Processed crude perlite was expanded at 55 plants in 28 States. The principal end uses were building construction products, 53%; fillers, 14%; horticultural aggregate, 14%; and filter aid, 8%. The remaining 11% includes miscellaneous uses and estimated expanded perlite consumption whose use is unknown.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production[1]	454	409	434	348	375
Imports for consumption[e]	245	229	187	153	160
Exports[e]	30	28	37	33	34
Consumption, apparent	669	610	584	468	500
Price, average value, dollars per ton, f.o.b. mine	43	45	48	49	52
Employment, mine and mill	113	110	103	97	102
Net import reliance[2] as a percentage of apparent consumption	32	33	26	26	25

Recycling: Not available.

Import Sources (2006–09): Greece, 100%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 by about 7% compared with that reported for 2009. Imports also increased as demand for perlite-based construction products began to recover from the low experienced in 2009.

The amounts of processed crude perlite sold or used in 2009 and 2010 were lower than they had been since the mid-1960s. Imports recovered slightly in 2010 but were still at levels not seen since the late 1990s. Correspondingly, apparent consumption of processed crude perlite, while increasing from that of 2009, was still only equivalent to that of 1988.

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 and Reserves: 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]
	2009	2010[e]	
United States	348	375	50,000
Greece	525	500	50,000
Hungary	65	65	3,000
Japan	220	220	([4])
Mexico	54	50	([4])
Turkey	230	220	([4])
Other countries	209	230	600,000
World total (rounded)	1,650	1,700	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 resource/reserve definitions and information concerning data sources.
[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 26.1 million tons of marketable product valued at $1.3 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, and merchant-grade phosphoric acid. 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, marketable	30,100	29,700	30,200	26,400	26,100
Sold or used by producers	30,200	31,100	28,900	25,500	28,300
Imports for consumption	2,420	2,670	2,750	2,000	2,100
Consumption[1]	32,600	33,800	31,600	27,500	30,400
Price, average value, dollars per ton, f.o.b. mine[2]	30.49	51.10	76.76	127.19	50.00
Stocks, producer, yearend	7,070	4,970	6,340	8,120	5,800
Employment, mine and beneficiation plant, number[e]	2,500	2,500	2,600	2,550	2,300
Net import reliance[3] as a percentage of apparent consumption	7	14	4	1	15

Recycling: None.

Import Sources (2006–09): Morocco, 100%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
Natural calcium phosphates:		
Unground	2510.10.0000	Free.
Ground	2510.20.0000	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]**

PHOSPHATE ROCK

Events, Trends, and Issues: In 2010, phosphate rock consumption and trade increased worldwide after depressed market conditions in 2008 and 2009. U.S. production was about the same as in 2009, as companies attempted to lower stocks of phosphate rock that had accumulated over the previous year. Domestic phosphoric acid and phosphate fertilizer production increased over that of 2009. The world spot price of phosphate rock began 2010 around $90 per ton and increased in the third quarter to around $150 per ton.

A new 3.9-million-ton-per-year phosphate rock mine in northern Peru began operation in July. The leading U.S. phosphate rock producer acquired a 35% share of the joint venture between the Brazilian and Japanese owners of the mine. The U.S. company will have the right to purchase up to 35% of the annual phosphate rock output to supplement its domestic phosphate rock production.

A new 5- million-ton-per-year phosphate rock mine began operation in Saudi Arabia late in 2010. The associated phosphate fertilizer plant was to open in 2011. World mine production capacity was projected to increase to 228 million tons by 2015 through mine expansion projects in Algeria, Brazil, China, Israel, Jordan, Syria, and Tunisia, and development of new mines in Australia, Kazakhstan, Namibia, and Russia.

World Mine Production and Reserves: Significant revisions were made to reserves data for Morocco, using information from the Moroccan producer and a report by the International Fertilizer Development Center. Reserves information for Russia was revised using official Government data and may not be comparable to the reserves definition in Appendix C. Reserves data for Algeria, Senegal, and Syria were revised based on individual company information.

	Mine production		Reserves[4]
	2009	2010[e]	
United States	26,400	26,100	1,400,000
Algeria	1,800	2,000	2,200,000
Australia	2,800	2,800	82,000
Brazil	6,350	5,500	340,000
Canada	700	700	5,000
China[5]	60,200	65,000	3,700,000
Egypt	5,000	5,000	100,000
Israel	2,700	3,000	180,000
Jordan	5,280	6,000	1,500,000
Morocco and Western Sahara	23,000	26,000	50,000,000
Russia	10,000	10,000	1,300,000
Senegal	650	650	180,000
South Africa	2,240	2,300	1,500,000
Syria	2,470	2,800	1,800,000
Togo	850	800	60,000
Tunisia	7,400	7,600	100,000
Other countries	8,620	9,500	620,000
World total (rounded)	166,000	176,000	65,000,000

World Resources: Domestic reserves 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.

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 resource/reserve definitions and information concerning data sources.
[5]Production data for China do not include small artisanal mines.

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 were 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. The leading demand sector for PGMs continued to be catalysts to decrease harmful emissions 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 and in the production of specialty silicones; 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 are used as investment tools in the form of exchange traded notes and exchange traded funds.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Mine production:[1]					
Platinum	4,290	3,860	3,580	3,830	3,500
Palladium	14,400	12,800	11,900	12,700	11,600
Imports for consumption:					
Platinum	114,000	181,000	150,000	183,000	153,000
Palladium	119,000	113,000	120,000	69,700	71,000
Rhodium	15,900	16,600	12,600	11,200	13,000
Ruthenium	36,000	48,700	49,800	21,200	14,000
Iridium	2,800	3,410	2,550	1,520	3,500
Osmium	56	23	11	68	14
Exports:					
Platinum	45,500	28,900	15,600	15,600	19,000
Palladium	53,100	41,800	26,400	30,300	35,000
Rhodium	1,600	2,210	1,980	1,220	2,200
Other PGMs	3,390	8,190	6,450	4,020	5,400
Price,[2] dollars per troy ounce:					
Platinum	1,144.42	1,308.44	1,578.26	1,207.55	1,600
Palladium	322.93	357.34	355.12	265.65	500
Rhodium	4,561.06	6,203.09	6,533.57	1,591.32	2,500
Ruthenium	193.09	573.74	324.60	97.28	198
Iridium	349.45	444.43	448.34	420.40	635
Employment, mine, number[1]	1,720	1,630	1,360	1,270	1,300
Net import reliance as a percentage of apparent consumption[e]					
Platinum	90	91	89	95	94
Palladium	75	73	79	62	58

Recycling: An estimated 26,000 kilograms of PGMs was recovered from new and old scrap in 2010.

Import Sources (2006–09): Platinum: South Africa, 21%; Germany, 17%; United Kingdom, 9%; Canada, 4%; and other, 49%. Palladium: Russia, 44%; South Africa, 21%; United Kingdom, 17%; Belgium, 5%; and other, 13%.

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

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

Government Stockpile: Sales of iridium and platinum from the National Defense Stockpile remained suspended through FY 2010.

Stockpile Status—9-30-10[3]

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2010**	**Disposals FY 2010**
Platinum	261	261	[4]778	—
Iridium	18	18	[4]186	—

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

PLATINUM-GROUP METALS

Events, Trends, and Issues: Prices of platinum, palladium, and rhodium trended higher during the first quarter of 2010, decreased in the middle of the year, and increased once again toward yearend. The price of iridium increased strongly in the first few months and stayed at that high level throughout the rest of the year, its highest level since 1981. Ruthenium prices increased toward the middle of the year, then decreased.

The slowly recovering global economy in 2010, compared with the poor economic conditions of 2009 and late 2008, affected the PGM industry. Some mines that had been previously placed on care-and-maintenance status were reopened in response to higher metal prices. Production of and demand for automobiles was higher throughout much of the world, particularly in developing nations such as China and India. This led to increased PGM demand in some regions because catalytic converters are the major end use of PGMs. The proportion of diesel cars in Western Europe, which use platinum in their catalytic converters, returned to around 50% after having dipped to 42% in 2009 as a result of Government scrappage plans. Those plans had led to increased purchases of smaller, more fuel-efficient gasoline-powered cars.

Compared with consumption in 2009, consumption of PGMs for industrial uses in the chemical and petroleum sectors increased. In contrast, consumption in the jewelry sector was lower in 2010 as a result of higher prices. Consumption in the jewelry sector can be expected to follow price trends for platinum. The United Kingdom mandated the hallmarking of all palladium jewelry, and future jewelry use for palladium may increase as that metal becomes more recognized and desired.

An increase in car sales in Europe and North America can be expected to result in an increase in use of platinum and palladium in these regions. 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. Research is likely to continue on fuel cells for automobiles, including research on the use of palladium rather than more expensive platinum in the catalysts. Investor interest in exchange-traded notes and funds is expected to continue to rise.

World Mine Production and Reserves: Russian reserves estimates were revised to reflect current data published in the Russian literature.

	Mine production				PGMs
	Platinum		Palladium		Reserves[5]
	2009	2010[e]	2009	2010[e]	
United States	3,830	3,500	12,700	11,600	900,000
Canada	4,600	5,500	6,500	9,400	310,000
Colombia	1,500	1,000	NA	NA	([6])
Russia	21,000	24,000	83,200	87,000	1,100,000
South Africa	141,000	138,000	75,100	73,000	63,000,000
Zimbabwe	7,230	8,800	5,680	6,600	([6])
Other countries	2,420	2,400	9,230	9,800	800,000
World total (rounded)	181,000	183,000	192,000	197,000	66,000,000

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: Many motor vehicle manufacturers have substituted palladium for the more expensive platinum in gasoline-engine 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, and laboratory experiments have increased that proportion to around 50%. For other end uses, PGMs can be substituted for other PGMs, with some losses in efficiency.

[e]Estimated. NA Not available. — Zero.
[1]Estimates from published sources.
[2]Engelhard unfabricated metal.
[3]See Appendix B for definitions.
[4]Actual quantity limited to remaining inventory.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Included with “Other countries.”

POTASH

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

Domestic Production and Use: In 2010, the production value of marketable potash, f.o.b. mine, was about $540 million. 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 75% 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, marketable[1]	1,100	1,100	1,100	700	900
Imports for consumption	4,470	4,970	5,800	2,220	4,700
Exports	332	199	222	303	380
Consumption, apparent[1]	5,200	5,900	6,700	2,600	5,200
Price, dollars per metric ton of K_2O, average, muriate, f.o.b. mine[2]	375	400	675	835	600
Employment, number:					
Mine	480	480	525	510	540
Mill	620	580	615	640	650
Net import reliance[3] as a percentage of apparent consumption	79	81	84	73	83

Recycling: None.

Import Sources (2006–09): Canada, 87%; Belarus, 5%; Russia,5 %; and other, 3%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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: In 2009, U.S. production was at its lowest point since 1943, and consumption was at the lowest point since 1962. World production was at its lowest level since 1993. In 2010, world potash markets began to recover after potash sales had collapsed from the combined effects of the world economic downturn, high prices, and weak demand.

The leading U.S. potash producer continued work on converting a closed underground mine into a solution mine. The company anticipated starting operations in late 2012, pending regulatory approvals. Another company planned to complete expansion of its solar evaporation ponds along the Great Salt Lake, Utah, in 2011 to increase production capacity of SOP. North Dakota issued its first potash exploration permit since 1976. The U.S. mining company would use solution mining methods to recover the potash because the deposits in North Dakota are too deep to use conventional underground mining techniques economically.

Plans were in place to increase world production capacity by 28%, from 42.9 million tons in 2010 to 54.7 million tons in 2014, with expansions of existing operations in Canada and Russia and new projects in Argentina, Belarus, Canada, Chile, China, Congo (Brazzaville), and Laos. In 2010, a major international mining company unsuccessfully bid to acquire the leading potash producer in Canada and the world. In November, the international company abandoned its attempt 10 days after the Canadian Government ruled that the sale of the potash company would not be in the best interest of Canada.

World Mine Production and Reserves: Reserves data for the United States, Chile, and Germany were updated using information published by the producers in the respective countries. For Germany, reserves are listed as exploitable reserves by the producing company. Reserves for China and Russia were updated from official Government sources from those countries and may not be exactly comparable to the reserve definition in Appendix C.

	Mine production		Reserves[4]
	2009	2010[e]	
United States	[1]700	[1]900	130,000
Belarus	2,490	5,000	750,000
Brazil	385	400	300,000
Canada	4,320	9,500	4,400,000
Chile	692	700	70,000
China	3,000	3,000	210,000
Germany	1,800	3,000	150,000
Israel	2,100	2,100	[5]40,000
Jordan	683	1,200	[5]40,000
Russia	3,730	6,800	3,300,000
Spain	435	400	20,000
Ukraine	12	12	25,000
United Kingdom	427	400	22,000
Other countries	—	—	50,000
World total (rounded)	20,800	33,000	9,500,000

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 resources of about 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. reserves figure above includes approximately 40 million tons in central Michigan. Estimated world resources total about 250 billion tons.

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 resource/reserve definitions and information concerning data sources.
[5]Total reserves 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 2010 was about $12 million. Domestic output came from 17 producers in 7 States. Pumice and pumicite were mined California, Oregon, New Mexico, Idaho, Nevada, Arizona, and Kansas, in descending order of production. Approximately 51% of all production came from California and Oregon. About 58% of mined pumice was used in the production of construction building block. Horticulture consumed nearly 25%; concrete admixture and aggregate, 7%; abrasives, 2%; and the remaining 8% was used for absorbent, filtration, laundry stone washing, and other applications.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, mine[1]	1,540	1,270	791	410	400
Imports for consumption	109	37	65	26	41
Exports[e]	18	9	15	11	13
Consumption, apparent	1,630	1,290	841	425	430
Price, average value, dollars per ton, f.o.b. mine or mill	28.85	22.85	20.13	29.97	30.00
Employment, mine and mill, number	355	300	220	150	145
Net import reliance[2] as a percentage of apparent consumption	6	2	6	4	7

Recycling: Not available.

Import Sources (2006–09): Greece, 72%; Turkey, 20%; Iceland, 3%; Mexico, 2%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010 decreased slightly to 400,000 tons, compared with 410,000 tons in 2009. A rise in imports, which remained low, offset the decrease in domestic production, which resulted in a slight increase in apparent consumption in 2010 compared with that of 2009. Imports increased by more than 50% compared with those of 2009. Approximately 98% of pumice imports originated from Greece and Mexico in 2010 to supply markets in the Eastern United States and Gulf Coast regions. The large quantity of pumice imports from Montserrat in 2009 was not repeated in 2010.

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. An increase in fuel prices would likely lead to increases in production expenditures; imports and competing materials could become more attractive than domestic products.

All domestic pumice and pumicite mining in 2010 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 and Reserves:

	Mine production		Reserves[3]
	2009	2010[e]	
United States[1]	410	400	Large in the United States. Quantitative estimates of reserves for most countries are not available.
Algeria	500	500	
Cameroon	600	600	
Chile	919	900	
Ecuador	600	600	
Ethiopia	35	35	
Greece	1,210	1,200	
Iran	1,500	1,500	
Italy	3,020	3,000	
New Zealand	200	200	
Saudi Arabia	800	800	
Spain	600	600	
Syria	958	950	
Turkey	3,500	3,500	
Other countries	2,250	2,200	
World total (rounded)	17,100	17,000	

World Resources: The identified U.S. resources of pumice and pumicite are concentrated in the Western States 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. Turkey and Italy are the leading producers of pumice and pumicite, followed by Iran, Greece, Syria, and Chile. There are large resources of pumice and pumicite on all continents.

Substitutes: The costs of transportation determine the maximum economic distance pumice and pumicite can be shipped and still remain 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.
[1]Quantity sold and used by producers.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.

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 2010, 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 price of as-grown quartz was estimated to be $100 per kilogram in 2010. Lumbered quartz, which is as-grown quartz that has been processed by sawing and grinding, ranged in price from $144 per kilogram to over $900 per kilogram in 2010, depending on the application. Other salient statistics were not available.

Recycling: None.

Import Sources (2006–09): The United States is 100% import reliant on cultured quartz crystal. Although no definitive data exist listing import sources for cultured quartz crystal, imported material is thought to be mostly from China, Japan, and Russia.

Tariff:

Item	Number	Normal Trade Relations 12-31-10
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, 2010, the Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center) contained 7,134 kilograms of natural quartz crystal. The stockpile has 11 weight classes for natural quartz crystal that range from 0.2 kilogram 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 DLA Strategic Materials stockpile in 2010, and the Federal Government does not intend to dispose of or sell any of the remaining material. Previously, only individual crystals in the DLA Strategic Materials stockpile inventory that weighed 10 kilograms or more and could be used as seed material were sold.

Stockpile Status—9-30-10[2]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Quartz crystal	7	([3])	—	—

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 will continue to increase, and consequently, quartz crystal production is expected to 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 and Reserves:[4] This information is unavailable, but the global reserves for lascas are 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]Less than ½ unit.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.

RARE EARTHS[1]

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

Domestic Production and Use: In 2010, 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 2010. The estimated value of refined rare earths imported by the United States in 2010 was $161 million, an increase from $113 million imported in 2009. Based on reported data through July 2009, the estimated 2009 distribution of rare earths by end use, in decreasing order, was as follows: chemical catalysts, 22%; metallurgical applications and alloys, 21%; petroleum refining catalysts, 14%; automotive catalytic converters, 13%; glass polishing and ceramics, 9%; rare-earth phosphors for computer monitors, lighting, radar, televisions, and x-ray-intensifying film, 8%; permanent magnets, 7%; electronics, 3%; and other, 3%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, bastnäsite concentrates	—	—	—	—	—
Imports:[2]					
Thorium ore (monazite or various thorium materials)	—	—	—	—	—
Rare-earth metals, alloy	867	784	564	188	250
Cerium compounds	2,590	2,680	2,080	1,500	1,400
Mixed REOs	1,570	2,570	2,390	4,750	4,700
Rare-earth chlorides	2,750	1,610	1,310	411	750
Rare-earth oxides, compounds	10,600	9,900	8,810	5,120	2,800
Ferrocerium, alloys	127	123	125	101	87
Exports:[2]					
Thorium ore (monazite or various thorium materials)	—	1	61	18	1
Rare-earth metals, alloys	733	1,470	1,390	4,920	640
Cerium compounds	2,010	1,470	1,380	840	840
Other rare-earth compounds	2,700	1,300	663	455	600
Ferrocerium, alloys	3,710	3,210	4,490	2,970	2,800
Consumption, apparent (excludes thorium ore)[3]	9,350	10,200	7,410	W	W
Price, dollars per kilogram, yearend:					
Bastnäsite concentrate, REO basis[e]	6.06	6.61	8.82	5.73	6.87
Monazite concentrate, REO basis[e]	0.87	0.87	0.87	0.87	0.87
Mischmetal, metal basis, metric ton quantity[4]	5–6	7–8	8–9	8–9	45–55
Stocks, producer and processor, yearend	W	W	W	W	W
Employment, mine and mill, number at yearend	65	70	100	110	125
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Small quantities, mostly permanent magnet scrap.

Import Sources (2006–09): Rare-earth metals, compounds, etc.: China, 92%; France, 3%; Japan, 2%; Austria, 1%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 **Daniel J. Cordier [(703) 648-7723, dcordier@usgs.gov, fax: (703) 648-7757]**

RARE EARTHS

Events, Trends, and Issues: Based on apparent consumption derived only from 8 months of trade data, domestic consumption of rare earths in 2010 increased significantly compared with that of 2009. Two of seven rare-earth import categories increased when compared with those of 2009—the categories "Rare-earth metals, alloy" and "Rare-earth chlorides." Owing to declining supply, prices for most rare-earth products increased rapidly in the third quarter of 2010. With improving economic conditions, consumption generally increased for cerium compounds used in automotive catalytic converters and in glass additives and glass-polishing compounds; rare-earth chlorides used in the production of fluid-cracking catalysts for oil refining; rare-earth compounds used in automotive catalytic converters and many other applications; and rare-earth metals and their alloys used in armaments and base-metal alloys. Consumption was stable in lighter flints, permanent magnets, pyrophoric alloys, and superalloys; 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. The trend appears to be 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 operation in 2007 and continued to operate throughout 2010. Bastnäsite concentrates and other rare-earth intermediates and refined products continued to be sold from mine stocks at Mountain Pass. Exploration efforts to develop rare earths projects surged in 2010, and investment and interest increased dramatically. Economic assessments continued in North America at Bear Lodge in Wyoming; Diamond Creek in Idaho; Elk Creek in Nebraska; Hoidas Lake in Saskatchewan, Canada; Lemhi Pass in Idaho-Montana; and Nechalacho (Thor Lake) in Northwest Territories, Canada. Other economic assessments took place in other locations around the world, including Dubbo Zirconia in New South Wales, Australia; Kangankunde in Malawi; Mount Weld in Western Australia, Australia; and Nolans Project in Northern Territory, Australia.

World Mine Production and Reserves: Reserves data for Australia, China, and India were updated based on data from the respective countries.

	Mine production[e]		Reserves[6]
	2009	2010	
United States	—	—	13,000,000
Australia	—	—	1,600,000
Brazil	550	550	48,000
China	129,000	130,000	55,000,000
Commonwealth of Independent States	NA	NA	19,000,000
India	2,700	2,700	3,100,000
Malaysia	350	350	30,000
Other countries	NA	NA	22,000,000
World total (rounded)	133,000	130,000	110,000,000

World Resources: Rare earths are relatively abundant in the Earth's crust, but discovered minable concentrations are less common than for most other ores. U.S. and world resources are contained primarily in 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. A very large resource enriched in heavy rare-earth elements is inferred for phosphorites of the Florida Phosphate District.

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]Defined as production + imports – exports + adjustments for industry stock changes; for 2007 and 2008, excludes producer stock changes (proprietary), and there were no producer stock changes in 2006.
[4]Price range from Elements—Rare Earths, Specialty Metals and Applied Technology, 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. For 2007 and 2008, excludes producer stock changes (proprietary).
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

RHENIUM

(Data in kilograms of rhenium content unless otherwise noted)

Domestic Production and Use: During 2010, ores containing rhenium were mined at four operations (two in Arizona, and one each in Montana 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 2010 was about $63 million.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production[1]	8,110	7,090	7,910	5,580	6,000
Imports for consumption	32,100	31,700	32,700	24,900	36,000
Exports	NA	NA	NA	NA	NA
Consumption, apparent	40,200	38,800	40,600	30,500	42,000
Price,[2] average value, dollars per kilogram, gross weight:					
Metal powder, 99.99% pure	1,260	1,620	2,030	2,460	2,300
Ammonium perrhenate	840	2,730	2,160	955	540
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	80	82	81	82	86

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 (2006–09): Rhenium metal powder: Chile, 93%; Netherlands, 3%; and other, 4%. Ammonium perrhenate: Kazakhstan, 57%; Chile, 12%; United Kingdom, 8%; China, 6%; and other, 17%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-10**
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 **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

RHENIUM

Events, Trends, and Issues: During 2010, average rhenium metal price, based on U.S. Census Bureau customs value, was about $2,300 per kilogram, 6% less than that of 2009. Rhenium imports for consumption increased by about 45%. 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 increased byproduct molybdenum production levels in 2010, while the one remaining smaller operation ceased byproduct molybdenum production in 2010.

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. In 2010, catalytic-grade APR price continued to decrease to about $4,700 per kilogram in October from about $4,900 per kilogram in February. Metal powder price continued to decrease from $4,900 per kilogram at the end of 2009 to about $4,500 in February, and further to about $3,700 per kilogram in October. However, low-priced rhenium from Chile was expected to come to an end with the expiration of several long-term supply agreements between the Chilean producer and its customers, the manufacturers of aerospace engines.

Consumption of catalyst-grade APR by the petroleum industry was expected to continue to remain strong. Demand for rhenium in the aerospace industry, although more unpredictable, was also expected to remain strong. However, the major aerospace companies were expected to continue testing superalloys that contain half the current rhenium content for engine blades, as well as rhenium-free alloys for other engine components.

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 and Reserves:

	Mine production[4]		Reserves[5]
	2009	2010[e]	
United States	5,580	6,000	390,000
Armenia	400	400	95,000
Canada	1,800	1,800	32,000
Chile[6]	25,000	25,000	1,300,000
Kazakhstan	3,000	2,500	190,000
Peru	5,000	5,000	45,000
Poland	2,400	4,500	NA
Russia	1,500	1,500	310,000
Other countries	1,500	1,500	91,000
World total (rounded)	46,200	48,000	2,500,000

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.
[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 resource/reserve definitions and information concerning data sources.
[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 cesium aluminosilicate mineral, or lepidolite, a lithium-bearing mica. There are rubidium occurrences in Maine and South Dakota, and rubidium may also be found with some evaporite minerals in other States; however, rubidium is not mined in the United States. Rubidium concentrate is imported from Canada for processing in the United States. Applications for rubidium and its compounds include biomedical research, electronics, specialty glass, and pyrotechnics. Biomedical applications include rubidium salts used in the treatment of epilepsy and rubidium-82 used as a blood-flow tracer. Rubidium is used as an atomic resonance frequency standard in atomic clocks, playing a vital role in global positioning systems (GPS). Rubidium-rich feldspars are used in ceramic applications for spark plugs and electrical insulators because of their high-dielectric capacity.

Salient Statistics—United States: One mine in Canada produced rubidium ore which was converted to byproduct concentrate. Part of that concentrate was then exported to the United States for further processing. Production data from the Canadian mine, and U.S. consumption, export, and import data, are not available. In the United States, rubidium consumption is small and may amount to only a few thousand kilograms per year. No market price is available because the metal is not traded. In 2010, one company offered 1-gram ampoules of 99.75%-grade rubidium (metal basis) for $70.00 each, a 2.3% increase from that of 2009. The price for 100 grams of the same material was $1,283.00, a 2.0% increase from that of 2009.

Recycling: None.

Import Sources (2006–09): The United States is 100% import reliant on byproduct rubidium concentrate imported from Canada.

Tariff:

Item	Number	Normal Trade Relations 12-31-10
Alkali metals, other	2805.19.9000	5.5% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Prepared by **Marc A. Angulo [(703) 648-7945, mangulo@usgs.gov, fax: (703) 648-7757]**

RUBIDIUM

Events, Trends, and Issues: Rubidium has been commercially available as a byproduct of lithium chemicals production for 40 years. Increases in lithium exploration are expected to yield discoveries of new rubidium resources, which may lead to expanded commercial applications. The most important use of rubidium has been in research and development, primarily in chemical and electronic applications. The use of rubidium as an atomic resonance frequency standard in atomic clocks continues to increase. Advances have been made in the use of rubidium in atomic circuit technology for quantum computing. Rubidium atoms are used to create quantum gates that transfer information in atomic circuits. The use of rubidium-82 positron emission tomography (PET) combined with computed tomography angiography (CT) in the evaluation and care of patients with suspected coronary artery disease continues to increase. Research in the use of rubidium in superconductors is increasing.

World Mine Production and Reserves:[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 pegmatites. The rubidium-bearing minerals lepidolite and pollucite may be found in zoned pegmatites, which are exceptionally coarse-grained plutonic rocks that form late in the crystallization of a silicic magma. Lepidolite, the principal ore mineral of rubidium, contains up to 3.5% rubidium oxide. Pollucite contains up to 1.5% rubidium oxide.

World Resources: World resources of rubidium are unknown. In addition to several significant rubidium-bearing zoned pegmatites in Canada, there are pegmatite occurrences in Afghanistan, Namibia, Peru, Russia, and Zambia. 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).

Substitutes: Rubidium and cesium have similar physical properties and may be used interchangeably in many applications; however, cesium is a preferred material in many applications because it is more electropositive than rubidium.

[1]See Appendix C for resource/reserve definitions and information concerning data sources.

SALT

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Domestic production of salt decreased slightly in 2010. The total value was estimated to be more than $1.8 billion. Twenty-seven companies operated 60 plants in 16 States. The estimated percentage of salt sold or used, by type, was rock salt, 44%; salt in brine, 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 38% of U.S. demand. The remaining markets for salt, in declining order, were distributors, 8%; agricultural, 4%; food, 4%; general industrial, 2%; water treatment, 2%; and other combined with exports, 2%.

Salient Statistics—United States:[1]	2006	2007	2008	2009	2010[e]
Production	44,400	44,500	48,000	46,000	45,000
Sold or used by producers[2]	40,600	45,500	47,400	43,100	45,000
Imports for consumption	9,490	8,640	13,900	14,700	15,000
Exports	973	833	1,030	1,450	1,000
Consumption:					
Reported	42,400	53,200	53,100	45,000	59,000
Apparent[2]	49,100	53,300	60,200	56,400	59,000
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant:					
Vacuum and open pan salt	145.90	154.95	158.59	178.67	170.00
Solar salt	65.06	61.50	64.33	72.09	70.00
Rock salt	24.98	27.84	31.39	36.08	35.00
Salt in brine	6.99	7.11	7.99	7.85	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	17	15	21	24	24

Recycling: None.

Import Sources (2006–09): Canada, 41%; Chile, 31%; Mexico, 9%; The Bahamas, 6%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Salt (sodium chloride)	2501.00.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: A major U.S. rock salt company in Detroit, MI, was acquired by the leading supplier of ice melting products in North America that is based in Cambridge, Ontario, Canada. The purchase was expected to assure the company a consistent supply of rock salt for its expanding business. The mine opened in 1906 and produces about 1 million tons of rock salt each year.

The New York City Health Department announced that its National Salt Reduction Initiative would encourage packaged food makers and restaurants to reduce salt use by 25% over 5 years for dietary health reasons. The American Heart Association published new guidelines calling for Americans to reduce their daily intake of sodium to 1,500 milligrams (3.8 grams of salt) from 2,300 milligrams (5.8 grams). To avoid the possible passage of any mandatory legislation regulating salt usage, several food processing companies voluntarily began reducing the salt content in the foods.

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

SALT

Many chefs have advocated using coarse sea salt for cooking and using exotic-flavored sea salts for finishing a dish. To address the concerns about dietary sodium levels, many food processing companies were converting from traditional iodized salt (from vacuum pan salt technology) to sea salt that allegedly contains less sodium. Some groups were concerned that sea salt did not have the quantity of iodine necessary to prevent cretinism, goiters, and mental impairment in young children.

A prolonged rainy season affected salt production in Indonesia. Annual salt production fell by `95%, creating the need for the country to import salt from Australia and India. Indonesia produced only 65,000 tons of salt in 2010 compared with 2009 output of 1.3 million tons. Annual salt demand was 2.9 million tons.

The price of salt in Gujarat, India, increased because the government raised the price of rented land leased for salt production. The rental rate was six times that being paid in a neighboring State. This may affect the future salt-harvesting enhancement projects the salt association planned.

Budget constraints in the United States for local and State governments may affect the availability and consumption of rock salt for highway deicing in 2011. It is anticipated that the domestic salt industry will strive to provide adequate salt supplies from domestic and foreign sources for emergency use in the event of adverse winter weather.

World Production and Reserves:

	Production		Reserves[4]
	2009	2010[e]	
United States[1]	46,000	45,000	Large. Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans contain a virtually inexhaustible supply of salt.
Australia	11,000	11,500	
Brazil	6,900	7,000	
Canada	14,400	14,000	
Chile	6,430	6,500	
China	59,500	60,000	
France	6,100	6,000	
Germany	16,400	16,500	
India	16,000	15,800	
Mexico	8,810	8,800	
Netherlands	5,000	5,000	
Poland	4,390	4,400	
Spain	4,550	4,600	
Ukraine	5,500	5,500	
United Kingdom	5,800	5,800	
Other countries	63,200	53,600	
World total (rounded)	280,000	270,000	

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 resource/reserve definitions and information concerning data sources.

SAND AND GRAVEL (CONSTRUCTION)[1]

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

Domestic Production and Use: Construction sand and gravel valued at $5.9 billion was produced by an estimated 3,900 companies from about 6,000 operations in 50 States. Leading producing States, in order of decreasing tonnage, were Texas, California, Arizona, Colorado, Wisconsin, Michigan, Minnesota, New York, Nevada, and Ohio, which together accounted for about 50% 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 2010, was about 590 million tons, a decrease of 3% compared with the revised total for the same period in 2009. Information released by several of the leading sand and gravel producers for the third quarter of 2010 indicated improved sales and revenues compared with those of the third quarter of 2009. 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production	1,330	1,240	1,040	[e]780	760
Imports for consumption	5	4	5	3	2
Exports	1	([3])	([3])	1	1
Consumption, apparent	1,320	1,240	1,050	[e]780	760
Price, average value, dollars per ton	6.47	7.04	7.48	7.70	7.70
Employment, mines, mills, and shops, number	38,500	38,000	35,200	30,800	27,700
Net import reliance[4] as a percentage of apparent consumption	1	([3])	([3])	([3])	([3])

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

Import Sources (2006–09): Canada, 75%; Mexico, 19%; The Bahamas, 4%; and other, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12-31-10**
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: With U.S. economic activity remaining sluggish, construction sand and gravel output for 2010 stayed near the low levels experienced in 2009. The flat demand for construction sand and gravel reflected the struggling U.S. construction industry, with unemployment in many areas over 20% for construction workers. It is estimated that 2011 domestic production will begin to improve as the small but important increases seen in the second half of 2010 continue in 2011. A rapid recovery to recent highs is unlikely, however, as tax revenues that fund government construction projects continue to be depressed by lower home values. Additionally, demand for new housing is suppressed by the inability of unemployed and underemployed consumers to afford new homes.

Crushed stone, the other major construction aggregate, often substituted for natural sand and gravel, especially in more densely populated areas of the Eastern United States. The construction sand and gravel industry was concerned with environmental, health, permitting, safety, and zoning regulations. Movement of sand and gravel operations away from densely populated centers was expected to continue where environmental, land development, and local zoning regulations discouraged them. Consequently, shortages of construction sand and gravel would support higher-than-average price increases in industrialized and urban areas.

World Mine Production and Reserves:

	Mine production		Reserves[5]
	2009	2010[e]	
United States	[e]780	760	Reserves 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 dominant 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 2010.

[e]Estimated. NA Not available.
[1]See also Sand and Gravel (Industrial) and Stone (Crushed).
[2]See Appendix A for conversion to short tons.
[3]Less than ½ unit.
[4]Defined as imports – exports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[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 $777 million was produced by 68 companies from 124 operations in 34 States. Leading States, in order of tonnage produced, were Illinois, Wisconsin, Texas, Oklahoma, Louisiana, Minnesota, Michigan, and California. Combined production from these States represented 59% of the domestic total. About 31% of the U.S. tonnage was used as glassmaking sand, 25% as hydraulic fracturing sand and well-packing and cementing sand, 13% as foundry sand, 8% as whole-grain silica, 7% as whole-grain fillers and building products, 4% as golf course sand, 3% as ground and unground silica for chemical applications, and 9% for other uses.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production	28,900	30,100	30,400	25,000	26,500
Imports for consumption	855	511	355	95	110
Exports	3,830	3,000	3,100	2,150	2,600
Consumption, apparent	25,900	27,600	27,700	23,000	24,000
Price, average value, dollars per ton	26.26	27.64	30.82	31.20	29.17
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 (2006–09): Canada, 74%; Mexico, 13%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010 increased by 6% compared with those of 2009. Mined output was sufficient to accommodate 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 about 24 million tons in 2010, up slightly from that of the previous year. Imports of industrial sand and gravel in 2010 increased to about 110,000 tons from 95,000 tons in 2009. 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 2010 increased to 2.6 million tons from 2.15 million tons in 2009.

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 2010. 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 and Reserves:

	Mine production[e]		Reserves[3]
	2009	2010	
United States	25,000	26,500	
Australia	5,200	5,200	Large. Industrial sand and gravel deposits are widespread.
Austria	1,500	1,500	
Belgium	1,800	1,800	
Bulgaria	650	650	
Canada	1,300	1,300	
Chile	1,400	1,400	
Czech Republic	1,364	1,370	
Egypt	1,750	1,750	
Finland	2,240	2,240	
France	5,000	5,000	
Gambia	1,100	1,100	
Germany	6,450	6,500	
Hungary	290	290	
India	1,700	1,700	
Iran	1,500	1,500	
Italy	13,800	14,000	
Japan	3,500	3,500	
Korea, Republic of	455	450	
Mexico	2,770	2,800	
Norway	1,500	1,500	
Poland	4,385	4,350	
Slovakia	620	620	
South Africa	2,310	2,300	
Spain	5,000	5,000	
Turkey	1,250	1,300	
United Kingdom	5,600	5,600	
Other countries	6,600	6,600	
World total (rounded)	106,000	108,000	

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 resource/reserve definitions and information concerning data sources.

SCANDIUM[1]

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

Domestic Production and Use: Demand for scandium decreased slightly in 2010. Domestically, scandium-bearing minerals have not been mined nor recovered from tailings since 1990. However, 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 in Mead, CO, and Urbana, IL. Capacity to produce ingot and distilled scandium metal was in Ames, IA; Phoenix, AZ; and Urbana, IL. Scandium used in the United States was essentially derived from foreign sources. Principal uses for scandium in 2010 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:	2006	2007	2008	2009	2010[e]
Price, yearend, dollars:					
Per kilogram, oxide, 99.0% purity	700	700	900	900	900
Per kilogram, oxide, 99.9% purity	1,400	1,400	1,400	1,400	1400
Per kilogram, oxide, 99.99% purity[2]	1,450	1,620	1,620	1,620	1,620
Per kilogram, oxide, 99.999% purity[2]	1,500	2,540	2,540	2,540	2,540
Per kilogram, oxide, 99.9995% purity[2]	2,100	3,260	3,260	3,260	3,260
Per gram, dendritic, metal[3]	208.00	208.00	188.00	189.00	193.00
Per gram, metal, ingot[4]	131.00	131.00	152.00	155.00	158.00
Per gram, scandium acetate, 99.99% purity[5, 6]	74.00	74.00	NA	NA	47.00
Per gram, scandium chloride, 99.9% purity[5]	48.70	48.70	57.40	60.40	62.40
Per gram, scandium fluoride, 99.9% purity[5]	193.80	193.80	224.20	224.60	229.00
Per gram, scandium iodide, 99.999% purity[5]	174.00	174.00	201.00	203.00	207.00
Per kilogram, scandium-aluminum alloy[2]	NA	74.00	74.00	74.00	74.00
Net import reliance[7] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2006–09): Although no definitive data exist listing import sources, imported material is thought to be mostly from China, Russia, and Ukraine.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 oxide remained unchanged for all purities while other scandium compounds increased slightly from those of the previous year. The supply of domestic and foreign scandium remained stable. Prices increased slightly in 2010, and 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 **Daniel J. Cordier [(703) 648-7723, dcordier@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 and Reserves:[8] 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 2010. Scandium occurs in many ores in trace amounts, but has not been found in sufficient concentration to be mined for scandium alone. 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 for 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 scandium oxide. 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. Scandium that was produced domestically was primarily 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 scandium 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 and sold in metric ton quantities) from Stanford Materials Corporation.
[3]Scandium pieces, 99.9% purity, distilled dendritic; 2006–07 prices converted from 0.5-gram price, and 2008–10 price from 2-gram price, from Alfa Aesar, a Johnson Matthey company.
[4]Metal ingot pieces, 99.9% purity, 2006–10, 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]Scandium acetate, 99.9% purity listing beginning in 2010.
[7]Defined as imports – exports + adjustments for Government and industry stock changes.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.

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 one other refiner 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; these have been 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, refinery	W	W	W	W	W
Imports for consumption, metal and dioxide	409	544	519	263	400
Exports, metal, waste and scrap	191	562	545	613	730
Consumption, apparent[1]	410	545	520	260	400
Price, dealers, average, dollars per pound, 100-pound lots, refined	24.57	33.08	32.29	23.07	35.00
Stocks, producer, refined, yearend	W	W	W	W	W
Net import reliance[2] as a percentage of apparent consumption	53	E	E	E	E

Recycling: 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 (2006–09): Belgium, 39%; Germany, 14%; Canada, 13%; Japan, 9%; and other, 25%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-10**
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 was unchanged in 2010 compared with that of 2009.

Domestic use of selenium in glass and in copiers in 2010 continued to decline. The use of selenium as a substitute for lead in free-machining brasses also was slightly higher owing to the improvements in the global economic conditions. 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. Continued increased interest in solar cell technologies has increased the consumption of selenium in CIGS solar cells.

World Refinery Production and Reserves:

	Refinery production		Reserves[3]
	2009	2010[e]	
United States	W	W	10,000
Belgium	200	200	—
Canada	173	170	6,000
Chile	70	70	20,000
Finland	65	65	—
Germany	700	680	—
Japan	780	780	—
Peru	45	45	9,000
Philippines	65	65	500
Russia	140	140	20,000
Other countries[4]	43	43	23,000
World total (rounded)	[5]2,280	[5]2,260	88,000

World Resources: Reserves for selenium are 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.

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. 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.

The selenium-tellurium photoreceptors used in some xerographic copiers and laser printers have been replaced by organic photoreceptors in newer machines. Amorphous silicon and cadmium telluride are the two principal competitors to copper indium diselenide in thin-film photovoltaic power cells.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Imports for consumption were used as a proxy for apparent consumption.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.
[4]In addition to the countries listed, Australia, China, Kazakhstan, 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.
[5]Excludes U.S. production.

SILICON

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

Domestic Production and Use: Estimated value of silicon alloys produced in the United States in 2010 was $770 million. Three companies produced silicon materials in seven plants. Of those companies, two produced ferrosilicon in four plants. Metallurgical-grade silicon metal was produced by two companies in four plants. One of the three companies 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 United States. The main consumers of silicon metal were producers of aluminum and aluminum alloys and the chemical industry. The semiconductor and solar industries, which manufacture chips for computers and photovoltaic cells from high-purity silicon, respectively, accounted for only a small percentage of silicon demand.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Ferrosilicon, all grades[1]	146	155	178	139	170
Silicon metal[2]	W	W	W	W	W
Imports for consumption:					
Ferrosilicon, all grades[1]	223	208	190	70	150
Silicon metal	146	147	168	113	130
Exports:					
Ferrosilicon, all grades[1]	5	7	10	9	15
Silicon metal	27	28	35	38	42
Consumption, apparent:					
Ferrosilicon, all grades[1]	363	359	350	217	290
Silicon metal[2]	W	W	W	W	W
Price,[3] average, cents per pound Si:					
Ferrosilicon, 50% Si	62.9	74.0	116	76.9	110
Ferrosilicon, 75% Si	54.9	65.6	109	68.9	110
Silicon metal[2]	79.3	113	162	116	140
Stocks, producer, yearend:					
Ferrosilicon, all grades[1]	16	14	21	4	13
Silicon metal[2]	W	W	W	W	W
Net import reliance[4] as a percentage of apparent consumption:					
Ferrosilicon, all grades[1]	59	58	49	36	44
Silicon metal[2]	<50	<50	<50	<50	<50

Recycling: Insignificant.

Import Sources (2006–09): Ferrosilicon: China, 46%; Russia, 24%; Venezuela, 14%; Canada, 9%; and other, 7%. Silicon metal: Brazil, 44%; South Africa, 28%; Canada, 17%; Australia, 10%; and other, 1%. Total: China, 26%; Brazil, 21%; Norway, 13%; Russia, 13%; and other, 27%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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: The global economic recovery, as measured by the expansion of global gross domestic product (estimated 2.7% increase from that of 2009 by the World Bank), coincided with growth in the silicon market during 2010. Domestic ferrosilicon production in 2010, expressed in terms of contained silicon, was expected to be 22% greater than that of 2009. Greater domestic production, along with a doubling of ferrosilicon imports from those in 2009, increased U.S. ferrosilicon apparent consumption by 38%. This was in line with the projected 38% increase in domestic steel production in 2010 compared with that in 2009. Annual average U.S. spot market prices also significantly rose in 2010 from those of 2009, as silicon material suppliers increased output to meet consumers' needs.

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 6% in 2010 compared with that in 2009. However, domestic chemical production was projected to increase by 3% in 2010.

World production of silicon materials increased in 2010 compared with that in 2009, mainly as a result of restarting ferrosilicon smelters that had been shut down at the end of 2008 and in 2009. One ferrosilicon plant in the Inner Mongolia Autonomous Region of China added about 320,000 tons of production capacity in 2009 and 2010, making it the largest plant of its kind at 650,000 tons of capacity. Other ferrosilicon plant expansions took place in Brazil, China, and Russia.

World Production and Reserves:

	Production[e, 5]		Reserves[6]
	2009	2010	
United States[7]	139	170	The reserves in most major producing countries are ample in relation to demand. Quantitative estimates are not available.
Brazil	224	240	
Canada	53	59	
China	4,310	4,600	
France	66	69	
Iceland	81	93	
India[7]	59	68	
Norway	301	330	
Russia	537	610	
South Africa	116	130	
Ukraine[7]	98	120	
Venezuela[7]	54	62	
Other countries	266	290	
World total (rounded)	6,310	6,900	

Ferrosilicon accounts for about four-fifths of world silicon production (gross-weight basis). The leading countries, in descending order of production, for ferrosilicon production were China, Russia, India, the United States, and Norway, and for silicon metal production, the leading countries were China, Norway, Brazil, and Russia. China was by far the leading producer of both ferrosilicon (3,900,000 tons) and silicon metal (780,000 tons) in 2010.

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]Metallurgical-grade silicon metal.
[3]Based on U.S. dealer import price.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]Production quantities are combined totals of estimated silicon content for ferrosilicon and silicon metal, as applicable, except as noted.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.
[7]Ferrosilicon only.

SILVER

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

Domestic Production and Use: In 2010, the United States produced approximately 1,280 tons of silver with an estimated value of $728 million. Silver was produced as a byproduct from 35 domestic 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 4,750 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Mine	1,160	1,280	1,250	1,250	1,280
Refinery:					
Primary	2,210	791	779	796	800
Secondary (new and old scrap)	1,110	1,220	1,530	1,340	1,600
Imports for consumption[2]	4,840	5,000	4,680	3,590	3,840
Exports[2]	1,670	797	685	478	600
Consumption, apparent[e]	5,130	5,380	6,150	5,360	5,850
Price, dollars per troy ounce[3]	11.61	13.43	15.02	14.69	17.75
Stocks, yearend:					
Treasury Department[4]	220	220	220	220	220
COMEX, NYSE Liffe[5]	3,540	4,200	3,900	3,550	3,000
Exchange Traded Fund[6]	3,770	5,350	8,240	12,400	16,000
Employment, mine and mill,[7] number	900	900	900	900	850
Net import reliance[8] as a percentage of apparent consumption[e]	67	66	70	64	65

Recycling: In 2010, 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 (2006–09):[2] Mexico, 56%; Canada, 24%; Peru, 13%; Chile, 4%; and other, 3%.

Tariff: No duties are imposed on imports of unrefined silver or refined bullion.

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

Government Stockpile: None.

Events, Trends, and Issues: Through mid-year 2010, silver prices averaged $17.75 per troy ounce. The overall rise in silver prices corresponded to continued investment interest and holdings in new silver exchange traded funds (ETF) that have opened since the first silver ETF was established in April 2006. Silver ETF inventories totaled 15,240 tons through the end of November.

Industrial demand for silver continued to decline, and in the United States, demand for silver in photography fell to slightly more than 160 tons, compared with a high of 190 tons in 2000. Although silver is still used in x-ray films, many hospitals have begun to use digital imaging systems. Approximately 99% of the silver in photographic wastewater may be recycled. Silver demand for use in coins, electronics, industrial applications, and jewelry increased, while photographic and silverware applications declined.

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

SILVER

Silver was used as a replacement metal for platinum in catalytic converters in automobiles. Silver also was used in clothing to help regulate body heat and to control odor in shoes and in 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 22,200 tons as a result of increased production at new and existing polymetallic mines. Global silver output increased owing to a full year's production from the San Cristobal Mine in Bolivia, the Dolores and Parmarejo Mines in Mexico, and the Kupol property in Russia. Production from several mines in Argentina also increased. Silver production increased at lead-zinc mines, such as the Lucky Friday Mine in Idaho, where production was at its highest level in 10 years. Production at the Greens Creek Mine in Alaska also increased owing to improved mining techniques, and production from the Bingham Canyon Mine in Utah increased because of increased mill throughput. In July, the Rochester Mine in Nevada was preparing to mine new ore zones that would extend mine life by several years.

World Mine Production and Reserves: Reserves information for Peru and Poland was revised based on new information from Government and industry sources.

	Mine production		Reserves[9]
	2009	2010[e]	
United States	1,250	1,280	25,000
Australia	1,630	1,700	69,000
Bolivia	1,300	1,360	22,000
Canada	600	700	7,000
Chile	1,300	1,500	70,000
China	2,900	3,000	43,000
Mexico	3,550	3,500	37,000
Peru	3,850	4,000	120,000
Poland	1,200	1,200	69,000
Russia	1,400	1,400	NA
Other countries	2,820	2,600	50,000
World total (rounded)	21,800	22,200	510,000

World Resources: Silver was obtained as a primary product from mines in Mexico, Peru, and Australia, in descending order of production. Silver was also obtained as a byproduct from lead-zinc mines, copper mines, and gold mines, in descending order of production. The polymetallic ore deposits from which silver is recovered account for more than two-thirds of U.S. and world resources of silver. Most recent silver discoveries have been associated with gold occurrences; however, copper and lead-zinc occurrences that contain byproduct silver will continue to account for a significant share of future reserves and resources.

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.
[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Ores and concentrates, refined bullion, doré, and other unwrought silver; excludes coinage, and waste and scrap material.
[3]Handy & Harman quotations.
[4]Balance in U.S. Mint only.
[5]NYSE Liffe: formerly Chicago Board of Trade.
[6]Held in the 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]See Appendix C for resource/reserve definitions and information concerning data sources.

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 2010 was estimated to be about $1.3 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 2009 reported data, the estimated 2010 distribution of soda ash by end use was glass, 46%; chemicals, 29%; soap and detergents, 10%; distributors, 6%; flue gas desulfurization and miscellaneous uses, 3% each; and, pulp and paper, 2%; and water treatment,1%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production2	11,000	11,100	11,300	9,310	10,000
Imports for consumption	7	9	13	6	30
Exports	4,820	5,130	5,370	4,410	5,000
Consumption:					
Reported	6,110	5,940	5,700	5,010	5,000
Apparent	6,100	6,030	5,860	4,950	5,000
Price:					
Quoted, yearend, soda ash, dense, bulk:					
F.o.b. Green River, WY, dollars per short ton	155.00	155.00	260.00	260.00	260.00
F.o.b. Searles Valley, CA, same basis	180.00	180.00	285.00	285.00	285.00
Average sales value (natural source), f.o.b. mine or plant, dollars per short ton	96.64	103.53	122.11	129.88	120.00
Stocks, producer, yearend	290	206	259	217	200
Employment, mine and plant, number	2,600	2,600	2,500	2,400	2,400
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 (2006–09): United Kingdom, 29%; China, 28%; Mexico, 22%; Japan, 7%; and other, 14%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Disodium carbonate	2836.20.0000	1.2% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: The global economic problems in 2009 continued in 2010. The downturn in the residential and commercial construction and automotive industries reduced glass usage and that affected soda ash consumption worldwide. In the third quarter of 2010, domestic soda ash production and export sales increased, especially to South America and southeast Asia. The U.S. soda ash export association raised the export price by $30 per ton effective October 1 citing that global soda ash demand was improving.

U.S. soda ash producers announced $10 per ton price increases in May and again in September. The increases were necessary to offset cost increases and to support continued investment in the soda ash business. By yearend, it was uncertain how much of the proposed price increases were accepted by consumers through contract negotiations.

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

SODA ASH

A Wyoming soda ash producer with seven synthetic soda ash plants in Europe withdrew from the U.S. export association effective after December 31, 2010. The company indicated that it was fully capable to logistically and technically serve its worldwide customers. This was the second soda ash company to leave the association since its formation in 1984.

Operators of the natural soda ash facility at Beypazari, Turkey, which came onstream in 2009, announced plans to double production capacity by early 2013. The plant was designed to produce one million tons of soda ash annually from underground trona beds. Production costs were estimated to be 30% to 40% lower than the Solvay synthetic soda ash process.

The adverse economic conditions throughout most of the world are forecast to improve beginning in 2011. 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 and export sales improve, U.S. consumption may be higher in 2011.

World Production and Reserves:

	Production		Reserves[4, 5]
Natural:	2009	2010[e]	
United States	9,310	10,000	[6]23,000,000
Botswana	250	250	400,000
Kenya	405	450	7,000
Mexico	—	—	200,000
Turkey	1,000	1,000	200,000
Uganda	NA	NA	20,000
Other countries	—	—	260,000
World total, natural (rounded)	11,100	11,700	24,000,000
World total, synthetic (rounded)	33,000	34,300	XX
World total (rounded)	44,000	46,000	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. 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 resource/reserve definitions and information concerning data sources.
[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 2010. The total value of natural and synthetic sodium sulfate sold was an estimated $42 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:	2006	2007	2008	2009	2010[e]
Production, total (natural and synthetic)[1]	290	312	319	292	300
Imports for consumption	61	43	69	77	60
Exports	158	101	107	140	190
Consumption, apparent (natural and synthetic)	193	254	281	229	170
Price, quoted, sodium sulfate (100% Na_2SO_4), bulk, f.o.b. works, East, dollars per short ton	134	134	134	134	140
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 (2006–09): Canada, 86%; China, 4%; Finland, 2%; Japan, 2%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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: China remained the leading exporter and producer of natural and synthetic sodium sulfate in the world. Jiangsu Province is the major area for sodium sulfate production. It was anticipated that this area would produce 4.8 million tons annually by 2013. As of 2008, China represented about three-fourths of world production capacity and more than 70% of world production.

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. However, with the major downturn in the world economies beginning in 2008 and continuing into 2010, many consumers have reverted to using more powdered laundry detergents because they are less expensive than their liquid counterparts. Sodium sulfate consumption in the domestic textile industry also has been declining because of imports of less-expensive textile products.

Sodium sulfate consumption in 2011 is expected to be comparable with that of 2010, with detergents remaining the leading sodium-sulfate-consuming sector. If the winter of 2010–11 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 between 2% to 3% per year in the next few years, especially in Asia and South America.

World Production and Reserves: Although data on mine production for natural sodium sulfate are not available, total world production of natural sodium sulfate is estimated to be about 6 million tons. Total world production of byproduct sodium sulfate is estimated to be between 1.5 and 2.0 million tons.

	Reserves[3]
United States	860,000
Canada	84,000
China	NA
Mexico	170,000
Spain	180,000
Turkey	100,000
Other countries	1,900,000
World total (rounded)	3,300,000

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, boric acid, cellulose, chromium chemicals, lithium carbonate, rayon, resorcinol, and silica pigments and from battery recycling. 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 resource/reserve definitions and information concerning data sources.

STONE (CRUSHED)[1]

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

Domestic Production and Use: Crushed stone valued at $11 billion was produced by 1,600 companies operating 4,000 quarries, 91 underground mines, and 195 sales/distribution yards in 50 States. Leading States, in descending order of production, were Texas, Pennsylvania, Missouri, Illinois, Florida, Georgia, Kentucky, Indiana, Ohio, and Virginia, together accounting for 50% of the total crushed stone output. Of the total crushed stone produced in 2010, about 68% was limestone and dolomite; 13%, granite; 7%, miscellaneous stone; 6%, traprock; and the remaining 6% was divided, in descending order of tonnage, among sandstone and quartzite, volcanic cinder and scoria, marble, calcareous marl, slate, and shell. It is estimated that of the 1.19 billion tons of crushed stone consumed in the United States in 2010, 44% was reported by use, 26% was reported for unspecified uses, and 30% of the total consumed was estimated for nonrespondents to the U.S. Geological Survey (USGS) canvasses. Of the 508 million tons reported by use, 82% was used as construction material, mostly for road construction and maintenance; 10%, for cement manufacturing; 2% each, for lime manufacturing and for agricultural uses; and 4%, 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 2010 was 872 million tons, a slight decrease compared with that of the same period of 2009. Third quarter shipments for consumption increased slightly compared with those of the same period of 2009. 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.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production	1,780	1,650	1,460	1,170	1,150
Imports for consumption	20	20	21	12	12
Exports	1	1	1	1	1
Consumption, apparent[3]	1,810	1,690	1,510	1,210	1,190
Price, average value, dollars per metric ton	8.03	8.55	9.32	9.66	9.91
Employment, quarry and mill, number[e, 4]	82,600	81,900	81,000	81,000	79,000
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 and concrete were recycled in 49 States and Puerto Rico. The amount of material reported to be recycled decreased by 12% in 2010 when compared with that of the previous year.

Import Sources (2006–2009): Canada, 43%; Mexico, 38%; The Bahamas, 17%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 about 1.15 billion tons in 2010, a slight decrease compared with that of 2009. Apparent consumption also decreased slightly to about 1.19 billion tons. Demand for crushed stone is anticipated to be flat for 2011 based on the slowdown in activity that some of the principal construction markets have experienced over the last 4 years. Long-term 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 prices of crushed stone are expected to be present in 2011, 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 and Reserves:

	Mine production		Reserves[6]
	2009	2010[e]	
United States	1,170	1,150	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 iron and steel 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 resource/reserve definitions and information concerning data sources.
[7]Consistent 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 $294 million, was sold or used by U.S. producers in 2010. Dimension stone was produced by 176 companies, operating 249 quarries, in 37 States. Leading producer States, in descending order by tonnage, were Texas, Wisconsin, Indiana, Georgia, and Vermont. These five States accounted for about 56% of the production and contributed about 49% of the value of domestic production. Approximately 34%, by tonnage, of dimension stone sold or used was limestone, followed by granite (29%), miscellaneous stone (19%), sandstone (15%), marble (2%), and slate (1%). By value, the leading sales or uses were for granite (34%), followed by limestone (32%), miscellaneous stone (15%), sandstone (11%), marble (4%), and slate (4%). Rough stone represented 53% of the tonnage and 40% of the value of all the dimension stone sold or used by domestic producers, including exports. The leading uses and distribution of rough stone, by tonnage, were in building and construction (47%), and in irregular-shaped stone (30%). Dressed stone mainly was sold for other uses, which included panels and veneer, tile, blackboards, exports, unspecified uses, structural and sanitary, and unlisted uses (27%), ashlars and partially squared pieces (24%), and curbing (19%), by tonnage.

Salient Statistics—United States:[2]	2006	2007	2008	2009	2010[e]
Sold or used by producers:					
Tonnage	1,850	1,920	1,800	1,620	1,450
Value, million dollars	334	346	324	328	294
Imports for consumption, value, million dollars	2,500	2,540	2,150	1,350	1,800
Exports, value, million dollars	76	74	66	48	130
Consumption, apparent, value, million dollars	2,760	2,810	2,400	1,630	1,960
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)	88	88	87	80	85
Granite only:					
Production	505	536	464	469	470
Exports (rough and finished)	108	112	103	75	128
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 (2006–09 by value): All dimension stone: Brazil, 21%; China, 20%; Italy, 17%; Turkey, 16%; and other, 26%. Granite only: Brazil, 37%; China, 26%; Italy, 16%; India, 14%; and other, 7%.

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 2010. 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)

Events, Trends, and Issues: The United States is the world's largest market for dimension stone. Imports of dimension stone increased in value to about $1.8 billion compared with $1.4 billion in 2009. Dimension stone exports increased to about $130 million. Apparent consumption, by value, was $1.96 billion in 2010—a $330 million, or 20%, increase from that of 2009. Dimension stone for construction and refurbishment was used in both commercial and residential markets, with 2010 activity improving compared with that of 2009. The weakening of the U.S. dollar has aided the U.S. export market for dimension stone. Additionally, the sluggish U.S. economy tended to decrease demand for and imports of dimension stone in the near term.

World Mine Production and Reserves:

	Mine production		Reserves[5]
	2009	2010[e]	
United States	1,620	1,450	Adequate except for certain special types and local shortages.
Other countries	NA	NA	
World total	NA	NA	

World Resources: Dimension stone resources of the world are sufficient. Resources can be limited on a local level or occasionally on a regional level by the lack of a particular kind of stone that is suitable for dimension purposes.

Substitutes: 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.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.

STRONTIUM

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

Domestic Production and Use: The United States is 100% import reliant on celestite, the most common strontium mineral, which is imported exclusively from Mexico. U.S. production of strontium minerals ceased in 1959. Domestic production of strontium carbonate, the principal strontium compound produced globally, ceased in 2006. A few domestic companies produce small amounts of downstream strontium chemicals. 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production	—	—	—	—	—
Imports for consumption:					
Strontium minerals	671	541	2,030	6,420	1,900
Strontium compounds	8,860	8,550	9,420	5,860	9,200
Exports, compounds	699	688	594	532	680
Consumption, apparent, celestite and compounds	8,830	8,400	10,900	11,800	10,400
Price, average value of mineral imports at port of exportation, dollars per ton	64	67	64	47	44
Net import reliance[2] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2006–09): Strontium minerals: Mexico, 100%. Strontium compounds: Mexico, 80%; Germany, 12%; and other, 8%. Total imports: Mexico, 91%; Germany, 5%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 **Marc A. Angulo [(703) 648-7945, mangulo@usgs.gov, fax: (703) 648-7757]**

STRONTIUM

Events, Trends, and Issues: Consumption of strontium minerals has dramatically declined from its peak in 1997 as a direct consequence of increased demand for liquid-crystal displays, which require little or no strontium carbonate, as an alternative to cathode-ray tubes (CRTs) for televisions. 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; however, the strontium consumption in pyrotechnics is likely to decline as nitrogen-base oxidizers are substituted for carbon-based oxidizers to minimize the smoke emitted while deploying pyrotechnic products, which will require less strontium nitrate to achieve the same color intensities.

In descending order of production, China, Spain, and Mexico are the world's leading producers of celestite; however, decreases in production in Mexico and Spain are expected in the near term. China is becoming more reliant on imported celestite because Chinese celestite reserves are smaller and of lower quality than those in other major producing countries. The Iranian celestite industry was expecting strong growth over the next 3 years owing to increased exports to China, coupled with the low cost of container freights and with government subsidies. With new suppliers to China and decreased demand for CRTs, Spanish production of celestite is expected to decrease, as a key celestite mine and refinery closed at the beginning of 2010. Turkey, which had been a leading celestite producer, ceased production.

World Mine Production and Reserves:[3]

	Mine production		Reserves[4]
	2009	2010[e]	
United States	—	—	—
Argentina	10,000	5,500	All other:
China[e]	210,000	200,000	6,800,000
Iran	2,000	2,000	
Mexico	37,600	30,000	
Morocco	2,600	2,700	
Pakistan	1,800	1,700	
Spain	138,000	180,000	
World total (rounded)	402,000	420,000	6,800,000

World Resources: World resources of strontium are thought to exceed 1 billion tons.

Substitutes: Barium can be substituted for strontium in ferrite ceramic magnets; however, the resulting barium composite will have a reduced maximum operating temperature when compared with that of strontium composites. Substituting for strontium in pyrotechnics is hindered because of the difficulty in obtaining the desired brilliance and visibility imparted 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 resource/reserve definitions and information concerning data sources.

SULFUR

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

Domestic Production and Use: In 2010, elemental sulfur and byproduct sulfuric acid were produced at 114 operations in 29 States and the U.S. Virgin Islands. Total shipments were valued at about $390 million. Elemental sulfur production was 9.1 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 66% of domestic consumption, and byproduct acid accounted for about 6%. The remaining 28% of sulfur consumed was provided by imported sulfur and sulfuric acid. About 91% of sulfur consumed was in the form of sulfuric acid. Agricultural chemicals (primarily fertilizers) composed about 60% of identified sulfur demand; petroleum refining, 24%; and metal mining, 4%. 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production:					
Recovered elemental	8,390	8,280	8,690	9,030	9,100
Other forms	674	817	753	750	800
Total (rounded)	9,060	9,100	9,450	9,780	9,900
Shipments, all forms	8,960	9,130	9,430	9,670	9,800
Imports for consumption:					
Recovered, elemental[e]	2,950	2,930	3,000	1,690	2,800
Sulfuric acid, sulfur content	793	851	1,690	413	530
Exports:					
Recovered, elemental	635	922	952	1,420	1,200
Sulfuric acid, sulfur content	79	110	86	83	70
Consumption, apparent, all forms	12,000	11,900	13,100	10,400	12,000
Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and/or plant	32.85	36.49	245.12	1.68	40.00
Stocks, producer, yearend	221	187	211	239	220
Employment, mine and/or plant, number	2,600	2,600	2,600	2,600	2,600
Net import reliance[1] as a percentage of apparent consumption	25	23	28	6	17

Recycling: Typically, between 2.5 million and 5 million tons of spent sulfuric acid is reclaimed from petroleum refining and chemical processes during any given year.

Import Sources (2006–09): Elemental: Canada, 74%; Mexico, 13%; Venezuela, 12%; and other, 1%. Sulfuric acid: Canada, 65%; India, 18%; Mexico, 7%; and other, 10%. Total sulfur imports: Canada, 72%; Mexico, 12%; Venezuela, 9%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2009. Domestic production of elemental sulfur from petroleum refineries and recovery from natural gas operations increased. Domestically, refinery sulfur production is expected to continue to increase, sulfur from natural gas processing is expected to decline over time, and byproduct sulfuric acid is expected to remain relatively stable, unless one or more of the remaining nonferrous smelters close.

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

SULFUR

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 the downturn in the world economy limits investments in those areas.

The contract sulfur prices in Tampa, FL, began 2010 at around $30 per ton. The price increased to about $130 per ton in May and remained at that level throughout July. By November, the Tampa price increased to about $150 per ton. Export prices were slightly higher than domestic prices.

Domestic phosphate rock consumption was higher in 2010 than in 2009, which resulted in increased demand for sulfur to process the phosphate rock into phosphate fertilizers.

World Production and Reserves:

	Production—All forms	
	2009	2010[e]
United States	9,780	9,900
Australia	930	930
Canada	6,940	7,000
Chile	1,600	1,600
China	9,370	9,400
Finland	615	615
France	1,310	1,300
Germany	3,760	3,800
India	1,150	1,200
Iran	1,570	1,600
Italy	740	740
Japan	3,350	3,400
Kazakhstan	2,000	2,000
Korea, Republic of	1,560	1,600
Kuwait	700	700
Mexico	1,700	1,700
Netherlands	530	530
Poland	730	750
Russia	7,070	7,100
Saudi Arabia	3,200	3,200
South Africa	539	540
Spain	637	640
United Arab Emirates	2,000	2,000
Uzbekistan	520	520
Venezuela	800	800
Other countries	4,810	4,800
World total (rounded)	67,900	68,000

Reserves[2]

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, sulfur production may not be in the country for which the reserves were attributed. For instance, sulfur from Saudi Arabian oil 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 resource/reserve definitions and information concerning data sources.

TALC AND PYROPHYLLITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Domestic talc production in 2010 was estimated to be 530,000 tons valued at $15 million. Three companies operated six talc-producing mines in three States in 2010. These three companies accounted for more than 99% of the U.S. talc production. Three other companies, two in California and one in Virginia, worked from stocks. Montana was the leading producer State, followed by Texas and Vermont. Sales of talc were estimated to be 562,000 tons valued at $66 million. Talc produced and sold in the United States was used for ceramics, 23%; paint and paper, 19% each; plastics, 9%; roofing, 7%; cosmetics, 4%; rubber, 3%; and other, 16%. About 170,000 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. The total estimated use of talc in the United States, with imported talc included, was plastics, 24%; ceramics, 18%; paint, 16%; paper, 15%; cosmetics and roofing, 6% each; rubber, 3%; and other, 12%. One company in California and one company in North Carolina mined pyrophyllite. Production of pyrophyllite increased slightly from that of 2009. Consumption was, in decreasing order by tonnage, in refractory products, ceramics, and paint.

Salient Statistics—United States:[1]	**2006**	**2007**	**2008**	**2009**	**2010**[e]
Production, mine	895	769	706	511	530
Sold by producers	900	720	667	512	562
Imports for consumption	314	221	193	120	170
Exports	253	271	244	188	240
Shipments from Government stockpile excesses	—	—	([2])	—	—
Consumption, apparent	956	719	655	443	460
Price, average, processed, dollars per ton	90	114	125	111	117
Employment, mine and mill	435	430	350	285	280
Net import reliance[3] as a percentage of apparent consumption	6	E	E	E	E

Recycling: Insignificant.

Import Sources (2006–09): China, 47%; Canada, 35%; Japan, 9%; France, 4%; and other, 5%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-10**
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—9-30-10[4]
(Metric tons)

Material	**Uncommitted inventory**	**Authorized for disposal**	**Disposal plan FY 2010**	**Disposals FY 2010**
Talc, block and lump	865	865	([5])	—
Talc, ground	621	621	([5])	—

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

TALC AND PYROPHYLLITE

Events, Trends, and Issues: Although economic conditions were thought to be improving in the United States, markets for talc continued to be at a much lower level than prior to the recession. The automotive and general manufacturing sectors improved slightly in 2010 but housing still remained stagnant through much of 2010, affecting sales of talc for such product applications as adhesives, caulks, ceramics, joint compounds, paint, and roofing. Export markets improved in 2010 with the stabilization of economies elsewhere in the world. Continued concerns over job losses and tight credit in the United States dampened consumer spending and hampered any improvement in the construction and manufacturing sectors in 2010. The slow recovery in major industries that use pyrophyllite to produce ceramic, paint, and refractory products limited growth in pyrophyllite sales in 2010.

U.S. production of talc increased by 3% to 4% and sales of talc increased by 9% to 10% from those of 2009. Exports increased 28% with China, Colombia, Indonesia, Malaysia, Mexico, and Singapore accounting for most of this increase, reflecting a greater growth in Asian and South American economies than elsewhere around the world. Mexico remained the leading destination for U.S. talc exports, accounting for 32% of the tonnage. Canada, the second leading export destination, accounted for 25% of the export tonnage, despite a slight decrease in exports in 2010. U.S. imports increased by 42% from those of 2009. In 2010, Canada and China supplied approximately 90% of the talc imported into the United States.

The leading global producer of talc announced that it would begin accepting offers for its talc division again. The company had reversed its decision to sell in 2009 because bids did not meet the company's expectations. The company also announced it would close its talc operation in Spain because talc reserves had been exhausted.

A talc operation near Madoc, Ontario, Canada, closed in 2010 after 130 years of operation. The Madoc site was an underground mine, and it could not compete with less costly surface-mining operations elsewhere.

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2009	2010[e]	
United States[1]	511	530	140,000
Brazil	401	410	227,000
China	2,300	2,300	Large
Finland	500	500	Large
France	420	420	Large
India	638	640	75,000
Japan	365	360	100,000
Korea, Republic of	907	910	14,000
Other countries	1,390	1,380	Large
World total (rounded)	7,430	7,450	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]Sales of talc suspended until approval of the Defense Logistics Agency, DLA Strategic Materials' (formerly Defense National Stockpile Center) 2011 Annual Materials Plan.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

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 2009 was estimated at about $127 million and was expected to be about $170 million in 2010 as measured by the value of imports.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Mine	—	—	—	—	—
Secondary	NA	NA	NA	NA	NA
Imports for consumption[e, 1]	1,160	1,160	1,290	798	1,500
Exports[e, 1]	949	511	662	326	320
Government stockpile releases[e, 2]	289	—	—	—	—
Consumption, apparent	498	644	629	473	1,200
Price, tantalite, dollars per pound of Ta_2O_5 content[3]	32	36	39	27	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 (2006–09): Tantalum contained in niobium (columbium) and tantalum ore and concentrate; tantalum metal; and tantalum waste and scrap—Australia, 17%; China, 17%; Kazakhstan, 12%; Germany, 10%; and other, 44%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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) 2010, which ended on September 30, 2010, the Defense Logistics Agency, DLA Strategic Materials (formerly the Defense National Stockpile Center), sold no tantalum materials. The DLA Strategic Materials announced that maximum disposal limits for FY 2011 had not been approved. The DLA Strategic Materials 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—9-30-10[6]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
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 2010 was estimated to increase about 150% from that of 2009. Tantalum waste and scrap was the leading imported tantalum material, accounting for more than 42% of tantalum imports. By weight, from 2006 through 2009, tantalum mineral concentrate imports for consumption were supplied 66% by Australia and 21% by Canada; metal, 27% by China, 27% by Kazakhstan, and 15% by Germany; and waste and scrap, 15% by China, 14% by Portugal, and 12% by Germany. The United States rebounded from financial market problems and the subsequent economic slowdown in 2008 and 2009, as the world economy began a slow recovery. Several tantalum mines were put on care and maintenance: Wodgina Mine (Australia) in December 2008, and Tanco (Canada) and Marropino (Mozambique) in April 2009; however, Marropino restarted in April 2010.

World Mine Production and Reserves: Reserves for Mozambique were revised based on information published by a mining company.

	Mine production[8]		Reserves[9]
	2009	2010[e]	
United States	—	—	—
Australia	81	80	40,000
Brazil	180	180	65,000
Canada	25	25	NA
Mozambique	113	110	3,200
Rwanda	104	100	NA
Other countries[10]	162	170	NA
World total (rounded)	665	670	110,000

World Resources: Identified resources of tantalum, most of which are in Australia and Brazil, 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 2010 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 concentrates, unwrought tantalum alloys and powder, tantalum waste and scrap, and other tantalum articles.

[2]Government stockpile inventory reported by DLA Strategic Materials is the basis for estimating Government stockpile releases.

[3]Price is an average (time-weighted average of prices sampled weekly) 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 resource/reserve definitions and information concerning data sources.

[10]Includes Burundi, Congo (Kinshasa), Ethiopia, Somalia, 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. Production of bismuth-telluride thermoelectric cooling devices decreased owing to the reduced manufacturing of automobiles containing seat-cooling systems. Other uses include those in photoreceptor and thermoelectric electronic devices, other 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:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, refinery	W	W	W	W	W
Imports for consumption, unwrought, waste and scrap	31	44	102	84	70
Exports	4	15	50	8	80
Consumption, apparent	W	W	W	W	W
Price, dollars per kilogram, 99.95% minimum[1]	89	92	211	150	210
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 (2006–09): China, 49%; Canada, 17%; Belgium, 13%; Philippines, 9%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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: In 2010, estimated domestic tellurium production remained the same as in 2009. Although detailed information on the world tellurium market was not available, world tellurium consumption was estimated to have increased in 2010. The price of tellurium increased in 2010 because of increased demand for solar cells. The majority of production of tellurium in Japan was used in the country's steel industry to replace lead in steel products.

World Refinery Production and Reserves:

	Refinery production		Reserves[3]
	2009	2010[e]	
United States	W	W	3,000
Canada	16	20	700
Japan	38	40	—
Peru	30	30	2,300
Russia	34	35	NA
Other countries[4]	NA	NA	16,000
World total (rounded)	NA	NA	22,000

World Resources: The figures shown for reserves 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 sources, 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. Increasing use of the leaching solvent extraction-electrowinning processes for copper extraction, which does not capture tellurium, has limited the future supply of tellurium supply from certain copper deposit types.

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. — Zero.
[1]For 2006 through 2009, the price listed was the average price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium. In 2010, the price listed was the average price published by Metal-Pages for 99.95% tellurium.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]Estimates include tellurium contained in copper resources only. See Appendix C for resource/reserve definitions and information concerning data sources.
[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:	2006	2007	2008	2009	2010[e]
Production, mine	(1)	(1)	(1)	(1)	(1)
Imports for consumption (gross weight):					
Unwrought and powders	—	—	916	1,600	1,800
Other	530	901	—	160	150
Total	530	901	916	1,760	1,950
Exports (gross weight):					
Unwrought and powders	—	155	43	260	200
Waste and scrap	—	190	51	75	50
Other	229	258	153	595	600
Total	229	603	247	930	850
Consumption[e]	300	300	670	830	1,100
Price, metal, dollars per kilogram[2]	4,650	4,560	4,900	5,700	5,930
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2006–09): Russia, 74%; Germany, 23%; Netherlands, 2%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 2010 as global supply continued to be relatively tight. The average price for high-purity granules and rods increased by about 4% in 2010 from that in 2009 and has more than tripled since 2005. China continued its policy of eliminating toll trading tax benefits on exports of thallium that began in 2006, thus contributing to tight supply conditions on the world market. In July, China canceled a 5% value-added-tax rebate on exports of many minor metals, including fabricated thallium products. Higher internal demand for many metals has prompted China to begin importing greater quantities of thallium.

In late 2009, a subsidiary of a Canadian junior exploration company released results of a drill program at an exploration sight in northwestern Argentina. The company claimed that, based on drilling results, it had discovered a potentially large deposit of thallium along with cesium, rubidium, silver, and zinc. If the zinc and silver were recoverable by leaching, the thallium mineralization was expected to be an important credit to the mining and processing costs.

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

THALLIUM

Beginning in 2009, there was a global shortage of the medical isotope technetium-99, which was widely used by physicians for medical imaging tests owing to its availability, cost, and the superior diagnostic quality of images produced. Two of five isotope-producing nuclear reactors in Canada and the Netherlands were closed for repair work, and it was unclear how long this shutdown would last. These reactors accounted for nearly 65% of the world's supply of technetium-99 in 2008. Technetium-99 has a very short half-life so it needs to be produced on a continual basis and cannot be stockpiled. Following the closure of these two plants, medical care facilities had a difficult time acquiring adequate supplies of technetium-99 and were forced to cancel scans or use alternative types of tests. The thallium isotope 201 was the most common alternative to technetium-99 for use in scans, such as the cardiac-stress test that monitors blood perfusion into heart tissue during vigorous exercise. It was estimated that before the shortage, thallium was used in about 25% of all cardiac-perfusion tests performed in the United States. In response to the shortage of technetium-99, some medical imaging equipment producers increased production of thallium isotope 201 in order to meet anticipated demand. In late 2010, the Canadian Nuclear Safety Commission approved the restart of the Chalk River National Research Universal reactor in Eastern Ontario, and production of medical isotopes, including technetium-99, was expected to resume by yearend, potentially reducing demand for thallium in 2011.

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 continued 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 and Reserves:[4]

	Mine production		Reserves[5]
	2009	2010[e]	
United States	([1])	([1])	32,000
Other countries	10,000	10,000	350,000
World total (rounded)	10,000	10,000	380,000

World Resources: World resources of thallium contained in zinc resources total about 17 million kilograms; most are in Canada, Europe, and the United States. Kazakhstan is believed to be one of the leading global producers of refined thallium. 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 electrical 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 resource/reserve definitions and information concerning data sources.

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 2010, 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 compounds used by the domestic industry was estimated to have decreased to $174,000 from $275,000 in 2009.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	10.0	—	—	26	—
Thorium ore and concentrates (monazite), ThO_2 content	0.70	—	—	1.82	—
Thorium compounds (oxide, nitrate, etc.), gross weight[2]	4.71	6.37	0.63	2.24	2.6
Thorium compounds (oxide, nitrate, etc.), ThO_2 content[2]	3.49	4.71	0.47	1.66	1.9
Exports:					
Thorium ore and concentrates (monazite), gross weight	—	1	61	18	1.3
Thorium ore and concentrates (monazite), ThO_2 content	—	0.07	4.27	1.26	0.1
Thorium compounds (oxide, nitrate, etc.), gross weight[2]	1.09	1.63	2.70	4.73	1.6
Thorium compounds (oxide, nitrate, etc.), ThO_2 content[2]	0.81	1.21	2.00	3.51	1.2
Consumption:					
Reported (ThO_2 content)	NA	NA	NA	NA	NA
Apparent[2]	2.68	3.51	([3])	([3])	0.7
Price, yearend, dollars per kilogram:					
Nitrate, welding-grade[4]	5.46	5.46	5.46	5.46	5.46
Nitrate, mantle-grade[5]	27.00	27.00	27.00	27.00	27.00
Oxide, yearend:					
99.9% purity[6]	82.50	NA	NA	NA	NA
99.99% purity[6]	175.00	200.00	252.00	252.00	252.00
Net import reliance[7] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2006–09): Monazite: United Kingdom, 72%; Canada, 28%. Thorium compounds: United Kingdom, 76%; France, 20%; India, 2%; and Canada, 2%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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.

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 2010. Domestic demand for thorium ores, compounds, metals, and alloys has exhibited a long-term declining trend. There were exports and domestic shipments of thorium material in the United States in 2010, according to the U.S. Census Bureau and the U.S. Geological Survey, respectively. In 2010, unreported thorium consumption was believed to be primarily in catalysts, microwave tubes, and optical equipment and was estimated to have increased.

Prepared by **Daniel J. Cordier [(703) 648-7723, dcordier@usgs.gov, fax: (703) 648-7757]**

THORIUM

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 September 2010, the average value of imported thorium compounds decreased to $67.65 per kilogram from the 2009 average of $122.56 per kilogram (gross weight). The average value of exported thorium compounds increased to $371.00 per kilogram based on data through September 2010, compared with $96.55 for 2009.

World Refinery Production and Reserves:

	Refinery production[8]		Reserves[9]
	2009	2010	
United States	—	—	440,000
Australia	—	—	[10]300,000
Brazil	NA	NA	16,000
Canada	NA	NA	100,000
India	NA	NA	290,000
Malaysia	—	—	4,500
South Africa	—	—	35,000
Other countries	NA	NA	90,000
World total	NA	NA	1,300,000

Reserves are contained primarily in the rare-earth ore mineral monazite and the thorium mineral thorite. 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. New demand is possible with the development and testing of thorium nuclear fuel in Russia and India. Reserves exist primarily in recent and ancient placer deposits and in thorium vein deposits, especially those in the Lemhi Pass area of Idaho. Lesser quantities of thorium-bearing monazite and thorite reserves occur in certain iron ore deposits and carbonatites. Thorium enrichment in iron ore is known in iron (Fe)-REE-thorium-apatite (FRETA) deposits, similar to the FRETA deposits in Mineville, NY, Pea Ridge, MO, and Scrub Oaks, NJ.

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]Thorium compound imports from the United Kingdom were believed to be material for nuclear fuel reprocessing or waste and were not used in calculating domestic apparent consumption. Thorium compound exports to Mexico were believed to be waste material shipped for disposal and were not used in calculating domestic apparent consumption. Apparent consumption calculation excludes ore and concentrates.

[3]Apparent consumption calculations in 2008 and 2009 result in negative numbers.

[4]Source: Defense Logistics Agency, DLA Strategic Materials (formerly the Defense National Stockpile Center); based on sales from the National Defense Stockpile in 1997.

[5]Source: Rhodia Canada, Inc., and Rhodia Electronics and Catalysis, Inc., f.o.b. port of entry, duty paid, ThO_2 basis.

[6]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.

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

[8]Estimates, based on thorium contents of rare-earth ores.

[9]See Appendix C for resource/reserve definitions and information concerning data sources.

[10]Includes thorium contained in mineralized sands.

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 91% of the primary tin consumed domestically in 2010. The major uses were as follows: electrical, 28%; cans and containers, 19%; construction, 13%; transportation, 12%; and other, 28%. On the basis of the average New York composite price, the estimated values of some critical items in 2010 were as follows: primary metal consumed, \$595 million; imports for consumption, refined tin, \$892 million; and secondary production (old scrap), \$278 million.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Secondary (old scrap)	11,600	12,200	11,500	11,000	11,700
Secondary (new scrap)	2,340	2,800	2,100	1,930	2,400
Imports for consumption, refined tin	43,000	34,600	36,300	33,000	37,500
Exports, refined tin	5,490	6,410	9,800	3,170	8,400
Shipments from Government stockpile excesses	8,409	4,540	60	—	—
Consumption, reported:					
Primary	29,200	23,700	22,900	24,700	25,000
Secondary	8,480	7,490	6,250	7,750	6,800
Consumption, apparent	58,000	43,700	38,600	42,400	38,020
Price, average, cents per pound:					
New York market	419	680	865	642	824
New York composite	565	899	1,130	837	1,079
London	398	659	837	615	801
Kuala Lumpur	398	658	838	609	800
Stocks, consumer and dealer, yearend	7,890	9,100	8,560	7,020	9,800
Net import reliance[1] as a percentage of apparent consumption	80	72	70	74	69

Recycling: About 14,000 tons of tin from old and new scrap was recycled in 2010. Of this, about 12,000 tons was recovered from old scrap at 2 detinning plants and 78 secondary nonferrous metal processing plants.

Import Sources (2006–09): Peru, 55%; Bolivia, 16%; China, 8%; Indonesia, 8%; and other, 13%.

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: On June 4, 2008, the Office of the Undersecretary of Defense suspended tin sales pending further research as a result of the Defense Logistics Agency, DLA Strategic Materials' (formerly Defense National Stockpile Center) reconfiguration. As a result of this suspension, the DLA Strategic Materials made no tin sales in calendar year 2010. The fiscal year 2011 Annual Materials Plan was set at 4,000 tons. The DLA Strategic Materials inventory was stored in the Hammond, IN, depot and was all "long horn" brand tin. When tin was last offered for sale, it was available via the basic ordering agreement and negotiated sales procedures.

Stockpile Status—9-30-10[2]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Pig tin	4,020	4,020	4,000	—

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 declined by 11% in 2010 compared with that of 2009. The monthly average composite price of tin rose substantially during the year. Higher prices in 2010 were attributed to lower production in key producing countries and to investment fund buying and selling.

Developments continued in major tin-consuming countries to move to new lead-free solders that usually contain greater amounts of tin than do leaded solders.

In response to higher tin prices in 2010, tin producers opened new tin mines and tin smelters and expanded existing operations, including ones in Australia, Bolivia, Canada, and Thailand. Tin exploration activity increased, especially in Australia and Canada. In Bolivia, old tin tailings were being evaluated for reclamation of tin.

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 production difficulties, some related to a Government shutdown of possibly illegal production sites.

World Mine Production and Reserves: Reserve figures were changed for several countries, including Bolivia, Brazil, China, Malaysia, and Russia, based on new information from official Government sources in those countries.

	Mine production		Reserves[3]
	2009	2010[e]	
United States	—	—	—
Australia	1,400	2,000	180,000
Bolivia	19,000	16,000	400,000
Brazil	13,000	12,000	590,000
China	115,000	115,000	1,500,000
Congo (Kinshasa)	9,400	9,000	NA
Indonesia	55,000	60,000	800,000
Malaysia	2,380	2,000	250,000
Peru	37,500	38,000	710,000
Portugal	30	100	70,000
Russia	1,200	1,000	350,000
Thailand	120	100	170,000
Vietnam	3,500	3,500	NA
Other countries	2,000	2,000	180,000
World total (rounded)	260,000	261,000	5,200,000

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 resource/reserve definitions and information concerning data sources.

TITANIUM AND TITANIUM DIOXIDE[1]

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Titanium sponge metal was produced by four operations in Nevada, Oregon, and Utah. Ingot was produced by 10 operations in 8 States. Numerous firms consumed ingot to produce wrought products and castings. In 2010, an estimated 75% of the titanium metal was used in aerospace applications. The remaining 25% was used in armor, chemical processing, marine, medical, power generation, sporting goods, and other nonaerospace applications. The value of sponge metal consumed was about $339 million, assuming an average selling price of $11.38 per kilogram.

In 2010, titanium dioxide (TiO_2) pigment, which was valued at about $3.0 billion, was produced by four companies at six facilities in five States. The estimated use of TiO_2 pigment by end use was paint (includes lacquers and varnishes), 59%; plastic, 26%; paper, 9%; and other, 6%. Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Titanium sponge metal:					
Production	W	W	W	W	W
Imports for consumption	24,400	25,900	23,900	16,600	17,000
Exports	1,380	2,000	2,370	820	250
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, reported	28,400	33,700	W	W	30,000
Price, dollars per kilogram, yearend	20.62	14.76	15.64	15.58	11.38
Stocks, industry yearend[e]	8,240	7,820	14,200	15,300	13,000
Employment, number[e]	350	400	350	300	300
Net import reliance[2] as a percentage of reported consumption	67	72	W	W	64
Titanium dioxide:					
Production	1,370,000	1,440,000	1,350,000	1,230,000	1,400,000
Imports for consumption	288,000	221,000	183,000	175,000	197,000
Exports	581,000	682,000	733,000	649,000	811,000
Consumption, apparent	1,080,000	979,000	800,000	756,000	786,000
Producer price index, yearend	165	162	170	164	184
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number[e]	4,300	4,300	4,200	3,800	3,400
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 29,000 tons in 2010. Estimated use of titanium as scrap and ferrotitanium by the steel industry was about 10,000 tons; by the superalloy industry, 1,000 tons; and in other industries, 1,000 tons. Old scrap reclaimed totaled about 1,000 tons.

Import Sources (2006–09): Sponge metal: Kazakhstan, 52%; Japan, 33%; Ukraine, 5%; Russia, 4%; and other, 6%. Titanium dioxide pigment: Canada, 38%; China, 13%; Germany, 7%; Finland, 6%; and other, 36%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-10**
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: Because TiO_2 pigment is used in paint, paper, and plastics, consumption is tied to the Gross Domestic Product (GDP). In June, the World Bank forecast global GDP growth to be 3.3% in 2010. Recovering demand from the construction and automotive industries led to an increase in global production of TiO_2 pigment compared with that in 2009. To meet rising domestic and global TiO_2 consumption, domestic production of TiO_2 pigment was estimated to be 1.4 million tons, a 14% increase compared with that in 2009. In Australia, TiO_2 pigment capacity increased to 150,000 tons per year from 110,000 tons per year through the expansion of an existing chloride-route plant.

Increasing demand and reduced inventories brought about by production curtailments made in 2009 and 2010 allowed several metal producers to resume plans to increase titanium sponge production capacity. In Japan, sponge capacity was expected to increase to 66,000 tons per year in 2011. In Russia, sponge capacity was expected to rise to 44,000 tons per year by 2014. In China, titanium metal capacity was forecasted to increase by 100,000 tons per year beyond existing capacity, but a schedule was not available for the expansion. In India, a 500-ton-per-year titanium sponge plant was under construction at Kollam. The plant is the first of its kind in India and was to be supplied with titanium tetrachloride from an existing TiO_2 producer. In the United States, new titanium production capacity neared completion in Ottawa, IL. Instead of sponge produced by magnesium reduction via the Kroll process, the plant produced titanium metal powder by sodium reduction by the Armstrong process. Production capacity was expected to be 2,000 tons per year by yearend 2011. At least three other Kroll-alternative titanium technologies were expected to be in the pilot-plant stage of development in 2011.

World Sponge Metal Production and Sponge and Pigment Capacity: Capacity estimates were revised based on new information from industry reports.

	Sponge production		Capacity 2010[3]	
	2009	2010[e]	Sponge	Pigment
United States	W	W	24,000	1,480,000
Australia	—	—	—	281,000
Belgium	—	—	—	74,000
Canada	—	—	—	90,000
China[e]	61,500	53,000	80,000	1,100,000
Finland	—	—	—	130,000
France	—	—	—	125,000
Germany	—	—	—	440,000
Italy	—	—	—	80,000
Japan[e]	25,000	30,000	60,000	309,000
Kazakhstan[e]	16,500	15,000	26,000	1,000
Mexico	—	—	—	130,000
Russia[e]	26,600	27,000	38,000	20,000
Spain	—	—	—	80,000
Ukraine[e]	6,830	6,500	10,000	120,000
United Kingdom	—	—	—	300,000
Other countries	—	—	—	900,000
World total (rounded)	[4]136,000	[4]132,000	238,000	5,660,000

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]Yearend operating capacity.

[4]Excludes U.S. production.

[5]See Appendix C for resource/reserve definitions and information concerning data sources.

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 2010 was about $470 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:	2006	2007	2008	2009	2010[e]
Production[2] (rounded)	300	300	200	200	200
Imports for consumption	1,030	1,220	1,110	927	1,230
Exports,[e] all forms	21	6	7	9	11
Consumption, estimated	1,510	1,600	1,440	1,360	1,500
Price, dollars per metric ton, yearend:					
Ilmenite, bulk, minimum 54% TiO_2, f.o.b. Australia	80	80	111	73	75
Rutile, bulk, minimum 95% TiO_2, f.o.b. Australia	475	488	525	533	760
Slag, 80%–95% TiO_2[3]	402-454	418-457	393-407	401-439	450-570
Stocks, mine, consumer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number[e]	246	225	144	194	180
Net import reliance[4] as a percentage of estimated consumption	67	76	78	68	81

Recycling: None.

Import Sources (2006–09): South Africa, 49%; Australia, 29%; Canada, 14%; Mozambique, 3%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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: Consumption of titanium mineral concentrates is tied to consumption of TiO_2 pigments primarily used in paint, paper, and plastics. Owing to increased production of TiO_2 pigment, domestic consumption of titanium mineral concentrates was estimated to have increased by 10% in 2010 compared with that in 2009. One of the two U.S. mineral producers acquired land that will extend mining operations near Starke, FL, though 2017. The life of the Stony Creek, VA, operation was recently extended to 2015 through the addition of the Brink deposit.

In Mozambique, plans were announced to expand ilmenite production capacity at the Moma mining operation to 1.8 million tons per year, a 50% increase compared with the existing design capacity. In October, a breach in a settling pond flooded nearby homes and disrupted mining operations at the Moma Mine for 1 month. In Vietnam, Government policies were being implemented to stop ilmenite exports, control illegal mining, and promote the development of upgraded products. An export ban was expected to be implemented in January 2011. The ban was approved in 2008 but has been repeatedly delayed to help mining companies hurt by global economic conditions.

Prepared by **Joseph Gambogi [(703) 648-7718, jgambogi@usgs.gov, fax: (703) 648-7757]**

TITANIUM MINERAL CONCENTRATES

World Mine Production and Reserves: The reserves estimates for Australia, Sierra Leone, and the United States were revised based on information derived from government and industry reports.

	Mine production 2009	Mine production 2010[e]	Reserves[5]
Ilmenite:			
United States[2]	[6]200	[6]200	2,000
Australia	1,020	1,070	100,000
Brazil	43	43	43,000
Canada[7]	650	700	31,000
China	500	600	200,000
India	420	420	85,000
Madagascar	47	150	40,000
Mozambique	283	350	16,000
Norway[7]	302	320	37,000
South Africa[7]	1,050	1,120	63,000
Sri Lanka	30	40	NA
Ukraine	300	300	5,900
Vietnam	412	410	1,600
Other countries	34	35	26,000
World total (ilmenite, rounded)	5,300	5,800	650,000
Rutile:			
United States	([8])	([8])	([8])
Australia	266	280	18,000
Brazil	3	3	1,200
India	20	20	7,400
Madagascar	2	6	NA
Mozambique	2	2	480
Sierra Leone	61	67	3,800
South Africa	127	130	8,300
Sri Lanka	11	12	NA
Ukraine	57	57	2,500
Other countries	—	—	400
World total (rutile, rounded)	[8]550	[8]580	42,000
World total (ilmenite and rutile, rounded)	5,800	6,300	690,000

World Resources: Ilmenite accounts for about 91% of the world's consumption of 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 one significant digit to avoid disclosing company proprietary data.
[3]Landed duty-paid value based on U.S. imports for consumption.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Includes rutile.
[7]Mine production is primarily used to produce titaniferous slag.
[8]U.S. rutile production and reserves data are included with ilmenite.

TUNGSTEN

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

Domestic Production and Use: One mine in California produced tungsten concentrates in 2010. Approximately eight companies in the United States processed tungsten concentrates, ammonium paratungstate, tungsten oxide, and/or scrap to make tungsten powder, tungsten carbide powder, and/or tungsten chemicals. Nearly 60 industrial consumers were surveyed on a monthly or annual basis. Data reported by these consumers indicated 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 2010 was $500 million.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Mine	—	W	W	W	W
Secondary	4,490	4,330	4,790	3,550	5,300
Imports for consumption:					
Concentrate	2,290	3,880	3,990	3,590	3,000
Other forms	9,700	9,050	9,060	6,410	9,300
Exports:					
Concentrate	130	109	496	38	400
Other forms	6,310	5,950	5,480	2,730	4,000
Government stockpile shipments:					
Concentrate	3,120	1,740	1,470	688	2,100
Other forms	16	31	51	12	—
Consumption:					
Reported, concentrate	W	W	W	W	W
Apparent,[1,2] all forms	13,300	13,300	13,800	11,600	14,000
Price, concentrate, dollars per mtu WO_3,[3] average:					
U.S. spot market, Platts Metals Week	200	189	184	151	180
European market, Metal Bulletin	166	165	164	150	150
Stocks, industry, yearend:					
Concentrate	W	W	W	W	W
Other forms	2,110	1,960	2,200	2,190	2,500
Net import reliance[4] as a percentage of apparent consumption	67	67	60	68	68

Recycling: In 2010, the tungsten contained in scrap consumed by processors and end users represented approximately 37% of apparent consumption of tungsten in all forms.

Import Sources (2006–09): Tungsten contained in ores and concentrates, intermediate and primary products, wrought and unwrought tungsten, and waste and scrap: China, 43%; Canada, 9%; Germany, 9%; Bolivia, 8%; and other, 31%.

Tariff: Item	Number	Normal Trade Relations[5] 12-31-10
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—9-30-10[6]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Metal powder	171	171	136	—
Ores and concentrates	17,000	17,000	3,630	2,670

Events, Trends, and Issues: World tungsten supply is dominated by Chinese production and exports. China's Government regulates its tungsten industry by limiting the number of exploration, mining, and export licenses; limiting or forbidding foreign investment; imposing constraints on mining and processing; establishing quotas on production and exports; adjusting export quotas to favor value-added downstream materials and products; and imposing export taxes on tungsten materials. China is 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 mining projects outside of China and increasing its use of tungsten scrap.

In 2010, global economic conditions improved and tungsten consumption increased compared with the low levels of 2009. The sole Canadian tungsten mine restarted production in October 2010 after being on care-and-maintenance status for 1 year. By November, a combination of recovering demand, Chinese controls on production and exports, and a temporary suspension of tungsten sales from Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center) resulted in tightening supplies of concentrates and increased prices.

In recent years, the tungsten industry has increased its monitoring of proposed legislation and scientific research regarding the impact of tungsten on human health and the environment.

World Mine Production and Reserves: Reserves for Canada were revised upward based on company data; reserves for China were revised upward based on new information from that country.

	Mine production		Reserves[7]
	2009	2010[e]	
United States	W	W	140,000
Austria	900	1,000	10,000
Bolivia	1,000	1,100	53,000
Canada	2,000	300	120,000
China	51,000	52,000	1,900,000
Portugal	900	950	4,200
Russia	2,500	2,500	250,000
Other countries	3,000	3,300	400,000
World total (rounded)	[2]61,300	[2]61,000	2,900,000

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 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. 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]Excludes U.S. production.
[3]A metric ton unit (mtu) of tungsten trioxide (WO_3) contains 7.93 kilograms of tungsten.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]No tariff for Canada and Mexico. Tariffs for other countries for some items may be eliminated under special trade agreements.
[6]See Appendix B for definitions.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.

VANADIUM

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

Domestic Production and Use: Seven U.S. firms that comprise most 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 97% of the domestic vanadium consumption in 2009. 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:	2006	2007	2008	2009	2010[e]
Production, mine, mill[1]	—	—	W	W	W
Imports for consumption:					
Ferrovanadium	685	1,440	2,720	353	1,080
Vanadium pentoxide, anhydride	1,920	2,390	3,700	1,120	2,500
Oxides and hydroxides, other	129	42	144	25	12
Aluminum-vanadium master alloys (gross weight)	405	1,110	618	282	900
Ash, ore, residues, slag	637	1,000	1,040	791	490
Sulfates	—	80	2	16	25
Vanadates	115	211	187	214	90
Vanadium metal, including waste and scrap	73	84	45	216	10
Exports:					
Ferrovanadium	389	154	281	672	460
Vanadium pentoxide, anhydride	341	327	249	401	180
Oxides and hydroxides, other	832	626	1,040	506	810
Aluminum-vanadium master alloys (gross weight)	1,700	1,700	1,390	447	830
Vanadium metal, including waste and scrap	491	49	57	23	8
Consumption:					
Apparent	256	3,520	5,960	1,220	4,100
Reported	4,030	4,970	5,170	5,000	5,100
Price, average, dollars per pound V_2O_5	7.86	7.40	12.92	5.43	6.40
Stocks, consumer, yearend	330	323	334	314	300
Net import reliance[2] as a percentage of apparent consumption	100	100	91	81	69

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 (2006–09): Ferrovanadium: Republic of Korea, 38%; Czech Republic, 30%; Canada, 20%; Austria, 9%; and other, 3%. Vanadium pentoxide: South Africa, 39%; Russia, 32%; China, 28%; and other, 1%.

Tariff: Ash, residues, slag, and waste and scrap enter duty-free.

Item	Number	Normal Trade Relations 12-31-10
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 **Désirée E. Polyak [(703) 648-4909, dpolyak@usgs.gov, fax: (703) 648-7757]**

VANADIUM

Events, Trends, and Issues: U.S. apparent consumption of vanadium recovered in 2010 from its relatively low level in 2009; apparent consumption of vanadium declined dramatically in 2009 from that of 2008 owing to the global economic downturn in 2009. Among the major uses for vanadium, production of carbon, full-alloy, and high-strength, low-alloy steels accounted for 14%, 41%, and 33% of domestic consumption, respectively. U.S. imports for consumption in 2010 were 69% more than that of the previous year. U.S. exports were approximately 12% more than those of the previous year. In 2010, U.S. steel production was expected to increase from that of 2009. Given the increase in steel demand, the vanadium industry was expected to continue to slowly recover.

Vanadium pentoxide (V_2O_5) prices continued to slowly increase to a high of $7.50 per pound of V_2O_5 in May 2010 before decreasing again in June. In May 2009, V_2O_5 prices averaged $4.13 per pound of V_2O_5, 45% less than average V_2O_5 prices in May 2010. Ferrovanadium (FeV) prices followed a similar trend with a high of $16.76 per pound of FeV in May 2010. In May 2009, FeV prices averaged $8.56 per pound of FeV, almost 50% less than average FeV prices in May 2010.

World Mine Production and Reserves:

	Mine production		Reserves[3]
	2009	2010[e]	(thousand metric tons)
United States	W	W	45
China	21,000	23,000	5,100
Russia	14,500	14,000	5,000
South Africa	17,000	18,000	3,500
Other countries	1,000	1,000	NA
World total (rounded)	53,500	56,000	13,600

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.

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. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Domestic vanadium mine and mill production did not take place from 1999–2007. In 2008, production commenced.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.

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 agriculture/horticulture, 43%; concrete aggregates (including cement premixes, concrete, and plaster), 36%; insulation, 7%; and other, 14%.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production[e, 1]	100	100	100	100	100
Imports for consumption[e, 2]	65	51	73	39	30
Exports[e]	5	5	5	3	2
Consumption, apparent, concentrate[e]	160	150	170	140	130
Consumption, exfoliated[e]	90	85	82	69	80
Price, average, concentrate, dollars per ton, ex-plant	[3]138	140	140	130	145
Employment, number[e]	95	100	100	75	80
Net import reliance[4] as a percentage of apparent consumption[e]	40	32	40	26	22

Recycling: Insignificant.

Import Sources (2006–09): China, 56%; South Africa, 42%; and other, 2%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12-31-10**
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 **Arnold O. Tanner [(703) 648-4791, atanner@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 18,000 tons for the first 8 months of 2010. South Africa provided 76%, Mozambique, 10%, and Australia, Brazil, and China, about 5% each.

An Australian company continued development of and production at the East African Namekara vermiculite deposit, a portion of the larger East African vermiculite project (EAVP). The EAVP has about 55 million tons of inferred resources and is considered to be one of the world's largest deposits. The company planned to increase annual production from the current 18,000 tons to 115,000 tons of vermiculite concentrate by 2014. The Namekara deposit has sufficient resources for more than 50 years at the expanded rate of production. The company secured a 25-year sales contract for all production. Another industrial minerals company was to market and distribute the product.

World Mine Production and Reserves:

	Mine production		Reserves[5]
	2009	2010[e]	
United States[e, 1]	100	100	25,000
Australia	12	15	NA
Brazil	20	15	NA
China	120	130	NA
Russia	25	25	NA
South Africa	193	210	14,000
Zimbabwe	10	5	NA
Other countries	24	26	14,000
World total	500	530	NA

World Resources: Marginal reserves of vermiculite 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, reserves 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.

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. Data are rounded to one significant digit to avoid disclosing company proprietary data.
[2]Excludes Canada and Mexico.
[3]Moeller, Eric, 2007, Vermiculite: Mining Engineering, v. 59, no. 6, June, p. 61–62. (Average of prices from range of sized grades.)
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.

WOLLASTONITE

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Wollastonite was mined by two companies in New York. U.S. production statistics are withheld by the U.S. Geological Survey (USGS) to protect company proprietary data. Wollastonite mined in the United States formed when impure limestone was metamorphosed or silica-bearing fluids were introduced into calcareous sediments during metamorphism. In both cases, calcite reacted with silica to produce wollastonite and carbon dioxide. Wollastonite also can crystallize directly from a magma that has high carbon content, but this is a less common occurrence. Domestic deposits of wollastonite have been identified in Arizona, California, Idaho, Nevada, New Mexico, New York, and Utah, but New York is the only State where long-term continuous mining has taken place.

The USGS does not collect consumption statistics for wollastonite. Plastics and rubber products, however, were estimated to account for 25% to 35% of U.S. consumption, followed by ceramics with 20% to 25%; paint, 10% to 15%; metallurgical applications, 10% to 15%; friction products, 10% to 15%; and miscellaneous, 10% to 15%.

Salient Statistics—United States: U.S. production, as reported in the trade literature, was about 65,000 tons in 2009. Production probably increased by 3% to 7% in 2010 compared with that in 2009. Comprehensive trade data are not available but exports were likely in the range of 24,000 to 28,000 tons and imports probably were less than 4,000 tons in 2010. Prices for wollastonite were reported in the trade literature to range from $80 to $1,984 per ton. Products with finer grain sizes and being more acicular in morphology sold for higher prices. Surface treatment, when necessary, also increased the selling price. The United States was thought to be a net exporter of wollastonite.

Recycling: None.

Import Sources (2006–09): Comprehensive trade data are not available but wollastonite has been imported from Canada, China, Finland, India, and Mexico.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Mineral substances not elsewhere specified or included	2530.90.8050	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

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

WOLLASTONITE

Events, Trends, and Issues: The U.S. wollastonite industry began a slow recovery after a significant downturn in demand in 2009 during the global economic recession. Production and exports of wollastonite increased slightly in 2010, primarily because of a continued growth in markets in Southeast Asia. Imports were likely to have remained unchanged in 2010.

The wollastonite industry is strongly dependent on sales to the ceramics, metallurgical, paints, and plastic industries, all of which declined during the global recession. With global economies slowly recovering, sales of wollastonite should improve during the next 2 to 3 years.

A South African producer planned to mine wollastonite at the Magata wollastonite project near Garies, Namaqualand. Resources were estimated to be 3.2 million tons at an average grade of 52% wollastonite. Production was planned to be about 9,000 tons per year in 2011. The company constructed a mill on-site, with anticipated capacity to be 17,400 tons per year in 2012 and 23,300 tons in April 2014.

World Mine Production and Reserves: World production data for wollastonite is not available for many countries and those that are available frequently are 2 to 3 years old. Estimated world production of crude wollastonite ore was in the range of 530,000 to 550,000 tons in 2010, slightly greater than that of 2009. Sales of refined wollastonite products probably were in the range of 450,000 to 490,000 t in 2010 compared with 430,000 to 470,000 t in 2009.

	Mine production		Reserves[1]
	2009	2010[e]	
United States	[e]65,000	67,000	World reserves of wollastonite were estimated to exceed 90 million tons, with probable reserves estimated to be 270 million tons. However, many large deposits have not been surveyed, so accurate reserve estimates are not available.
China	[e]290,000	300,000	
Finland	16,000	16,000	
India	110,000	120,000	
Mexico	40,000	30,000	
Other	[e]9,500	9,500	
World total (rounded)	530,000	540,000	

World Resources: World resources have not been estimated for wollastonite. The larger reserves were in China, Finland, India, Mexico, Spain, and the United States, which account for most of the global wollastonite production. Significant wollastonite resources also are in Canada, Chile, Kenya, Namibia, South Africa, Sudan, Tajikistan, Turkey, and Uzbekistan.

Substitutes: The acicular nature of many wollastonite products allows it to compete with other acicular materials, such as ceramic fiber, glass fiber, steel fiber, and several organic fibers, such as aramid, polyethylene, polypropylene, and polytetrafluoroethylene in products where improvements in dimensional stability, flexural modulus, and heat deflection are sought. Wollastonite also competes with several nonfibrous minerals or rocks, such as kaolin, mica, and talc, which are added to plastics to increase flexural strength, and such minerals as barite, calcium carbonate, gypsum, and talc, which impart dimensional stability to plastics. In ceramics, wollastonite competes with carbonates, feldspar, lime, and silica as a source of calcium and silica. Its use in ceramics depends on the formulation of the ceramic body and the firing method.

[e]Estimated.
[1]See Appendix C for resource/reserve definitions and information concerning data sources.

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 2010. 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. Yttria-stabilized zirconia was used 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 2010 by end use was as follows: phosphors (all types), 81%; ceramics, 12%; metallurgy, 5%; and electronics and lasers, 2%.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
In monazite	—	—	—	—	—
Yttrium, alloys, compounds, and metal[e, 2]	742	676	616	450	760
Exports, in ore and concentrate	NA	NA	NA	NA	NA
Consumption, estimated[3]	742	676	616	450	760
Price, dollars:					
Monazite concentrate, per metric ton[4]	300	300	300	300	300
Yttrium oxide, per kilogram, 99.9% to 99.99% purity[5]	10–85	10–85	10–85	10–85	38–41
Yttrium metal, per kilogram, 99.9% purity[5]	68–155	68–155	68–155	68–155	73–99
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 (2006–09): Yttrium compounds, greater than 19% to less than 85% weight percent yttrium oxide equivalent: China, 93%; Japan, 6%; France, 1%; and other, insignificant. Import sources based on Journal of Commerce data (2009 only): China, 75%; Japan, 15%; France, 8%; Austria, 1%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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 **Daniel J. Cordier [(703) 648-7723, dcordier@usgs.gov, fax: (703) 648-7757]**

YTTRIUM

Events, Trends, and Issues: Estimated yttrium consumption in the United States decreased in 2009 and was expected to increase in 2010. The United States required yttrium for use in phosphors and in electronics, especially those used in defense applications.

Yttrium production and marketing within China continued to be competitive. 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 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 compounds for phosphors. Smaller amounts were used in ceramics, electronic devices, lasers, and metallurgical applications.

China was the primary source of most of the yttrium consumed in the United States. About 90% of the imported yttrium compounds, metal, and alloys were sourced from China, with lesser amounts from Japan, France, and Austria.

World Mine Production and Reserves:

	Mine production[e, 7]		Reserves[8]
	2009	2010	
United States	—	—	120,000
Australia	—	—	100,000
Brazil	15	15	2,200
China	8,800	8,800	220,000
India	55	55	72,000
Malaysia	4	4	13,000
Sri Lanka	—	—	240
Other countries	—	—	17,000
World total (rounded)	8,900	8,900	540,000

World Resources: Although reserves may be sufficient to satisfy near-term demand at current rates of production, economics, environmental issues, and permitting and trade restrictions could affect the mining or availability of many of the rare-earth elements, including yttrium. 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-bearing 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. Yttrium is associated with most rare-earth deposits. It occurs in various minerals in differing concentrations and occurs in a wide variety of geologic environments, including alkaline granites and intrusives, carbonatites, hydrothermal deposits, laterites, placers, and vein-type deposits.

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), Journal of Commerce.
[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 2005 and estimated for 2006 through 2010.
[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 resource/reserve definitions and information concerning data sources.

ZEOLITES (NATURAL)

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Natural zeolites were mined by 10 companies in the United States, with 1 other company working from stockpiled materials or zeolites purchased from other producers for resale. Chabazite was mined in Arizona; clinoptilolite was mined in California, Idaho, Nevada, New Mexico, and Texas; and mordenite was mined in Nevada. New Mexico was the leading producing State in 2010, followed by Idaho, Texas, Arizona, California, and Nevada.

Natural zeolites mined in the United States are associated with the alteration of volcanic tuffs in alkaline lake deposits and open hydrologic systems. Commercial deposits are in Arizona, California, Idaho, Nevada, New Mexico, Oregon, and Texas. Smaller, noncommercial deposits also are found in several other Midwestern and Western States. Zeolite minerals such as chabazite, clinoptilolite, erionite, mordenite, and phillipsite occur in these deposits, but the most commonly mined zeolites are chabazite, clinoptilolite, and mordenite.

U.S. consumption of natural zeolites was 58,500 tons in 2010. Domestic uses for natural zeolites were, in decreasing order by tonnage, animal feed, odor control, pet litter, water purification, fungicide or pesticide carrier, wastewater cleanup, gas absorbent, horticultural applications (soil conditioners and growth media), oil absorbent, desiccant, and aquaculture. Animal feed, odor control, pet litter, and water purification applications accounted for more than 75% of the domestic sales tonnage.

Salient Statistics—United States:	**2006**	**2007**	**2008**	**2009**	**2010[e]**
Production, mine	63,200	57,400	60,100	59,500	59,000
Sales, mill	55,900	57,400	58,500	59,400	58,500
Price, range of value, dollars per ton[1]	30-900	30-900	30-900	30-900	30-900

Recycling: Natural zeolites used for most applications are not recycled. Natural zeolites used for such applications as desiccants, gas absorbents, wastewater cleanup, or water purification may be reused after reprocessing of the spent zeolites.

Import Sources (2006–09): Comprehensive trade data are not available for natural zeolites. Nearly all exports and imports are synthetic zeolites. Small amounts of natural zeolites have been imported from Bulgaria and India.

Tariff: Item	Number	Normal Trade Relations 12-31-10
Mineral substances not elsewhere specified or included	2530.90.80.50	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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

ZEOLITES (NATURAL)

Events, Trends, and Issues: Markets for natural zeolites generally were smaller and less associated with construction and manufacturing applications than most other industrial minerals. Consequently, the recent U.S. economic recession had only a relatively minor impact on the industry. However, construction markets outside of the United States, where natural zeolites are widely used as dimension stone, lightweight aggregate, and pozzolan, were affected by the 2008–09 recession because of the reduced level of building activity. World production probably remained unchanged in 2010 from that of 2009 because of the overall lack of economic growth in many regions of the globe.

World Mine Production and Reserves:[2] Natural zeolite production data are not available for most countries. Countries mining large tonnages of zeolites typically use them in low-value applications. The ready availability of zeolite-rich rock at low cost and the shortage of competing minerals and rocks are probably the most important factors for its large-scale use. It is also likely that a significant percentage of the material sold as zeolites in some countries is ground or sawn volcanic tuff that contains only a small amount of zeolites. Some examples of such usage are dimension stone (as an altered volcanic tuff), lightweight aggregate, pozzolanic cement, and soil conditioners.

World reserves of natural zeolites have not been estimated. Deposits occur in many countries but companies rarely, if ever, publish reserve data. Further complicating estimates of reserves is the fact that much of the reported world production includes altered volcanic tuffs that contain low to moderate concentrations of zeolites. These typically are used in high-volume construction applications and therefore some deposits should be excluded from reserve estimates because it is the rock itself and not its zeolite content that makes the deposit valuable.

	Mine production[2]		Reserves[3]
	2009	2010[e]	
United States	59,500	59,000	
China[e,4]	2,000,000	2,000,000	
Japan[e,4]	155,000	150,000	
Jordan[e]	[5]425,000	140,000	World reserves are
Korea, Republic of	165,000	210,000	not determined but are
Slovakia	90,000	85,000	estimated to be large.
Turkey[4]	100,000	100,000	
Other	5,500	5,000	
World total (rounded)	3,000,000	2,750,000	

World Resources: World resources have not been estimated for natural zeolites. An estimated 120 million tons of clinoptilolite, chabazite, erionite, mordenite, and phillipsite is present in near-surface deposits in the Basin and Range province in the United States. Possible resources in the United States may approach 10 trillion tons for zeolite-rich deposits.

Substitutes: For pet litter, natural zeolites compete with other mineral-based litters, such as those manufactured using attapulgite, bentonite, diatomite, fuller's earth, and sepiolite; organic litters made from shredded corn stalks and paper, straw, and wood shavings; and litters made using silica gel. Diatomite, perlite, pumice, vermiculite, and volcanic tuff compete with natural zeolite as lightweight aggregate. Zeolite desiccants compete against such products as magnesium perchlorate and silica gel. Zeolites compete with bentonite, gypsum, montmorillonite, peat, perlite, silica sand, and vermiculite in various soil amendment applications. Carbon, diatomite, or silica sand may substitute for zeolites in water purification applications. As an oil absorbent, zeolites compete mainly with bentonite, diatomite, fuller's earth, sepiolite, and a variety of polymer and natural organic products.

[e]Estimated.
[1]Estimate based on values reported by U.S. producers and prices published in the trade literature. Bulk shipments typically range from $100 to $200 per ton.
[2]Estimates for countries that do not report production represent a range with possibly 15% to 20% variability, rather than an absolute value.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.
[4]Includes pozzolan applications.

ZINC

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

Domestic Production and Use: The value of zinc mined in 2010, based on zinc contained in concentrate, was about $1.65 billion. It was produced in 4 States at 12 mines operated by 4 companies. Two facilities—one primary and the other secondary—produced the bulk of refined zinc metal of commercial grade in 2010. 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 were lead, sulfuric acid, cadmium, silver, gold, and germanium.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production:					
Mine, zinc in ore and concentrate	727	803	778	736	720
Primary slab zinc	113	121	125	94	120
Secondary slab zinc	156	157	161	109	85
Imports for consumption:					
Zinc in ore and concentrate	383	271	63	74	30
Refined zinc	895	758	725	686	700
Exports:					
Zinc in ore and concentrate	825	816	725	785	700
Refined zinc	3	8	3	3	4
Shipments from Government stockpile	30	10	([1])	([1])	—
Consumption, apparent, refined zinc	1,190	1,040	1,010	893	901
Price, average, cents per pound:					
North American[2]	158.9	154.4	88.9	77.9	104
London Metal Exchange (LME), cash	148.5	147.0	85.0	75.1	100
Reported producer and consumer stocks, slab zinc, yearend	60	55	56	49	49
Employment:					
Mine and mill, number[3]	1,680	2,290	2,520	1,580	1,740
Smelter primary, number	246	264	250	248	250
Net import reliance[4] as a percentage of apparent consumption (refined zinc)	77	73	72	77	77

Recycling: In 2010, about 41% (85,000 tons) of the slab zinc produced in the United States was recovered from secondary materials—mainly electric arc furnace dust, as well as galvanizing residues.

Import Sources (2006–09): Ore and concentrate: Peru, 69%; Ireland, 16%; Mexico, 13%; and Canada, 2%. Metal: Canada, 73%; Mexico, 13%; Kazakhstan, 3%; Republic of Korea, 3%; and other, 8%. Waste and scrap: Canada, 64%; Mexico, 24%; Italy, 4%; Thailand, 3%; and other, 5%. Combined total: Canada, 59%; Peru, 16%; Mexico, 13%; Ireland, 3%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations[5] 12-31-10
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).

Government Stockpile:

Stockpile Status—9-30-10[6, 7]

Material	Uncommitted inventory	Authorized for disposal	Disposal plan FY 2010	Disposals FY 2010
Zinc	7	7	[8]8	—

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

ZINC

Events, Trends, and Issues: Global zinc mine production in 2010 was forecast to increase to 12 million tons, mostly owing to increases in zinc mine production in Australia and China. According to the International Lead and Zinc Study Group, refined metal production increased by 11% to 12.5 million tons, while world metal consumption increased by 13% to 12.3 million tons, resulting in a market surplus of 233,000 tons of metal. A smaller surplus is anticipated in 2011. Demand for zinc generally follows industrial production or, more generally, global economic growth. Global economic activity expanded during 2010, albeit at a sluggish pace. The rate of growth in the United States and Japan was slower than that of Europe and the major emerging economies—most notably Brazil, China, and India. The rise in global zinc consumption in 2010 was credited to a strong recovery of consumption in Europe (24%) as well as continued strong growth in consumption in China (11%).

Domestically, production continued to ramp up at two recently reopened zinc mining complexes in Tennessee. However, overall zinc mine production decreased in 2010 from that of 2009 owing to the loss of production from mines in Montana and Washington, both of which had ceased operations in 2009. Primary production returned to normal levels in 2010, as production at the zinc refinery in Tennessee was near capacity throughout the year. Secondary zinc production decreased from that of 2009, as the zinc smelter in Pennsylvania halted production from July through November as a result of a fire at the plant.

After declining through the first half of the year, average monthly zinc prices rebounded during the second half of 2010. The LME cash price for Special High Grade zinc averaged 110 cents per pound in January, decreased to 79 cents per pound by midyear, and then rose to 106 cents per pound by October.

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

	Mine production[9]		Reserves[10]
	2009	2010[e]	
United States	736	720	12,000
Australia	1,290	1,450	53,000
Bolivia	422	430	6,000
Canada	699	670	6,000
China	3,100	3,500	42,000
India	695	750	11,000
Ireland	386	350	2,000
Kazakhstan	480	480	16,000
Mexico	390	550	15,000
Peru	1,510	1,520	23,000
Other countries	1,490	1,580	62,000
World total (rounded)	11,200	12,000	250,000

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. — Zero.
[1]Less than ½ unit.
[2]Platts Metals Week price for North American Special High Grade zinc; based on the London Metal Exchange cash price plus premiums or discounts, depending on market conditions.
[3]Includes mine and mill employment at all zinc-producing mines. Source: Mine Safety and Health Administration.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]No tariff for Canada, Mexico, and Peru for items shown.
[6]See Appendix B for definitions.
[7]Sales of zinc under Basic Ordering Agreement DLA-ZINC-004 were suspended on August 6, 2008.
[8]Actual quantity limited to remaining inventory.
[9]Zinc content of concentrate and direct shipping ore.
[10]See Appendix C for resource/reserve definitions and information concerning data sources.

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. Typically, both elements are in the ore in a zirconium-to-hafnium ratio of about 50:1. Two firms produced zircon from surface-mining operations in Florida and Virginia. Zirconium metal and hafnium metal were produced from zirconium chemical intermediates by two domestic producers, one in Oregon and the other in Utah. Zirconium chemicals were produced by the metal producer in Oregon and by at least 10 other companies. Ceramics, foundry applications, opacifiers, and refractories are the leading end uses for zircon. Other end uses of zircon include abrasives, chemicals, metal alloys, and welding rod coatings. The leading consumers of zirconium metal and hafnium metal are the nuclear energy and chemical process industries.

Salient Statistics—United States:	2006	2007	2008	2009	2010[e]
Production, zircon (ZrO_2 content)	W	W	W	W	W
Imports:					
Zirconium, ores and concentrates (ZrO_2 content)	23,500	13,000	22,300	9,370	11,600
Zirconium, unwrought, powder, and waste and scrap	256	299	318	451	590
Zirconium, wrought	492	485	715	526	368
Zirconium oxide[1]	2,820	3,740	5,060	2,810	2,370
Hafnium, unwrought, waste and scrap	4	4	12	5	6
Exports:					
Zirconium ores and concentrates (ZrO_2 content)	49,600	43,000	27,400	25,700	34,000
Zirconium, unwrought, powder, and waste and scrap	271	328	591	223	653
Zirconium, wrought	1,610	1,830	2,080	2,080	1,650
Zirconium oxide[1]	3,340	2,400	2,970	3,050	6,110
Consumption, zirconium ores and concentrates, apparent (ZrO_2 content)	W	W	W	W	W
Prices:					
Zircon, dollars per metric ton (gross weight):					
Domestic[2]	785	763	788	830	850
Imported, f.o.b.[3]	791	872	773	850	860
Zirconium, unwrought, import, France, dollars per kilogram[4]	20	29	41	51	61
Hafnium, unwrought, import, France, dollars per kilogram[4]	209	246	225	421	398
Net import reliance[5] as a percentage of apparent consumption:					
Zirconium	E	E	E	E	E
Hafnium	NA	NA	NA	NA	NA

Recycling: In-plant recycled zirconium came from scrap generated during metal production and fabrication and was recycled by companies in Oregon and Utah. Scrap zirconium metal and alloys 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 (2006–09): Zirconium mineral concentrates: Australia, 48%; South Africa, 47%; and other, 5%. Zirconium, unwrought, including powder: France, 51%; Germany, 10%; United Kingdom, 10%; South Africa, 9%; and other, 20%. Hafnium, unwrought: France, 60%; Germany, 20%; Canada, 7%; United Kingdom, 6%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12-31-10
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).

Government Stockpile: None.

Prepared by **Joseph Gambogi [(703) 648-7718, jgambogi@usgs.gov, fax: (703) 648-7757]**

ZIRCONIUM AND HAFNIUM

Events, Trends, and Issues: Domestic consumption of zirconium mineral concentrates increased significantly compared with that of 2009. Domestic mining of heavy minerals continued near Stony Creek, VA, and Starke, FL.

In 2010, demand for zircon in ceramic, foundry, opacifier, and refractory products increased significantly and was returning to 2007 levels. The number of heavy mineral exploration and mining projects underway declined in recent years. Several projects that had been delayed in 2008 and 2009 owing to lagging consumption resumed. Heavy mineral exploration and mining projects were underway in Australia, Canada, India, Kenya, Madagascar, Mozambique, Russia, Senegal, South Africa, and the United States. Global production of zirconium concentrates (excluding the United States) increased slightly compared with that of 2009. In Australia, heavy mineral mining resumed in the Tiwi Islands, and shipments of a zircon-rutile concentrate began in August. In the Eucla Basin, production at the Jacinth-Ambrosia operation was being ramped up to 300,000 tons per year of zircon concentrate. Meanwhile, in Western Australia, mining operations at Eneabba were idled owing to declining ore grade. In Mozambique, mine production was increasing at the Moma operation to 80,000 tons per year of zircon.

World Mine Production and Reserves: World primary hafnium production statistics are not available. Hafnium occurs with zirconium in the minerals zircon and baddeleyite. The reserves estimates for Australia and other countries have been revised based on new information from Government and company reports. Quantitative estimates of hafnium reserves are not available.

	Zirconium mine production (thousand metric tons)		Zirconium reserves[6] (thousand metric tons, ZrO_2)
	2009	2010[e]	
United States	W	W	3,400
Australia	476	481	23,000
Brazil	18	18	2,200
China	130	140	500
India	31	31	3,400
Indonesia	63	60	NA
South Africa	392	390	14,000
Ukraine	35	35	4,000
Other countries	19	30	5,000
World total (rounded)	[7]1,160	[7]1,190	56,000

World Resources: Resources of zircon in the United States included about 14 million tons associated with titanium resources in heavy-mineral sand deposits. Phosphate and sand and gravel deposits have the potential to yield substantial amounts of zircon as a future byproduct. Eudialyte and gittinsite are zirconium silicate minerals that have a potential for zirconia production. Identified world resources of zircon exceed 60 million tons.

Resources of hafnium in the United States are estimated to be about 130,000 tons, available in the 14-million-ton domestic resources of zircon. World resources of hafnium are associated with those of zircon and baddeleyite and exceed 1 million tons.

Substitutes: Chromite and olivine can be used instead of zircon for some foundry applications. Dolomite and spinel refractories can also substitute for zircon in certain high-temperature applications. 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]Unit value based on U.S. imports for consumption from France.
[5]Defined as imports – exports.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.
[7]Excludes U.S. production.

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
metric dry ton (mdt)	= excludes excess free moisture
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
short dry ton (sdt)	= excludes excess free moisture
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 2010 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 2010 (fiscal year 2010) is the period October 1, 2009, through September 30, 2010. 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 2010 refers to material sold or traded from the stockpile in FY 2010.

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—Reserves and Resources

Reserves data are dynamic. They may be reduced as ore is mined and/or the extraction feasibility diminishes, or more commonly, they may continue to increase as additional deposits (known or recently discovered) are developed, or currently exploited deposits are more thoroughly explored and/or new technology or economic variables improve their economic feasibility. Reserves may be considered a working inventory of mining companies' supply of an economically extractable mineral commodity. As such, magnitude of that inventory is necessarily limited by many considerations, including cost of drilling, taxes, price of the mineral commodity being mined, and the demand for it. Reserves will be developed to the point of business needs and geologic limitations of economic ore grade and tonnage. For example, in 1970, identified and undiscovered world copper resources were estimated to contain 1.6 billion metric tons of copper, with reserves of about 280 million metric tons of copper. Since then, about 400 million metric tons of copper have been produced worldwide, but world copper reserves in 2010 were estimated to be 630 million metric tons of copper, more than double those in 1970, despite the depletion by mining of more than the original reserves estimate.

Future supplies of minerals will come from reserves and other identified resources, currently undiscovered resources in deposits that will be discovered in the future, and material that will be recycled from current in-use-stocks of mineral or from minerals in waste disposal sites. Undiscovered deposits of minerals constitute an important consideration in assessing future supplies. USGS reports provide estimates of undiscovered mineral resources using a three-part assessment methodology (Singer and Menzie, 2010). Mineral-resource assessments have been carried out for small parcels of land being evaluated for land reclassification, for the Nation, and for the world.

Reference Cited

Singer, D.A., and Menzie, W.D., 2010, Quantitative mineral resource assessments—An integrated approach: Oxford, United Kingdom, Oxford University Press, 219 p.

Part 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 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.

[1]Based on U.S. Geological Survey Circular 831, 1980.

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.

Inferred Reserve Base.—The in-place part of an identified resource from which inferred reserves are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a deposit and for which there may be no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base, for which there is geologic evidence.

Reserves.—That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as “extractable reserves” and “recoverable reserves” are redundant and are not a part of this classification system.

Marginal Reserves.—That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technological factors.

Economic.—This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Subeconomic Resources.—The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources.—Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. Undiscovered resources may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, undiscovered resources may be divided into two parts:

Hypothetical Resources.—Undiscovered resources that are similar to known mineral bodies and that may be reasonably expected to exist in the same producing district or region under analogous geologic conditions. If exploration confirms their existence and reveals enough information about their quality, grade, and quantity, they will be reclassified as identified resources.

Speculative Resources.—Undiscovered resources that may occur either in known types of deposits in favorable geologic settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources/Reserves.—That part of any resource/reserve category that is restricted from extraction by laws or regulations. For example, restricted reserves meet all the requirements of reserves except that they are restricted from extraction by laws or regulations.

Other Occurrences.—Materials that are too low grade or for other reasons are not considered potentially economic, in the same sense as the defined resource, may be recognized and their magnitude estimated, but they are not classified as resources. A separate category, labeled other occurrences, is included in figures 1 and 2. In figure 1, the boundary between subeconomic and other occurrences is limited by the concept of current or potential feasibility of economic production, which is required by the definition of a resource. The boundary is obviously uncertain, but limits may be specified in terms of grade, quality, thickness, depth, percent extractable, or other economic-feasibility variables.

Cumulative Production.—The amount of past cumulative production is not, by definition, a part of the resource. Nevertheless, a knowledge of what has been produced is important in order to understand current resources, in terms of both the amount of past production and the amount of residual or remaining in-place resource. A separate space for cumulative production is shown in figures 1 and 2. Residual material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

FIGURE 1.—Major Elements of Mineral-Resource Classification, Excluding *Reserve Base* and *Inferred Reserve Base*

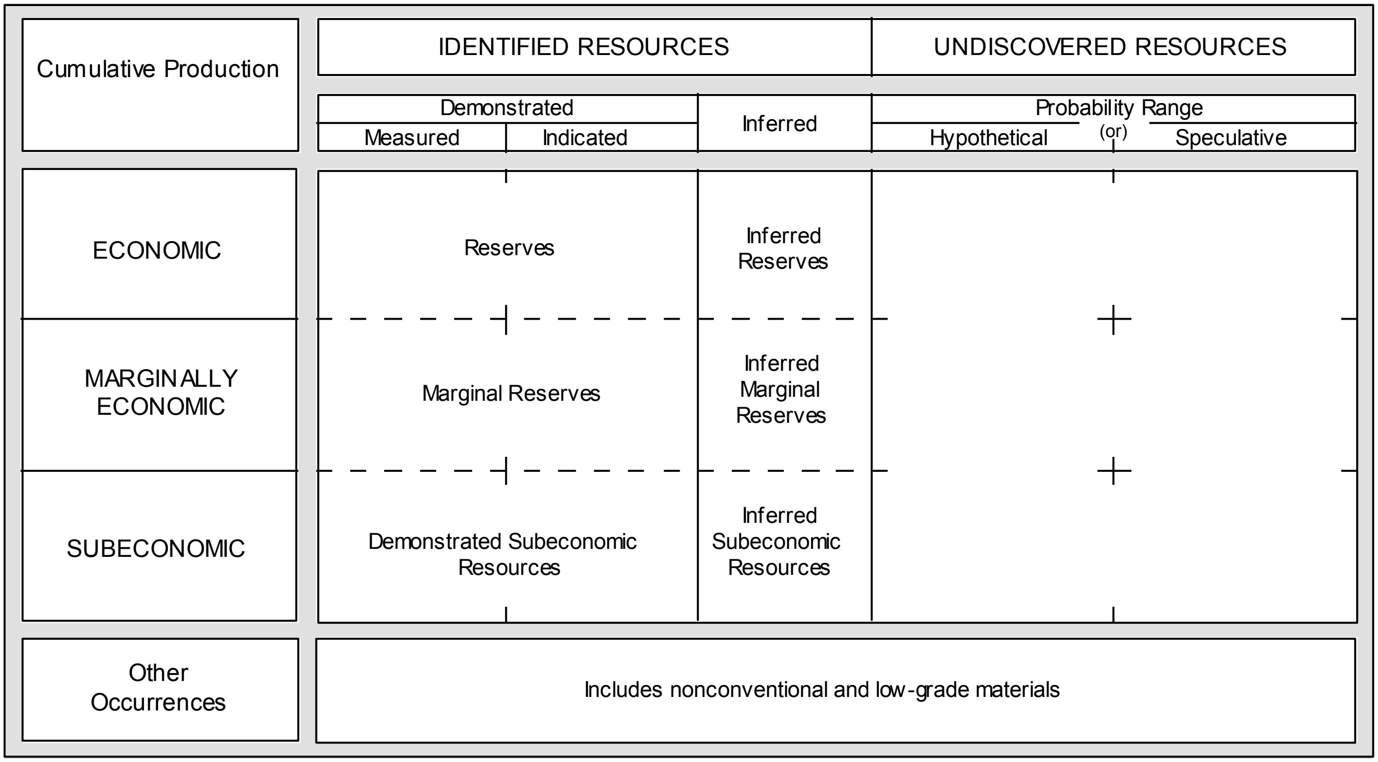
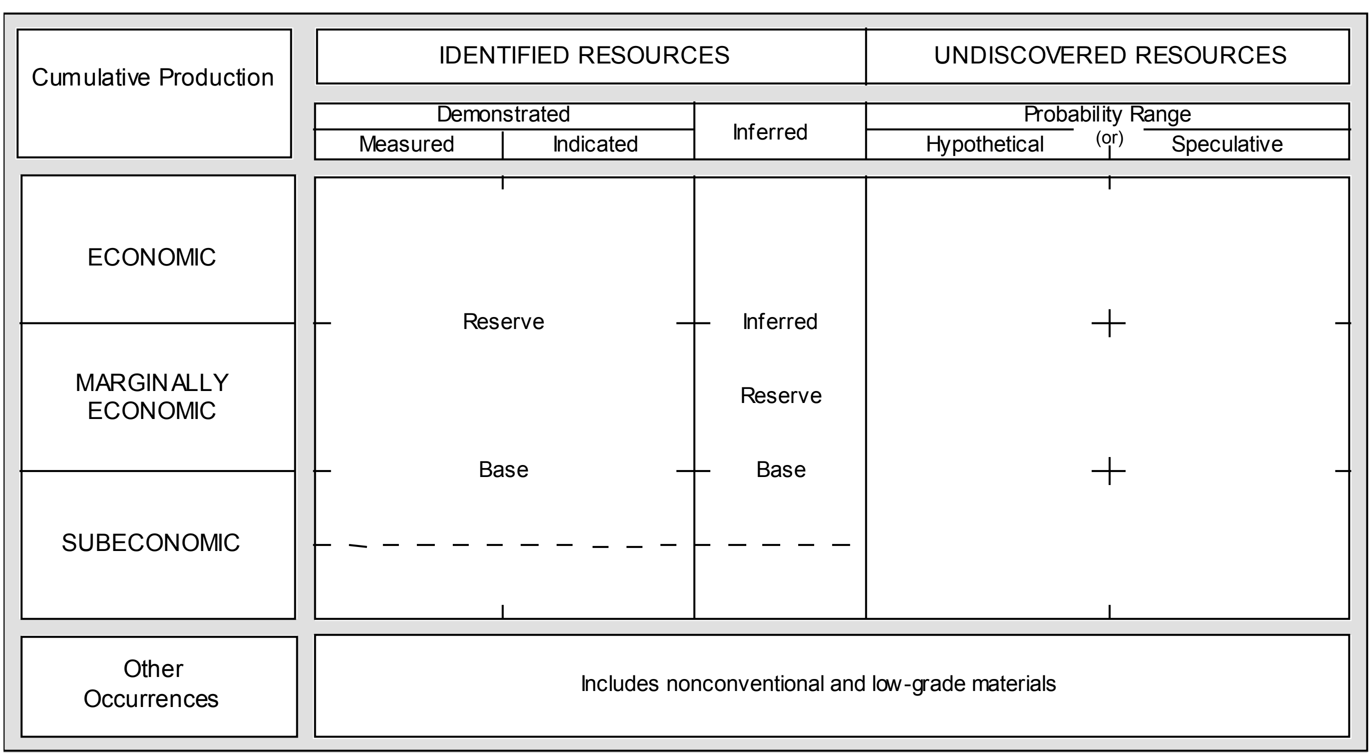


FIGURE 2.—*Reserve Base* and *Inferred Reserve Base* Classification Categories



Part B—Sources of Reserves Data

National reserves information for most mineral commodities found in this report, including those for the United States, is 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 estimates compiled by countries for selected mineral commodities are a primary source of national reserves information. Lacking national assessment information by governments, sources such as academic articles, company reports, presentations by company representatives, and trade journal articles, or a combination of these, serve as the basis for national reserves information reported in the mineral commodity sections of this publication.

A national estimate may be assembled from the following: historically reported reserves information carried for years without alteration because no new information is available, historically reported reserves 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 bases for some reserves 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 to the USGS. Reassessment of reserves is a continuing process, and the intensity of this process differs for mineral commodities, countries, and time period.

Some countries have specific definitions for reserves data, and reserves for each country are assessed separately, based on reported data and definitions. An attempt is made to make reserves consistent among countries for a mineral commodity and its byproducts. For example, the Australasian Joint Ore Reserves Committee (JORC) established the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (the JORC Code) that sets out minimum standards, recommendations, and guidelines for public reporting in Australasia of exploration results, mineral resources, and ore reserves. Companies listed on the Australian Securities Exchange and the New Zealand Stock Exchange are required to report publicly on ore reserves and mineral resources under their control, using the JORC Code (http://www.jorc.org/).

Data reported for individual deposits by mining companies are compiled in Geoscience Australia's national mineral resources database and used in the preparation of the annual national assessments of Australia's mineral resources. Because of its specific use in the JORC Code, the term "reserves" is not used in the national inventory, where the highest category is "Economic Demonstrated Resources" (EDR). In essence, EDR combines the JORC Code categories proved reserves and probable reserves, plus measured resources and indicated resources. This is considered to provide a reasonable and objective estimate of what is likely to be available for mining in the long term. Accessible Economic Demonstrated Resources represent the resources within the EDR category that are accessible for mining. Reserves for Australia in Mineral Commodity Summaries 2011 are Accessible EDR. For more information, see Australia's Identified Mineral Resources 2010 (http://www.ga.gov.au/minerals/mineral-resources/aimr.html).

In Canada, the Canadian Institute of Mining, Metallurgy, and Petroleum (CIM) provides standards for the classification of mineral resources and mineral reserves estimates into various categories. The category to which a resource or reserve estimate is assigned depends on the level of confidence in the geologic information available on the mineral deposit, the quality and quantity of data available on the deposit, the level of detail of the technical and economic information that has been generated about the deposit, and the interpretation of the data and information. For more information on the CIM definition standards, see http://www.cim.org/UserFiles/File/CIM_DEFINITON_STANDARDS_Nov_2010.pdf.

Russian reserves for most minerals, which had been withheld, have been released with increasing frequency within the past 3 or 4 years and can appear in a number of sources, although no systematic list of Russian reserves is published. Russian reserves data for various minerals appear at times in journal articles, such as those in the journal Mineral'nye Resursy Rossii [Mineral Resources of Russia (MRR)], which is published by the Russian Ministry of Natural Resources. Russian reserves data are often published according to the Soviet reserves classification system, which is still in use in many countries of the former Soviet Union, but also at times published according to the JORC system based on analyses made by Western firms. It is sometimes not clear if the reserves are being reported in ore or mineral content. It is also in many cases not clear which definition of reserves is being used, as the system inherited from the former Soviet Union has a number of ways in which the term reserves is defined, and these definitions qualify the percentage of reserves that are included. For example, the Soviet reserves classification system, besides the categories A,B,C1, and C2, which represent progressively detailed knowledge of a mineral deposit based on exploration data, has other subcategories cross-imposed upon the system. Under the broad category reserves (zapasy), there are subcategories that include balance reserves (economic reserves or balansovye zapasy) and outside the balance reserves (uneconomic reserves or zabalansovye zapasy) as well as categories that include explored, industrial, and proven reserves, and the reserves totals can vary significantly depending on the specific definition of reserves being reported.

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	Harold R. Newman
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	Omayra Bermúdez-Lugo
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 (Myanmar)	Yolanda Fong-Sam
Cambodia	Yolanda Fong-Sam
China	Pui-Kwan Tse
East Timor	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
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	Richard M. Levine
Germany[2]	Steven T. Anderson
Greece[2]	Harold R. Newman
Hungary[2]	Mark Brininstool
Iceland	Harold R. Newman
Ireland[2]	Alberto A. Perez
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]	Mark Brininstool
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]	Mark Brininstool
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	Susan G. Wacaster
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