U.S. Geological Survey

MINERAL COMMODITY SUMMARIES 1997

ALUMINUM	FLUORSPAR	MANUFACTURED ABRASIVES	SELENIUM
ANTIMONY	GALLIUM	MERCURY	SILICON
ARSENIC	GARNET	MICA	SILVER
ASBESTOS	GEMSTONES	MOLYBDENUM	SODA ASH
BARITE	GERMANIUM	NICKEL	SODIUM SULFATE
BAUXITE	GOLD	NITROGEN	STONE
BERYLLIUM	GRAPHITE	PEAT	STRONTIUM
BISMUTH	GYPSUM	PERLITE	SULFUR
BORON	HAFNIUM	PHOSPHATE ROCK	TALC
BROMINE	HELIUM	PLATINUM	TANTALUM
CADMIUM	ILMENITE	POTASH	TELLURIUM
CEMENT	INDIUM	PUMICE	THALLIUM
CESIUM	IODINE	QUARTZ CRYSTAL	THORIUM
CHROMIUM	IRON ORE	RARE EARTHS	TIN
CLAYS	IRON AND STEEL	RHENIUM	TITANIUM
COBALT	KYANITE	RUBIDIUM	TUNGSTEN
COLUMBIUM	LEAD	RUTILE	VANADIUM
COPPER	LIME	SALT	VERMICULITE
DIAMOND	LITHIUM	SAND AND GRAVEL	YTTRIUM
DIATOMITE	MAGNESIUM	SCANDIUM	ZINC
FELDSPAR	MANGANESE		ZIRCONIUM

This report is the earliest Government publication to furnish estimates covering 1996 nonfuel mineral industry data. Most of the estimates are based on at least 6 months of data. These reports contain information about the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for over 90 individual minerals and materials. Most data are rounded to no more than 3 significant figures.

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INSTANT INFORMATION

In an effort to facilitate the rapid dissemination of information and publications on minerals and materials, two electronic document dissemination systems are now available for use. One, MINES FaxBack, is a simple-to-operate automated fax response system that operates 24 hours a day, seven days a week. A user needs access to a fax machine with a touch-tone telephone. After calling MINES FaxBack, the requester is guided by a series of voice messages to assist in ordering the desired documents. Information on approximately 90 commodities, 50 States, and 190 countries is now available on MINES FaxBack. MINES FaxBack can be accessed by calling (703) 648-4999, using the touch-tone telephone attached to the user's fax machine.

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KEY PUBLICATIONS

Minerals Yearbook—Annual publications that review the mineral industry of the United States and foreign countries. Contains statistical data on materials and minerals and includes information on economic and technical trends and developments. The Yearbook is published in three volumes: Volume I, Metals and Minerals; Volume II, Area Reports, Domestic; and Volume III, Area Reports, International.

Mineral Industry Surveys—Periodic statistical and economic reports 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, depending on the need for current data. (See Annual Reviews below.)

Annual Reviews—Yearly Mineral Industry Surveys covering the individual commodities, states, and countries appearing in the *Minerals Yearbook*.

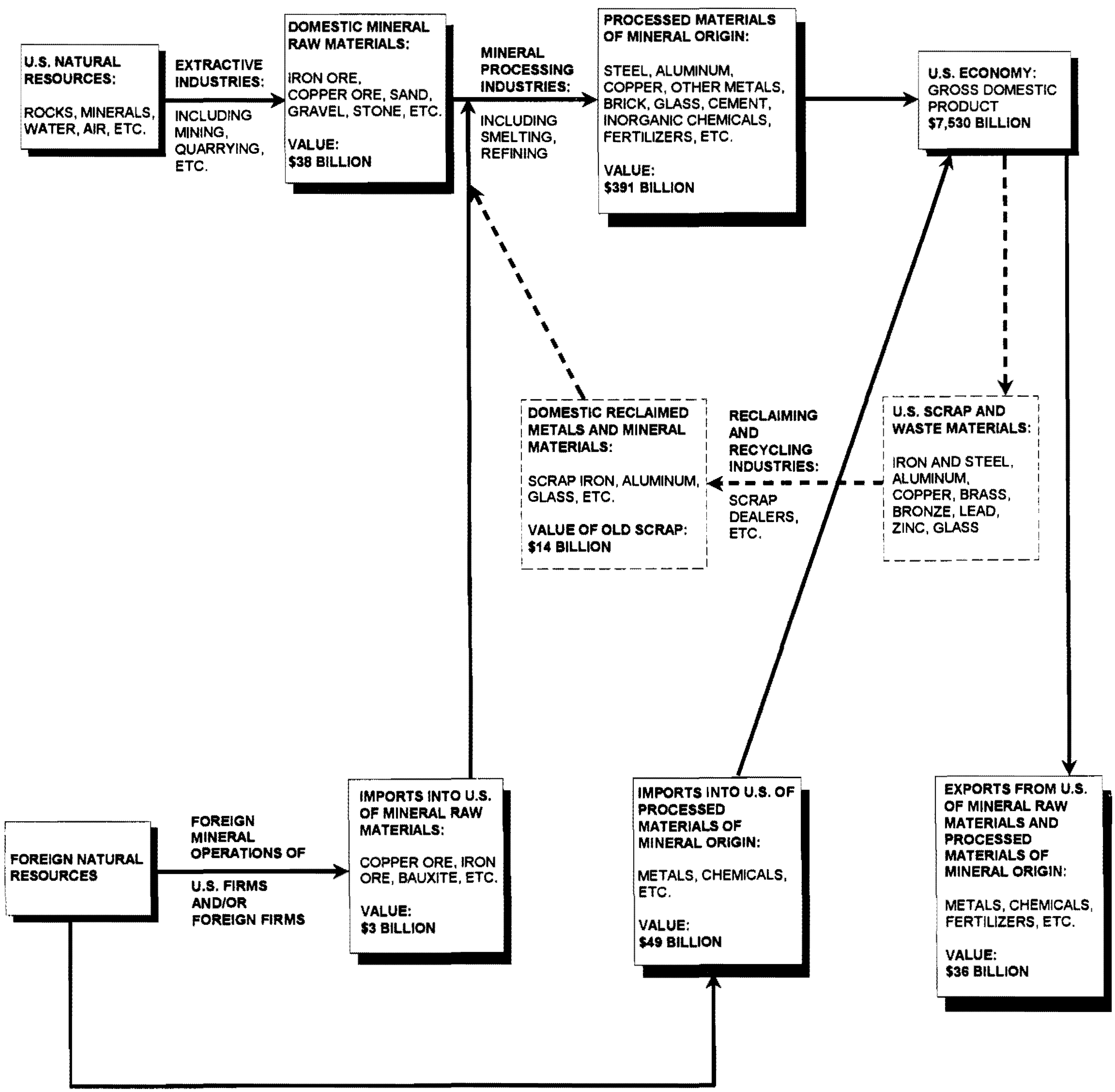
Mineral Perspectives—Reports that present timely data on mineral developments in foreign geographic areas.

WHERE TO OBTAIN PUBLICATIONS

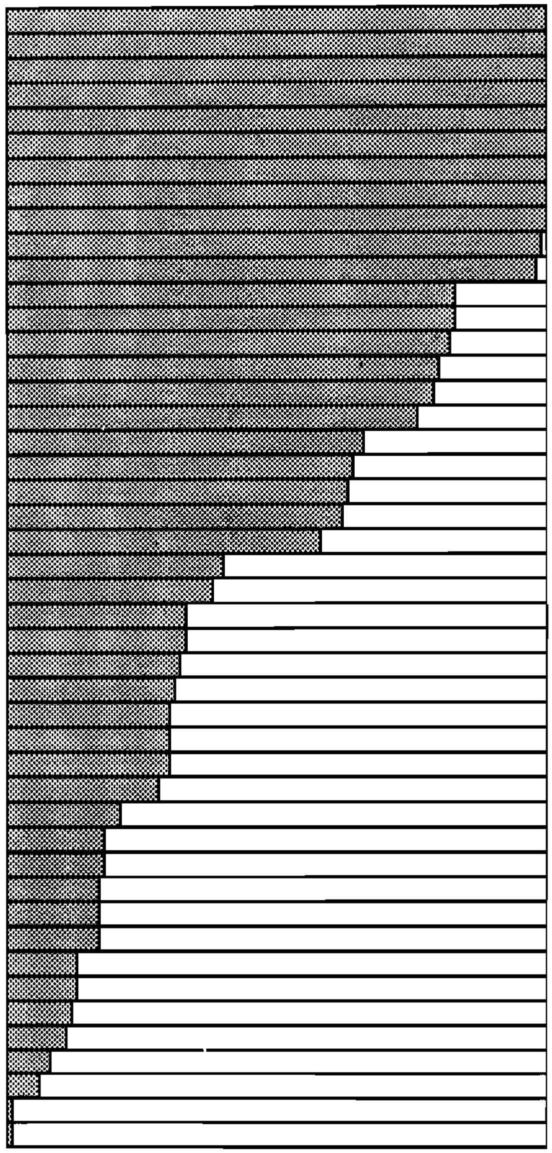
- *Mineral Industry Surveys* can be obtained free of charge by calling (412) 892-4412.
- Special studies such as *Mineral Commodity Summaries* and *Mineral Perspectives* are sold by the U.S. Government Printing Office, Washington, D.C.

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

(ESTIMATED VALUES IN 1996)



1996 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS



COMMODITY	PERCENT	MAJOR SOURCES (1992-95)[1]
ARSENIC	100	China, Chile, Mexico
BAUXITE and ALUMINA	100	Australia, Jamaica, Guinea, Brazil
COLOMBIUM (niobium)	100	Brazil, Canada, Germany
GRAPHITE (natural)	100	Canada, Mexico, China, Madagascar, Brazil
MANGANESE	100	South Africa, Gabon, Australia, France
MICA, sheet (natural)	100	India, Belgium, Brazil, China, Argentina
STRONTIUM	100	Mexico, Germany
THALLIUM	100	Belgium, Canada, Mexico
THORIUM	100	France
FLUORSPAR	99	China, South Africa, Mexico
GEMSTONES	98	Israel, Belgium, India, United Kingdom
COBALT	83	Zambia, Norway, Canada, Finland, Russia
TIN	83	Brazil, Bolivia, Indonesia, China
TUNGSTEN	82	China, Russia, Germany, Bolivia, United Kingdom
TANTALUM	80	Australia, Germany, Thailand, Brazil
CHROMIUM	79	South Africa, Turkey, Russia, Kazakstan, Zimbabwe
POTASH	76	Canada, Belarus, Russia, Israel, Germany
BARITE	66	China, India, Mexico, Morocco, Canada
STONE (dimension)	64	Italy, Spain, India, Canada
NICKEL	63	Canada, Norway, Australia, Russia
IODINE	62	Japan, Chile
PEAT	58	Canada
DIAMOND (dust, grit, and powder)	40	Ireland, China, Russia
SELENIUM	38	Canada, Philippines, Japan, Belgium
CADMIUM	33	Canada, Belgium, Mexico, Germany
ZINC	33	Canada, Mexico, Spain
RARE EARTHS	32	France, China, India, Japan, United Kingdom
SILICON	31	Norway, Brazil, Russia, Canada
ASBESTOS	30	Canada
GYPSUM	30	Canada, Mexico, Spain
MAGNESIUM COMPOUNDS	30	China, Canada, Austria, Mexico, Greece
PUMICE	28	Greece, Ecuador, Turkey
ALUMINUM	21	Canada, Russia, Venezuela, Brazil
NITROGEN (fixed), AMMONIA	18	Trinidad and Tobago, Canada, Former Soviet Union
SALT	18	Canada, Mexico, Bahamas, Chile
IRON and STEEL	17	European Union, Canada, Japan, Brazil, Mexico
IRON ORE	17	Canada, Brazil, Venezuela, Australia, Mauritania
LEAD	17	Canada, Mexico, Peru, Australia
COPPER	13	Canada, Chile, Mexico
SODIUM SULFATE	13	Canada, Mexico
CEMENT	12	Canada, Spain, Mexico, Greece, Colombia
SULFUR	11	Canada, Mexico, Germany, Japan
MICA, scrap and flake (natural)	8	Canada, India, Finland, Japan, Germany
PERLITE	6	Greece
IRON and STEEL SLAG	1	Canada, South Africa
LIME	1	Canada, Mexico

[1] In descending order of importance

Additional commodities for which there is some import dependency include:

Antimony	China, Bolivia, Mexico, South Africa
Bismuth	Mexico, Belgium, China, United Kingdom
Gallium	France, Russia, Germany, Hungary
Germanium	China, United Kingdom, Ukraine, Russia, Belgium
Ilmenite	South Africa, Australia, Canada
Indium	Canada, France, Russia, Italy
Kyanite	South Africa
Mercury	Russia, Canada, Kyrgyzstan, Germany
Platinum	South Africa, United Kingdom, Russia, Germany, Belgium
Rhenium	Chile, Germany, Sweden
Rutile	Australia, South Africa, Sierra Leone
Silver	Mexico, Canada, Peru, Chile
Titanium (sponge)	Russia, Japan, China, Ukraine
Vanadium	South Africa, Canada, Russia, Mexico
Vermiculite	South Africa
Zirconium	Australia, South Africa

SIGNIFICANT EVENTS, TRENDS, AND ISSUES

The Mineral Sector of the U.S. Economy

The U.S. economy and, consequently, the demand for minerals grew at a moderate rate in 1996. Demand for metals, such as steel and copper, was relatively stable or increased compared with 1995. For example, the decline in steel consumed in motor vehicle manufacturing (reflecting lower vehicle sales) during the first three quarters was offset by an increase in steel consumed in construction during the same period. Demand for industrial minerals, especially crushed stone and cement, generally increased compared with the previous year. More detailed information on events, trends, and issues in the mineral and material sector is presented below and in the commodity sections that follow.

Overall Performance

The value of processed materials of mineral origin produced in the United States during 1996 was estimated to be $391 billion, a slight increase (1.2%) compared with 1995. The estimated value of U.S. raw nonfuel minerals production in 1996 was $38 billion, a slight decrease (0.9%) compared with 1995. The value of U.S. minerals production has increased in 30 of the last 36 years.

Total U.S. trade in raw minerals and processed materials of mineral origin was valued at $88 billion in 1996. Imports of processed mineral materials were valued at an estimated $49 billion, while exports of these materials were valued at an estimated $33 billion. Imports of metal ores and concentrates and of raw industrial minerals increased almost 8% to $2.6 billion. Raw minerals exports increased slightly to $3.1 billion. Demand for metals and other mineral-based materials used extensively in motor vehicle manufacturing declined slightly in 1996 because of the estimated 4% decline in automobile manufacture. The motor vehicle manufacturing sector is a major consumer of other mineral-based materials, chiefly aluminum, copper, lead, platinum-group metals, zinc, glass, plastics, and steel.

The domestic construction industry provided for modest growth in minerals demand. The construction sector is the largest consumer of brick clay, cement, sand and gravel, and stone. Road construction expenditures in 1996 maintained the high levels of the last few years as a result of the 6-year Federal highway and mass transit program reauthorized in 1991. Large amounts of asphalt, cement, crushed stone, and sand and gravel are used in road-building. Apartment building construction and new home construction increased in 1996, which had a salutary effect on the consumption of brick clay, cement, sand and gravel, steel, and stone.

Responding to domestic and world demand for fertilizer nutrients, the domestic mineral fertilizer manufacturing sector operated at full capacity, which resulted in a strong demand for fixed nitrogen, phosphate rock, and sulfur. Although global fertilizer nutrient consumption increased substantially, U.S. demand at the farm level, where fertilizers are consumed, was lower because of adverse weather conditions.

The Uruguay Round of the General Agreements on Tariffs and Trade (GATT) became effective January 1, 1995. GATT rules, such as those that address market access affected by tariff and nontariff market barriers, are significant to U.S. minerals producers. For example, Uruguay Round GATT agreements eliminate tariffs (during a 10-year period) on steel imposed by the United States and its trading partners, including the European Union and Japan.

Legislation to reform the Mining Law of 1872 has been considered by the Congress and the Administration for the past several years; however, legislation to reform the Mining Law was not enacted in 1996. The Mining Law gives U.S. citizens and corporations the right to prospect for certain minerals on particular Federal lands and confers the right to file claims that permit the claimants to mine and sell minerals found. The Mining Law does not provide for a royalty payment to the Federal Government for minerals that are mined. Under the Mining Law, claimants also may apply for a patent that transfers ownership of minerals and mineral lands to the claimant.

In fiscal year 1996 the Defense Logistics Agency sold excess mineral materials valued at $391 billion (see "Government Stockpile" in the commodity sections that follow). The Defense Production Act, which provides authority for priorities, allocations, and defense-related supply expansions, is expected to continue.

Outlook

The U.S. economy is expected to continue to grow at a moderate rate for the near term, providing a mild stimulus to the Nation's materials-consuming industries. Inflation is expected to remain low, thus permitting a continuance of low interest rates conducive to an expanding economy. Although motor vehicle sales have declined slightly from their 1994 peak, relatively strong sales are expected to continue because of moderate auto loan interest rates and advantageous monetary exchange rates. The 6-year Federal highway and mass transit

TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

	1992	1993	1994	1995	1996[e]
Total mine production:[1]					
Metals	11,547	10,819	12,111	14,064	12,654
Industrial minerals	20,574	21,177	23,085	24,421	25,510
Coal	20,978	18,767	20,060	19,451	19,289
Employment:[2]					
Coal mining	103	86	90	85	81
Metal mining	42	40	39	41	41
Industrial minerals, except fuels	76	76	78	80	83
Chemicals and allied products	567	573	578	578	567
Stone, clay, and glass products	396	399	411	417	418
Primary metal industries	525	520	537	552	549
Average weekly earnings of production workers:[3]					
Coal mining	755	767	803	828	854
Metal mining	655	659	699	735	759
Industrial minerals, except fuels	550	585	610	624	657
Chemicals and allied products	625	639	654	675	700
Stone, clay, and glass products	490	506	526	534	555
Primary metal industries	587	611	641	643	662

[e]Estimated.

[1]Million dollars.

[2]Thousands of production workers.

[3]Dollars.

Sources: U.S. Geological Survey; U.S. Department of Energy, Energy Information Administration; U.S. Department of Labor, Bureau of Labor Statistics.

program reauthorized at yearend 1991 will continue to provide an impetus for consumption of stone, sand and gravel, and steel through 1997. The demand prospect for mineral fertilizer materials (i.e., fixed nitrogen, phosphate rock, potash, and sulfur) is expected to be robust in the coming year because low world stocks of grains and oilseeds should stimulate increased planting.

Significant International Events [1]

In addition to the further delineation of the world class resource base and development potential of the Voisey's Bay nickel deposit in Labrador, Canada, and the Busang gold deposit in Kalimantan, Indonesia, 1996 was marked by the ongoing capacity of Canadian equity capital markets to generate investments for worldwide exploration and mining development. Canadian capital markets contributed a significant share of more than $3.5 billion (U.S.) in corporate exploration expenditures in 1996 as reported by the Metals Economics Group (MEG) of Halifax, Nova Scotia. The MEG study which, covers the exploration budgets of 223 companies, captures about 76% of total worldwide expenditures. Exploration budgets were distributed regionally as follows: Latin America (27.3%), Australia (18.9%), Canada (13.1%), Africa (11.9%), Asia and the Pacific (11.8%), United States (9.7%), and the rest of the world (7.3%). The areas most benefitting from increased exploration expenditures in 1996, compared with 1995, were Asia and the Pacific, Canada, and Africa.

Global commodity priorities were focused on gold,

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

	1992	1993	1994	1995	1996[e]
Gross domestic product (billion dollars)	6,240	6,550	6,940	7,250	7,530
Capital expenditures (billion dollars):					
All industries	546 [1]	490	550 [p]	594 [p]	603
Manufacturing	174 [1]	134	153 [p]	172 [p]	185
Mining and construction	9 [2]	31	36 [p]	36 [p]	34
Industrial production (1987=100):					
Total index	108	112	118	122	126
Manufacturing	108	112	120	124	128
Stone, clay, and glass products	95	98	102	104	106
Primary metals	102	108	117	119	120
Iron and steel	105	112	119	122	124
Nonferrous metals	98	102	112	115	115
Chemicals and chemical products	114	115	121	125	129
Mining	99	98	100	100	101
Metals	164	162	163	169	165
Coal	108	103	113	113	114
Oil and gas extraction	93	93	93	92	93
Stone and earth minerals	99	101	107	112	116
Capacity utilization (percent):[3]					
Total industry	80	81	84	84	83
Mining	87	87	90	89	90
Metals	87	84	85	87	84
Stone and earth minerals	84	85	89	91	91
Housing starts (thousands)	1,200	1,290	1,460	1,350	1,500
Automobile production (thousands)	5,660	5,980	6,610	6,350	6,050
Highway construction, all public, expenditures (billion dollars)	29	31	33 [p]	35 [e]	36

[e]Estimated. [p]Preliminary.

[1]From survey of new plant equipment and expenditures.

[2]From survey of new plant equipment and expenditures, mining industry only.

[3]1996 estimates based on seasonally adjusted figures.

Sources: U.S. Department of Commerce, Federal Reserve Board, American Automobile Manufacturers' Association, and U.S. Department of Transportation.

diamonds, nickel, steel, aluminum, cobalt, and base-metals, the latter despite the effect of the copper trading scandal on copper markets. The demand for industrial minerals and construction materials was fueled by new economic growth in Asia and Latin America, along with the need to rebuild aging infrastructure in North America and Europe. Trends in privatization of state-owned mining and processing enterprises in Europe, Asia, Africa, and Latin America continued with more willingness of governments to take on private joint-venture partners in countries where the national sentiment was to maintain ownership of natural resources.

Africa

Africa witnessed a major resurgence in mineral exploration and mineral project planning in 1996. Diamond exploration and development continued in South Africa, Botswana, Namibia, Angola, and Zaire, while the gold rush continued in Africa, especially in Burkina Faso, Eritrea, Ethiopia, Ghana, Mali, Niger, Tanzania, and Zaire. Canadian, South African, and Australian companies were leading the current exploration activity in Africa. The Central African Republic, Côte d'Ivoire, Guinea, and Senegal were also experiencing increased interest by international investors in their gold resources. Gold output continued to surpass old production records in Ghana and Zimbabwe. Other new activity in Africa's mineral industry included rutile exploration at Akonolinga in Cameroon, the investigation of the Biankouma-Touba nickel deposit in Côte d'Ivoire, and the development of new bauxite deposits and the resumption of diamond exploration in Guinea. In Kenya, the only fluorspar producer was privatized and a Canadian firm was evaluating coastal ilmenite sands. Processing operations to recover cobalt from stockpiled pyrite concentrates at Kilembe in Uganda were underway. Mining began at the Hartley platinum mine in Zimbabwe during March 1996. Offshore Africa showed significant petroleum exploration activity. New development occurred off Cameroon, Côte d'Ivoire, Equatorial Guinea, Guinea-Bissau, Nigeria, and Senegal. The development of Chad's Doba Basin and the utilization of flared natural gas in Nigeria were progressing rapidly.

At approximately 490 tons, gold production in South Africa in 1996 was the lowest in 40 years. The depreciating value of the South African rand helped offset higher internal gold production costs and lower dollar export earnings. The six major South African mining houses continued both their corporate "unbundling" and their diversification of investments outside of South Africa, with a particular eye to new exploration and development opportunities elsewhere in Africa. As part of Black Economic Empowerment initiatives in South Africa, two African-owned mining-related commercial firms were established in 1996, stimulated by offers to purchase unbundled Anglo-American assets. In the policy arena, the South African Government was expected to release its Green Paper on Mining by yearend. Expectations were that it would promote a positive environment for growth and employment in the mining sector.

The Zambia Privatization Agency issued an international tender to prospective investors to buy the mining and electricity distribution assets of the national mining corporation. A company formed by former employees of the corporation acquired 100% ownership of the closed Kabwe lead-zinc mine and announced plans to restart production initially from old tailings.

Civil war adversely affected mining in Liberia, Rwanda, Somalia, and Sudan; however, in the Central African Republic, diamond production continued despite repeated attempted coups. In Sierra Leone, the rutile mine remained closed in 1996 but reported little external damage to major equipment resulting from insurgent actions at the site in January 1995. Despite political uncertainties, most of 1996 saw increased interest by foreign investors in the minerals sector of Zaire. A Canadian firm acquired a 72% interest in the gold mines and properties of a Zairian firm and had announced plans for a $20 million development program. However, the Mobale gold mine near Kamituga in eastern Zaire was heavily damaged, and normal supply routes through Bukavu were disrupted during fighting between the Zaire army and local insurgents late in the year.

In north Africa, private investment has contributed significantly to the mining and metallurgical segments of the Egyptian and Moroccan economies. A number of major new industrial projects in cement, fertilizers, metals, and petrochemicals attracted private investment capital. In Egypt, the sole aluminum producer reduced Government equity in favor of private capital by 20%, while continuing its expansion program to raise annual smelter capacity by 60,000 tons in 1997 to a total annual capacity of 240,000 tons. The country's iron and steel producer has embarked on an expansion and modernization program costing $350 million. The expansion is scheduled for completion in 1997. Morocco and Western Sahara host over 50% of the world's phosphate rock reserves and are the world's largest phosphate rock exporters. The Sidi Chennane mine became operational in 1996 and should have an annual capacity of 5 million tons by 1998.

Middle East

In the Middle East, aluminum smelter expansion activities have progressed on schedule in Bahrain and in Dubai, United Arab Emirates. The expansion of Bahrain's aluminum smelter is expected to be operational by May 1997, and additional capacity at Dubai's aluminum smelter is scheduled for completion by September 1997. A U.S.-based firm began commercial exploitation of the Al Masane polymetallic deposit in Saudi Arabia. The deposit is estimated by ASDC to total 7.2 million tons containing 5.3% zinc, 1.42% copper, 40 grams per ton

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1996 [1]

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$735,000	17	1.93	Cement (portland), stone (crushed), lime, sand and gravel (construction), clays.
Alaska[2]	523,000	25	1.37	Zinc, lead, gold, sand and gravel (construction), stone.
Arizona	3,530,000	1	9.25	Copper, sand and gravel (construction), cement (portland), molybdenum, lime.
Arkansas	453,000	29	1.19	Stone (crushed), bromine, cement (portland), sand and gravel (construction), gemstones.
California	2,840,000	3	7.43	Sand and gravel (construction), cement (portland), boron minerals, gold, stone (crushed).
Colorado	528,000	23	1.38	Sand and gravel (construction), cement (portland), molybdenum, stone (crushed), gold.
Connecticut	103,000	44	0.27	Stone (crushed), sand and gravel (construction), stone (dimension), clays, gemstones.
Delaware[2]	10,700	50	0.03	Sand and gravel (construction), magnesium compounds, gemstones.
Florida	1,540,000	8	4.03	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), clays.
Georgia	1,720,000	6	4.51	Clays, stone (crushed), cement (portland), stone (dimension), sand and gravel (construction).
Hawaii[2]	112,000	43	0.29	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), gemstones.
Idaho	411,000	32	1.08	Gold, phosphate rock, molybdenum, sand and gravel (construction), silver.
Illinois	777,000	16	2.04	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), clays.
Indiana	617,000	21	1.62	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Iowa	490,000	28	1.28	Stone (crushed), cement (portland), sand and gravel (construction), gypsum, lime.
Kansas	524,000	24	1.37	Cement (portland), helium (Grade-A), stone (crushed), salt, sand and gravel (construction).
Kentucky	452,000	30	1.19	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays.
Louisiana	428,000	31	1.12	Salt, sulfur (Frasch), sand and gravel (construction), stone (crushed), sand and gravel (industrial).
Maine	73,100	45	0.19	Sand and gravel (construction), cement (portland), stone (crushed), cement (masonry), peat.
Maryland[2]	324,000	36	0.85	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts	191,000	39	0.50	Sand and gravel (construction), stone (crushed), stone (dimension), lime, clays.
Michigan	1,510,000	9	3.95	Iron ore (usable), cement (portland), sand and gravel (construction), magnesium compounds, stone (crushed), salt.

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1996 [1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Minnesota	$1,800,000	4	4.72	Iron ore (usable), sand and gravel (construction), stone (crushed), sand and gravel (industrial), stone (dimension).
Mississippi	140,000	42	0.37	Sand and gravel (construction), clays, cement (portland), stone (crushed), sand and gravel (industrial).
Missouri	1,250,000	10	3.28	Lead, stone (crushed), cement (portland), lime, zinc.
Montana	523,000	26	1.37	Gold, copper, cement (portland), zinc, sand and gravel (construction).
Nebraska	147,000	41	0.39	Cement (portland), sand and gravel (construction), stone (crushed), clays, cement (masonry).
Nevada	3,200,000	2	8.37	Gold, silver, sand and gravel (construction), copper, diatomite.
New Hampshire[2]	43,900	47	0.11	Sand and gravel (construction), stone (crushed), stone (dimension), clays, gemstones.
New Jersey[2]	222,000	38	0.58	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.
New Mexico	963,000	12	2.52	Copper, potash, sand and gravel (construction), cement (portland), stone (crushed).
New York	891,000	15	2.33	Stone (crushed), cement (portland), salt, sand and gravel (construction), zinc.
North Carolina	731,000	18	1.92	Stone (crushed), phosphate rock, lithium minerals, sand and gravel (construction), sand and gravel (industrial).
North Dakota	30,300	49	0.08	Sand and gravel (construction), lime, clays, sand and gravel (industrial), gemstones.
Ohio	934,000	13	2.45	Stone (crushed), salt, sand and gravel (construction), lime, cement (portland).
Oklahoma	372,000	34	0.98	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), gypsum.
Oregon	251,000	37	0.66	Stone (crushed), sand and gravel (construction), cement (portland), lime, diatomite.
Pennsylvania[2]	1,040,000	11	2.72	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Rhode Island[2]	31,900	48	0.08	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), gemstones.
South Carolina	495,000	27	1.30	Cement (portland), stone (crushed), gold, sand and gravel (construction), cement (masonry).
South Dakota	353,000	35	0.93	Gold, cement, (portland), sand and gravel (construction), stone (crushed), stone (dimension).
Tennessee	648,000	19	1.70	Stone (crushed), zinc, cement (portland), sand and gravel (construction), clays.
Texas	1,780,000	5	4.67	Cement (portland), sand and gravel (construction), stone (crushed), magnesium metal, lime.
Utah	1,560,000	7	4.09	Copper, gold, magnesium metal, sand and gravel (construction), molybdenum.
Vermont[2]	66,800	46	0.17	Sand and gravel (construction), stone (dimension), stone (crushed), talc and pyrophyllite, gemstones.

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1996 [1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Virginia	$529,000	22	1.39	Stone (crushed), cement (portland), sand and gravel (construction), lime, kyanite.
Washington	626,000	20	1.64	Sand and gravel (construction), magnesium metal, cement (portland), stone (crushed), gold.
West Virginia	191,000	40	0.50	Stone (crushed), cement (portland), sand and gravel (construction), lime, salt.
Wisconsin	399,000	33	1.04	Stone (crushed), sand and gravel (construction), copper, sand and gravel (industrial), lime.
Wyoming	918,000	14	2.41	Soda ash, clays, helium (Grade-A), cement (portland), stone (crushed).
Undistributed	145,000	XX	0.38	
Total	38,200,000	XX	100.00	

XX Not applicable.

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

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

silver, and 1.19 grams per ton gold.

Asia and the Pacific

In October 1996, the Australian Government proposed legislative amendments to its 3-year-old Native Title Act (NTA). Under the proposals, a Federal minister could override Aboriginal concerns if these threatened a project of major economic benefit to Australia. The manager-operator of the Argyle diamond mine in Western Australia, did not renew its marketing agreement with the Central Selling Organization upon the expiration of the contract. Argyle, the world's biggest single-mine producer of diamond with output equivalent to about 40% of world production, now sells all of its rough (uncut) production through its European Sales Office in Antwerp, Belgium. The Australian Government ended its 12-year-old policy of restricting uranium production to three sites following the Federal election in March 1996 and the installation of the Liberal-National Party Coalition Government. In China, the Standing Committee of the 8th National People's Congress approved the amendments to the Mineral Resources Law on August 29, 1996, taking effect on January 1, 1997. The amendments strengthen the State ownership of China's mineral resources and allow the local governments responsibility for guaranteeing exploration and exploitation of mineral resources. The amendments also allow private enterprises and Sino-foreign joint-venture companies to participate in the exploration and exploitation of mineral resources under the supervision of the State in China. Also, on August 29, 1996, the Committee approved the Coal Law that took effect on December 1, 1996. The Coal Law stated that all coal resources in China continued to be the property of the State and will remain so regardless of any changes in the surface land ownership or the right of use of the land where the coal is located. The State protects lawful exploration rights and mining rights from any encroachment and ensures against any interference and disruption of operations in mining areas and exploration sites. The Coal Law also confirms that mining rights cannot be sold or leased. The Ministry of Coal Industry is responsible for administrating and enforcing the Coal Law. The Indian Government announced in October 1996 that applications for foreign investment of up to of 50% in a particular project or company in the minerals industry would be given automatic approval. However, in the case of diamonds and other precious stones, gold, and silver, the Foreign Investment Promotion Board will continue to consider each application on a case-by-case basis. India's largest private aluminum company began boosting capacity at its Renukoot Smelter in Uttar Pradesh State.

Daily ore throughput and copper and gold production at the Grasberg mine in Irian, Jaya, Indonesia was planned to be increased; a prefeasibility study supported mine expansion. The construction of Indonesia's first copper smelter at Gresik near Surabaya, Java began in July.

Reserve increases were announced at the major Busang gold find in East Kalimantan, Indonesia. In December 1996, measured and indicated reserves of 23 million ounces of gold and an additional inferred resource of 34 million ounces of gold were reported, making this one of the world's larger gold deposits.

In Japan, on June 13, 1996, a major Japanese trading company, announced that it incurred a $1.8 billion loss during the past 10 years as a result of unauthorized copper trading activity by a senior official in its nonferrous metals division. The huge copper trading loss was raised to $2.6 billion in August 1996. The news occupied the world's financial headlines and caused the price of copper to drop to its 2-year low in mid-1996. In December, three major copper producers announced plans to expand their domestic smelting capacity by 10% to 20% by the year 2000 to meet the growing demand for copper in the Southeast Asian region. In 1996, several major Japanese copper producers also increased their investment in overseas mine development in Canada and Chile to secure the raw materials required for their domestic smelters.

In the Philippines, an agreement was approved in March 1996 for a 50-year lease agreement covering the Carmen copper mine and concentrator in the central island of Cebu. An investment of $65 million to rehabilitate and reopen the mine within 2 years was provided. The Philippine Government's Asset Privatization Trust announced on May 7, 1996, that it was selling its Nonoc nickel mine, smelter, and refinery on Nonoc Island in the southern Philippines to a consortium of Australian, British, Filipino, and Hong Kong investors, for $333 million. In addition to rehabilitating the nickel smelter and refinery, the consortium was planning to construct, within 16 months, a 1,360-ton-per-year cobalt refinery. The final agreement between the Government, landowners, and the Australian firm that will operate the mine, for the mining of the Gold Ridge gold deposits on Guadalcanal Island, Solomon Islands, was signed in October 1996, in the National Parliament in Honiara.

Europe and Central Eurasia

The European Union (EU) increased from 12 to 15 countries, when Austria, Finland, and Sweden formally became members. After a period of low growth and recession in most areas, Western Europe's economic development was moving ahead. There continued to be an increase in investment flows in 1996. The modest economic growth in major EU countries resulted in increased consumption of minerals, allowing prices to rise to profitable levels for producers of some commodities. Efforts were continuing by various EU nations toward (1) privatization of nationalized mining companies and State-owned mineral enterprises, (2) liberalization of investment laws allowing foreign ownership of mining companies, and (3) increased repatriation of profits. Government support for high-cost production was withdrawn or significantly reduced. Various incentives, including tax relief, revised regulations, and less government involvement have also been offered to encourage exploration.

In Western Europe, exploration for gold, bauxite, copper, lead, and zinc continued. Discoveries of gold mineralization in southwest Greenland; southern Sardinia, Italy; east-central Portugal; and the West Central Highlands of Scotland, United Kingdom, encouraged further exploration efforts. Also, the discovery of diamondiferous kimberlites in West Greenland has increased exploration in that area. Exploration for copper in France and Portugal and lead and zinc in Ireland and Spain continued. Zinc production began at the Mulikkorame mine near Pyhajarvi Finland in mid-1996.

In 1996, the countries of Eastern Europe and Central Europe developed market economy systems through the denationalization of state-owned and -operated commercial enterprises. The rapid decline of industrial production that occurred in this region from 1990-94, following the dissolution of central economic planning and attendant organizations, such as the Council for Mutual Economic Assistance, largely had abated by yearend 1994. In both 1995 and 1996, the production of some sectors of the minerals industries in these countries stabilized and in some cases displayed growth (crude steel generally and refined copper in Poland). In 1996, a marked degree of stability was discernible in the republics of the former Yugoslavia, owing chiefly to the effective implementation of the current peace accords. Foreign investment in Eastern and Central Europe continued to focus on two principal areas: gold exploration and mine development and acquisition of cement plants and construction materials enterprises. Cement plants and associated limestone and gypsum quarries in the Czech Republic, Hungary, Poland, and Slovakia continued to attract Western European investors.

In the countries of the former Soviet Union (FSU), 1996 saw a continuation of the trend for the recovery of mineral production and the reversal of the steep decline in mineral output that followed the breakup of the FSU. In 1996, net increases or decreases in mineral production in the FSU occurred at a slower rate than from 1992 to 1994 when the decrease was often precipitous. The rate of recovery for mineral production varied from country to country and sector to sector.

Again, in 1996, operation of mining enterprises continued to be driven by the need to generate hard currency through exports, irrespective of other operating or market considerations. There has been no significant increase in domestic FSU mineral consumption, which had fallen dramatically after the breakup. Some of the worst performing mineral industry sectors were those that produced mineral products mainly for domestic consumption and those that had limited export markets.

Processes to convert the mineral industries of the FSU countries to a market economy continued in the form of privatization, foreign investment, and foreign participation in the management of mineral industries. The FSU countries continued to try to attract foreign investment in their mineral sectors. As in previous years, Western participation took a number of forms with the most prominent being investment in the development of gold and oil deposits; metals trading; toll smelting; supplying equipment and raw materials to enterprises in return for output; purchasing shares of enterprises; and providing managerial and technical expertise. Kazakstan took the lead in soliciting the aid of foreign management, having turned over the majority of its major mining and metallurgical industries to foreign managers for a limited number of years. A number of other FSU countries followed suit on a more limited scale. In addition to increased reliance on expatriate managers, the FSU countries continued reorganizing domestic governmental structures involved in managing and directing the mineral sector and related activities. For example Russia went through a major reorganization of its governmental departments. The majority of Russian government agencies involved in mineral exploration, nonfuel mineral production, and environmental issues were abolished. Their functions were transferred to the newly created Russian Ministries for Industry and Natural Resources and the State Committee for the Protection of the Environment.

Latin America and Canada

Privatization of state-owned mineral firms, and joint ventures between foreign investors and domestic private and public sectors in Latin America, created new and changing capital investment flows. According to the United Nations Economic Commission for Latin America and the Caribbean, private capital flows to the region in 1996 approached $55 billion. From 0.7% growth in 1995, the combined regional gross domestic product (GDP) grew about 3% in 1996 and was projected to increase about 4.3% in 1997. According to the Metals Economic Group, $963 million was spent on mineral exploration in Latin America in 1996 with Chile and Peru being the most actively explored. During 1996, more than 60 junior exploration and mining companies were active throughout the length of the Andean chain. As a result of changes to the petroleum laws of Argentina, Bolivia, Chile, and Peru, there was increased interest in exploration by international oil firms.

Despite a plunge of 50% in the value of the peso versus the dollar and an overall sag in the economy and the GDP, Mexico's mineral industry continued to maintain a position of prominence in production and exports, particularly in the metals sector. A combination of improvement of world metals prices and the peso devaluation enabled Mexican companies to sell into the world markets at enhanced prices and significantly reduced mining and processing costs, thus increasing export revenues and net income. Production of industrial minerals, mainly construction materials, suffered somewhat because of lowered demand caused by the economic recession. Although privatization in the mining sector with increased foreign investment continued, the Government unexpectedly canceled the proposed sale of several petrochemical plants it had offered to foreign buyers.

The signing of the Cuban Liberty and Solidarity (Libertad) Act, also known as the Helms-Burton Law, by the U.S. President in March, affected the minerals industry directly because of the importance of nickel production and trade to the Cuban economy and because of the increased interest by foreign exploration companies in Cuba, which resulted from its changes in foreign investment laws and mining regulations. Elements of the U.S. law, which allows U.S. citizens whose properties were expropriated by the Cuban Government the right to sue in U.S. courts any foreign company presently using such properties and which denies foreign company officials entry into U.S. territory, generated criticism from other nations. In November, the World Trade Organization agreed to hear the European Union's complaint that the law violates open trade rules. Also in November, Canada passed legislation that allows Canadian companies sued in U.S. courts to counter-sue in Canadian courts to recover damages resulting from the Helms-Burton Act. The President of the United States suspended the implementation of the right to sue in U.S. courts at yearend.

Central American countries wrestled with problems ranging from the restoration of political stability to the establishment of workable mining laws and privatization. The interest of foreign mining companies in each Central American country increased almost as fast as the respective countries promulgated workable mining laws. Unusually large copper deposits were further delineated in Panama, and exploration for gold was on the increase in most of the countries of the region.

In 1996, the South American trading bloc MERCOSUR (Argentina, Brazil, Paraguay, and Uruguay) aggressively sought Chile's accession to MERCOSUR. Currently, the two economic blocs, MERCOSUR and the ANDEAN PACT (Bolivia, Colombia, Ecuador, Peru, and Venezuela) are negotiating a free trade accord.

In Argentina, privatization of business ownership and operations continued. New investments in Argentina, aided by Federal and provincial investment laws that encouraged mineral exploration and development, were directed toward copper, gold, crude oil, natural gas, petrochemicals, and gas pipelines. By yearend construction was completed on more than one-half of the $903 million Bajo de la Alumbrera project. A slurry pipeline is being built to help export 800,000 tons of copper concentrates a year.

Bolivia has recently undertaken significant legal and regulatory reforms, including the enactment of a single corporate income tax rate of 25%. A new environmental law was put in place to balance the need for improved environmental protection with the imperative of sustainable economic development. Bolivia is also nearing the completion of a revised mining code ensuring equal treatment of foreign and domestic investors; providing maximum legal and technical protection to holders of mineral rights; and facilitating and motivating exploration, mineral development, and profitable mineral production. The Bolivian Government has established two programs to encourage domestic and foreign entrepreneurs to invest in the mining sector. The first allows for the transfer of ownership and management of state-owned corporations to private shareholders, via a 50/50 joint venture, referred to as "capitalization" between investors and Bolivian citizens. The second is aimed at attracting foreign investment into the mineral fuels sector, via the Bolivia-Brazil energy integration agreement.

The state-owned steel industry of Brazil was privatized in 1996 and the petrochemical and mining sectors proceeded toward privatization. New projects in the petroleum sector, however, will be open to joint ventures. The state-owned mining giant is scheduled for privatization in early 1997.

The Chilean state-owned copper mining corporation was proceeding with the materialization of its principal projects in its 1994-2000 6-year-plan including the Radomiro Tomic mine and the expansion of the Andina and El Teniente's Esmeralda project. Radomiro Tomic is expected to be in full production by the start of 1998, adding 150,000 tons of copper cathodes to the company's total production. Andina required an investment of $322 million to increase production by 111,000 tons annually, and the Esmeralda project required a $205 million investment to allow the El Teniente Division to maintain a production level of 350,000 tons per year.

During 1996, Peru continued with its privatization, capitalization, and joint-venture programs. Peru's largest and world's fourth largest zinc producer, sold its Casapalca polymetallic unit for $12.7 million to a Brazilian company, which offered to commit an additional $100 million to upgrade the existing mine and concentrating plant.

Since the early 1990's, Venezuela has taken steps to open petroleum investment to the private sector. In January 1996, the Government awarded eight new exploration and production concessions of light to medium crude to foreign private companies. The concessions and other opportunities for foreign investment in the sector, such as awards of additional marginal fields and participation in the petrochemical and heavy oil projects, are tied to the state-owned petroleum company's plans to double its petroleum, condensate, and natural gas output by 2005 through joint ventures and other associations. Venezuela has embarked on privatization efforts with limited success in the past, but continued with divestment plans in sectors such as steel and ferroalloys.

A positive year for the Canadian economy saw some uneven spots in Quebec and the Maritime Provinces, where unemployment remained unacceptably high. However, all expectations were for a strong 1997 with foreign investment continuing to support the boom in mining and resource sectors. With interest rates the lowest they have been since World War II and the Federal deficit almost gone, Canada seemed poised for what various international studies have predicted would be the best economic performance of any developed nation in 1997. Benefits from the North American Free Trade Agreement (NAFTA) plus the general expansion of world trade are pointing toward earnings abroad exceeding expenditures for the first time since the mid-1980's. Late in 1996, Canada signed a trade treaty with Chile, eliminating tariffs on the greater part of the $0.5 billion yearly trade between the two countries and paving the way for Chile to join Canada, the United States, and Mexico in the NAFTA. Overall, total 1996 exploration expenditures in Canada ($461.8 million) were second only to those in Australia ($665.9 million).

Many Canadian mining companies, however, continued to turn to Latin America for exploration and development because of less restrictive laws and legal challenges than in their own country. Nonetheless, the mining industry within Canada was spurred by higher prices for base metals, and also by some conspicuous exploration successes, such as the Voisey's Bay nickel-copper-cobalt deposit. Argentia, Newfoundland, was selected as the site for the smelter/refinery complex to process the nickel and cobalt concentrates produced at Voisey's Bay.

The Government of Quebec reported that its own geologists found gossans near Sept-Iles grading in the ranges of 1.4% to 2.2% nickel, 1.5% to 5.9% copper, and 0.12% cobalt in an 800-square-kilometer area. In British Columbia, development of the new Huckleberry open pit copper-molybdenum-gold-silver mine continued. Elsewhere, near Gander, Newfoundland, development of what is thought to be the largest antimony mine outside China also continued. A milestone was passed when the Canadian Government's cabinet gave full approval and support to the Lac de Gras diamond project in the Northwest Territories near the Arctic Circle. In Manitoba, the country's largest nickel-producing firm continued its expansion of mines and facilities at the Thompson Nickel Belt.

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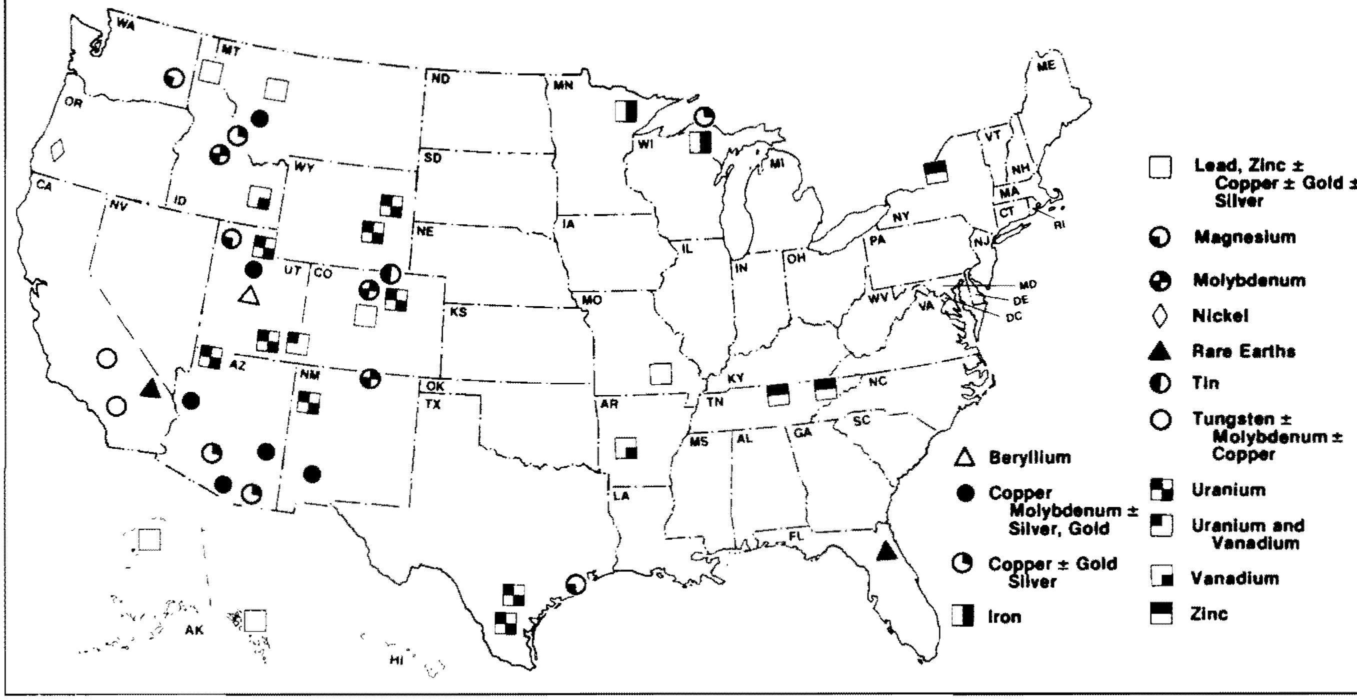
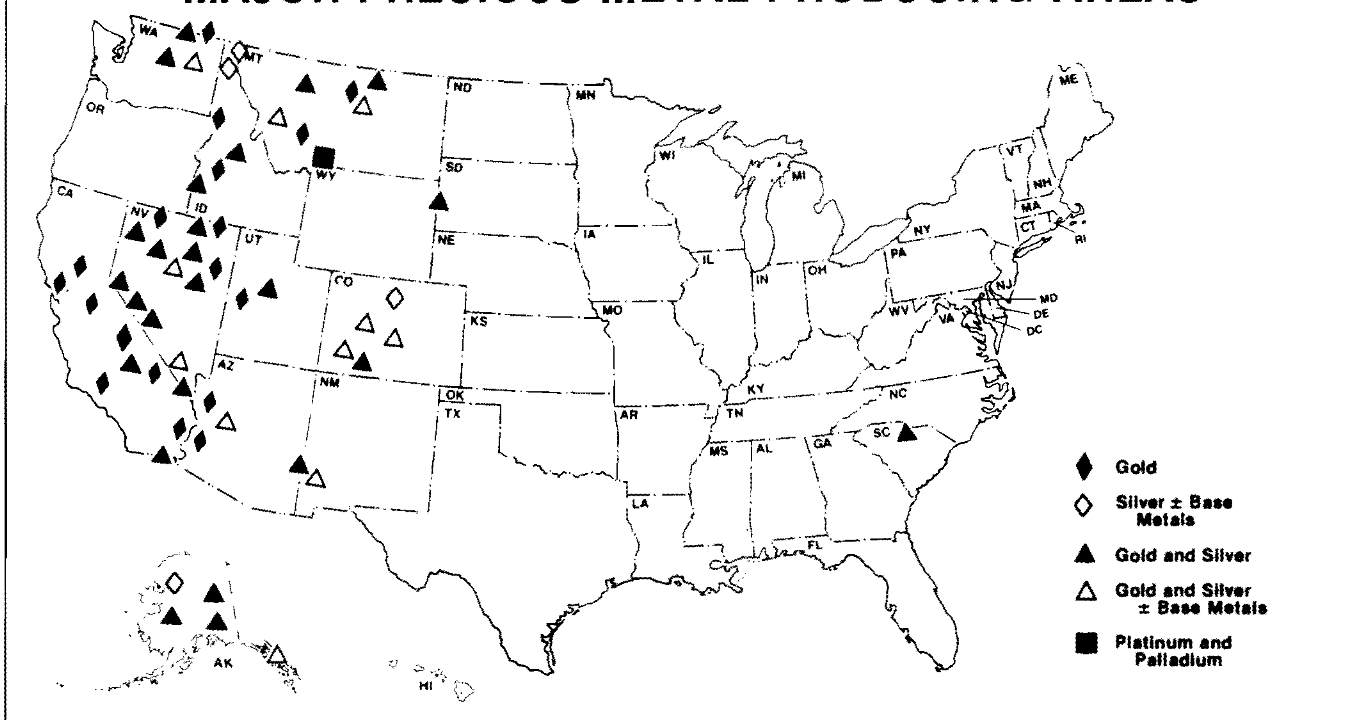
[1]The regimes of some countries mentioned in this volume may not be recognized by the U.S. Government. The information contained herein is technical and statistical and is not to be construed as conflicting with or contradictory to U.S. foreign policy.

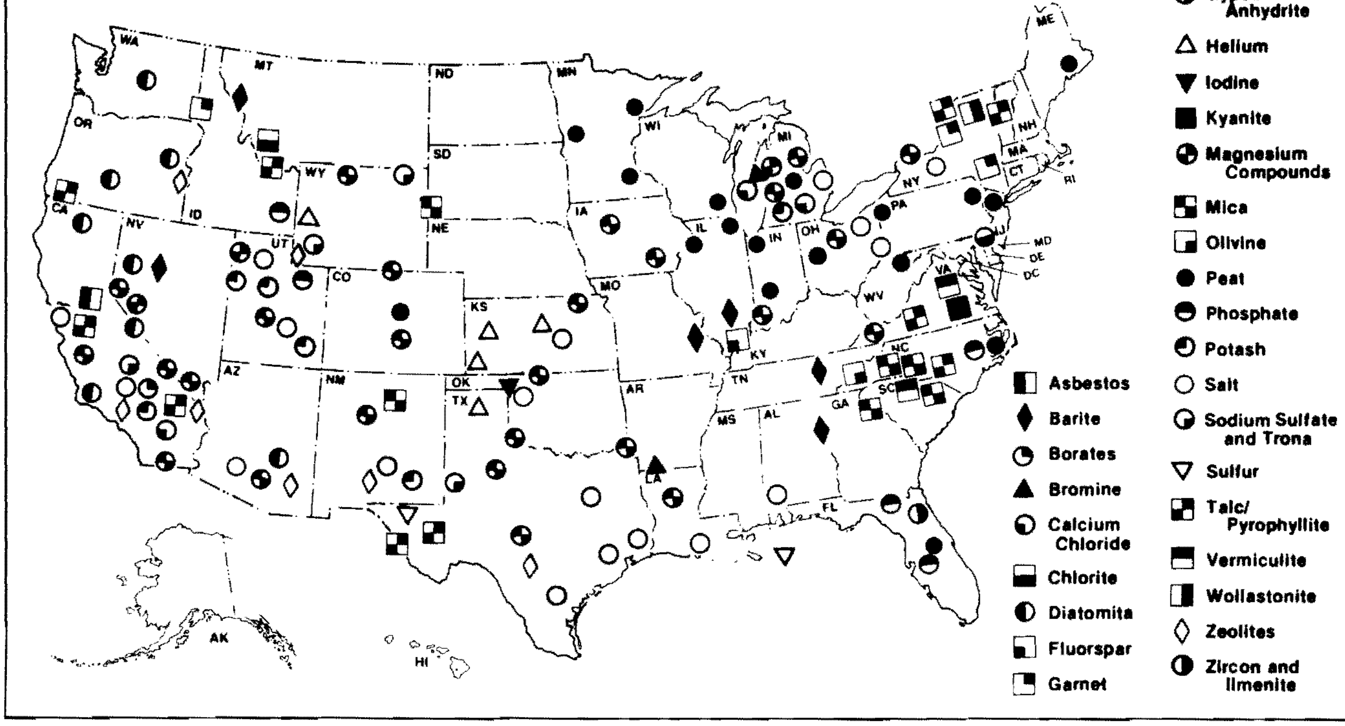
MAJOR BASE METAL PRODUCING AREAS



MAJOR PRECIOUS METAL PRODUCING AREAS



MAJOR INDUSTRIAL ROCK AND MINERAL PRODUCING AREAS - Part I



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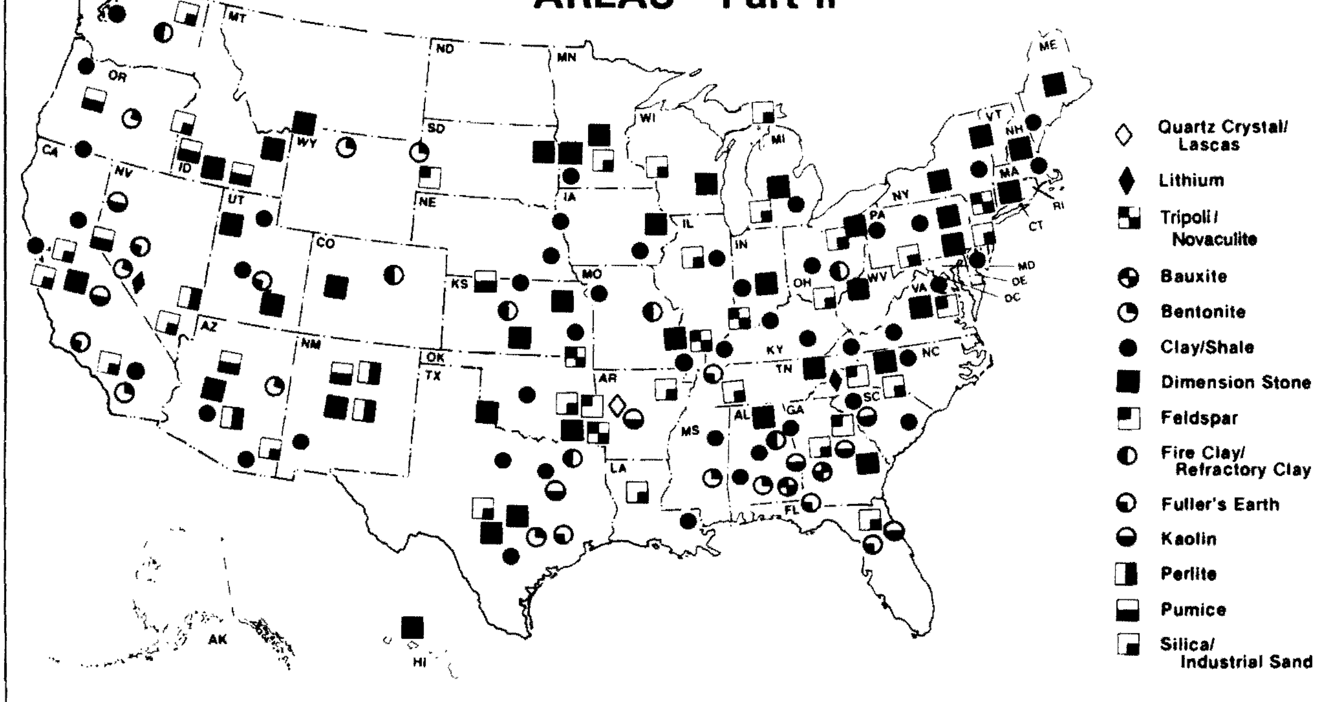

ALUMINUM[1]

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

Domestic Production and Use: In 1996, 13 companies operated 22 primary aluminum reduction plants. Montana, Oregon, and Washington accounted for 40% of the production; Kentucky, North Carolina, South Carolina, and Tennessee, 20%; other States, 40%. Based on published market prices, output of primary metal in 1996 was valued at $5.6 billion. Aluminum consumption, by an estimated 25,000 firms, was centered in the East Central United States. Transportation accounted for an estimated 32% of domestic consumption in 1996; packaging, 28%; building, 15%; electrical, 8%; consumer durables, 8%; and other, 9%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Primary	4,042	3,695	3,299	3,375	3,600
Secondary (from old scrap)	1,610	1,630	1,500	1,510	1,400
Imports for consumption	1,730	2,540	3,380	2,970	2,800
Exports	1,450	1,210	1,370	1,610	1,500
Shipments from Government stockpile excesses[2]	(55)	—	—	—	—
Consumption, apparent[3]	5,730	6,600	6,880	6,320	6,300
Price, ingot, average U.S. market (spot), cents per pound	57.5	53.3	71.2	85.9	70.0
Stocks: Aluminum industry, yearend	1,880	1,980	2,070	2,000	2,000
LME, U.S. warehouses, yearend	214	168	16	14	20
Employment: Primary reduction[e], number	20,000	18,700	17,800	17,700	18,000
Secondary smelter[e], number	3,600	3,600	3,600	3,600	3,600
Net import reliance[4] as a percent of apparent consumption	1	19	30	23	21

Recycling: Aluminum recovered in 1996 from purchased scrap was about 3.1 million tons, of which about 55% came from new (manufacturing) scrap and 45% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 20% of apparent consumption.

Import Sources (1992-95): Canada, 64%; Russia, 16%; Venezuela, 5%; Brazil, 3%; and other, 12%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Unwrought (in coils)	7601.10.3000	2.6% ad val.	18.5% ad val.
Unwrought (other than aluminum alloys)	7601.10.6000	Free	11.0% ad val.
Waste and scrap	7602.00.0000	Free	Free.

Depletion Allowance: None.[1]

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Aluminum	57	—	57	—

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ALUMINUM

Events, Trends, and Issues: Domestic primary aluminum production increased slightly in 1996 as companies slowly began to restart some of the production capacity that had been temporarily idled. By the end of the year, domestic smelters were operating at about 85% of engineered or rated capacity.

U.S. imports for consumption continued to decline in 1996. Although Russia remained second only to Canada as a major shipper of aluminum products to the United States, the level of its shipments continued to decline from the record high level reached in 1994. Exports of aluminum declined for the first time since 1993.

The price of primary aluminum ingot continued to decrease, but at a much slower pace than in the previous year. In January, the average monthly U.S. spot price for primary ingot quoted by Platt's Metals Week was 75.1 cents per pound; by August, the price had decreased to 69.4 cents per pound. Prices on the London Metal Exchange (LME) followed the trend of the U.S. spot prices. The monthly average LME cash price for August was 66.4 cents per pound. Prices in the aluminum scrap markets paralleled the general trend of primary ingot prices. The buying price for aluminum used beverage can scrap, as quoted by American Metal Market, decreased from a 58- to 60-cent-per-pound range in January to a 50- to 52-cent-per-pound range at the end of August.

World production increased as producers slowly brought back on-stream primary production capacity that had been temporarily idled over the past few years. Demand for aluminum during the first part of the year was weak in response to the general slowing of the world economy. Inventories of metal held by producers, as reported by the International Primary Aluminum Institute, declined during the first half of 1996. Inventories of metal held by the LME, however, rose during the same period and were approaching 1 million tons by the end of September. This increase reversed the rapid decline in LME inventories that began in June 1994, which saw inventory levels drop from more than 2.6 million tons to slightly more than 0.5 million tons by September 1995.

World Smelter Production and Capacity:

	Production		Yearend capacity	
	1995	1996[e]	1995	1996[e]
United States	3,375	3,600	4,180	4,180
Australia	1,297	1,370	1,420	1,420
Brazil	1,188	1,200	1,210	1,210
Canada	2,172	2,270	2,280	2,280
France	400	400	422	422
Norway	847	860	887	907
Russia	2,722	2,850	2,970	2,970
Venezuela	630	630	630	630
Other countries	6,770	7,350	8,200	8,480
World total (rounded)	19,400	20,500	22,200	22,500

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

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

[e]Estimated.
[1]See also Bauxite.
[2]Data in parentheses denote stockpile acquisitions.
[3]Domestic primary metal production + recovery from old aluminum scrap + net import reliance.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.

ANTIMONY

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

Domestic Production and Use: One antimony mine operated in Idaho. Primary antimony metal and oxide were produced by six companies operating processing plants utilizing both foreign and domestic feed material. Two plants were in Texas, and single plants were in Idaho, Montana, Nebraska, and New Jersey. A very small amount of antimony was recovered as a byproduct from the smelting of lead and silver-copper ores. Virtually all antimony metal and oxide produced domestically was derived from imports. The estimated value of primary antimony metal and oxide produced in 1996 was $110 million. The estimated distribution of antimony uses was flame retardants, 55%; transportation, including batteries, 18%; chemicals, 10%; ceramics and glass, 7%; and other, 10%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine	W	W	W	W	W
Smelter: Primary	20,100	22,000	25,500	23,500	22,700
Secondary[1]	NA	NA	NA	NA	NA
Imports for consumption	31,200	30,900	41,500	36,600	35,000
Exports of metal, alloys, oxide, and waste and scrap	5,770	4,220	7,850	8,200	5,400
Consumption, apparent[2]	NA	NA	NA	NA	NA
Price, average, cents per pound[3]	79	77	178	228	152
Stocks, yearend	8,740	9,080	10,900	10,600	11,000
Employment, plant, number[e]	115	100	100	100	100
Net import reliance[4] as a percent of apparent consumption	NA	NA	NA	NA	NA

Recycling: Traditionally, the bulk of secondary antimony has been recovered as antimonial lead, most of which was generated and then also consumed by the battery industry. However, changing trends in this industry indicate that lesser amounts of secondary antimony are being produced than heretofore thought. The data from this industry are currently under review.

Import Sources (1992-95): Metal: China, 82%; Hong Kong, 5%; Mexico, 5%; Kyrgyzstan, 4%; and other, 4%. Ore and concentrate: China, 37%; Canada, 20%; Kyrgyzstan, 16%; Bolivia, 7%; and other, 20%. Oxide: China, 36%; Mexico, 18%; Bolivia, 17%; South Africa, 15%; and other, 14%. Total: China, 58%; Bolivia, 12%; Mexico, 11%; South Africa, 7%; and other, 12%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Ore and concentrates	2617.10.0000	Free	Free.
Antimony and articles thereof, including waste and scrap	8110.00.0000	Free	4.4¢/kg.
Antimony oxide	2825.80.0000	Free	4.4¢/kg.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Antimony	24,771	1,991	24,771	2,718

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ANTIMONY

Events, Trends, and Issues: In 1996, antimony production from domestic source materials was derived mainly from the recycling of lead-acid batteries and from the country's only operating antimony mine. Recycling plus U.S. mine output supplied only a modest portion of the estimated domestic demand.

The antimony metal price experienced a fairly steady decline during 1996. The price started the year at $2.10 per pound, by spring had declined to $1.50 per pound, and by summer had dropped to $1.25 per pound, where it remained into the fall. These prices were still considerably higher than the traditional price for antimony metal that prevailed for years prior to the sharp price increases of 1994. The supply disruptions in China that were thought to have caused the dramatic price escalation in 1994 seemed to have largely abated, although definitive reports from China were difficult to obtain.

Government stockpile sales of antimony continued for the fourth year, after being resumed in 1993 for the first time since 1988. Public Law 104-201 provided the authorization for the sales. In 1996, the Defense Logistics Agency (DLA) conducted a negotiated bid offering on the second Tuesday of every month. The DLA announced that is Annual Materials Program for fiscal year 1997 permitted the disposal of up to 3,000 tons of antimony, the same as for fiscal year 1996. Antimony was stockpiled in 12 DLA depots, with the Curtis Bay, MD, warehouse holding the largest inventory.

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

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	W	W	80,000	90,000
Bolivia	6,500	6,000	310,000	320,000
China	75,000	74,000	NA	NA
Kyrgyzstan	2,500	3,000	NA	NA
Mexico	1,500	2,000	180,000	230,000
Russia	7,000	7,000	NA	NA
South Africa	4,500	4,000	240,000	250,000
Other countries	6,000	4,000	NA	NA
World total (may be rounded)	[7]103,000	[7]100,000	[8]NA	[8]NA

World Resources: U.S. resources are mainly in Idaho, Nevada, Alaska, and Montana. Principal identified world resources, estimated at 5.1 million tons, are in China, Bolivia, Kyrgyzstan, Russia, South Africa, and Mexico. Additional antimony resources may occur in "Mississippi Valley Type" lead deposits in the eastern United States.

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

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Data under review. See Recycling Section.
[2]Domestic mine production + secondary production from old scrap + net import reliance (see footnote 4).
[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 B.
[6]See Appendix C for definitions.
[7]Excludes U.S. production.
[8]Estimates currently in preparation.

ARSENIC

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: All arsenic metal and compounds consumed in the United States were imported, principally from China. More than 95% of the arsenic consumed was in compound form, principally as arsenic trioxide. Three principal manufacturers of wood preservatives consumed most of the arsenic trioxide for the production of arsenic acid for formulation of chromated copper arsenate (CCA) wood preservatives. Arsenic acid was also consumed by one manufacturer of arsenical herbicides. Metallic arsenic was consumed in the manufacture of nonferrous alloys, principally in lead alloys used in lead-acid batteries. About 15 tons of high-purity arsenic was consumed in the manufacture of semiconductor materials. About 90% of all arsenic was consumed in the production of wood preservatives; the balance was consumed in glass manufacturing, agricultural chemicals, nonferrous alloys, and miscellaneous uses. The value of arsenic metal and compounds consumed was estimated at $20 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Imports for consumption:					
Metal	740	767	1,330	557	250
Trioxide[1]	30,700	27,500	26,800	29,000	29,000
Arsenic acid	40	—	5	([2])	1
Exports, metal	94	364	79	430	20
Consumption, apparent, arsenic content	23,900	21,300	21,500	22,300	22,000
Price, cents per pound, average:[3]					
Trioxide, Mexican	29	33	32	33	33
Metal, Chinese	56	44	40	66	53
Net import reliance[4] as a percent of apparent consumption	100	100	100	100	100

Recycling: Process water and contaminated runoff collected at wood treatment plants are reused in pressure treatment. Gallium arsenide scrap from the manufacture of semiconductor devices is reprocessed for gallium and arsenic recovery. Domestically, no arsenic is recovered from arsenical residues and dusts at nonferrous smelters, although some of these materials are processed for recovery of other metals.

Import Sources (1992-95): China, 50%; Chile, 16%; Mexico, 12%; and other, 22%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Metal	2804.80.0000	Free	13.2¢/kg.
Trioxide	2811.29.1000	Free	Free.
Sulfide	2813.90.1000	Free	Free.
Acid[6]	2811.19.1000	2.3% ad val.	4.9% ad val.

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

Government Stockpile: None.

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ARSENIC

Events, Trends, and Issues: Domestic demand for arsenic in the wood preservative industry was relatively unchanged in 1996, despite projected growth in the domestic housing industry. Demand in 1995 had been boosted by in-process construction and restocking by distributors of pressure-treated lumber following the 1994 surge in housing construction. The apparent demand for arsenic metal for nonferrous alloys, especially battery-lead alloys, remained low for the second consecutive year. Consumers, fearing disruptions from Chinese suppliers, may have overbought in 1994, reducing their need for additional material in the subsequent 2 years. Also, continued growth in market share for maintenance-free automotive batteries, which require little or no arsenic, may be further lowering demand for arsenic metal.

Because of the toxicity of arsenic and its compounds, numerous environmental and workplace regulations proposed or amended during 1996 specify limitations for arsenic releases or exposure levels. In May, the Environmental Protection Agency issued revised rules for reportable quantities, under the Community Right-to-Know Act of 1986, for its list of extremely hazardous substances, which includes numerous arsenic compounds. The reportable quantity for arsenic compounds remained at 1 pound. In July, the Occupational Safety and Health Administration, as part of a review process to modify out-of-date regulations, proposed revision of medical surveillance requirements for certain workers exposed to inorganic arsenic, including elimination of the semiannual sputum cytology examinations and reduction, from semiannual to annual, of the frequency of required chest x rays.

World Production, Reserves, and Reserve Base:

	Production (Arsenic trioxide)		Reserves and reserve base[7] (Arsenic content)
	1995	1996[e]	
United States	—	—	
Belgium	2,000	2,000	
Chile	6,400	6,500	World reserves and reserve
China	13,000	13,000	base are thought to be about
France	5,000	4,000	20 and 30 times, respectively,
Kazakstan	1,500	1,500	annual world production.
Mexico	4,500	4,500	
Namibia	2,300	2,300	
Philippines	2,000	2,000	
Russia	1,500	1,500	
Other countries	2,600	3,000	
World total	41,000	41,000	

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

Substitutes: Substitutes for arsenic compounds exist in most of its major uses, although arsenic compounds may be preferred because of lower cost and superior performance. The wood preservatives pentachlorophenol and creosote may be substituted for CCA when odor and paintability are not problems and where permitted by local regulations. A recently developed alternative, ammoniacal copper quaternary, which avoids using chrome and arsenic, has yet to gain widespread usage. Nonwood alternatives, such as concrete, steel, or plastic lumber, may be substituted in some applications for treated wood. A South American hardwood, ipe, which requires no chemical treatment, has been used in some localities in oceanfront boardwalks.

[e]Estimated.
[1]Arsenic trioxide (As_2O_3) contains 75.7% arsenic by weight.
[2]Less than ½ unit.
[3]Calculated from Bureau of the Census import data.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]Tariff is free for Canada, Israel, Caribbean Basin countries, and designated Beneficiary Andean and developing countries.
[7]See Appendix C for definitions. The reserve base for the United States was estimated at 80,000 tons.

ASBESTOS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: One firm in California accounted for 100% of domestic production. Asbestos was consumed in roofing products, 48%; friction products, 32%; packings 12%; and other, 8%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production (sales), mine	16	14	10	9	9
Imports for consumption	32	31	26	22	23
Exports[1]	25	28	18	15	16
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, apparent	33	32	27	22	23
Price: average value, dollars per ton, f.o.b.	394	435	506	W	W
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number	70	70	30	30	30
Net import reliance[2] as a percent of apparent consumption	21	9	30	32	30

Recycling: Insignificant.

Import Sources (1992-95): Canada, 99%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Asbestos	2524.00.0000	Free	Free.

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

Government Stockpile:

Stockpile Status—9-30-96
(Metric tons)

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Amosite	30,849	—	30,849	—
Chrysotile	9,767	—	9,767	—
Crocidolite	33	—	33	—

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ASBESTOS

Events, Trends, and Issues: Domestic sales of asbestos were unchanged from those of 1995. Imports and exports increased 5% and 7% respectively, according to the Bureau of the Census. It is likely that a large percentage of the exports were either reexports, asbestos-containing products, or nonasbestos products. Exports of asbestos fiber were estimated to be approximately 9,000 tons. Apparent consumption increased 5%. Almost all of the asbestos consumed in the United States was chrysotile. Canada remained the largest supplier of asbestos for domestic consumption.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	9	9	Moderate	Large
Brazil	190	190	Moderate	Moderate
Canada	511	510	Large	Large
China	240	240	Large	Large
Kazakstan	250	250	Large	Large
Russia	800	800	Large	Large
South Africa	95	95	Moderate	Moderate
Zimbabwe	150	150	Moderate	Moderate
Other countries	155	156	Large	Large
World total (rounded)	2,400	2,400	Large	Large

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

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

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]May include nonasbestos materials.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.

BARITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Barite sales in 1996 increased strongly from the 1995 level of 540,000 tons to about 650,000 tons, and the value increased accordingly to about $30 million. Sales came from six States, with slightly less than 80% of the total coming from Nevada. The second largest producing State was Georgia. A small mine in Tennessee restarted for several months. About 1.3 million tons of ground barite from both domestic production and imports was sold in 1996 as reported by the domestic grinders and crushers. Nearly 90% of the barite sold in the United States was used as a weighing agent in oil- and gas-well-drilling fluids, mostly in the Gulf of Mexico region with much smaller amounts used in the Pacific coast, western Canada, and Alaska areas. Industrial end uses for barite include an additive to cement, rubber, and urethane foam as a weighing material. Barite is also used in automobile paint primer for metal protection and gloss, "leaded" glass, and as the raw material for barium chemicals. In the metal casting industry, barite is part of the mold-release compounds. Barite has become part of the friction products (brake and clutch pads) for transportation vehicles. Because barite strongly reduces x-rays and γ rays, it is used in cement vessels that contain radioactive materials, gastro-intestinal x-ray "milkshakes," and the faceplates and funnelglass of cathode-ray tubes used for television sets and computer monitors.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Sold or used, mine	326	315	583	543	650
Imports for consumption: Crude barite	323	766	1,010	960	1,300
Ground barite	31	38	58	80	60
Other	12	11	13	10	10
Exports	12	18	14	16	18
Consumption, apparent[1] (crude barite)	668	1,100	1,640	1,570	1,930
Consumption[2] (ground and crushed)	999	1,090	1,250	1,210	1,600
Price, average value, dollars per ton, mine	60.22	61.16	37.22	41.00	50.00
Employment, mine and mill[e], number	350	330	350	400	350
Net import reliance[3] as a percent of apparent consumption	52	72	64	65	66

Recycling: None.

Import Sources (1992-95): China, 65%; India, 24%; Mexico, 6%; Morocco, 2%; and other, 3%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Crude barite	2511.10.5000	$1.25/mt	$3.94/mt.
Ground barite	2511.10.1000	$1.92/mt	$7.38/mt.
Witherite	2511.20.0000	1.8% ad val.	30% ad val.
Oxide, hydroxide, and peroxide	2816.30.0000	2% ad val.	10.5% ad val.
Other sulfates	2833.27.0000	0.6¢/kg ad val.	4.2¢/kg ad val.
Other chlorides	2827.38.0000	4.2% ad val.	28.5% ad val.
Other nitrates	2834.29.5000	3.5% ad val.	10% ad val.
Carbonate	2836.60.0000	2.3% ad val.	8.4% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: The demand for barite increased following modest expansions in the economies of the United States and other industrialized countries. Barite is used primarily in petroleum well drilling and historically has had a positive relationship to petroleum price trends and drill rig usage. Worldwide barite consumption grew modestly as there was an overcapacity in the oil producing countries, centered in the Organization of Petroleum Exporting Countries (OPEC) Several of the OPEC countries withheld production to maintain stable prices in petroleum and gas markets. Due to relatively long lead times in this industry, it was rational to explore and develop while in overcapacity.

In the United States drilling in the Gulf of Mexico for deeper natural gas deposits in Louisiana, south Texas, offshore Texas, and Oklahoma continued unabated. The demand for jack up and semisubmersible drilling rigs in the Gulf of Mexico was strong. This demand followed a price increase of 14% for light sweet crude futures from the first week of January 1996 to the week of July 19, 1996. Contrarily, natural gas prices decreased by 9% over the same time period. The rotary rig count in the United States rose from 762 for the week of December 22, 1995, to 790 in the week

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BARITE

of July 19, 1996. The rig count continued to climb through the rest of the year, reaching 819 rigs in the week of October 4, 1996.

In the United States reported barite prices rose due to a change in the mix of material sold from the mines and mills. That is, more ground barite was sold through the mine-located and independent mills relative to the amount of crude and jigged ore sold directly from the mines.

Imports for consumption of lower cost foreign barite were double domestic production. The major sources of imported barite have high-grade deposits, relatively low labor costs, and relatively low cost (per ton-mile) of ocean transportation to the gulf coast grinding plants. Often the cost of ocean transportation from other continents is lower per ton than the cost of rail transportation from Georgia and Missouri to the end-use regions. Nevada mines, crushers, and grinders are competitive in the California market, and are trying to reenter the Gulf of Mexico market through negotiated railroad tariff reductions. Over the past several years, China and India have had problems supplying low-cost barite into the Gulf coast but not enough to encourage domestic owners of Missouri barite mines to reopen any of those mines.

The Environmental Protection Agency (EPA) deleted barium sulfate from the category "barium compounds" on the list of toxic chemicals for which reporting was required under section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). The action was based on EPA's conclusion that barium sulfate met the deletion criteria of EPCRA section 313(d)(3). By promulgating this rule, EPA was relieving facilities of their obligation to report releases of barium sulfate that occurred during the 1993 reporting year, and releases that occur in subsequent years.

The principal environmental impact of chemically inert barite is the land disturbance normally associated with mining. Mud pits at petroleum well drilling sites, which contain some barite, are treated according to the chemical content other than barite. The mud in the pits may be dewatered and covered, dewatered and spread over the ground, or transported to special waste handling facilities according to the base drilling fluid (water or oil).

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	543	650	28,000	60,000
Canada	57	60	11,000	14,600
China	1,500	1,500	35,000	150,000
France	70	70	2,000	2,500
Germany	150	145	1,000	1,500
India	575	550	28,000	32,000
Iran	150	150	NA	NA
Ireland	60	60	1,000	1,500
Kazakstan	150	150	NA	NA
Mexico	248	230	7,000	8,500
Morocco	265	270	10,000	11,000
Romania	105	100	NA	NA
Thailand	50	50	9,000	15,000
Turkey	158	155	4,000	20,000
United Kingdom	85	80	100	600
Other countries	190	195	20,000	161,000
World total (may be rounded)	4,356	4,415	170,000	500,000

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

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

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

BAUXITE AND ALUMINA[1]

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

Domestic Production and Use: Domestic ore, which accounted for less than 1% of the U.S. requirement for bauxite, was mined by one company from surface mines in Alabama and Georgia; virtually all of it was used in the production of nonmetallurgical products, such as abrasives, chemicals, proppants, and refractories. Thus, nearly all bauxite, and certainly all metallurgical bauxite, was imported; of the total, about 95% was converted to alumina. Also, the United States imported nearly half of the alumina it required. Of the total alumina used, about 90% went to primary aluminum smelters and the remainder to nonmetallurgical uses. Annual alumina capacity was 5.5 million tons, with four Bayer refineries in operation at yearend.

Salient Statistics—United States:[2]	1992	1993	1994	1995	1996[e]
Production, bauxite, mine	W	W	W	W	W
Imports of bauxite for consumption[3]	11,400	11,900	11,200	10,800	10,500
Imports of alumina[4]	4,700	3,940	3,120	4,000	4,300
Exports of bauxite[3]	68	92	137	120	170
Exports of alumina[4]	1,140	1,240	1,040	1,040	920
Shipments of bauxite from Government stockpile excesses	437	565	5	874	650
Consumption, apparent, bauxite and alumina (in aluminum equivalents)[5]	4,860	4,510	3,840	4,330	4,370
Price, bauxite, dollars per ton, f.o.b. mine	15-18	15-24	15-24	15-18	15-18
Stocks, bauxite, industry, yearend	2,300	1,600	1,600	1,700	1,600
Employment, bauxite mine, number	35	35	35	20	20
Net import reliance,[6] bauxite and alumina as a percent of apparent consumption	100	100	99	99	100

Recycling: None.

Import Sources (1992-95):[7] Bauxite: Guinea, 36%; Jamaica, 29%; Brazil, 14%; Guyana, 12%; and other, 9%. Alumina: Australia, 71%; Jamaica, 9%; Suriname, 7%; and other, 13%. Total: Australia, 31%; Jamaica, 21%; Guinea, 20%; Brazil, 9%; and other, 19%.

Tariff: Import duties on bauxite and alumina were abolished in 1971 by Public Law 92-151. Only imports from non-most-favored nations were dutiable. Countries that supplied commercial quantities of bauxite or alumina to the United States during the first 7 months of 1996 had most-favored-nation status.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Bauxite, metal grade:				
Jamaica-type	10,500	673	10,500	[8]610
Suriname-type	4,980	—	4,980	—
Bauxite, refractory-grade, calcined	153	36	95	[9]2

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BAUXITE AND ALUMINA

Events, Trends, and Issues: World output of bauxite and alumina for 1996 increased to accommodate the approximately 5% increase in world primary aluminum metal production.

U.S. alumina plant engineered capacity remained essentially unchanged from that of yearend 1995. The 600,000-ton-per-year alumina plant in St. Croix, VI, remained idle.

Spot prices for metallurgical-grade alumina, as published by Metal Bulletin, decreased significantly during the first three quarters of 1996. The published price range began the year at $220 to $250 per ton. By the end of September, the price range had decreased to $145 to $150 per ton.

The fiscal year (FY) Annual Materials Plan (AMP) submitted by the Defense National Stockpile Center proposed the sale of 915,000 dry metric tons of metallurgical-grade bauxite (610,000 tons of Jamaica-type and 305,000 tons of Suriname-type) during the period October 1, 1996, to September 30, 1997. In addition, the FY 1997 AMP provided for the sale of 81,000 calcined metric tons of refractory-grade bauxite from the National Defense Stockpile. These are the maximum amounts that could be sold under the new AMP and not necessarily the amounts that would actually be offered for sale.

World Bauxite Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[10]	Reserve base[10]
	1995	1996[e]		
United States	W	W	20,000	40,000
Australia	42,655	43,400	5,600,000	7,900,000
Brazil	8,761	8,800	2,800,000	2,900,000
China	5,000	5,500	150,000	1,500,000
Guinea	14,400	14,400	5,600,000	5,900,000
Guyana	2,100	2,100	700,000	900,000
India	4,800	5,000	1,000,000	1,200,000
Jamaica	10,857	11,800	2,000,000	2,000,000
Russia	3,100	3,100	200,000	200,000
Suriname	3,300	3,300	580,000	600,000
Venezuela	5,184	4,000	320,000	350,000
Other countries	9,009	9,500	3,800,000	4,400,000
World total (rounded)	[11]109,000	[11]111,000	23,000,000	28,000,000

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

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

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]See also Aluminum. As a general rule, 4 tons of dried bauxite are required to produce 2 tons of alumina, which, in turn, provide 1 ton of primary aluminum metal.
[2]Includes U.S. Virgin Islands.
[3]Includes all forms of bauxite, expressed as dry equivalent weights.
[4]Calcined equivalent weights.
[5]The sum of U.S. bauxite production and net import reliance (all in aluminum equivalents).
[6]Defined as imports - exports + adjustments for Government and industry stock changes (all in aluminum equivalents).
[7]Aluminum equivalents.
[8]Sold under long-term contract commenced in 1993.
[9]Dry equivalent weight - 2,930 metric tons.
[10]See Appendix C for definitions.
[11]Excludes U.S. production.

BERYLLIUM

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

Domestic Production and Use: One company in Utah mined bertrandite ore and recovered beryllium hydroxide from this ore and from imported and domestic beryl. Beryllium hydroxide was shipped to a plant in Ohio, where it was converted into beryllium metal, alloys, and oxide. Another company in Pennsylvania purchased beryllium oxide from Asia and converted this material into beryllium alloys. Small quantities of beryl were recovered as a byproduct of U.S. pegmatite mining operations in various States. Beryllium consumption of 220 tons was valued at approximately $78 million, based on the producer price for beryllium-copper master alloy. Beryllium was used as an alloy and oxide in electronic components, 54%; as an alloy and oxide in electrical components, 19%; as an alloy, oxide, and metal in aerospace and defense applications, 14%; and as an alloy, metal, and oxide in other applications, 13%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine	193	198	173	202	217
Imports for consumption, ore and metal	6	8	53	32	45
Exports, metal	41	20	29	61	50
Shipments from Government stockpile excesses[1]	[2]15	[2]31	[2](2)	[2](19)	—
Consumption: Apparent	159	183	198	198	220
Reported	196	196	174	227	220
Price, dollars:					
Domestic, metal, vacuum-cast ingot, per pound	308	308	275	308	327
Domestic, metal, powder blend, per pound	280	295	295	295	385
Domestic, beryllium-copper master alloy, per pound of contained beryllium	160	160	160	160	160
Domestic, beryllium oxide, powder, per pound	72.50	72.50	72.50	70.50	77.00
Stocks, consumer, yearend	111	114	113	162	160
Employment, number:					
Mine, full-time equivalent employees[e]	25	25	25	25	25
Primary refineries[e]	400	400	400	400	400
Net import reliance[3] as a percent of apparent consumption	E	E	13	E	E

Recycling: Substantial quantities of new scrap generated in the processing of beryllium-copper alloys were recycled. Small quantities of obsolete military equipment containing metallic beryllium were recycled.

Import Sources (1992-95): Ore, metal, scrap, and master alloy: Russia, 40%; Kazakstan, 21%; China, 12%; France, 10%; and other, 17%.

Tariff: Item	**Number**	**Most favored nation (MFN) 12/31/96**	**Non-MFN[4] 12/31/96**
Ore and concentrates	2617.90.0030	Free	Free.
Unwrought beryllium	8112.11.6000	8.5% ad val.	25.0% ad val.
Beryllium, wrought	8112.19.0000	5.5% ad val.	45.0% ad val.
Beryllium-copper master alloy	7405.00.6030	3.6% ad val.	28.0% ad val.
Beryllium oxide or hydroxide	2825.90.1000	3.7% ad val.	25.0% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposals Jan.-Sept. 96**
Beryl ore (11% BeO)	545	—	545	—
Beryllium-copper master alloy	268	—	—	—
Beryllium metal	363	—	—	—

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BERYLLIUM

Events, Trends, and Issues: Increased sales for telecommunications and consumer applications partially were responsible for the upturn in beryllium demand in 1996. Beryllium-aluminum alloys were increasing market share by substituting for aluminum, magnesium, titanium, or resin-matrix composites in some defense aerospace and commercial satellite applications.

In August, the International Trade Commission (ITC) made a preliminary determination that beryllium metal and high-beryllium alloys (beryllium content greater than 30%) from Kazakstan were being sold in the United States at less than fair value. As a result, it established a preliminary antidumping duty of 70.8%; the period under investigation was July 1, 1995, through December 31, 1995. The ITC was expected to finalize its ruling within 120 days after the preliminary decision. The United States imported 23 tons of beryllium metal and scrap in 1995; however, no beryllium imports from Kazakstan were recorded in 1996 through July.

After completing a merger with another Canadian firm, the original property owner plans to resume work on a beryllium prospect near Thor Lake, Northwest Territories. This property, which has an average grade of 1% BeO in a variety of beryllium-containing minerals totaling 500,000 tons of reserves, was investigated as a beryllium prospect in the late 1980's. In 1990, the owner halted production plans because of insufficient orders for the potential products. The new company announced that it will conduct a feasibility study to determine the economics of producing either beryllium metal or beryllium oxide.

The Defense Logistics Agency continued to offer 2,000-pound lots of beryl from the National Defense Stockpile for sale once a month. No bids for the material were received. In its fiscal year 1997 Annual Materials Plan, the Defense Logistics Agency has authority to sell about 1,800 tons of beryl.

Beryllium dust and fines have been recognized as the cause of berylliosis, a chronic lung disease. Harmful effects are minimized by maintaining a clean workplace and requiring the use of safety equipment.

World Mine Production, Reserves, and Reserve Base:

	Mine production	
	1995	1996[e]
United States	202	217
Brazil	34	34
China[e]	55	55
Kazakstan[e]	4	4
Russia[e]	32	30
Other countries	([6])	1
World total	327	341

Reserves and reserve base[5]

The United States has very little beryl that can be economically handsorted from pegmatites. The Spor Mountain area, Utah, contains a large reserve base of bertrandite, which was being mined. Domestic deposits of bertrandite ores in Utah and Texas contain about 21,000 tons of beryllium. The world reserves and reserve base are not sufficiently well delineated to report consistent figures for all countries.

World Resources: No quantitative information is available on foreign resources of beryllium-bearing minerals and rocks. The identified resources of beryllium in known domestic deposits are estimated at 66,000 tons of contained beryllium.

Substitutes: Because of the relatively high price of beryllium, uses are expected to continue principally in applications that require its light weight, high strength, and high thermal conductivity. Steel, titanium, and graphite composites may be substituted for beryllium metal; phosphor bronze may be substituted for beryllium-copper alloys, but with substantial loss of performance. Aluminum nitride can substitute for beryllium oxide in some applications.

[e]Estimated. E Net exporter. NA Not available.
[1]Data in parentheses denote stockpile acquisitions.
[2]Data represent the net difference between the estimated beryllium content of beryl shipped for upgrading and stockpile receipts of beryllium metal. These data are not included in net import reliance calculations.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.
[6]Less than ½ unit.

BISMUTH

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

Domestic Production and Use: One refinery in Nebraska produced bismuth as a byproduct of lead refining. Thirty-five companies in the Eastern United States accounted for an estimated three-fourths of the bismuth consumed in 1996. Based on the average annual price, the value of bismuth consumed was estimated at more than $12 million. About 62% of bismuth was used in pharmaceuticals and chemicals, 20% in fusible alloys and solders, 15% in metallurgical additives, and 3% in other uses.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery	W	W	W	W	W
Imports for consumption	1,620	1,330	1,660	1,450	1,600
Exports[1]	90	70	160	261	120
Shipments from Government stockpile excesses	91	—	145	139	137
Consumption, reported	1,300	1,300	1,450	([2])	([2])
Price, average, domestic dealer, dollars per pound	2.66	2.50	3.25	3.85	3.60
Stocks, yearend, consumer	272	323	402	390	400
Employment, plant, number[e]	30	30	30	30	30
Net import reliance[3] as a percent of apparent consumption	W	W	W	W	W

Recycling: Bismuth was recovered from fusible alloy scrap, contributing about 5% of the U.S. supply.

Import Sources (1992-95): Mexico, 35%; Belgium, 31%; China, 12%; the United Kingdom, 7%; and other, 15%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Articles thereof, including waste and scrap	8106.00.0000	Free	7.5% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Bismuth	229	136	229	84

Events, Trends, and Issues: On April 15, 1996, the only domestic producer announced that it had reached agreement with the City of Omaha, NE, to cease all operations at its Omaha refinery by February 1, 1998, and remediate the property for use as a park. The company stopped refining lead at Omaha on June 1, 1996, but planned to continue processing other materials, including bismuth, at the plant until February 1998.

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BISMUTH

Bismuth was used in several newly developed applications designed to provide nontoxic substitutes for lead. New products include bismuth fishing sinkers; bismuth shot for waterfowl hunting; and bismuth-containing brass, pigments, ceramic glazes, solders, lubricating greases, and crystal ware. In order to make a large impact on the bismuth market, lead would have to be banned or severely restricted nationwide for a major use. This happened, when seven large faucet makers, representing about one-half of domestic faucet sales, agreed in July 1995, to remove essentially all lead from plumbing fixtures in the settlement of a suit brought by the State of California and the Natural Resources Defense Fund. However, demand for bismuth in this sector had not yet increased in 1996.

World production of bismuth has not increased for 3 years, owing mainly to low prices. World lead production has also declined in recent years, limiting the amount of bismuth that can be produced. The domestic price drifted down from $4.20 per pound to $3.30 per pound during 1996, and averaged $3.60 per pound. This was the first year in the past 3 years that the price did not increase. The Defense Logistics Agency (DLA) sold 137 tons of bismuth from the National Defense Stockpile in fiscal year 1996. The DLA was authorized to dispose of 136 tons in fiscal year 1997.

The U.S. Fish and Wildlife Service again conditionally approved the use of 97% bismuth - 3% tin shot for waterfowl hunting in the 1996-97 hunting season. Recent studies have shown bismuth-tin shot to be nontoxic to waterfowl. Bismuth-tin shot is an alternative to steel shot, which replaced lead shot for waterfowl hunting in 1991.

A potential supply problem caused by the shutdown of production by the only domestic producer will likely be ameliorated by production anticipated from the Tasna Mine in Bolivia, the only mine in the world where bismuth is the primary product, and by the startup of a new smelter in British Columbia that will upgrade one Canadian company from campaign producer to steady producer.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	W	W	9,000	14,000
Australia	—	—	18,000	27,000
Bolivia	—	—	5,000	10,000
Canada	126	125	5,000	30,000
China	700	700	20,000	40,000
Japan	177	175	9,000	18,000
Kazakstan	25	25	5,000	10,000
Mexico	900	900	10,000	20,000
Peru	1,000	1,000	11,000	42,000
Other countries	110	100	15,000	35,000
World total (rounded)	[6]3,040	[6]3,030	110,000	250,000

World Resources: Bismuth is recovered in the United States during the processing of domestic and imported lead ores and concentrates. It is also potentially recoverable as a byproduct of the processing of molybdenum and tungsten ores, although extraction of bismuth from these ores is for the most part not economic. World reserves of bismuth are usually associated with lead deposits, except in China and North Korea, where bismuth is found with tungsten ores, and in Australia, where it is found with copper-gold ores. Bismuth minerals rarely occur in sufficient quantities to be mined as principal products, except in Bolivia and possibly in China.

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

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Includes bismuth, bismuth alloys, and waste and scrap.
[2]Data currently under review.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]Most of reserves and reserve base represent bismuth recoverable from the lead reserve base. See Appendix C for definitions.
[6]Excludes U.S. production.

BORON

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

Domestic Production and Use: The estimated value of boric oxide contained in minerals and compounds produced in 1996 was $498 million. Domestic production of boron minerals primarily as sodium borates, by four companies was centered in southern California. The largest producer operated an open pit tincal and kernite mine and associated compound plants. A second firm, using Searles Lake brines as raw material at two plants, accounted for the remaining output. A third company continued to process small amounts of calcium and calcium sodium borates. A fourth company used an in-situ process. Principal consuming firms were in the North Central and Eastern States. The reported end-use distribution pattern for boron compounds consumed in the United States in 1996 was estimated as glass products, 56%; agriculture, 7%; fire retardants, 6%; soaps and detergents, 5%; and other, 26%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[1]	554	574	550	495	622
Imports for consumption, gross weight:					
Borax	16	40	9	9	10
Boric acid	6	17	20	16	20
Colemanite	30	90	27	45	40
Ulexite	42	149	120	153	150
Exports, gross weight of boric acid and refined borates	489	481	498	588	590
Consumption: Apparent	356	481	389	312	234
Reported	345	321	296	NA	NA
Price, dollars per ton, granulated pentahydrate borax in bulk, carload, works[2]	250	304	324	324	375
Stocks, yearend[3]	NA	NA	NA	NA	NA
Employment, number	900	900	900	900	900
Net import reliance[4] as a percent of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1992-95): Borax: Turkey, 98%; Chile, 1%; and other, 1%.
Boric acid: Italy, 56%; Chile, 32%; Turkey, 6%; and other, 6%.
Colemanite: Turkey, 98%; Peru, 1%; and other, 1%.
Ulexite: Turkey, 97%; and, Chile, 3%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Borates:			
Refined borax:			
Anhydrous	2840.11.0000	0.3% ad val.	1.2% ad val.
Other	2840.19.0000	0.1% ad val.	0.4% ad val.
Other	2840.20.0000	3.7% ad val.	25% ad val.
Perborates:			
Sodium	2840.30.0010	3.7% ad val.	25% ad val.
Other	2840.30.0050	3.7% ad val.	25% ad val.
Boric acids	2810.00.0000	1.5% ad val.	8.5% ad val.
Natural borates:			
Sodium	2528.10.0000	Free	Free.
Other:			
Calcium	2528.90.0010	Free	Free.
Other	2528.90.0050	Free	Free.

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

Government Stockpile: None.

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BORON

Events, Trends, and Issues: The United States was the world's second largest producer of boron compounds during 1996 and exported about one-half of domestic production. Exported materials competed with borax, boric acid, colemanite, and ulexite primarily from Turkey, the largest producer of boron ore in the world.

Imports of borates from northern Chile continued. Ulexite is mined in Chile for the production of boric acid, synthetic colemanite, and refined ulexite for use in ceramics, insulating and reinforcing fiberglass, and agriculture.

One company sold its electric and steam generating facility in California to a local utility company for $70 million. The net proceeds from the sale were used to reduce debt. The company leased the facilities for a term of 15 years. Electricity and steam produced were used to produce soda products and boron chemicals.

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

	Production—all forms		Reserves[7]	Reserve base[7]
	1995	1996[e]		
United States	800	900	40,000	80,000
Argentina	140	140	2,000	9,000
Bolivia	10	10	4,000	19,000
Chile	90	90	8,000	41,000
China	140	140	27,000	36,000
Iran	1	1	1,000	1,000
Kazakstan	80	80	14,000	15,000
Peru	27	30	4,000	22,000
Turkey	1,100	1,200	30,000	150,000
World total (may be rounded)	2,400	2,500	170,000	420,000

World Resources: Large domestic resources of boron materials occur in California, chiefly in sediments and their contained brines. Extensive resources also occur in Turkey. Small deposits are being mined in South America. World resources are adequate to supply demand at current rates for the foreseeable future.

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

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

BROMINE

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

Domestic Production and Use: The quantity of bromine sold or used in the United States from four companies operating in Arkansas and Michigan accounted for 100% of elemental bromine production valued at an estimated $150 million. Arkansas continued to be the Nation's leading bromine producer, and bromine was the leading mineral commodity in terms of value produced in the State.

Estimated bromine use was fire retardants, 27%; agriculture, 15%; petroleum additives, 15%; well drilling fluids, 10%; sanitary preparations, 5%; and other uses, 28%. Other uses included intermediate chemicals used in the manufacture of other products and bromide solutions used alone or in combination with other chemicals.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[1]	171	177	195	218	227
Imports for consumption, elemental bromine and compounds[2]	15	19	24	12	12
Exports, elemental bromine and compounds	22	19	18	14	14
Consumption, apparent[3]	157	267	197	306	315
Price, cents per kilogram, bulk, purified bromine	73.3	69.5	79.5	85.3	66.1
Stocks, producer, yearend, elemental bromine[e]	—	—	—	—	—
Employment, number	1,200	1,600	1,600	1,600	1,700
Net import reliance[4] as a percent of apparent consumption	—	—	—	E	E

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

Import Sources (1992-95): Israel, 83%; Netherlands, 9%; France, 5%; and other, 3%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Bromine	2801.30.2000	6.6% ad val.	37% ad val.
Bromochloromethane	2903.49.1000	Free	25% ad val.
Ammonium, calcium, or zinc bromide	2827.59.2500	Free	25% ad val.
Decabromodiphenyl and octabromodiphenyl oxide	2909.30.0700	17.1% ad val.	15.4¢/kg + 70.5% ad val.
Ethylene dibromide	2903.30.0500	5.4% ad val.	46.3% ad val.
Hydrobromic acid	2811.19.3000	2.5% ad val.	25% ad val.
Potassium bromate	2829.90.0500	1.9% ad val.	25% ad val.
Potassium or sodium bromide	2827.51.0000	Free	22¢/kg.
Methyl bromide	2903.30.1520	Free	25% ad val.
Sodium bromate	2829.90.2500	2.2% ad val.	25% ad val.
Tetrabromobisphenol A	2908.10.2500	1.2¢/kg + 16.6% ad val.	15.4¢/kg + 62% ad val.

Depletion Allowance: 5% on brine wells (Domestic and Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Two bromine companies completed plans to expand domestic capacity. A third company was building a bromine plant with capacity between 9 and 14 million kilograms at Manistee, MI. The plant will produce elemental bromine and brominated salts from brines used to produce magnesium hydroxide. The plant is expected to be operational in late 1997.

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BROMINE

The U.S. Environmental Protection Agency planned to work on an essential-use exemption for methyl bromide in the that event effective alternatives are not found by 2001. Methyl bromide was listed as a Class I ozone depleting substance in the 1990 Clean Air Act and is scheduled to be phased out in 2001. In 1996 a study by the U.S. Department of Agriculture, found that methyl iodide may be a replacement in most uses.

Israel is the second largest producer of bromine in the world. Bromine was produced from brines after production of potash and magnesium.

A study on using bromine in gold processing reported higher results for bromine than for cyanide when using activated carbon.

During 1996, a supplier of brines in Arkansas sued a bromine company that processed bromine from the brines for higher royalty payments. Bromine is produced from brines that were leased from various owners of mineral rights. Payments to the mineral rights owners is based on the value of the first product, that is, bromine. The basis for the suit was to base the royalty payments on the value of flame retardants manufactured from the bromine. The suit was settled. The bromine producers in Arkansas will be able to continue producing bromine using the unitization method if the company has 75% of the mining rights to the brine in the area.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States[1]	218	227	11,000	11,000
Azerbaijan	2.0	2.0	300	300
China	19	19	NA	NA
France	2.0	2.0	1,600	1,600
India	1.5	1.5	([7])	([7])
Israel	135.0	135.0	([8])	([8])
Italy	.3	.3	([7])	([7])
Japan	15.0	15.0	([9])	([9])
Spain	.2	.2	1,400	1,400
Turkmenistan	7.0	7.0	700	700
Ukraine	3.5	4.0	400	400
United Kingdom	28.0	28.0	([7])	([7])
World total (rounded)	430.0	440.0	NA	NA

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

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

[e]Estimated. NA Not available. E Net exporter.
[1]Sold or used by U.S. producers.
[2]Imports calculated from items shown in tariff section.
[3]Includes recycled product beginning in 1993.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.
[7]From waste bitterns associated with solar salt. See World Resources section.
[8]From the Dead Sea. See World Resources section.
[9]From seawater. See World Resources section.

CADMIUM

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

Domestic Production and Uses: Two companies, one in Illinois and one in Tennessee, recovered cadmium as a byproduct of the smelting and refining of zinc concentrates. A third company, in Pennsylvania, began recovering cadmium from spent nickel-cadmium (Ni-Cd) batteries at the end of 1995. Based on the average New York dealer price, the combined output of primary and secondary metal in 1996 was valued at $4.0 million. The estimated consumption pattern included batteries, 67%; pigments, 14%; coatings and plating, 8%; stabilizers for engineering plastics and similar synthetic products, 8%; nonferrous alloys, 2%; and other, including electrooptics, 1%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery[1]	1,620	1,090	1,010	1,270	1,450
Imports for consumption, metal	1,960	1,420	1,110	848	720
Exports of metal, alloys, and scrap	213	38	1,450	1,050	40
Shipments from Government stockpile excesses	—	185	209	214	243
Consumption, apparent	3,270	3,010	1,040	1,160	2,200
Price, metal, dollars per pound[2]	0.91	0.45	1.13	1.84	1.25
Stocks, yearend, producer and distributor	933	579	423	542	750
Employment, smelter and refinery, number	190	195	125	125	145
Net import reliance[3] as a percent of apparent consumption	50	64	3	E	33

Recycling: To date, cadmium recycling has been practical only for Ni-Cd batteries, some alloys, and dust from electric arc furnaces. The exact amount recycled is not known. In 1995, the U.S. steel industry generated more than 500,000 tons of electric furnace dust, typically containing 0.003% to 0.07% Cd. At least 20 States have collection networks for recycling Ni-Cd batteries.

Import Sources (1992-95): Metal: Canada, 42%; Belgium, 15%; Mexico, 12%; Germany, 7%; and other, 24%.

Tariff: Item	Number	Canada and Mexico 12/31/96	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Cadmium sulfide	2830.30.0000	Free	3.1% ad val.	25% ad val.
Pigments and preparations based on cadmium compounds	3206.30.0000	Free	3.1% ad val.	25% ad val.
Unwrought cadmium; waste and scrap; powders	8107.10.0000	Free	Free	33¢/kg.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Cadmium	2,020	115	2,020	—

Events, Trends, and Issues: Demand for rechargeable Ni-Cd batteries continued to grow worldwide, although at a somewhat slower rate than in past years. More than 60% of the cadmium consumed by Western countries goes into batteries, making batteries the principal end use. Japan continued to be the largest refiner of cadmium and also a net importer of cadmium metal. About 91% of the cadmium consumed by Japanese industry goes into batteries.

About 75% of the Ni-Cd batteries being produced by Western manufacturers are for cellular telephones and other cordless electronic equipment. The remaining 25% are used for industrial purposes, such as emergency power supplies for telephone exchanges and hospital operating rooms. These percentages are expected to change as sales of electric vehicles (EV's) accelerate in the United States, the European Union, and Japan.

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CADMIUM

Ni-Cd batteries could conceivably capture 30% of the midterm (2000-2005) EV battery market, but competition from both lithium-ion and nickel-metal hydride batteries may be intense because of environmental concerns about cadmium. Much of the battery development work in the United States and Japan was driven by the impending requirement that, by 2003, 10% of new vehicles sold in California must be emission free. The U.S. Advanced Battery Consortium, a partnership between domestic automobile manufacturers and the Electric Power Research Institute, is working with the U.S. Department of Energy to evaluate and improve a variety of prototype battery systems for EV's. Seven U.S. and Japanese automobile manufacturers were prepared to meet the 2003 deadline and at least three planned to offer new production models for purchase or lease before the end of 1997. In Europe, French automobile manufacturers are poised to mass-produce Ni-Cd powered EV's, after field testing some 50 EV's for more than 6 years at the port of La Rochelle. Most of the EV's in the La Rochelle tests are powered by Ni-Cd batteries. In October 1996, British sponsors bought 14 French EV's to field test them in the Midlands city of Coventry for at least a year. France planned to have 100,000 EV's on its highways by the year 2000.

On May 11, 1995, the U.S. Environmental Protection Agency published new, simplified regulations governing the collection and management of spent Ni-Cd batteries and several other widely generated hazardous wastes. The regulations were designed to encourage environmentally sound recycling of Ni-Cd batteries and to keep them out of the municipal waste stream. The bulk of the batteries currently being collected go to a nickel and chromium reclamation plant in western Pennsylvania, where the cadmium is recovered in an innovative, $5 million facility - the first of its kind. The cadmium is fumed off in special distillation furnaces, condensed, and cast into shot with a purity greater than 99.95%. Cadmium also is recovered from lead-zinc baghouse dust , which is generated on site during the smelting of stainless steel wastes.

The U.S. market for cadmium-based pigments has shrunk significantly since 1988 because of the adoption of stricter environmental regulations and the increased availability of alternative pigments. Both suppliers and consumers are concerned about recyclability and potential liability. Further substitution, however, is becoming increasingly difficult.

The price of cadmium metal has been extremely volatile over the last 10 years. At one point in 1988, the weekly quotation reached $8.50 to $9.10 per pound. In 1992, the price collapsed because of global recessionary forces, the loss of traditional markets, which was due to environmental concerns, and the introduction of stricter occupational exposure standards. An all time low of $0.38 to $0.48 per pound was recorded in the spring of 1993. The price partially recovered in late 1994 and peaked at $2.05 to $2.20 on November 21, 1995, only to falter again in mid-1996. The quotation on November 22, 1996, was $0.80 to $0.90.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	1,270	1,450	70,000	210,000
Australia	842	950	55,000	150,000
Belgium	1,710	1,700	—	—
Canada	2,360	2,400	80,000	170,000
Germany	1,150	1,200	6,000	8,000
Japan	2,652	2,700	10,000	15,000
Mexico	689	700	35,000	40,000
Other countries	7,830	7,900	280,000	380,000
World total (rounded)	18,500	19,000	540,000	970,000

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

Substitutes: Coatings of zinc or vapor-deposited aluminum can substitute for cadmium in some plating applications. However, cadmium is still required in situations where the surface characteristics of the coating are critical (e.g., fasteners for aircraft). Cerous sulfide (Ce_2S_3) was being evaluated as an alternative to some of the red cadmium-based pigments used to color plastics.

[e]Estimated. E Net exporter.
[1]Primary and secondary metal.
[2]Average New York dealer price for 99.95% purity in 5-short-ton lots. Source: *Platt's Metals Week.*
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.

CEMENT

(Data in thousand metric tons, unless otherwise noted)[1]

Domestic Production and Use: In 1996, approximately 75 million tons of portland cement and 3.6 million tons of masonry cement were produced at a total of 118 plants, spread among 37 States, by 1 State agency and 45 companies. In addition, there were two cement plants in Puerto Rico. The ex-plant value of production, excluding Puerto Rico, was about $5.5 billion, and the dominant portland cement component was used to make concrete worth almost $24 billion. Total cement consumption was about 90 million tons. There were 109 plants making clinker—the main intermediate product in cement manufacture—with a total calculated annual production capacity of about 76 million tons. Together with 9 other cement plants that were just grinding facilities for clinker produced elsewhere, total finish grinding capacity at yearend amounted to almost 91 million tons. If Puerto Rico is included, the clinker and grinding capacities become about 77 million tons and almost 93 million tons, respectively. The top 5 cement companies together accounted for about 36% of total U.S. clinker production and capacity and the top 10 companies accounted for about 60%. California, Texas, Pennsylvania, Michigan, Missouri, and Alabama, in descending order, were the six largest cement-producing States and together accounted for 50% of total U.S. production. In terms of use, cement manufacturers sold about 70% of their portland cement output to ready mixed concrete producers; 11% to producers of concrete products, such as block, pipe, and precast slabs; 10% to contractors (largely for roadpaving); 4% to building material dealers; and 5% to miscellaneous users, including Government and other contractors.

Salient Statistics—United States:[2]	1992	1993	1994	1995	1996[e]
Production, portland and masonry[3]	69,585	73,807	77,948	76,906	78,600
Shipments to final customers, including exports	76,520	80,099	85,934	86,561	92,600
Imports for consumption[4]	4,548	5,532	9,072	11,473	10,700
Exports	746	625	633	759	750
Consumption, apparent[5]	74,124	79,198	86,370	86,612	89,400
Price, average mill value, dollars per ton	54.61	56.36	61.88	68.46	70.00
Stocks, mill yearend	5,272	4,788	4,805	5,813	5,000
Employment, mine and mill[e], number	17,700	17,900	17,900	17,800	17,900
Net import reliance[6] as a percent of apparent consumption	6	7	10	11	12

Recycling: None.

Import Sources (1992-95): Canada, 41%; Spain, 10%; Mexico, 8%; Greece, 7%; and other, 34%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[7] 12/31/96
Cement clinker	2523.10.0000	Free	$1.32/mt.
White nonstaining portland cement	2523.21.0000	13¢/mt	$1.76/mt.
Other portland cement	2523.29.0000	Free	$1.32/mt.
Aluminous cement	2523.30.0000	Free	$1.32/mt.
Other hydraulic cement	2523.90.0000	Free	$1.32/mt.

Depletion Allowance: Certain raw materials for cement production, such as limestone, bauxite, and gypsum, have depletion allowances.

Government Stockpile: None.

Events, Trends, and Issues: The generally robust construction market in 1996 supported higher consumption levels for cement. To a significant degree, demand growth in 1996 was met through increased production, whereas that in 1995 had been met largely through increased imports. Although there was expectation of some leveling of demand in 1997, the long-term prognosis for cement consumption levels was optimistic, and a number of companies were engaged in plant modernization projects, including capacity upgrades, accordingly.

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CEMENT

There continued to be concern over the environmental impact of cement manufacture, particularly the emissions of carbon dioxide and cement kiln dust (CKD). Although the Environmental Protection Agency has yet to release guidelines on CKD emissions, it declined to rule the material a hazardous waste. A number of cement companies burn a proportion of solid or liquid waste materials in their kilns as a low-cost substitute for fossil fuels. Technically, cement kilns can be an effective and benign way of destroying such wastes; the viability of the practice, and the type of waste(s) burned, hinge on applicable current and future environmental regulations and their associated costs. The overall trend appears to be towards increased use of waste fuels, but some individual companies are abandoning the practice. A number of environmental issues also affect cement raw materials quarries, but these are common to other types of mines as well.

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

World Production and Capacity:

	Cement production		Yearend clinker capacity	
	1995	1996[e]	1995[e]	1996[e]
United States (includes Puerto Rico)	78,320	84,000	77,285	80,000
Brazil	[e]25,500	30,000	35,000	38,000
China	445,610	450,000	400,000	410,000
France	[e]21,000	20,000	27,000	27,000
Germany	[e]40,000	40,000	49,000	49,000
India	[e]70,000	70,000	75,000	80,000
Indonesia	[e]19,500	22,500	22,500	27,000
Italy	[e]35,000	35,000	45,000	45,000
Japan	90,474	90,000	97,500	96,400
Korea, Republic of	55,130	56,500	57,000	58,000
Mexico	23,971	28,000	40,000	43,000
Russia	[e]36,400	36,000	80,000	80,000
Spain	[e]25,000	25,000	23,000	23,000
Taiwan	22,478	24,000	23,000	23,000
Thailand	[e]26,500	35,000	30,000	35,000
Turkey	33,153	35,000	30,000	31,000
Other countries	[e]373,300	375,000	350,000	360,000
World total (rounded)	[e]1,421,300	1,460,000	1,500,000	1,500,000

World Resources: Although individual company's reserves are subject to exhaustion, cement raw materials, especially limestone, are geologically widespread and abundant and, overall, shortages are unlikely in the foreseeable future. Local shortages generally can be met through outside purchases, and both clinker and cement are widely traded on the world market.

Substitutes: Virtually all portland cement is utilized either in making concrete or mortars and, as such, competes with substitutes for concrete in the construction sector. These substitutes include brick clay, glass, aluminum, steel, fiberglass, wood, and stone. In the important road paving market, the main competitor is asphalt. There is a small but growing use in the United States of natural and synthetic pozzolans as partial or complete substitutes for portland cement for some concrete applications. Pozzolan use is much more widespread overseas.

[e]Estimated.
[1]See Appendix A for conversion to short tons.
[2]Portland plus masonry cement, unless otherwise noted. Excludes Puerto Rico.
[3]Includes cement made from imported clinker.
[4]Hydraulic cement. Excludes clinker.
[5]Production of cement (including from imported clinker) + imports (excluding clinker) - exports - changes in stocks.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix B.

CESIUM

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

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

Salient Statistics—United States: Salient statistics, such as production, consumption, imports, and exports, are not available.

The cesium market is very small. As a result, there is no active trading of the metal and, therefore, no official market price. However, several companies publish prices for cesium and cesium compounds. These prices are relatively stable for several years. The per-unit price for the metal or compounds purchased from these companies varies inversely with the quantity of material purchased. For example, in 1996, one company offered 1-gram ampoules of 99.98% grade cesium metal at $40.80. The price for 100 grams of the same material from this company was $535.00 or $5.35 per gram. At another company, the price for a 1-gram ampoule of 99.95% pure cesium was $38.64.

Recycling: None.

Import Sources (1992-95): The United States is 100% import reliant. Canada is the major source of cesium ores. Other possible sources of cesium-bearing material include Germany and the United Kingdom.

Tariff:

Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[1] 12/31/96
Alkali metals, other	2805.19.0000	6.2% ad val.	25% ad val.
Chlorides, other	2827.39.5000	3.7% ad val.	25% ad val.

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

Government Stockpile: None.

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CESIUM

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

World Mine Production, Reserves, and Reserve Base: Data on mine production of cesium are not available. Cesium forms independent minerals in pegmatites, and is commonly obtained as a coproduct in the processing of titanium, beryllium, and lithium minerals. Reserves and the reserve base are associated mainly with the cesium silicate mineral pollucite, concentrates of which contain more than 20% cesium.

	Reserves[2]	Reserve base[2]
Canada	70,000,000	73,000,000
Namibia	7,000,000	9,000,000
Zimbabwe	23,000,000	23,000,000
Other countries	NA	NA
World total (may be rounded)	100,000,000	110,000,000

World Resources: World resources of cesium are not known.

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

NA Not available.
[1]See Appendix B.
[2]See Appendix C for definitions.

CHROMIUM

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

Domestic Production and Use: The United States consumes about 16% of world chromite ore production in various forms of imported materials (chromite ore, chromium ferroalloys, chromium metal, and chromium chemicals). Imported chromite was consumed by two chemical firms, one metallurgical firm, and four refractory firms to produce chromium chemicals, chromium ferroalloys, and chromite-containing refractories, respectively. Consumption of chromium ferroalloys and metal by end use was: stainless and heat-resisting steel, 74%; full-alloy steel, 10%; superalloys, 3%; and others, 13%. The value of chromium materials consumption was about $430 million. Secondary chromium is recovered from stainless steel scrap.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Production: Mine	—	—	—	—	—
Secondary	102	92	99	113	104
Imports for consumption	324	330	273	416	400
Exports	18	21	33	27	63
Government stockpile releases	(30)	68	49	44	41
Consumption: Reported (excludes secondary)	334	327	310	298	264
Apparent[2] (includes secondary)	378	484	390	566	497
Price, chromite, yearend:					
Turkish, dollars per metric ton, Turkey	110	110	110	230	230
South African, dollars per metric ton, South Africa	60	60	60	80	80
Stocks, industry, yearend	118	103	101	80	65
Net import reliance[3] as a percent of apparent consumption	73	81	75	80	79

Recycling: In 1996, chromium contained in purchased stainless steel scrap accounted for 21% of demand.

Import Sources (1992-95): Chromium contained in chromite ore and chromium ferroalloys and metal: South Africa, 37%; Turkey, 15%; Russia ,11%; Kazakstan, 6%; Zimbabwe, 6%; and other, 25%.

Tariff:[4] Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Ore and concentrate	2610.00.0000	Free	Free.
Ferrochromium, high-carbon	7202.41.0000	1.9% ad val.	7.5% ad val.

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

Government Stockpile: The National Defense Stockpile Agency submitted the Annual Materials Plan for 1997 in February 1996. Congress passed the plan in September. The plan was to become effective in November 1996. The plan set maximum amounts of material that may be sold as follows: chromite ore, 90,700 tons of chemical grade, 227,000 tons of metallurgical grade, and 90,700 tons of refractory grade; chromium ferroalloys, 31,800 tons.

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96	Average chromium content
Chromite ore:					
Chemical-grade	175	44.7	122	—	28.6%
Metallurgical-grade	384	259	384	[6](51.9)	28.6%
Refractory-grade	231	90.7	85.7	9.98	[e]23.9%
Chromium ferroalloys:					
Ferrochromium:					
High-carbon	695	39.0	399	39.0	71.4%
Low-carbon	283	—	—	—	71.4%
Ferrochromium-silicon	52.7	2	—	0.255	42.9%
Chromium metal	7.72	—	—	—	[e]100%

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CHROMIUM

Events, Trends, and Issues: Chromite ore is not produced in the United States, Canada, or Mexico. Chromite ore is produced in the Western Hemisphere only in Brazil and Cuba. Virtually all of Brazilian production is consumed in Brazil. Cuban production is small. The two largest chromite ore producers, accounting for about two-thirds of world production, Kazakstan and South Africa, are both currently undergoing major political change. Economic and political reorganization in the former Soviet Union has resulted in reduced demand. This lull in demand may be followed by strong growth-driven demand resulting from the institution of reforms in those countries. South Africa has been the major supplier of chromite ore to Western industrialized countries. In 1995, prices recovered from having been suppressed by excess production capacity resulting from the dissolution of the U.S.S.R.[7] in 1991 and excess ferrochromium capacity resulting from expansion worldwide during 1990-92. Western economy demand remains firm while industry restructures. Chromium markets weakened in 1996 as the stainless steel industry adjusted after 2 consecutive years of growth in excess of 10%.

Chromium releases into the environment are regulated by the U.S. Environmental Protection Agency. Workplace exposure is regulated by the U.S. Occupational Safety and Health Administration.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	1995	1996[e]	(shipping grade)[9]	
United States	—	—	—	10,000
Albania	250	250	6,100	6,100
Brazil	360	350	14,000	23,000
Finland	610	600	38,000	46,000
India	1,230	1,100	27,000	67,000
Iran	129	100	2,400	2,400
Kazakstan	2,400	2,400	320,000	320,000
Russia	151	150	4,000	460,000
South Africa	5,100	5,000	3,100,000	5,500,000
Turkey	800	800	8,000	20,000
Zimbabwe	631	600	140,000	930,000
Other countries	368	350	29,000	37,000
World total (may be rounded)	12,000	12,000	3,700,000	7,500,000

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

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

[e]Estimated.
[1]Data in thousand metric tons of contained chromium, unless noted otherwise.
[2]Calculated demand for chromium is production + imports - exports + stock adjustment.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]In addition to the tariff items listed, certain imported chromium materials (see U.S. Code, chapter 26, sections 4661 and 4672) are subject to excise tax.
[5]See Appendix B.
[6]Reinstatement of previously sold material.
[7]As constituted before Dec. 1991.
[8]See Appendix C for definitions. Reserves and reserve base data are rounded to no more than two significant figures.
[9]Shipping-grade chromite ore is deposit quantity and grade normalized to 45% Cr_2O_3.

CLAYS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 1996, clays were produced in most States except Alaska, Delaware, Hawaii, Rhode Island, Vermont, and Wisconsin. The leading 90 firms supplied 83% of the output, and about 190 firms provided the remainder. Together, these firms operated about 820 mines. Estimated value of all marketable clay produced was about $1.7 billion. Major domestic uses for specific clays were estimated as follows: kaolin—52% paper, 13% kiln furniture, 6% fiberglass, 4% paint, and 3% rubber; ball clay—25% floor and wall tile, 21% sanitaryware, and 13% pottery; fire clay—69% grogs, calcines, and firebrick; bentonite—22% foundry sand bond, 19% iron ore pelletizing, and 18% drilling mud; fuller's earth—73% absorbent uses and 12% insecticide dispersant; and common clay—50% brick, 25% cement, and 16% lightweight aggregate.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Production, mine:					
Kaolin	8,740	8,830	8,770	9,480	9,530
Ball clay	854	911	1,050	993	968
Fire clay[2]	383	459	458	583	495
Bentonite	2,950	2,870	3,290	3,820	4,110
Fuller's earth	2,410	2,480	2,640	2,640	2,580
Common clay	24,900	25,300	25,900	25,600	26,300
Total[3]	40,200	40,700	42,000	43,100	44,000
Imports for consumption	41	39	36	35	42
Exports	4,160	4,150	4,620	4,680	4,800
Consumption, apparent	36,100	36,600	37,600	38,500	39,200
Price, average, dollars per ton:					
Kaolin	107	107	116	117	114
Ball clay	42	42	43	46	49
Fire clay	27	25	25	22	16
Fuller's earth	100	92	92	101	102
Common clay	5	5	5	6	5
Bentonite	39	36	41	36	36
Stocks, yearend[4]	NA	NA	NA	NA	NA
Employment[e], number: Mine	5,000	4,500	3,950	4,900	4,900
Mill	9,000	9,000	9,000	9,000	9,000
Net import reliance[5] as a percent of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1992-95): Mexico, 31%; China, 20%; United Kingdom, 20%; Canada, 15%; and other, 14%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[6] 12/31/96
Kaolin and other kaolinitic clays, whether or not calcined	2507.00.0000	19.5¢/mt	$2.46/mt.
Bentonite	2508.10.0000	23.6¢/mt	$3.20/mt.
Fuller's and decolorizing earths	2508.20.0000	14.8¢/mt	$1.48/mt.
Fire clay	2508.30.0000	29.5¢/mt	$1.97/mt.
Common blue and other ball clays	2508.40.0010	28¢/mt	$1.97/mt.
Other clays	2508.40.0050	28¢/mt	$1.97/mt.
Chamotte or dinas earth	2508.70.0000	Free	Free.
Activated clays and earths	3802.90.2000	2.5% ad val.	0.6¢ per kg + 30% ad val.
Expanded clays and mixtures	6806.20.0000	2.9% ad val.	30% ad val.

Depletion Allowance: Kaolin, ball clay, bentonite, fuller's earth, and fire clay, 14% (Domestic), 14% (Foreign); clay used for extraction of alumina or aluminum compounds, 22% (Domestic); clay and shale used for making brick, tile, and lightweight aggregate, 7.5% (Domestic), 7.5% (Foreign); clay used in making drainage and roofing tile, flowerpots, and kindred products, 5% (Domestic), 5% (Foreign).

Government Stockpile: None.

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CLAYS

Events, Trends, and Issues: The total tonnage of clays sold or used by domestic producers increased 2% in 1996. There was an increase in sales and/or use for bentonite, common clay, and kaolin. Imports for consumption increased 20% to 42,000 tons. China and the United Kingdom were the major sources for imported clays. Exports increased 3% to 4.8 million tons. Canada, Finland, Japan, and the Netherlands were major markets for exported clays. U.S. apparent consumption was estimated to be 39.2 million tons.

An International Agency for Research on Cancer (IARC) panel met in October to review the health risk posed by several forms of silica. The IARC panel concluded that there was sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or cristobalite from occupational sources and inadequate evidence for amorphous silica. A monograph detailing the results of the study will be published in March 1997.

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

World Resources: Clays are divided for commercial purposes into kaolin, ball clay, fire clay, bentonite, fuller's earth, and common clay. Resources of these types of clay are extremely large except for lesser resources of high-grade ball clay and sodium-bentonite. Resources of kaolin in Georgia are estimated to be 5 to 10 billion tons.

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

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

COBALT

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

Domestic Production and Use: Domestic mine production ceased at the end of 1971, and the only U.S. cobalt refinery stopped processing imported nickel-cobalt matte in late 1985. Most secondary cobalt is derived from recycled superalloy or cemented carbide scrap and from spent catalysts. About 13 recyclers accounted for nearly all the cobalt recycled in superalloy scrap. There were two producers of extra-fine cobalt powder: One produced powder from imported primary metal and another produced powder from recycled materials. In addition to the powder producers, six companies were known to be active in the production of cobalt compounds. More than 100 industrial consumers were surveyed on a monthly or annual basis. About 85% of U.S. consumption of cobalt was in five major end uses. Superalloys, used mainly in aircraft gas turbine engines, accounted for about 42% of U.S. demand; cemented carbides, paint driers, and magnetic alloys each accounted for about 11%; catalysts about 10%; and other, 15%. The total estimated value of cobalt consumed in 1996 was $450 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine	—	—	—	—	—
Secondary	1,610	1,570	1,570	1,540	1,500
Imports for consumption	5,760	5,950	6,780	6,440	6,900
Exports	1,420	795	1,360	1,300	1,500
Shipments from Government stockpile excesses	—	289	1,500	1,550	2,000
Consumption:					
Reported (includes secondary)	6,380	6,430	6,990	7,000	7,300
Apparent (includes secondary)	6,590	7,310	8,470	8,660	8,900
Price, average annual spot for cathodes, dollars per pound	22.93	13.79	24.66	29.21	26.00
Stocks, industry, yearend	1,760	1,460	1,490	1,060	1,060
Net import reliance[1] as a percent of apparent consumption	76	79	81	82	83

Recycling: About 1,500 tons of cobalt was recycled from purchased scrap in 1996. This represented about 20% of estimated reported consumption for the year.

Import Sources (1992-95): Cobalt contained in metal, oxide, and salts: Zambia, 21%; Norway, 19%; Canada, 14%; Finland, 14%; and other, 32%. Since 1991, imports from Zaire and Zambia have decreased, while imports from Finland, Norway, and Russia have increased.

Tariff: Item	Number	Most favored nation (MFN)[2] 12/31/96	Non-MFN[3] 12/31/96
Unwrought cobalt, alloys	8105.10.3000	5.1% ad val.	45% ad val.
Unwrought cobalt, other	8105.10.6000	Free	Free.
Cobalt matte, waste, and scrap	8105.10.9000	Free	Free.
Wrought cobalt and cobalt articles	8105.90.0000	4.8% ad val.	45% ad val.
Chemical compounds:			
Cobalt oxides and hydroxides	2822.00.0000	0.1% ad val.	1.7% ad val.
Cobalt sulfates	2833.29.1000	1.4% ad val.	6.5% ad val.
Cobalt chlorides	2827.34.0000	4.2% ad val.	30% ad val.
Cobalt carbonates	2836.99.1000	4.2% ad val.	30% ad val.
Cobalt acetates	2915.23.0000	4.2% ad val.	30% ad val.
Cobalt ores and concentrates	2605.00.0000	Free	Free.

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

Government Stockpile: Sales of National Defense Stockpile cobalt began in March 1993. The Department of Defense's proposed new material disposal authority includes 2,720 tons (6 million pounds) of cobalt during fiscal year 1997 and 2,720 tons (6 million pounds) of cobalt during fiscal year 1998.

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Cobalt	18,300	655	11,900	903

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COBALT

Events, Trends, and Issues: World cobalt supply continued to increase. Refinery production in the first half of 1996 was higher than production during the first half of 1995. Cobalt exports from Russia and sales from the National Defense Stockpile also contributed to supply. The free market price for cobalt cathode decreased from approximately $32 per pound in January to $20 per pound in July. In August the price began to increase. By the end of September the price was approximately $23 per pound.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	—	—	—	860,000
Australia	2,500	2,500	52,000	420,000
Canada	5,270	5,300	45,000	260,000
Cuba	1,560	1,600	1,000,000	1,800,000
New Caledonia[5]	800	800	230,000	860,000
Philippines	—	—	—	400,000
Russia	3,500	3,500	140,000	230,000
Zaire	1,650	2,500	2,000,000	2,500,000
Zambia	5,000	6,000	360,000	540,000
Other countries	1,810	1,900	90,000	1,200,000
World total (may be rounded)	22,100	24,100	4,000,000	9,000,000

World Resources: The cobalt resources of the United States are estimated to be about 1.3 million tons. Most of these resources are in Minnesota, but other important occurrences are in Alaska, California, Idaho, Missouri, Montana, and Oregon. Although large, most domestic resources are in subeconomic concentrations that will not be economical in the foreseeable future. In addition, with the exception of Idaho, any cobalt production from these deposits would be as a byproduct of another metal. The identified world cobalt resources are about 11 million tons. The vast majority of these resources are in nickel-bearing laterite deposits, with most of the rest occurring in nickel-copper sulfide deposits hosted in mafic and ultramafic rocks in Australia, Canada, and Russia, and in the sedimentary copper deposits of Zaire and Zambia. In addition, millions of tons of hypothetical and speculative cobalt resources exist in manganese nodules and crusts on the ocean floor. Cobalt reserves and reserve base for Australia have been revised to be consistent with data published by the Australian Bureau of Resource Sciences.

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

[e]Estimated.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]No tariff for Canada or Mexico.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]Overseas territory of France.

COLUMBIUM (NIOBIUM)

(Data in thousand kilograms of columbium content, unless otherwise noted)

Domestic Production and Use: There has been no significant domestic columbium-mining industry since 1959, with the exception of small unreported quantities of columbium-bearing concentrates produced in 1989-92. Domestic columbium resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Most metal, ferrocolumbium, other alloys, and compounds were produced by six companies with seven plants. Feed for these plants included imported concentrates, columbium oxide, and ferrocolumbium. Consumption was mainly as ferrocolumbium by the steel industry and as columbium alloys and metal by the aerospace industry, with plants in the Eastern and Midwestern United States, California, and Washington. The estimated value of reported columbium consumption, in the form of ferrocolumbium and nickel columbium, in 1996 was about $55 million. Major end-use distribution of reported columbium consumption was as follows: high-strength low-alloy steels, 37%; carbon steels, 33%; superalloys, 17%; stainless and heat-resisting steels, 12%; and other, 1%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine	([1])	—	—	—	—
Imports for consumption:					
Concentrates, tin slags, and other[2]	NA	NA	NA	NA	NA
Ferrocolumbium[e]	2,450	2,190	2,590	3,580	2,900
Exports, concentrate, metal, and alloys[e]	350	300	320	370	300
Consumption, reported:					
Raw material	NA	NA	NA	NA	NA
Ferrocolumbium[e 3]	2,460	2,470	2,750	2,900	2,800
Consumption, apparent	3,500	3,500	3,700	3,800	3,800
Price: Columbite, dollars per pound[4]	2.83	2.67	2.60	2.97	3.00
Pyrochlore, dollars per pound[5]	2.75	2.75	NA	NA	NA
Stocks, industry, processor and consumer, yearend	NA	NA	NA	NA	NA
Employment	NA	NA	NA	NA	NA
Net import reliance[6] as a percent of apparent consumption	100	100	100	100	100

Recycling: Insignificant.

Import Sources (1992-95): Brazil, 67%; Canada, 22%; Germany, 3%; and other, 8%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[7] 12/31/96
Columbium ores and concentrates	2615.90.6030	Free	Free.
Columbium oxide	2825.90.1500	3.7% ad val.	25% ad val.
Ferrocolumbium	7202.93.0000	5.0% ad val.	25% ad val.
Columbium, unwrought:			
Waste and scrap	8112.91.0500	Free	Free.
Alloys, metal, and powders	8112.91.4000	4.9% ad val.	25% ad val.
Columbium, wrought	8112.99.0000	4.9% ad val.	45% ad val.

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

Government Stockpile: The National Defense Stockpile uncommitted inventories shown below include 343,000 kilograms in nonstockpile-grade concentrates and 151,000 kilograms in nonstockpile-grade ferrocolumbium. The Department of Defense proposed to dispose of about 27,200 kilograms of ferrocolumbium in fiscal year 1997 and about 45,400 kilograms in fiscal year 1998.

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Columbium:				
Carbide powder	10	—	—	—
Concentrates	786	—	—	—
Ferrocolumbium	535	—	422	—
Metal	73	—	—	—

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COLUMBIUM (NIOBIUM)

Events, Trends, and Issues: For the first one-half year, overall reported consumption of columbium decreased slightly compared with that of the previous year. Consumption of columbium by the steelmaking sector was virtually unchanged, while demand for columbium in superalloys was down by about 6%. For the same period, overall columbium imports were down by about 20%, owing to a substantial decrease in the volume of columbium mineral concentrates from Canada. Brazil was the leading supplier, providing about 60% of total imports. In late November, the published price for columbite ore was quoted at a range of $2.80 to $3.20 per pound of contained columbium and tantalum pentoxides. The published price for steelmaking-grade ferrocolumbium was quoted at $6.58 per pound of contained columbium, and for high-purity ferrocolumbium and nickel columbium at $18.50 and $20.50 per pound of contained columbium, respectively. The published price for columbium oxide was quoted at $8.17 per pound of oxide, and the published price for columbium metal was quoted at a range of $30 to $50 per pound.

It is estimated that in 1997 domestic columbium mine production will be zero and U.S. apparent consumption will be about 3.9 million kilograms. The majority of total U.S. demand will be supplied by columbium imports in upgraded forms.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[e 8]	Reserve base[e 8]
	1995	1996[e]		
United States	—	—	—	Negligible
Australia	109	110	NA	NA
Brazil	15,300	15,000	3,300,000	3,600,000
Canada	2,360	2,400	140,000	410,000
Nigeria	13	10	64,000	91,000
Zaire	1	1	32,000	91,000
Zimbabwe	1	1	NA	NA
Other countries[9]	—	1	6,000	9,000
World total (rounded)	17,800	17,500	3,500,000	4,200,000

World Resources: Most of the world's identified resources of columbium are outside the United States and occur mainly as pyrochlore in carbonatite deposits. On a worldwide basis, resources are more than adequate to supply projected needs. The United States has approximately 360 million kilograms of columbium resources in identified deposits, most of which were considered uneconomic at 1996 prices for columbium.

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

[e]Estimated. NA Not available.
[1]A small unreported quantity was produced.
[2]Metal, alloys, synthetic concentrates, and columbium oxide.
[3]Includes nickel columbium and a small quantity of other columbium materials.
[4]Average value, contained pentoxides for material having a Nb_2O_5 to Ta_2O_5 ratio of 10 to 1.
[5]Average value, contained pentoxide.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix B.
[8]See Appendix C for definitions.
[9]Excludes any production from Bolivia, China, and countries in the former Soviet Union.

COPPER

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

Domestic Production and Use: Domestic mine production, which had remained unchanged in 1995, resumed the upward trend begun in 1984, rising to 1.9 million metric tons valued at about $4.5 billion. The five principal mining States, in descending order, Arizona, Utah, New Mexico, Nevada, and Montana, accounted for 98% of domestic production; copper was also recovered at mines in six other States. While copper was recovered at about 40 mines operating in the United States, 15 mines accounted for about 96% of production. Seven primary and 4 secondary smelters, 7 electrolytic and 6 fire refineries, and 14 solvent extraction-electrowinning operations were operating at yearend. Refined copper and direct melt scrap were consumed at about 35 brass mills; 15 rod mills; and 600 foundries, chemical plants, and miscellaneous consumers. Copper and copper alloy products were consumed[1] in building construction, 40%; electric and electronic products, 25%; industrial machinery and equipment, 12%; transportation equipment, 13%; and consumer and general products, 10%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine	1,760	1,800	1,850	1,850	1,900
Refinery: Primary[2]	1,710	1,790	1,840	1,930	2,000
Secondary[3]	433	460	392	352	330
Copper from all old scrap	555	543	500	442	400
Import for consumption:					
Ores and concentrates	102	37	82	127	120
Refined	289	343	470	429	550
All imports	593	637	763	808	950
Exports: Ores and concentrates	266	227	261	239	200
Refined	177	217	157	217	180
All exports	676	685	752	894	840
Consumption: Refined, reported	2,180	2,360	2,680	2,530	2,620
Apparent, primary and old scrap[4]	2,300	2,510	2,680	2,540	2,760
Price, average, cents per pound:					
Domestic producer, cathode	107.4	91.6	111.0	138.3	108
London Metal Exchange, high-grade	103.7	86.8	104.6	133.1	102
Stocks, yearend, refined[5]	205	153	119	163	170
Employment, mine and mill, thousands	13.6	13.3	13.1	13.8	14.0
Net import reliance[6] as a percent of apparent consumption	2	7	13	7	13

Recycling: Old scrap, converted to refined metal and alloys, provided 400,000 tons of copper, equivalent to 15% of apparent consumption. Purchased new scrap, derived from copper fabricating operations, yielded 880,000 tons of contained copper; 78% of the copper contained in new scrap was consumed at brass mills. Of the total copper recovered from scrap, copper smelters and refiners recovered 26%; ingot makers, 10%; brass mills, 57%; and miscellaneous manufacturers, foundries, and chemical plants, 7%. Copper in all old and new, refined or remelted scrap comprised 35% of U.S. copper supply.

Import Sources (1992-95): Canada unalloyed, 50%; Chile, 19%; Mexico, 13%; and other, 18%. Refined copper comprised 55% of imports of unwrought copper.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Canada 12/31/96	Mexico 12/31/96	Non-MFN[7] 12/31/96
Unrefined copper; anodes	7402.00.0000	0.6% ad val.[8]	Free	0.4% ad val.[8]	6% ad val.[8]
Refined and alloys; unwrought	7403.00.0000	1% ad val.	Free	Free	6% ad val.
Copper powder	7406.10.0000	3.2% ad val.	1.0% ad val.	Free	49% ad val.
Copper wire (bare)	7408.11.6000	3.6% ad val.	0.8% ad val.	Free	28% ad val.

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

Government Stockpile: None. The stockpile of about 20,000 tons of refined copper was liquidated in 1993. The stockpile of about 8,100 tons of brass was liquidated in 1994.

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COPPER

Events, Trends, and Issues: World mine production of copper rose significantly for the second consecutive year, increasing by about 5% in 1996. Most of the increase came from expanding capacity in South America, particularly Chile, where more than 400,000 tons of new capacity came on-stream. Domestic copper companies continued to invest in Chilean and Peruvian properties in an effort to expand production and reduce costs. In the United States, production was projected to rise about 3% owing to startup of the Robinson Mine in Nevada and underground mining at the Mission Complex in Arizona, and a full year of production at the Southside Extension of the Morenci Mine in Arizona.

According to data compiled by the International Copper Study Group, the world supply and demand for refined copper for the first 8 months of 1996 were nearly in balance. Combined inventories held at London Metal Exchange (LME) and Comex warehouses declined nominally from the low December 1995 level. This followed 2 years where a large apparent world supply deficit led to a large drawdown in reported inventories and record high average annual prices for 1995. Both world and U.S. demand for refined copper were projected to increase by 3% for 1996. Domestic net imports of refined copper rose by almost 75% as refined production was unable to keep pace with the growth in refined consumption. Refined production was below expectation as a new smelter in Utah, commissioned in 1995 to replace an existing smelter, continued to encounter startup problems that resulted in lower production from the associated refinery.

Copper prices remained relatively high during the first 5 months of 1996, the U.S. producer price for refined copper averaging about $1.22 per pound. However, the market exhibited a high degree of volatility amid speculation about a pending market surplus and market manipulation. In June, following revelation by a Japanese company that its head copper trader had amassed losses in excess of $1.8 billion from unauthorized trades over a 10-year period, prices fell sharply; the U.S. producer price was projected to average only $0.94 for the second half of the year. At yearend, the company and its trading partners were under investigation by authorities in the United States, Europe, and Japan.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[9]	Reserve base[9]
	1995	1996[e]		
United States	1,850	1,900	45,000	90,000
Australia	437	440	7,000	23,000
Canada	726	700	10,000	23,000
Chile	2,490	3,000	88,000	163,000
China	370	400	3,000	8,000
Indonesia	444	480	11,000	15,000
Kazakstan	260	220	14,000	20,000
Mexico	332	350	15,000	27,000
Peru	381	430	7,000	24,000
Poland	384	380	20,000	36,000
Russia	591	620	20,000	30,000
Zaire	29	30	10,000	30,000
Zambia	329	350	12,000	34,000
Other countries	1,430	1,400	40,000	75,000
World total (rounded)	10,000	10,700	310,000	610,000

World Resources: Land-based resources are estimated at 1.6 billion tons of copper, and resources in deep-sea nodules are estimated at 0.7 billion tons.

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

[e]Estimated.
[1]Some electrical components are included in each end use. Estimated after Copper Development Association, 1995.
[2]Includes production from imported ores and concentrates.
[3]From both primary and secondary refineries.
[4]Defined as primary refined production + copper from old scrap converted to refined metal and alloys + refined imports - refined exports ± changes in refined stocks.
[5]Held by industry, Government, and the Commodity Exchange, Inc.; Government stocks were liquidated in 1993.
[6]Defined as imports - exports + adjustments for Government and industry stock changes for refined copper.
[7]See Appendix B.
[8]Value of copper content.
[9]See Appendix C for definitions.

DIAMOND (INDUSTRIAL)

(Data in million carats, unless otherwise noted)

Domestic Production and Use: Industrial diamond output declined slightly, but the United States continued to be the world's largest consumer of industrial diamond. Most industrial diamond produced domestically was synthetic grit and powder. The output was from two major firms, one each in New Jersey and Ohio. Six firms recovered and sold industrial diamond as their principal product. Additional firms recovered industrial diamond in secondary operations. Most consumption was accounted for by the following industry sectors: machinery manufacturing, mineral services, stone and ceramic production, abrasive industries, construction, and transportation equipment manufacturing. Mineral services, primarily drilling, accounted for most industrial stone consumption.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Bort, grit, and powder and dust; natural and synthetic:					
Production: Manufactured diamond	95.0	105	104	115	110
Secondary[2]	3.4	15.9	16.0	26.1	48
Imports for consumption	97.3	133	174	188	212
Exports and reexports	83.6	107	153	101	107
Sales from Government stockpile excesses	10.4	—	2.0	.2	1
Consumption, apparent	122	146	141	228	263
Price, value of imports, dollars per carat	.70	.61	.51	.43	.45
Net import reliance[3] as a percent of apparent consumption	19	18	15	38	40
Stones, natural:					
Production: Mine	—	—	—	—	([4])
Secondary	.1	.1	.1	.3	.3
Imports for consumption[5]	9.8	5.2	2.8	4.1	3.2
Exports and reexports[6]	5.6	3.4	4.4	5.2	3.8
Sales from Government stockpile excesses	—	1.3	3.1	.3	.6
Consumption, apparent	4.3	1.9	NA	NA	NA
Price, value of imports, dollars per carat	4.56	6.85	9.41	6.62	6.97
Net import reliance[3] as a percent of apparent consumption	98	95	NA	NA	NA

Recycling: At least 2 million carats of old scrap were salvaged.

Import Sources (1992-95): Bort, grit, and powder and dust; natural and synthetic: Ireland, 60%; China, 5%; Russia, 5%; and other, 30%. Stone, natural: United Kingdom, 28%; Ireland, 27%; Zaire, 15%; and other, 30%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[7] 12/31/96
Miners' diamond, carbonados	7102.21.1010	Free	Free.
Other	7102.21.1020	Free	Free.
Industrial diamond, natural advanced	7102.21.3000	2.9% ad val.	30% ad val.
Industrial diamond, natural not advanced	7102.21.4000	Free	Free.
Industrial diamond, other	7102.29.0000	Free	Free.
Dust, grit, or powder	7105.10.0000	Free	Free.

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DIAMOND (INDUSTRIAL)

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

Government Stockpile: Excess crushing bort and industrial stones were sold at auction.

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Crushing bort	0.816	0.503	0.724	0.993
Industrial stones	4.65	0.210	1.58	0.573

Events, Trends, and Issues: The United States will continue to be the largest market for industrial diamond through the remainder of this decade. Both domestic and world demand for diamond grit and powder will experience growth through the next 5 years. Increases in demand for synthetic grit and powder are expected to be greater than for natural diamond material. Constant-dollar prices of synthetic diamond products probably will continue to decline as production increases make them more cost-effective. However, the consolidation of major synthetic diamond producers could stabilize prices.

World Mine Production, Reserves, and Reserve Base:[8]

	Mine production		Reserves[e 9]	Reserve base[e 9]
	1995	1996[e]		
United States	—	([4])	—	Unknown
Australia	22.4	23.0	500	900
Botswana	5.3	5.0	130	200
Brazil	.9	.9	5	15
China	.9	.9	10	20
Russia	9.0	9.0	40	65
South Africa	5.4	5.5	70	150
Zaire	13.0	13.0	150	350
Other countries	.8	.7	80	200
World total (may be rounded)	57.7	58.0	980	1,900

World Resources: Potential for the discovery of diamond resources in the United States, Canada, and Russia has improved. However, the significance of deposits already discovered will take several more years of evaluation. Technology has been developed to synthesize diamond powder, dust, and grit for industrial use worldwide; firms in the United States and Japan manufacture synthetic stones. World resources of natural industrial diamond in the stone-size range are unknown.

Substitutes: Competitive materials include manufactured abrasives (such as cubic boron nitride, fused aluminum oxide, and silicon carbide) and natural abrasives (such as garnet, emery, and corundum). Synthesized polycrystalline diamond is competitive with natural stones in many applications. Research continues on additional uses of synthetic polycrystalline compacts and shapes as substitutes for stones and on the uses of diamond films and diamond-like carbon coatings.

[e]Estimated. NA Not available.
[1]Industry stocks and employment are unknown.
[2]Includes both new and old scrap after 1992.
[3]Defined as imports - exports including reexports + adjustments for Government and industry stock changes.
[4]Less than ½ unit.
[5]May include synthetic miners diamond.
[6]Includes diamonds in manufactured abrasive products.
[7]See Appendix B.
[8]Natural industrial diamond only.
[9]See Appendix C for definitions.

DIATOMITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: The estimated value of processed diatomite, f.o.b. plant, was $174 million in 1996. Six companies with 12 processing facilities in 4 States produced diatomite. California and Nevada were the principal producing States. End uses of diatomite were filter aid, 70%; fillers, 11%; and other, 19%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[1]	595	599	613	687	700
Imports for consumption	([2])	([2])	([2])	([2])	([2])
Exports	163	165	157	144	137
Consumption, apparent	432	436	456	543	563
Price, average value, dollars per ton, f.o.b. plant	237	251	248	249	249
Stocks, producer, yearend	36	36	36	36	36
Employment, mine and plant[e], number	1,000	1,000	1,000	1,000	1,000
Net import reliance[3] as a percent of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (1992-95): Mexico, 56%; France, 31%; and other, 13%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Diatomite, crude or processed	2512.00.0000	Free	Free.

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

Government Stockpile: None.

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DIATOMITE

Events, Trends, and Issues: The United States remained the largest producer and consumer of diatomite and exported processed diatomite to 75 countries, primarily for filtration use.

Diatomite is finding new applications in biotechnology, particularily in pharmaceutical applications, in toxic liquid waste thickening, and other environmental cleanup technologies.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States[1]	687	700	250,000	500,000
Denmark[6]	96	96		NA
France	100	110	Other	2,000
Germany	50	50	countries:	NA
Korea, Republic of	80	80	550,000	NA
Mexico	47	50		2,000
Spain	36	40		NA
Former Soviet Union[7]	110	120		NA
Other countries	164	165		NA
World total (may be rounded)	1,370	1,410	800,000	Large

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

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

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

FELDSPAR

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: U.S. feldspar production (including aplite) in 1996 had an estimated value of $38 million. The three largest producers accounted for over one-half of the output, with eight other companies supplying the remainder. Operations in North Carolina provided about 55% of the output and facilities in six other States contributed smaller quantities.

Production of lithium ores and mica yielded moderate quantities of byproduct or coproduct feldspar and feldspar-silica mixtures, and feldspar processors reported coproduct recovery of mica and silica sand.

Feldspar is ground for industry use to about 20 mesh for glassmaking and to 200 mesh or finer for most ceramic and filler applications. It was estimated that feldspar shipments went to at least 31 States and to foreign destinations, including Canada and Mexico. In ceramics and glass, feldspar functions as a flux. Estimated 1996 end-use distribution of domestic feldspar was glass, 69%, and pottery and other, 31%.

Salient Statistics—United States:	**1992**	**1993**	**1994**	**1995**	**1996[e]**
Production, marketable	725	770	765	880	900
Imports for consumption	13	7	7	9	10
Exports	18	18	17	15	15
Consumption, apparent	720	759	755	874	895
Price, average value, marketable production, dollars per ton	39.31	40.78	40.78	42.50	42.44
Stocks, producer, yearend[1]	NA	NA	NA	NA	NA
Employment, mine and preparation plant, number	400	400	400	400	400
Net import reliance[2] as a percent of apparent consumption	2	E	E	E	E

Recycling: Insignificant.

Import Sources (1992-95): Mexico, 98%; and other, 2%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Feldspar	2529.10.0000	Free	49¢/t.

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

Government Stockpile: None.

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FELDSPAR

Events, Trends, and Issues: Shipments of glass containers, the largest end use of feldspar, have been somewhat flat in the United States. Plastic containers have provided strong competition, especially in the soft drink market. According to one industry source, one niche, beer bottles, could see positive growth in 1996. Growth in glass containers could take place in other areas, such as South America, Eastern Europe, and India. The switch from glass to plastic containers in these countries appears less likely, because the cost of raw materials for plastics outside the United States is more expensive.

Feldspar's other large end use continued to be in ceramics, such as tile, plumbing fixtures, electrical insulators, and dinnerware. Usage of plumbing fixtures (sanitaryware) often follows housing starts, which were projected by a non-Government source to reach 1.4 million units in 1996. This was an increase of 3% compared with activity in 1995.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[4]
	1995	1996[e]	
United States	880	900	Significant in the United States and assumed to be similar in other countries.
Brazil	145	145	
France	300	310	
Germany	350	350	
India	65	65	
Italy	1,600	1,600	
Japan	57	60	
Korea, Republic of	320	330	
Mexico	140	150	
Norway	100	100	
Russia	55	55	
Spain	225	230	
Thailand	590	600	
Turkey	400	420	
Uzbekistan	70	70	
Venezuela	170	170	
Other countries	643	645	
World total (may be rounded)	6,110	6,200	

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

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

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

[1]Change in stocks assumed to be zero for apparent consumption and net import reliance calculations.

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

[3]See Appendix B.

[4]See Appendix C for definitions.

FLUORSPAR

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 1996, fluorspar shipments totaled 8,000 tons from one mining company in southern Illinois. An estimated 91% of U.S. reported fluorspar consumption went into the production of hydrofluoric acid (HF) in Kentucky, Louisiana, and Texas, and aluminum fluoride in Texas. HF is the primary feedstock for the manufacture of virtually all organic and inorganic fluorine-bearing chemicals, and is also a key ingredient in the processing of aluminum and uranium. An estimated 5% of the reported fluorspar consumption was consumed as a flux in steelmaking and in iron and steel foundries. The remainder was consumed in primary aluminum production, glass manufacture, enamels, welding rod coatings, and other uses or products. To supplement domestic fluorine supplies, about 53,400 tons of fluorosilicic acid (equivalent to 94,000 tons of 92% fluorspar) was recovered from phosphoric acid plants processing phosphate rock. Fluorosilicic acid was used primarily in water fluoridation, either directly or after processing into sodium silicofluoride, and to make aluminum fluoride for the aluminum industry.

Salient Statistics—United States:	**1992**	**1993**	**1994**	**1995**	**1996**[e]
Production: Finished, all grades[e 1]	[2]52	[2]60	[2]49	[2]51	8
Fluorspar equivalent from phosphate rock	106	116	97	98	94
Imports for consumption:					
Acid grade	423	434	434	470	485
Metallurgical grade	111	63	59	88	54
Fluorspar equivalent from hydrofluoric acid plus cryolite	106	99	108	114	150
Exports[3]	14	13	24	42	30
Sales from Government stockpile	4	21	273	153	97
Consumption: Apparent[4]	569	556	310	445	692
Reported	485	447	486	525	530
Stocks, yearend, consumer and dealer[5]	75	78	284	405	230
Employment, mine and mill, number	130	130	130	130	5
Net import reliance[6] as a percent of apparent consumption	91	90	84	89	99

Recycling: Primary aluminum producers recycled HF and fluorides from smelting operations. HF is recycled in the petroleum alkylation process.

Import Sources (1992-95): China, 57%; South Africa, 23%; Mexico, 16%; and other, 4%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[7] 12/31/96
Acid grade (more than 97% CaF_2)	2529.22.0000	$1.24/t	$5.51/t.
Metallurgical grade (less than 97% CaF_2)	2529.21.0000	Free	13.5% ad val.

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

Government Stockpile: During fiscal year 1996, the Defense National Stockpile Center (DNSC) was authorized to sell 118,000 tons (130,000 short dry tons) of acid grade and 136,000 tons (150,000 short dry tons) of metallurgical grade. During the 1996 fiscal year, the DNSC sold 115,000 tons (125,000 short dry tons) of acid grade. This included nearly 34,000 tons (36,000 short dry tons) actually sold in September 1995, but under the fiscal year 1996 disposal authority. Sales of metallurgical grade only amounted to 15,500 tons (17,100 short dry tons). Under the proposed fiscal year 1997 Annual Materials Plan, the DNSC plans to sell 91,000 tons (100,000 short dry tons) of acid grade and 136,000 tons (150,000 short dry tons) of metallurgical grade.

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FLUORSPAR

Stockpile Status—9-30-96
(thousand metric tons)

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Acid grade	412	265	353	80
Metallurgical grade	151	54	151	15

Events, Trends, and Issues: The last remaining domestic fluorspar mining company, located in southern Illinois, ceased production at the beginning of the year. Its parent company subsequently closed the Kentucky hydrofluoric acid plant that had been supplied by the Illinois mining company.

Production of chlorofluorocarbons (CFC's) ceased at the end of 1995. In 1996, consumer stocks of CFC's were depleted much sooner than had been anticipated, which resulted in a dramatic runup in prices for traditional CFC's, such as R-12 and R-502. This motivated consumers to convert from CFC's to replacement hydrofluorocarbons and hydrochlorofluorocarbons. There was a healthly increase in the seasonal demand for these replacement fluorocarbons. The increased demand for fluorocarbon replacements means increased demand for HF, which was expected to be in tight supply in the fourth quarter of 1996 and into 1997. The tight supply situation should ease later in 1997 when production ramps up at the HF plant in Amherstberg, Canada, which is resuming production after being mothballed for several years.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8 9]	Reserve base[8 9]
	1995	1996[e]		
United States	51	8	W	10,000
Brazil	80	80	W	W
China	1,900	1,900	27,000	46,000
France	125	120	10,000	14,000
Kenya	91	80	2,000	3,000
Mexico	523	590	19,000	23,000
Morocco	105	95	W	W
South Africa	196	225	30,000	36,000
Spain	97	100	6,000	8,000
United Kingdom	64	60	2,000	3,000
Other countries	708	700	[10]114,000	[11]167,000
World total (rounded)	3,940	3,950	210,000	310,000

World Resources: Identified world fluorspar resources were approximately 400 million tons of contained fluorspar. Resources of equivalent fluorspar from domestic phosphate rock were approximately 32 million tons. World resources of fluorspar from phosphate rock were estimated at 330 million tons.

Substitutes: Olivine and/or dolomitic limestone were used as substitutes for fluorspar. Byproduct fluorosilicic acid from phosphoric acid production was used as a substitute in aluminum fluoride production.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Shipments.
[2]Includes fluorspar from National Defense Stockpile reprocessed by Ozark-Mahoning Co., Ilinois.
[3]Exports are all general imports reexported or National Defense Stockpile material exported.
[4]Excludes fluorspar equivalent of fluorosilicic acid, hydrofluoric acid, and cryolite.
[5]Industry stocks plus National Defense Stockpile material committed for sale pending shipment.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix B.
[8]See Appendix C for definitions.
[9]Measured as 100% calcium fluoride.
[10]Includes Brazil, Morocco, and the United States.
[11]Includes Brazil and Morocco.

GALLIUM

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

Domestic Production and Use: No domestic primary gallium recovery was reported in 1996. Two companies in Oklahoma and Utah recovered and refined gallium from scrap and impure gallium metal. Imports of gallium, which supplied most of U.S. gallium consumption, were valued at about $7.9 million. Gallium arsenide (GaAs) components represented about 95% of domestic gallium consumption. About 88% of the gallium consumed was used in optoelectronic devices, which include light-emitting diodes (LED's), laser diodes, photodetectors, and solar cells. Integrated circuits represented 12% of gallium demand. The remainder (less than 1%) was used in research and development, specialty alloys, and other applications. Optoelectronic devices were used in areas such as consumer goods, medical equipment, industrial components, telecommunications, and aerospace applications. Integrated circuits were used in defense applications and high-performance computers.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, primary[e]	—	—	—	—	—
Imports for consumption	8,480	15,600	16,900	18,100	25,000
Exports	NA	NA	NA	NA	NA
Consumption: Reported	10,600	11,300	15,500	16,900	21,000
Consumption: Apparent	NA	NA	NA	NA	NA
Price, yearend, dollars per kilogram, 99.99999%-pure	425	400	395	425	425
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, refinery[e], number	20	20	20	20	20
Net import reliance[1] as a percent of apparent consumption	NA	NA	NA	NA	NA

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

Import Sources (1992-95): France, 46%; Russia, 19%; Germany, 17%; Hungary, 4%; and other, 14%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[2] 12/31/96
Gallium metal	8112.91.1000	3.4% ad val.	25.0% ad val.
Gallium arsenide wafers, undoped	2851.00.0010	2.8% ad val.	25.0% ad val.
Gallium arsenide wafers, doped	3818.00.0010	Free	25.0% ad val.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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GALLIUM

Events, Trends, and Issues: The largest gallium recovery facility in the world (50,000 kilograms per year, located in Australia) reopened at the beginning of 1996 because of increased gallium demand. Rising demand for gallium in Japan and the United States during the past 3 years led to the release of inventories from Russia and Kazakstan; however, this was lower purity material and required additional purification to meet most consumer standards. As a result of the short supplies of high-purity gallium, consumers reported significant price increases in 1996. In Japan, gallium prices by mid-1996 were reported to be 30% higher than at the beginning of the year. New scrap, primarily generated during the production of GaAs, has provided an increasing share of world gallium supply.

Work continued to improve the qualities of GaAs and to improve yields. One firm, as part of the Government-sponsored title III program, produced longer single-crystal 100-millimeter boules and demonstrated the ability to produce 150-millimeter GaAs boules. These types of advancements have the potential to reduce the cost of GaAs components, and thus, increase their market share. In addition, work continued throughout the world to develop blue laser diodes and light-emitting diodes, based on gallium nitride.

World Production, Reserves, and Reserve Base: Data on world production of primary gallium were unavailable because data on the output of the few producers were considered to be proprietary. However, in 1996, world primary production was estimated to be about 63,000 kilograms, with Australia, Russia, Japan, and Kazakstan as the largest producers. Countries with smaller output were China, Hungary, and Slovakia. Refined gallium production was estimated to be about 70,000 kilograms. France was the largest producer of refined gallium, using as feed material crude gallium produced in Australia. Germany and Japan were the other large gallium refining countries.

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

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

Substitutes: Liquid crystals made from organic compounds are used in visual displays as substitutes for light-emitting diodes. Indium phosphide components can be substituted for GaAs-based infrared laser diodes, and GaAs competes with helium-neon lasers in visible laser diode applications. Silicon is the principal competitor for GaAs in solar cell applications. Because of their enhanced properties, GaAs-based integrated circuits are used in place of silicon in many defense-related applications, and there are no effective substitutes for GaAs in these applications.

[e]Estimated. NA Not available.

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

[2]See Appendix B.

GARNET, INDUSTRIAL[1]

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

Domestic Production and Use: Garnet was produced in 1996 by five firms, four in New York and one in Idaho. Output of crude garnet was valued at $11 million, while refined material sold or used was valued at $18 million. Major end uses for garnet were abrasive blasting media, 45%; water filtration, 15%; waterjet cutting, 10%; and abrasive powders, 10%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production (crude)	54,100	44,000	51,000	53,000	54,000
Sold by producers (refined)	46,100	55,800	40,600	34,900	35,000
Imports for consumption[e]	6,000	12,200	6,000	6,000	6,000
Exports[e]	8,880	11,400	10,000	8,500	9,000
Consumption, apparent	45,700	56,600	37,500	31,700	32,200
Price, range of value, dollars per ton	100-2,000	100-2,000	100-2,000	85-1,500	90-1,600
Stocks, producer[e]	8,640	4,900	4,000	4,700	4,500
Employment, mine and mill, number	150	150	160	180	200
Net import reliance[2] as a percent of apparent consumption	E	E	E	E	E

Recycling: Relatively small amounts of garnet reportedly are recycled.

Import Sources (1992-95[e]): Australia, 85%; India, 10%; and China, 5%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Emery, natural corundum, natural garnet, and other natural abrasives, crude	2513.20.1000	Free	Free.
Emery, natural corundum, natural garnet, and other natural abrasives, other than crude	2513.20.9000	0.4¢/kg.	2.2¢/kg.
Natural abrasives on woven textile	6805.10.0000	1.5% ad val.	20% ad val.
Natural abrasives on paper or paperboard	6805.20.0000	1.5% ad val.	20% ad val.
Natural abrasives sheets, strips, disks, belts, sleeves, or similar form	6805.30.0000	1.5% ad val.	20% ad val.

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

Government Stockpile: None.

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GARNET, INDUSTRIAL

Events, Trends, and Issues: Production capacity in the United States and abroad may increase significantly during the next several years in response to anticipated increases in demand. Some forecasts indicate that global markets for industrial garnet may grow beyond 300,000 tons within 5 years. Markets for blasting media and water jet cutting are expected to lead demand. Additional capacity planned in the United States and worldwide would help to stabilize prices.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	53,000	54,000	5,000,000	25,000,000
Australia	30,000	30,000	1,000,000	7,000,000
China	15,000	15,000	Moderate to Large	Moderate to Large
India	15,000	15,000	500,000	20,000,000
Other countries	17,000	17,000	6,500,000	20,000,000
World total (rounded)	130,000	130,000	Moderate	Large

World Resources: World resources of garnet are large and occur in a wide variety of rocks, particularly gneisses and schists. Garnet also occurs as contact-metamorphic deposits in crystalline limestones, pegmatites, and serpentinites, and in high-temperature intrusive contacts and vein deposits. In addition, alluvial garnet is a coproduct with many heavy mineral sand and gravel deposits throughout the world. Large domestic resources of garnet are concentrated in coarsely crystalline gneiss near North Creek, NY. One of the world's largest known garnet deposits is in Rangley County, ME. Significant domestic resources of garnet also occur in Idaho, Montana, New Hampshire, North Carolina, and Oregon. In addition to the United States, major garnet deposits exist in Australia, China, and India, where they are mined for foreign and domestic markets; deposits in Russia and Turkey also have been mined in recent years, primarily for internal markets.

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

[e]Estimated. E Net exporter.
[1]Excludes gem and synthetic garnet.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.

GEMSTONES[1]

(Data in million dollars, unless otherwise noted)

Domestic Production and Use: Domestic commercial gemstone production includes amber, agates, beryls, coral, freshwater pearls, garnets, jade, jasper, mother-of-pearl, opals, quartz, sapphire, topaz, turquoise, and many other gem materials. Output of natural gemstones was primarily from Tennessee, Alabama, Arkansas, Oregon, North Carolina, and Arizona. Reported output of synthetic gemstones was from nine firms in California, New York, Michigan, Arizona, and New Jersey. There was considerable production of freshwater pearls in Tennessee; turquoise in Arizona and Nevada; beryl, tourmaline, and amethyst in Maine; tourmaline, beryl, kunzite, and garnet in California; and sapphire in Montana. Major uses were jewelry, carvings, and gem and mineral collections.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production:[2] Natural[3]	66.2	57.7	50.5	60.0	62.0
Synthetic	18.9	18.1	22.2	26.0	26.0
Imports for consumption	4,950	5,850	6,440	6,540	7,140
Exports, including reexports	1,450	1,630	2,240	2,520	2,660
Consumption, apparent	3,480	4,300	4,270	4,110	4,570
Price	Variable, depending on size, type, and quality				
Stocks, yearend[4]	NA	NA	NA	NA	NA
Employment, mine,[5] number	800	1,000	1,000	850	850
Net import reliance[6] as a percent of apparent consumption	98	98	98	98	98

Recycling: Insignificant.

Import Sources (1992-95 by value): Israel, 30%; Belgium, 22%; India, 21%; United Kingdom, 4%; and other, 23%. Diamond imports were about 90% of the total value of gem imports.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[7] 12/31/96
Diamonds, unworked or sawn	7102.31.0000	Free	Free.
Diamond, ½ carat or less	7102.39.0010	Free	10% ad val.
Diamond, cut, more than ½ carat	7102.39.0050	Free	10% ad val.
Precious stones, unworked	7103.10.2000	Free	Free.
Precious stones, simply sawn	7103.10.4000	16.8% ad val.	50% ad val.
Rubies, cut	7103.91.0010	Free	10% ad val.
Sapphires, cut	7103.91.0020	Free	10% ad val.
Emeralds, cut	7103.91.0030	Free	10% ad val.
Other precious, cut but not set	7103.99.1000	1.3% ad val.	10% ad val.
Other precious stones, other	7103.99.5000	16.8% ad val.	50% ad val.
Imitation precious stones	7018.10.2000	1.7% ad val.	20% ad val.
Synthetic cut, but not set	7104.90.1000	1.9% ad val.	10% ad val.
Pearls, natural	7101.10.0000	Free	10% ad val.
Pearls, cultured	7101.21.0000	1.3% ad val.	10 % ad val.
Pearls, imitation not strung	7018.10.1000	6.4% ad val	60% ad val.

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

Government Stockpile: The National Defense Stockpile (NDS) does not contain an inventory of gemstones per se. However, portions of the industrial diamond inventory are of near-gem or gem quality. Additionally, the beryl and quartz inventories contain some gem-quality materials, and the inventory of synthetic ruby and sapphire could be used by the gem industry. The Defense Logistics Agency is currently disposing of materials from the NDS.

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GEMSTONES

Events, Trends, and Issues: A notable change in U.S. gem diamond production may be developing. Except for a few gem diamonds found each year in Arkansas, U.S. diamond output has been negligible. However, test mining for diamonds has been conducted near the Colorado-Wyoming border, and a plant with the capacity to produce 100,000 carats per year was completed in the area during 1996. Exploration for diamonds also has been underway in other States (e.g., Alaska, Arkansas, Michigan, Minnesota, and Wisconsin).

Demand for gemstones, including synthetics and simulants, is expected to increase in the United States and other industrialized nations as personal disposable income rises. A survey conducted by a domestic jewelry retailers association indicates that (in decreasing order of preference) diamonds, emeralds, sapphires, and rubies were the favorite gemstone jewelry of U.S. consumers.

World Mine Production,[8] Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[9]
	1995	1996[e]	
United States	—	—	World reserves and reserve base of gem diamond are substantial. No reserves or reserve base data are available for other gemstones.
Angola	450	650	
Australia	18,300	20,000	
Botswana	11,500	11,500	
Brazil	600	600	
Central African Republic	400	400	
China	230	250	
Ghana	580	600	
Namibia	1,380	1,300	
Russia	9,000	9,000	
Sierra Leone	113	200	
South Africa	4,300	4,500	
Venezuela	229	200	
Zaire	4,000	4,000	
Other countries	820	800	
World total (may be rounded)	51,900	54,000	

World Resources: Most of the world gem diamond reserves are in southern Africa, Russia, and Western Australia. Estimation of a reserve base is difficult to determine because of the changing economic evaluation of near-gem materials and new discoveries in Australia, Canada, and Russia.

Substitutes: Plastics, glass, metals, wood, paper, and other materials are substituted for gemstones. Synthetic materials that have the same appearance and chemical and physical properties are substituted for natural gemstones. Simulants, materials with a similar appearance but with different chemical and physical properties, also are substituted for natural gemstones.

[e]Estimated. NA Not available.
[1]Excludes industrial diamond and garnet. See Diamond (Industrial) and Garnet (Industrial).
[2]Reported and estimated minimum production only.
[3]Natural includes production of freshwater pearls, natural and cultured.
[4]Stock data are not available and are assumed to be zero for apparent consumption and net import reliance calculation.
[5]Estimate includes operators of fee site deposits.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix B.
[8]Data in thousands of carats of gem diamond.
[9]See Appendix C for definitions.

GERMANIUM

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

Domestic Production and Use: The value of domestic refinery production of germanium, based on the 1996 producer price, was approximately $36 million. Industry-generated scrap, imported concentrates, and processed residues from certain domestic base metal ores were the feed materials for the production of refined germanium in 1996. The domestic industry consisted of three germanium refineries, one each in New York, Oklahoma, and Pennsylvania, and two base metal mining operations, one in Tennessee and another in Alaska. Both of these mining companies supplied domestic and export markets with germanium-bearing materials generated from the mining of zinc ores. The major end uses for germanium were fiber-optic systems, 40%; polymerization catalysts, 25%; infrared optics, 15%; electrical/solar applications, 15%; and other uses (phosphors, metallurgy, and chemotherapy), 5%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery[e]	13,000	10,000	10,000	10,000	18,000
Total imports[1]	13,000	15,000	15,000	16,000	25,000
Exports	NA	NA	NA	NA	NA
Consumption[e]	33,000	29,000	25,000	27,000	25,000
Price, producer, yearend, dollars per kilogram:					
Zone refined	1,060	1,060	1,060	1,375	2,000
Dioxide, electronic grade	660	660	660	880	1,300
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant,[e 2] number	100	100	100	110	120
Net import reliance[3] as a percent of apparent consumption	NA	NA	NA	NA	NA

Recycling: More than half of the metal used during the manufacture of most electronic and optical devices is routinely recycled as new scrap. As a result of the low unit use of germanium in microelectronic devices, little germanium returns as old scrap.

Import Sources (1992-95):[4] China, 18%; United Kingdom, 15%; Ukraine, 14%; Russia, 14%; Belgium, 12%; and other, 27%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Germanium oxides	2825.60.0000	3.7% ad val.	25% ad val.
Waste and scrap	8112.30.3000	Free	Free.
Metal, unwrought	8112.30.6000	3.3% ad val.	25% ad val.
Other	8112.30.9000	5.1% ad val.	45% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Germanium	68,207	—	40,007	—

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GERMANIUM

Events, Trends, and Issues: Monthly average free market prices for minimum 99.99% germanium dioxide, published by Metal Bulletin (London), increased rapidly throughout 1996 and reached the $1,400 to $1,445 per kilogram range by midyear. Later in the year, prices stabilized owing to the reported sale of 6.5 metric tons of germanium metal from the Ukrainian stockpile, the overhang of near-term sales from the Russian stockpile, and the signed authority for sales by the U.S. Defense Logistics Agency. As in 1995, a shortage of production and increased demand for virgin germanium led to a very tight world supply of germanium materials in 1996. In the near term, it is once again expected that this shortfall in supply will be moderated by increased production from North American sources, releases from various national stockpile holdings, and increased shipments from China. It is currently projected that fiber optics will provide the principal market for germanium well into the next century.

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

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	10,000	18,000	450,000	500,000
Other countries	35,000	35,000	NA	NA
World total	45,000	53,000	NA	NA

World Resources: The available resources of germanium are associated with some zinc and lead-zinc-copper sulfide ores. Worldwide germanium resources would increase substantially if germanium were to be recovered from ash and flue dusts resulting from burning certain coals for power generation.

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

[e]Estimated. NA Not available.
[1]Does not include imports of germanium dioxide and other germanium compounds for which data are not available.
[2]Employment related to primary germanium refining is indirectly related to zinc refining.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]Total imports from republics of the former Soviet Union (Estonia, Lithuania, Russia, and Ukraine) account for 32% of the 1992-95 imports.
[5]See Appendix B.
[6]See Appendix C for definitions.

GOLD

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

Domestic Production and Use: Gold was produced by about 75 major lode mines, a dozen or more large placer mines, nearly all in Alaska, and numerous smaller placer mines, mostly in Alaska and in the western States. In addition, a small amount of domestic gold was recovered as a byproduct of processing base metals, chiefly copper. Twenty-five mines yielded the majority of the gold produced in the United States. The value of 1996 mine production was about $4.1 billion. Commercial-grade refined gold came from about 2 dozen producers. A few dozen companies, out of several thousand companies and artisans, dominated the fabrication of gold into commercial products. Jewelry manufacturing was centered principally in the New York, NY, and Providence, RI, areas; and to a lesser extent, in California, Florida, and Texas.

Salient Statistics—United States:	**1992**	**1993**	**1994**	**1995**	**1996[e]**
Production: Mine	330	331	327	320	325
Refinery: Primary	284	243	241	([2])	([2])
Secondary	163	152	148	([2])	([2])
Imports[3]	159	144	114	126	160
Exports[3]	308	726	395	347	600
Consumption, reported	110	91	76	([4])	([4])
Stocks, yearend, Treasury[5]	8,150	8,140	8,140	8,140	8,140
Price, dollars per ounce	344.97	360.91	385.41	385.50	390.00
Employment, mine and mill,[e] number	14,800	14,700	14,100	14,700	15,200
Net import reliance[6] as a percent of apparent consumption	E	E	E	E	E

Import Sources (1992-95):[3] Canada, 67%; Bolivia, 5%; Chile, 5%; Mexico, 4%; and other, 19%.

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

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

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

Events, Trends, and Issues: Domestic gold mine production in 1996 was estimated at slightly below the record levels of recent years, but high enough to maintain the United States' position as the world's second largest gold-producing nation, after South Africa. Domestic output continued to be dominated by Nevada and California, where combined production accounted for nearly 80% of the U.S. total. Gold mine closures recently have outpaced new gold mine openings and expansions in the United States. At the same time, the average output per mine has increased, resulting in a trend to fewer but larger gold mining operations in the United States. Most of the larger companies are successfully replacing their annual production with new reserves, but smaller companies are finding this more difficult. Projections indicate that worldwide gold exploration expenditures increased in 1996; however, there was a decrease in the percentage of these funds focused on gold targets within the United States.

During the first 11 months of the year, the Engelhard Industries/London daily price of gold ranged from a low of about $374 per troy ounce, in November, to nearly $416, in February. This price range was slightly above the low and high reported for all of 1995.

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GOLD

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1995	1996[e]		
United States	320	325	5,600	6,100
Australia	254	285	3,400	4,700
Brazil	72	80	800	1,300
Canada	150	160	1,500	3,500
China[e]	140	150	NA	NA
Russia	132	120	3,100	3,400
South Africa	524	490	19,000	37,000
Uzbekistan	75	75	3,000	3,300
Other countries	583	600	9,500	12,000
World total (may be rounded)	2,250	2,300	[8]46,000	[8]71,000

Of an estimated 121,000 tons of gold mined from historical times through 1996, about 15% is thought to have been lost, used in dissipative industrial uses, or otherwise unrecoverable or unaccounted for. Of the remaining 103,000 tons, an estimated 35,000 tons is official stocks held by central banks and about 68,000 tons is privately held as coin, bullion, and jewelry.

World Resources: Total world resources of gold are estimated at 86,000 tons, of which 15% to 20% is byproduct resources. South Africa has about one-half of all world resources, and Brazil and the United States have about 12% each. Some of the 9,000-ton U.S. resource would be recovered as byproduct gold.

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

[e]Estimated. E Net exporter. NA Not available.
[1]Metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Data under review.
[3]Refined bullion, doré, ores, concentrates, and precipitates.
Excludes:
a. Waste and scrap.
b. Official monetary gold.
c. Gold in fabricated items.
d. Gold in coins. In 1991, the last year for which estimates are available, net imports amounted to 3.5 metric tons.
e. Net bullion flow , in metric tons, to market from foreign stocks at the New York Federal Reserve Bank, 61.65 (1991), 136.4 (1992), 582.2 (1993), 216.6 (1994), 243.9 (1995), and 485.0 (1996 estimated).

[4]Publication discontinued after 1994 owing to insufficient response by industry to the voluntary survey for consumption data..
[5]Includes gold in Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix C for definitions.
[8]Excludes China and some other countries for which data were not available. Reserve base estimates have increased substantially because of newly acquired information from Australia and South Africa.

GRAPHITE (NATURAL)

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Natural graphite was not produced domestically in 1996. Natural graphite was consumed by approximately 200 manufacturing firms, primarily in the Northeastern and Great Lakes regions. The main uses of natural graphite were estimated to be in refractories, 25%; brake linings, 22%; lubricants, 5%; dressings and molds in foundry operations, 6%; and other, 42%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine	—	—	—	—	—
Imports for consumption	50	52	53	61	60
Exports	20	17	20	37	25
Consumption, apparent	30	35	33	24	35
Price, imports (average dollars per ton at foreign ports):					
Flake	708	612	629	658	675
Lump and chip (Sri Lankan)	1,070	789	709	610	600
Amorphous (Mexican)	125	127	138	143	150
Stocks, yearend	NA	NA	NA	NA	NA
Net import reliance[1] as a percent of apparent consumption	100	100	100	100	100

Recycling: Used refractory recycling is growing with the recycled market being principally in less demanding service conditions, such as safety linings and insulation.

Import Sources (1992-95): Canada, 30%; Mexico, 28%; China, 20%; Madagascar, 7%; and other, 15%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[2] 12/31/96
Crystalline flake (not including flake dust)	2504.10.1000	Free	3.6¢/kg.
Other	2504.90.0000	Free	10% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Sri Lanka, amorphous lump	5	—	—	—
Madagascar, crystalline flake	14	1	14	—
Other than Sri Lanka and Madagascar crystalline	2	1	2	1

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GRAPHITE (NATURAL)

Events, Trends, and Issues: Graphite was near to supply-demand balance in 1995. Demand was met largely by imports of flake from Canada, China, and Madagascar; lump and chip from Sri Lanka; and amorphous graphite from China and Mexico. Graphite electrode consumption in steelmaking has been decreasing since the late 1980's due to increased efficiency of the iron and steel producers. Applicators of natural graphite in lubrication applications are also decreasing due to changes in lubricant compositions and processing technologies.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	1995	1996[e]		
United States	—	—	—	1,000
Brazil	36	36	500	1,000
Canada	22	22	1,500	2,700
China	350	350	5,500	310,000
India	90	90	740	740
Korea, Republic of	4	4	3,200	20,000
Madagascar	10	10	980	980
Mexico	45	45	3,100	3,100
Other countries	163	163	5,500	43,000
World total (may be rounded)	720	720	[e]21,000	380,000

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

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

[e]Estimated. NA Not available.

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

[2]See Appendix B.

[3]See Appendix C for definitions.

GYPSUM

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 1996, output of crude gypsum was 17 million tons valued at $125 million. Leading States were Oklahoma, Iowa, Texas, Nevada, Michigan, California, and Indiana, which together accounted for 70% of total output. Thirty companies mined crude gypsum at 57 mines in 19 States, and 12 companies calcined gypsum at 69 plants in 28 States. Of the total supply of crude gypsum (26.5 million tons, including 1.5 million tons of byproduct gypsum), 20. million tons was calcined for gypsum products, and 6 million tons was used mainly as cement retarder or as agricultural land plaster. Calcined gypsum was sold as prefabricated product or as industrial or building plaster. Sales of gypsum reached 4 million tons for use in cement and 2 million tons for agriculture and other uses.

Capacity at operating gypsumboard plants in the United States was 25.1 billion square feet per year while sales were 24.6 billion square feet, representing a capacity utilization of 98%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Crude	14,800	15,800	17,200	16,600	17,000
Byproduct	630	846	950	1,220	1,500
Calcined	15,100	15,200	16,700	16,700	17,700
Prefabricated products (million square feet)	19,200	21,400	23,200	22,500	24,000
Imports, crude, including anhydrite	7,180	7,390	8,470	8,160	8,000
Exports, crude, not ground or calcined	98	69	89	79	100
Consumption, crude, apparent[1]	22,300	24,000	26,300	26,400	26,500
Price: Average crude, f.o.b. mine, dollars per ton	6.82	6.74	6.70	7.29	7.50
Average calcined, f.o.b. plant, dollars per ton	16.58	17.88	17.23	17.37	18.00
Stocks, producer, crude, yearend	2,350	2,320	2,600	2,100	2,000
Employment, mine and calcining plant, number	6,700	6,700	6,700	6,700	6,700
Net import reliance[2] as a percent of apparent consumption	31	31	31	32	30

Recycling: A relatively small amount of byproduct gypsum generated in flue gas desulfurization, phosphate rock acidulation, and other chemical processes is used for agricultural and wallboard purposes.

Import Sources (1992-95): Canada, 70%; Mexico, 23%; Spain, 4%; and other, 3%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Gypsum; anhydrite	2520.10.0000	Free	Free.

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

Government Stockpile: None.

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GYPSUM

Events, Trends, and Issues: Some forecasts indicate that gypsum demand in North American markets will rise by approximately 3% per year throughout the 1990's. This demand will be driven primarily by the construction industry, particularly in the United States where more than 90% of the gypsum consumed is used for wallboard products, building plasters, and the manufacture of portland cement.

Utilization of byproduct gypsum from industrial processes and electric utility flue gas wastes will remain low. More favorable economic circumstances that support byproduct gypsum as a replacement for natural gypsum (e.g., rising ore costs) are necessary to encourage further substitution.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	16,600	17,000	700,000	Large
Australia	2,000	2,100		
Canada	7,960	8,200	450,000	Large
China	11,000	12,000		
Egypt	1,200	1,200		
France	5,000	5,000		
India	1,600	1,900		
Iran	8,230	8,500		
Italy	1,200	1,200	Reserves and reserve base are large in major producing countries, but data are not available.	
Japan	3,900	4,000		
Mexico	4,920	5,000		
Poland	950	1,000		
Spain	7,500	7,500		
Thailand	8,530	8,600		
United Kingdom	2,500	2,800		
Other countries	15,000	14,000		
World total (rounded)	98,100	100,000	Large	Large

World Resources: Domestic resources are adequate, but are unevenly distributed. There are no significant gypsum deposits on the eastern seaboard of the United States, and large imports from Canada augment the domestic supply of crude ore in industrial areas. Large deposits occur in the Great Lakes region, midcontinent region, California, and other States. Foreign resources are adequate, but are not evenly distributed.

Substitutes: Other construction materials may be substituted for gypsum, especially cement, lime, lumber, masonry, and steel. There is no practical substitute for gypsum in portland cement. Byproduct gypsum now substitutes for crude gypsum in special agricultural applications, and several producers use some byproduct gypsum in place of crude gypsum for cement set-retarding and manufacturing wallboard.

[e]Estimated.
[1]Defined as crude + byproduct + net import reliance.
[2]Defined as imports - exports + adjustments for industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.

HELIUM

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

Domestic Production and Use: During 1996, the estimated value of Grade-A (99.995% or better) helium extracted at the U.S. Bureau of Land Management's Exell Helium Plant was $11.8 million; the estimated value of Grade-A helium extracted by private industry was about $182.7 million. The total sales value for domestic consumption and exports was $194.5 million. Twelve private industry plants and one Government facility extracted helium from natural gas: five of the privately owned plants were in Kansas, three in Texas, two in Colorado, and one each in Utah and Wyoming. An additional six private industry plants refined helium directly from the Government's crude helium pipeline: four of the plants were in Kansas, one in Oklahoma, and one in Texas. The estimated 1996 domestic consumption of 67.1 million cubic meters (2.4 billion cubic feet) was used for cryogenic applications, 24%; for welding cover gas, 20%; for pressurizing and purging, 19%; for controlled atmospheres, 11%; and other, 18%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Helium extracted from natural gas[2]	92.0	99.3	112.0	101.0	103.2
Withdrawn from storage[3]	2.4	(3.8)	(11.6)	(5.2)	(10.1)
Grade-A helium sales	94.4	95.6	100.4	96.1	98.1
Imports for consumption	—	—	—	—	—
Exports[4]	30.7	28.0	25.0	27.7	26.3
Consumption, apparent[4]	63.7	67.5	75.4	68.1	67.1
Employment, plant[e], number	600	600	615	635	631
Net import reliance[5] as a percent of apparent consumption	E	E	E	E	E

Price: The price of Grade-A gaseous helium was $1.983 per cubic meter ($55 per thousand cubic feet) f.o.b. Helium Operations facilities in 1996. The Federal Government's price for bulk liquid helium was $2.524 per cubic meter measured as gas ($70 per thousand cubic feet), with additional charges for container services and rent. Private industry's price for gaseous helium was about $1.802 per cubic meter ($50 per thousand cubic feet), with some producers posting surcharges to this price.

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

Import Sources (1992-96): None.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[6] 12/31/96
Helium	2804.29.0010	3.7% ad val.	25.0% 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: The Federal Helium Reserve is an operation run pursuant to Public Law 86-777. During 1996, Helium Operations accepted over 37 million cubic meters (1,333 million cubic feet) of private helium for storage and redelivered nearly 22 million cubic meters (792 million cubic feet) for a net increase in privately owned storage of more than 15 million cubic meters (541 million cubic feet). On September 30, 1996, 971 million cubic meters (35 billion cubic feet) of helium was in storage, of which 111 million cubic meters (4.0 billion cubic feet) was owned by private firms.

Events, Trends, and Issues: Several events occurred during 1996. A crude helium plant near Dumas, TX, ended production in December 1995. A crude helium plant near Baker, OK, began production in 1996. Responsibility for and operation of the Department of the Interior's Helium Operations was transferred from the U.S. Bureau of Mines to the U.S.Bureau of Land Management. In addition, the U.S. Bureau of Mines was closed on March 30, 1996, and the President signed the The Helium Privatization Act of 1996. The Act will end production and sale of refined helium by Helium Operations for Federal agencies use. Other parts of the Helium Program, such as operation of the helium storage system for both Government and private organizations and collection of helium royalties and fees, will continue.

It is estimated that in 1997 domestic production of helium will be over 101 million cubic meters (3.6 billion cubic feet) and that U.S. apparent consumption will be more than 72 million cubic meters (2.6 billion cubic feet). Exports from the United States are expected to decline because of planned production increases of an Algerian helium plant.

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HELIUM

World Production, Reserves, and Reserve Base:

	Production 1995	Production 1996[e]	Reserves[8]	Reserve base[8]
United States	101.0	103.2	8,200	[9]13,000
Algeria	3.8	3.8	NA	2,100
Canada	NA	NA	NA	2,100
China	NA	NA	NA	1,100
Netherlands	NA	NA	NA	720
Poland	1.4	1.4	NA	830
Former Soviet Union[10]	4.2	4.2	4.2	9,200
Other countries	NA	NA	NA	2,100
World total (rounded)	111	112	NA	31,000

World Resources: The identified helium resources of the United States were estimated to be about 13 billion cubic meters (470 billion cubic feet) as of January 1, 1995. This includes 1.0 billion cubic meters (34 billion cubic feet) of helium stored in the Cliffside Field, 6.7 billion cubic meters (240 billion cubic feet) of helium in helium-rich natural gas (0.30% helium or more), and 5.2 billion cubic meters (190 billion cubic feet) in helium-lean natural gas (less than 0.30% helium). The Hugoton and Riley Ridge Fields are currently depleting gasfields and contain an estimated 4.4 billion cubic meters (160 billion cubic feet) of helium. The remaining 2.4 billion cubic meters (86 billion cubic feet) of helium-rich gas resources is nondepleting. Riley Ridge contains 3.4 billion cubic meters (120 billion cubic feet) of helium of which 2.0 billion cubic meters (71 billion cubic feet) is now included in the depleting classification because this gas is now being produced. Future supplies will probably come from known helium-rich natural gas with little fuel value and helium-lean resources. The identified helium-lean resources of 5.4 billion cubic meters (195 billion cubic feet) include 1.3 billion cubic meters (46 billion cubic feet) of measured and 3.9 billion cubic meters (140 billion cubic feet) of indicated helium resources. No resource studies have been performed since this report was last published; estimated production was subtracted from previous resource values where applicable.

Helium resources of the world exclusive of the United States were estimated to be 18.0 billion cubic meters (650 billion cubic feet). The locations and volumes of the principal deposits, in billion cubic meters, are the former Soviet Union, 9.2; Algeria, 2.1; Canada, 2.1; China, 1.1; Poland, 0.8; and the Netherlands, 0.7. As of January 1, 1996, Helium Operations had analyzed nearly 21,000 gas samples from 26 countries and the United States in a program to identify world helium resources.

Substitutes: There is no substance that can be substituted for helium 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 flammability 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.

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

[2]Helium content of both Grade-A and crude helium (consisting of approximately 70% helium and 30% nitrogen).

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

[4]Grade-A helium.

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

[6]See Appendix B.

[7]The author is an industrial engineer with the Bureau of Land Management, Helium Operations, in Amarillo, TX.

[8]See Appendix C for definitions.

[9]All domestic measured and indicated helium resources in the United States.

[10]As constituted before Dec. 1991.

ILMENITE[1]

(Data in thousand metric tons of contained TiO_2, unless otherwise noted)

Domestic Production and Use: Two firms produced ilmenite concentrate from heavy-mineral sands operations in Florida, and one firm produced ilmenite in California as a byproduct of sand and gravel production. Based on average prices, the value of U.S. ilmenite consumption in 1996 was about $275 million. Major coproducts of ilmenite from heavy-mineral sands deposits are rutile and zircon. About 99% of the ilmenite and titanium slag was consumed by five titanium pigment producers. The remainder was used in welding rod coatings and for manufacturing alloys, carbides, and chemicals.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	W	W	W	W	W
Imports for consumption[2]	615	564	584	586	590
Exports[e]	16	7	9	15	7
Consumption:[2] Reported	882	889	W	W	W
Apparent	W	W	W	W	W
Price, dollars per metric ton:					
Ilmenite:					
Bulk, 54% TiO_2, f.o.b. Australian ports	65	63	77	83	93
Slag:[e]					
80% TiO_2, f.o.b. Sorel, Quebec	276	276	278	244	297
85% TiO_2, f.o.b. Richards Bay, South Africa	322	330	334	349	351
Stocks, mine, distributor and consumer, yearend[2]	254	218	208	137	150
Employment, mine and mill[3], number	400	395	400	400	400
Net import reliance[4] as a percent of apparent consumption	W	W	W	W	W

Recycling: None.

Import Sources (1992-95): South Africa, 58%; Australia, 26%; Canada, 8%; and other, 8%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Ilmenite and ilmenite sand	2614.00.6020	Free	Free.
Titanium slag	2620.90.5000	Free	Free.

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

Government Stockpile: None.

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ILMENITE

Events, Trends, and Issues: Another year of near record titanium pigment consumption resulted in a high demand for ilmenite and titanium slag concentrates. Consequently, prices for ilmenite and slag concentrates increased moderately. Although total imports of ilmenite plus slag were nearly unchanged, imports of slag decreased 16% while imports of ilmenite increased 19%. Imports of ilmenite from Australia increased significantly.

Exploration and development of titanium mineral deposits continued in 1996. These activities were most evident in Australia, Canada, India, Indonesia, Mozambique, Russia, South Africa, Ukraine, the United States, and Vietnam. Producers continued efforts to develop higher grade concentrates. In Canada, a producer of titanium slag initiated a project to produce an upgraded version of titanium slag suitable for use by chloride-base pigment production.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	W	W	8,000	59,000
Australia	1,130	1,150	33,000	88,000
Brazil	56	60	18,000	18,000
Canada (slag)	652	650	31,000	36,000
China	80	80	30,000	41,000
Egypt	—	—	—	1,700
Finland	—	—	1,400	1,400
India	162	160	30,000	38,000
Italy	—	—	—	2,200
Madagascar	—	—	—	19,000
Malaysia	84	90	—	1,000
Norway (ilmenite and slag)	374	320	40,000	40,000
South Africa (slag)	842	840	63,000	63,000
Sri Lanka	34	35	13,000	13,000
Ukraine	100	100	5,900	13,000
Other countries	5	5	1,000	1,000
World total (rounded)	[7]3,520	[7]3,490	270,000	440,000

World Resources: Ilmenite supplies about 90% of the world's demand for titaniferous material. World ilmenite resources total about 1 billion tons of titanium dioxide. Major resources occur in Australia, Canada, China, India, New Zealand, Norway, South Africa, Ukraine, and the United States.

Substitutes: Rutile and synthetic rutile were extensively used to produce titanium dioxide pigment.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]See also Rutile and Titanium and Titanium Dioxide.
[2]Includes titanium slag from Canada, Norway, and South Africa and leucoxene from Australia.
[3]Includes operating employees shown under Rutile, subject to the same footnoted comments.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.
[7]Excludes U.S. production.

INDIUM

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: No indium was recovered from ores in the United States in 1996. Domestically produced indium was derived from the upgrading of lower grade imported indium metal. Two companies, one each in New York and Rhode Island, were the major producers of indium metal and indium products in 1996. Several firms produced high-purity indium shapes, alloys, and compounds. Thin-film coatings, which are used in applications such as liquid crystal displays and electroluminescent lamps, continued to be the largest end use. Indium semiconductor compounds were used in infrared detectors, high-speed transistors, and high-efficiency photovoltaic devices. Estimated uses in 1996 were about the same as in 1995: coatings, 45%; solders and alloys, 35%; electrical components and semiconductors, 15%; and research and other, 5%. The estimated value of primary metal consumed in 1996, based on the average price, was $13.5 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery	—	—	—	—	—
Imports for consumption	36.3	73.4	70.2	85.2	45.0
Exports	NA	NA	NA	NA	NA
Consumption[e]	30.0	35.0	40.0	43.0	45.0
Price, average annual, dollars per kilogram (99.97% indium)	218	200	138	375	300
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number	NA	NA	NA	NA	NA
Net import reliance[1] as a percent of apparent consumption	NA	NA	NA	NA	NA

Recycling: Small quantities of old scrap were recycled. Recycling of new scrap, the scrap from fabrication of indium products, has become significant.

Import Sources (1992-95): Canada, 45%; France, 11%; Russia, 10%; Italy, 9%; and others, 25%. Imports from Russia increased significantly in 1994. Those from China increased even more dramatically in 1995 (but not enough to rank China among the top four sources).

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[2] 12/31/96
Unwrought, waste and scrap	8112.91.3000	Free	25% ad. val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept.96
Indium	1.56	—	—	—

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INDIUM

Events, Trends, and Issues: Estimated domestic indium consumption remained fairly steady at about 45 tons in 1996. Although world consumption was steady, increased production from China and Russia over the past 2 years, resumed production from France, and much greater use of recycling lowered the demand for indium from other traditional sources, causing the price to drop from $16.25 per troy ounce in January to $6.53 per troy ounce in December 1996. After the price of indium reached its high in 1995, recycling became economical and stockpiles of scrap were tapped throughout 1996, easing the demand for primary metal.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production[e]		Reserves[3]	Reserve base[3]
	1995	1996		
United States	—	—	300	600
Belgium	18	15	([4])	([4])
Canada	40	15	700	2,000
China	40	45	400	1,000
France	40	45	([4])	([4])
Italy	12	12	([4])	([4])
Japan	61	40	100	150
Peru	4	4	100	150
Russia	20	20	200	300
Other countries	4	4	800	1,500
World total (may be rounded)	239	200	2,600	5,700

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

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

[e]Estimated. NA Not available.

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

[2]See Appendix B.

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

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

IODINE

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

Domestic Production and Use: Iodine produced in 1996 from companies operating in Oklahoma accounted for 100% of the elemental iodine value estimated at $16 million. The operation at Woodward, OK, continued production of iodine from subterranean brines. A second company operated a miniplant in Kingfisher County, OK, using waste brine associated with oil production. A third company continued production at Vici, OK, and exported iodine to Germany. Of the consumers that participate in the annual survey, 25 plants reported consumption of iodine in 1995. Major consumers were located in the East. Prices of crude iodine in drums published in December ranged between $15 and $16 per kilogram. Imports of iodine through October averaged $13.50 per kilogram.

Establishing an accurate end-use pattern for iodine was difficult because intermediate iodine compounds were marketed before reaching their final end uses. The downstream uses of iodine were as animal feed supplements, catalysts, inks and colorants, pharmaceutical, photographic equipment, sanitary and industrial disinfectants, stabilizers, and other uses.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	2,000	1,940	1,630	1,220	1,200
Imports for consumption, crude content	3,750	3,620	4,360	3,950	4,000
Exports	1,810	1,220	1,200	1,220	2,000
Shipments from Government stockpile excesses	115	0.045	218	133	—
Consumption:					
Apparent	3,930	4,330	4,780	3,540	4,000
Reported	3,400	3,550	3,690	3,680	NA
Price, average c.i.f. value, dollars per kilogram, crude	9.03	7.98	8.02	10.32	13.50
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number	50	50	35	35	40
Net import reliance[1] as a percent of apparent consumption	52	56	66	90	62

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

Import Sources (1992-95): Japan, 53%; Chile, 46%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[2] 12/31/96
Iodine, crude	2801.20.0000	Free	Free.
Iodide, calcium and cuprous	2827.60.1000	Free	25% ad val.
Iodide, potassium	2827.60.2000	2.8% ad val.	7.5% ad val.
Iodides and iodide oxides, other	2827.60.5000	4.2% ad val.	25% ad val.

Depletion Allowance: 5% on brine wells (Domestic and Foreign); 14% on solid minerals (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 95
Stockpile-grade	2,362	—	2,362	—

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IODINE

Events, Trends, and Issues: Japan continued to be the largest producer of iodine in the world. Production was primarily from underground brines associated with gas production. The deregulation of the refining/marketing operation of Japanese oil companies on April 1, 1996, may cut unprofitable marketing operations in order to compete in a more open market. The iodine market, which is tied to gas production, may be affected by the availability of alternative heating fuels.

Chile was the second largest producer with three companies producing iodine during the year.

One U.S. operation bought the plant of a consumer of iodine that manufactured iodine derivatives. Another U.S. operation, which closed in 1992 because of low market prices for iodine, was preparing to go back into production.

Methyl iodide was tested by the U.S. Department of Agriculture and was found to be an effective fumigant for controling four species of fungi, one species of nematode, and seven species of weeds. Based on the results of 15 laboratory and field trials, methyl iodide was more effective than methyl bromide as a fumigant. Methyl bromide has an ozone depletion potential (ODP) of 0.65 and is scheduled to be phased out of production, importation, and use as an agricultural chemical in the United States by 2001 and under the Montreal protocol by 2010. Methyl iodide has an ODP of less than 0.016 and appeares to be a replacement for methyl bromide in most uses. Methyl iodide is about five time more expensive, but could utilize the same equipment as methyl bromide.

Producers of medical contrast media, about 46% to 67% iodine, continued steady growth as newer technologies advanced. Imaging media consist largely of x-rays and use iodine, and to a lesser extent barium, for intestinal applications.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	1995	1996[e]		
United States	1,220	1,200	550,000	550,000
Azerbaijan	350	350	171,000	NA
Chile	5,000	5,000	900,000	1,200,000
China	500	500	400,000	400,000
Indonesia	80	80	100,000	100,000
Japan	6,200	6,200	4,000,000	7,000,000
Russia	160	160	NA	NA
Turkmenistan	250	250	172,000	NA
World total (rounded)	13,800	13,800	NA	NA

World Resources: In addition to the fields listed in the reserve base, seawater contains 0.05 parts per million iodine, or approximately 76 billion pounds . Seaweeds of the Laminaria family are able to extract and accumulate up to 0.45% iodine on a dry basis. Although not as economical as the production of iodine as a byproduct of gas, oil, and nitrate, the seaweed industry represented a major source of iodine prior to 1959 and is a large resource.

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

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

IRON ORE[1]

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

Domestic Production and Use: Value of usable ore shipped from mines in Minnesota, Michigan, and six other States in 1996 was estimated at $1.7 billion. Iron ore was produced by 17 companies operating 17 mines, 10 concentration plants, and 10 pelletizing plants. The mines included 16 open pits and 1 underground operation. Virtually all ore was concentrated before shipment. Nine mines operated by five companies accounted for 99.2% of production.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, usable	55.6	55.7	58.4	62.5	60.0
Shipments	55.6	56.3	57.6	61.1	60.0
Imports for consumption	12.5	14.1	17.5	17.5	17.0
Exports	5.1	5.1	5.0	5.3	5.0
Consumption: Reported (ore and total agglomerate)[3]	75.1	76.8	80.2	83.1	80.0
Apparent	65.6	66.2	70.9	72.5	72.6
Price (Oct.), Lake Superior pellets, cents per ltu of Fe[4]	72.5-74.0	72.5-74.0	72.5-74.0	72.5-74.0	72.5-74.0
Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore	22.9	21.3	21.3	23.6	23.0
Employment, mine, concentrating and pelletizing plant, quarterly average, number	8,000	7,800	7,200	7,400	7,400
Net import reliance[5] as a percent of apparent consumption (iron in ore)	12	14	18	14	17

Recycling: Insignificant.

Import Sources (1992-95): Canada, 54%; Brazil, 22%; Venezuela, 18%; Australia, 3%; and other, 3%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[6] 12/31/96
Concentrates	2601.11.0030	Free	Free.
Coarse ores	2601.11.0060	Free	Free.
Fine ores	2601.11.0090	Free	Free.
Pellets	2601.12.0030	Free	Free.
Briquettes	2601.12.0060	Free	Free.
Sinter	2601.12.0090	Free	Free.

Depletion Allowance:[7] 15.0% (Domestic), 14.0% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic iron ore production, consumption, and trade were about the same as in 1995. The U.S. steel industry was undergoing structural changes potentially unfavorable to the iron ore sector. Minimills under construction or proposed were expected to add 10 million to 15 million tons of capacity to the flat-rolled market by the end of the decade. Also, tougher environmental regulations, especially those restricting coke oven gas emissions, were expected to force the closure of some older integrated facilities. However, those changes also may benefit those companies providing alternatives to scrap. Because of concern over the availability of low residue scrap, investment in alternative ironmaking technologies has become more attractive, and a number of companies have moved in that direction. One alternative to scrap is direct-reduced iron (DRI). Five projects were under consideration that, if completed, would increase U.S. DRI capacity from 0.5 to considerably more than 4 million metric tons per year. In Minnesota, a company was formed to pursue the development of DRI on the Mesabi Iron Range.

International prices are negotiated between seller and buyer on an annual basis. Although international prices increased for the second consecutive year, 1996 prices were considerably lower than those of 1991. There was a trend in the international market away from sintering of iron ore toward pelletization. This was driven, in large part, by environmental considerations. Australia and Brazil continued to be the leading exporters of iron ore with a combined total of about 60% of the world total.

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IRON ORE

Although iron ore is produced in more than 50 countries, 5 of them account for more than two-thirds of the total. The United States ranked fifth in world production. Most ore was consumed domestically. Virtually all exports consisted of pellets shipped via the Great Lakes to Canadian steel companies that are partners in U.S. taconite projects in Michigan and Minnesota. The United States continued to be a net importer of iron ore.

World pig iron production levels have remained nearly flat since 1990. During this period five areas or countries (China, Europe, the former Soviet Union (FSU),[8] Japan, and North America) accounted for 82% of the world's pig iron production. In three of these (Europe, Japan, and North America), pig iron production has remained virtually constant. Production fell considerably in the FSU and rose dramatically in China. Production has also increased substantially in other parts of Asia, particularly India, South Korea, and Taiwan. This trend is expected to continue.

The increase in consumption in Asia is primarily expected to benefit Australia. Australia and Brazil each account for about 30% of the world total of exports, while the next closest exporter accounts for less than 10% of the world total. Of the two, Australia appears to be better positioned to take advantage of growth of iron ore consumption in Asia because of Australia's proximity and the consequent lower freight rates.

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

	Mine production		Crude ore		Iron content	
	1995	1996[e]	Reserves	Reserve base	Reserves	Reserve base
United States	62	60	16,000	25,000	3,800	6,000
Australia	143	143	18,000	32,200	10,000	18,000
Brazil	186	185	11,000	17,000	6,500	10,000
Canada	39	38	12,000	26,000	4,600	10,000
China[e]	249	250	9,000	9,000	3,500	3,500
India	59	60	5,400	12,000	3,300	6,300
Liberia	—	—	900	1,600	500	800
Mauritania	12	12	400	700	200	300
Russia	78	78	34,300	42,000	12,700	15,600
South Africa	32	32	4,000	9,300	2,500	5,900
Sweden	22	22	3,000	4,600	1,600	2,400
Ukraine	45	45	21,800	27,000	8,000	10,000
Other countries	108	108	15,000	25,300	25,800	35,300
World total (may be rounded)	1,000	1,000	151,000	232,000	83,000	124,000

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

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

[e]Estimated.
[1]See also Iron and Steel Scrap.
[2]Agglomerates, concentrates, direct-shipping ore, and byproduct ore for consumption.
[3]Includes weight of lime, flue dust, and other additives used in producing sinter for blast furnaces.
[4]Delivered rail of vessel at lower lake ports.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B.
[7]Analagous to depreciation, but applies to the ore reserve rather than the plant. Federal tax law allows this deduction from taxable corporate income, recognizing that an ore deposit is a depletable asset that must eventually be replaced by another deposit.
[8]As constituted before Dec. 1991.
[9]See Appendix C for definitions.

IRON AND STEEL[1]

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

Domestic Production and Use: The iron and steel industry and ferrous foundries produced goods valued at about $73 billion. The steel industry consisted of 79 companies that produced raw steel at 119 locations, with combined raw steel production capability of 116 million tons. Indiana accounted for about 22% of total raw steel production, followed by Ohio, 16%, and Pennsylvania, 9%. Pig iron was produced by 15 companies operating integrated steel mills, with approximately 58 blast furnaces, of which about 41 were in continuous operation. Integrated companies accounted for about 59% of total steel production, including output of their electric arc furnaces. The distribution of steel shipments was estimated as follows: warehouses and steel service centers, 23%; transportation (predominantly for automotive production), 14%; construction, 12%; cans and containers, 4%; and others, 47%. Ferrous foundries, numbering about 1,000, continued to be importers of pig iron into the United States, mainly from Brazil and Russia.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Pig iron production[2]	47.4	48.2	49.4	50.9	49.9
Steel production:	84.3	88.8	91.2	95.2	95.4
Basic oxygen furnaces, percent	62.0	60.6	60.7	59.6	58.1
Electric arc furnaces, percent	38.0	39.4	39.3	40.4	41.9
Open hearth furnaces, percent	—	—	—	—	—
Continuously cast steel, percent	79.3	85.7	89.5	91.0	93.1
Shipments:					
Steel mill products	74.6	80.8	86.3	88.4	91.5
Steel castings[3]	.9	1.4	1.0	.9	.8
Iron castings[3]	7.4	11.9	13.2	13.0	12.7
Imports of steel mill products	15.5	17.7	27.3	22.1	24.5
Exports of steel mill products	3.9	3.6	3.5	6.4	5.0
Apparent steel consumption[4]	86.2	92.0	104	108	112
Producer price index for steel mill products (1982=100)[5]	106.4	108.2	113.4	120.1	115.5
Steel mill product stocks at service centers, yearend[6]	5.3	5.7	6.6	5.9	6.0
Total employment, average,[7] number					
Blast furnaces and steel mills	187,000	175,000	172,000	172,000	166,000
Iron and steel foundries	120,000	119,000	125,000	130,000	127,000
Net import reliance[8] as a percent of apparent consumption	13	15	22	21	17

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

Import Sources (1992-95): European Union[9], 29%; Canada, 20%; Japan, 11%; Brazil, 8%; and other, 32%.

Tariff:[10] Item	Number	Most favored nation (MFN)[11] 12/31/96	Canada 12/31/96	Mexico 12/31/96	Non-MFN[12] 12/31/96
Pig iron	7201.10.0000	Free	Free	Free	$1.11/t.
Carbon steel:					
Semifinished	7207.12.0050	3.4%	0.8%	2.9%	20%.
Structual shapes	7216.33.0090	0.7%	0.1%	0.6%	2%.
Bars, hot-rolled	7213.20.0000	1.5%	0.3%	1.3%	5.5%.
Sheets, hot-rolled	7208.39.0030	3.9%	0.9%	3.4%	20%.
Hot-rolled, pickled	7208.27.0060	4.1%	1.0%	3.5%	0.4¢/kg+20%.
Cold-rolled	7209.18.2550	2.6%	0.6%	2.2%	20%.
Galvanized	7210.49.0090	5.2%	1.3%	4.5%	21.5%.
Stainless steel:					
Semifinished	7218.91.0015	4.2%	1.0%	3.6%	29%.
	7218.99.0015	4.2%	1.0%	3.6%	29%.
Bars, cold-finished	7222.20.0075	8.5%	2.1%	7.4%	29%.
Pipe and tube	7304.41.3045	[13]6.1%	[13]1.5%	Free	29%.
Cold-rolled sheets	7219.33.0035	8.1%	2.0%	7.0%	29%.

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IRON AND STEEL

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: Steel production and shipments continued to increase during 1996, and plants operated at near effective capacity. Although demand remained strong and imports continued below peak 1994 levels, spot prices and profits generally declined for the major producers, partly as a result of low contract prices negotiated during 1994, high fixed capital and labor costs, and continuing environmental costs.

As the six major integrated steel producers continued to lose market share to efficient and less costly minimills, more new minimill construction was in progress. New facilities opened as employee-owned companies or as joint ventures with foreign companies. Nearly 15 million tons of additional electric arc furnace steel output, especially from new thin-slab minimills, is planned or under construction owing to lower capital, fixed, and operating costs. This additional capacity would continue to exert downward pressure on steel prices unless the market grows at a similar pace.

Imports of steel mill products rose above those of 1995, but were still below the peak 1994 level. Export activity declined below the record 1995 level, and continued to be primarily regular shipments to Canadian and Mexican customers.

World Production:

	Pig iron		Raw steel	
	1995	1996[e]	1995	1996[e]
United States	50.9	49.9	95.2	95.4
Brazil	25.1	22.4	25.1	24.3
China	102	104	93.0	97.9
European Union[9]	102	91.2	150	146
Japan	74.9	73.8	102	97.5
Korea, Republic of	21.0	23.0	36.8	39.3
Russia	39.8	31.2	51.3	49.3
Ukraine	17.7	18.3	22.3	22.1
Other countries	91.9	94.3	177	154
World total (rounded)	525	508	752	726

World Resources: Not applicable. See Iron Ore.

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

[e]Estimated.
[1]Production and shipments data source is the American Iron and Steel Institute (AISI); see also Iron Ore and Iron and Steel Scrap.
[2]More than 95% of iron made is transported molten to steelmaking furnaces located at the same site.
[3]U.S. Department of Commerce, Bureau of the Census. Data for years prior to 1993 may not be comparable due to changes in survey panel.
[4]Defined as steel shipments + imports - exports + adjustments for industry stock changes + adjustment for imports of semifinished steel products.
[5]Bureau of Labor Statistics.
[6]Steel Service Center Institute.
[7]Bureau of Labor Statistics. Blast furnaces and steel mills: SIC 3312; Iron and steel foundries: SIC 3320.
[8]Defined as imports - exports + adjustments for Government and industry stock changes.
[9]Data are for the expanded European Union, which, as of Jan. 1, 1995, was joined by Austria, Finland, and Sweden.
[10]All tariff percentages are ad valorem.
[11]No tariff for Israel and certain Caribbean and Andean nations.
[12]See Appendix B.
[13]No tariff for use in civil aircraft.

IRON AND STEEL SCRAP[1]

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

Domestic Production and Use: Total value of 1997 domestic purchases (receipts of ferrous scrap by all domestic consumers from brokers, dealers, and other outside sources) and exports was estimated at $7 billion, compared with $8.5 billion in 1995. Manufacturers of pig iron, raw steel, and steel castings accounted for about three-fourths of the domestic steel industry, using scrap together with pig iron to produce steel products for the construction, transportation, oil and gas, machinery, container, appliance, and various other consumer industries. The ferrous castings industry consumed most of the remainder to produce cast iron and steel products, such as motor blocks, pipe, and machinery parts. Relatively small quantities were used for producing ferroalloys, for the precipitation of copper, and by the chemical industry; these uses totaled less than 1 million tons.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Home scrap	21	21	20	20	14
Purchased scrap[2]	50	54	57	59	52
Imports for consumption[3]	1.4	1.6	1.9	2.2	2.3
Exports[3]	9.4	10.0	9.0	10.5	9.1
Consumption: Reported	63	68	70	72	70
Price, average, dollars per metric ton delivered:					
No. 1 Heavy Melting composite price, Iron Age					
Average: Pittsburgh, Philadephia, Chicago	83.88	109.98	126.81	135.03	130
Stocks, consumer, yearend	3.7	3.7	4.1	4.2	4.0
Employment, dealers, brokers, processors,[4] number	37,000	37,000	37,000	37,000	37,000
Net import reliance[5] as a percent of					
apparent consumption	E	E	E	E	E

Recycling: All iron and steel scrap is recycled material that is a vital raw material for the production of new steel and cast iron products. The steel and foundry industries in the United States have been structured to recycle scrap, and, as a result, are highly dependent upon scrap. The steel industry in North America has been recycling steel scrap for over 150 years through about 16,000 car dismantlers and 2,000 scrap processors. In the United States alone, nearly 70 million tons of steel apparently were recycled in steel mills and foundries in 1996. 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 31% home scrap (new recirculating scrap from current operations), 23% prompt scrap (produced in steel-product manufacturing plants), and 46% obsolete (old) scrap.

Import Sources (1992-95): Canada, 77%; Mexico, 7%; Venezuela, 6%; Japan, 4%; and other, 6%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[6] 12/31/96
Iron and steel waste and scrap:			
No. 1 bundles	7204.41.0020	Free	74¢/mt.
No. 1 Heavy Melting	7204.49.0020	Free	74¢/mt.
No. 2 Heavy Melting	7204.49.0040	Free	74¢/mt.
Shredded	7204.49.0070	Free	74¢/mt.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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IRON AND STEEL SCRAP

Events, Trends, and Issues: Raw steel production in 1996 was an estimated 95.4 million tons, only slightly more than that produced in 1995. Net shipments of steel mill products were estimated at nearly 91.5 million tons compared with 88.4 million tons for 1995.

The domestic ferrous castings industry shipped an estimated 13 million tons of all types of iron castings in 1996, and an estimated 0.9 million ton of steel castings, including investment castings.

Scrap prices in the United States continued at fairly high levels throughout 1996 as a result of strong demand, and were comparable to 1995 prices. Composite prices published by *Iron Age Scrap Price Bulletin* for No. 1 Heavy Melting steel scrap delivered to purchasers in Chicago, Philadelphia, and Pittsburgh averaged about $130 per metric ton.

As reported by *Iron Age Scrap Price Bulletin*, the average price for nickel-bearing stainless steel scrap delivered to purchasers in Pittsburgh was about $712 per metric ton in 1996, significantly lower than the 1995 average price of $827 per metric ton.

Total exports of ferrous scrap decreased to about 9.1 million metric tons, having an estimated value of about $1.5 billion, down from the 1995 figure of 10.4 million tons.

The problem of accidental meltings of radioactive sources contained in scrap, primarily lost or discarded shielded radioactive gauges, continues to be a concern. Twenty-five accidental radioactive material smeltings have occurred in the United States since 1981, and hundreds more have been prevented because radioactive materials were discovered before they were melted. The costs associated with melting a radioactive source, including decontaminating a facility, disposing and storing radioactive electric furnace dust, and shutdown of steel production, can be as high as $24 million per melt. The U.S. Nuclear Regulatory Commission (NRC) created, in 1995, the NRC-State Working Group on Regulation of Radioactive Materials to evaluate regulations concerning the control of and accountability for licensed devices and to develop recommendations for alternative regulatory approaches. The working group submitted its recommendations to the NRC in 1996, including increased regulatory oversight and penalties.

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

World Resources: Not applicable.

Substitutes: About 1.6 million tons of direct-reduced iron was used in the United States in 1996 as a substitute for iron and steel scrap.

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

IRON AND STEEL SLAG

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Ferrous slags are valuable coproducts of iron- and steelmaking. In 1996, approximately 21.7 million tons of iron and steel slags, valued at about $150 million[1] (f.o.b), were consumed. Of this, iron or blast furnace slag accounted for about 65% of the tonnage and was worth about $122 million. Steel slags, produced from open hearth, basic oxygen, and electric arc furnaces, accounted for the remainder. There were 16 slag-processing companies, of which 3 processed only iron slag, 5 processed only steel slag, and the remainder did both. Slag processing occurred at almost 100 sites Nationwide: iron slags at 24 sites in 12 States and steel slags at 82 sites in 29 States. The North Central region (Illinois, Indiana, Michigan, Ohio) accounted for 53% of total sales of slag of domestic origin. Iron and steel slags were used mainly as construction raw materials. The major uses (by mass) for iron slag were for road bases, 40%; asphaltic concrete aggregate and other concrete applications, 38%; and fill, 10%. Steel slags mainly were used for road bases, 39%; fill, 19%; and asphaltic concrete aggregate, 15%. Approximately 90% of iron and steel slag shipments were by truck, generally to within a 65-kilometer radius of the plant, and rail and waterway transport each accounted for about 5% of shiptments, and included destinations farther afield.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, marketed[2]	21,400	19,000	20,100	21,000	21,400
Imports for consumption	100	162	199	280	280
Exports	4	4	4	4	4
Consumption, apparent	21,500	19,200	20,300	21,300	21,700
Price average value, dollars per ton, f.o.b. plant	6.25	6.65	6.99	6.89	6.90
Stocks, yearend	NA	NA	NA	NA	NA
Employment[e]	3,000	3,000	2,500	2,500	2,500
Net import reliance[3] as a percent of reported consumption	1	1	1	1	1

Recycling: No longer regarded as waste or minimally useful byproducts of iron- and steelmaking, ferrous slags today are viewed as valuable coproducts of ferrous smelting and are among the most voluminous of recycled materials. Apart from the large outside markets for slag in the construction sector, some iron and steel slags are utilized internally—being recycled to the furnaces as ferrous and flux feed. Entrained metal, particularly in steel slag, routinely is recovered during slag processing for return to the furnaces. However, data for such furnace feed uses are unavailable.

Import Sources (1992-95): NA. 1995 only: Canada, 47%; South Africa, 25%; other, 28%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Granulated slag	2618.00.0000	Free	10% ad val.
Basic slag	3103.20.0000	Free	Free.
Slag, dross, scalings, from manufacture of iron and steel	2619.00.3000	17.7¢/ton	73.8¢/ton.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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IRON AND STEEL SLAG

Events, Trends, and Issues: Sales of iron and steel slags are increasing slowly but depend, to a large degree, on the cost and availability of natural aggregates—slag's main competitor in the construction sector. Although data are lacking, there appears to be growing demand in the U.S. concrete industry for granulated blast furnace slag as a pozzolan or cement extender (in blended cements); such use is common overseas. The long-term availability of iron slag likely will decline as remaining blast furnaces are decommissioned. It is unclear if imports will increase to compensate. Steel slag availability is more assured.

Iron and steel slags have been proposed for regulation under various waste classifications by Federal and State agencies. Citing slag's widespread marketability and general chemical inertness, the industry has been largely successful at keeping slag exempted from such regulation.

World Mine Production, Reserves, and Reserve Base: Not strictly applicable because slag is not a mining product, per se. Production data for the world are unavailable, but it may be estimated that recent annual world iron and steel slag output is on the order of 250 to 300 million tons, based on typical ratios of slag to crude iron and steel output.

World Resources: Not applicable.

Substitutes: Crushed stone and sand and gravel are the predominant aggregate substitutes in the construction sector. Certain rock types, as well as silica fume and fly ash, are pozzolan substitutes in blended cements.

[e]Estimated. NA Not available

[1]The reported value of slag excludes the value of any entrained metal that may be recovered during slag processing and returned to the iron and, especially, steel furnaces. Value data for such recovered metal were unavailable.

[2]Data for actual production of marketable slag are unavailable. Output may be estimated as equivalent to 25% to 30% of crude (pig) iron production and 10% to 15% of crude steel output.

[3]Defined as imports - exports. Data are unavailable to allow adjustments for changes in stocks.

[4]See Appendix B.

KYANITE AND RELATED MINERALS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: One firm in Virginia, with integrated mining and processing operations, produced kyanite from hard-rock open pit mines. Two companies produced synthetic mullite at one operation each; one was in Georgia and the other in Kentucky. It was estimated that 90% of the kyanite/mullite output was used in refractories: 55% for smelting and processing ferrous metals, 20% for nonferrous metals, and 15% for glassmaking and ceramics. Nonrefractory uses accounted for the remainder.

Salient Statistics—United States:	**1992**	**1993**	**1994**	**1995**	**1996[e]**
Production: Mine	W	W	W	W	W
Synthetic mullite	W	W	W	W	W
Imports for consumption (andalusite)	6	12	8	3	10
Exports[e]	35	33	35	35	35
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, apparent	W	W	W	W	W
Stocks, producer	NA	NA	NA	NA	NA
Employment, kyanite mine and plant[e], number	150	150	150	150	150
Net import reliance[1] as a percent of apparent consumption	W	W	W	W	W

Price: U.S. kyanite, 54% to 60% Al_2O_3, 35-325 Tyler mesh, 18-ton lots, explant, raw, $140 to $168 per ton; calcined, $248 to $276 per ton. Andalusite, Transvaal, South Africa, 57.5% Al_2O_3, 2,000 ton bulk, f.o.b., $180 to $200; 59.5% Al_2O_3, 2,000 ton bulk, f.o.b., $220 to $240.

Recycling: Insignificant.

Import Sources (1992-95): South Africa, 96%; and other, 4%.

Tariff: **Item**	**Number**	**Most favored nation (MFN) 12/31/96**	**Non-MFN[2] 12/31/96**
Andalusite, kyanite, and sillimanite	2508.50.0000	Free	Free.
Mullite	2508.60.0000	2.9% ad val.	30% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposals Jan.-Sept. 96**
Kyanite, lump	1.1	—	1.1	—

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KYANITE AND RELATED MATERIALS

Events, Trends, and Issues: Developments in the refractories industry in general included new products on the market. Monolithic refractories, or those that are made or formed in one piece, were being used in a growing number of ways. This was especially because of the availability of advanced castables (refractories), self-flow castables, improved gunning mixes, etc., according to a non-Government source. Several U.S. companies have responded to the global marketplace by opening refractory plants in other countries.

U.S. imports of andalusite from South Africa have averaged about 8,000 tons per year since 1992. Traditional markets for andalusite have been Western Europe and the Far East, especially Japan. There has been growth in demand for andalusite in emerging economies in Eastern Europe, especially Poland and the Czech Republic.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves and reserve base[3]
	1995	1996	
United States	W	W	Large in the United States and South Africa; may be large in other countries.
France	50	50	
India	27	28	
South Africa	191	190	
Other countries	8	7	
World total[4] (may be rounded)	276	275	

World Resources: Immense 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 area and in Idaho. Other resources are in aluminous gneiss in southern California. These resources are not economical to mine at present, but some may be eventually. The characteristics of kyanite resources in the rest of the world are thought to be similar to those in the United States.

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

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix B.
[3]See Appendix C for definitions.
[4]Excludes the United States and countries for which information is not available.

LEAD

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

Domestic Production and Use: The value of recoverable mined lead in 1996, based on the average U.S. producer price, was $445 million. Seven lead mines in Missouri plus lead-producing mines in Alaska, Colorado, Idaho, and Montana yielded most of the total. Primary lead was processed at two smelter-refineries in Missouri, a smelter in Montana, and a refinery in Nebraska. Of the 30 smelters that produced secondary lead, 17 had annual capacities of 10,000 tons or more and accounted for more than 90% of secondary production. Lead was consumed at about 170 manufacturing plants. The transportation industries were the principal users of lead, consuming 65% of it for batteries, fuel tanks, solder, seals, and bearings. Electrical, electronic, and communications uses (including batteries), ammunition, television glass, construction (including radiation shielding), and protective coatings accounted for approximately 28% of consumption. The balance was used in ballast and weights, ceramics and crystal glass, tubes and containers, type metal, foil, wire, and specialized chemicals.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine, lead in concentrates	407	362	370	394	430
Primary refinery:					
From domestic ore	284	310	328	374	340
From imported materials[1]	21	25	23	W	W
Secondary refinery, old scrap	861	838	877	926	970
Imports for consumption, lead in concentrates	5	1	1	3	5
Exports, lead in concentrates	72	42	39	66	25
Imports for consumption, metal, wrought and unwrought	198	202	237	271	250
Exports, metal, wrought and unwrought	70	59	54	57	60
Shipments from Government stockpile excesses, metal	—	19	65	34	40
Consumption: Reported	1,240	1,290	1,450	1,600	1,550
Apparent	1,270	1,340	1,490	1,540	1,560
Price, average, cents per pound: U.S.	35.1	31.7	37.2	42.3	48.8
London	24.5	18.4	24.8	28.6	36.0
Stocks, metal, producers, consumers, yearend	103	95	78	90	75
Employment: Mine and mill (peak), number	1,700	1,500	1,300	1,200	1,200
Primary smelter, refineries	600	600	600	600	600
Secondary smelters, refineries	1,700	1,800	1,800	1,800	1,800
Net import reliance[2] as a percent of apparent consumption	10	15	19	17	17

Recycling: About 1 million tons of secondary lead was produced, an amount equivalent to 64% of domestic lead consumption. Nearly all of it was recovered from old (post-consumer) scrap. About 880,000 tons (equivalent to 57% of domestic lead consumption) was recovered from used batteries alone.

Import Sources (1992-95): Lead in concentrates: Mexico, 54%; Peru, 28%; Canada, 6%; and other, 12%. Metal, wrought and unwrought: Canada, 68%; Mexico, 21%; Peru, 9%; Australia, 1%; and other, 1%. Total lead content: Canada, 67%; Mexico, 21%; Peru, 9%; Australia, 1%; and other, 2%.

Tariff: Item	Number	Most favored nation (MFN)[3] 12/31/96	Non-MFN[4] 12/31/96
Unwrought (Refined)	7801.10.0000	3.1% ad val.	10.0% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Lead	391	4	391	33

Events, Trends, and Issues: During 1996, the price for lead increased significantly in the U.S. and world markets. The average North American Producer and London Metal Exchange prices for the first 9 months of the year were

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LEAD

about 16% and 28%, respectively, above the averages for the previous year, as refined lead remained in short supply and stocks in industrialized countries remained at, or below, the levels at yearend 1995. U.S. mine production rose by about 9%, but primary refinery production declined by 8%, mainly owing to the permanent closure in May of one refinery. Secondary refinery production continued to increase, rising by 4% over that of 1995. U.S. apparent consumption of lead increased slightly in 1996 as strong demand continued for both original equipment and replacement lead-acid batteries in the automotive industry. In addition, demand for industrial-type batteries, particularly in the telecommunications and computer sectors, increased appreciably.

The U.S. Environmental Protection Agency (EPA) issued a direct final rule, effective January 1, 1996, prohibiting the introduction into commerce of any gasoline for highway motor vehicle use that is produced with lead additives or contains incidental trace levels of more than 0.05 gram of lead per gallon. The rule also removed or modified resulting unnecessary requirements for gasoline recordkeeping, reporting, and automobile labeling. EPA and the U.S. Department of Housing and Urban Development also jointly issued a final rule on March 6, 1996, requiring sellers and lessors to disclose the presence of known lead-based paint and/or lead-based paint hazards as part of the sale or lease of their housing. The effective date of the rule was September 6, 1996, for owners of more than four residential dwellings, and December 6, 1996, for owners of four or fewer dwellings. On August 29, EPA also issued a final rule regulating the training and certification of individuals engaged in lead-based paint abatement activities in target housing and child-occupied facilities.

The European Environment Commissioner and Environment Ministers of member countries of the Organization for Economic Cooperation and Development, meeting in February 1996, adopted a declaration to advance national and cooperative efforts to reduce risks from exposure to lead. Highest priority was directed to actions that would effectively phase down the use of lead in gasoline, eliminate exposure of children to lead in toys and other products with which they are in contact, and eliminate the exposure to lead from solder used in food and beverage containers.

In electric vehicle (EV) developments, a major U.S. automobile manufacturer planned to build, annually, 2,000 electric cars powered by conventional lead-acid batteries. The cars, weighing about 1,360 kilograms, were expected to have a range of 130 to 145 kilometers between charges. Also, a consortium representing 80% of the global manufacturers of lead-acid batteries announced plans for a 3-year, $17.5 million research program to develop a maintenance-free, sealed, recombinant lead-acid battery for EV applications.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	394	430	8,000	20,000
Australia	455	490	20,000	34,000
Canada	210	260	4,000	13,000
China	430	450	7,000	11,000
Mexico	164	170	1,000	2,000
Morocco	73	70	500	1,000
Peru	233	230	2,000	3,000
South Africa	88	90	2,000	3,000
Sweden	100	100	500	1,000
Other countries	560	510	24,000	36,000
World total (may be rounded)	2,710	2,800	69,000	120,000

World Resources: In recent years, significant lead resources have been demonstrated in association with zinc and/or silver or copper in Alaska, Australia, Canada, China, India, Mexico, Pakistan, and South Africa. Identified lead resources of the world total more than 1.5 billion tons.

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

[e]Estimated. W Withheld to avoid disclosing company proprietary data; Included with "from domestic ore."
[1]Included in imports for calculating net import reliance (see footnote 2).
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]No tariff for Mexico and 0.6% ad val. for Canada.
[4]See Appendix B.
[5]See Appendix C for definitions.

LIME[1]

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

Domestic Production and Use: In 1996, lime producers at 114 plants in 32 States sold or used 19.0 million tons (20.9 million short tons) of lime valued at about $1.13 billion, an increase of about 500,000 tons (550,000 short tons) and $30 million from 1995 levels. The level of commercial sales actually increased by about 800,000 tons (880,000 short tons), but the captive sector saw a decrease of about 300,000 tons (330,000 short tons). The increase in commercial sales was the result of increased quicklime sales in the environmental sector. Ten companies, operating 34 plants, accounted for 66% of the total output. Principal producing States, in decreasing order, were Ohio, Missouri, Alabama, Pennsylvania, Kentucky, Texas, and Illinois. These seven States produced 11.8 million tons (13.0 million short tons) or 63% of the total output. Based on monthly data, the leading commercial markets were chemical and industrial, environmental, steel, and construction, in descending order of importance.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[3]	16,200	16,700	17,400	18,500	19,000
Imports for consumption	193	201	204	289	260
Exports	59	69	74	72	55
Consumption, apparent[4]	16,300	16,900	17,500	18,700	19,200
Quicklime average value, dollars per ton at plant	55.48	55.02	56.43	56.77	57.00
Hydrate average value, dollars per ton at plant	72.15	67.84	67.71	72.09	72.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and plant, number	5,500	5,500	5,500	5,500	5,600
Net import reliance[5] as a percent of apparent consumption	—	—	—	1	1

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

Import Sources (1992-95): Canada, 91%; Mexico, 8%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[6] 12/31/96
Quicklime	2522.10.0000	Free	0.2¢/kg.[7]
Slaked lime	2522.20.0000	Free	0.3¢/kg.[7]
Hydraulic lime	2522.30.0000	Free	0.2¢/kg.[7]

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

Government Stockpile: None.

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LIME

Events, Trends, and Issues: The lime industry continued to add new capacity in 1996. Kilns totaling 330,000 tons (363,000 short tons) of new annual capacity were added at existing plants in Nevada, Ohio, Tennessee, and Virginia. At the same time, two plants in Illinois and Michigan were closed, which subtracted about 185,000 tons (204,000 short tons) of annual capacity, for an overall net gain of 145,000 tons (160,000 short tons) of annual capacity. This continues the construction boom that began in 1993 and is expected to continue at least into 1998. Construction during this 6-year period will have added more than 4.4 million tons (4.9 million short tons) of new annual capacity, while the industry will have lost 1.0 million tons (1.1 million short tons) of annual capacity.

World Lime Production and Limestone Reserves and Reserve Base:

	Production		Reserves and reserve base[8]
	1995	1996[e]	
United States	18,500	19,000	Adequate for all countries listed.
Belgium	1,800	1,800	
Brazil	5,700	5,700	
Canada	2,600	2,700	
China	20,000	20,000	
France	2,600	2,600	
Germany	8,000	8,000	
Italy[9]	3,500	3,500	
Japan (quicklime only)	7,900	7,900	
Mexico	6,600	6,600	
Poland	2,500	2,500	
Romania	1,700	1,700	
South Africa, (sales)	1,700	1,700	
United Kingdom	2,500	2,500	
Other countries	34,000	35,000	
World total (rounded)	120,000	121,000	

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 uses, such as agriculture, fluxing, and sulfur removal. Limestone contains less reactive material, is slower to react, and may have other disadvantages to lime depending on the use; however, limestone is considerably less expensive than lime. Calcined gypsum is an alternative material in industrial plasters and mortars. Cement and lime kiln dust and fly ash are potential substitutes for some construction uses of lime.

[e]Estimated. NA Not available.
[1]Data are for quicklime, hydrated lime, and refractory dead-burned dolomite. Excludes Puerto Rico, unless noted.
[2]See Appendix A for conversion to short tons.
[3]Sold or used by producers.
[4]Stocks data are not available; stock changes are assumed to be zero for apparent consumption and net import reliance calculations.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B.
[7]Rates include weight of the container.
[8]See Appendix C for definitions.
[9]Includes hydraulic lime.

LITHIUM

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

Domestic Production and Use: The United States was the largest producer and consumer of lithium minerals and compounds worldwide. The value of domestic lithium production was estimated to be about $115 million in 1996. Two companies produced lithium compounds for domestic consumption as well as for export to other countries.

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

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	W	W	W	W	W
Imports for consumption	770	810	851	1,140	1,200
Exports	2,100	1,700	1,700	1,900	2,000
Consumption: Apparent	W	W	W	W	W
Estimated[1]	2,300	2,300	2,500	2,600	2,600
Price, yearend, dollars per kilogram:					
Lithium carbonate	4.32	4.21	4.41	4.34	4.34
Lithium hydroxide, monohydrate	5.53	5.71	5.62	5.62	5.62
Stocks, producer, yearend	W	W	W	W	W
Employment, mine and mill[e], number	230	230	230	230	230
Net import reliance[2] as a percent of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1992-95): Chile, 98%; and other, 2%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Other alkali metals	2805.19.0000	6.2% ad val.	25% ad val.
Lithium oxide and hydroxide	2825.20.0000	3.7% ad val.	25% ad val.
Lithium carbonate:			
U.S.P. grade	2836.91.0010	3.7% ad val.	25% ad val.
Other	2836.91.0050	3.7% ad val.	25% ad val.

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

Government Stockpile: None.

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LITHIUM

Events, Trends, and Issues: Two new South American lithium brine operations are expected to begin producing near yearend. The Argentine operation, a subsidiary of one of the major U.S. lithium companies, should enter the lithium carbonate and lithium chloride markets early in 1997. This operation will provide the lithium carbonate feedstock necessary for the production of value-added chemical products at the company's North American operations. Expectations are that as the Argentine production approaches design capacity, mining and lithium carbonate production in North Carolina will be phased back and eventually discontinued.

Lithium carbonate from the second lithium brine project in Chile, operated by a Chilean fertilizer producer, should enter the lithium carbonate market in early 1997. This company announced plans to offer large quantities of lithium carbonate at significantly lower prices than are currently available. The two U.S. producers reported that they will be able to compete at the announced price levels.

Another U.S. company that has been one of the only large-scale recyclers of lithium batteries announced plans to sell large quantities of lithium hydroxide monohydrate. The recycling company intended to reprocess the lithium hydroxide, if necessary, repackage all the material, and offer it at substantially lower prices than offered by other companies. These lower prices may make lithium additives to portland cement concrete more feasible for preventing the silica alkali reaction that can cause premature cracking of concrete. This is an especially serious problem in California.

The California-based company purchased 31,000 tons of the material from the Department of Energy's stockpile, while the remaining 10,000 tons was purchased by another domestic company.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	W	W	340,000	410,000
Argentina[e]	8	30	NA	NA
Australia[e]	1,700	1,800	150,000	160,000
Bolivia	—	—	—	5,400,00
Brazil	32	32	910	NA
Canada	660	660	180,000	360,000
Chile	2,000	2,100	1,300,000	1,400,000
China[5]	320	320	NA	NA
Namibia[e]	52	50	NA	NA
Portugal	160	160	NA	NA
Russia[e]	800	800	NA	NA
Zaire	—	—	—	320,000
Zimbabwe	520	500	23,000	27,000
World total (may be rounded)	[6]6,300	[6]6,600	[7]2,000,000	[8]8,100,000

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

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

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Based primarily on monitoring at the concentrate stage and assuming a 15% lithium loss during conversion of concentrate into chemicals.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]These estimates denote only an approximate order of magnitude; no basis for more exact estimates is available. Output by China and Russia has never been reported.
[6]Excludes U.S. production.
[7]Excludes Argentina, China, Namibia, Portugal, and Russia.
[8]Excludes Argentina, Brazil, China, Namibia, Portugal, and Russia.

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 68% of U.S. magnesium compounds production. Magnesium oxide and other compounds were recovered from seawater by four companies in California, Delaware, Florida, and Texas; from well brines by three companies in Michigan; and from lake brines by two companies in Utah. Magnesite was mined by one company in Nevada, and olivine was mined by two companies in North Carolina and Washington. About 69% of the magnesium compounds consumed in the United States was used for refractories. The remainder was consumed in agricultural, chemical, construction, environmental, and industrial applications.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	418	386	345	360	450
Imports for consumption	179	256	287	328	250
Exports	49	52	46	54	60
Consumption, apparent	548	590	586	634	640
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant[e], number	650	650	650	600	600
Net import reliance[2] as a percent of apparent consumption	24	35	41	43	30

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

Import Sources (1992-95): China, 69%; Canada, 10%; Austria, 4%; Mexico, 3%; Greece, 3%; and other, 11%.

Tariff:[3] Item	Number	Most favored nation (MFN) 12/31/96	Canada 12/31/96	Non-MFN[4] 12/31/96
Crude magnesite	2519.10.0000	Free	Free	$10.33/ton.
Dead-burned and fused magnesia	2519.90.1000	0.2¢/kg	Free	1.7¢/kg.
Caustic-calcined magnesia	2519.90.2000	$1.24/ton	Free	$20.70/ton.

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

Government Stockpile: None.

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MAGNESIUM COMPOUNDS

Events, Trends, and Issues: Several U.S. magnesium compounds producers announced capacity increases in 1996. One producer began operating a 15,000-ton-per-year magnesium hydroxide plant in Lenoir City, TN, in the third quarter using magnesite from China as a feed material. This company also operates a similar 30,000-ton-per-year magnesium hydroxide facility near Pittsburgh, PA, and the largest magnesia/magnesium hydroxide production plant in Michigan. This company's primary business is aerospace and defense, so the firm announced that it would sell its 81% interest in its aggregates and magnesia operations to concentrate on its core business. The sole magnesite producer in Nevada plans to install additional mining equipment to double its magnesite mining capabilities. A dead-burned magnesia producer in Michigan is installing a shaft kiln and upgrading other plant equipment to increase its annual production capacity from 160,000 tons to 200,000 tons. The United States is increasing production capacity at a time when imports of Chinese magnesia are decreasing, mostly because of the Chinese export licensing system. Reports of dead-burned magnesia smuggling from China have surfaced as a result of the imposition of these licensing fees.

In Europe, two companies, one in France and one in Germany, ceased production of fused magnesia, decreasing the total world capacity by 25,000 tons per year. Increases in capacity by a producer in the United Kingdom would add back 12,000 tons of annual capacity by the end of 1996. Total world capacity was estimated to be about 45,000 tons per year before the closures.

One of the Australian magnesia producers planned to construct a 25,000-ton-per-year magnesium hydroxide plant near Melbourne to supply environmental applications. Full production at the plant was scheduled for the end of 1996. If domestic and export markets grow as expected, the company plans to construct a second magnesium hydroxide plant near Sydney. The other Australian magnesia producer announced plans to sell its magnesia subsidiary and concentrate on its gold mining business.

World Mine Production, Reserves, and Reserve Base:

	Magnesite production		Magnesite reserves and reserve base[5]	
	1995	1996[e]	Reserves	Reserve base
United States	W	W	10,000	15,000
Australia	81	90	NA	NA
Austria	202	200	15,000	20,000
Brazil	81	80	45,000	65,000
China[e]	346	340	750,000	1,000,000
Greece	58	55	30,000	30,000
India	115	120	30,000	45,000
Korea, North[e]	461	460	450,000	750,000
Russia[e]	202	200	650,000	730,000
Serbia and Montenegro	22	20	5,000	10,000
Slovakia[e]	346	340	20,000	30,000
Spain	115	100	10,000	30,000
Turkey	519	520	65,000	160,000
Other countries	95	100	420,000	480,000
World total (may be rounded)	[6]2,640	[6]2,630	2,500,000	3,400,000

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

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

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

MAGNESIUM METAL[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Three companies in Texas, Utah, and Washington produced primary magnesium in 1996 valued at approximately $514 million. An electrolytic process was used at plants in Texas and Utah to recover magnesium from seawater and lake brines, respectively. A thermic process was used to recover magnesium from dolomite in Washington. The aluminum industry remained the largest consumer of magnesium, accounting for 55% of domestic primary metal use. Magnesium was a constituent in aluminum-base alloys that were used for packaging, transportation, and other applications. Castings and wrought magnesium products accounted for 22% of U.S. consumption of primary metal; desulfurization of iron and steel, 12%; cathodic protection, 5%; reducing agent in nonferrous metals production, 2%; and other uses, 4%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Primary	137	132	128	142	143
Secondary	57	59	62	65	65
Imports for consumption	12	37	29	35	43
Exports	52	39	45	38	41
Consumption: Reported, primary	94	101	112	109	110
Apparent	142	148	149	171	171
Price, yearend:					
Metals Week, U.S. spot Western, dollars per pound, average	1.50	1.46	1.63	2.09	1.75
Metal Bulletin, free market, dollars per metric ton, average	2,625	2,260	3,125	4,138	2,700
Stocks, producer and consumer, yearend	13	26	19	21	25
Employment[e], number	1,450	1,400	1,400	1,400	1,400
Net import reliance[2] as a percent of apparent consumption	E	E	E	E	E

Recycling: In 1996, about 30,000 tons of the secondary production was recovered from old scrap.

Import Sources (1992-95): Canada, 40%; Russia, 34%; Mexico, 6%; Ukraine, 5%; and other, 15%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Canada 12/31/96	Mexico 12/31/96	Non-MFN[3] 12/31/96
Unwrought metal	8104.11.0000	8.0% ad val.	1.6% ad val.	Free	100% ad val.
Unwrought alloys	8104.19.0000	6.5% ad val.	1.3% ad val.	2.6% ad val.	60.5% ad val.
Wrought metal	8104.90.0000	14.8¢/kg on Mg content + 3.5% ad val.	2.9¢/kg on Mg content + 0.7% ad val.	Free	88¢/kg on Mg content + 20.0% ad val.

Depletion Allowance: Dolomite, 14% (Domestic and Foreign); magnesium chloride, 5% (Domestic and Foreign).

Government Stockpile: None.

Events, Trends, and Issues: In contrast with 1995, free-market magnesium prices fell dramatically in 1996 and averaged $2,700 per ton by the end of October, a 56% decline from prices at the beginning of the year. Despite antidumping duties, Russia continued to supply most of the U.S. imports of primary magnesium because of the exempted relationship between certain producers and exporters.

As a result of an administrative review, the International Trade Administration (ITA) amended its antidumping order on imports of pure magnesium from Canada. For the period August 1, 1994, to July 31, 1995, the ITA determined that the weighted average dumping margin for magnesium imports from the largest Canadian magnesium producer was 0%. This deposit rate will be effective for all pure magnesium imported into the United States from this company after August 12, 1996, the publication date of the final result.

The European Commission (EC) also established antidumping duties on Russian and Ukrainian magnesium imports. The minimum import price for Russian magnesium was established at 2,602 ECU per ton, and the minimum import price on Ukrainian magnesium was 2,568 ECU per ton. Under terms of an undertaking agreement, however, these duties will be suspended for some imports. Under a clause in the undertaking agreement between the EC, Russia, and Ukraine, specified small quantities of magnesium that are invoiced to a EC-approved importer will not be subject to the duties, even though they are brought in below the minimum value.

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MAGNESIUM METAL

U.S. auto manufacturers continued to replace aluminum and steel in some applications with magnesium. One firm planned to use a urethane-covered magnesium armature for the steering wheels of some of its redesigned pickup trucks, standard-size sports-utility vehicles, and vans at a savings of one-half of the weight of the steel components that it replaces. Another manufacturer chose magnesium alloy components for two new applications—seats in some 1997 model minivans and battery cases for the company's new electric vehicles. Although only 2,000 to 3,000 of the electric vehicles will be made annually, magnesium will be used in a number of other components, such as seat frames. Another auto manufacturer planned to use magnesium die-cast support brackets in its 1997 sports-utility vehicles. Each vehicle will use one 2.3- to 2.7-kilogram bracket, replacing an assembly of steel stampings that weighs about 6.4 kilograms. The total annual requirement was expected to be between 800 and 900 tons of magnesium alloy AM60.

Magnesium recycling capacity is planned in the United States and Canada to handle additional scrap that is expected to be generated by automotive component production. One U.S. firm planned to double recycling capacity at its Madison, IL, plant to 18,000 tons per year by the end of 1998 and to build a 17,000-ton-per-year nonferrous metal recycling facility in Foley, AL. The new plant will also have the capability to produce 4,500 tons of magnesium alloy anodes annually. Another magnesium recycler announced that it would build a new magnesium recycling facility in Bellvue, OH, with a total annual capacity of 13,600 tons, which was scheduled to be in operation by the second quarter of 1997. A Norwegian firm planned to construct a 15,000-ton-per-year alloy casting line and establish technology to recycle and reprocess some residues at its Becancour, Canada, magnesium production plant. Both projects were expected to be completed by yearend 1997.

After completing a feasibility study, regional officials said that they would go forward with the planned primary magnesium production project in Iceland. A 50,000-ton-per-year plant, using new technology that does not produce commercial byproduct chlorine, was to be completed in Reykjanes by the second half of 1999. A Jordanian potash producer announced plans to construct a new plant to produce magnesium from brines from the Dead Sea. The company signed a memorandum of understanding with the Russian Government to construct a 50,000-ton-per-year plant on the Jordanian shore of the Dead Sea. No completion date for the project was scheduled. In addition to its new primary magnesium plant, Israel had plans to construct a $40 million magnesium diecasting plant. The project, a 50-50 joint venture between two firms, will produce 4,000 tons per year of magnesium diecastings at a plant at kibbutz Neve Ur. Completion of the plant is scheduled for 1998.

World Primary Production, Reserves, and Reserve Base:

	Primary production		Reserves and reserve base[4]
	1995	1996[e]	
United States	142	143	Domestic magnesium metal production is derived from natural brines and dolomite, and the reserves and reserve base for this metal are sufficient to supply current and future requirements. To a limited degree, the existing natural brines may be considered a renewable resource wherein any magnesium removed by humans may be renewed by nature in a short span of time.
Brazil	10	11	
Canada	48	50	
China[e]	40	40	
France	12	13	
Kazakstan[e]	—	5	
Norway	35	38	
Russia[e]	38	35	
Serbia and Montenegro	2	2	
Ukraine[e]	13	10	
World total	339	347	

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 billions of tons, and magnesium can be recovered from seawater at places along world coastlines where salinity is high.

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

[e]Estimated. E Net exporter.
[1]See also Magnesium Compounds.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.

MANGANESE

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

Domestic Production and Use: Manganese ore containing 35% or more manganese was not produced domestically in 1996. Manganese ore was consumed mainly by about 15 firms with plants principally in the Eastern and Midwestern United States. The majority of ore consumption was related to steel production, directly in pig iron manufacture and indirectly through upgrading ore to ferroalloys and metal. Ore was used otherwise for such nonmetallurgical purposes as producing dry cell batteries, as an ingredient in plant fertilizers and animal feed, and as a colorant for brick. Leading identifiable end uses of manganese were construction, machinery, and transportation, which were estimated to be 23%, 14%, and 12%, respectively, of total manganese demand. Most of the rest went to a variety of other iron and steel applications. Value of domestic consumption was estimated from foreign trade data as about $500 million.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Production, mine[2]	—	—	—	—	—
Imports for consumption:					
Manganese ore	247	232	331	394	430
Ferromanganese	304	347	336	310	350
Silicomanganese[3]	257	316	273	305	310
Exports:					
Manganese ore	13	16	15	15	32
Ferromanganese	13	18	11	11	9
Shipments from Government stockpile excesses:[4]					
Manganese ore	425	254	134	115	140
Ferromanganese	(128)	(1)	9	18	—
Consumption, reported:[5]					
Manganese ore	438	389	449	486	470
Ferromanganese	339	341	347	348	350
Consumption, apparent, manganese[6]	596	696	694	676	716
Price, average value, 46% to 48% Mn metallurgical ore, dollars per mtu cont. Mn, c.i.f. U.S. ports	3.25	2.60	2.40	2.40	2.55
Stocks, producer and consumer, yearend:					
Manganese ore	276	302	269	309	310
Ferromanganese	28	30	36	33	38
Net import reliance[7] as a percent of apparent consumption	100	100	100	100	100

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

Import Sources (1992-95): Manganese ore: Gabon, 58%; Australia, 18%; Mexico, 10%; Brazil, 8%; and other, 6%. Ferromanganese: South Africa, 37%; France, 26%; Brazil, 10%; Mexico, 7%; and other, 20%. Manganese contained in all manganese imports: South Africa, 27%; Gabon, 15%; Australia, 12%; France, 12%; and other, 34%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[8] 12/31/96
Ore and concentrate	2602.00.0040/60	Free	2.2¢/kg of contained Mn.
Manganese dioxide	2820.10.0000	4.7% ad val.	25% ad val.
High-carbon ferromanganese	7202.11.5000	1.5% ad val.	10.5% ad val.
Silicomanganese	7202.30.0000	3.9% ad val.	23% ad val.
Metal, unwrought	8111.00.4500	14% ad val.	20% ad val.

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

Government Stockpile: Committed inventories and disposals tabulated may include nonstockpile-grade material. The Defense Logistics Agency (DLA), U.S. Department of Defense, listed additional uncommitted inventories of nonstockpile-grade materials, as follows: 16,400 tons of natural battery ore, 81 tons of chemical ore, and 392,000 tons of metallurgical ore. DLA's Fiscal Year 1996 and 1997 Annual Materials Plans that specified maximum sales quantities included all forms of manganese in Government inventories.

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MANGANESE

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Battery: Natural ore	115	2	115	2
Synthetic dioxide	3	—	3	—
Chemical ore	149	—	149	—
Metallurgical ore	763	166	763	16
Ferromanganese:				
High-carbon	968	—	760	—
Medium-carbon	18	—	—	—
Silicomanganese	0.2	—	—	—
Electrolytic metal	10	0.02	10	2

Events, Trends, and Issues: A slight further advance in raw steel production sustained domestic manganese demand. Price developments varied for the principal forms of manganese used. The price of ore rose moderately, the first instance of an increase since 1989. Prices declined for imported high-carbon ferromanganese and silicomanganese; the price for the latter fell by one-third by September. The world scene was marked by the activity of Japanese firms forming international joint ventures for production of refined ferromanganese and electrolytic manganese dioxide. The manganese industries of Georgia and Ukraine were in various stages of transition to privatization. Manganese is an essential element for people, animals, and plants, but it can be harmful in excessive amounts. Thus, manganese can be an industrial poison, but generally is not a hazard.

World Mine Production, Reserves, and Reserve Base:

	Mine production 1995	Mine production 1996[e]	Reserves[9]	Reserve base[9]
United States	—	—	—	—
Australia	1,070	950	30,000	80,000
Brazil	[e]905	900	21,000	56,000
China	[e]1,000	1,000	40,000	100,000
Gabon	[e]895	830	45,000	150,000
Georgia	[e]150	30	7,000	49,000
India	[e]627	630	24,000	36,000
Mexico	[e]174	165	4,000	9,000
South Africa	[e]1,350	1,400	370,000	4,000,000
Ukraine	[e]1,100	1,100	135,000	520,000
Other countries	[e]309	350	Small	Small
World total (rounded)	[e]7,580	7,400	680,000	5,000,000

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

Substitutes: There is no satisfactory substitute for manganese in its major applications.

[e]Estimated.
[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]For silicomanganese, imports more nearly represent amount consumed than does reported consumption; internal evaluation indicates that reported consumption of silicomanganese is considerably understated.
[4]Net quantity including effect of stockpile upgrading program. Data in parentheses denote increases in inventory.
[5]Total manganese consumption cannot be approximated from consumption of manganese ore and ferromanganese because of the use of ore in making manganese ferroalloys and metal.
[6]Thousand metric tons, manganese content. Based on estimates of average content for all significant components except imports, for which content is reported.
[7]Defined as imports - exports + adjustments for Government and industry stock changes.
[8]See Appendix B.
[9]Thousand metric tons, manganese content. See Appendix C for definitions.

MANUFACTURED ABRASIVES

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

Domestic Production and Use: Fused aluminum oxide was produced by 5 companies at 10 plants in the United States and Canada. Production of regular-grade fused aluminum oxide was valued at about $50 million and production of high-purity fused aluminum oxide was valued at about $15 million. Silicon carbide was produced by four companies at four plants in the United States and Canada. U.S. and Canadian production of crude silicon carbide was valued at about $35 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, United States and Canada (crude):					
Fused aluminum oxide, regular	143,000	132,000	133,000	126,000	135,000
Fused aluminum oxide, high-purity	24,200	21,300	29,200	33,100	32,000
Silicon carbide	84,300	74,900	84,700	85,900	75,000
Imports for consumption					
Fused aluminum oxide	136,000	158,000	145,000	213,000	110,000
Silicon carbide	89,000	115,000	110,000	172,000	160,000
Exports					
Fused aluminum oxide	12,000	11,000	13,000	11,000	11,000
Silicon carbide	14,000	17,000	16,000	20,000	15,000
Consumption: Apparent					
Fused aluminum oxide	NA	NA	NA	NA	NA
Silicon carbide	NA	NA	NA	NA	NA
Price, range of value, dollars per ton					
Fused aluminum oxide, regular	395	362	361	358	360
Fused aluminum oxide, high-purity	594	621	557	468	500
Silicon carbide	516	540	531	495	500
Stocks, producer	NA	NA	NA	NA	NA
Employment, mine and mill, number	NA	NA	NA	NA	NA
Net import reliance[1] as a percent of apparent consumption	NA	NA	NA	NA	NA

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

Import Sources (1992-95): Fused aluminum oxide crude: Canada, 57%; Australia, 29%; and other, 14%. Fused aluminum oxide grain: Canada, 30%; Austria, 27%; China, 22%; and other, 21%. Silicon carbide crude: China, 58%; Canada, 34%; and other, 8%. Silicon carbide grain: Norway, 44%; Brazil, 18%; Germany, 10%; and other, 28%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[2] 12/31/96
Fused aluminum oxide, crude	2818.10.1000	Free	Free.
Fused aluminum oxide, grain	2818.10.2000	1.3% ad val.	4.1% ad val.
Silicon carbide, crude	2849.20.1000	Free	Free.
Silicon carbide, grain	2849.20.2000	0.5% ad val.	1.6% ad val.

Depletion Allowance: None.

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Fused aluminum oxide, crude	169,000	20,745	169,000	13,608
Fused aluminum oxide, grain	30,171	814	30,171	2,283
Silicon carbide, crude	20,853	2	20,853	—

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MANUFACTURED ABRASIVES

Events, Trends, and Issues: Producers in the United States and Canada will continue to face strong competition from abroad. In particular, low-cost silicon carbide from China may lead to diminished production in North America.

World Production Capacity:

	Fused aluminum oxide capacity		Silicon carbide capacity	
	1995	1996[e]	1995	1996[e]
United States and Canada	220,000	220,000	100,000	100,000
Argentina	—	—	6,000	6,000
Australia	100,000	75,000	—	—
Austria	60,000	60,000	—	—
Brazil	100,000	100,000	43,000	43,000
China	400,000	400,000	250,000	250,000
France	45,000	45,000	16,000	16,000
Germany	150,000	150,000	36,000	36,000
India	20,000	20,000	13,000	13,000
Japan	55,000	55,000	90,000	90,000
Mexico	—	—	25,000	25,000
Norway	—	—	80,000	80,000
Venezuela	—	—	20,000	20,000
Other countries	150,000	175,000	250,000	250,000
World total (rounded)	1,300,000	1,300,000	930,000	930,000

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

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

[e]Estimated. NA Not available.

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

[2]See Appendix B.

MERCURY

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

Domestic Production and Use: Mercury, recovered solely as a byproduct, was produced at eight gold mining operations in California, Nevada, and Utah. Other gold mines in those States were thought to have recovered mercury, but data were not available to make reliable estimates. In response to decreasing primary production and the stringent restrictions placed on the disposal of mercury-containing products, secondary production continued to increase. Several companies in the eastern and central United States recovered mercury from a variety of secondary sources, such as batteries, electrical apparatus, fluorescent light tubes, instruments, dental amalgams, and chlor-alkali wastewater sludges. The value of mercury used in the United States was estimated at $3 million. It was estimated that 35% of domestic consumption was used in the production of chlorine and caustic soda, 26% for electric and electronic applications, 10% for measuring instruments, 7% for dental supplies, and 22% for other.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine	64	W	W	W	W
Secondary, industrial	176	350	466	534	550
Imports for consumption	92	40	129	377	550
Exports	977	389	316	179	100
Shipments from Government stocks:[2]					
National Defense Stockpile	267	543	86	—	—
U.S. Department of Energy	103	—	—	—	—
Consumption: Reported	621	558	483	436	400
Apparent	W	W	W	W	W
Price, average value, dollars per flask, New York, dealer	201.39	187.00	194.45	247.39	260.00
Stocks, industry, yearend[3]	436	384	469	352	300
Net import reliance[4] as a percent of apparent consumption	W	W	W	W	W

Recycling: Secondary mercury from old scrap was equivalent to about two-thirds of apparent domestic consumption in 1996.

Import Sources (1992-95): Russia, 46%; Canada, 33%; Kyrgyzstan, 7%; Germany, 6%; and other, 8%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Mercury	2805.40.0000	1.7% ad val.	5.7% ad val.

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

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

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Mercury	4,410	—	4,410	—

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MERCURY

Events, Trends, and Issues: Consumption declined for the fourth consecutive year because of the gradual elimination of mercury from many products and processes. Mercury use in consumer batteries has dropped to less than one metric ton per year since its use has been restricted to alkaline button cells for hearing aids, pagers, and other small electronic devices. Military and medical equipment still use mercuric-oxide batteries because of the lack of acceptable substitutes. State and Federal studies are continuing the development of effective substitutes for mercury in switches, electrical devices, and dental amalgams; however, commercial production of these new products is not expected for several years. One of the few exceptions is a new low-mercury fluorescent light tube that became available in 1995. The 4-foot tube contains only 10 milligrams of mercury, compared with 22.8 milligrams in the previous year or with an industry average of 38.4 milligrams per tube in 1990. The low-mercury content in these new tubes should allow for their disposal as nonhazardous waste.

Ever stricter environmental restrictions and the advancement of new technology is expected to further reduce the future use of mercury in many devices. As production of primary mercury in the United States continues to be contingent on the mining of other minerals, secondary production will become an even more important component of domestic supply.

Sales from the National Defense Stockpile remained suspended pending completion of an analysis of the potential impact to the environment resulting from sales.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	W	W	3,000	4,000
Algeria	292	250	2,000	3,000
China	550	500	([7])	([7])
Mexico	15	15	5,000	9,000
Italy	—	—	—	69,000
Kyrgyzstan	170	200	7,500	13,000
Spain	1,497	1,400	76,000	90,000
Ukraine	40	50	2,500	4,000
Other countries	256	385	30,000	48,000
World total (may be rounded)	2,820	2,800	130,000	240,000

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

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

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]One metric ton (1,000 kilograms) = 29.0082 flasks.
[2]Metal sold from the National Defense Stockpile and surplus secondary mercury released from U.S. Department of Energy stocks.
[3]Consumer stocks only.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.
[7]Included in "Other countries."

MICA (NATURAL), SCRAP AND FLAKE[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Scrap and flake mica production, excluding low-quality sericite, was estimated to be 109,000 metric tons in 1996. North Carolina accounted for about 68% of U.S. production. The remaining output came from Georgia, New Mexico, South Carolina, and South Dakota. Scrap mica was recovered principally from mica and sericite schist and from feldspar, kaolin, and lithium beneficiation. The majority of domestic production was processed into small particle-size mica by wet and dry grinding. Primary uses were joint compound, paint, roofing, oil well drilling additives, and rubber products. The value of 1996 scrap mica production was estimated at $6.6 million. Ground mica sales were valued at $30 million. There were nine domestic producers of scrap and flake mica.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production:[2 3] Mine	85	88	110	108	109
Ground	84	92	95	98	100
Imports, mica powder and mica waste	12	14	18	16	18
Exports, mica powder and mica waste	4	5	6	7	8
Consumption, apparent[4]	95	105	97	112	119
Price, average, dollars per ton, reported:					
Scrap and flake	51	51	66	52	61
Ground:					
Wet	745	838	1,007	974	1,000
Dry	168	152	151	174	170
Stocks, producer, yearend[e]	7	7	14	13	10
Employment, mine,[e 5] number	80	80	364	360	NA
Net import reliance[6] as a percent of apparent consumption	12	12	1	5	8

Recycling: None.

Import Sources (1992-95): Canada, 69%; India, 25%; Finland, 2%; Japan, 1%; and other, 3%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[7] 12/31/96
Mica powder	2525.20.0000	1.4% ad val.	20% ad val.
Mica waste	2525.30.0000	Free	8.8¢/ kg.

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

Government Stockpile: None.

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MICA (NATURAL), SCRAP AND FLAKE

Events, Trends, and Issues: Production of ground mica in the United States increased for the fifth consecutive year. The increase is a reflection of a continued improvement in construction activity. Part of this demand is attributable to an increase in hurricane and flood damage, especially in the southeastern United States. The United States remained the major producer of scrap and flake mica in 1996. Imported mica scrap and flake is used primarily for making mica paper and as a filler and reinforcer in plastics.

The principal environmental impact of mica mining was the land disturbance commonly associated with surface mining.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	1995	1996[e]		
United States[2]	108	109	Large	Large
Brazil	7	7	Large	Large
Canada	18	18	Large	Large
India	1	1	Large	Large
Korea, Republic of	44	45	Large	Large
Russia	23	23	Large	Large
Other countries	41	40	Large	Large
World total	242	243	Large	Large

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

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

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

MICA (NATURAL), SHEET[1]

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: A minor amount of sheet mica, estimated at less than 500 kilograms, was produced in 1996. The domestic consuming industry was dependent on imports and shipments of Government stockpile excesses to meet demand for sheet mica. During 1996, an estimated 5,100 tons of unworked mica split block and mica splittings valued at $1.3 million was consumed by 14 companies in 7 States, mainly in the East and Midwest. Most was fabricated into parts for electronic and electrical equipment. An additional estimated 1,100 tons of imported worked mica valued at $7.2 million was also consumed.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine[e]	([2])	([2])	([2])	([2])	([2])
Imports, plates, sheets, and strips; worked mica; split block; splittings; other > $0.55/kg	3,460	4,310	2,610	4,230	6,190
Exports, plates, sheets, and strips; worked mica; crude and rifted into sheet or splittings > $0.55/kg	606	909	1,003	935	900
Shipments from Government stockpile excesses	264	165	134	511	1,400
Consumption, apparent	2,250	2,180	1,740	3,800	6,690
Price, average value, dollars per kilogram, muscovite mica, reported:					
Block	80	95	66	73	75
Splittings	1.53	1.55	1.59	1.70	1.75
Stocks, fabricator and trader, yearend[e]	NA	502	503	NA	NA
Net import reliance[3] as a percent of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1992-95): India, 62%; Belgium, 17%; Brazil, 6%; China, 4%; and other, 11%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Split block mica	2525.10.0010	Free	Free.
Mica splittings	2525.10.0020	Free	Free.
Unworked-other	2525.10.0050	Free	Free.
Plates, sheets, and strips of agglomerated or reconstructed mica	6814.10.0000	4.3% ad val.	40% ad val.
Worked mica and articles of mica - other	6814.90.0000	4.1% ad val.	45% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Block:				
Muscovite	1,387	2	1,310	459
Phlogopite	8	—	—	—
Film, muscovite	115	34	96	276
Splittings:				
Muscovite	6,002	33	6,002	234
Phlogopite	307	50	307	226

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MICA (NATURAL), SHEET

Events, Trends, and Issues: Demand for sheet mica increased as imports of splittings from India increased to meet demand for electrical equipment, especially transformers. Imports remained the principal source of sheet mica, and shipments from Government stockpile excesses increased to become a significant source of supply. The availability of good quality mica remained in short supply. There were no environmental problems associated with the manufacture of mica products.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	([2])	([2])	Very small	Small
India	2,100	2,000	Very large	Very large
Russia	1,500	1,500	Moderate	Large
Other countries	200	200	Moderate	Large
World total	3,800	3,700	Large	Large

World Resources: There has been no formal evaluation of world resources of sheet mica because of the sporadic occurrence of this material. Large deposits of mica-bearing rock are known to exist in countries such as Brazil, India, and Madagascar. Limited resources of sheet mica are available in the United States. These domestic resources are uneconomic because of the high cost of hand labor required to mine and process the sheet mica.

Substitutes: Many materials can be substituted for mica in many electrical and electronic uses. Substitutes include acrylic, Benelex®, cellulose acetate, Delrin®, Duranel® N, fiberglass, fishpaper, Kapton®, Kel F®, Kydex®, Lexan®, Lucite®, Mylar®, nylon, nylatron, Nomex®, Noryl®, phenolics, Plexiglass®, polycarbonate, polyester, styrene, Teflon®, vinyl-PVC, and vulcanized fiber. Mica paper made from scrap mica can be substituted for sheet mica in electrical uses.

[e]Estimated. NA Not available.
[1]See also Mica (Natural), Scrap and Flake.
[2]Less than ½ unit.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.

MOLYBDENUM

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

Domestic Production and Use: In 1996, molybdenum, valued at about $430 million (based on average oxide price), was produced by 12 mines. Molybdenum ore was produced at three mines in Colorado and Idaho, whereas nine mines in Arizona, Montana, New Mexico, and Utah recovered molybdenum as a byproduct. Three plants converted molybdenite (MoS_2) concentrate to molybdic oxide, from which intermediate products, such as ferromolybdenum, metal powder, and various chemicals, were produced. Iron and steel producers accounted for about 75% of the molybdenum consumed. Major end-use applications were as follows: machinery, 35%; electrical, 15%; transportation, 15%; chemicals, 10%; oil and gas industry, 10%; and others, 15%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine	49,700	36,800	46,800	60,900	57,000
Imports for consumption	3,831	3,400	2,280	5,570	5,000
Exports, all primary forms	36,000	30,000	37,000	51,300	47,500
Consumption: Reported	17,200	17,700	18,800	19,900	18,700
Apparent	21,000	16,000	20,400	16,100	14,500
Price, average value, dollars per kilogram[1]	4.85	5.13	4.60	17.50	7.50
Stocks, mine and plant concentrates, product, and end-use	21,900	19,900	11,500	12,400	12,400
Employment, mine and plant, number	750	680	700	700	700
Net import reliance[2] as a percent of apparent consumption	E	E	E	E	E

Recycling: Secondary molybdenum in the form of molybdenum metal or superalloys was recovered, but the amount was small. About 1,000 tons of molybdenum was reclaimed from spent catalysts. Although some molybdenum was recycled as a minor constituent of scrap alloy steels and iron, the use of such scrap did not generally depend on its molybdenum content.

Import Sources (1992-95): China, 17%; United Kingdom, 16%; Canada, 14%; Chile, 14%; and other, 39%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Molybdenum ore and concentrates, roasted	2613.10.0000	13¢/kg + 1.9% ad val.	$1.10/kg + 15% ad val.
Molybdenum ore and concentrates, other	2613.90.0000	19¢/kg	77.2¢/kg.
Molybdenum chemicals:			
Molybdenum oxides and hydroxides	2825.70.0000	3.2% ad val.	20.5% ad val.
Molybdates of ammonium	2841.70.1000	4.3% ad val.	29% ad val.
Molybdates, all others	2841.70.5000	3.7% ad val.	25% ad val.
Molybdenum pigments:			
Molybdenum orange	3206.20.0020	3.7% ad val.	25% ad val.
Miscellaneous chemical products:			
Mix of two or more inorganic compounds of molybdenum	3823.90.3400	2.8% ad val.	18% ad val.
Ferroalloys:			
Ferromolybdenum	7202.70.0000	4.5% ad val.	31.5% ad val.
Molybdenum metals:			
Powders	8102.10.0000	12¢/kg + 1.6% ad val.	$1.10/kg + 15% ad val.
Unwrought	8102.91.1000	13.9¢/kg + 1.9% ad val.	$1.10/kg + 15% ad val.
Waste and scrap	8102.91.5000	Free	Free.
Wrought	8102.92.0000	6.6% ad val.	60% ad val.
Wire	8102.93.0000	5.7% ad val.	60% ad val.
Other	8102.99.0000	4.8% ad val.	45% ad val.

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MOLYBDENUM

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

Government Stockpile: None.

Events, Trends, and Issues: The Questa molybdenum mine, Questa, NM, was being prepared for operation. A new section has been developed for use of load haul dump vehicles, and production is expected to be about 460 metric tons of contained molybdenum per month. U.S. mine output of molybdenum in 1996 decreased 5% compared with that of 1995. Reported consumption of molybdenum also decreased about 6%; exports declined about 7%, and U.S. producer inventories were about the same as those of 1995.

The year 1996 was uneventful for the molybdenum industry, and prices of concentrates and molybdenum products moderated toward the year's end. The domestic price for technical-grade molybdic oxide averaged $7.50 per kilogram of contained molybdenum during 1996. Mine capacity utilization was 50%.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]	(thousand metric tons)	
United States	60,900	57,000	2,700	5,400
Armenia	800	800	20	30
Bulgaria	—	—	([5])	10
Canada	9,536	10,000	450	910
Chile	17,889	18,000	1,100	2,500
China	17,500	18,000	500	1,000
Iran	1,200	1,000	50	140
Kazakstan	700	900	130	200
Mexico	3,810	4,000	90	230
Mongolia	1,830	2,000	30	50
Peru	3,630	4,000	140	230
Russia	7,300	8,000	240	360
Uzbekistan	500	700	60	150
Other countries	—	—	—	590
World total (rounded)	126,000	124,000	5,500	12,000

World Resources: Identified resources amount to about 5.4 million metric tons of molybdenum in the United States and more than 12 million metric tons in the world. Molybdenum occurs both as the principal metal sulfide in large low-grade porphyry molybdenum deposits and as a subsidiary metal sulfide in low-grade porphyry copper deposits. Resources of molybdenum are adequate to supply world needs for the foreseeable future.

Substitutes: There is little substitution for molybdenum in its major application as an alloying element in steels, and cast irons. In fact, because of the availability and versatility of the metal, industry has sought to develop new materials that benefit from the alloying properties of molybdenum. Potential substitutes for molybdenum include chromium, vanadium, columbium, and boron in alloy steels; tungsten in tool steels; graphite, tungsten, and tantalum for refractory materials in high-temperature electric furnaces; and chrome-orange, cadmium-red, and organic-orange pigments for molybdenum orange.

[e]Estimated. E Net exporter.
[1]Major producer price per kilogram of molybdenum contained in technical-grade molybdic oxide.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]Less than ½ unit.

NICKEL

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

Domestic Production and Use: The United States has only one nickel smelter. This smelter, near Riddle, OR, operated at full capacity in 1996, producing ferronickel from imported ores. The adjoining mine was idle all year. On a monthly or annual basis, 164 facilities reported nickel consumption. The principal consuming State was Pennsylvania, followed by West Virginia and New Jersey. Approximately 46% of the primary nickel consumed went into stainless and alloy steel production, 33% into nonferrous alloys and superalloys, 14% into electroplating, and 7% into other uses. Ultimate end uses were as follows: transportation, 29%; chemical industry, 14%; electrical equipment, 10%; construction, 9%; fabricated metal products, 8%; petroleum, 8%; machinery, 7%; household appliances, 6%; and other, 9%. Total estimated value of apparent primary consumption was $1.2 billion.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine	6,670	2,460	—	1,560	—
Plant	8,960	4,880	—	8,290	14,600
Imports: Ore	3,580	2,970	—	8,200	16,800
Primary[1]	119,000	126,000	127,000	149,000	146,000
Secondary[1]	9,510	6,710	6,060	7,900	7,660
Exports: Primary	8,560	7,180	7,420	9,750	12,800
Secondary	25,300	26,000	34,500	41,800	32,000
Consumption: Reported, primary	101,000	105,000	107,000	124,000	117,000
Reported, secondary	55,900	54,000	58,600	64,400	55,000
Apparent, primary	119,000	122,000	133,000	150,000	158,000
Price, average annual, London Metal Exchange					
Cash, dollars per metric ton	7,001	5,293	6,340	8,228	7,515
Cash, dollars per pound	3.176	2.401	2.876	3.732	3.409
Stocks: Government, yearend	33,800	31,600	26,800	19,800	13,600
Consumer, yearend	17,500	14,400	11,000	12,300	10,600
Producer, yearend[2]	10,100	15,700	10,200	14,100	12,200
Employment, yearend, number: Mine	10	2	1	15	1
Smelter	250	33	22	250	250
Port facility[3]	23	5	3	25	25
Net import reliance[4] as a percent of apparent consumption	59	63	64	59	63

Recycling: About 55,000 tons of nickel was recovered from purchased scrap in 1996. This represented about 32% of reported consumption for the year.

Import Sources (1992-95): Canada, 42%; Norway, 14%; Australia, 11%; Russia, 9%; and other, 24%.

Tariff: Item	Number	Canada, Mexico, and most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Nickel oxide, chemical grade	2825.40.0000	Free	Free.
Ferronickel	7202.60.0000	Free	6.6¢/kg.
Nickel oxide, metallurgical grade	7501.20.0000	Free	Free.
Unwrought nickel, not alloyed	7502.10.0000	Free	6.6¢/kg.
Waste and scrap	7503.00.0000	Free	6.6¢/kg.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Nickel	10,300	5,690	9,490	6,090

Events, Trends, and Issues: Demand for nickel-bearing stainless steel has improved substantially in the United States since 1992. However, a large part of the increase was being met by imported stainless from, in decreasing order, the European Union, Japan, and Canada. U.S. production of stainless steel increased 12% between 1994-95, with nickel-bearing grades accounting for 65% of the 2.06 million tons made in 1995. In 1996, domestic shipments of stainless sheet and strip were down about 4% from the all-time high of 1995.

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NICKEL

Nickel supply and demand have been closely balanced since early 1995. Growing demand for austenitic stainless steel in the developing countries and an improving global economy have encouraged nickel producers to open new mines and upgrade older operations despite weak prices for the metal in 1993 and 1994. London Metal Exchange (LME) inventories peaked at 151,000 tons in November 1994 and then fell steadily over the next 20 months, eventually leveling off at 40,000 tons in the fall of 1996. Nickel prices have improved considerably since mid-1994, but continue to be kept in check by large exports of cathode and powder from Russia to the West. For the week ending November 22, 1996, the LME cash price for 99.8%-pure nickel averaged $6,744 per metric ton ($3.06 per pound). The new Mount Keith Mine in Western Australia already exceeded its design capacity of 28,000 tons per year of nickel in concentrate and was being upgraded to 37,000 tons per year. Part of the concentrate was being shipped to the recently expanded Harjavalta smelter in Finland. In Cuba, a Canadian company began modernizing and upgrading the 37-year-old mining and beneficiating complex at Moa Bay.

The discovery of a world class nickel-copper-cobalt deposit in 1993 at Voisey's Bay, Labrador, Canada, has drastically altered the long-term nickel supply picture. Mining of the high-grade sulfide deposit is to begin by the year 2000. The concentrate produced at Voisey's Bay will be processed on the island of Newfoundland. A state-of-the art smelting and refining complex is to be built at Argentia, 130 kilometers west of St. John's. The Argentia complex will be the largest nickel smelting and refining facility in the Western World, producing about 122,000 tons of nickel per year.

Programs were underway in the European Union, Japan, and the United States to develop advanced nickel-based batteries for electric vehicles. Beginning in 2003, 10% of all motor vehicles sold within California must have zero tailpipe emissions—a requirement revised in 1996 that only electric vehicles can presently satisfy.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	1,560	—	23,000	2,500,000
Australia	101,000	113,000	2,200,000	6,800,000
Botswana	18,700	22,000	480,000	900,000
Brazil	32,700	34,000	670,000	4,300,000
Canada	181,000	189,000	6,200,000	14,000,000
China	37,000	37,000	730,000	900,000
Colombia	24,200	31,000	560,000	740,000
Cuba	42,700	51,000	18,000,000	23,000,000
Dominican Republic	49,000	50,000	450,000	680,000
Finland	4,380	4,100	80,000	100,000
Greece	19,900	21,000	450,000	900,000
Indonesia	88,200	89,000	3,200,000	13,000,000
New Caledonia	121,000	122,000	4,500,000	15,000,000
Philippines	15,100	13,000	410,000	11,000,000
Russia	251,000	250,000	6,600,000	7,300,000
South Africa	29,800	32,000	2,500,000	2,600,000
Zimbabwe	11,700	12,000	77,000	100,000
Other countries	6,510	5,900	250,000	10,000,000
World total (may be rounded)	1,040,000	1,080,000	47,000,000	110,000,000

World Resources: Identified world resources in deposits averaging 1% nickel or greater contain a total of 130 million tons of nickel. About 60% of the nickel is in laterites and 40% is in sulfide deposits. World resources of lower grade nickel deposits are very large. In addition, there are extensive deep-sea resources of nickel in manganese crusts and nodules covering large areas of the ocean floor, particularly in the Pacific Ocean.

Substitutes: With few exceptions, substitutes for nickel would result in increased cost or some tradeoff in the economy or performance of the product. Present and potential nickel substitutes include aluminum, coated steels, and plastics in the construction and transportation industries; nickel-free specialty steels in the power generating, petrochemical, and petroleum industries; and titanium and plastics in severe corrosive applications.

[e]Estimated.
[1]Imports for consumption as reported by the U.S. Bureau of the Census.
[2]Stocks of producers, agents, and dealers held only in the United States.
[3]Employment at port facility in Coos Bay, OR, used exclusively for drying and transshipping imported nickel ore.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.

NITROGEN (FIXED)—AMMONIA

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

Domestic Production and Use: U.S. ammonia producers operated at near 100% of capacity under prevailing conditions of supply-demand balance, firm prices for nitrogen compounds in all forms, and favorable profit margins. Sixty percent of total U.S. ammonia production capacity was concentrated in Louisiana, 40%; Oklahoma, 14%; and Texas, 6%; owing to large indigenous reserves of natural gas feedstock. Ammonia plants in the Midwest accounted for another 16% of capacity, with the remainder equally divided between the Southern, Southeastern, and Western States. Downstream nitrogen compound operating rates ranged from 90% to more than 100%. Urea producers operated at 91% of design capacity, compared with 93% in 1995.

Approximately 80% of U.S. apparent domestic ammonia consumption was for fertilizer use, including anhydrous ammonia for direct application, urea, ammonium nitrate, ammonium phosphates, and other nitrogen compounds. Ammonia was also used to produce plastics, synthetic fibers, and resins, 10%; explosives, 4%; and numerous other chemicals, 6%.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Production[2]	13,400	12,600	13,400	13,300	13,800
Imports for consumption	2,690	2,660	3,450	3,630	3,500
Exports	354	378	215	319	500
Consumption, apparent	15,600	15,100	16,500	15,600	16,900
Stocks, producer, yearend	1,060	852	956	963	900
Price, dollars per ton, average annual, f.o.b. gulf coast[3]	106	121	211	191	215
Employment, plant, number	2,500	2,500	2,500	2,500	2,500
Net import reliance[4] as a percent of apparent consumption	14	17	19	15	18

Recycling: None.

Import Sources (1992-95): Trinidad and Tobago, 35%; Canada, 32%; former Soviet Union, 20%; Mexico, 8%; and other, 5%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Ammonia, anhydrous	2814.10.0000	Free	Free.
Ammonia, aqueous	2814.20.0000	Free	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Prepared by **George A. Rabchevsky, (703) 648-7711 [Fax: (703) 648-7722].**

NITROGEN (FIXED)—AMMONIA

Events, Trends, and Issues: The U.S. fertilizer industry experienced one of its best years in history, bolstered by global supply-demand balance and solid export demand for domestic fertilizers and grain. Prices for most nitrogen commodities were at 20-year highs, operating costs were down, and profit margins up. Ammonium phosphate exports to China, India, and other ports of call continued at a high level. The favorable situation and projected outlook produced a new round of capacity expansion by the nitrogen fertilizer industry, including the construction of new capacity in the United States, Canada, and Trinidad and Tobago. Canadian producers also planned to reactivate several idle ammonia plants and to expand existing capacity.

U.S. ammonia import tonnage continued at record high levels, led by Trinidad and Tobago, the former Soviet Union, Canada, and Mexico, in order of importance.

Although domestic feedgrain acreage fell 10%, and foodgrains, 3%, from 1995 levels, overall crop acreage declined only 2% owing to a rebound in oilseeds and cotton. A wet spring hampered fertilizer application and lowered yields. The outlook for 1997 was optimistic, in light of prospects for improved domestic fertilizer demand and a continuation of firm market conditions for fertilizers and grains at the global level.

World Ammonia Production, Reserves, and Reserve Base:

	Plant production		Reserves and reserve base[6]
	1995	1996[e]	
United States	13,300	13,800	Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries.
Canada	3,500	3,600	
China	19,500	20,200	
Germany	2,100	2,200	
India	7,710	7,900	
Indonesia	2,850	3,000	
Japan	1,400	1,400	
Mexico	2,100	2,050	
Netherlands	2,500	2,550	
Russia	7,500	7,900	
Trinidad and Tobago	1,700	1,700	
Ukraine	2,200	2,200	
Other countries	25,240	25,300	
World total (may be rounded)	91,600	93,500	

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 demand.

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 Bulletins MA28B and MQ28B (DOC).
[3] Source: Green Markets Fertilizer Intelligence Weekly, a Pike and Fischer publication.
[4] Defined as imports - exports + adjustments for Government and industry stock changes.
[5] See Appendix B.
[6] See Appendix C for definitions.

PEAT

(Data in thousand metric tons, unless otherwise noted)[1]

Domestic Production and Use: The estimated f.o.b. plant value of marketable peat production in the contiguous United States was about $14 million in 1996. Alaskan peat output was valued at $450,000 by the State Department of Natural Resources, Division of Geological and Geophysical Surveys, in Fairbanks, AK. Large firms, operating bogs over a wide geographic area in the United States, reported relatively level production, along with a moderate increase in sales. Peat was harvested and processed by about 65 producers in 21 States. Reed-sedge peat accounted for about 70% of total U.S. peat production by volume, followed by sphagnum moss, 13%; humus, 12%; and hypnum moss, 6%. Geographically, about 85% of U.S. peat production was from the Great Lakes and Southeast Regions, led by Florida, Michigan, and Minnesota. The remainder was produced in the Midwest, Northeast, and West.

Approximately 95% of domestic peat was sold for horticulture/agriculture usage, including general soil improvement, potting soils, earthworm culture, nursery business, and golf course maintenance and construction, in order of importance. Other applications included seed inoculants, vegetable cultivation and mushroom culture, mixed fertilizers, and packing for flowers and plants. In the industrial sector, peat found widespread use as an oil absorbent, an efficient filtration medium for the removal of waterborne contaminants in mine waste streams, and municipial storm drainage. Peat also was used as an effective sterile absorbent in feminine hygiene products, and, to a lesser extent, as a fuel source.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	599	616	574	588	535
Commercial sales	652	612	552	660	667
Imports for consumption	639	648	669	669	740
Exports	22	8	23	23	18
Consumption, apparent[2]	1,230	1,290	1,240	1,100	1,260
Price, average value, f.o.b. mine, dollars per ton	25.68	27.54	27.22	25.80	25.34
Stocks, producer, yearend	308	269	252	384	380
Employment, mine and plant, number	650	650	650	800	1,000
Net import reliance[3] as a percent of apparent consumption	49	53	53	57	58

Recycling: None.

Import Sources (1992-95): Canada, 100%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Peat	2703.00.0000	Free	Free.

Depletion Allowance: 5% (Domestic).

Government Stockpile: None.

Prepared by **David Morse, (703) 648-4994 [Fax: (703) 648-7722].**

PEAT

Events, Trends, and Issues: Several operations were idled owing to permitting problems associated with increasingly stringent Federal regulations and the proliferation of subsidized composting programs. A major horticultural peat firm in the United States planned to close, given the existing climate of diminishing returns.

The Canadian sphagnum peat industry continued to capitalize on the environmentally restricted U.S. peat industry by shipping another record high volume. In 1996, Canadian peat shipments to the United States were proceeding at an annual rate of 735,000 tons, representing an increase of about 10% in volume and 5% in value. Thus, the aggressive marketing strategy adopted some years back by the Canadian industry resulted in an increase in the U.S. net import reliance from 53% to 58% between 1995 and 1996.

The public and private sectors introduced new peat products, including renewable sphagnum top moss used as a decorative accessory by the floral industry and encapsulated sphagnum moss beads that effectively captured heavy metals in industrial waste stream effluents. The outlook for horticulture during the remainder of the century is bright, according to U.S. Department of Agriculture market research studies. U.S. peat production will likely be governed principally by future wetlands environmental regulation, the ability to permit new bogs, competition from recycled natural organic materials, and Canadian competition.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	588	535	15,000	6,400,000
Belarus	10,315	10,000	([6])	([6])
Canada	1,010	1,050	22,000	300,000,000
Estonia	4,952	4,500	([6])	([6])
Finland	5,500	5,800	64,000	6,400,000
Germany	2,980	2,950	42,000	450,000
Ireland	6,850	6,500	160,000	820,000
Latvia	4,4021	4,200	([6])	([6])
Lithuania	4,714	4,500	([6])	([6])
Russia	63,000	60,000	([6])	([6])
Sweden	1,650	1,700	([6])	([6])
Ukraine	21,000	22,000	([6])	([6])
Other countries	1,020	1,000	4,900,000	150,000,000
World total (rounded)	128,000	125,000	5,200,000	460,000,000

World Resources: World resources of peat were estimated to be 1.9 trillion tons, of which the former Soviet Union has about 770 billion tons and Canada about 510 billion tons. Domestic deposits of peat occur in all 50 States, with estimated resources of about 310 billion tons or about 16% of the world total.

Substitutes: Natural organic materials may be composted and compete in certain applications. The superior water-holding capacity and physiochemical properties of peat limit substitution alternatives.

[e]Estimated.
[1]See Appendix A for conversion to short tons.
[2]Defined as production + imports - exports + adjustments for industry stocks.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.
[6]Included with "Other countries."

PERLITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: The estimated value (f.o.b. mine) of processed perlite produced in 1996 was $20.4 million. Crude ore production came from eight mines operated by six companies in four Western States. New Mexico continued to be the major producing State. Processed ore was expanded at 62 plants in 31 States. The principal end uses were building construction products, 69%; filter aid, 10%; horticultural aggregate, 10%; fillers, 9%; and other, 2%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[1]	541	569	644	700	701
Imports for consumption[e]	65	70	70	84	85
Exports[e]	29	26	30	40	40
Consumption, apparent	577	613	684	744	746
Price, average value, dollars per ton, f.o.b. mine	30.32	30.63	30.03	27.93	29.16
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill	115	115	125	125	125
Net import reliance[2] as a percent of apparent consumption	6	7	6	6	6

Recycling: Not available.

Import Sources (1992-95): Greece, 100%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Mineral substances, not specifically provided for	2530.10.0000	Free	Free.

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

Government Stockpile: None.

Prepared by **Wallace P. Bolen, (703) 648-7727 [Fax: (703) 648-7722].**

PERLITE

Events, Trends, and Issues: Processed ore production and apparent consumption increased for the fifth straight year. Supplies of domestic processed ore were tight in 1996 due to strong demand from expanders who were trying to fill a void left when a producer in California was temporarily shutdown. The shutdown occurred because of a landslide at the mining operation. The supply-demand situation is expected to stabilize when the site reopens in 1997.

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

Domestic perlite continued to encounter transportation cost disadvantages in some areas of the Eastern United States compared with Greek imports. However, Western U.S. perlite exports to Canada partially offset imports into the Eastern United States.

New uses of perlite were being researched, which may increase domestic consumption.

World Processed Perlite Production, Crude Ore Reserves, and Reserve Base:

	Production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	700	701	50,000	200,000
Greece	200	200	50,000	300,000
Japan	200	200	([5])	([5])
Turkey	165	175	([5])	([5])
Other countries	215	225	600,000	1,500,000
World total (may be rounded)	1,480	1,500	700,000	2,000,000

World Resources: Too little information is available in perlite-producing countries to estimate resources with any reliability.

Substitutes: Alternate materials can be substituted for all uses of perlite, if necessary. Long-established competitive commodities include diatomite, expanded clay and shale, pumice, slag, and vermiculite.

[e]Estimated. NA Not available.
[1]Processed perlite sold and used by producers.
[2]Defined as imports - exports + adjustments for Government and industry stock changes; changes in stocks not available and assumed to be zero for apparent consumption and net import reliance calculations.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]Included with "Other countries."

PHOSPHATE ROCK

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Phosphate rock ore was mined by 10 firms in 4 States, and upgraded into an estimated 42.5 million metric tons of marketable product valued at about $900 million f.o.b. mine. Florida and North Carolina accounted for about 87% of total domestic output, with the remainder produced in southeastern Idaho and northwestern Utah. Approximately 90% of U.S. phosphate rock demand was for conversion into wet-process phosphoric acid and superphosphoric acid, which are used principally as intermediates in the manufacture of granular and liquid ammonium phosphate fertilizers for domestic consumption and export. About 50% of U.S. wet-process phosphoric acid production was consumed for exports in the form of upgraded granular diammonium and monoammonium phosphate fertilizer materials, triple superphosphate fertilizer, and merchant grade phosphoric acid. Industrial applications accounted for about 6% of U.S. phosphate rock demand, while another 6% was directly exported, principally to countries in the Far East and Western Europe. Calcium phosphate animal feed supplements, essential to livestock nutrition, were derived from defluorinated phosphoric acid and defluorinated phosphate rock, while purified phosphoric acid was used in a variety of industrial applications. Phosphate rock was mined by three western firms as feedstock for high-purity, industrial-grade elemental phosphorus manufacture in wholly owned electric furnace facilities in Idaho and Montana.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[1]	47,000	35,500	41,100	43,500	42,500
Sold or used by producers	45,100	40,100	43,900	43,700	41,000
Imports for consumption	1,530	534	620	1,080	1,000
Exports	3,720	3,200	2,800	2,760	2,800
Consumption[2]	42,900	38,300	42,900	42,000	40,900
Price, average value, dollars per ton, f.o.b. mine[3]	22.53	21.38	21.14	21.75	20.50
Stocks, producer, yearend	12,600	9,220	5,980	5,710	5,500
Employment, mine and beneficiation plant, number	5,800	5,600	5,000	5,000	5,500
Net import reliance[4] as a percent of apparent consumption	E	4	5	E	E

Recycling: None. Limited to phosphate rock conversion products.

Import Sources (1992-95): Morocco, 99%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Natural calcium phosphates:			
Unground	2510.10.0000	Free	Free.
Ground	2510.20.0000	Free	Free.

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

Government Stockpile: None.

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PHOSPHATE ROCK

Events, Trends, and Issues: The U.S. phosphate industry continued to experience favorable economic trends in 1996, associated with a sustained period of supply-demand balance that commenced during 1995. Phosphate rock mines were operating at 90% of capacity and wet-process phosphoric acid and elemental phosphorus plants at near 100%. Ammonium phosphate plants operated at 95% of capacity to satisfy strong export demand. U.S. planted crop acreage and domestic fertilizer consumption are expected to increase significantly between 1996 and 1997 owing to below normal grain inventories at the domestic and global levels. Balanced phosphate supply-demand conditions at the global level were favored by a combination of restricted production and relatively low grain inventories.

Restructuring of the domestic phosphate industry continued into 1996, as evidenced by the consolidation of mines and plants in North Carolina and northern Florida by a major Canadian potash firm and by the consolidation of a new mining operation in central Florida by an existing U.S. phosphate producer. The new 3.5-million-ton-per-year mine at South Pasture in Hardee County, FL, began operations in the fall of 1995 and continued to supply phosphate rock to a wholly owned conversion facility at Plant City, FL.

World phosphate rock production increased slightly compared with output in 1995.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	43,500	42,500	1,200,000	4,440,000
Brazil	3,530	4,000	330,000	370,000
China	21,000	22,000	210,000	210,000
Israel	4,063	4,200	180,000	180,000
Jordan	4,984	5,000	90,000	570,000
Kazakstan	2,200	2,400	—	100,000
Morocco and Western Sahara	20,200	20,500	5,900,000	21,400,000
Russia	8,800	9,000	—	1,000,000
Senegal	1,600	1,650	—	160,000
South Africa	2,790	2,800	2,500,000	2,500,000
Togo	2,000	2,500	—	60,000
Tunisia	7,410	7,300	—	270,000
Other countries	9,092	9,000	1,000,000	2,500,000
World total (rounded)	131,000	133,000	11,000,000	34,000,000

World Resources: Phosphate rock resources occur principally as sedimentary marine phosphorites. Significant igneous occurrences are found in Russia and South Africa. Large phosphate resources have been identified on the continental shelves and on sea mounts in the Atlantic and Pacific Oceans.

Substitutes: There are no substitutes for phosphorus in agriculture.

[e]Estimated. E Net exporter.
[1]Marketable.
[2]Defined as sold or used + imports - exports.
[3]Marketable phosphate rock, weighted value, all grades, domestic and export.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.

PLATINUM-GROUP METALS

(Platinum, palladium, rhodium, ruthenium, iridium, osmium)
(Data in kilograms,[1] unless otherwise noted)

Domestic Production and Use: Ore containing the platinum-group metals (PGM) was mined, concentrated, and smelted in Montana, and the resultant PGM matte was exported to Belgium for refining and separation of the individual PGM. In addition, refined PGM were recovered as byproducts of copper refining by two companies in Texas and Utah. Secondary metal was refined by about 20 firms, mostly on the east and west coasts. PGM were sold by at least 90 processors and retailers, largely in the Northeast, and were used primarily by the following industries: automotive, electrical and electronic, chemical, and dental and medical. The automotive, chemical, and petroleum-refining industries used PGM mainly as catalysts. The other industries used PGM in a variety of ways that took advantage of their chemical inertness and refractory properties. Domestic mine production of platinum and palladium was valued at $45 million in 1996.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Mine production:[2] Platinum	1,650	2,050	1,960	1,590	1,600
Palladium	5,440	6,780	6,440	5,260	5,000
Imports for consumption: Refined					
Platinum	57,600	57,200	56,500	71,500	70,000
Palladium	61,100	78,900	92,500	124,000	110,000
Rhodium	7,750	7,210	7,820	9,600	10,000
Ruthenium	2,740	4,490	9,880	7,520	20,000
Iridium	207	896	926	1,450	2,000
Osmium	57	130	55	73	600
Exports: Refined					
Platinum	12,100	16,100	15,500	15,000	14,000
Palladium	17,700	26,200	29,900	26,000	24,000
Rhodium	834	767	791	741	300
Price, average daily, New York, dollars per troy ounce:					
Platinum	360.90	374.77	411.30	425.36	410.00
Palladium	89.07	122.97	156.20	153.35	135.00
Rhodium	2,465.24	1,137.36	636.00	463.30	330.00
Employment, mine, number	500	400	445	500	500

Recycling: An estimated 60 metric tons of PGM was recovered from new and old scrap in 1996.

Import Sources (1992-95): Platinum: South Africa, 61%; United Kingdom, 10%; Russia, 7%; Germany, 4%; and other, 18%. Palladium: Russia, 36%; South Africa, 25%; United Kingdom, 12%; Belgium, 11%; and other, 16%.

Tariff: All unwrought and semimanufactured PGM can be imported duty free.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Platinum	14,100	—	311	—
Palladium	39,300	—	467	—
Iridium	920	—	—	—

In addition to these quantities, the stockpile contains 406 kilograms of nonstockpile-grade platinum and 69 kilograms of nonstockpile-grade palladium.

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PLATINUM-GROUP METALS

Events, Trends, and Issues: Domestic mine production of platinum and palladium remained essentially unchanged from the previous year, despite lower average prices for both metals. Domestic PGM consumption increased slightly, owing in part to improved sales of new cars and trucks.

In 1996, the average platinum price decreased, reversing a 5-year trend of gradually rising averages. Through the first 9 months, the price ranged between $404 and $462 per troy ounce. Similarly, the average palladium price decreased. During the first 9 months of 1996, palladium prices ranged between $154 and $179. Analysts attributed the lower prices in part to increased Russian exports.

World Mine Production, Reserves, and Reserve Base:

	Mine production				PGM	
	Platinum		Palladium		Reserves[3]	Reserve base[3]
	1995	1996[e]	1995	1996[e]		
United States[2]	1,590	1,600	5,260	5,000	250,000	780,000
Canada	6,040	6,000	7,100	7,000	250,000	280,000
Russia	18,000	20,000	48,000	50,000	5,900,000	6,000,000
South Africa	118,000	120,000	49,400	50,000	50,000,000	59,000,000
Other countries	1,360	2,000	2,200	2,000	31,000	31,000
World total (rounded)	145,000	150,000	112,000	110,000	56,000,000	66,000,000

World Resources: World resources of PGM are estimated to be 100 million kilograms. U.S. resources are estimated to be 9 million kilograms.

Substitutes: Some automotive companies have substituted palladium for the higher priced platinum in catalytic converters. Although palladium is less resistant to poisoning by sulfur and lead than platinum, it may be useful in controlling emissions from diesel-powered vehicles.

[e]Estimated.
[1]Multiply by 32.1507 to convert from kilograms to troy ounces.
[2]Estimates from published sources.
[3]See Appendix C for definitions.

POTASH

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

Domestic Production and Use: In 1996, the value of production of marketable potash, f.o.b. mine was about $275 million, owing to declining sales and prices. Domestic potash was produced in four States: New Mexico, Utah, California, and Michigan. The majority of the production occurred in southwestern New Mexico, where four companies operated five mines at the beginning of the year. These five mines were conventional underground mines of bedded deposits, which have projected lifetimes that range from about 10 years to more than 100 years at present prices. New Mexico potash ore was beneficiated by flotation, heavy media separation, dissolution-recrystallization, and washing, and provided about 80% of the U.S. total producer sales. In Utah, one company brought underground potash to the surface by solution mining. The potash was recovered from the brine by solar evaporation to crystals and flotation. Another Utah company collected subsurface brines from an interior basin for solar evaporation to crystals and flotation. A third Utah company collected lake brines for solar evaporation to crystals, flotation, and dissolution-recrystallization. In California, one company recovered potash and coproducts borax pentahydrate, soda ash, and saltcake from subsurface brines from an interior basin using mechanical evaporation. At the end of the first quarter, the company ceased potash production. In Michigan, a company used solution mining and recovery by mechanical evaporation.

The fertilizer industry accounted for more than 85% of the U.S. potash sales, and the chemical industry accounted for close to 15%. About 70% of the potash was produced as potassium chloride (muriate of potash). Potassium sulfate (sulfate of potash) and potassium magnesium sulfate (sulfate of potash-magnesia), required by certain crops and soils, composed about 25% of potash production. Potash was transported by train, truck, and barges to warehouses, wholesalers, and retailers, with some potash being sold from barges used as temporary warehouses. Retailers sold potash and potash blended with other fertilizers in dry or liquid form for distribution.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, marketable	1,710	1,510	1,400	1,480	1,380
Imports for consumption	4,250	4,360	4,800	4,820	4,850
Exports	663	415	464	409	400
Consumption, apparent	5,350	5,430	5,810	5,810	5,840
Price, dollars per metric ton of K_2O, average, muriate, f.o.b. mine[1]	134	128	131	137	133
Stocks, producer, yearend	283	305	234	312	300
Employment (number): Mine	1,000	795	845	900	880
Employment (number): Mill	1,180	910	810	840	810
Net import reliance[2] as a percent of apparent consumption	68	72	76	75	76

Recycling: None.

Import Sources (1992-95): Canada, 92%; Belarus, 2%; Russia, 2%; Israel, 2%; Germany, 1%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Crude salts, sylvinite, etc.	3104.10.0000	Free	Free.
Potassium chloride	3104.20.0000	Free	Free.
Potassium sulfate	3104.30.0000	Free	Free.
Potassium nitrate	2834.21.0000	Free	Free.
Potassium-sodium nitrate mixtures	3105.90.0010	Free	Free.

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

Government Stockpile: None.

Events, Trends, and Issues: The world remained in overcapacity at about the same rate as that of 1995. The Canadian potash industry operated at about 75% capacity, which was about 45% for the largest producer and about 90% for all the others; the Former Soviet Union producers operated at about 60% capacity. While capacity remained about the same as last year, Belarus, Canadian, German, and Russian mines were temporarily closed during the summer to augment less-than-full-capacity production schedules to reduce producer potash stocks to normal levels.

A large integrated U.S. fertilizer producer, with potash mines located in Saskatchewan and New Mexico, merged with a U.S. muriate of potash producer, with brine wells located in Saskatchewan and Michigan. The owner of a Carlsbad,

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POTASH

NM, potash producer purchased two other Carlsbad potash mines and mills, and, at the end of the year, three companies operated five mines.

In June 1996, the U.S. Department of Justice, Antitrust Division, in Cleveland, OH, dropped its 3-year investigation of alleged antitrust actions (price fixing). In September 1996, the magistrate of the Federal District Court in St. Paul, MN, recommended a summary judgment against the plaintiffs to the judge of the civil antitrust suit. The magistrate concluded that the plaintiffs had failed to produce sufficient evidence of the alleged price fixing. The class action suit dated from the summer of 1993.

In 1996, potassium chloride prices declined slightly in the United States, while prices apparently stayed level around the world owing to reduced schedules and temporary mine closures. The U.S. spring weather was unusually wet in wheat and corn/soybean areas, occasionally reducing access to planting and fertilizer dispensing machinery, resulting in less fertilizer consumption for that period. Grain prices rose strongly while predictions of reduced worldwide grain stocks were headlined. Strong fall fertilizer application was due to good weather and expectations of next year's attempt at record crop production.

It is estimated that in 1997 domestic mine production will be 1.4 million tons and that the U.S. apparent consumption will be 6.0 million tons.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	1,480	1,380	73,000	250,000
Azerbaijan[e]	50	50	NA	NA
Belarus	2,790	2,600	800,000	1,000,000
Brazil	223	270	50,000	600,000
Canada	9,010	8,400	4,400,000	9,700,000
Chile	50	60	10,000	50,000
China	80	80	320,000	320,000
France	802	760	10,000	30,000
Germany	3,280	3,200	730,000	870,000
Israel	1,330	1,300	44,000	[5]590,000
Italy	—	—	20,000	40,000
Jordan	1,070	950	44,000	[5]590,000
Russia	2,814	2,700	1,800,000	[6]2,200,000
Spain	650	650	20,000	35,000
Thailand	—	—	30,000	100,000
Ukraine	55	50	25,000	30,000
United Kingdom	582	570	23,000	30,000
World total (may be rounded)	24,300	23,000	8,400,000	17,000,000

World Resources: Estimated domestic potash resources total about 6 billion tons. Most of this lies at depths between 6,000 and 10,000 feet in a 1,200-square-mile area of Montana and North Dakota as an extension of the Williston Basin deposits in Saskatchewan, Canada. The Paradox Basin in Utah contains approximately 2 billion tons, mostly at depths of more than 4,000 feet. An unknown, but apparently large, quantity of potash lies about 7,000 feet under central Michigan. The U.S. reserve figure includes a conservative estimate of 25 million tons of reserves in central Michigan. Estimated world resources total about 250 billion tons. The potash deposits in the former Soviet Union contain large amounts of carnallite; it is not clear if this can be mined in a free-market, competitive economy. Large resources, about 10 billion tons and mostly carnallite, occur in Thailand.

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

[e]Estimated. NA Not available.

[1]Average prices based on actual sales; excludes soluble and chemical muriates.

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

[3]See Appendix B.

[4]See Appendix C for definitions.

[5]Total reserve base in the Dead Sea is equally divided between Israel and Jordan.

[6]A reserve of 22,300,000 tons was reported by I. D. Sokolov in Basic Tasks of the Potash Industry up to the Year 2000, Zhurnal Vsesoyuznogo Khimicheskogo Obshchestva Im. D. I. Mendeleyeva, v. 32, No. 4, July-Aug. 1987, pp. 383-387.

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 1996 was $10.8 million. Domestic output came from 14 producers in 6 States. The principal producing States were New Mexico and Oregon, with combined production accounting for about 72% of the national total. The remaining production was from Arizona, California, Idaho, and Kansas. About 60% of the pumice was consumed for building blocks and the remainder was used in abrasives, concrete, laundries, and many other uses.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine[1]	481	469	490	529	465
Imports for consumption	257	143	143	238	200
Exports[e]	11	18	18	16	15
Consumption, apparent	727	594	615	751	650
Price, average value, dollars per ton, f.o.b. mine or mill	30.99	25.68	24.08	24.99	22.96
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number	50	50	50	60	60
Net import reliance[2] as a percent of apparent consumption	34	21	20	30	28

Recycling: Not available.

Import Sources (1992-95): Greece, 85%; Ecuador, 7%; Turkey, 6%; and other, 2%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Crude or in irregular pieces, including crushed pumice	2513.11.0000	Free	Free.
Other	2513.19.0000	0.2¢/kg	1.7¢/kg.

Depletion Allowance: 5% (Domestic), 5% (Foreign).

Government Stockpile: None.

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PUMICE AND PUMICITE

Events, Trends, and Issues: The apparent consumption of 650,000 tons in 1996 was 13% less than 1995's apparent consumption. The decrease in consumption was due to decreased demand for pumice, particularly in the southwestern United States. Secondarily, pumice sales and production were down due to litigation concerning pumice mining on public lands.

It is estimated that in 1997 domestic mine production of pumice and pumicite will be about 500,000 tons, with U.S. apparent consumption at approximately 700,000 tons. Imports, mainly from Greece, continue to maintain markets on the East Coast and Gulf Coast States of the United States.

Although pumice and pumicite were plentiful in the Western United States, changes in laws and public land designations could make many deposits decreasingly accessible to mining. Pumice and pumicite were sensitive to mining cost and should domestic production cost increase, it was expected that imports and competing materials might replace domestic pumice in many markets.

All domestic mining of pumice in 1996 was by open pit methods and generally occurred in relatively remote areas where land use conflicts were not severe. Although the generation and disposal of reject fines in mining and milling resulted in a dust problem at some operations, the environmental impact was restricted to a small geographical area.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States[1]	529	465	Large	Large
Chile	450	450	NA	NA
France	500	525	NA	NA
Germany	625	650	NA	NA
Greece	900	900	NA	NA
Italy	4,650	4,500	NA	NA
Spain	600	600	NA	NA
Turkey	1,200	1,200	NA	NA
Other countries	1,350	1,350	NA	NA
World total (rounded)	10,800	10,700	NA	NA

World Resources: The identified U.S. domestic resources of pumice and pumicite in the West are estimated to be at least 25 million tons. The estimated resources in the Western and Great Plains States are 250 million to 450 million tons.

Substitutes: Transportation cost determines the maximum distance that pumice and pumicite can be shipped and remain competitive with alternate materials. Competitive materials that can be substituted for pumice and pumicite for several end uses include expanded shale and clay, diatomite, and crushed aggregates.

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

QUARTZ CRYSTAL (INDUSTRIAL)

(Data in metric tons, unless otherswise noted)

Domestic Production and Use: Domestic production of cultured quartz crystal has been relatively stable for the past few years. Lascas[1] mining continued in Arkansas, and four U.S. firms produced cultured quartz crystal by using lascas as feed material. Electronic applications accounted for most industrial uses of quartz crystal; other uses included special optical applications. Virtually all quartz crystal used for electronics was cultured rather than natural crystal. Electronic-grade quartz crystal was essential for making filters, frequency controls, and timers in electronic circuits employed for a wide range of products, such as communications equipment, computers, and many consumer goods (e.g., television receivers and electronic games).

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine[2]	778	454	544	435	440
Plant, cultured (as grown)	407	394	294	360	370
Imports for consumption:					
Lascas	NA	NA	NA	NA	NA
Cultured	6	8	19	47	50
Exports:					
Lascas	—	—	—	90	90
Natural electronic	NA	NA	NA	NA	NA
Cultured (mostly lumbered)	15	24	38	35	40
Consumption, apparent:					
Natural electronic	([3])	([3])	([3])	([3])	([3])
Cultured	398	378	275	368	380
Price, average value, dollars per kilogram:					
Lascas	0.90	1.23	1.20	1.20	1.20
Cultured (lumbered)	105.67	251.69	300.00	300.00	300.00
Stocks, producer, yearend:					
Lascas (for cultured crystal only)	100	150	190	190	190
Natural electronic	([3])	([3])	([3])	([3])	([3])
Cultured	200	200	200	200	200
Employment, mine, processing plant[e], number	10	10	15	15	15
Net import reliance[4] as a percent of apparent consumption, lascas	NA	NA	NA	NA	NA

Recycling: None.

Import Sources (1992-95): This information is no longer available.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Sands:			
Other than natural	2506.10.0010	Free	Free.
Other	2506.10.0050	Free	Free.
Quartzite	2506.21.0000	Free	Free.

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QUARTZ CRYSTAL (INDUSTRIAL)

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Quartz crystal	214	120	214	—

Events, Trends, and Issues: Trends indicate that demand for quartz crystal devices should continue to grow, and consequently, quartz crystal production should remain strong well into the future. Growth of the consumer electronics market (e.g., personal computers, electronic games, and cellular telephones), particularly in the United States, will continue to promote domestic production. The growing global electronics market may require additional production capacity worldwide.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States[e 2]	435	440	Moderate	Moderate
Brazil	NA	NA	Large	Large
Other countries	NA	NA	NA	NA
World total	NA	NA	Large	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 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 eletronic circuits. Other materials, such as dipotassium tartrate, are usable only in specific applications as oscillators and filters.

[e]Estimated. NA Not available.
[1]Lascas is a nonelectronic-grade quartz used as a feedstock for growing cultured quartz crystal and for production of fused quartz.
[2]Lascas only; specimen and jewelry material excluded.
[3]Less than ½ unit.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.

RARE EARTHS[1]

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

Domestic Production and Use: Rare earths were mined by one company in 1996. Bastnasite, a rare-earth fluocarbonate mineral, was mined as a primary product by a firm in Mountain Pass, CA. The United States was a leading producer and processor of rare earths, and continued to be a major exporter and consumer of rare-earth products. Domestic ore production was valued at an estimated $64 million. Refined rare-earth products were produced primarily by three companies; one with a plant in Mountain Pass, CA; another with operations in Phoenix, AZ, and Freeport, TX; and a third with a plant in Chattanooga, TN. The estimated value of refined rare earths consumed in the United States was more than $500 million. The approximate distribution in 1995 by end use was as follows: automotive catalytic converters, 44%; petroleum refining catalysts, 25%; permanent magnets, 11%; glass polishing and ceramics, 9%; metallurgical additives and alloys, 8%; phosphors, 3%; and miscellaneous <1%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production:					
Bastnasite concentrates[2]	20,700	17,800	20,700	22,200	20,000
Monazite concentrates	W	W	W	—	—
Imports:[3]					
Thorium ore (monazite)	—	—	—	22	—
Rare-earth metals, alloys	352	235	284	905	442
Cerium compounds	806	1,270	1,890	4,091	4,723
Mixed REO's	295	249	354	678	918
Rare-earth chlorides	728	1,080	2,410	1,249	988
Rare-earth oxide, compounds	3,100	3,730	5,140	6,499	13,669
Ferrocerium, alloys	94	105	92	78	97
Exports:[3]					
Thorium ore, monazite	—	3	27	—	—
Rare-earth metals, alloys	44	194	329	444	272
Cerium compounds	1,930	1,620	4,460	5,117	5,913
Other rare-earth compounds	1,310	1,090	2,410	1,546	2,524
Ferrocerium, alloys	2,430	4,270	3,020	3,471	2,685
Consumption, apparent[4]	21,400	17,000	18,200	25,400	29,500
Price, dollars per kilogram, yearend:					
Bastnasite concentrate, REO basis	2.87	2.87	2.87	2.87	2.87
Monazite concentrate, REO basis	.41	.40	.46	.44	.47
Mischmetal, metal basis	12.68	12.68	12.68	9.50	9.50
Stocks, producer and processor, yearend	W	NA	NA	NA	NA
Employment, mine and mill, number	372	352	350	280	NA
Net import reliance[4] as a percent of apparent consumption	33	E	E	6	32

Recycling: Small quantities, mostly permanent magnet scrap.

Import Sources (1992-95): Monazite: Australia, 89%; and Malaysia 11%. Oxides, compounds, and metal: France, 48%; China, 35%; India, 11%; Japan, 4%; and other, 2%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Thorium ores and concentrates (monazite)	2612.20.0000	Free	Free.
Rare-earth metals, whether or not intermixed or interalloyed	2805.30.0000	5.0% ad val.	31.3% ad val.
Cerium compounds	2846.10.0000	6.5% ad val.	35% ad val.
Mixtures of REO's except cerium oxide	2846.90.2010	Free	25% ad val.
Mixtures of rare-earth chlorides, except cerium chloride	2846.90.2050	Free	25% ad val.
Rare-earth compounds, individual REO's (excludes cerium compounds)	2846.90.8000	3.7% ad val.	25% ad val.
Ferrocerium and other pyrophoric alloys	3606.90.3000	5.9% ad val.	56.7% ad val.

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RARE EARTHS

Depletion Allowance: Percentage method, monazite, 22% on thorium content and 14% on rare-earth content (Domestic), 14% (Foreign); bastnasite and xenotime, 14% (Domestic and Foreign).

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
REO in sodium sulfate	—	454	—	—

Events, Trends, and Issues: Domestic demand for rare earths in 1996 was higher than in 1995. Compared with 1995, the use of rare earths continued to increase as the domestic economy improved through the first two quarters of the year. In the third quarter the domestic economy slowed sharply, keeping interest rates stable and inflation on the decline. Imports were very strong going into the third quarter for individual rare-earth compounds, including cerium compounds. Rare-earth prices remained competitve throughout 1996, with firming of domestic prices for cerium and neodymium because of strong demand. Demand continued to grow for cerium used in automotive catalytic converters and for neodymium used in permanent magnet applications. China remained a major source of separated rare-earth compounds and alloys, and is expected to continue as a major world supplier.

The *21st Rare Earth Research Conference* was held in the United States in Duluth, MN, on July 7-11, 1996. The *Third International Conference on f Elements* is scheduled for September 14-19, 1997, in Paris, France.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e] 1995	Mine production[e] 1996	Reserves[6]	Reserve base[6]
United States	[7]22,200	[7]20,000	13,000,000	14,000,000
Australia	—	—	5,200,000	5,800,000
Brazil	400	400	280,000	310,000
Canada	—	—	940,000	1,000,000
China	[8]48,000	50,000	43,000,000	48,000,000
India	2,700	2,700	1,100,000	1,300,000
Malaysia	[8]448	400	30,000	35,000
South Africa	—	—	390,000	400,000
Sri Lanka	120	120	12,000	13,000
Thailand	—	—	1,000	1,100
Former Soviet Union	6,000	6,000	19,000,000	21,000,000
Zaire	11	10	1,000	1,000
Other countries	5	5	21,000,000	21,000,000
World total (rounded)	79,900	79,600	100,000,000	110,000,000

World Resources: Rare earths are relatively abundant in the Earth's crust, but discovered minable concentrations are less common than for most other ores. It is expected that substantial additional resources will be discovered as the industry completes its fourth decade of major industrial expansion. U.S. and world resources are contained primarily in bastnasite and monazite. Bastnasite deposits in China and the United States constitute the largest percentage of the world's rare-earth economic resources, while monazite deposits in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, and the United States constitute the second largest segment. Xenotime, rare-earth-bearing (ion adsorption) clays, loparite, phosphorites, apatite, eudyalite, secondary monazite, cheralite, and spent uranium solutions make up most of the remaining resources. Undiscovered resources of rare earths are thought to be very large relative to expected demand.

Substitutes: Substitutes are available for many applications, but generally are less effective.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Data includes lanthanides and yttrium, but excludes most scandium. See also Scandium and Yttrium.
[2]As reported in Unocal Corp. annual reports and as authorized from Molycorp, Inc., personnel. Data rounded to three significant digits.
[3]REO equivalent or contents of various materials were estimated. Data from U.S. Bureau of the Census. Data rounded to three significant digits.
[4]Monazite concentrate production was not included in the calculation of apparent domestic consumption and net import reliance. Data rounded to three significant digits. Net import reliance defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.
[7]Number reported in published reports or from company representatives.

RHENIUM

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

Domestic Production and Use: During 1996, ores containing rhenium were mined by nine operations. Rhenium compounds are included in molybdenum concentrates derived from porphyry copper deposits in the southwestern United States, and rhenium itself was recovered as a byproduct from roasting such molybdenum concentrates. Rhenium-containing products included ammonium perrhenate, perrhenic acid, and metal powder. The major uses of rhenium were in petroleum-reforming catalysts and in high-temperature superalloys used in jet engine components, representing about 30% and 60%, respectively, of the total demand. Rhenium was used in petroleum-reforming catalysts for the production of high-octane hydrocarbons, which are used in the production of lead-free gasoline. Bimetallic platinum-rhenium catalysts have replaced many of the monometallic catalysts. Rhenium is used in superalloys, improving the strength properties, at high temperatures (1,000° C), of nickel-based alloys. Some of the uses for rhenium alloys were in thermocouples, temperature controls, heating elements, ionization gauges, mass spectrographs, electron tubes and targets, electrical contacts, metallic coatings, vacuum tubes, crucibles, electromagnets, and semiconductors. The estimated value of rhenium consumed in 1996 was $15 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[1]	16,000	12,200	15,500	17,000	18,500
Imports for consumption	12,100	5,900	8,200	12,800	15,500
Exports			Negligible		
Consumption: Estimated	6,800	6,900	12,900	16,200	17,000
Apparent	W	W	W	W	W
Price, average value, dollars per kilogram:					
Metal powder, 99.99% pure	1,500	1,500	1,560	1,100	1,100
Ammonium perrhenate	1,100	1,100	1,100	700	700
Stocks, yearend, consumer, producer, dealer	W	W	W	W	W
Employment[2], number			Small		
Net import reliance[3] as a percent of apparent consumption	W	W	W	W	W

Recycling: Small amounts of molybdenum-rhenium and tungsten-rhenium scrap were processed during the past few years by several companies.

Import Sources (1992-95): Chile, 55%; Germany, 15%; Sweden, 15%; and other, 15%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Other inorganic acids, other—rhenium, etc.	2811.19.6050	4.2% ad val.	25% ad val.
Salts of peroxometallic acids, other—ammonium perrhenate	2841.90.2000	3.1% ad val.	25% ad val.
Rhenium, etc., (metals) waste and scrap	8112.91.0500	Free	Free.
Rhenium, (metals) unwrought; powders	8112.91.5000	3.4% ad val.	25% ad val.
Rhenium, etc., (metals) wrought; etc.	8112.99.0000	4.9% ad val.	45% ad val.

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

Government Stockpile: None.

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RHENIUM

Events, Trends, and Issues: During 1996, the rhenium metal price averaged $1,100 per kilogram for rhenium metal and $700 per kilogram for ammonium perrhenate. Imports of rhenium increased for 1996 compared with those of 1995. Chile, Germany, Japan, and Sweden supplied the majority of the rhenium imported. The United States relies on imports for much of its supply of rhenium.

It is estimated that in 1997 U.S. consumption of rhenium will be about 18,000 kilograms.

Owing to the scarcity and minor output of rhenium, its production and processing pose no known threat to the environment. In areas where it is recovered, pollution control equipment for sulfur dioxide also prevents most of the rhenium from escaping into the atmosphere.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves[5]	Reserve base[5]
	1995	1996		
United States	17,000	18,500	390,000	4,500,000
Armenia	100	100	95,000	120,000
Canada	3,000	1,500	32,000	1,500,000
Chile	4,000	4,000	1,300,000	2,500,000
Kazakstan	200	200	190,000	250,000
Peru	3,000	2,000	45,000	550,000
Russia	500	500	310,000	400,000
Uzbekistan	300	300	59,000	400,000
Other countries	100	100	91,000	360,000
World total (may be rounded)	28,200	27,200	2,500,000	11,000,000

World Resources: Most rhenium occurs with molybdenum in porphyry copper deposits. Identified U.S. resources are estimated to be about 5 million kilograms, and the identified resources of the rest of the world are approximately 6 million kilograms. In Kazakstan, rhenium also exists in sedimentary copper deposits.

Substitutes: Substitutes for rhenium in platinum-rhenium catalysts are being evaluated continually. Iridium and tin have achieved commercial success in one such application. Other metals being evaluated for catalytic use include gallium, germanium, indium, selenium, silicon, tungsten, and vanadium. The use of these and other metals in bimetallic catalysts may decrease rhenium's share of the catalyst market. Materials that can substitute for rhenium in various end uses are as follows: cobalt and tungsten for coatings on copper X-ray targets, rhodium and rhodium-iridium for high-temperature thermocouples, tungsten and platinum-ruthenium for coatings on electrical contacts, and tungsten and tantalum for electron emitters.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Calculated rhenium contained in MoS_2 concentrates. Recovered quantities are considerably less and are withheld.
[2]Less than 100 people.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.

RUBIDIUM

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

Domestic Production and Use: Although rubidium is not recovered from any domestically mined ores, it is thought that at least one domestic company manufactured rubidium products from imported lepidolite ore. Small quantities of rubidium, usually in the form of chemical compounds, were used mainly in research and development. Rubidium also was used in electronic and medical applications.

Salient Statistics—United States: Salient statistics, such as production, consumption, imports, and exports, are not available.

The rubidium market is very small. There is no active trading of the metal and, therefore, no market price. However, several companies publish prices for rubidium and rubidium compounds. These prices are relatively stable for several years. The per-unit price for the metal or compounds purchased from these companies varies inversely with the quantity of material purchased. For example, in 1996, one company offered 1-gram ampoules of 99.8%-grade rubidium metal at $42.40. The price for 100 grams of the same material from this company was $571.00 or $5.71 per gram. At another company, the price for a 1-gram ampoule of 99.6% pure rubidium was $32.75.

Recycling: None.

Import Sources (1992-95): The United States is 100% import reliant. Although there is no information on the countries shipping rubidium-bearing material to the United States, Canada is thought to be the major source of this raw material.

Tariff:

Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[1] 12/31/96
Alkali metals, other	2805.19.0000	6.2% ad val.	25% ad val.

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

Government Stockpile: None.

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RUBIDIUM

Events, Trends, and Issues: Rubidium and its compounds were largely the subject of laboratory study, and were of little commercial significance. No major breakthroughs or developments were anticipated that would change the production or consumption patterns. Domestic rubidium production is entirely dependent on imported lepidolite ores. Because of the small scale of production of rubidium products, no significant environmental problems have been encountered.

World Mine Production, Reserves, and Reserve Base: Data on mine production of rubidium are not available. Reserves and the reserve base[2] for rubidium in North America were estimated at 2 million and 2.3 million kilograms, respectively.

World Resources: Rubidium forms no known minerals in which it is the predominant metallic constituent. It occurs chiefly as a replacement for potassium, especially in minerals formed late in the crystallization of pegmatites. Meaningful estimates of world rubidium resources have not been made, but lepidolite, a potassium lithium mica, may contain up to 1.35% rubidium, and pollucite, a cesium silicate, may contain up to 3.15% rubidium.

Substitutes: The properties of cesium and its compounds are so similar to those of rubidium and its compounds that compounds of rubidium and cesium are used interchangeably in many applications.

[1]See Appendix B.
[2]See Appendix C for definitions.

RUTILE[1]

(Data in thousand metric tons of contained TiO_2, unless otherwise noted)

Domestic Production and Use: Rutile was produced at one mine in Florida. At two other mines in Florida, rutile was included in a bulk concentrate containing mostly ilmenite and leucoxene. The major coproduct of these mines is zircon. Synthetic rutile was produced at one plant in Alabama. The value of U.S. rutile consumption in 1996, including synthetic rutile, was about $290 million. Two firms, with facilities in Nevada and Oregon, used titanium tetrachloride primarily made from rutile to manufacture titanium. Of 16 consuming firms, mainly in the Eastern United States, 5 companies used 95% of the rutile consumed to produce titanium dioxide (TiO_2) pigment. Welding-rod coatings and miscellaneous applications, which include fiberglass and titanium metal, consumed 5%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	W	W	W	W	W
Imports for consumption[2]	299	349	311	295	353
Exports[e]	7	3	4	6	3
Shipments from Government stockpile excesses	—	1	18	17	—
Consumption: Reported[2]	438	436	478	439	440
Consumption: Apparent	W	W	W	W	W
Price, dollars per ton of rutile, yearend: Bulk, f.o.b. Australian ports	405	378	420	600	650
Stocks, mine, distributor and consumer, yearend	140	179	141	52	100
Employment, mine and mill[3], number	400	395	400	400	400
Net import reliance[4] as a percent of apparent consumption	W	W	W	W	W

Recycling: None.

Import Sources (1992-95): Australia, 56%; South Africa, 28%; Sierra Leone, 14%; and other, 2%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Rutile concentrate	2614.00.6040	Free	Free.
Synthetic rutile	2614.00.3000	Free	30% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Stockpile-grade rutile (gross weight)	0.01	2.07	—	—

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RUTILE

Events, Trends, and Issues: In 1996, imports of rutile concentrates were estimated to have increased 20% compared with 1995. However, imports of natural rutile decreased slightly while imports of synthetic rutile increased 49%. A global shortage of natural rutile resulted in increased prices for natural and synthetic rutile concentrtates.

Exploration and development of titanium mineral deposits continued in 1996. These activities were most evident in Africa, Australia, Canada, India, Indonesia, Mozambique, Russia, Ukraine, the United States, and Vietnam. Producers continued efforts to develop higher grade concentrates. In Australia, a synthetic producer initiated a project to produce an upgraded product lower in uranium and thorium content. Sierra Leone's loss as a major source of natural rutile continued to affect the global market.

Fewer environmental pollution problems are encountered when pigment is produced from rutile rather than ilmenite. The chloride process, using a rutile feed, generates about 0.2 ton of waste per ton of TiO_2 product; the sulfate process, using ilmenite, generates about 3.5 tons of waste per ton of product. Producing synthetic rutile from ilmenite results in about 0.7 ton of waste, mainly iron oxide, per ton of product. Direct chlorination of ilmenite generates about 1.2 tons of waste, mainly ferric chloride, per ton of TiO_2.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	W	W	500	1,800
Australia	190	190	4,300	43,000
Brazil	2	2	40	85,000
India	13	15	6,600	7,700
Italy	—	—	—	8,800
Sierra Leone	—	—	3,100	3,100
South Africa	84	90	8,300	8,300
Sri Lanka	2	2	4,800	4,800
Ukraine	3	3	2,500	2,500
World total (may be rounded)	[7]294	[7]302	30,000	170,000

World Resources: Identified world resources of rutile (including anatase) total about 230 million tons of contained TiO_2. Major rutile resources occur in Australia, India, Italy, Sierra Leone, South Africa, and the United States.

Substitutes: Ilmenite, titaniferous slag, and synthetic rutile made from ilmenite may be used instead of natural rutile for making pigment, metal, and welding-rod coatings.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]See also Ilmenite and Titanium and Titanium Dioxide.
[2]Includes synthetic rutile.
[3]Employment at three sand deposit operations in Florida, which produced either rutile concentrate or a titanium mineral concentrate, where ilmenite and zircon were major coproducts and where employees were not assigned to specific commodities.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.
[7]Excludes U.S. production.

SALT

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Domestic production of salt decreased an estimated 5% in 1996, with total value exceeding an estimated $930 million. Twenty-seven companies operated 67 plants in 14 States. The estimated percentage of salt sold or used, by type, was salt in brine, 50%; rock salt, 32%; vacuum pan, 10%; and solar salt, 8%.

The chemical industry consumed about 45% of total salt sales, with salt brine representing about 89% of the type of salt used for feedstock. Chlorine and caustic soda manufacture was the main consuming sector within the chemical industry. Salt for highway deicing accounted for 28% of U.S. demand. The remaining markets for salt, in declining order, were distributors, 9%; food and agricultural, 7%; general industrial, 8%; primary water treatment, 1%; and other, 2%.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Production	36,000	39,200	40,100	42,100	40,100
Sold or used by producers	34,800	38,200	39,700	40,800	40,100
Imports for consumption	5,390	5,870	9,630	7,090	9,500
Exports	992	688	742	670	950
Consumption: Reported	39,700	44,400	47,200	46,500	48,700
Apparent	39,200	43,400	48,600	47,200	48,700
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant:					
Vacuum and open pan salt	113.20	111.97	115.35	118.63	111.00
Solar salt	32.56	34.51	34.77	30.82	26.00
Rock salt	19.63	20.28	22.33	21.80	21.00
Salt from brine	4.35	5.24	5.40	6.91	7.00
Stocks, producer, yearend[e 2]	1,230	1,000	400	1,300	—
Employment, mine and plant, number	4,150	4,150	4,150	4,150	4,150
Net import reliance[3] as a percent of apparent consumption	11	12	18	14	18

Recycling: None.

Import Sources (1992-95): Canada, 44%; Mexico, 23%; The Bahamas, 12%; Chile, 11%; and other, 10%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Iodized salt	2501.00.0000	Free	26% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: In April, a major domestic salt company decided not to construct a new mine at Hampton Corners, NY, which would replace the rock salt mine that closed because of flooding in 1995. The company decided that the proposed mine did not meet certain financial criteria. In August, the same company announced it planned to sell all of its salt assets in North America and the Caribbean to another U.S. salt company, pending approval by the U.S. Department of Justice. The acquisition would include rock salt mines in Ohio and Louisiana; vacuum pan operations in Michigan, New York, and Ohio, and solar salt plants in Utah and on Bonaire in the Netherlands Antilles.

A Texas-based salt company announced it planned to construct a vacuum pan salt facility in Tioga, PA, in conjuction with a solution mining project that would develop caverns for hydrocarbon storage. The brine from solution mining of underground halite beds would be the feedstock for the salt plant that would have an annual capacity of 450,000 tons, which would be the largest vacuum pan plant in the United States.

Prepared by Dennis S. Kostick, (703) 648-7715 [Fax: (703) 648-7722].

SALT

A major U.S. salt company announced plans to increase production capacity at its Goderich, Ontario, Canada, rock salt mine from 4.1 million tons to 5.9 million tons. The project was estimated to cost $12 million, and was scheduled to be on-stream by early 1997.

The outlook for the domestic salt industry is favorable for the next few years depending on the severity of this winter's weather. Many weather forecasters were forecasting below-normal temperatures that increases the likelihood of adverse conditions that would require large quantities of deicing salt.

World Production, Reserves, and Reserve Base:

	Production		Reserves and reserve base[5]
	1995	1996[e]	
United States[1]	42,100	40,200	Large. Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans comprise an inexhaustible supply of salt.
Australia	8,480	8,500	
Brazil	6,100	5,500	
Canada	10,900	11,000	
China	25,000	27,000	
France	7,350	7,300	
Germany	10,800	11,000	
India	9,500	9,500	
Italy	3,400	3,500	
Mexico	7,670	7,600	
Poland	4,000	4,000	
Russia	2,000	2,000	
Spain	3,400	3,500	
Ukraine	3,000	3,000	
United Kingdom	7,100	7,200	
Other countries	38,200	39,200	
World total (may be rounded)	189,000	190,000	

World Resources: World resources of salt are practically unlimited. Domestic resources of rock salt and salt from brine are in the Northeast, Central Western, and southern Gulf Coast States. Saline lakes and solar evaporation salt facilities are near populated regions in the Western United States. Almost every country in the world has salt deposits or solar evaporation operations of various sizes.

Substitutes: There are no economic substitutes or alternates for salt. Calcium chloride and calcium magnesium acetate, hydrochloric acid, and potassium chloride can be substituted for salt in deicing, certain chemical processes, and food flavoring, but at a higher cost.

[e]Estimated.
[1]Excludes Puerto Rico.
[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 producted and salt sold or used.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.

SAND AND GRAVEL (CONSTRUCTION)[1]

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

Domestic Production and Use: Construction sand and gravel valued at $4.3 billion was produced by 4,010 companies from 5,741 operations in 50 States. Leading States, in order of volume, were California, Texas, Michigan, Ohio, Arizona, Washington, Illinois, Colorado, Wisconsin, and Minnesota, which together accounted for about 52% of the total output. It is estimated that about 41% of the 963 million metric tons of construction sand and gravel produced in 1996 was for unspecified uses. Of the remaining total, about 42% was used as concrete aggregates; 25% for road base and coverings and road stabilization; 13% as asphaltic concrete aggregates and other bituminous mixtures; 13% as construction fill; 2% for concrete products such as blocks, bricks, pipes, etc.; 2% for plaster and gunite sands; and the remainder for snow and ice control, railroad ballast, roofing granules, filtration, and other miscellaneous uses.

The estimated output of construction sand and gravel in the 48 conterminous States shipped for consumption in the first 9 months of 1996 was about 661 million tons, which represents an increase of 2.6% compared with the same period of 1994. Additional production information by quarter for each State, geographic region, and the United States is published in the Quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	834	[e]869	891	910	963
Imports for consumption	1	1	1	1	1
Exports	1	1	1	1	1
Consumption, apparent	834	869	891	910	963
Price, average value, dollars per ton	4.01	4.06	4.20	4.29	4.43
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill[e], number	41,600	42,000	42,500	42,500	42,500
Net import reliance[3] as a percent of apparent consumption	—	—	—	—	—

Recycling: Asphalt road surfaces and cement concrete surfaces and structures were recycled on a limited, but increasing, basis.

Import Sources (1992-95): Canada, 72%; Bahamas, 16%; Mexico, 3%; and other, 9%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Sand, construction	2505.90.0000	Free	Free.
Gravel, construction	2517.10.0000	Free	30% ad val.

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

Government Stockpile: None.

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SAND AND GRAVEL (CONSTRUCTION)

Events, Trends, and Issues: Construction sand and gravel output increased 5.8% in 1996. It is estimated that 1997 domestic production and U.S. apparent consumption will be about 975 million tons each, a 1.2% increase.

The construction sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions. Shortages in urban and industrialized areas were expected to continue to increase because of local zoning regulations and land development. For these reasons, movement of sand and gravel operations away from highly populated centers is expected to continue.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	1995	1996[e]	
United States	910	963	The reserves and reserve base are controlled largely by land use and/or environmental constraints. Local shortages of sand or gravel are common.
Other countries	NA	NA	
World total	NA	NA	

World Resources: Sand and gravel resources of the world are large. However, due to their geographic distribution, environmental restrictions, and quality requirements for some uses, their extraction is sometimes uneconomic. The most important commercial sources of sand and gravel have been river flood plains, river channels, and glacial deposits. Marine deposits are being used presently in the United States, mostly for beach erosion control, and as a source of construction aggregates in other countries.

Substitutes: Crushed stone remains the predominant alternative for construction aggregate use.

[e]Estimated. NA Not available.
[1]See also Sand and Gravel (Industrial).
[2]See Appendix A for conversion to short tons.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.

SAND AND GRAVEL (INDUSTRIAL)

(Data in thousand metric tons, unless otherwise noted)[1]

Domestic Production and Use: Industrial sand and gravel valued at about $502 million was produced by 79 companies from 144 operations in 35 States. Leading States, in order of volume, were Illinois, Michigan, New Jersey, California, and Wisconsin. Combined production from these States represented 43% of the national total. About 38% of the national tonnage was used as glassmaking sand, 24% as foundry sand, 6% as abrasive sand, 6% as hydraulic fracturing sand, and the remainder for many other uses.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	25,200	26,200	27,300	28,200	28,600
Imports for consumption	164	44	24	65	90
Exports	1,340	1,750	1,880	1,870	2,000
Consumption, apparent	24,000	24,500	25,400	26,400	26,700
Price, average value, dollars per ton	17.24	17.33	17.86	17.82	17.56
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill[e], number	1,500	1,500	1,500	1,450	1,450
Net import reliance[2] as a percent 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 amount of reused silica.

Import Sources (1992-95): Australia, 52%; Belgium, 43%; Guyana, 3%; and other, 2%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
95% or more silica and not more than 0.6% iron oxide	2505.10.1000	Free	$1.97/t.

Depletion Allowance: Industrial sand or pebbles, 14% (Domestic and Foreign).

Government Stockpile: None.

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SAND AND GRAVEL (INDUSTRIAL)

Events, Trends, and Issues: The United States was the world's largest producer and consumer of industrial sand and gravel based on estimated world production figures. However, it was difficult to collect definitive numbers on silica sand and gravel production in most nations because of the wide range of terminologies and specifications for silica from country to country. Attempts to improve the accuracy of data on world industrial sand and gravel production are ongoing, and revisions should be expected.

The United States remained a major exporter of silica sand, shipping sand to almost every region of the world. This was attributed to the high quality and advanced processing techniques of a large variety of grades of silica, meeting virtually every specification for silica sand and gravel. Imports of silica are generally of two types: small-quantity shipments of very high purity silica or a few large shipments of lower grade silica that is shipped only when special circumstances were achieved (i.e., very favorable freight rates).

Industrial sand and gravel sold or used increased about 1.5% in 1996 compared with 1995. It is estimated that 1997 domestic production and U.S. apparent consumption will be about 29 million tons and 27 million tons, respectively.

The industrial sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions in 1996. Local shortages were expected to continue to increase owing to local zoning regulations and land development alternatives. This is expected to continue to cause a movement of sand and gravel operations away from high-population centers.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves and reserve base[4]
	1995	1996	
United States	28,200	28,600	
Australia	2,500	2,500	Large. Silica is abundant in the Earth's crust. The reserves and reserve base are controlled by the location of population centers.
Austria	7,500	7,750	
Belgium	2,500	2,500	
Brazil	2,700	2,700	
Canada	1,650	1,700	
France	7,000	6,750	
Germany	10,000	10,300	
India	1,300	1,400	
Italy	4,000	4,000	
Japan	3,740	3,700	
Mexico	1,290	1,320	
Netherlands	23,000	22,000	
Paraguay	1,500	1,500	
South Africa	2,180	2,300	
Spain	2,000	2,000	
Sweden	1,500	1,500	
United Kingdom	3,600	3,700	
Other countries	13,800	14,000	
World total (rounded)	120,000	120,000	

World Resources: Sand and gravel resources of the world are sizable. However, because of their geographic distribution, environmental restrictions, and quality requirements for some uses, extraction of these resources is sometimes uneconomic. Quartz-rich sand and sandstones, the main source of industrial silica sand, occur throughout the world.

Substitutes: Silica sand continues to be the major material used for glassmaking and for foundry and molding sands; alternates are zircon, olivine, staurolite, and chromite sands.

[e]Estimated. E Net exporter. NA Not available.
[1]See Appendix A for conversion to short tons.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.

SCANDIUM

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

Domestic Production and Use: Demand for scandium increased in 1996. Although scandium was not mined domestically in 1996, quantities sufficient to meet demand were available from domestic concentrates and tailings. Principal domestic sources of scandium were tailings previously generated by mining fluorite at Crystal Mountain, MT, and tailings previously produced from tantalum processing in Muskogee, OK. Companies that processed scandium ores, concentrates, and low-purity compounds to produce refined scandium products were in Mead, CO; Urbana, IL; and Newport, TN . Capacity to produce ingot and distilled scandium metal was located in Phoenix, AZ; Urbana, IL; and Ames, IA. Scandium used in the United States was derived from both domestic and foreign sources. Principal uses for scandium in 1996 were metallurgical research, high-intensity metal halide lamps, analytical standards, electronics, and laser research.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery	W	W	W	W	W
Imports for consumption	NA	NA	NA	NA	NA
Exports	NA	NA	NA	NA	NA
Consumption	W	W	W	W	W
Price, yearend, dollars:					
Per kilogram, oxide, 99.0% purity	1,500	1,600	1,600	1,500	1,400
Per kilogram, oxide, 99.9% purity	3,000	3,300	3,300	3,300	2,900
Per kilogram, oxide, 99.99% purity	5,000	5,200	5,200	5,100	4,400
Per kilogram, oxide, 99.999% purity	10,000	9,000	9,000	7,650	6,750
Per gram, powder, metal[1]	372.00	372.00	372.00	372.00	372.00
Per gram, sublimed, metal[2]	312.00	312.00	169.00	169.00	169.00
Per gram, scandium bromide, 99.99% purity[3]	NA	80.00	80.00	80.00	80.00
Per gram, scandium chloride, 99.9% purity[3]	NA	62.00	37.00	37.00	37.00
Per gram, scandium fluoride, 99.9% purity[3]	NA	129.00	77.00	77.00	77.00
Per gram, scandium iodide, 99.999% purity[3]	NA	78.00	78.00	78.00	78.00
Stocks	NA	NA	NA	NA	NA
Employment, processors, number	12	12	12	8	5
Net import reliance[4] as a percent of apparent consumption	NA	NA	NA	NA	NA

Recycling: Minor, recovered from laser crystal rods.

Import Sources (1992-95): Not available.

Tariff: Item	Number	Most-favored-nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Mineral substances not elsewhere specified or included: Including scandium ores	2530.90.0000	Free	Free.
Rare-earth metals, scandium and yttrium, whether or not intermixed or inter-alloyed including scandium	2805.30.0000	5.0% ad val.	31.3% ad val.
Mixtures of rare-earth oxides except cerium oxide, including scandium oxide mixtures	2846.90.2010	Free	25% ad val.
Rare-earth compounds, including individual rare-earth oxides, hydroxides, nitrates, and other individual compounds, including scandium oxide	2846.90.8000	3.7% ad val.	25% ad val.
Aluminum alloys, other: Including scandium-aluminum	7601.20.9090	Free	10.5% ad val.

Depletion Allowance: Percentage method, 14% (Domestic), 14% (Foreign).

Government Stockpile: None.

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SCANDIUM

Events, Trends, and Issues: Nominal prices for domestically produced scandium compounds were lower for the fourth consecutive year. The supply of domestic and foreign scandium remained strong despite increased demand. Although demand increased in 1996, the total market remained very small. Domestic increases in demand were almost exclusively the result of acquisitions for metallurgical research.

Scandium's use continued to increase in metal halide lighting. Scandium additions, as the metal or the iodide, mixed with other elements, were added to halide light bulbs to adjust the color to appear like natural sunlight. Demand also continued to increase for scandium-aluminum alloys. Future development is expected to occur in alloys for aerospace and specialty markets, including sports equipment. Market activity increased in 1996, primarily to meet demand for alloying. Scandium's availability from the former Soviet Union (former U.S.S.R.) increased substantially back in 1992, after export controls were relaxed, and sales to the Western World have been increasing. China also continued to supply a small quantity of goods to the U.S. market.

The price of scandium materials varies greatly based on purity and quantity. The weight-to-price ratio of scandium metals and compounds was generally much higher for gram quantities than for kilogram purchases. Kilogram prices for scandium metal ingot were typically double the cost of the starting scandium compound, while higher purity distilled or sublimed metal ranged from four to six times the cost of the starting material.

World Mine Production, Reserves, and Reserve Base: Scandium was produced as a byproduct material in China, Kazakstan, and Russia. Foreign mine production data were not available. No scandium was mined in the United States in 1996. Scandium occurs in many ores in trace amounts but has not been found in sufficient quantities to be considered a reserve or reserve base.[6] As a result of its low concentration, scandium has been produced exclusively as a byproduct during processing of various ores or recovered from previously processed tailings or residues.

World Resources: Resources of scandium are abundant, especially when considered in relation to actual and potential demand. Scandium is rarely concentrated in nature due to its lack of affinity to combine with the common ore forming anions. It is widely dispersed in the lithosphere and forms solid solutions in over a 100 minerals. In the Earth's crust, scandium is primarily a trace constituent of ferromagnesium minerals. Concentrations in these minerals (amphibole-hornblende, pyroxene, and biotite) typically range from 5 to 100 parts per million equivalent Sc_2O_3. Ferromagnesium minerals commonly occur in the igneous rocks, basalt, and gabbro. Enrichment of scandium also occurs in rare-earth minerals, wolframite, columbite, cassiterite, beryl, garnet, muscovite, and the aluminum phosphate minerals. Recent domestic production has primarily been from the scandium-yttrium silicate mineral, thortveitite, and from byproduct leach solutions from uranium operations. Future production is expected from tantalum residues. One of the principal domestic scandium resources is the fluorite tailings from the Crystal Mountain deposit near Darby, MT. Tailings from the mined-out fluorite operations, which were generated from 1952 to 1971, contain the scandium mineral, thortveitite, and other associated scandium-enriched minerals. Resources are also contained in the tantalum residues previously processed at Muskogee, OK. Smaller resources are contained in tungsten, molybdenum, and titanium minerals from the Climax molybdenum deposit in Colorado, and in kolbeckite (sterrettite), varisite, and crandallite at Fairfield, UT. Other lower grade domestic resources are present in ores of aluminum, iron, molybdenum, nickel, phosphate, tantalum, tin, titanium, tungsten, zinc, and zirconium. Process residues from tungsten operations in the United States also contain significant amounts of scandium.

Foreign resources are known in China, Kazakstan, Madagascar, Norway, and Russia. China's resources are in tin, tungsten, and iron deposits in Jiangxi, Guangxi, Guangdong, Fujian, and Zhejian Provinces. Resources in Russia and Kazakstan are in the Kola Peninsula apatites and in uranium-bearing deposits, respectively. Scandium in Madagascar is contained in pegmatites in the Befanomo area. Resources in Norway are dispersed in the thortveitite-rich pegmatites of the Iveland-Evje Region and a deposit in the northern area of Finnmark. An occurrence of the mineral thortveitite is reported for Kobe, Japan. Undiscovered scandium resources are thought to be very large.

Compared to the Earth, significantly higher scandium concentrations have been measured in extraterrestrial rocks. Crystalline rocks from the Earth's moon are higher in scandium by a factor of three.

Substitutes: In scandium's few applications, such as lighting and lasers, it is generally not subject to substitution.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Less than 250 micron, 99.9% purity, 1990 through 1995 prices converted from 0.5 gram price, from Alfa Aesar.
[2]Lump, sublimed dendritic 99.99% purity, from Alfa Aesar.
[3]Bromide, chloride, and fluoride in crystalline or crystalline aggregate form and scandium iodide as powder from Alfa Aesar.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.

SELENIUM

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

Domestic Production and Use: Primary selenium was recovered from anode slimes generated in the electrolytic refining of copper. Three copper refineries, one in Utah and two in Texas, accounted for domestic production of primary selenium. The value of production was $3 million. Anode slimes from other primary electrolytic refiners were exported for processing. The estimated consumption of selenium by end use was as follows: electronics, 25%; glass manufacturing, 25%; chemicals and pigments, 20%; and other, including agriculture and metallurgy, 20%. In electronics, high-purity selenium was used primarily as a photoreceptor on the drums of plain paper copiers. In glass manufacturing, selenium was used as a decolorant in container glass and other soda-lime silica glasses and to reduce solar heat transmission in architectural plate glass. Cadmium sulfoselenide red pigments, which have good heat stability, were used in ceramics and plastics. Chemical uses included rubber compounding chemicals, gun bluing, catalysts, human dietary supplements, and antidandruff shampoos. Dietary supplements for livestock were the largest agricultural use. Selenium was added to copper, lead, and steel alloys to improve their machinability and to replace lead in brasses for plumbing applications.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery	243	283	360	373	350
Imports for consumption, metal and dioxide	371	382	411	324	350
Exports, metal, waste and scrap	175	261	246	269	270
Consumption, apparent[1]	490	460	530	517	520
Price, dealers, average, dollars per pound, 100-pound lots, refined	5.13	4.90	4.90	4.89	3.20
Stocks, producer, refined, yearend	W	W	W	W	W
Employment, number	NA	NA	NA	NA	NA
Net import reliance[2] as a percent of apparent consumption	48	39	31	38	38

Recycling: There was no domestic production of secondary selenium. Scrap xerographic materials were exported for recovery of the contained selenium. An estimated 90 tons of selenium metal recovered from scrap was imported in 1996.

Import Sources (1992-95): Canada, 43%; Philippines, 22%; Japan, 12%; Belgium, 11%; and other, 12%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Selenium metal	2804.90.0000	Free	Free.
Selenium dioxide	2811.29.2000	Free	Free.

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

Government Stockpile: None.

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SELENIUM

Events, Trends, and Issues: Domestic and world selenium demand was about the same in 1996 as it was in 1995. World selenium production remained at about the 1995 level, so the oversupply situation was not eased. The use of selenium in glass, chemicals, and agriculture remained strong.

Selenium is a candidate as an additive to no-lead, free-machining brass for plumbing applications. Ordinary free-machining brass contains up to 7% lead. Industry consortia have tested several lead-free brasses that could be used as substitutes as more stringent regulations on lead in drinking water take effect. Bismuth is the main replacement additive; however, its supply is limited and selenium reduces the quantity of bismuth needed, without decreasing alloy properties.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States	373	350	10,000	19,000
Belgium	250	250	—	—
Canada	553	550	7,000	15,000
Chile	46	45	19,000	30,000
Finland	30	30	—	—
Germany	115	115	—	—
Japan	551	550	—	—
Peru	14	14	2,000	5,000
Philippines	40	40	2,000	3,000
Serbia and Montenegro	30	30	1,000	1,000
Sweden	30	30	—	—
Zambia	25	25	3,000	6,000
Other countries	17	17	27,000	55,000
World total (rounded)	[5]2,070	[5]2,050	70,000	130,000

World Resources: In addition to the reserve base of selenium, which is contained in identified economic copper deposits, 2.5 times this quantity of selenium was estimated to exist in copper or other metal deposits that were undeveloped, of uneconomic grade, or as yet undiscovered. Coal contains an average of 1.5 parts per million of selenium, which is about 80 times the average for copper deposits, but recovery of selenium from coal appears unlikely in the foreseeable future.

Substitutes: High-purity silicon has replaced selenium in high-voltage rectifiers and is the major substitute for selenium in low- and medium-voltage rectifiers. Other inorganic semiconductor materials, such as silicon, cadmium, tellurium, gallium, and arsenic, as well as organic photoconductors, substitute for selenium in photoelectric applications. Other substitutes include cerium oxide in glass manufacturing; tellurium in pigment and rubber compounding; and bismuth, lead, and tellurium in free-machining alloys.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Calculated using reported shipments, imports of selenium metal, and estimated exports of selenium metal, excluding scrap.

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

[3]See Appendix B.

[4]See Appendix C for definitions.

[5]In addition to the countries listed, Australia, China, India, Kazakstan, Russia, the United Kingdom, and Zimbabwe are known to produce refined selenium.

SILICON

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

Domestic Production and Use: Estimated value of silicon metal and alloys (excluding semiconductor-grade silicon) produced in the United States in 1996 was about $700 million. Ferrosilicon was produced by five companies in six plants, while production of silicon metal was distributed between five companies in eight plants. Most of the ferrosilicon and silicon metal plants were east of the Mississippi River or in the Pacific Northwest. Most ferrosilicon was consumed in the ferrous foundry and steel industries, predominantly in the eastern one-half of the United States. The main consumers of silicon metal were aluminum producers and the chemical industry.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	370	367	390	396	414
Imports for consumption	193	212	255	250	226
Exports	38	31	32	47	44
Consumption, apparent	532	557	616	609	597
Price,[1] average, cents per pound Si:					
Ferrosilicon, 50% Si	36.9	40.8	43.9	57.9	64.0
Ferrosilicon, 75% Si	35.4	40.6	40.8	58.1	63.0
Silicon metal	60.0	66.4	64.1	69.5	90.9
Stocks, producer, yearend	57	48	45	35	34
Employment, plant,[e] number	2,300	NA	NA	NA	NA
Net import reliance[2] as a percent of apparent consumption	30	34	37	35	31

Recycling: Insignificant.

Import Sources (1992-95): Norway, 21%; Brazil, 18%; Russia, 13%; Canada, 12%; and other, 36%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Ferrosilicon, 55%-80% Si:			
More than 3% Ca	7202.21.1000	1.1% ad val.	11.5% ad val.
Other	7202.21.5000	1.5% ad val.	11.5% ad val.
Ferrosilicon, 80%-90% Si	7202.21.7500	1.9% ad val.	9% ad val.
Ferrosilicon, more than 90% Si	7202.21.9000	5.8% ad val.	40% ad val.
Ferrosilicon, other:			
Ferrosilicon, more than 2% Mg	7202.29.0010	Free	4.4¢/kg Si.
Ferrosilicon, other	7202.29.0050	Free	4.4¢/kg Si.
Silicon, more than 99.99% Si	2804.61.0000	2.2% ad val.	25% ad val.
Silicon, 99.00%-99.99% Si	2804.69.1000	5.3% ad val.	21% ad val.
Silicon, other	2804.69.5000	7.6% ad val.	45% ad val.

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

Government Stockpile: Information on silicon carbide in the National Defense Stockpile is discussed in the "Manufactured Abrasives" chapter.

Events, Trends, and Issues: Overall consumption for silicon increased slightly compared with that of the previous year. Demand for silicon ferroalloys closely follows overall iron and steel production, whereas demand for silicon metal largely reflects the health of the aluminum and chemical industries. Consumption of ferrosilicon and miscellaneous silicon alloys was about 365,000 tons, while consumption of silicon metal was about 232,000 tons.

In late November, the "dealer import" price for 50%-grade ferrosilicon was $0.63 to $0.65 per pound, and the import price for 75%-grade ferrosilicon was $0.585 to $0.605 per pound. The import price for silicon metal started the year at $0.75 to $0.77 per pound, rose to $0.93 to $0.98 by mid-June, then fell to $0.85 to $0.89 in late November. Silicon metal prices continued to be influenced by strong demand and antidumping duties imposed in the United States.

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SILICON

For the first one-half year, total gross ferrosilicon imports increased by more than 10%. Norway and Iceland continued as the leading suppliers, with about 60% of both total quantity and value. For the same period, silicon metal imports decreased by more than 20%, with Russia providing about 40% of total imports.

In early September, the U.S. Department of Commerce (DOC) announced in the Federal Register final results of its administrative review of the antidumping duty order on silicon metal from Brazil. DOC's review of Brazil covered four manufacturers/exporters. As a result of its review, DOC determined that margins of 16.81% and 31.6% existed for two of the concerns, respectively, for the period July 1, 1992, through June 30, 1993.

It is estimated that in 1997 domestic production of silicon-containing ferroalloys and metal will be more than 400,000 tons, and U.S. apparent consumption will be about 600,000 tons.

World Production, Reserves, and Reserve Base:

	Production[e]		Reserves and reserve base[4]
	1995	1996	
United States	396	414	The reserves and reserve base in most major producing countries are ample in relation to demand. Quantitative estimates are not available.
Australia	30	30	
Brazil	270	270	
Canada	60	60	
China	715	720	
Egypt	30	30	
France	130	130	
Germany	15	15	
Iceland	45	45	
India	55	60	
Kazakstan	230	230	
Norway	375	375	
Poland	35	35	
Romania	15	15	
Russia	270	270	
South Africa	90	90	
Spain	25	25	
Sweden	15	15	
Ukraine	195	195	
Venezuela	25	25	
Other countries	90	100	
World total (rounded)	3,100	3,100	

World Resources: The 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.

Substitutes: Various metals and alloys, such as aluminum and silicomanganese, can be substituted for ferrosilicon in some applications. Germanium and gallium arsenide are the principal substitutes for silicon in semiconductor and infrared applications.

[e]Estimated. NA Not available.

[1]Based on U.S. dealer import price.

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

[3]See Appendix B.

[4]See Appendix C for definitions.

SILVER

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

Domestic Production and Use: Silver produced by about 120 mines in 18 States had an estimated value of $300 million. The following three States accounted for nearly three-fourths of the 1996 mine production: Nevada, 45%; Idaho, 16%; and Arizona, 12%. Precious metal ores accounted for approximately one-half of domestic silver production; the other one-half was recovered from base metal ores. There were 22 principal refiners of commercial-grade silver with an estimated output of approximately 2,000 tons. About 30 fabricators accounted for more than 90% of the silver consumed in arts and industry. The remainder was consumed mostly by small companies and artisans. The largest silver fabricators were principally in the Northeast. Approximately 50% of the refined silver consumed domestically in 1996 was used in the manufacture of photographic products; 20% in electrical and electronic products; 10% in electroplated ware, sterlingware, and jewelry; and 20% in other.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine	1,800	1,640	1,490	1,640	1,800
Refinery: Primary	2,160	1,790	1,810	([2])	([2])
Secondary	1,760	2,020	1,700	([2])	([2])
Imports for consumption[3]	3,220	2,500	2,600	3,250	3,000
Exports[3]	1,010	811	967	2,890	2,600
Shipments from Government stockpile excesses	356	404	186	220	—
Price, average, New York, dollars per troy ounce	3.94	4.30	5.29	5.15	5.30
Stocks, yearend: Treasury Department[4]	775	912	882	NA	900
COMEX, CBT[5]	9,380	10,500	10,400	6,290	5,000
Department of Defense	29	34	15	13	20
Employment, mine and mill[6], number	1,600	1,100	1,000	1,200	1,400

Recycling: About 2,000 tons of silver was recovered from recycled material in 1996.

Import Sources[2] (1992-95): Mexico, 37%; Canada, 33%; Peru, 15%; Chile, 10%; and other, 5%.

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

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Silver	1,450	—	1,450	300

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SILVER

Events, Trends, and Issues: Domestic silver production increased 10% following the reopening of several mines, in response to an improved silver price. It was estimated that domestic silver consumption remained essentially unchanged from the previous year.

The Government continued to dispose of the silver held in the National Defense Stockpile, using it primarily for the production of commemorative coins and the Eagle silver bullion coins. During the past 15 years, from 1982 through late 1996, the Government has reduced the quantity of silver held in the stockpile from nearly 4,300 tons to less than 1,500 tons.

In 1996, the average silver price remained essentially unchanged from the previous year. Through the first 9 months, the daily price ranged between $4.86 and $5.79 per troy ounce.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1995	1996[e]		
United States	1,640	1,800	31,000	72,000
Australia	920	900	29,000	33,000
Canada	1,195	1,200	37,000	47,000
Mexico	2,400	2,400	37,000	40,000
Peru	1,908	2,000	25,000	37,000
Other countries	6,540	6,500	120,000	190,000
World total (may be rounded)	14,600	14,800	280,000	420,000

World Resources: Approximately two-thirds of world silver resources are associated with copper, lead, and zinc deposits. The remaining one-third is in vein deposits in which silver is the most valuable metallic component. Although most recent discoveries have been primarily gold and silver deposits, significant future reserves and resources are expected from major base metal discoveries that contain byproduct silver.

Substitutes: Aluminum and rhodium substitute for silver in mirrors and other reflecting surfaces. Tantalum can be used in place of silver for surgical plates, pins, and sutures. Stainless steel is an alternate material used widely in the manufacture of table flatware. Nonsilver batteries being developed may replace silver batteries in some applications. Silverless black and white film, film with reduced silver content, and xerography are alternatives to some uses of silver in photography.

[e]Estimated. NA Not available.
[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Data under review.
[3]Refined bullion, plus silver content of ores, concentrates, precipitates, and doré; excludes coinage, waste, and scrap material.
[4]Balance in Mint only.
[5]COMEX: Commodity Exchange Inc., New York. CBT: Chicago Board of Trade.
[6]Source: Mine Safety and Health Administration.
[7]Includes silver recoverable as a byproduct of base metal ores. See Appendix C for definitions.

SODA ASH

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Five companies in Wyoming and one in California composed the U.S. soda ash (sodium carbonate) industry, which was the largest in the world. The six producers, with a combined annual nameplate capacity of 12 million tons, operated at 84% of nameplate capacity. Sodium bicarbonate, sodium sulfate, potassium chloride, potassium sulfate, borax, and other minerals were produced as coproducts from sodium carbonate production in California. Sodium bicarbonate, sodium sulfite, sodium tripolyphosphate, and chemical caustic soda were manufactured as coproducts at several of the Wyoming soda ash plants. The total estimated value of domestic soda ash produced in 1996 was $778 million.[1]

The reported distribution of soda ash by end use was glass, 48%; chemicals, 25%; soap and detergents, 12%; distributors, 5%; pulp and paper and miscellaneous, 3% each; and water treatment and flue gas desulfurization, 2% each.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[2]	9,380	8,960	9,320	10,100	10,100
Imports for consumption	72	89	79	83	95
Exports	2,960	2,800	3,230	3,570	3,650
Consumption: Reported	6,320	6,310	6,240	6,500	6,550
Apparent	6,360	6,350	6,260	6,510	6,550
Price: Quoted, yearend, soda ash, dense, bulk, f.o.b. Green River, WY, dollars per short ton	98.00	98.00	105.00	105.00	105.00
F.o.b. Searles Valley, CA, same basis	123.00	123.00	130.00	130.00	130.00
Average sales value (natural source), f.o.b. mine or plant, same basis	80.93	74.34	70.44	74.50	77.00
Stocks, producer, yearend	371	274	203	306	300
Employment, mine and plant, number	2,800	2,800	2,800	2,800	2,800
Net import reliance[3] as a percent 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 (1992-95): Canada, 99%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Disodium carbonate	2836.20.0000	1.2% ad val.	8.5% ad val.

Depletion Allowance: 14% (Domestic), 14% (Foreign). For natural only.

Government Stockpile: None.

Events, Trends, and Issues: Several soda ash capacity expanions, closures, and acquisitons were announced in 1996. The largest U.S. soda ash-producing company, which was the only domestic producer that was exclusively U.S.-owned, formed a joint venture with two Japanese soda ash companies; one was a glass producer and the other a soda ash distributor. The two Japanese companies would own 20% of the partnership and would provide $150 million to finance part of a 635,000-ton-per-year expansion project. The Japanese partners will export their share of soda ash to their host country.

Another Japanese company, which was a partner in a Wyoming soda ash venture, announced it planned to close its synthetic soda ash facility in Chiba, Japan, in 1997. The announcement followed a decision by its Belgian-owned U.S. partner to expand production capacity by more than 50% to 3.18 million tons. A second Wyoming jointventure partnership with another Japanese soda ash producer closed a plant in Japan in September.

In April, a U.S. soda ash producer in California purchased the synthetic soda ash operations of a producer in Australia. The facility has an annual capacity of 400,000 tons. The U.S. company also acquired the soda ash operation in France of a former European soda ash producer. These transactions resulted in this U.S. company becoming the third largest soda ash producer in the world.

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SODA ASH

The European Economic Commission opened its investigation in 1996 of antiumping practices by several U.S. soda ash producers. The Commission determined in 1995 that most of the U.S. industry sold soda ash at less than the prevailing European sales prices, and imposed provisional duties on all but one of the U.S. companies. The Commission continued its investigation into 1997.

The outlook for soda ash through 1997 is very good. World demand for soda ash was expected to grow 1.5% to 2% annually through the remainder of this century. Domestic demand should be slightly higher than in 1996; however, soda ash consumption in the glass container manufacturing sector is estimated to decline further.

World Production, Reserves, and Reserve Base:

	Production		Reserves[5 6]	Reserve base[6]
Natural	1995	1996[e]		
United States	10,100	10,100	[7]23,000,000	[7]39,000,000
Botswana	202	150	400,000	NA
Chad	NA	NA	NA	NA
Kenya	145	150	7,000	NA
Mexico	—	—	200,000	450,000
Turkey	—	—	200,000	240,000
Uganda	NA	NA	20,000	NA
Other countries	—	—	260,000	220,000
World total, natural (rounded)	10,400	10,400	24,000,000	40,000,000
World total, synthetic (rounded)	21,000	21,000	—	—
World total (rounded)	31,000	31,000	—	—

World Resources: Soda ash is obtained from trona and sodium carbonate-rich brines. The world's largest deposit of trona is in the Green River Basin of Wyoming. About 47 billion metric tons of identified soda ash resources could be recovered from the 56 billion tons of bedded trona[4] and the 47 billion tons of interbedded or intermixed trona and halite that are in beds more than 1.2 meters thick. About 34 billion tons of reserve base soda ash could be obtained from the 36 billion tons of halite-free trona and the 25 billion tons of interbedded or intermixed trona and halite that are in beds more than 1.8 meters thick. Underground room-and-pillar mining, using a combination of conventional, continuous, and shortwall mining equipment, is the primary method of mining Wyoming trona ore. The method has an average 45% mining recovery, which is higher than the 30% average mining recovery from solution mining. Improved solution mining techniques, such as horizontal drilling to establish communication between well pairs, could increase this extraction rate and enable companies to develop some of the deeper economic trona. Wyoming trona resources are being depleted at the rate of about 15 million tons per year (8.3 million tons of soda ash). Searles and Owens Lakes in California contain an estimated 815 million tons of soda ash reserves. There are at least 62 identified natural sodium carbonate deposits in the world, some of which have been quantified. Although soda ash can be manufactured from salt and limestone, both of which are practically inexhaustible, synthetic soda ash is more costly to produce and generates environmentally deleterious wastes. Commercial mining of nahcolite is presently being done by one producer in Colorado, and two other companies are trying to obtain financing for development of competing nahcolite projects. None of the ventures are associated with oil shale mining or with dawsonite recovery.

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.
[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]See Appendix B.
[5]The reported quantities are sodium carbonate only. About 1.8 tons of trona yields 1 ton of sodium carbonate.
[6]See Appendix C for definitions.
[7]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 a total of two plants in California and Texas. Total production of natural and synthetic sodium sulfate increased an estimated 24% compared with that of the 1995. Approximately 44% of total production was a byproduct from facilities that manufacture rayon and various chemicals. The total value of sodium sulfate sold was an estimated $44 million.

Estimates of U.S. sodium sulfate consumption by end use were soap and detergents, 40%; textiles, 25%; glass, 15%; and paper and miscellaneous, 20%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Natural	337	327	298	327	325
Synthetic[1]	216	210	180	124	195
Imports for consumption	158	163	190	206	175
Exports	155	89	65	66	100
Consumption, apparent (natural and synthetic)	544	616	611	609	595
Price: Quoted, sodium sulfate (100% Na_2SO_4), bulk, f.o.b. works, East, dollars per short ton	114.00	114.00	114.00	114.00	114.00
Average sales value (natural source), f.o.b. mine or plant, dollars per metric ton	91.79	76.53	81.25	84.55	85.00
Stocks, producer, yearend, natural	47	42	34	16	16
Employment, well and plant, number	240	240	240	240	240
Net import reliance[2] as a percent of apparent consumption	E	13	22	26	13

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 (1992-95): Canada, 95%; Mexico, 4%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Disodium sulfate:			
Saltcake (crude)	2833.11.1000	Free	Free.
Other	2833.11.5000	0.4% ad val.	3.6% ad val.
Anhydrous	2833.11.5010	0.4% ad val.	3.6% ad val.
Other	2833.11.5050	0.4% ad val.	3.6% ad val.

Depletion Allowance: 14% (Domestic), 14% (Foreign); for natural only.

Government Stockpile: None.

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SODIUM SULFATE

Events, Trends, and Issues: The international demand for powdered laundry detergents continued in 1996, especially in Mexico, Europe, and the Pacific rim. Mexican producers of natural sodium sulfate supplied most of their output to domestic detergent manufacturers, resulting in reduced exports to the United States. This provided the opportunity for U.S. sodium sulfate producers to increase their export sales, because Mexico had been a major supplier to various world markets.

An idled hydrochloric acid facility in Monument, NM, that produced byproduct sodium sulfate resumed operations in October. The plant's new rate of recovery of sodium sulfate was 32,000 tons annually. A new sales and marketing company was formed to sell the sodium sulfate. This company is based in Tulsa, OK, with a sales office in Charlotte, NC.

The outlook for sodium sulfate in 1997 is forecast to be comparable to 1996, with detergents remaining the largest sodium sulfate-consuming sector.

World Production, Reserves, and Reserve Base:

	Production		Reserves[4]	Reserve base[4]
Natural	1995	1996[e]		
United States	327	325	860,000	1,400,000
Argentina	10	10	NA	NA
Canada	301	300	84,000	270,000
Iran	280	290	NA	NA
Mexico	525	550	170,000	230,000
Spain	600	600	180,000	270,000
Turkey	307	80	100,000	NA
Turkmenistan[5]	45	50	NA	200
Other countries	135	160	100,000	200,000
World total, natural (rounded)	2,500	2,400	[6]3,300,000	[7]4,600,000
World total, synthetic (rounded)	1,500	1,600	—	—
World total (rounded)	4,000	4,000	—	—

World Resources: Sodium sulfate resources are sufficient to last hundreds of years at the present rate of world consumption. In addition to the countries listed in World Production, the following countries also contain identified resources of sodium sulfate: Botswana, China, Egypt, Italy, Mongolia, Romania, and South Africa. Commercial production from domestic resources is from deposits in California and Texas. The brine in Searles Lake, CA, contains about 450 million metric tons of sodium sulfate resource, representing about 35% of the lake brine. In Utah, about 12% of the dissolved salts in the Great Salt Lake is sodium sulfate, representing about 400 million tons of resource. An irregular, 21-meter-thick mirabilite deposit is associated with clay beds 4.5 to 9.1 meters below the lake bottom near Promontory Point, UT. Several playa lakes in west Texas contain underground sodium sulfate-bearing brines and crystalline material. Other economic and subeconomic deposits of sodium sulfate are near Rhodes Marsh, NV; Grenora, ND; Okanogan County, WA; and Bull Lake, WY. Sodium sulfate can also be obtained as a byproduct from the production of ascorbic acid, boric acid, cellulose, chromium chemicals, lithium carbonate, rayon, resorcinol, and silica pigments. The quantity and availability of byproduct sodium sulfate are dependent on the production capabilities of the primary industries and the sulfate recovery rates.

Substitutes: In pulp and paper, emulsified sulfur and caustic soda (sodium hydroxide) can replace sodium sulfate. In detergents, a variety of products can substitute for sodium sulfate. In glassmaking, soda ash and calcium sulfate have been substituted for sodium sulfate with less-than-perfect results.

[e]Estimated. E Net exporter. NA Not available.
[1]Source: Bureau of the Census. Synthetic production data are revised in accordance with recent updated Census statistics.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]Part of the former Soviet Union. Data are inadequate to formulate reliable estimates for individual countries of the former Soviet Union.
[6]Excludes Argentina, Iran, and Turkmenistan. Includes nonproducing nations.
[7]Excludes Argentina, Iran, and Turkey. Includes nonproducing nations.

STONE (CRUSHED)[1]

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

Domestic Production and Use: Crushed stone valued at $7.2 billion was produced by 1,500 companies operating 3,700 active quarries in 48 States. Leading States, in order of production, were Texas, Pennsylvania, Florida, Missouri, Illinois, Georgia, Ohio, Kentucky, North Carolina, and Virginia, together accounting for about 51% of the total output. It is estimated that, of the 1.3 billion tons of crushed stone produced in 1996, about 39% was for unspecified uses. Of the remaining total, about 83% was used as construction aggregates mostly for highway and road construction and maintenance; 14% for chemical and metallurgical uses, including cement and lime manufacture; 2% for agricultural uses; and 1% for special uses and products. To provide a more accurate estimate of the consumption patterns for crushed stone, the "unspecified uses" are not included in the above percentages. Of the total crushed stone produced in 1996, about 71% was limestone and dolomite; 15%, granite; 8%, traprock; and the remaining 6%, was shared, in descending order of quantity, by sandstone and quartzite, miscellaneous stone, marble, calcareous marl, slate, shell, and volcanic cinder and scoria.

The estimated output of crushed stone in the 48 conterminous States shipped for consumption in the first 9 months of 1996 was 970 million tons, which represents an increase of about 3.5% compared with the same period of 1995. Additional production information by quarters for each State, geographic region, and the United States is published in the Quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production	[e]1,050	1,120	1,230	1,260	1,300
Imports for consumption	7	8	9	11	10
Exports	4	5	5	6	6
Consumption, apparent	[e]1,053	1,123	1,234	1,265	1,304
Price, average value, dollars per metric ton	5.31	5.30	5.39	5.36	5.43
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e] [3]	75,000	76,000	77,000	77,200	77,500
Net import reliance[4] as a percent of apparent consumption	—	—	—	—	—

Recycling: Road surfaces made of asphalt and crushed stone and, to a lesser extent, cement concrete surfaces and structures were recycled on a limited but increasing basis in most States.

Import Sources (1992-95): Canada, 53%; Mexico, 27%; The Bahamas, 10%; and other, 10%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Crushed and broken stone	2517.10.0000	Free	30% ad val.

Depletion Allowance: (Domestic and Foreign) 14% for chemical and metallurgical uses; 5% if used for riprap, ballast, road material, concrete aggregate, and similar purposes.

Government Stockpile: None.

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STONE (CRUSHED)

Events, Trends, and Issues: Crushed stone output increased 2.8% in 1996. It is estimated that 1997 domestic production and U.S. apparent consumption will be about 1.34 billion tons each, a 3% increase.

The crushed stone industry continued to be concerned with safety regulations and environmental restrictions. Shortages in some urban and industrialized areas were expected to continue to increase owing to local zoning regulations and land development alternatives. This is expected to continue to cause a relocation of crushed stone quarries away from high-population centers.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[6]
	1995	1996[e]	
United States	1,260	1,300	Adequate except where special
Other countries	NA	NA	types are needed or where
World total	NA	NA	local shortages exist.

World Resources: Stone resources of the world are very large. High-purity limestone and dolomite suitable for chemical and metallurgical use are limited in many geographical areas. The largest resources of high-purity limestone and dolomite in the United States are in the central and eastern parts of the country.

Substitutes: Crushed stone substitutes for roadbuilding include sand and gravel and slag. Substitutes for aggregate include sand and gravel, slag, sintered or expanded clay or shale, and perlite or vermiculite.

[e]Estimated. NA Not available.
[1]See also Stone (Dimension).
[2]See Appendix A for conversion to short tons.
[3]Excluding office staff.
[4]Defined as imports - exports + adjustments for Government and industry stock changes. Changes in stocks were assumed to be zero in the net import reliance and apparent consumption calculations because data on stocks were not available.
[5]See Appendix B.
[6]See Appendix C for definitions.

STONE (DIMENSION)[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Dimension stone totaling 1.33 million tons (1.47 short tons) valued at $231 million was produced by 145 companies at 234 quarries in 36 States. Dimension stone was used in rough blocks in building, 25%; ashlar, 12%; rough blocks for monuments, 12%; dressed monumental, 4%; and other, 47%. Leading producing States were Indiana, Georgia, Vermont, and Wisconsin, which together accounted for 45% of the output. Of the total, 42% was granite; 31%, limestone; 13%, sandstone; 3%, slate; 3%, marble; and 8%, other.

Salient Statistics—United States:[2]	1992	1993	1994	1995	1996[e]
Production: Tonnage	1,140	1,280	1,190	1,160	1,330
Value, million dollars	198	226	218	233	231
Imports for consumption, value, million dollars	404	398	440	478	480
Exports, value, million dollars	55	53	53	52	50
Consumption, apparent, value, million dollars	547	571	605	659	661
Price	Variable, depending on type of product				
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill[3], number	3,000	3,000	3,000	3,000	3,000
Net import reliance[4] as a percent of apparent consumption (based on value)	64	60	64	64	64
Granite only:					
Production	594	624	499	495	500
Imports for consumption	466	494	NA	NA	NA
Exports (rough and finished)	119	143	170	163	170
Consumption, apparent	941	975	NA	NA	NA
Price	Variable, depending on type of product				
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill[3], number	1,500	1,500	1,500	1,500	1,500
Net import reliance[4] as a percent of apparent consumption (based on tonnage)	37	36	NA	NA	NA

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

Import Sources (1992-95) (based on value): Dimension stone: Italy, 45%; Spain, 11%; India, 10%; Canada, 7%; and other, 27%. Granite only: Italy, 43%; Canada, 14%; India, 17%; Brazil, 12%; and other, 14%.

Tariff: Dimension stone tariffs ranged from free to 6.9% ad valorem for most favored nations in 1996 according to type, size, value, and degree of preparation.

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STONE (DIMENSION)

Depletion Allowance: 14% (Domestic and Foreign); 5% if used for rubble and other nonbuilding purposes.

Government Stockpile: None.

Events, Trends, and Issues: Dimension stone imports increased to a value of $480 million in 1996. Imports exceeded the value of domestic production. Computerized design is becoming more prominent in the industry with the use of etching and contour cutting of memorial stones. The trend is continuing for the use of a "natural stone" finish to provide a rustic earthy setting. Key areas of growth are in niche markets: granite and marble in kitchens and bathrooms, limestone in landscaping, ledges, and tiles.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	1995	1996[e]	
United States	1,160	1,330	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 concrete, steel, aluminum, resin agglomerated stone, and plastics.

[e]Estimated. NA Not available.
[1]See also Stone (Crushed).
[2]Includes Puerto Rico.
[3]Excluding office staff.
[4]Defined as imports - exports + adjustments for Government and industry stock changes. Changes in stocks were assumed to be zero in the net import reliance and apparent consumption calculations because data on stocks were not available.
[5]See Appendix C for definitions.

STRONTIUM

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

Domestic Production and Use: No strontium minerals have been produced in the United States since 1959. The most common strontium mineral, celestite, which consists primarily of strontium sulfate, was imported exclusively from Mexico. A company in Georgia was the only major U.S. producer of strontium compounds. Primary strontium compounds were used in the faceplate glass of color television picture tubes, 75%; ferrite ceramic magnets, 8%; pyrotechnics and signals, 7%; and other, 10%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, strontium minerals	—	—	—	—	—
Imports for consumption:					
Strontium minerals	19,700	11,600	16,000	12,700	14,000
Strontium compounds	13,000	15,300	20,000	20,800	21,000
Exports, compounds	650	260	1,120	1,160	1,200
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, apparent, celestite and compounds	W	W	W	W	W
Price, average value of mineral imports at port of exportation, dollars per ton	68	73	68	71	70
Stocks, consumer, yearend, celestite only	W	W	W	W	W
Net import reliance[2] as a percent of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1992-95): Strontium minerals: Mexico, 100%. Strontium compounds: Mexico, 86%; and Germany, 14%. Total imports: Mexico, 93%, and Germany, 7%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Mexico 12/31/96	Non-MFN[3] 12/31/96
Celestite	2530.90.0010	Free	Free	0.3¢/kg.
Alkaline earth metals (strontium and barium)	2805.22.1000	3.7% ad val.	Free	25% ad val.
Compounds:				
Strontium nitrate	2834.29.2000	4.2% ad val.	Free	25% ad val.
Strontium carbonate	2836.92.0000	4.2% ad val.	Free	25% ad val.
Strontium oxide, hydroxide, peroxide	2816.20.0000	4.2% ad val.	Free	25% ad val.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Celestite[1]	5,100	—	5,100	—

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STRONTIUM

Events, Trends, and Issues: Although there is celestite in the National Defense Stockpile, none of it is stockpile grade; its total value is listed as zero. The stockpile goal was reduced to zero in 1969, and at that time the stockpile contained both stockpile- and nonstockpile-grade material. Since then, all the stockpile-grade celestite has been sold. Although the nonstockpile-grade celestite has been offered for sale, none has been sold since 1979. The fiscal year 1997 Annual Materials Plan, announced at the end of September 1996 by the Defense National Stockpile Center, identified 3,300 tons of celestite to be offered for disposal.

World Mine Production, Reserves, and Reserve Base:[4]

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	—	—	—	1,360,000
Algeria	5,400	5,400		
China	35,000	35,000		
Iran	20,000	20,000		
Mexico	71,500	75,000	Other:	Other:
Pakistan	1,500	1,500	6,800,000	10,600,000
Spain	12,000	12,000		
Tajikistan	NA	NA		
Turkey	25,000	25,000		
United Kingdom	—	—		
World total (may be rounded)	[6]170,000	[6]170,000	6,800,000	12,000,000

World Resources: Resources in the United States are several times the reserve base. World resources, although not thoroughly evaluated, are thought to exceed 1 billion tons.

Substitutes: Although it is possible to substitute for strontium in some of its applications, such a change would adversely affect product performance and/or cost. For example, barium could replace strontium in color television picture tube glass only after extensive circuit redesign to reduce operating voltages that produce harmful secondary X-rays. Barium replacement of strontium in ferrite ceramic magnets would decrease the maximum energy and temperature characteristics of the magnets. Substituting for strontium in pyrotechnics would be impractical because the desired brilliance and visibility are imparted only by strontium and its compounds.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]The strontium content of celestite is 43.88%; this amount was used to convert units of celestite.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]Metric tons of strontium minerals.
[5]See Appendix C for definitions.
[6]Excludes Tajikistan.

SULFUR

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

Domestic Production and Use: In 1996, elemental sulfur and byproduct sulfuric acid were produced at 168 operations in 30 States, Puerto Rico, and the U.S. Virgin Islands. Total shipments were valued at about $450 million. Total elemental sulfur production was 10.3 million metric tons; Texas and Louisiana accounted for about 50% of domestic production. Elemental sulfur was recovered at petroleum refineries, natural gas processing plants, and coking plants by 59 companies at 150 plants in 26 States, Puerto Rico, and the U.S. Virgin Islands. Elemental sulfur was produced by one company at two mines in two States, using the Frasch method of mining. Byproduct sulfuric acid, representing 13% of sulfur in all forms, was recovered at 16 nonferrous smelters in 10 States by 11 companies. Domestic elemental sulfur provided 69% of domestic consumption and byproduct acid 11%. The remaining 20% of sulfur consumed was imported sulfur and sulfuric acid. About 90% of sulfur was consumed in the form of sulfuric acid. Agricultural chemicals (primarily fertilizers) comprised 67% of sulfur demand; chemicals, organic and inorganic, 8%; metal mining, 6%; and petroleum refining, 5%. Other uses, accounting for 14% of demand, were widespread because a multitude of industrial products require sulfur in one form or another during some stage in their manufacture.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Frasch	2,320	[1]1,900	2,960	3,150	W
Recovered elemental	7,050	[2]7,720	7,160	7,250	[3]10,300
Other forms	1,300	1,430	1,380	1,400	1,500
Total	10,700	11,100	11,500	11,800	11,800
Shipments, all forms	11,000	10,500	11,700	12,100	11,800
Imports for consumption:					
Recovered, elemental	2,730	2,040	1,650	2,510	2,000
Sulfuric acid, sulfur content	649	797	696	628	650
Exports:					
Frasch and recovered elemental	966	656	899	906	1,000
Sulfuric acid, sulfur content	46	46	46	56	35
Consumption, apparent, all forms	13,400	12,600	13,100	14,300	13,400
Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and/or plant	48.14	31.86	28.60	43.74	38.00
Stocks, producer, yearend	809	1,380	1,160	583	800
Employment, mine and/or plant, number	3,200	3,100	3,100	3,100	3,100
Net import reliance[4] as a percent of apparent consumption	20	12	12	21	11

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

Import Sources (1992-95): Frasch and recovered: Canada, 68%; Mexico, 31%; and other, 1%. Sulfuric acid: Canada, 71%; Germany, 10%; Japan, 5%; Mexico, 5%; and other, 9%. Total sulfur imports: Canada, 70%; Mexico, 18%; Germany, 5%; Japan, 3%; and other, 4%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Sulfur, crude or unrefined	2503.10.0000	Free	Free.
Sulfur, all kinds, other	2503.90.0000	Free	Free.
Sulfur, sublimed or precipitated	2802.00.0000	Free	Free.
Sulfuric acid	2807.00.0000	Free	Free.

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

Government Stockpile: None.

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SULFUR

Events, Trends, and Issues: Although domestic sulfur demand was reasonably strong, the availability of excess sulfur worldwide forced price reductions by suppliers to maintain market share. Sulfur consumers were looking for alternative sources of supply to keep their costs down, and for this reason the United States saw its first shipments of molten sulfur from Germany. Reduced prices prompted the single domestic Frasch company to cut production at its mines off-shore Louisiana and in west Texas by an equivalent of 350,000 tons per year in an attempt to balance supply and demand and to stabilize prices. The price slide that began early in the year seemed to be leveling off by yearend, and slight increases were expected.

Prices of imports from Canada reached a low enough level that some Canadian producers withheld product from the United States market rather than face the possibility of an antidumping investigation. After several years of investigation, the U.S. Department of Commerce levied antidumping duties against several Canadian sulfur producers that were exporting to the United States from December 1, 1991, through November 30, 1992.

Domestic sulfur production is expected to increase slightly for the next few years, with Frasch production remaining relatively stable at reduced levels as long as both mines continue to operate. Recovered production should continue its slow but consistent growth. Small quantities of sulfur or sulfuric acid recovered from electric powerplants should enter the market during the next few years. Apparent consumption of sulfur is projected to be 13.5 million tons in 1997.

World Production, Reserves, and Reserve Base:

	Production—All forms		Reserves[6]	Reserve base[6]
	1995	1996[e]		
United States	11,800	11,800	140,000	230,000
Canada	9,010	9,100	160,000	330,000
China	6,530	6,000	100,000	250,000
France	1,100	1,100	10,000	20,000
Iraq	475	475	130,000	500,000
Japan	2,860	2,900	5,000	15,000
Mexico	2,880	3,000	75,000	120,000
Poland	2,440	2,000	130,000	300,000
Russia	4,000	4,000	NA	NA
Saudi Arabia	2,200	2,200	100,000	130,000
Spain	702	600	50,000	300,000
Other countries	10,300	10,800	500,000	1,300,000
World total (may be rounded)	54,300	54,000	1,400,000	3,500,000

World Resources: Resources of elemental sulfur in evaporite and volcanic deposits and sulfur associated with natural gas, petroleum, tar sands, and metal sulfides amount to about 5 billion tons. The sulfur in gypsum and anhydrite is almost limitless, and some 600 billion tons are contained in coal, oil shale, and shale rich in organic matter, but low-cost methods have not been developed to recover sulfur from these sources. The domestic resource is about one-fifth of the world total.

Substitutes: There are no adequate substitutes for sulfur at present or anticipated price levels; some acids, in certain applications, may be substituted for sulfuric acid.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Includes 10 months of Frasch sulfur data. Two remaining months of Frasch data included with recovered sulfur data to conform with proprietary data requirements.
[2]Includes corresponding Frasch sulfur data for November and December.
[3]Includes Frasch sulfur data.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix C for definitions.

TALC AND PYROPHYLLITE

(Data in thousand metric tons, unless noted)

Domestic Production and Use: The total estimated crude ore value of 1996 domestic production was $31 million. There were 13 talc-producing mines in 6 States in 1996. Companies in Montana, New York, Texas, and Vermont accounted for 99% of domestic production. Ground talc was consumed in ceramics, 35%; paint, 19%; paper, 18%; roofing, 6%; plastics, 4%; cosmetics, 3%; and other, 15%. Two firms in North Carolina and one firm in California accounted for 100% of domestic pyrophyllite production, which increased slightly from that of 1995. Consumption was in ceramics, refractories, and insecticides, in decreasing order of tonnage.

Salient Statistics—United States:[1]	1992	1993	1994	1995	1996[e]
Production, mine	997	968	935	1,060	976
Sold by producers	817	900	923	901	899
Imports for consumption	80	100	155	146	142
Exports	175	135	154	183	179
Shipments from Government stockpile excesses	([2])	—	—	—	—
Consumption, apparent	902	933	936	1020	939
Price, crude or ground, dollars per ton	15-325	13-400	7-350	7-560	7-525
Stocks, producer, yearend	80	80	80	80	NA
Employment, mine and mill	880	800	750	750	750
Net import reliance[3] as a percent of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1992-95): China, 38%; Canada, 26%; Japan, 24%; and other, 12%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Crude, not ground	2526.10.0000	0.02¢/kg	0.6¢/kg.
Ground, washed, powdered	2526.20.0000	1.4% ad val.	35.0% ad val.
Cut or sawed	6815.99.2000	Free	2.2¢/kg.

Depletion Allowance: Block steatite talc: 22% (Domestic), 14% (Foreign). Other: 14% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-96
(Metric tons)

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 95
Talc, block and lump	974	3	974	6
Talc, ground	988	—	988	—

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TALC AND PYROPHYLLITE

Events, Trends, and Issues: Production and sales decreased 8% and 1% respectively, from those of 1995. Apparent consumption decreased 8% in 1996. Exports increased 2% from those of 1995. Canada, was the major importers of U.S. talc. Imports for consumption decreased 23% from those of 1995. Canada, China, and Japan supplied approximately 82% of the imported talc.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States[1]	1,060	976	136,000	544,000
Brazil	460	470	14,000	54,000
China	2,400	2,400	Large	Large
India	456	450	4,000	9,000
Japan	994	1,000	132,000	200,000
Korea, Republic of	730	730	14,000	18,000
Other countries	1,050	1,174	Large	Large
World total (may be rounded)	7,150	7,200	Large	Large

World Resources: The United States is self-sufficient in most grades of talc and related minerals. Domestic and world resources are estimated to be approximately five times the quantity of reserves.

Substitutes: The major substitutes for talc are clay and pyrophyllite in ceramics; calcium carbonate, diatomite, kaolin, and mica in paint; calcium carbonate and kaolin in paper; clays, feldspar, mica, silica, and wollastonite in plastics; and calcium carbonate, kaolin, and silica in rubber.

[e]Estimated. E Net exporter. NA Not Available
[1]Excludes pyrophyllite.
[2]Less than ½ unit.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.

TANTALUM

(Data in thousand kilograms of tantalum content, unless otherwise noted)

Domestic Production and Use: There has been no significant domestic tantalum-mining industry since 1959, with the exception of small unreported quantities of tantalum-bearing concentrates produced in 1989-92. Domestic tantalum resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Most metal, alloys, and compounds were produced by four companies; tantalum units were obtained from imported concentrates and metal and from foreign and domestic scrap. Tantalum was consumed mostly in the form of metal powder, ingot, fabricated forms, compounds, and alloys. The major end use for tantalum was in the production of electronic components, about 60% of use, mainly in tantalum capacitors. The value of tantalum consumed in 1996 was estimated at about $140 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine	([1])	—	—	—	—
Imports for consumption, concentrate, tin slags, and other[2]	NA	NA	NA	NA	NA
Exports, concentrate, metal, alloys, waste, and scrap[e]	150	170	190	220	300
Consumption: Reported, raw material	NA	NA	NA	NA	NA
Consumption: Apparent	375	410	430	515	490
Price, tantalite, dollars per pound[3]	28.19	26.41	26.24	26.98	27.75
Stocks, industry, processor, yearend	NA	NA	NA	NA	NA
Employment	NA	NA	NA	NA	NA
Net import reliance[4] as a percent of apparent consumption	85	85	80	80	80

Recycling: Combined prompt industrial and obsolete scrap consumed represented about 20% of apparent consumption.

Import Sources (1992-95): Australia, 28%; Germany, 14% (majority of imports of unknown origin); Thailand, 11%; Brazil, 8%; and other, 39%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Synthetic tantalum-columbium concentrates	2615.90.3000	Free	30% ad val.
Tantalum ores and concentrates	2615.90.6060	Free	Free.
Tantalum oxide	2825.90.9000	3.7% ad val.	25% ad val.
Potassium fluotantalate	2826.90.0000	3.1% ad val.	25% ad val.
Tantalum, unwrought:			
Waste and scrap	8103.10.3000	Free	Free.
Powders	8103.10.6030	3.2% ad val.	25% ad val.
Alloys and metal	8103.10.6090	3.2% ad val.	25% ad val.
Tantalum, wrought	8103.90.0000	5.1% ad val.	45% ad val.

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

Government Stockpile: The uncommitted inventories shown below include a small quantity in nonstockpile-grade tantalum capacitor-grade metal powder, 454,000 kilograms in nonstockpile-grade minerals, and 65,300 kilograms in tantalum metal ingots with status (inventory) not yet determined. The Department of Defense proposed to dispose of about 907 kilograms of tantalum carbide powder, about 45,400 kilograms of tantalum minerals, and about 9,070 kilograms of tantalum oxide in each of fiscal years 1997 and 1998.

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Tantalum:				
Carbide powder	13	—	—	—
Metal	184	—	—	—
Minerals	1,130	—	340	—
Oxide	74	—	—	—

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TANTALUM

Events, Trends, and Issues: Overall consumption of tantalum was down in 1996. U.S. sales of tantalum capacitors for the first one-half year decreased by about 5% compared with that of the similar period in 1995. For the same period, imports for consumption of tantalum mineral concentrates rose by more than 10%, with Australia supplying about 50% of both quantity and value. In late November, the published spot price for tantalite ore was quoted in the range of $27 to $28.50 per pound of contained pentoxide. Industry sources indicated that the average selling prices for some tantalum products were as follows (per pound of contained tantalum): powder, $100 to $180; wire, $170 to $250; and sheet, $100 to $150. Tantalum oxide was selling at an average of $40 to $90 per pound of oxide, and the average selling price for tantalum carbide was $45 to $60 per pound.

It is estimated that in 1997 domestic mine production will be zero and U.S. apparent consumption will be about 500,000 kilograms.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e 6]		Reserves[e 7]	Reserve base[e 7]
	1995	1996		
United States	—	—	—	Negligible
Australia	274	280	4,500	9,100
Brazil	50	50	900	1,400
Canada	26	30	1,800	2,300
Malaysia	—	—	900	1,800
Nigeria	2	2	3,200	4,500
Zaire	1	1	1,800	4,500
Zimbabwe	2	2	NA	NA
Other countries[8]	1	1	1,400	1,800
World total (may be rounded)	356	366	15,000	26,000

World Resources: Most of the world's resources of tantalum occur outside the United States. On a worldwide basis, identified resources of tantalum are considered adequate to meet projected needs. These resources are largely in Australia, Brazil, Canada, Egypt, Malaysia, Nigeria, and Zaire. The United States has about 1.4 million kilograms of tantalum resources in identified deposits, most of which were considered uneconomic at 1996 prices.

Substitutes: The following materials can be substituted for tantalum, but usually with less effectiveness: columbium in superalloys and carbides; aluminum and ceramics in electronic capacitors; glass, titanium, zirconium, columbium, and platinum in corrosion-resistant equipment; and tungsten, rhenium, molybdenum, iridium, hafnium, and columbium in high-temperature applications.

[e]Estimated. NA Not available.
[1]A small unreported quantity was produced.
[2]Metal, alloys, and synthetic concentrates; exclusive of waste and scrap.
[3]Average value, contained tantalum pentoxides, 60% basis.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]Excludes production of tantalum contained in tin slags.
[7]See Appendix C for definitions.
[8]Excludes any production from Bolivia, China, and countries in the former Soviet Union.

TELLURIUM

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

Domestic Production and Use: Tellurium and tellurium dioxide of commercial grades were recovered from anode slimes at one electrolytic copper refinery in the United States. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide. Tellurium was used mainly in the production of free-machining steels. It was used as a minor additive in copper and lead alloys and malleable cast iron, as an accelerator in rubber compounding, in thermoelectric applications, and as a semiconductor in thermal-imaging and photoelectric applications. Tellurium was added to selenium-base photoreceptor alloys to increase the photo speed. In 1996, the estimated consumption was for iron and steel products, 50%; catalysts and chemicals, 25%; additives to nonferrous alloys, 10%; photoreceptors and thermoelectric devices, 10%; and other uses, 5%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery	W	W	W	W	W
Imports for consumption:					
Unwrought, waste and scrap[1]	48	45	27	46	70
Exports	NA	NA	NA	NA	NA
Consumption, apparent	NA	NA	NA	NA	NA
Price, dollars per pound, 99.7% minimum[2]	35	32	26	23	21
Stocks, producer, refined, yearend	W	W	W	W	W
Employment, number	NA	NA	NA	NA	NA
Net import reliance[3] as a percent of apparent consumption	NA	NA	NA	NA	NA

Recycling: There was no domestic secondary production of tellurium. However, some tellurium may have been recovered abroad from selenium-base photoreceptor scrap exported for recycling.

Import Sources (1992-95): Philippines, 18%; Japan, 18%; United Kingdom, 18%; Belgium, 17%; and other, 29%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Metal	2804.50.0000	Free	25.0% ad val.

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

Government Stockpile: None.

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TELLURIUM

Events, Trends, and Issues: Domestic and world tellurium demand decreased in 1996, but production remained steady, resulting in continued oversupply. Detailed information on the world tellurium market was not available.

The U.S. Environmental Protection Agency removed tellurium metal from its list of extremely hazardous substances. It had been put on the list using data for a tellurium compound that was already on the list. When the data were reviewed, it was found that the much less toxic metallic tellurium did not meet the criteria for inclusion.

Cadmium telluride remains one of the most promising thin-film photovoltaic (PV) module compounds for power generation, achieving some of the highest power conversion ratios yet obtained. Research is being planned at Sandia National Laboratory, part of the U.S. Department of Energy, that will include cadmium telluride in solar cell development tests.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	W	W	3,000	6,000
Canada	45	45	700	1,500
Japan	45	45	—	—
Peru	19	19	500	1,600
Other countries	NA	NA	16,000	29,000
World total (rounded)	[6]NA	[6]NA	20,000	38,000

World Resources: The reserve base includes only tellurium contained in economic copper deposits. Significant quantities of tellurium are contained in economic gold and lead deposits, but currently none is recovered. Deposits of coal, copper, and other metals that are undeveloped or of subeconomic grade contain several times the amount of tellurium contained in identified economic copper deposits. However, it is unlikely that tellurium contained in these deposits can be recovered economically.

Substitutes: The chief substitutes for tellurium are selenium, bismuth, and lead in metallurgical applications; selenium and sulfur in rubber compound applications; and selenium, germanium, and organic compounds in electronic applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Imports of boron and tellurium are grouped together under the Harmonized Code System; however, imports of boron are thought to be small relative to tellurium.
[2]Yearend prices quoted by the sole producer.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions. Tellurium contained in copper resources only.
[6]In addition to the countries listed, Australia, Belgium, China, France, Germany, Kazakstan, the Philippines, Russia, and the United Kingdom produce refined tellurium, but output is not reported and available information is inadequate for formulation of reliable production estimates.

THALLIUM

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

Domestic Production and Use: Thallium is a byproduct metal recovered in some countries from flue dusts and residues collected in the smelting of copper, zinc, and lead ores. Although thallium was contained in ores mined or processed in the United States, it was not recovered domestically in 1996. The estimated value of thallium consumed in 1996 was $360,000. Research and development in the use of thallium-base superconductor materials accounted for a significant portion of domestic consumption in 1996. Thallium also was used in electronics, alloys, glass manufacturing, and pharmaceuticals.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Imports for consumption[1]	838	273	630	1,179	200
Exports	NA	NA	NA	NA	NA
Consumption[e]	800	300	630	700	300
Price, metal, dollars per kilogram[2]	750	800	950	1,100	1,200
Net import reliance[3] as a percent of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1992-95): Belgium, 52%; Canada, 24%; and Mexico, 24%.

Tariff: Item	Number	Most favored nation (MFN)[4] 12/31/96	Non-MFN[5] 12/31/96
Unwrought; waste and scrap; powders	8112.91.6000	4.9% ad val.	25% ad val.

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

Government Stockpile: None.

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THALLIUM

Events, Trends, and Issues: Research and development activities of both a basic and applied nature were conducted during 1996 to improve and expand the use of thallium. These experimental activities concerned essentially all existing uses of thallium as well as its potential use in superconductor alloys.

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. The United Nations Environment Program's Basel Convention, instituted to control the export of "hazardous wastes" from developed to developing nations, currently includes thallium, thallium compounds, and metal waste consisting of alloys of thallium among its list of hazardous materials to be banned from export. It is expected that, in accordance with the Basel Convention, export restrictions on thallium-containing materials will be in place by January 1, 1998.

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

	Mine production		Reserves[7]	Reserve base[7]
	1995	1996		
United States	([8])	([8])	32,000	120,000
Other countries	15,000	15,000	350,000	530,000
World total (may be rounded)	15,000	15,000	380,000	650,000

World Resources: World resources of thallium contained in zinc resources are about 17 million kilograms; most are located in Europe, Canada, and the United States. An additional 630 million kilograms is in the world's coal resources. The average thallium content of the Earth's crust has been estimated at 0.7 parts per million.

Substitutes: While other light-sensitive materials can substitute for thallium and its compounds in specific electronic applications, ample supplies of thallium discourage development of substitute materials.

[e]Estimated. NA Not available.
[1]Unwrought; waste and scrap; powders, including thallium contained in compounds.
[2]Estimated price of 99.999%-pure granules in 100-gram lots.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]No tariff for Canada and Mexico according to the North American Free Trade Agreement.
[5]See Appendix B.
[6]Estimates, based on thallium content of zinc ores.
[7]See Appendix C for definitions.
[8]Thallium contained in mined base metal ores, estimated at 450 to 500 kilograms per year, is separated from the base metals but not extracted for commercial use.

THORIUM

(Data in metric tons of thorium oxide (ThO_2) equivalent, unless otherwise noted)

Domestic Production and Use: Monazite, a rare-earth and thorium phosphate mineral, is the primary source of the world's thorium. It was not mined domestically in 1996. In prior years, monazite had been recovered by dredging methods by a company at Green Cove Springs, FL. Production had been as a byproduct during processing for titanium and zirconium minerals and monazite was recovered for its rare-earth content. Essentially all thorium compounds and alloys consumed by the domestic industry were derived from imports, stocks of previously imported materials, or materials shipped from U.S. Government stockpiles. About eight companies processed or fabricated various forms of thorium for nonenergy uses, such as ceramics, carbon arc lamps, magnesium-thorium alloys, and welding electrodes. The value of thorium metal, alloys, and compounds used by the domestic industry was estimated to be about $1 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, refinery[1]	—	—	—	—	—
Imports: Thorium ore and concentrates (monazite), gross weight	—	—	—	40	12
Imports: Compounds	14	18	3	20	29
Exports: Thorium ore and concentrates (monazite), gross weight	5	—	33	—	([2])
Exports: Compounds	([2])	([2])	([2])	([2])	([2])
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, reported[e]	40	13	17.3	18.1	NA
Price, yearend, dollars per kilogram:					
Nitrate, welding-grade[3]	5.46	5.46	5.46	5.46	5.46
Nitrate, mantle-grade[4]	21.36	22.25	23.30	23.30	23.30
Oxide, yearend: 99.0% purity[5]	63.80	65.00	63.80	NA	NA
99.9% purity[5]	NA	NA	NA	88.50	90.00
99.99% purity	107.00	107.00	107.25	107.25	107.25
Stocks, industrial, yearend	NA	NA	NA	NA	NA
Employment, mine	—	—	—	—	—
Net import reliance[6] as a percent of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1992-95): Monazite: Australia, 89%; and Malaysia, 11%. Thorium compounds: France, 99%; and Canada, Switzerland, and United Kingdom, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[7] 12/31/96
Thorium ores and concentrates (monazite)	2612.20.0000	Free	Free.
Thorium compounds	2844.30.1000	6.9% ad val.	35% ad val.

Depletion Allowance: Percentage method: Monazite, 22% on thorium content, 14% on rare-earth and yttrium content (Domestic); 14% (Foreign).

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Thorium nitrate	3,219	—	2,969	—
(thorium oxide equivalent in thorium nitrate)	1,539	—	1,420	—

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THORIUM

Events, Trends, and Issues: Domestic mine production of thorium-bearing monazite ceased at the end of 1994 as world demand for thorium-bearing ores remained depressed. Imports supplied essentially all of the thorium consumed in the United States in 1996. Imports of thorium compounds increased from the previous year to meet demand in catalysis. Overall, domestic consumption remained small at 18.1 tons, a slight increase from the previous year.

Based on import data through July 1996, the unit value of imports of thorium ore and concentrates (monazite), was $406 per metric ton gross weight. The average value of thorium compounds, imported during the same time period, was $58 per kilogram.

Worldwide demand for thorium-bearing rare-earth ores remained low. A French firm continued to seek approval to build a monazite separation plant in Pinjarra, Western Australia, Australia. The disposal of thorium is the primary concern in obtaining permitting for the Australian plant. The company reinitiated development of the Pinjarra project as a result of the French Government's decision in 1994 to disallow any further disposal of thorium residues within the country.

The use of thorium in the United States has decreased significantly since 1990. Increased costs to monitor and dispose of thorium have caused the domestic processors to switch to thorium-free materials.

Real and potential costs related to compliance with State and Federal regulations, proper disposal, and monitoring of thorium's radioactivity have limited thorium's commercial value. It is forecast that thorium's use will continue to decline unless a low-cost disposal process is developed.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production 1995	Refinery production 1996	Reserves[8]	Reserve base[8]
United States	—	—	160,000	300,000
Australia	—	—	300,000	340,000
Brazil	NA	NA	16,000	18,000
Canada	NA	NA	100,000	100,000
India	NA	NA	290,000	300,000
Malaysia	—	—	4,500	4,500
Norway	—	—	170,000	180,000
South Africa	NA	NA	35,000	39,000
Other countries	NA	NA	90,000	100,000
World total (rounded)	NA	NA	1,200,000	1,400,000

Reserves and reserve base are contained primarily in the rare-earth ore mineral, monazite. Without demand for the rare earths, monazite would probably not be recovered for its thorium content. Other ore minerals with higher thorium contents, such as thorite, would be more likely sources if demand significantly increased. No new demand, however, is expected. Reserves exist primarily in recent and ancient placer deposits. Lesser quantities of thorium-bearing monazite reserves occur in vein deposits and carbonatites.

World Resources: Thorium resources occur in provinces similar to those of reserves. The largest share are contained in placer deposits. Resources of more than 500,000 tons are contained in placer, vein, and carbonatite deposits. Disseminated deposits in various other alkaline igneous rocks contain additional resources of more than 2 million tons. Large thorium resources are found in Australia, Brazil, Canada, Greenland, India, South Africa, and the United States.

Substitutes: Nonradioactive substitutes have been developed for many applications for thorium. Yttrium compounds have replaced thorium compounds in incandescent lamp mantles. A magnesium alloy containing lanthanides, zirconium, and yttrium can substitute for magnesium-thorium alloys in aerospace applications.

[e]Estimated. NA Not available.
[1]All domestically consumed thorium was derived from imported materials.
[2]Less than ½ unit.
[3]Source: U.S. Department of Defense, Defense Logistics Agency. Based on sales from the National Defense Stockpile.
[4]Source: Rhône-Poulenc Basic Chemicals Co., f.o.b. port of entry, duty paid, ThO_2 basis, f.o.b. Ontario, Canada, duty unpaid, 1992-93. Rhône-Poulenc Basic Chemicals Co., Shelton, CT, 1994-96.
[5]Source: Rhône-Poulenc Basic Chemicals Co., f.o.b. port of entry, duty paid.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix B.
[8]See Appendix C for definitions.

TIN

(Data in metric tons of contained tin, unless otherwise noted)

Domestic Production and Use: In 1996, there was no domestic tin mine production. Production of tin at the only U.S. tin smelter, at Texas City, TX, stopped in 1989. Twenty-five firms consumed about 85% of the primary tin. The major uses were as follows: cans and containers, 30%; electrical, 20%; construction, 10%; transportation, 10%; and other, 30%. The estimated value of primary metal consumption in 1996, based on the New York composite price, was $356 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine	([1])	([1])	([1])	—	—
Secondary (old scrap)	8,900	6,900	7,400	7,600	8,000
Secondary (new scrap)	4,800	5,100	4,300	3,500	4,000
Imports for consumption: Refined tin	27,300	33,700	32,400	33,200	33,000
Exports: Refined tin	1,890	2,600	2,560	2,790	3,600
Shipments from Government stockpile excesses	6,310	6,020	5,620	5,000	11,000
Consumption reported: Primary	35,000	34,600	33,700	35,100	36,000
Secondary	10,100	11,900	8,530	10,700	10,000
Consumption, apparent	43,600	44,200	43,300	47,000	48,400
Price, average, cents per pound:					
New York market	283	239	255	295	291
New York composite	402	350	369	416	449
London	277	233	248	282	281
Kuala Lumpur	272	232	245	278	277
Stocks, consumer and dealer, yearend	10,700	10,800	10,400	11,400	10,000
Employment, mine and primary smelter,[e] number	5	5	—	—	—
Net import reliance[2] as a percent of apparent consumption	80	84	83	84	83

Recycling: About 12,000 tons of tin from old and new scrap was recycled in 1996. Of this, about 7,600 tons was recovered from old scrap at 7 detinning plants and 110 secondary nonferrous metal processing plants.

Import Sources (1992-95): Brazil, 30%; Bolivia, 21%; Indonesia, 18%; China, 15%; and other, 16%.

Tariff: Most major imports of tin, including unwrought metal, waste and scrap, and unwrought tin alloys, enter duty free.

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Pig tin	115,879	—	115,879	11,355

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TIN

Events, Trends, and Issues: The Steel Recycling Institute (SRI), Pittsburgh, PA, announced that the domestic steel can recycling rate reached 56% in 1995, compared with a 53% rate in 1994. SRI observed that 1995's figures represented 18 billion steel cans weighing 1.5 million tons. SRI continued to emphasize the importance of aerosol can recycling and noted that 90 million Americans had access to aerosol can recycling programs being conducted in 3,600 communities.

Public Law 104-201 provided for continued tin disposals from the National Defense Stockpile. Daily spot sales were the major method of disposal, with one long-term contract sale for 5,000 tons made in September. The Defense Logistics Agency (DLA), announced that it would drastically alter its sales procedures for fiscal year 1997 by conducting two long-term negotiated bid sales for 5,000 tons each (in February and July) and by conducting monthly spot sales (held the first Wednesday of each month) for 200 tons each until 2,000 tons were sold. This approach represented a major shift by DLA toward long-term contract sales and away from spot sales. DLA announced that its Annual Materials Program for fiscal year 1997 called for sales of up to 12,000 tons of stockpile tin. Stockpile tin is warehoused at 10 depots, with the largest holdings at Hammond, IN, and Anniston, IL.

A major domestic tinplate producer proceeded with construction of a new joint-venture tinplate mill in Belmont County, OH. Completion was anticipated for late 1996, and the cost was estimated at $80 million. It would be the first domestic tinplating facility built since the early 1960's and would replace that producer's current 50-year-old tin mill.

The world tin industry's major research and development laboratory, based in the United Kingdom, was in its second full year under its new structure. It is now privatized, with funding supplied by numerous major tin producing firms rather than by the Association of Tin Producing Countries. The organization reported progress in several areas of research to develop new tin uses; among these was a tinfoil capsule to replace lead foil capsules on wine bottles, and a new noncyanide-based electrolyte called "Stanzec" that produces a coating of tin and zinc that could replace cadmium as an environmentally acceptable anticorrosion coating on steel.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	1995	1996[e]		
United States	—	—	20,000	40,000
Australia	8,180	8,000	210,000	600,000
Bolivia	14,400	16,000	450,000	900,000
Brazil	16,800	18,000	1,200,000	2,500,000
China	52,000	50,000	1,600,000	1,600,000
Indonesia	38,400	38,000	750,000	820,000
Malaysia	6,400	5,000	1,200,000	1,200,000
Peru	22,300	22,000	20,000	40,000
Portugal	8,000	8,000	70,000	70,000
Russia	9,000	9,000	300,000	300,000
Thailand	3,000	3,000	940,000	940,000
Zaire	1,000	1,000	510,000	510,000
Other countries	10,000	13,000	180,000	620,000
World total (may be rounded)	189,000	190,000	7,000,000	10,000,000

World Resources: U.S. resources of tin, primarily in Alaska, were insignificant compared with those of the rest of the world. Sufficient world resources, principally in western Africa, southeastern Asia, Australia, Bolivia, Brazil, China, and Russia were available to sustain current production rates well into the next century.

Substitutes: Aluminum, glass, paper, plastic, or tin-free steel substitute for tin in cans and containers. Other materials that substitute for tin are epoxy resins for solder; aluminum alloys, copper-base alloys, and plastics for bronze; plastics for bearing metals that contain tin; and compounds of lead and sodium for some tin chemicals.

[e] Estimated.
[1] Negligible.
[2] Defined as imports - exports + adjustments for Government and industry stock changes.
[3] See Appendix C for definitions.

TITANIUM AND TITANIUM DIOXIDE[1]

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Titanium sponge metal was produced by two firms with operations in Nevada and Oregon. Ingot was made by the two sponge producers and by nine other firms in seven States. About 30 companies produced titanium forgings, mill products, and castings. In 1996, an estimated 65% of the titanium metal used was in aerospace applications. The remaining 35% was used in the chemical process industry, power generation, marine, ordnance, medical, and other nonaerospace applications. The value of sponge metal consumed was about $286 million, assuming an average selling price of $4.50 per pound.

In 1996, titanium dioxide (TiO_2) pigment, valued at about $2.6 billion, was produced by 5 companies at 11 plants in 9 States. In 1996, TiO_2 was used in paint, varnishes, and lacquers, 47%; paper, 25%; plastics, 18%; and other, 10%. Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	**1992**	**1993**	**1994**	**1995**	**1996[e]**
Titanium metal:					
Production, sponge	W	W	W	W	W
Imports for consumption, sponge	684	2,160	6,470	7,560	8,970
Exports, all metal forms	8,020	7,890	9,660	10,800	12,100
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption of sponge metal, reported	14,200	15,100	17,200	21,500	28,800
Price, sponge, dollars per pound, yearend	3.75	3.75	4.00	4.40	4.50
Stocks, sponge, industry yearend[e]	1,929	2,905	5,570	5,270	4,000
Employment, reduction plants[e], number	350	350	300	300	300
Net import reliance,[2] sponge only, as a percent of apparent consumption	W	W	W	W	W
Titanium dioxide:					
Production	1,140,000	1,160,000	1,250,000	1,250,000	1,230,000
Imports for consumption	169,000	172,00	176,000	183,000	165,000
Exports	270,000	290,000	352,000	342,000	275,000
Consumption, apparent	1,000,000	1,030,000	1,090,000	1,080,000	1,140,000
Price, rutile, list, dollars per pound, yearend	0.94	0.94	0.93	1.01	1.09
Stocks, producer, yearend	108,000	123,000	106,000	120,000	98,300
Employment[e], number	4,500	4,600	4,600	4,600	4,600
Net import reliance[2] as a percent of apparent consumption	E	E	E	E	E

Recycling: New scrap metal recycled by the titanium industry was about 25,000 tons in 1996. In addition, estimated use of titanium as scrap and in the form of ferrotitanium made from scrap by the steel industry was 4,700 tons; by the superalloy industry, 730 tons; and in other industries, 510 tons. Old scrap reclaimed was about 200 to 400 tons. Minor amounts of TiO_2 were recycled.

Import Sources (1992-95): Sponge metal: Russia, 72%; Japan, 16%; China, 6%; Ukraine, 2%; and other, 4%. Titanium dioxide pigment: Canada, 36%; Germany, 13%; France, 12%; United Kingdom, 11%; and other, 28%.

Tariff: **Item**	**Number**	**Most favored nation (MFN) 12/31/96**	**Non-MFN[3] 12/31/96**
Waste and scrap metal	8108.10.1000	Free	Free.
Unwrought metal	8108.10.5000	15.0% ad val.	25.0% ad val.
Wrought metal	8108.90.6000	15.0% ad val.	45.0% ad val.
Titanium dioxide pigments	3206.10.0000	6.0% ad val.	30.0% ad val.
Titanium oxides	2823.00.0000	5.8% ad val.	30.0% ad val.

Depletion Allowance: Not applicable.

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TITANIUM AND TITANIUM DIOXIDE

Government Stockpile: In addition to the quantities shown below, the stockpile contained 9,860 tons of nonstockpile-grade sponge metal.

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Titanium sponge metal	23,600	—	—	—

Events, Trends, and Issues: In 1996, domestic production of titanium pigments was close to the record level achieved in 1995. Apparent domestic demand increased slightly while published prices increased moderately. Owing to depressed global demand, many pigment producers temporarily delayed the addition and expansion of capacity. However, several expansions were expected in 1997 and 1998 to meet expected increases in demand.

Demand for titanium metal products increased significantly in 1996. Increased demand was largely attributed to increased demand by the commercial aircraft market. However, demand by selected nonaerospace markets, particularly titanium golf clubs, experienced unexpectedly high growth. To meet increased demands, production of nearly all forms of titanium metal products increased significantly. Imports of titanium, primarily in the form of titanium sponge and waste and scrap, also increased significantly. The leading import sources were Russia, Japan, and the United Kingdom. At yearend, several producers were considering expanding their capability to produce titanium ingot.

World Sponge Metal Production and Sponge and Pigment Capacity:

	Sponge production		Capacity 1996	
	1995	1996[e]	Sponge	Pigment
United States	W	W	29,500	1,360,000
Australia	—	—	—	164,000
Belgium	—	—	—	80,000
Canada	—	—	—	91,000
China[e]	2,000	2,000	7,000	45,000
Finland	—	—	—	80,000
France	—	—	—	225,000
Germany	—	—	—	350,000
Italy	—	—	—	80,000
Japan	16,700	20,500	25,800	326,000
Kazakstan[e]	5,000	9,000	35,000	1,000
Russia[e]	16,000	21,000	35,000	20,000
Spain	—	—	—	65,000
Ukraine[e]	—	—	—	120,000
United Kingdom[e]	—	—	—	275,000
Other countries	—	—	—	585,000
World total (may be rounded)	[4]33,000	[4]35,000	130,000	3,900,000

World Resources: Resources of titanium minerals are discussed in the sections on ilmenite and rutile. Most titanium for domestic sponge production was obtained from rutile or rutile substitutes. The sources for pigment production were ilmenite, slag, and rutile.

Substitutes: There are few substitutes for titanium in aircraft and space use without some sacrifice of performance. For industrial uses, high-nickel steel, zirconium, and, to a limited extent, the superalloy metals may be substituted. There is no cost-effective substitute for TiO_2 pigment.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data.
[1]See also Ilmenite and Rutile.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]Excludes U.S. production.

TUNGSTEN

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

Domestic Production and Use: In 1996, one mine in California produced tungsten concentrate. The mine operated at an annual rate well below capacity. End uses of tungsten included metalworking, mining, and construction machinery and equipment, 80%; electrical and electronic machinery and equipment and transportation, 9%; lamps and lighting, 8%; chemicals, 2%; and other, 1%. The total estimated value of primary tungsten materials consumed in 1996 was $400 million.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine shipments	W	W	W	W	W
Imports for consumption, concentrate	2,500	1,700	3,000	4,200	3,100
Exports, concentrate	38	63	44	10	32
Government stockpile shipments, concentrate	—	—	—	—	—
Consumption: Reported, concentrate	4,300	[1]2,900	[1]3,600	6,300	6,200
Apparent, all forms	7,100	7,100	10,900	14,000	15,100
Price, concentrate, dollars per mtu WO_3,[2] average:					
U.S. spot market, Metals Week	56	43	45	62	67
European market	58	35	42	64	55
Stocks, producer and consumer, yearend concentrate	750	640	800	675	680
Employment, mine and mill, number	47	33	20	20	20
Net import reliance[3] as a percent of apparent consumption	86	82	81	84	82

Recycling: During 1996, the quantity of scrap reprocessed into intermediates was about 2,700 tons, representing approximately 18% of apparent consumption of tungsten in all forms.

Import Sources (1992-95): China, 30%; Russia, 13%; Germany, 10%; Bolivia, 7%; and other, 40%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Ore	2611.00.3000	Free	$1.10/kg W cont.
Concentrate	2611.00.6000	37.5¢/kg W cont.	$1.10/kg W cont.
Ferrotungsten	7202.80.0000	5.6% ad val.	35.0% ad val.
Tungsten powders	8101.10.0000	9.1% ad val.	58.0% ad val.
Ammonium tungstate	2841.80.0010	8.2% ad val.	49.5% ad val.
Tungsten carbide	2849.90.3000	9.5% ad val.	55.5% ad val.

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

Government Stockpile: The inventory shown below includes the following quantities of nonstockpile-grade tungsten (tons): ore and concentrate, 10,060; ferrotungsten, 533; metal powder, 151; and carbide powder, 51.

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Ore and concentrate	34,600	—	—	—
Metal powder	900	—	—	—
Ferrotungsten	900	—	—	—
Carbide powder	900	—	—	—

Events, Trends, and Issues: Apparent consumption of tungsten products increased by about 8% during 1996 compared with that of 1995, resulting from a slowing of the continued growth in the U.S. economy that began in late 1993. Demand for cemented carbide end-use products was particularly strong compared with that of 1995, whereas demand in most other end-use sectors decreased from that of the previous year. Demand for ferrotungsten, however, was about the same.

Availability of tungsten materials from China, the major supplier to the world market, became progressively more limited during 1996. Early in the year, China cut tungsten exports by 5% because of its reduced reserves and weak

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TUNGSTEN

prices in the international markets. This was followed by a 1-month annual maintenance shutdown of China's major tungsten mines and ammonium paratungstate plants. By midyear, China had resumed production at approximately one-half of its major tungsten mines. However, most of its small-sized mines were closed owing to shortages of electrical supply.

During 1996, world market supply met demand not through an increase in mine production, but rather through major drawdown of stocks. At midyear, there was no active mining in the Commonwealth of Independent States (CIS), no CIS stock releases in the prior 2 months, and claims by China that no more of their stocks were available. In addition, Russian producers of tungsten concentrate had to operate with prolonged down times owing to low prices, thereby incurring debts. Hence, the future supply of tungsten is uncertain unless more mines are open and new deposits are utilized.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	W	W	140,000	200,000
Australia	—	—	1,000	200,000
Austria	—	—	10,000	15,000
Bolivia	800	800	53,000	100,000
Brazil	100	100	20,000	20,000
Burma	500	500	15,000	34,000
Canada	—	—	260,000	490,000
China	21,000	20,000	940,000	1,300,000
France	—	—	20,000	20,000
Kazakstan	100	100	—	38,000
Korea, North	900	900	—	35,000
Korea, Republic of	—	—	58,000	77,000
Portugal	500	500	25,000	25,000
Russia	5,400	5,400	250,000	420,000
Tajikistan	100	75	23,000	
Thailand	60	60	30,000	30,000
Turkmenistan	—	—	—	10,000
Uzbekistan	300	300	—	20,000
Other countries	1,000	1,000	280,000	360,000
World total (may be rounded)	31,000	30,000	2,100,000	3,300,000

World Resources: More than 90% of the world's estimated tungsten resources are outside the United States, with about 45% in China. In addition to China and the United States, countries with significant resources are Australia, Austria, Bolivia, Brazil, Burma, Canada, Kazakstan, North Korea, Republic of Korea, Peru, Portugal, Russia, Spain, Tajikistan, Thailand, Turkey, Turkmenistan, and Uzbekistan.

Substitutes: Cemented tungsten carbide remained a primary cutting-tool insert material because of its versatility in meeting technical requirements in many turning and milling operations. However, ceramics, ceramic-metallic composites, and other materials continued to be developed and utilized as substitutes to meet the changing needs of the world market. Increased quantities of carbide cutting-tool inserts were coated with nitrides, oxides, and carbides to extend the life of the inserts. Tungsten remained the preferred and essentially unsubstitutable material for filaments, electrodes, and contacts in lamp and lighting applications. An electrodeless, nontungsten lamp was introduced to the market for commercial and industrial use.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

[1]Excludes 3 months of withheld data.

[2]A metric ton unit (mtu) of tungsten trioxide (WO_3) contains 7.93 kilograms of tungsten.

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

[4]See Appendix B.

[5]See Appendix C for definitions.

VANADIUM

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

Domestic Production and Use: The U.S. vanadium industry consisted of nine firms, but only eight had active operations. Raw materials included Idaho ferrophosphorus slag, petroleum residues, spent catalysts, utility ash, and vanadium-bearing iron slag. The chief use of vanadium was as an alloying agent for iron and steel. Vanadium was also important in the production of aerospace titanium alloys and as a catalyst for the production of maleic anhydride and sulfuric acid. Major end-use distribution was as follows: transportation, 27%; building and heavy construction, 33%; machinery and tools, 28%; and other, 12%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production:					
Mine, recoverable basis	W	W	W	W	W
Mill, recovered basis[1]	W	W	W	W	W
Petroleum residues, recovered basis	1,350	2,870	2,830	1,990	2,650
Imports for consumption:					
Ores, slag, residues	838	1,450	1,900	1,900	1,750
Vanadium pentoxide, anhydride	206	70	294	547	460
Oxides and hydroxides, other	103	19	3	36	25
Aluminum-vanadium master alloys (gross weight)	50	19	38	78	90
Ferrovanadium	592	1,630	1,910	1,950	1,900
Exports:					
Vanadium pentoxide, anhydride	26	126	335	229	250
Oxides and hydroxides, other	1,110	895	1,050	1,010	1,100
Aluminum-vanadium master alloys (gross weight)	60	866	1,030	660	700
Other compounds	2,020	989	—	—	—
Ferrovanadium	213	219	374	340	350
Shipments from Government stockpile	—	—	—	—	—
Consumption: Reported	4,080	3,970	4,280	4,640	4,700
Consumption: Apparent	W	W	W	W	W
Price, average, dollars per pound V_2O_5	2.28	1.45	2.95	2.80	3.19
Stocks, producer and consumer, yearend	1,080	900	1,110	1,100	980
Employment, mine and mill, number	430	430	400	390	390
Net import reliance[2] as a percent of apparent consumption	W	W	W	W	W

Recycling: Some tool steel scrap was recycled primarily for its vanadium content. Vanadium was also recycled as a minor component of scrap iron and steel alloys, which were recycled principally for their iron content. An increasing amount of vanadium was also recycled from spent chemical process catalysts.

Import Sources (1992-95):[3] South Africa, 33%; Canada, 17%; Russia, 12%; Mexico, 6%; Germany, 5%; and other, 27%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[4] 12/31/96
Slag	2619.00.9000	Free	Free.
Ash and residues	2620.50.0000	Free	Free.
Vanadium pentoxide anhydride	2825.30.0010	13.9% ad val.	40% ad val.
Vanadium oxides and hydroxides, other	2825.30.0050	16.0% ad val.	40% ad val.
Vanadates	2841.90.1000	10.1% ad val.	40% ad val.
Ferrovanadium	7202.92.0000	4.2% ad val.	25% ad val.
Aluminum-vanadium master alloys	7601.20.9030	Free	10.5% ad val.
Waste and scrap	8112.40.3000	Free	Free.

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

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VANADIUM

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Vanadium pentoxide	373	17	146	89

Events, Trends, and Issues: The U.S. International Trade Commission (ITC) determined on June 22, 1995, that ferrovanadium and nitrided vanadium imports from Russia caused injury to U.S. industry, and Russian exporters to the United States were subjected to antidumping deposits. The result of the ITC action was that Russia lost its role as the top supplier of ferrovanadium to the U.S. market. U.S. ferrovanadium imports in 1995 totaled 1,954 tons, an increase of only 9% over 1994 imports. Russia accounted for 59% of 1994 imports, but only 8% in 1995. Belgium, China, the Czech Republic, the Republic of Korea, and South Africa, none of which shipped ferrovanadium to the United States in 1994, made up the difference in imports from Russia. Together they accounted for 47% of imports in 1995. Ferrovanadium imports in the first 6 months of 1996 totaled 855 tons. The Czech Republic increased its share of imports from 15% in all of 1995 to 31% in the first 7 months of 1996. Canada was in first place with a 34% share, while Russia declined to less than 4%.

Vanadium consumption in the United States for the first 7 months of 1996 increased by about 9% over consumption in the first 7 months of 1995. Consumption in the two largest end use categories, carbon steel and full alloy steel, increased by 12% and 40%, respectively. Consumption in the tool steel end use category was essentially unchanged, while consumption in the high-strength low-alloy end use category decreased 16%.

World Mine Production, Reserves, and Reserve Base:

	Mine production 1995	Mine production 1996[e]	Reserves[5]	Reserve base[5]
United States	W	W	45,000	4,000,000
Australia	—	—	30,000	350,000
Brazil	—	—	—	24,000
China	5,000	5,500	2,000,000	3,000,000
Finland	—	—	—	100,000
Russia	10,000	10,500	5,000,000	7,000,000
South Africa	15,500	16,000	3,000,000	12,000,000
Other countries	3,200	3,500	—	1,000,000
World total (may be rounded)	[6]33,700	[6]36,000	10,000,000	27,000,000

World Resources: World resources of vanadium exceeded 63 million tons. Vanadium occurs in deposits of titaniferous magnetite, phosphate rock, and uraniferous sandstone and siltstone, in which it constitutes less than 2% of the host rock. Significant amounts are also present in bauxite and carboniferous materials, such as crude oil, coal, oil shale, and tar sands. Because vanadium is usually recovered as a byproduct or coproduct, demonstrated world resources of the element are not fully indicative of available supplies. While domestic resources are adequate to supply current domestic needs, a substantial part of U.S. demand is currently met by foreign material because of price advantages.

Substitutes: Steels containing various combinations of other alloying elements can be substituted for steels containing vanadium. Among various metals that are to some degree interchangeable with vanadium as alloying elements in steel are columbium, manganese, molybdenum, titanium, and tungsten. 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. W Withheld to avoid disclosing company proprietary data.
[1]Produced from domestic materials.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]The European Union, Canada, and Austria produced vanadium alloys and chemicals solely from imported raw materials.
[4]See Appendix B.
[5]See Appendix C for definitions.
[6]Excludes U.S. mine production and production from petroleum residues.

VERMICULITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: One company, with mining and processing facilities in South Carolina, remained the largest producer of vermiculite concentrate. Three other companies each had an active operation for producing concentrate, two in South Carolina and one in Virginia. Most of the vermiculite concentrate was shipped to 22 exfoliating plants in 15 States. The end uses for exfoliated vermiculite were estimated to be agriculture, 55%; insulation, 26%; and lightweight concrete aggregates (including concrete, plaster, and cement premixes) and other, 19%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production[1]	190	190	180	170	W
Imports for consumption[e]	40	30	30	30	30
Exports[e]	8	7	7	6	5
Consumption, apparent, concentrate	222	213	203	194	W
Consumption, exfoliated	140	140	130	130	130
Price, average value, concentrate, dollars per ton, f.o.b. mine	W	W	W	W	W
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill[e], number	230	230	230	230	230
Net import reliance[2] as a percent of apparent consumption	14	11	11	12	W

Recycling: Insignificant.

Import Sources (1992-95):[e] South Africa, 99%; and other, 1%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Mineral substances not specifically provided for	2530.10.0000	Free	Free.
Exfoliated vermiculite as mixtures and articles of heat-insulating, sound-insulating, or sound-absorbing materials	6806.20.0000	2.9% ad val.	30% ad val.

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

Government Stockpile: None.

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VERMICULITE

Events, Trends, and Issues: Besides the traditional end uses for vermiculite, possible new applications include detoxification of water and soil, nuclear waste containment and removal, and industrial spill containment and clean-up.

Prices for South African vermiculite exported to Europe were reported to have increased in the first half of 1996 by 9% to 13%. The lowest grade material, fine, bulk, f.o.b. Rotterdam, increased to $180 per ton. High grade, large flake material, f.o.b. Rotterdam, reached $260 per ton. South African vermiculite imported into the United States was listed in late 1996, bulk, f.o.b. barge, Gulf Coast, at $127 per ton for fine material and $209 per ton for high-grade material.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1995	1996[e]		
United States[1]	170	W	25,000	100,000
Russia	40	40	NA	NA
South Africa	222	220	20,000	80,000
Other countries[5]	46	60	5,000	20,000
World total	478	[6]320	50,000	200,000

World Resources: Marginal reserves of vermiculite, occurring in Colorado, Nevada, North Carolina, Texas, and Wyoming, are estimated to be 2 to 3 million tons. Resources in other countries may include material that does not exfoliate as well as U.S. and South African vermiculite. Total world resources are estimated to be up to three times the reserve amount.

Substitutes: Expanded perlite is a substitute for vermiculite in lightweight concrete and plaster. Other more dense but less costly material substitutes in these applications are expanded clay, shale, slate, and slag. Alternate materials for loosefill fireproofing insulation include fiberglass, perlite, and slag wool. In agriculture, substitutes include peat, perlite, sawdust, bark and other plant materials, and synthetic soil conditioners.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Concentrate sold and used by producers.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]Excludes the United States (1996) and countries for which information is not available.
[6]Excludes the United States.

YTTRIUM[1]

(Data in metric tons of yttrium oxide (Y_2O_3) content, unless otherwise noted)

Domestic Production and Use: The rare-earth element, yttrium, was mined by one company as a constituent of the mineral bastnasite, but was not recovered as a separate element during processing. Bastnasite, a rare-earth fluocarbonate mineral, was mined as a primary product by one company at Mountain Pass, CA. Bastnasite's yttrium content is very small, and represents a potential minor source of the element. Yttrium used by the domestic industry was imported primarily as compounds.

Yttrium was used in many applications. Principal uses were in phosphors used in color televisions and computer monitors, trichromatic fluorescent lights, temperature sensors, and X-ray intensifying screens. As a stabilizer in zirconia, yttrium was used in wear-resistant and corrosion-resistant cutting tools, seals and bearings, high-temperature refractories for continuous-casting nozzles, jet engine coatings, oxygen sensors in automobile engines, and simulant gemstones. In electronics, yttrium-iron-garnets were components in microwave radar to control high frequency signals. Yttrium was an important component in yttrium-aluminum garnet laser crystals used in industrial cutting and welding, medical and dental surgical procedures, temperature and distance sensing, photoluminescence, photochemistry, digital communications, and nonlinear optics. Yttrium was also used in heating-element alloys, superalloys, and high-temperature superconductors. The approximate distribution in 1995 by end use was as follows: lamp and cathode ray tube phosphors, 66%; structural ceramics and components, 29%; oxygen sensors, laser crystals, and miscellaneous, 5%.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production, mine	W	W	W	—	—
Imports for consumption:					
In monazite	—	—	—	0.4	—
In xenotime and yttrium concentrate[2]	NA	NA	NA	NA	NA
Exports, in ore and concentrate	NA	NA	NA	NA	NA
Consumption, estimated	NA	NA	344	365	370
Stocks, processor, yearend	NA	NA	NA	NA	NA
Net import reliance[e 3] as a percent of apparent consumption	100	100	100	100	100
Price, dollars:[4]					
Monazite concentrate, per metric ton	207-241	204-238	233-272	222-259	237-277
Yttrium oxide, per kilogram, 99.0% to 99.99% purity	15-116	16-116	20-116	17-110	17-85
Yttrium metal, per kilogram, 99.0% to 99.9% purity	140-550	135-350	135-350	150-200	95-200

Recycling: Small quantities, primarily from laser crystals and synthetic garnets.

Import Sources (1995):[e] Yttrium compounds: China, 69%; and Japan, 31%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[5] 12/31/96
Thorium ores and concentrates (monazite)	2612.20.0000	Free	Free.
Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed	2805.30.0000	5.0% ad val.	31.3% ad val.
Yttrium bearing materials and compounds containing by weight >19% but<85% Y_2O_3	2846.90.4000	Free	25% ad val.
Rare-earth compounds, including yttrium oxide, yttrium nitrate, and other individual compounds	2846.90.8000	3.7% ad val.	25% ad val.

Depletion Allowance: Percentage method: Monazite: 22% on thorium content and 14% on yttrium and rare-earth content (Domestic), 14% (Foreign). Xenotime: 14% (Domestic and Foreign).

Government Stockpile: None.

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YTTRIUM

Events, Trends, and Issues: Yttrium demand increased in 1996 as prices were stable to slightly lower. Yttrium markets continued to be competitive, although China was the source of most of the world's supply. The U.S. economy showed strong growth in the first half of 1996, and demand for yttrium in most uses increased.

Yttrium was consumed primarily in the form of high-purity compounds, especially the oxide and nitrate.

World Mine Production, Reserves, and Reserve Base:

	Mine production[6]		Reserves[7]	Reserve base[7]
	1995	1996[e]		
United States	—	—	120,000	130,000
Australia	—	—	100,000	110,000
Brazil	15	15	400	1,500
Canada	—	—	3,300	4,000
China	1,274	1,300	220,000	240,000
India	55	55	36,000	38,000
Malaysia	8	8	13,000	21,000
South Africa	14	14	4,400	5,000
Sri Lanka	2	2	240	260
Thailand	1	1	600	600
Former Soviet Union[8]	60	60	9,000	10,000
Zaire	1	1	570	630
World total (rounded)	1,450	1,460	510,000	560,000

World Resources: Large resources of yttrium in monazite and xenotime are available worldwide in ancient and recent placer deposits (monazite and xenotime), weathered clay deposits (ion-adsorption ore), carbonatites, and uranium ores. Additional large subeconomic resources of yttrium occur in other monazite-bearing deposits, apatite-magnetite rocks, sedimentary phosphate deposits, deposits of columbium-tantalum minerals, and certain uranium ores, especially those of the Blind River District in Canada. It is probable that the world's resources are very large relative to expected demand.

Substitutes: Substitutes for yttrium are available for some applications, but generally are much less effective. In most uses, especially in phosphors, electronics, and lasers, yttrium is not subject to substitution by other elements. As a stabilizer in zirconia ceramics, yttria may be substituted with calcia or magnesia.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]See also Rare-Earths and Scandium.
[2]This import category typically includes yttrium concentrates.
[3]Essentially all yttrium consumed domestically was imported or refined from imported ores and concentrates.
[4]Monazite concentrate price derived from Metals Bulletin; yttrium concentrate prices from Industrial Minerals (London); yttrium oxide and metal prices from Elements (a TradeTech publication), Molycorp Inc., and Rhône-Poulenc Basic Chemicals Co.
[5]See Appendix B.
[6]Includes yttrium contained in rare-earth ores.
[7]See Appendix C for definitions.
[8]As constituted before Dec. 1991.

ZINC

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

Domestic Production and Use: The value of zinc mined in 1996 was about $800 million. Essentially all came from 22 mines, and about 77% of it came from only 5 mines. More than 93% of the total mine output was from Alaska, Missouri, New York, and Tennessee; Alaska alone accounted for more than half. Three primary and eight secondary smelters refined zinc metal of commercial grade in 1996. About 75% of slab zinc consumption was in Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania. Of the total slab zinc consumed, about 55% was used in galvanizing, 20% in zinc-base alloys, 11% in brass and bronze, and 14% in other uses. Zinc compounds and dusts were used principally by the agricultural, chemical, paint, and rubber industries. Major coproducts of zinc mining and smelting were cadmium, germanium, lead, silver, and sulfur.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Mine, recoverable[1]	523	488	570	614	620
Primary slab zinc	272	240	217	232	230
Secondary slab zinc	128	141	139	131	130
Imports for consumption:					
Ore and concentrate	45	33	27	10	10
Refined zinc	644	724	793	856	840
Exports: Ore and concentrate	307	311	389	424	430
Refined zinc	1	1	6	3	1
Shipments from Government stockpile	—	18	39	14	20
Consumption: Apparent, refined zinc	1,050	1,120	1,180	1,240	1,240
Apparent, all forms	1,280	1,340	1,400	1,460	1,470
Price, average, cents per pound:					
Domestic producers	58.4	46.2	49.3	55.8	51.0
London Metal Exchange, cash	56.2	43.6	45.3	46.8	46.0
Stocks, slab zinc, yearend	82	77	80	71	60
Employment: Mine and mill[e], number	2,300	2,500	2,700	2,700	2,700
Smelter primary[e], number	1,500	1,300	1,000	1,000	1,000
Net import reliance[2] as a percent of apparent consumption of:					
Refined zinc	61	67	70	71	70
All forms of zinc	33	36	35	35	33

Recycling: In 1996, an estimated 355,000 tons of zinc in waste and scrap, including 115,000 tons in old scrap, was recovered in the form of slab zinc, brass, zinc-base alloys, dust, oxide, and other chemicals. Another 50,000 tons of zinc in scrap was exported, whereas 35,000 tons was imported.

Import Sources (1992-95): Ore and concentrate: Mexico, 52%; Peru, 33%; Canada, 5%; and other, 10%. Metal: Canada, 60%; Mexico, 11%; Spain, 9%; Peru, 5%; and other, 15%. Combined total: Canada, 60%; Mexico, 13%; Spain, 9%; and other, 18%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Canada 12/31/96	Mexico 12/31/96	Non-MFN[3] 12/31/96
Ore and concentrate	2608.00.0030	1.0¢/kg on lead content	0.3¢/kg on lead content	Free Free	3.7¢/kg on zinc content.
Unwrought metal	7901.11.0000	1.5% ad val.	0.3% ad val.	Free	5.0% ad val.
Alloys, casting-grade	7901.12.1000	12.6% ad val.	3.8% ad val.	13.3% ad val.	45.0% ad val.
Alloys	7901.20.0000	12.6% ad val.	3.8% ad val.	Free	45.0% ad val.
Waste and scrap	7902.00.0000	Free	Free	Free	11.0% ad val.
Hard zinc spelter	2620.11.0000	0.9% ad val.	0.3% ad val.	1.0% ad val.	5.0% ad val.
Zinc oxide	2817.00.0000	Free	Free	Free	5.5% ad val.

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ZINC

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

Government Stockpile:

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Zinc	259	5	259	13

Events, Trends, and Issues: Domestic mine production increased slightly in 1996, because of increased output at the Red Dog Mine in Alaska, the leading producer in the United States. Exports of zinc ore and concentrate increased slightly, to 430 tons. The United States is expected to remain the world's largest exporter of zinc concentrates and importer of zinc metal for at least the next decade, because of inadequate refinery production capacity. Available primary annual capacity in 1996 was 250,000 tons.

Domestic zinc consumption continued its upward trend. Most zinc metal was used for galvanizing and alloy production. The United States is the largest consumer of zinc and zinc products, but domestic metal production capacity accounts for less than one-fourth of the quantity consumed. Canada and Mexico are the leading sources of zinc to the United States, because of their geographical proximity and low tariffs. The North American Free Trade Agreement, which went into effect on January 1, 1994, lowered tariffs on zinc and zinc-containing products from Canada and Mexico.

World Mine Production, Reserves, and Reserve Base:

	Mine production[4]		Reserves[5]	Reserve base[5]
	1995	1996[e]		
United States	644	650	16,000	50,000
Australia	930	900	17,000	65,000
Canada	1,110	1,120	21,000	56,000
China	950	1,000	5,000	9,000
Mexico	364	350	6,000	8,000
Peru	689	700	7,000	12,000
Other countries	2,430	2,490	72,000	130,000
World total (may be rounded)	7,120	7,200	140,000	330,000

World Resources: Conventional identified zinc resources of the world are about 1.8 billion tons. Zinc-bearing coals, mostly in the central United States, also have a resource potential of millions of tons of zinc that could be recovered during coal beneficiation.

Substitutes: Aluminum, plastics, and magnesium are major competitors as diecasting materials. Aluminum, steel, and plastics substitute for galvanized sheet. Plastic coatings, paint, and cadmium and aluminum alloy coatings replace zinc for corrosion protection; aluminum alloys are used in place of brass. Many elements are substitutes for zinc in chemical, electronic, and pigment uses.

[e]Estimated.
[1]Zinc recoverable after smelting and refining.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]Zinc content of concentrate and direct shipping ore.
[5]See Appendix C for definitions.

ZIRCONIUM AND HAFNIUM

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Zircon sand was produced at two mines in Florida. Zirconium and hafnium metal were produced from zircon sand by two domestic producers, one each in Oregon and Utah. Both metals are present in the ore typically in a Zr to Hf ratio of 50:1. Primary zirconium chemicals were produced by the Oregon metal producer and at a plant in New Jersey. Secondary zirconium chemicals were produced by about 10 other companies as well. Zirconia (ZrO_2) was produced from zircon sand at plants in Alabama, New Hampshire, New York, and Ohio, and the metal producer in Oregon.

Zircon ceramics opacifiers, refractories, and foundry applications are the largest end uses for zirconium. Other end uses of zirconium include abrasives, chemicals, metal alloys, welding rod coatings, and sandblasting. The largest market for hafnium metal is as an addition in superalloys.

Salient Statistics—United States:	1992	1993	1994	1995	1996[e]
Production: Zircon (ZrO_2 content)[1]	70,300	W	W	W	W
Imports:					
Zirconium, ores and concentrates (ZrO_2 content)	24,300	45,500	53,300	60,800	61,900
Zirconium, alloys, waste and scrap (ZrO_2 content)	745	798	837	884	857
Zirconium oxide (ZrO_2 content)	NA	1,990	2,400	4,370	6,100
Hafnium, unwrought, waste and scrap	2	3	5	5	7
Exports:					
Zirconium ores and concentrates (ZrO_2 content)	18,100	23,400	20,800	26,200	24,200
Zirconium, alloys, waste and scrap (ZrO_2 content)	2,310	2,020	1,640	1,680	1,610
Consumption, zirconium ores and concentrates, apparent, (ZrO_2 content)[2]	78,000	W	W	W	W
Prices:					
Zircon, dollars per ton:					
Domestic	215	NA	278	319	400
Imported, f.o.b. U.S. east coast	255	200	220	325	400
Zirconium sponge, dollars per pound	9-12	9-12	9-12	9-12	9-12
Hafnium sponge, dollars per kilogram	165-210	165-210	165-210	165-210	165-210
Net import reliance[2] as a percent of apparent consumption					
Zirconium	8	W	W	W	W
Hafnium	NA	NA	NA	NA	NA

Recycling: Zirconium metal was recycled by four companies, one each in California, Michigan, New York, and Texas. The majority of the zirconium recycled came from scrap generated during metal production and fabrication. Zircon foundry mold cores and spent or rejected zirconia refractories are often recycled. Recycling of hafnium metal was insignificant.

Import Sources (1992-95): Zirconium ores and concentrates: Australia, 56%; South Africa, 43%; and other, 1%. Zirconium, wrought, unwrought, waste and scrap: France, 54%; Canada, 16%; Germany, 13%; Japan, 11%; and other, 6%. Hafnium, unwrought, waste and scrap: France, 93%; Germany, 4%; and other, 3%.

Tariff: Item	Number	Most favored nation (MFN) 12/31/96	Non-MFN[3] 12/31/96
Zirconium ores and concentrates	2615.10.0000	Free	Free.
Germanium oxides and ZrO_2	2825.60.0000	3.7 ad val.	25% ad val.
Ferrozirconium	7202.99.1000	4.2% ad val.	25% ad val.
Zirconium, waste and scrap	8109.10.3000	Free	Free.
Zirconium, other unwrought, powders	8109.10.6000	4.2% ad val.	25% ad val.
Zirconium, other wrought, alloys	8109.90.0000	4.8% ad val.	45% ad val.
Unwrought hafnium, waste and scrap	8112.91.2000	Free	25% ad val.

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

Government Stockpile: In addition to 14,500 tons of baddeleyite ore held in the National Defense Stockpile, the U.S. Department of Energy (DOE) held over 500 tons of zirconium in various forms. DOE also maintained a supply of approximately 35 tons of hafnium.

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ZIRCONIUM AND HAFNIUM

Stockpile Status—9-30-96

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposals Jan.-Sept. 96
Baddeleyite	14,500	—	—	—

Events, Trends, and Issues: Demand for zirconium ores and concentrates outpaced supply, causing prices to increase sharply. Shortages of material were expected in the coming years. Plans were underway to develop the Old Hickory deposit located south of Richmond, VA.

Availability of hafnium continued to exceed supply. Surpluses were stockpiled in the form of hafnium oxide. The demand for nuclear-grade zirconium metal, the production of which necessitates hafnium's removal, produces more hafnium than can be consumed by the metal's uses.

Zirconium and hafnium exhibit nearly identical properties and are not separated for most applications. However, zirconium and hafnium are separated for certain nuclear applications. Because hafnium is a strong absorber of thermal neutrons, zirconium-clad fuel rods in nuclear reactors are hafnium-free to improve reactor efficiency. At the same time, hafnium is used in reactor control rods to regulate the fission process through neutron absorption.

World Mine Production, Reserves, and Reserve Base: World primary hafnium production statistics are not available. Hafnium occurs with zirconium in the minerals zircon and baddeleyite.

	Zirconium				Hafnium	
	Mine production[e] (thousand metric tons)		Reserves[4]	Reserve base[4] (million metric tons, ZrO_2)	Reserves[4]	Reserve base[4] (thousand metric tons, HfO_2)
	1995	1996				
United States	W	W	1.7	5.3	32	97
Australia	510	500	6.3	27.0	114	484
Brazil	15	17	.4	.4	7	7
China[e]	15	15	.5	1.0	NA	NA
India	18	18	3.4	3.8	42	46
South Africa	250	260	14.3	14.3	259	259
Ukraine[e]	60	65	4.0	6.0	NA	NA
Other countries	29	25	.9	4.1	NA	NA
World total (rounded)	[5]897	[5]900	32	62	450	890

World Resources: Resources of zircon in the United States included about 14 million tons associated with titanium resources in heavy-mineral sand deposits. Phosphate and sand and gravel deposits have the potential to yield substantial amounts of zircon as a future byproduct. Eudialyte and gittinsite are zirconium silicate minerals that have a potential for zirconia production. Identified world resources of zircon exceed 60 million tons.

Resources of hafnium in the United States are estimated to be about 130,000 tons, available in the 14-million-ton domestic resources of zircon. World resources of hafnium are associated with those of zircon and baddeleyite and exceed 1 million tons.

Substitutes: Chromite and olivine can be used instead of zircon for some foundry applications. Dolomite and spinel refractories can also substitute for zircon in certain high-temperature applications. Columbium (niobium), stainless steel, and tantalum provide limited substitution in nuclear applications, while titanium and synthetic materials may substitute in some chemical plant uses.

Silver-cadmium-indium control rods are used in lieu of hafnium at numerous nuclear power plants. Zirconium can be used interchangeably with hafnium in certain superalloys; in others, only hafnium produces the desired or required grain boundary refinement.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]ZrO_2 content of zircon is typically 65%.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]Excludes the United States.

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 (mt)	= 2,204.6 pounds, avoirdupois or 1,000 kilograms
1 metric ton (mt)	= 1.1023 short ton
1 pound (lb)	= 453.6 grams
1 short ton (st)	= 2,000 pounds, avoirdupois
1 short ton unit (stu)	= 1% of 1 short ton or 20 pounds, avoirdupois
1 short dry ton (sdt)	= 2,000 pounds, avoirdupois, excluding moisture content
1 troy ounce (tr oz)	= 1.09714 avoirdupois ounces
1 troy pound	= 12 troy ounces

APPENDIX B

Non-Most-Favored-Nation Trade Areas

The countries or areas for which non-most-favored-nation (Non-MFN) rates apply are the following:

Afghanistan
Cambodia
Cuba
Laos
North Korea
Vietnam

Most favored nation (MFN), Non-MFN, and special tariff rates including the U.S. Generalized System of Preferences are given in the "Harmonized Tariff Schedule of the United States" published by the United States International Trade Commission, Washington, DC 20436. It is available in many public libraries or can be purchased from the United States Government Printing Office, Washington, DC 20402.

APPENDIX C

A Resource/Reserve Classification for Minerals[1]

INTRODUCTION

Through the years, geologists, mining engineers, and others operating in the minerals field have used various terms to describe and classify mineral resources, which as defined herein include energy materials. Some of these terms have gained wide use and acceptance, although they are not always used with precisely the same meaning.

The U.S. Geological Survey collects information about the quantity and quality of all mineral resources. In 1976, the Survey and the U.S. Bureau of Mines developed a common classification and nomenclature, which was published as U.S. Geological Survey Bulletin 1450-A—*"Principles of the Mineral Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey."* Experience with this resource classification system showed that some changes were necessary in order to make it more workable in practice and more useful in long-term planning. Therefore, representatives of the U.S. Geological Survey and the U.S. Bureau of Mines collaborated to revise Bulletin 1450-A. Their work was published in 1980 as U.S. Geological Survey Circular 831—*"Principles of a Resource/Reserve Classification for Minerals."*

Long-term public and commercial planning must be based on the probability of discovering new deposits, on developing economic extraction processes for currently unworkable deposits, and on knowing which resources are immediately available. Thus, resources must be continuously reassessed in the light of new geologic knowledge, of progress in science and technology, and of shifts in economic and political conditions. To best serve these planning needs, known resources should be classified from two standpoints: (1) purely geologic or physical/chemical characteristics—such as grade, quality tonnage, thickness, and depth—of the material in place: and (2) profitability analyses based on costs of extracting and marketing the material in a given economy at a given time. The former constitutes important objective scientific information of the resource and a relatively unchanging foundation upon which the latter more valuable economic delineation can be based.

The revised classification systems, designed generally for all mineral materials, is shown graphically in figures 1 and 2; their components and usage are described in the text. The classification of mineral and energy resources is necessarily arbitrary, because definitional criteria do not always coincide with natural boundaries. The system can be used to report the status of mineral and energy-fuel resources for the Nation or for specific areas.

RESOURCE/RESERVE DEFINITIONS

A dictionary definition of resource, "something in reserve or ready if needed," has been adapted for mineral and energy resources to comprise all materials, including those only surmised to exist, that have present to anticipated future value.

Resource.—A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Original Resource.—The amount of a resource before production.

Identified Resources.—Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and sub-economic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into measured, indicated, and inferred.

Demonstrated.—A term for the sum of measured plus indicated.

Measured.—Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and(or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurements are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resource are well established.

Indicated.—Quantity and grade and(or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observation.

Inferred.—Estimates are based on an assumed continuity beyond measured and(or) indicated resources, for which there is geologic evidence. Inferred resources may or may not be supported by samples or measurements.

Reserve Base.—That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources). The term "geologic reserve" has been applied by others generally to the

[1]Based on U.S. Geological Survey Circular 831, 1980.

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 to an understanding of current resources, in terms of both the amount of past production and the amount of residual or remaining in-place resource. A separate space for cumulative production is shown in figure 1. Residual material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

FIGURE 1.–Major Elements of Mineral-Resource Classification, Excluding *Reserve Base* and *Inferred Reserve Base*

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical (or)	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUBECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		
Other Occurrences	Includes nonconventional and low-grade materials				

FIGURE 2.–*Reserve Base* and *Inferred Reserve Base* Classification Categories

Cumulative Production	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical (or)	Speculative
ECONOMIC	Reserve		Inferred		
MARGINALLY ECONOMIC	Base		Reserve		
SUBECONOMIC			Base		
Other Occurrences	Includes nonconventional and low-grade materials				