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INSTANT INFORMATION

Information about the U.S. Geological Survey, its programs, staff, and products may be accessed via the Internet at http://www.usgs.gov. Aerial photography, digital data, geologic, and map products and information are available by contacting the Earth Science Information Center at 1-888-ASK-USGS. Water data and information may be obtained by contacting the Water Information Center at 1-800-426-9000.

This publication has been prepared by the Minerals Information Team. Information about the team and its publications may be accessed via the Internet at http://minerals.er.usgs.gov/minerals or by writing: Chief Scientist, Minerals Information Team, 988 National Center, Reston, VA 20192. Information about the team and its publications may also be received from MINES FaxBack. MINES FaxBack is a simple-to-operate automated fax response system that operates 24 hours a day, 7 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.

KEY PUBLICATIONS

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

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

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.

Metal Industry Indicators—A monthly publication that provides economic indicators of mineral activities.

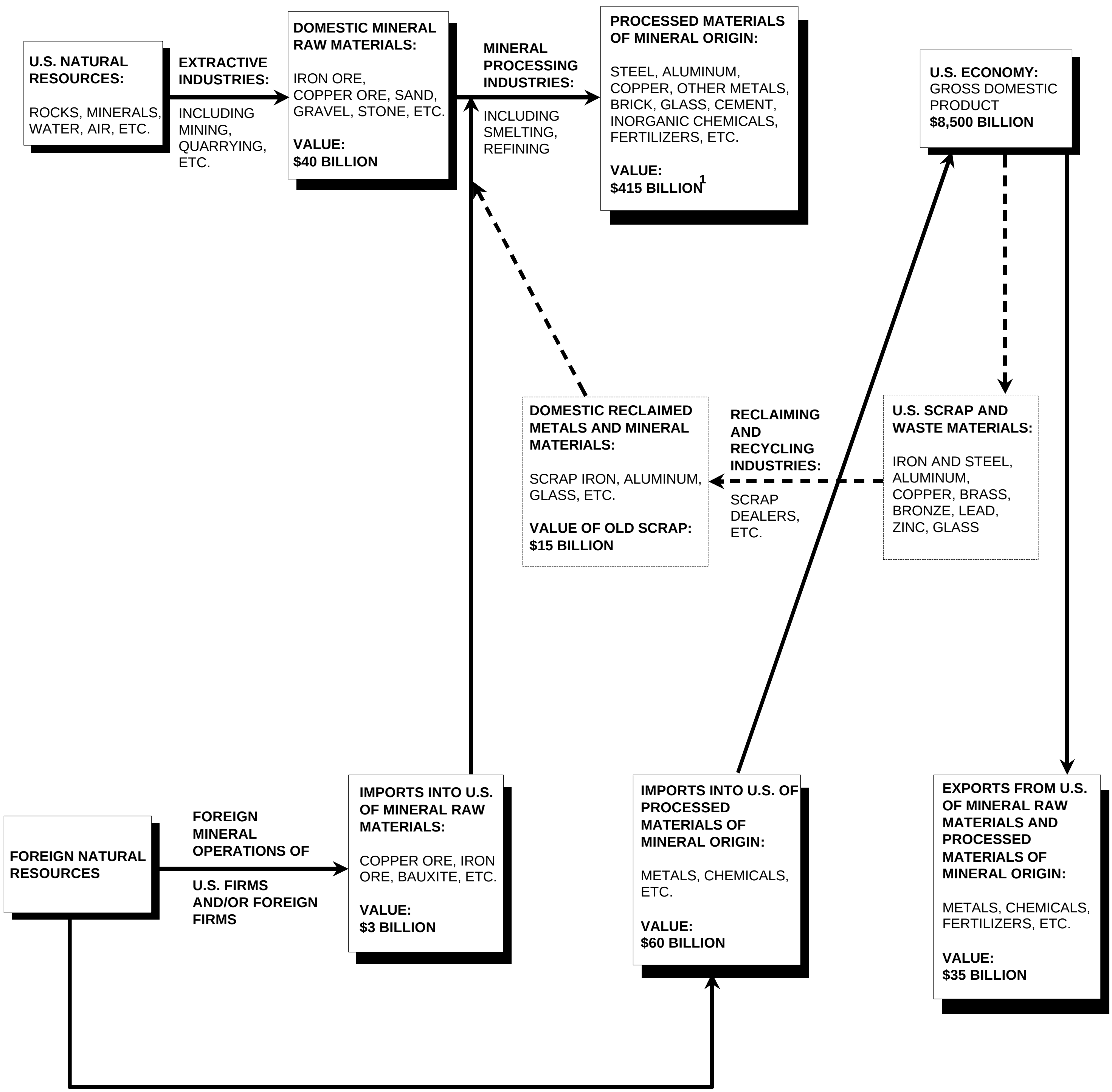
WHERE TO OBTAIN PUBLICATIONS

- *Mineral Commodity Summaries* and the *Minerals Yearbook* are sold by the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954. To order by telephone, call (202) 512-1800.

- *Mineral Industry Surveys* and *Metal Industry Indicators* can be obtained free of charge by calling (412) 892-4338 or writing NIOSH Printing Office, Pittsburgh Research Laboratory, P.O. Box 18070, Pittsburgh, PA 15236.

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

(ESTIMATED VALUES IN 1998)



[1] This value cannot be directly related to gross domestic product because it implicitly includes the cost of intermediate goods and services used in producing mineral products. Gross domestic product excludes such costs and its value is determined either in terms of sales for final consumption or in the income generated by producing goods and services.

1998 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS

Commodity	Percent	Major Sources (1994-97)[1]
ARSENIC	100	China, Hong Kong, Japan
BAUXITE and ALUMINA	100	Australia, Guinea, Jamaica, Brazil
BISMUTH	100	Belgium, Mexico, United Kingdom, China
COLUMBIUM (niobium)	100	Brazil, Canada, Germany
FLUORSPAR	100	China, South Africa, Mexico
GRAPHITE (natural)	100	Mexico, Canada, China, Madagascar
MANGANESE	100	South Africa, Gabon, Australia, France
MICA, sheet (natural)	100	India, Belgium, Germany, China
STRONTIUM	100	Mexico, Germany
THALLIUM	100	Mexico, Belgium, Canada, Germany
THORIUM	100	France
YTTRIUM	100	China, France, United Kingdom, Belgium
GEMSTONES	99	Israel, Belgium, India
PLATINUM	94	South Africa, United Kingdom, Germany, Russia
PALLADIUM	88	Russia, South Africa, Belgium, United Kingdom
TIN	85	Brazil, Indonesia, Bolivia, China
ANTIMONY	84	China, Mexico, Bolivia, South Africa
BARITE	80	China, India, Mexico, Morocco
POTASH	80	Canada, Russia, Belarus
TANTALUM	80	Australia, Thailand, China, Brazil
CHROMIUM	79	South Africa, Russia, Turkey, Zimbabwe, Kazakhstan
TUNGSTEN	78	China, Russia, Germany, Bolivia
COBALT	77	Norway, Finland, Zambia, Canada
IODINE	72	Chile, Japan
ZINC	70	Canada, Mexico, Spain, Peru
STONE (dimension)	69	Italy, India, Brazil, Canada
NICKEL	65	Canada, Norway, Russia, Australia
PEAT	60	Canada
DIAMOND (dust, grit, and powder)	51	Ireland, China, Germany
PUMICE	32	Greece, Ecuador, Turkey
SILICON	32	Norway, Russia, Brazil, Canada
RARE EARTHS	29	China, France, Japan, United Kingdom
MAGNESIUM COMPOUNDS	28	China, Canada, Austria, Greece
GYPSUM	26	Canada, Mexico, Spain
ALUMINUM	25	Canada, Russia, Venezuela, Mexico
CADMIUM	21	Canada, Australia, Belgium, Mexico
LEAD	21	Canada, Mexico, Peru, Australia
NITROGEN (fixed), AMMONIA	19	Trinidad and Tobago, Canada, Mexico, Venezuela
IRON and STEEL	18	European Union, Canada, Japan, Brazil
SULFUR	18	Canada, Mexico, Germany
CEMENT	17	Canada, Spain, Venezuela, Greece
IRON ORE	17	Canada, Brazil, Venezuela, Australia
SALT	17	Canada, Chile, Mexico, The Bahamas
COPPER	16	Canada, Chile, Mexico
MAGNESIUM	16	Canada, Russia, China, Mexico
MICA, scrap and flake (natural)	13	Canada, India, Finland, Japan
PERLITE	13	Greece
SODIUM SULFATE	8	Canada, Mexico
ASBESTOS	6	Canada
BERYLLIUM	4	Russia, Kazakhstan, France, Canada
PHOSPHATE ROCK	4	Morocco
IRON and STEEL SLAG	3	Canada, South Africa
LIME	1	Canada, Mexico

[1]In descending order of importance

Additional commodities for which there is some import dependency but data are withheld or are insufficient to determine import-reliance levels:

Gallium	France, Russia, Canada, Germany
Germanium	Russia, Belgium, United Kingdom, China
Ilmenite	South Africa, Australia, Canada
Indium	Canada, Russia, China, France
Kyanite	South Africa
Lithium	Chile
Mercury	Russia, Canada, Kyrgyzstan, Spain
Rhenium	Chile, Germany, Kazakhstan, Netherlands
Rutile	Australia, South Africa
Selenium	Canada, Philippines, Belgium, Japan
Tellurium	United Kingdom, Canada, Philippines, Peru
Titanium (sponge)	Russia, Japan, Kazakhstan, China
Vanadium (ferrovanadium)	Canada, Russia, China, Czech Republic
Vermiculite	South Africa, China
Zirconium	Australia, South Africa

SIGNIFICANT EVENTS, TRENDS, AND ISSUES

The Mineral Sector of the U.S. Economy

The U.S. economy expanded at a moderate rate in 1998 and, consequently, the consumption of minerals and mineral-based products increased. However, shipments of processed metal products from U.S. manufacturers declined sharply because of an increase in imports, especially for steel. A continued low inflation rate, stable to declining interest rates, declining fuel costs, and increases in employment bolstered consumer confidence and expenditures throughout the year. The increase in employment resulted in increased taxes paid at both the Federal and State levels, which helped the United States achieve a budget surplus and, which increased revenues in 48 of 50 States. The Federal budget surplus and low inflation are positive indicators that the economy will continue to expand in the coming year; however, most economists in Government and industry believe that economic growth will occur at a slower pace than in 1998. Consumption of metals, both domestic and imported, was relatively stable or increased compared with that of 1997. Consumption of most industrial minerals, especially crushed stone and cement, increased compared with that of the previous year. More detailed information on events, trends, and issues in the mineral and mineral products sectors 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 1998 was estimated to be $415 billion, which was essentially the same as in 1997. The estimated value of U.S. raw nonfuel minerals production in 1998 was over $40 billion, a slight decrease compared with that of 1997, mostly because of falling metal prices, and the first decline since 1991. However, the estimated production value of all industrial minerals increased over 7.5% or $2.1 billion and almost offset the $2.4 billion drop in the estimated value of metals production. The total value of U.S. minerals production has increased in 31 of the last 38 years.

Total U.S. trade in raw minerals and processed materials of mineral origin was valued at $98 billion in 1998. Imports of processed mineral materials were valued at an estimated $60 billion, which was an increase of about $5 billion over that of 1997 and reflected the major increase in the quantity of steel imports. Exports of these materials were valued at an estimated $35 billion, which was a decline of nearly $2 billion from that of 1997, and partly reflected the poor performance of the Southeast Asian economies. Imports of metal ores and concentrates and of raw industrial minerals increased slightly to almost $3 billion. Raw minerals exports were essentially unchanged with an estimated value of about $3 billion. Consumption of metals and other mineral-based materials used extensively in motor vehicle manufacturing increased in 1998 because of a large increase in production of automotive products. The motor vehicle manufacturing sector is a major consumer of steel and other mineral-based materials, chiefly aluminum, copper, lead, platinum-group metals, zinc, glass, and plastics.

The domestic construction industry also contributed to the modest growth in minerals consumption. Construction is the largest consumer of brick clay, cement, sand and gravel, and stone. Road construction expenditures in 1998 maintained the high levels of the last few years as a result of signing in to law of the Transportation Equity Act for the 21st century. Large quantities of asphalt, cement, crushed stone, and sand and gravel are used in road building. Apartment building construction and new home construction increased in 1998, which had a positive 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 again operated at nearly full capacity, which resulted in a strong demand for fixed nitrogen, phosphate rock, and sulfur. Global fertilizer nutrient consumption increased substantially and U.S. consumption at the farm level increased in anticipation of higher domestic and world demand for coarse grains and other high volume agricultural products.

In fiscal year 1998, the Defense Logistics Agency sold excess mineral materials valued at $462 million (see “Government Stockpile” in the commodity sections that follow). The Defense Production Act provides authority for priorities, allocations, and defense-related supply expansions.

Outlook

Growth in the U.S. economy is expected to continue in 1999, but at a slower rate providing a mild stimulus to the Nation's materials-consuming industries. Inflation is expected to remain low, thus permitting a continuance of the low interest rates that are conducive to an expanding economy. Strong motor vehicle sales are expected to continue because low automobile loan interest rates and advantageous monetary exchange rates. The budgeted increase in Federal spending for highways and mass transit is expected to continue to provide an impetus for greater consumption of stone, sand and gravel, and steel. The demand prospect for mineral fertilizer materials (i.e., fixed nitrogen, phosphate rock, potash,

TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

	1994	1995	1996	1997	1998[e]
Total mine production:[1]					
Metals	12,100	14,000	13,000	13,100	10,600
Industrial minerals	23,100	24,600	25,800	27,400	29,500
Coal	20,100	19,500	19,700	19,800	19,600
Employment:[2]					
Coal mining	90	84	80	79	74
Metal mining	39	41	42	41	39
Industrial minerals, except fuels	78	80	81	81	83
Chemicals and allied products	578	580	575	572	582
Stone, clay, and glass products	411	418	423	431	442
Primary metal industries	537	553	553	556	557
Average weekly earnings of production workers:[3]					
Coal mining	803	828	858	863	847
Metal mining	699	735	763	791	826
Industrial minerals, except fuels	610	624	648	671	684
Chemicals and allied products	654	675	699	716	740
Stone, clay, and glass products	526	534	555	569	593
Primary metal industries	641	643	662	683	683

[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.

and sulfur) is expected to be weaker in the coming year because of reduced world trade in grains caused by the ongoing recession in Southeast Asia. Economic weakness in this region could also hold down exports of U.S.-produced metal products and finished durable goods and result in an increase in imports of these items into the United States.

Significant International Events[1]

Repercussions continued in 1998, virtually throughout the world, from the effects of financial turmoil that began during the previous year in East and Southeast Asia. It began with credit overextension into uncollectible loans, runs on currencies, bank failures, and a critical contraction of value in equity markets resulting in a general loss of confidence. The fragility of emerging economies became apparent in light of the global recessionary pressures initiated by the financial instability in East and Southeast Asia. Steel that was normally exported by the successor states of the former Soviet Union (FSU) to Asia and elsewhere rapidly lost markets in those regions. Moreover, the Asian economic crisis, followed by devaluation of the Russian ruble, which improved the terms of trade for Russian exports, resulted in increasing amounts of steel exported to markets in the European Union (EU) and the United States. Beyond the ruble's devaluation, the near insolvency of the Russian banking system, which plays a major role in that country's mineral industries; the downgrading of Russia's credit rating to CCC; and plans by its Government to pay wage arrears by printing more money; have all contributed to a major decline in investor confidence in the Russian Federation and, by extension, to the rest of the Commonwealth of Independent States. The outcome for these issues and their impact on mineral supply and demand is far from obvious.

At yearend 1998, warehouse copper stocks at Singapore and New Orleans were burgeoning to levels not seen in years as Asian countries reduced their consumption of

[1]The regimes of some countries 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.

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

	1994	1995	1996	1997	1998[e]
Gross domestic product (billion dollars)	6,950	7,270	7,660	8,100	8,500
Capital expenditures (billion dollars):					
All industries	550	594	603 [1]	NA	NA
Manufacturing	153	172	185 [1]	NA	NA
Mining and construction	36	36	34 [1]	NA	NA
Industrial production (1992=100):					
Total index	109	114	120	127	131
Manufacturing	110	116	121	130	135
Stone, clay, and glass products	108	111	118	122	126
Primary metals	113	117	120	125	124
Iron and steel	114	118	119	124	120
Nonferrous metals	113	116	121	127	127
Chemicals and chemical products	105	107	110	115	116
Mining	103	102	104	106	104
Metals	100	102	104	110	109
Coal	104	104	105	108	110
Oil and gas extraction	102	100	102	103	100
Stone and earth minerals	109	113	115	120	124
Capacity utilization (percent):[2]					
Total industry	83	84	82	83	82
Mining	88	87	89	89	87
Metals	86	87	88	91	89
Stone and earth minerals	86	87	86	86	86
Housing starts (thousands)	1,460	1,350	1,480	1,470	1,610
Automobile production (thousands)	6,610	6,350	6,080	6,030	NA
Highway construction, all public, expenditures (billion dollars)	33	35	37 [p]	39 [e]	41

[e]Estimated. [p]Preliminary. NA Not available.

[1]Planned expenditures.

[2]1998 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.

metals. In the fourth quarter of 1998, base metal prices, especially for copper and nickel, fell to levels that had not been seen in 10 to 12 years. Precious-metal prices remained sluggish throughout 1998. Gold prices showed weak spurts of bullishness from time to time, while platinum prices gradually declined. Not least of the mineral commodity problems facing the world was overproduction of petroleum and the consequent driving of its price down to levels affecting the entire economies of various major producers.

Certain Asian countries were faced with the problem of pulling themselves into more realistic modes of operation. Their economic troubles arose from use of the so-called Japan development model, which stresses heavy state guidance in selecting industrial investments; augmented export promotion; restricted foreign participation in banking and finance; and continuous juggling of barriers to imports. This has led to excesses of productive capacity that have reduced the total value of many enterprises below their current level of debt. As with the other Asian countries, Japan itself presents a de facto dual economy in which only insiders have access to scarce resources, especially bank loans. The difficulties

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1998[p 1]

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$947,000	14	2.36	Cement (portland), stone (crushed), lime, sand and gravel (construction), cement (masonry).
Alaska	911,000	16	2.27	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	2,820,000	3	7.04	Copper, sand and gravel (construction), cement (portland), molybdenum, stone (crushed).
Arkansas	598,000	24	1.49	Stone (crushed), bromine, cement (portland), sand and gravel (construction), sand and gravel (industrial).
California	2,970,000	2	7.41	Sand and gravel (construction), cement (portland), boron (B_2O_3), stone (crushed), gold.
Colorado	604,000	23	1.51	Sand and gravel (construction), cement (portland), molybdenum, stone (crushed), gold.
Connecticut[2]	105,000	43	.26	Stone (crushed), sand and gravel (construction), stone (dimension), clays (common), gemstones.
Delaware[2]	11,200	50	.03	Sand and gravel (construction), magnesium compounds, gemstones.
Florida	1,960,000	5	4.90	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), zirconium concentrates.
Georgia	2,140,000	4	5.33	Clays (kaolin), stone (crushed), cement (portland), clays (fuller's earth), sand and gravel (construction).
Hawaii	85,500	45	.21	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), gemstones.
Idaho	444,000	31	1.11	Phosphate rock, molybdenum, silver, gold, sand and gravel (construction).
Illinois	862,000	17	2.15	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime.
Indiana	698,000	21	1.74	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Iowa	524,000	28	1.31	Stone (crushed), cement (portland), sand and gravel (construction), gypsum (crude), lime.
Kansas	535,000	27	1.33	Cement (portland), salt, helium (Grade-A), stone (crushed), helium (crude).
Kentucky	489,000	30	1.22	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (ball).
Louisiana	379,000	33	.95	Salt, sulfur (Frasch), sand and gravel (construction), stone (crushed), sand and gravel (industrial).
Maine	76,200	46	.19	Sand and gravel (construction), cement (portland), stone (crushed), peat, cement (masonry).
Maryland	358,000	34	.89	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts	192,000	40	.48	Stone (crushed), sand and gravel (construction), stone (dimension), lime, clays (common).
Michigan	1,660,000	7	4.15	Cement (portland), iron ore (usable), sand and gravel (construction), magnesium compounds, stone (crushed).
Minnesota	1,560,000	8	3.88	Iron ore (usable), sand and gravel (construction), stone (crushed), stone (dimension), sand and gravel (industrial).

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1998[p 1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Mississippi	$190,000	41	0.47	Sand and gravel (construction), cement (portland), clays (fuller's earth), stone (crushed), sand and gravel (industrial).
Missouri	1,360,000	9	3.38	Stone (crushed), cement (portland), lead, lime, zinc.
Montana	500,000	29	1.25	Copper, gold, palladium, cement (portland), molybdenum.
Nebraska	174,000	42	.43	Cement (portland), sand and gravel (construction), stone (crushed), lime, clays (common).
Nevada	3,100,000	1	7.72	Gold, silver, copper, sand and gravel (construction), lime.
New Hampshire[2]	53,100	47	.13	Sand and gravel (construction), stone (crushed), stone (dimension), gemstones.
New Jersey[2]	301,000	35	.75	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.
New Mexico	860,000	18	2.15	Copper, potash (K_2O), sand and gravel (construction), cement (portland), stone (crushed).
New York	939,000	15	2.34	Stone (crushed), cement (portland), sand and gravel (construction), salt, zinc.
North Carolina	785,000	19	1.96	Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), feldspar.
North Dakota	34,700	48	.09	Sand and gravel (construction), lime, sand and gravel (industrial), clays (common), gemstones.
Ohio	1,150,000	12	2.87	Stone (crushed), sand and gravel (construction), salt, lime, cement (portland).
Oklahoma	408,000	32	1.02	Cement (portland), stone (crushed), sand and gravel (construction), sand and gravel (industrial), iodine (crude).
Oregon	272,000	36	.68	Stone (crushed), sand and gravel (construction), clays (common), cement (portland), lime, diatomite.
Pennsylvania	1,280,000	11	3.19	Stone (crushed), cement (portland), sand and gravel (construction), lime, cement (masonry).
Rhode Island[2]	27,800	49	.07	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), gemstones.
South Carolina	589,000	25	1.47	Stone (crushed), cement (portland), cement (masonry), sand and gravel (construction), gold.
South Dakota	269,000	37	.67	Gold, cement (portland), sand and gravel (construction), stone (crushed), stone (dimension).
Tennessee	709,000	20	1.77	Stone (crushed), zinc, cement (portland), sand and gravel (construction), clays (ball).
Texas	1,920,000	6	4.80	Cement (portland), stone (crushed), sand and gravel (construction), magnesium metal, lime.
Utah	1,300,000	10	3.25	Copper, sand and gravel (construction), magnesium metal, gold, cement (portland).
Vermont[2]	96,000	44	.24	Stone (crushed), stone (dimension), sand and gravel (construction), talc and pyrophyllite, gemstones.
Virginia	679,000	22	1.69	Stone (crushed), cement (portland), sand and gravel (construction), lime, clays (fuller's earth).
Washington	583,000	26	1.45	Sand and gravel (construction), magnesium metal, cement (portland), stone (crushed), gold.

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1998[p 1]—Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
West Virginia	$204,000	39	0.51	Stone (crushed), cement (portland), lime, sand and gravel (construction), salt.
Wisconsin[2]	261,000	38	.65	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), lime, stone (dimension).
Wyoming	1,060,000	13	2.65	Soda ash, clays (bentonite), helium (Grade-A), cement (portland), stone (crushed).
Undistributed	44,500	XX	.11	
Total	40,100,000	XX	100.00	

[p]Preliminary. XX Not applicable.

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

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

that wounded the East and Southeast Asian economies—weak banks, over-investment, policy lending, and especially excess capacity—are a spectre threatening China. Paradoxically, however, China has a huge capital surplus that goes to properties or equities in Hong Kong, oil operations in various countries, contributions to the International Monetary Fund (IMF) to bail out Thailand, and especially (much of it) to U.S. Treasury bonds and mortgage-backed securities.

It had been widely believed that Europe, and the oncoming EU, would represent a bastion of economic vigor, but the Russian financial debacle took its toll of this optimism. In Germany, the EU’s strongest economy, the Green Party, mainly comprising environmentalists, has acquired unusual strength and has secured several cabinet positions, including that of foreign minister. The Green Party platform includes proposals for higher taxes and abolition of nuclear power production. In 1999 the EU will implement a single currency controlled by one central bank, thus European economic policy (so far as monetary and fiscal policy are concerned) will be operated by central bankers. The integrated European economy will tend to be “statist” and not responsive to any single national or economic will. While it is hoped that Europe will be able to compete effectively with the United States and Japan, the future of Europe as one market is anything but clear.

After the collapse of the Mexican peso in 1995, Latin American economies were recovering until price weaknesses in commodities (copper, oil, gold, and other base metals) left many banks holding very expensive loans on their balance sheets. Capital markets for project-finance bonds essentially closed down, so these loans could not be syndicated. Mine financings, in particular, had been the beneficiaries of such loan syndication. Thailand, the Republic Korea, and Indonesia were dealing with the standard IMF prescription: higher taxes, curtailed spending, and banking reforms, much like Mexico. But Mexico rejected the Asian model of creating showpiece products in such industries as automobiles and high-tech electronics. Instead, Mexico exposed its industrial giants to global competition. Foreign capital poured in to underwrite sound new ventures.

World mining may be entering some lean years, so far as new capital is concerned, because of depressed prices for base and precious metals and with many investment capital sources tending to switch into super-safe U.S. Government debt instruments. An additional factor in the world mining equation is the difference between mining and most (or all) other industries: mineral resources are fixed in place, geographically, and cannot be moved to a better climate, a more industrialized country, or a better labor pool. The physical location of mineral resources is an invariant in the world economy of capital investment, production, and trade. It is still true that serious risk, and great opportunity, characterize mining the world over. But mining is, and has been for thousands of years, fundamental to the creation of wealth.

Asia and the Pacific

Massive investment by industry in virtually every sector across Asia and the Pacific, made on the conjecture that record-breaking growth would continue without interruption, has essentially come to a halt owing to the financial crisis that began in the region in 1997. Basic commodities including metals, minerals, and fossil fuels are overabundant, supply has greatly outstripped demand, and prices have been dropping. As a result, growth not only has slowed in the region, it has reversed. Asian economies, recently viewed as models of development and growth, have gone into recession and a deflationary trend that threatens to spread across the globe. In 1998, this created a challenge for various countries of the region that were not very willing to cut excess production capacity through tight monetary policies. They thought that such action would cause massive bankruptcies and layoffs in order to bring supply and demand back into equilibrium. Instead, many of these countries have chosen to address the economic downturn by lowering interest rates and raising government spending to pump up demand rather than eliminating excess capacity by cutting production and the workforce, thus decreasing supply.

The Australian Government proposed several initiatives to assist the country's declining mining industry stemming from the deterioration of the world economy. The key initiative is the introduction of a 10% goods and services tax (GST) to replace a number of indirect taxes. The GST would help exporters such as mining companies, because their taxes would be rebated at the point of export. The industry is also looking forward to the abolition of the fringe benefit tax on housing in remote areas and to replacement of the current system of rebates on the taxing of diesel fuel, a major expense in many mining operations. Additionally, the Government is planning to examine the tax status of certain nonrecoverable expenses, such as mineral exploration and feasibility studies, that are not currently tax-deductible. The Government also has plans to end the policy that restricts Australia to just three uranium mining sites, one of which has been depleted since 1979.

As the economy of China continued to grow, its Government restructured its State Council to enhance economic reform and promote social development. The new Government structure has 29 ministries or commissions under the State Council's purview. For mineral production, four industry ministries (Coal, Machine Building, Metallurgical, and Chemical), and three corporations (China National Nonferrous Metals Industry, China National Petroleum and Natural Gas, and China Petrochemical) were abolished and reorganized as State Bureaus or Administrations under the State Economic and Trade Commission. The Ministry of Geology and Mineral Resources, the State Land Management Bureau, the State Marine Bureau, and the State Surveying Bureau were combined to form the Ministry of Land and Resources.

P.T. Freeport Indonesia focused on reducing costs and increasing production at its Grasberg copper-gold mine in Irian Jaya Province, Indonesia. With a fourth concentrator coming into production, it achieved a record average mill throughput of 201,200 metric tons per day (t/d) of ore during the second quarter of 1998. Current expansion plans project a mill throughput of 230,000 t/d by yearend. Further capacity was being added in the form of a new 200,000-ton-per-year copper smelter and refinery, costing $650 million, at Gresik. Finally, at the Batu Hijau operation in Sumbawa, capacity was being developed for a throughput of about 222,000 t/yr of copper, silver, and gold.

For the first time since the end of World War II, and after several years of near stagnation, Japan's economy experienced a severe recession in 1998. The country's gross domestic product decreased 0.7% in 1997 and is projected to decline 1.8% in 1998. The depressed real estate and stock markets have caused Japan's major banks to carry a heavy load of bad loans, with limited funds available for making loans to companies facing financial difficulty. As a result, the number of corporate bankruptcies reached a record high in 1998. Japan's investment in mineral exploration, mining, and mineral processing, as well as consumption of major mineral commodities such as aluminum, cement, coal, copper, lead, steel, and zinc in 1998 are substantially lower than that of 1997. Exports of cement, refined copper, and steel are being pushed to a higher level to maintain production of these major commodities.

Middle East

World overproduction and weak demand in Asian markets caused lower petroleum prices in 1998. Lower petroleum prices, however, fostered increased output in 1998 as the Organization of Petroleum Exporting Countries (OPEC) raised production quotas by 9.8%. Meanwhile, the United Nations Security Council allowed an increase in Iraq's petroleum export ceiling from $2 billion to $5.26 billion over 6 months. These actions resulted in a further price decline to $11.67 per barrel for OPEC reference crudes, down $8 since October 1997. Although OPEC members pledged to reduce output through the end of 1998, their production actually increased by about 2.9 million barrels per day (bbl/d). Iran alone exceeded its pledge by 370,000 bbl/d. In mid-1998, Iran opened its borders to exploration and development at a time when unilateral U.S. Government sanctions effectively excluded U.S. companies from purchasing Iranian oil and imposed secondary sanctions on non-U.S. companies investing in Iranian oil and gas developments. The Iranian parliament, or Majlis, approved a $6.3 billion ceiling on new foreign investments through 2000.

Saudi Arabia was revising its mining code to improve administrative procedures and provide a more attractive investment climate. In 1998, the Government solicited U.S. company suggestions as to how they might participate in Saudi Arabian projects. Applications were solicited by yearend 1998 for companies to complete the exploration and possible development of known bauxite and copper resources in the country.

Africa

Civil wars, internal conflicts, and armed border conflicts continued to destabilize a number of African countries, significantly increasing political risks and constraining new investment in mineral exploration and development. Among those affected in 1998 were Algeria, Angola, Cameroon, the two Congos, Liberia, Eritrea, Ethiopia, Guinea, Guinea-Bissau, Nigeria, Rwanda, Sierra Leone, Somalia, and Sudan. Late in the year, troops from Angola, Namibia, Zambia, and Zimbabwe, under the umbrella of the Southern African Development Community, in addition to forces from Chad, Rwanda, Sudan, and Uganda, had been drawn into the civil war in the Democratic Republic of the Congo (Congo-Kinshasa). Efforts to revise mining legislation were underway in Congo-Kinshasa, in spite of the ongoing war, and in South Africa and Uganda. In Congo-Kinshasa mineral rights were a major issue in 1998 with the legal ownership of some concessions called in question by the Government.

In a major display of regional cooperation, 16 francophone central and west African countries, under the umbrella of the Organisation pour l'Harmonisation du Droit des Affaires en Afrique signed an accord to harmonize foreign investment laws. The 16 countries were Benin, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Cote d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Mali, Niger, Senegal, and Togo. New mining laws designed to promote new foreign investment were also put in place in Botswana, Sierra Leone, and Tanzania in 1998.

In South Africa, a Minerals & Mining Policy White Paper issued in October will lead to the first major post-Apartheid change in mineral policy. It proposes vesting mineral rights in the State and introducing a "use it and keep it" principle for mineral rights, designed to free up unused mineral rights for new foreign investors and for new local black economic empowerment groups. The Government planned to use tax disincentives or other performance standards rather than expropriation to free up unused mineral rights, but final policies were still under discussion.

Production trends were affected by depressed world mineral commodity prices and the widespread civil unrest described above, and African mineral production was generally in decline in 1998. In countries where significant currency devaluations have occurred, however, especially in South Africa, low international commodity prices have been offset by higher local currency returns, allowing some marginal operations to remain in production. Hurt by the Asian financial crisis and the drop in world demand, iron ore, steel, and ferroalloy production in South Africa and Zimbabwe was expected to be less than in 1997. The export of excess South African steel products into stronger U.S. markets led to antidumping actions by the United States against South Africa and several other countries. South Africa, which accounts for over 20% of newly mined world gold production, produced about 475 tons of gold in 1998, a 4% decline from 1997. This was attributed to the rationalization and sale or closure of high-cost gold mines during the major restructuring of the South African gold industry in 1998. Ghana, Africa's second largest gold producer, also anticipated a lower gold output owing to a major energy supply crisis in the country in 1998. The energy crisis also accounted for the drop in Kaiser Aluminum's Ghana aluminum smelter production to 20% of capacity. Copper and cobalt production, principally from Congo-Kinshasa and Zambia, continued their decline from the previous year. The state mining company in Congo-Kinshasa, La Generale des Carrieres et des Mines, struggled to maintain output at from 5% to 10% of capacity. In Zambia, the state-owned Zambia Consolidated Copper Mines (ZCCM), was unable to complete the privatization of its main Nchanga and Nkana Divisions after a major U.S.-Canadian-South African consortium withdrew from negotiations, seriously jeopardizing ZCCM's economic viability. By yearend, production levels were expected to drop below 300,000 t/yr of copper, with ZCCM being forced to seek financial support from the Government. In South Africa, coal and titanium production was expected to remain steady in 1998, while production of platinum-group metals in South Africa and Zimbabwe increased in response to a decline in platinum-group metal exports from Russia. Despite weak markets, diamond production appeared to hold steady in Botswana and South Africa, while new offshore marine production in Namibia and new alluvial production in Angola accounted for increased diamond production in both countries. An armed attack on the new Yetwene mine of Diamond Works Ltd. of Canada in Angola, in November 1998, set back hopes for diamond production expansion in that country. Fighting in the Mbuji-Maya diamond mining areas of Congo-Kinshasa was expected to significantly reduce that country's normal production levels of about 20 million carats per year.

In general, international exploration companies in Africa were cutting exploration expenditures back, some down to the minimum required to hold leases. According to the Metals Economics Group, exploration expenditures in Africa, in line with the worldwide trend, declined by 25% in 1998 from $662 million to $494 million.[2] The difficulty in raising new equity capital for exploration, particularly by the junior exploration companies following the Bre-X gold stock scandal in 1997, led to an exodus of some companies from Africa and a search by others for various arrangements with the major mining companies. Several U.S. and South African companies bought into joint-venture or option agreements with junior companies throughout Africa.

Major world-class deep-water petroleum discoveries in Angola in 1998 could contribute to a tripling of Angolan oil production to over 2 Mbbl/d in the next 5 years, surpassing that of Nigeria.

Europe and Central Eurasia

The successor states of the FSU and the countries of Eastern Europe continued to develop their market economy structures throughout 1998. Starting from a

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[2]Metals Economics Group, 1998, Overview of worldwide exploration budgets: Metals Economics Group, Strategic Report, September/October, p. 1-5.

common centrally planned economy base, but with differences in culture, industrial and social infrastructure, and natural resource endowment, the countries of the FSU and Eastern Europe showed wide variations within the transition process to a market-based economic system. Centripetal tendencies, however, continued to mark progress in Western Europe toward economic and possible political unity within the EU framework. During the year agreement was reached in the EU on a common currency and future admissions policies.

The nations of Western Europe, collectively, remained a major world minerals processing and consuming region and, consequently, a major determinant of world demand for all mineral commodities. But although the region's role as a mineral producer has diminished over the years, Western Europe continues to be a major producer of copper, iron, lead, and zinc. Some encouraging developments have been the start-up of major gold-mining operations in Spain and Sardinia. Two gold mines are being developed in Scotland along with lead-zinc mines in Ireland. Mineral exploration and development have been encouraged by the updating of mining legislation, deregulation, and tax relief. Exploration in Western Europe continued for copper, gold, lead, and zinc, as well as for diamond in Scandinavia. Exploration sought copper in Ireland and gold in several parts of Western Europe. Continuing discovery of mineralized areas has stimulated further effort.

When the Central European countries (the Czech Republic, Hungary, Poland, and Slovakia) and the Balkans (Albania, Bulgaria, Romania, and successor states of the former Yugoslavia), were under central planning as members of the Soviet-based Council for Mutual Economic Assistance (CMEA), they developed mineral industries that were insulated from the world market. Also, they were then greatly dependent on the U.S.S.R. for many base metals and substantial amounts of coal, crude oil, and natural gas. Following the dissolution of central planning systems in the region, it became clear that many mineral industries could not be sustained economically. Only Poland appeared to have economically viable resources of coal, copper, lead, salt, silver, sulfur, and zinc. After an economic winnowing process, industries that have survived in the region have been increasingly able to attract foreign investment. By 1998, major minerals-oriented foreign investment in Central Europe centered on industrial minerals such as quarry products, cement plants, and construction materials. Foreign investment was visible also in the base metals sector in Hungary and Poland. In the Balkans, Bulgaria's copper and gold potential continued to attract interest of foreign investors. Exploration for gold continued in the Czech Republic, Hungary, and Slovakia. In the Balkans, however, political instability remained a major obstacle to foreign investment.

In Eastern Europe and Central Eurasia, Russia, Kazakhstan, and Ukraine remained the FSU's dominant producers of most mineral commodities. Russia continued as a major world producer and exporter of a broad range of minerals that included copper, diamond, gold, nickel, platinum- group metals, and oil and natural gas. Kazakhstan is a major world producer of chromite.

Mineral production in the FSU underwent extensive transformation through joint ventures, downsizing, conglomeration, renovation, changed production profiles, stock issues, contracting for foreign management, and the sale of companies to foreign and domestic investors. For Russia and several other FSU countries, the effects from the Asian economic crisis were compounded by such internal economic problems as the governments' inability to collect revenues needed to implement reforms prescribed by the IMF.

Regional issues also arose in 1998 as the poor performance of the global economy exacerbated natural tensions between the EU-member nations vis a vis the transition-economy countries of the FSU and the non-EU Central European and Balkan countries. The two regions remained asymmetrical to each other, as the transitional-economy countries required further transformation and economic development to be on a par with Western Europe. Interaction in the minerals sector between these two regions was based on this asymmetry. Western Europe imported mineral commodities from the former centrally planned economies, smelted raw materials in them on a toll basis, sold equipment and technology to them, and invested in mineral enterprises and development in these countries, largely without reciprocal activities on the latter's part. Several years before the financial crisis of 1998, large-scale steel exports from Central Europe and the FSU to the EU resulted in vigorous protests by the EU labor unions to EU policy-making forums. The current financial crisis appears to have added currency to this issue.

Latin America and Canada

Although the Mexican peso and the Canadian dollar have been under pressure versus other major currencies, the focus of monetary concern shifted to Brazil, where capital flight put the Brazilian REAL in jeopardy. Action by the IMF to support Brazil's currency, specifically a new line of credit, could prevent a fall in the exchange rate, a surging inflation, possible economic collapse, and a major recession in all of Latin America. One of the biggest issues for Latin American countries is whether, or to what extent, mining will suffer from the withdrawal of capital owing to lack of confidence in emerging markets. The Asian economic contractions did not seem seriously to impair basic interest in exploration and mine development activity in Latin America, but the Russian collapse, with attendant effects in European countries and the United States, brought trouble in the form of diminishing confidence in emerging markets everywhere. Capital projects requiring significantly large financings began to wither, and there is no clear indication of whether 1999 will see improvement or deterioration of the availability of risk monies. One further problem, critically affecting the economies of Colombia, Mexico, and Venezuela, was the sag in world petroleum prices to unforeseen lows.

Exploration continued at a brisk pace in much of Latin America, but not quite like that of 1997, which may have marked the high point in expenditures by foreign companies. Low base-metal prices, particularly for copper, diverted effort to other pursuits, especially gold. Although gold prices were low, fluctuating in the $270 to $300 range, there were still many managers who believed that the right-sized ore body of suitable grade could nonetheless afford a reasonable profit if costs could be held to $200 or perhaps $230 per ounce with bulk extraction and heap leaching. After having been generally up in 1997, gold production seemed to be holding its own in 1998. Output of base metals, however, particularly copper, was less predictable in the face of falling prices. Unless the world financial picture changes abruptly, it is probable that 1999 will see significantly lower production of metals and a diminution of capital investment in Latin American mining.

Money continued to flow into exploration of Mexico's mineral potential, particularly in gold, silver, and base metals. This money came from probably the largest contingent of foreign mining companies in any Latin American country, numbering about 375 at the beginning of 1998. Of the $1.78 billion forecast by the Mexican Chamber of Mines to be spent in mining in 1998, a significant part will represent expenditures by foreign companies. Turmoil in global financial markets interfered with privatization of the country's main rail facilities, but did not change the commitment to privatization overall. The world's largest wollastonite mine was scheduled to open at yearend 1998 in the State of Sonora. Closed since 1991, the La Perla iron ore mine in Chihuahua was reopened. In the State of Oaxaca, a $2.5 billion investment was scheduled in an iron and steel complex with a capacity of 10 million metric tons of steel per year to be ready in 2000. Because of low copper prices, however, development of the La Mariquita copper project in Sonora, including both mining and solvent extraction, was halted. Total direct foreign investment in Mexico was about $12.5 billion, and the country was the second largest exporter of crude oil in the world.

Argentina, with a rapidly growing gross domestic product, expected a total investment in its mining sector of $3.3 billion between 1997 and 2000, all from private sources. Of this overall amount, 25% was earmarked for exploration and 75% for facilities and production. Among the largest outlays scheduled are Agua Rica (copper-gold), $200 million; Bajo de la Alumbrera (copper-gold), $900 million; Cerro Vanguardia (gold-silver), $195 million; El Pachon (copper-molybdenum), $450 million; Potasio Rio Colorado (potash), $150 million; and Salar del Hombre Muerto (lithium), $110 million. In that three of these projects involve copper as the principal mineral, low prices may delay completion of the financings. Canadian and Australian companies have been the leaders in mining investment in Argentina, while U.S. companies have tended to be more cautious by waiting to see if economic and political stability in that country will endure. Late in the year BHP announced that its Agua Rica operation would be placed on care and maintenance owing to weak copper prices.

Bolivia continued to seek the guarantee of private investment to sponsor growth of its economy by removing most barriers to overseas investment and any discrimination against foreign enterprises. In the San Cristobal region of the Southern Altiplano, a very large polymetallic deposit was discovered, comprising a projected 200 million ounces of silver, 1.8 Mt of zinc, and 0.6 Mt of lead. One or two new gold mines were opened, or planned for opening, in late 1998. Vista Gold of Canada, however, decided to suspend operations at two mines, the underground Capacirca mine and the Amayapampa open pit mine under development, owing to gold price weakness. One of Latin America's biggest infrastructure projects, the $2-billion, 3,150-kilometer Bolivian-Brazil natural gas pipeline, was expected to begin operation at yearend 1998.

Brazil, in many ways the current financial linchpin of Latin American economies, saw its thriving mineral production threatened by withdrawal of foreign risk capital and a potential drop in the value of its REAL, mostly attributable to foreign bankers' late-1998 reluctance to be involved in emerging markets. The IMF negotiated with Brazil in terms of a $42 billion line of credit, to be backed up with ancillary support from the foreign banks, but the longer the Brazilian elections postponed definitive action, the less interested the banks seem to be in assuming a supporting role. The banks, furthermore, were concerned over the effects of IMF arrangements in such countries as Indonesia. Privatizations of state-owned corporations continued in Brazil, some on a large enough scale to provide at least some interim support to the national treasury.

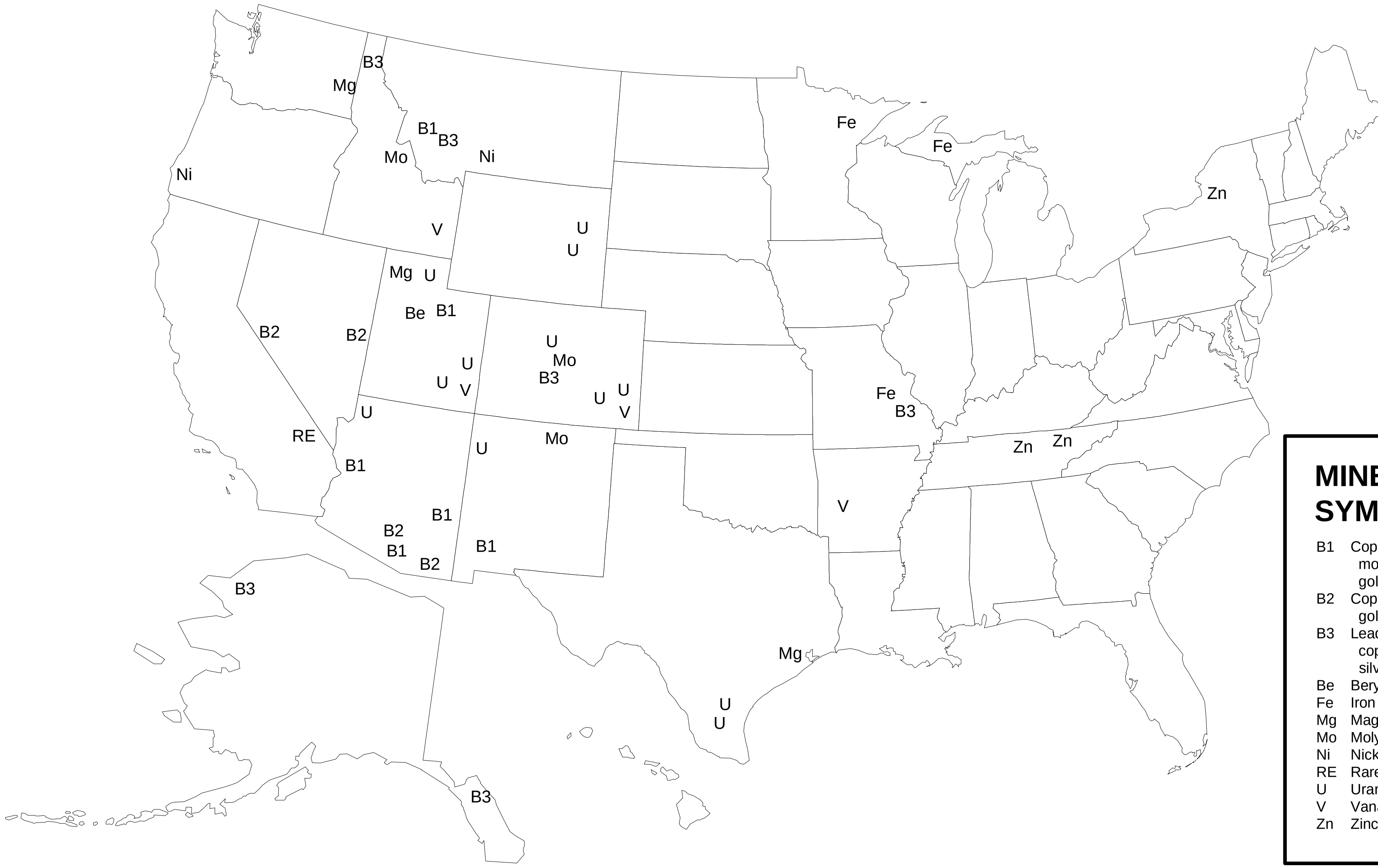
Exploration in Chile, mainly for copper and gold, continued at ever-increasing levels, estimated to cost about $230 million in 1998. Likewise, copper and gold led the list of mineral commodity exports which, in toto, amounted to $8.2 billion in 1997. About 52% of the exploration expenditures were by 22 Canadian companies, 14% from 4 European companies, 13% by 6 U.S. companies, 12% by 8 Chilean companies, and 9% by 7 Australian companies. But the actual and potential loss of Asian buyers already exerted its effect. Until copper prices improve, the Coloso concentrates leach plant near Antofagasta was placed on care and maintenance, which will reduce copper output by about 37,000 t/yr. Cementos Polpaico announced plans to spend $150 million to build two new cement plants, each to produce 800,000 t/yr, for start-up in 2000.

Already suffering the financial consequences of low petroleum prices, Colombia struggled to come to terms with terrorist groups destroying petroleum pipelines and rail infrastructure and abducting key personnel in mineral extraction operations. A greater-than tenfold increase in foreign direct investment in Colombia from 1990 to 1997 reached about $5.3 billion in 1997, of which mining and petroleum realized about $1.7 billion. By 1998, the picture changed to one of decreasing production of metals and industrial minerals, complicated by terrorist intimidation and foreign concerns about emerging markets. Although petroleum operations were interrupted, coal activity continued, including privatization of mines, consolidation of properties, and an increase in output and exports.

Mining activity in Peru included sharp increases in foreign investment, more than doubling from 1996 to 1997, but much of this involved plans and development for copper extraction. Against the spectre of weakening copper prices in 1998, a number of projects stayed in the feasibility stage until the economics of production could be established. Gold production, already predicated on existing low prices, increased steadily to a high of about 77 tons in 1997 and a projected further increase in 1998.

In Canada, mineral production began to be influenced by falling prices. At least nine mines, producing gold or base metals, were placed on suspension. Another eight mines were closed permanently, most because of exhaustion of ore reserves. In spite of reduced profits for many mining companies owing to lower commodity prices, especially for copper, nickel, lead and zinc, exploration expenditures remained robust. New openings included the Ekati diamond-mine complex near Lac de Gras, Canada's first diamond production, in late 1998. Other production of diamond seemed to be on schedule for 2001. The very large Voisey's Bay nickel-copper project is languishing for the time being because of a plethora of political, technical, and environmental directives, claims, and counter claims as First Nation interests, Newfoundland political interests, and Inco Ltd.'s plans were debated.

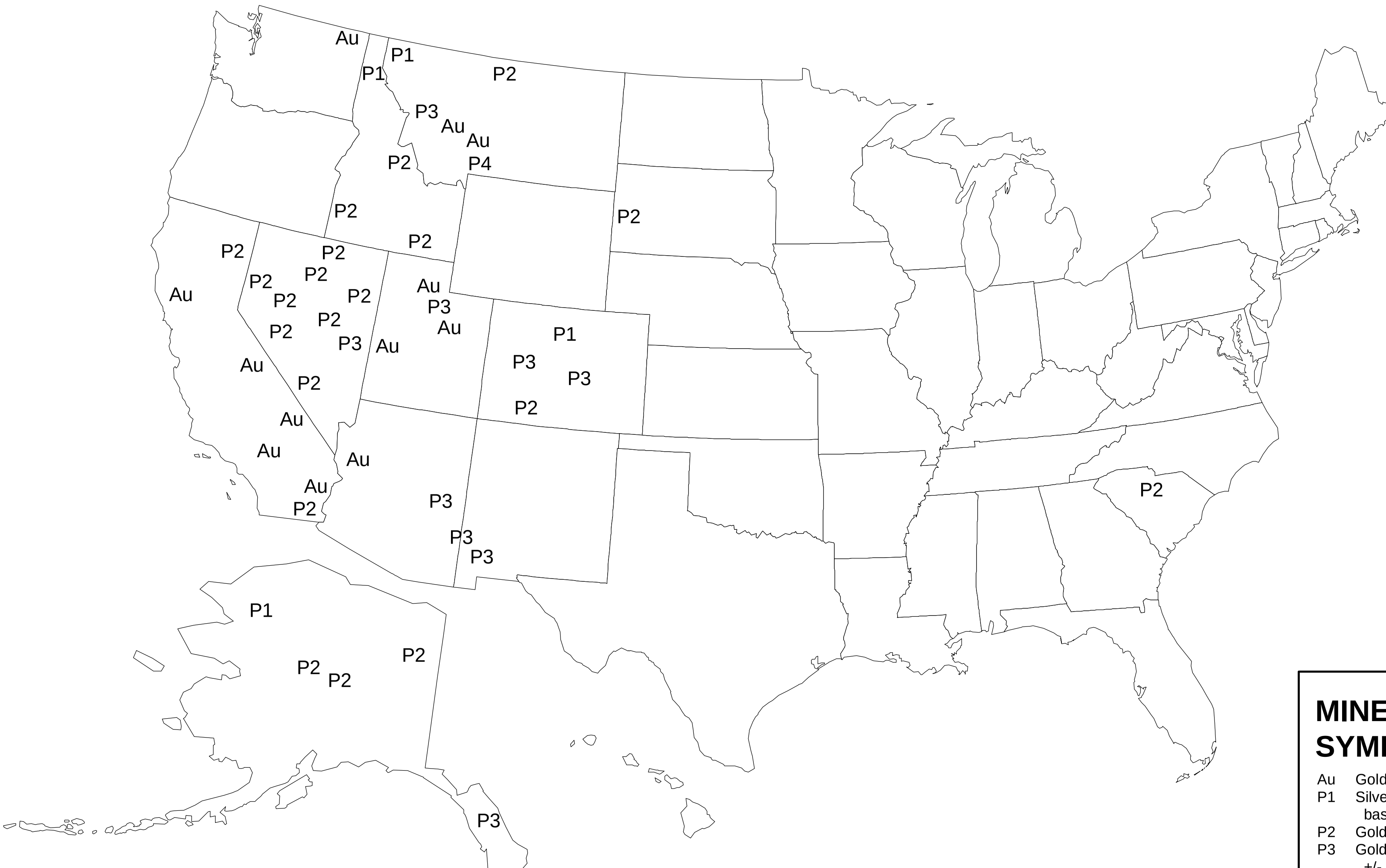
MAJOR BASE AND FERROUS METAL PRODUCING AREAS



MINERAL SYMBOLS

B1	Copper and molybdenum +/- gold, silver
B2	Copper +/- gold, silver
B3	Lead, zinc +/- copper +/- gold +/- silver
Be	Beryllium
Fe	Iron
Mg	Magnesium
Mo	Molybenum
Ni	Nickel
RE	Rare earths
U	Uranium
V	Vanadium
Zn	Zinc

MAJOR PRECIOUS METAL PRODUCING AREAS



MINERAL SYMBOLS

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

MAJOR INDUSTRIAL ROCK AND MINERAL PRODUCING AREAS - PART 1

MINERAL SYMBOLS

Asb	Asbestos	Mica	Mica
Ba	Barite	Ol	Olivine
B	Borates	Peat	Peat
Br	Bromine	P	Phosphate
Dia	Diatomite	K	Potash
Gar	Garnet	Salt	Salt
Gyp	Gypsum/ anhydrite	NaS	Sodium sulfate
		S	Sulfur
He	Helium	Talc	Talc/ pyrophyllite
Irz	Ilmenite, rutile, and zircon	Tr	Trona
I	Iodine	Vm	Vermiculite
Ky	Kyanite	Wol	Wollastonite
Mg	Magnesium compounds	Zeo	Zeolites

MAJOR INDUSTRIAL ROCK AND MINERAL PRODUCING AREAS - PART II

MINERAL SYMBOLS

BC	Ball clay
Bent	Bentonite
Clay	Clay/shale
D-S	Dimension stone
Fel	Feldspar
FC	Fire clay/ refractory clay
Ful	Fuller's earth
Kao	Kaolin
Li	Lithium
Per	Perlite
Pum	Pumice
Si	Silica/ industrial sand
Trip	Tripoli/novaculite

ABRASIVES (MANUFACTURED)

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

Domestic Production and Use: Fused aluminum oxide was produced by four companies at eight plants in the United States and Canada. Production of regular-grade fused aluminum oxide was valued at more than $38 million and production of high-purity fused aluminum oxide was valued at more than $9 million. Silicon carbide was produced by three companies at three plants in the United States and Canada. Domestic and Canadian production of crude silicon carbide had an estimated value of $43 million. Bonded and coated abrasive products account for most abrasive uses of fused aluminum oxide and silicon carbide.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production, United States and Canada (crude):					
Fused aluminum oxide, regular	133,000	126,000	124,000	93,500	106,000
Fused aluminum oxide, high-purity	29,200	20,100	22,700	14,200	16,000
Silicon carbide	84,700	75,400	73,600	68,200	71,000
Imports for consumption (U.S.):					
Fused aluminum oxide	145,000	213,000	131,000	138,000	180,000
Silicon carbide	110,000	172,000	182,000	240,000	270,000
Exports (U.S.):					
Fused aluminum oxide	13,000	11,000	11,900	10,700	9,000
Silicon carbide	16,000	20,000	14,200	16,100	10,200
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	361	358	353	370	328
Fused aluminum oxide, high-purity	557	468	576	570	575
Silicon carbide	531	495	490	490	496
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 (1994-97): Fused aluminum oxide crude: Canada, 55%; Australia, 27%; and other, 18%. Fused aluminum oxide grain: China, 46%; Canada, 19%; Austria, 16%; and other, 19%. Silicon carbide crude: China, 71%; Canada, 21%; and other, 8%. Silicon carbide grain: Norway, 30%; China, 22%; Brazil, 24%; Canada, 6%; and other, 18%.

Tariff: **Item**	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[2] 12/31/98**
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—9-30-98[3]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 1998**	**Disposals FY 1998**
Fused aluminum oxide, crude	114,539	13,376	114,539	27,216	27,216
Fused aluminum oxide, grain	21,486	1,241	21,486	5,443	4,283
Silicon carbide, crude	4,203	4,494	4,203	8,165	8,165

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ABRASIVES (MANUFACTURED)

Events, Trends, and Issues: Imports and higher operating costs continue to challenge producers in the United States and Canada. Strong foreign competition, particularly from China, is expected to persist and further curtail production in North America. If current disposal rates and sale schedules continue, all silicon carbide and fused aluminum oxide in the National Defense Stockpile will be sold by yearends 1999 and 2003, respectively.

World Production Capacity:

	Fused aluminum oxide capacity		Silicon carbide capacity	
	1997	1998[e]	1997	1998[e]
United States and Canada	220,000	220,000	90,000	90,000
Argentina	—	—	5,000	5,000
Australia	50,000	50,000	—	—
Austria	60,000	60,000	—	—
Brazil	50,000	50,000	43,000	43,000
China	450,000	450,000	450,000	450,000
France	40,000	40,000	16,000	16,000
Germany	80,000	80,000	36,000	36,000
India	40,000	40,000	5,000	5,000
Japan	50,000	50,000	60,000	60,000
Mexico	—	—	30,000	30,000
Norway	—	—	80,000	80,000
Venezuela	—	—	40,000	40,000
Other countries	80,000	80,000	185,000	185,000
World total (rounded)	1,100,000	1,100,000	1,000,000	1,000,000

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

Substitutes: Natural and manufactured abrasives, such as garnet or metallic abrasives, can be 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.
[3]See Appendix C for definitions.

ALUMINUM[1]

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

Domestic Production and Use: In 1998, 13 companies operated 23 primary aluminum reduction plants. Montana, Oregon, and Washington accounted for 40% of the production; New York, Maryland, Ohio, and West Virginia, 20%; other States, 40%. Based on published market prices, the value of primary metal production in 1998 was $5.3 billion. Aluminum consumption, by an estimated 25,000 firms, was centered in the East Central United States. Transportation accounted for an estimated 36% of domestic consumption in 1998; packaging, 25%; building, 14%; electrical, 8%; consumer durables, 7%; and other, 10%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Primary	3,299	3,375	3,577	3,603	3,700
Secondary (from old scrap)	1,500	1,510	1,580	1,530	1,500
Imports for consumption	3,380	2,980	2,810	3,080	3,300
Exports	1,370	1,610	1,500	1,570	1,500
Shipments from Government stockpile excesses	—	—	—	57	([2])
Consumption, apparent[3]	6,880	6,320	6,600	6,690	6,900
Price, ingot, average U.S. market (spot), cents per pound	71.2	85.9	71.3	77.1	65.0
Stocks: Aluminum industry, yearend	2,070	2,000	1,860	1,880	1,950
LME, U.S. warehouses, yearend	16	14	12	([2])	—
Employment, primary reduction, number	17,800	17,800	18,200	18,000	18,300
Net import reliance[4] as a percent of apparent consumption	30	23	22	23	25

Recycling: Aluminum recovered in 1998 from purchased scrap was about 3.5 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 (1994-97): Canada, 62%; Russia, 17%; Venezuela, 6%; Mexico, 3%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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—9-30-98[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Aluminum	—	—	—	9	9

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ALUMINUM

Events, Trends, and Issues: Domestic primary aluminum production increased slightly in 1998 as some previously idled capacity was brought back on-stream. Idled production capacity at the Reynolds Metals Co. smelters in Massena, NY, Longview, WA, and Troutdale, OR, was gradually reactivated during the year.[7] However, as of the beginning of October, approximately 470,000 tons of annual domestic capacity remained closed.

In a joint press release issued at the end of July, the Aluminum Company of America (Alcoa) and Alumax Inc. announced that the Alumax stockholders approved the company's merger with Alcoa effective immediately. The combined company would have approximately 100,000 employees and would operate in 250 locations in 30 countries.

U.S. imports for consumption increased significantly in 1998. Russia remained second only to Canada as a major shipper of aluminum materials to the United States, and the level of its ingot shipments increased dramatically during the first half of the year reaching levels equivalent to those for all of 1997.

The price of primary aluminum ingot in the United States trended downward during the first part of 1998. In January, the average monthly U.S. market price for primary ingot quoted by Platt's Metals Week was 71.9 cents per pound; by August the price had fallen to 63.3 cents per pound. Prices on the London Metal Exchange (LME) followed the trend of U.S. market prices. The monthly average LME cash price for August was 59.5 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 55- to 56-cent-per-pound range at the beginning of the year to a 44- to 45-cent-per-pound range at the end of August.

World production increased as producers continued to bring back on-stream primary capacity that had been temporarily idled and to start up new capacity expansions. Despite the economic crises in Asia, aluminum demand in the United States and Western Europe remained relatively strong. Inventories of metal held by producers, as reported by the International Primary Aluminium Institute, and inventories held by the LME fluctuated during the year with some indications that an upward trend was possible during the latter half of the year.

World Smelter Production and Capacity:

	Production		Yearend capacity	
	1997	1998[e]	1997	1998[e]
United States	3,600	3,700	4,190	4,190
Australia	1,500	1,580	1,550	1,740
Brazil	1,200	1,200	1,220	1,220
Canada	2,330	2,340	2,330	2,360
China	2,000	2,200	2,380	2,580
France	390	420	430	430
Norway	919	950	953	988
Russia	2,910	2,960	2,970	2,970
South Africa	660	660	666	666
Venezuela	640	600	638	639
Other countries	5,290	5,550	6,730	6,970
World total (rounded)	21,400	22,200	24,100	24,800

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 and Alumina.
[2]Less than ½ unit.
[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.
[6]See Appendix C for definitions.
[7]Reynolds Metals Co, 1998, Reynolds Metals Co. reports first-quarter results: Richmond, VA, Reynolds Metals Co. press release, April 16, 1998, 5 p.

ANTIMONY

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

Domestic Production and Use: One silver mine in Idaho produced antimony as a byproduct, and an additional very small amount was recovered as a byproduct of the smelting of lead and silver-copper ores. Virtually all primary antimony metal and oxide produced domestically was derived from imports. Primary antimony metal and oxide was produced by five companies at processing plants that used both foreign and domestic feed material. Two plants were in Texas, and single plants were in Idaho, Montana, and New Jersey. The estimated value of primary antimony metal and oxide produced in 1998 was $50 million. Secondary antimony was recovered, mostly in alloy form, at lead smelters; its value, based on the price of antimony metal, was about $11 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:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Mine (recoverable antimony)[1]	215	262	242	356	500
Smelter: Primary	25,500	23,500	25,600	26,700	23,000
Secondary[2]	12,200	10,500	7,780	7,550	7,000
Imports for consumption	41,500	36,600	37,600	39,300	41,000
Exports of metal, alloys,[3] oxide, and waste and scrap[3]	7,850	8,200	4,450	3,900	4,500
Shipments from Government stockpile	1,850	1,130	4,300	2,930	3,000
Consumption, apparent[4]	46,100	43,300	45,000	46,600	45,600
Price, metal, average, cents per pound[5]	178	228	147	98	70
Stocks, yearend	10,900	10,600	11,000	10,600	12,000
Employment, plant, number[e]	100	100	100	100	80
Net import reliance[6] as a percent of apparent consumption	73	75	82	83	84

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

Import Sources (1994-97): Metal: China, 79%; Mexico, 7%; Hong Kong, 5%; Kyrgyzstan, 5%; and other, 4%. Ore and concentrate: Bolivia, 43%; China, 23%; Kyrgyzstan, 10%; Canada, 9%; and other, 15%. Oxide: China, 41%; Mexico, 17%; South Africa, 14%; Bolivia, 13%; and other, 15%. Total: China, 56%; Mexico, 11%; Bolivia, 10%; South Africa, 7%; and other, 16%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[7] 12/31/98**
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—9-30-98[8]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 1998**	**Disposals FY 1998**
Antimony	16,600	3,280	16,600	4,540	4,560

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ANTIMONY

Events, Trends, and Issues: In 1998, antimony production from domestic source materials was derived mainly from the recycling of lead-acid batteries. Recycling plus the small U.S. mine output supplied less than one-fifth of the estimated domestic demand.

The antimony metal price experienced a slight decline during 1998. The price started the year at $0.80 per pound; by spring it had declined to $0.73 per pound, and by fall it had slipped to $0.70 per pound. Industry observers attributed the price erosion, now in its fourth year, to continuing large supplies on the market from China.

Government stockpile sales of antimony continued for the sixth year, after being resumed in 1993 for the first time since 1988. Public Law 103-160 provided the authorization for the sales. During the year, the Defense Logistics Agency (DLA) held sales for antimony on the fourth Tuesday of the month, with the format still being the negotiated bid process. The DLA announced that its Annual Materials Plan for fiscal year 1998 permitted the disposal of up to 5,000 tons of antimony, the same amount allotted in 1997. Antimony was stockpiled in 12 DLA depots, with the largest inventories stored in New Haven, IN, and Somerville, NJ.

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[9]	Reserve base[9]
	1997	1998[e]		
United States	356	500	80,000	90,000
Bolivia	8,700	9,000	310,000	320,000
China	120,000	110,000	900,000	1,900,000
Kyrgyzstan	1,200	1,200	120,000	150,000
Russia	6,000	6,000	350,000	370,000
South Africa	5,000	5,000	240,000	250,000
Tajikistan	1,200	1,200	50,000	60,000
Other countries	7,000	7,000	25,000	75,000
World total (may be rounded)	149,000	140,000	2,100,000	3,200,000

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

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

[e]Estimated.
[1]Data for 1994-97 from 10-K reports. Estimate for 1998 based on 10-Q reports for the first two quarters.
[2]After an intensive review in 1997, secondary antimony figures were revised downward to reflect a changing industry pattern.
[3]Gross weight.
[4]Domestic mine production + secondary production from old scrap + net import reliance (see footnote 6).
[5]New York dealer price for 99.5% to 99.6% metal, c.i.f. U.S. ports.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix B.
[8]See Appendix C for definitions.
[9]See Appendix D for definitions.

ARSENIC

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

Domestic Production and Use: Arsenic is not recovered from domestic ores; all arsenic metal and compounds consumed in the United States are imported. More than 95% of the arsenic consumed is in compound form, principally arsenic trioxide, which is subsequently converted to arsenic acid. Production of chromated copper arsenate (CCA), a wood preservative, accounts for more than 90% of the domestic consumption of arsenic trioxide. CCA is manufactured primarily by three companies. Another company uses arsenic acid to produce arsenical herbicides. Arsenic metal is consumed in the manufacture of nonferrous alloys, principally lead alloys for use in lead-acid batteries. It is estimated that about 15 tons per year of high-purity arsenic is used in the manufacture of semiconductor material. The value of arsenic metal and compounds consumed domestically in 1988 was estimated at $20 million.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Imports for consumption:					
Metal	1,330	557	252	909	1,200
Compounds	20,300	22,100	21,200	22,800	28,000
Exports, metal	79	430	36	61	40
Estimated consumption[1]	21,500	22,300	21,400	23,700	29,000
Value, cents per pound, average:[2]					
Metal, Chinese	40	66	40	32	40
Trioxide, Mexico	32	33	33	31	30
Net import reliance[3] as a percent of apparent consumption	100	100	100	100	100

Recycling: Arsenic is not recovered from consumer end product scrap. However, process water and contaminated runoff collected at wood treatment plants are reused in pressure treatment, and 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 (1994-97): Metal: China, 86%; Hong Kong, 5%; Japan, 3%; and other, 6%. Trioxide: China, 50%; Chile, 22%; Mexico, 11%; and other, 17%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[4] 12/31/98**
Metal	2804.80.0000	Free	13.2¢/kg.
Trioxide	2811.29.1000	Free	Free.
Sulfide	2813.90.1000	Free	Free.
Acid[5]	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: Wood preservatives are expected to remain the major domestic use for arsenic. As a result, the demand for arsenic in the United States should continue to correlate closely with the demand for new housing, and the growth in the renovation or replacement of existing structures using pressure–treated lumber. In general, the demand for arsenic-based wood preservatives appears positive, barring greater acceptance of alternative preservatives.

Because of the toxicity of arsenic and its compounds, environmental regulation is expected to become increasingly stringent. This should adversely affect the demand for arsenic in the long term, but have only minor impacts in the near term.

World Production, Reserves, and Reserve Base:

	Production (Arsenic trioxide) 1997	Production (Arsenic trioxide) 1998[e]	Reserves and reserve base[6] (Arsenic content)
United States	—	—	
Belgium	2,000	2,000	
Chile	6,000	6,000	World reserves and reserve base are thought to be about 20 and 30 times, respectively, annual world production. The reserve base for the United States is estimated at 80,000 tons.
China	15,000	15,000	
France	2,500	3,000	
Ghana	4,600	5,000	
Kazakhstan	1,500	2,000	
Mexico	3,000	3,000	
Philippines	2,000	2,000	
Russia	1,500	1,500	
Other countries	2,500	3,000	
World total (rounded)	41,000	42,000	

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.

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

ASBESTOS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: One firm in California accounted for 100% of domestic production. Asbestos was consumed in roofing products, 48%; friction products, 29%; gaskets, 17%; and other, 6%.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998**[e]
Production (sales), mine	10	9	10	7	6
Imports for consumption	26	22	22	21	16
Exports[1]	18	15	15	20	18
Shipments from Government stockpile excesses	—	—	—	—	3
Consumption, apparent	27	22	22	21	16
Price, average value, dollars per ton, f.o.b.	506	W	W	W	W
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number	30	30	30	30	30
Net import reliance[2] as a percent of apparent consumption	30	32	32	5	6

Recycling: Insignificant.

Import Sources (1994-97): Canada, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
Asbestos	2524.00.0000	Free	Free.

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

Government Stockpile:

Stockpile Status—9-30-98[4]
(Metric tons)

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Amosite	29,322	—	29,322	—	—
Chrysotile	5,934	60	5,934	18,144	2,663
Crocidolite	33	—	33	—	—

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ASBESTOS

Events, Trends, and Issues: Domestic sales of asbestos, imports, exports, and apparent consumption decreased from those of 1997. Some exports under the export category were likely to have been reexports, asbestos-containing products, or nonasbestos products. Exports were estimated to be approximately 6,000 tons. 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[5]	Reserve base[5]
	1997	1998[e]		
United States	7	6	Moderate	Large
Brazil	170	170	Moderate	Moderate
Canada	447	420	Large	Large
China	245	245	Large	Large
Kazakhstan	125	120	Large	Large
Russia	700	680	Large	Large
South Africa	60	60	Moderate	Moderate
Zimbabwe	160	150	Moderate	Moderate
Other countries	156	99	Large	Large
World total (rounded)	2,070	1,950	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 cost effective 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. Most domestic production is exported; imports account for almost all domestic consumption.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]See Appendix D for definitions.

BARITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Barite sales in 1998 decreased slightly from the 1997 level of 692,000 tons to about 660,000 tons, and the value decreased accordingly to about $18 million. Sales came from six States, with the preponderance coming from Nevada. The second largest producing State was Georgia. About 3.1 million tons of ground barite from both domestic production and imports was sold in 1998 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, gastrointestinal x-ray “milkshakes,” and the faceplates and funnelglass of cathode-ray tubes used for television sets and computer monitors.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Sold or used, mine	583	543	662	692	660
Imports for consumption: Crude barite	1,010	965	1,470	2,210	2,605
Ground barite	58	80	70	34	25
Other	13	10	14	12	13
Exports	14	16	31	22	15
Consumption, apparent[1] (crude barite)	1,640	1,570	2,170	2,920	3,275
Consumption[2] (ground and crushed)	1,250	1,370	1,870	2,180	3,100
Price, average value, dollars per ton, mine	32.76	19.15	22.21	22.45	22.70
Employment, mine and mill, number[e]	350	400	350	380	410
Net import reliance[3] as a percent of apparent consumption	64	65	70	76	80

Recycling: None.

Import Sources (1994-97): China, 78%; India, 14%; Mexico, 4%; Morocco, 2%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
Crude barite	2511.10.5000	$1.25/t	$3.94/t.
Ground barite	2511.10.1000	$0.64/t	$7.38/t.
Witherite	2511.20.0000	0.6% ad val.	30% ad val.
Oxide, hydroxide, and peroxide	2816.30.0000	2% ad val.	10.5% ad val.
Other chlorides	2827.38.0000	4.2% ad val.	28.5% ad val.
Other sulfates	2833.27.0000	0.6% ad val.	4.2% 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: Barite is used primarily in petroleum well drilling and historically has had a positive relationship to petroleum price trends and drill rig usage. The domestic demand for barite continued in the spring of 1998, following expansions in the exploration and development activities both onshore and offshore along the Gulf Coast of the United States in the spring of 1997, and slowed down in the summer of 1998. This slowdown of activity occurred following declines in oil futures prices below normally profitable levels in the United States. The month-to-same-month price differences from 1997 to 1998 averaged, for light sweet crude oil futures, a decrease of nearly $6 per barrel, and only $0.37 per million British Thermal Units (BTU) of natural gas. Oil prices reached critical levels, causing the strong downturn in drilling activity despite relatively stable natural gas futures. Exploration/production drilling in the Gulf of Mexico offshore of Louisiana and Texas for petroleum deposits declined from 142 rigs at the end of February to 111 at the end of October 1998. The average futures price for light sweet crude went from $16.06 per barrel to $13.78 per barrel over the same time period of February to October. The average futures natural gas price declined from $2.21 per million BTU during the first week of March to $1.97, same basis, in the first week of September.

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BARITE

In the United States, estimated barite prices at the mine for the different products sold by the domestic producers were essentially unchanged, exhibiting a price elastic market.

Imports for consumption of lower-cost foreign barite were approximately quadruple domestic production. The major sources of imported barite have high-grade deposits, relatively low labor costs, and relatively low-cost (per ton-mile) ocean transportation (relative to land) to the U.S. 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 Nevada to the end-use regions. Nevada mines, crushers, and grinders are competitive in the California market and sell portions of their production to same-company mills along the U.S. Gulf Coast.

Over the past year, China has had problems with decisions of legal mine control and shipping barite past the Three Gorge Dam construction site.

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 exclusive of 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, oil, or synthetic).

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1997	1998[e]		
United States	692	660	27,000	60,000
Canada	103	100	11,000	14,600
China	3,500	3,300	35,000	150,000
France	76	80	2,000	2,500
Germany	120	110	1,000	1,500
India	400	450	28,000	32,000
Iran	150	150	NA	NA
Kazakhstan	250	270	NA	NA
Mexico	237	240	7,000	8,500
Morocco	270	250	10,000	11,000
Thailand	55	60	9,000	15,000
Turkey	160	160	4,000	20,000
United Kingdom	100	110	100	600
Other countries	820	260	20,000	161,000
World total (may be rounded)	6,930	6,200	150,000	480,000

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 D for definitions.

BAUXITE AND ALUMINA[1]

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

Domestic Production and Use: Domestic ore, which for many years has accounted for less than 1% of the U.S. requirement for bauxite, was mined by one company from surface mines in Alabama and Georgia; virtually all of it was used in the production of nonmetallurgical products, such as abrasives, chemicals, and refractories. Thus, nearly all bauxite consumed in the United States was imported; of the total, about 95% was converted to alumina. Also, the United States imported about one-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 6.2 million tons, with five Bayer refineries in operation at yearend.

Salient Statistics—United States:[2]	1994	1995	1996	1997	1998[e]
Production, bauxite, mine	W	W	W	NA	NA
Imports of bauxite for consumption[3]	11,200	10,800	10,700	11,200	10,500
Imports of alumina[4]	3,120	4,000	4,330	3,830	3,900
Exports of bauxite[3]	137	120	154	97	100
Exports of alumina[4]	1,040	1,040	918	1,270	1,400
Shipments of bauxite from Government stockpile excesses[3]	5	874	612	1,430	1,200
Consumption, apparent, bauxite and alumina (in aluminum equivalents)[5]	3,840	4,330	4,380	4,210	4,000
Price, bauxite, average value U.S. imports (f.a.s.) dollars per ton	26	24	27	25	24
Stocks, bauxite, industry, yearend[3]	1,600	1,730	1,930	2,260	2,100
Net import reliance,[6] bauxite and alumina, as a percent of apparent consumption	99	99	100	100	100

Recycling: None.

Import Sources (1994-97):[7] Bauxite: Guinea, 38%; Jamaica, 29%; Brazil, 16%; Guyana, 9%; and other, 8%. Alumina: Australia, 72%; Jamaica, 8%; Suriname, 7%; and other, 13%. Total: Australia, 32%; Guinea, 22%; Jamaica, 20%; Brazil, 10%; and other, 16%.

Tariff: Import duties on bauxite and alumina were abolished in 1971 by Public Law 92-151. Only imports from non-normal-trade-relations nations were dutiable. Countries that supplied commercial quantities of bauxite or alumina to the United States during the first 7 months of 1998 had normal-trade-relations status.

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

Government Stockpile:

Stockpile Status—9-30-98[8]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Bauxite, metal grade:					
Jamaica-type	8,670	1,340	8,670	1,220	1,220
Suriname-type	3,740	911	3,740	813	813
Bauxite, refractory-grade, calcined	74	46	4	81	[9]20

Events, Trends, and Issues: World output of bauxite and alumina for 1998 increased slightly to accommodate the modest increase in world primary aluminum metal production.

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BAUXITE AND ALUMINA

U.S. alumina plant engineered capacity remained essentially unchanged from that of yearend 1997. However, the 600,000-ton-per-year alumina plant in St. Croix, VI, which had been idled since 1994, was brought back onstream.

Spot prices for metallurgical-grade alumina, as published by Metal Bulletin, decreased gradually during the first three quarters of the year. The published price range began the year at $205 to $225 per ton. By the end of September, the price range had decreased to $165 to $185 per ton.

The revised fiscal year (FY) 1999 Annual Materials Plan submitted by the Defense National Stockpile Center proposed the sale of 3.56 million dry metric tons of metallurgical-grade bauxite (2.03 million tons of Jamaica-type and 1.52 million tons of Suriname-type) from the National Defense Stockpile during the period October 1, 1998, to September 30, 1999. In addition, the revised FY 1999 plan provided for the sale of 61,000 calcined metric tons of refractory-grade bauxite. These are the maximum amounts that could be sold under the new plan 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]
	1997	1998[e]		
United States	NA	NA	20,000	40,000
Australia	44,100	45,000	3,200,000	7,000,000
Brazil	12,300	12,500	3,900,000	4,900,000
China	8,000	8,500	720,000	2,000,000
Guinea	16,500	16,500	7,400,000	8,600,000
Guyana	2,500	2,600	700,000	900,000
India	5,800	6,000	1,500,000	2,300,000
Jamaica	11,900	12,600	2,000,000	2,000,000
Russia	3,350	3,400	200,000	200,000
Suriname	4,000	4,000	580,000	600,000
Venezuela	5,080	4,500	320,000	350,000
Other countries	9,290	9,370	4,100,000	4,700,000
World total (rounded)	123,000	125,000	25,000,000	34,000,000

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

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

[e]Estimated. NA Not available. 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). Treated as separate commodities, the net import reliance equaled 100% for bauxite and 31% for alumina in 1998. For the years 1994-97, the net import reliance ranged from about 99% to 100% for bauxite and from 32% to 42% for alumina.
[7]Aluminum equivalents.
[8]See Appendix C for definitions.
[9]Dry equivalent weight—31,500 metric tons.
[10]See Appendix D for definitions. Revisions for Australia, Brazil, Guinea, and India were based on updated data published by official Government sources.

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 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 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 240 tons was valued at more than $80 million, based on the producer price for beryllium-copper master alloy. The use of beryllium (as an alloy, metal, and oxide) in electronic and electrical components, and aerospace and defense applications accounted for more than 80% of consumption.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production, mine shipments	173	202	211	231	230
Imports for consumption, ore and metal	53	32	20	20	35
Exports, metal	29	61	57	40	60
Shipments from Government stockpile excesses[1]	[2](2)	[2](19)	—	—	—
Consumption: Apparent	198	198	197	240	240
Reported	174	227	234	259	260
Price, dollars:					
Domestic, metal, vacuum-cast ingot, per pound	275	308	327	327	327
Domestic, metal, powder blend, per pound	295	385	385	385	385
Domestic, beryllium-copper master alloy, per pound of contained beryllium	160	160	160	160	160
Domestic, beryllium oxide, powder, per pound	72.50	70.50	77.00	77.00	77.00
Stocks, consumer, yearend	113	162	139	110	75
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	13	E	E	4	4

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

Import Sources (1994-97): Ore, metal, scrap, and master alloy: Russia, 42%; Kazakhstan, 19%; France, 8%; Canada, 8%; and other, 23%.

Tariff: **Item**	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[4] 12/31/98**
Beryllium ore and concentrates	2617.90.0030	Free	Free.
Beryllium oxide or hydroxide	2825.90.1000	3.7% ad val.	25.0% ad val.
Beryllium-copper master alloy	7405.00.6030	1.2% ad val.	28.0% ad val.
Beryllium unwrought:			
Waste and scrap	8112.11.3000	Free	Free.
Other	8112.11.6000	8.5% ad val.	25.0% ad val.
Beryllium, wrought	8112.19.0000	5.5% ad val.	45.0% ad val.

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

Government Stockpile:

Stockpile Status—9-30-98[5]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 1998**	**Disposals FY 1998**
Beryl ore (11% BeO)	469	42	469	73	—
Beryllium-copper master alloy	222	18	222	45	45
Beryllium metal	363	—	—	—	—

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BERYLLIUM

Events, Trends, and Issues: For the first one-half year, sales of beryllium products improved compared with those of the previous year. Sales were boosted by strong demand for copper beryllium alloys from the aerospace, oil and gas, and communications markets. Imports for consumption of ore and metal increased, with Canada providing all of the ore imports and Kazakhstan, France, and Russia the leading suppliers of metal imports. Metal exports were up, with Japan, France, the United Kingdom, and Germany the major recipients of the materials. Beryllium price quotations remained unchanged.

For fiscal year (FY) 1998, ending September 30, 1998, the Defense Logistics Agency (DLA) had authority to sell about 1,810 tons of beryl ore and about 1,130 tons of beryllium copper master alloy from the National Defense Stockpile. In May and September 1998, the DLA sold a total of about 1,130 tons of beryllium copper master alloy valued at about $6.34 million. The sales exhausted DLA's authority for beryllium copper master alloy disposals under the Annual Materials Plan in FY 1998. There were no sales of beryl ore in FY 1998. For FY 1999, the Department of Defense (DOD) planned to dispose of about 1,810 tons of beryl ore and about 1,130 tons of beryllium copper master alloy. Also, the DOD proposed to dispose of about 36 tons of beryllium metal.

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	
	1997	1998[e]
United States	231	230
Brazil	([7])	([7])
China[e]	55	55
Kazakhstan[e]	4	4
Russia[e]	40	40
Other countries	1	1
World total	331	330

Reserves and reserve base[6]

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.

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.
[1]Data in parentheses denote stockpile acquisitions.
[2]Data represent the 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]See Appendix D for definitions.
[7]Less than ½ unit.

BISMUTH

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

Domestic Production and Use: One refinery in Nebraska formerly produced bismuth as a byproduct of lead refining, but bismuth operations ceased on June 30, 1997. There is no longer any domestic production of primary bismuth. Thirty-five companies, mostly in the Eastern United States, accounted for an estimated three-fourths of the bismuth consumed in 1998. The value of bismuth consumed was estimated at more than $14.3 million. About 48% of the bismuth was used in pharmaceuticals and chemicals, 33% in fusible alloys, solders, and cartridges, 17% in metallurgical additives, and 2% in other uses.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, refinery	W	W	W	W	—
Imports for consumption, metal	1,660	1,450	1,490	2,170	2,700
Exports, metal, alloys, scrap	160	261	151	206	225
Shipments from Government stockpile excesses	145	139	137	229	—
Consumption, reported	1,490	2,150	1,520	1,530	1,800
Price, average, domestic dealer, dollars per pound	3.25	3.85	3.65	3.50	3.60
Stocks, yearend, consumer	402	390	122	213	150
Employment, refinery, number of workers[e 1]	30	30	30	30	—
Net import reliance[2] as a percent of apparent consumption	W	W	W	W	100

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

Import Sources (1994-97): Belgium, 36%; Mexico, 32%; United Kingdom, 12%; China, 7%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
Articles thereof, including waste and scrap	8106.00.0000	Free	7.5% ad val.

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

Government Stockpile:

Stockpile Status—9-30-98[4]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Bismuth	—	—	—	85	85

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BISMUTH

Events, Trends, and Issues: Bismuth was used in several applications designed to provide nontoxic substitutes for lead. Such products include bismuth fishing sinkers; bismuth shot for waterfowl hunting; and bismuth-containing brass, pigments, ceramic glazes, solders, lubricating greases, and crystal ware. In response to California court action, major faucet makers agreed in July 1995 to remove lead from plumbing fixtures. The Safe Drinking Water Act Amendments of 1996 require that all new and repaired pipes and fixtures for potable water be lead-free after August 1998. Demand for bismuth in this sector increased moderately in 1998.

The use of bismuth in shot for waterfowl hunting increased significantly in 1998. The U.S. Fish and Wildlife Service granted final approval for the use of 97% bismuth-3% tin shot for waterfowl hunting in 1997. The shot is nontoxic to waterfowl who discover and ingest spent shot. It is an alternative to steel shot, which replaced lead shot for waterfowl hunting in 1991. Bismuth-tin shot has much better dropping power than steel shot.

World lead mine production has increased moderately in recent years, but world primary lead refinery production has actually leveled off, limiting the amount of bismuth that can be produced. World mine and refinery production of bismuth rose moderately in 1998. The domestic price increased from $3.33 per pound to $4.08 per pound during the first quarter, then declined to $3.65 per pound during the second quarter. The price continued to drift downward for the rest of the year, reaching $3.40 per pound by the end of the third quarter. The average price for the year increased from $3.50 to about $3.60 per pound, following 2 years of decline.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1997	1998[e]		
United States	—	—	9,000	14,000
Australia	—	—	18,000	27,000
Bolivia	350	500	10,000	20,000
Canada	183	200	5,000	30,000
China	600	750	20,000	40,000
Japan	168	200	9,000	18,000
Kazakhstan	115	115	5,000	10,000
Mexico	1,640	1,650	10,000	20,000
Peru	1,000	1,000	11,000	42,000
Other countries	150	150	15,000	35,000
World total (rounded)	4,210	4,560	110,000	260,000

World Resources: 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. Bismuth is potentially recoverable as a byproduct of the processing of molybdenum and tungsten ores, although extraction of bismuth from these ores is usually not economic.

Substitutes: Antibiotics, magnesia, and alumina can replace bismuth in pharmaceutical applications. Titanium dioxide-coated mica flakes and fish scale extracts are substitutes in pigment uses. Indium can replace bismuth in low-temperature solders. Resins can replace bismuth alloys jigs used for holding metal shapes during 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]Data for first 6 months of 1997.
[2]Defined as imports - exports + adjustments for Government and industry stock changes.
[3]See Appendix B.
[4]See Appendix C for definitions.
[5]See Appendix D for definitions.

BORON

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

Domestic Production and Use: The estimated value of boric oxide contained in minerals and compounds produced in 1998 was $440 million. Domestic production of boron minerals, primarily as sodium borates, by four companies was centered in southern California. The largest producer operated an open pit tincal and kernite mine and associated compound plants. A second firm, using Searles Lake brines as raw material, accounted for the majority of the remaining output. A third company continued to process small amounts of calcium and calcium sodium borates. A fourth company used an in-situ process. Principal consuming firms were in the North Central and Eastern States. The reported distribution pattern for boron compounds consumed in the United States in 1998 was as follows: Glass products, 71%; soaps and detergents, 5%; agriculture, 4%; fire retardants, 4%; and other, 16%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production[1]	550	728	581	604	619
Imports for consumption, gross weight:					
Borax	9	9	11	54	63
Boric acid	20	16	25	26	25
Colemanite	27	45	44	44	38
Ulexite	120	153	136	157	170
Exports, gross weight of boric acid and refined borates	498	588	381	473	473
Consumption: Apparent	389	312	234	483	504
Consumption: Reported	296	NA	367	403	NA
Price, dollars per ton, granulated pentahydrate borax in bulk, carload, works[2]	324	324	375	340	340
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 (1994-97): Boric acid: Chile, 35%; Turkey, 30%; Bolivia, 14%; Italy, 13%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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 largest producer of boron compounds during 1998 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.

Importation 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.

The in-situ borate project produced synthetic calcium borate product that was being tested for usage in the glass industry.

The only domestic underground operation continued production during the year.

Neodymium-iron-boron alloys are used to produce the strongest magnetic material known. Interest in magnetic levitation (Maglev) trains was renewed as a federal law authorized $1 billion to explore and construct a Maglev segment. Maglev uses magnetic fields to lift a train above a guide way. The new transportation law sets aside at least $55 million for various regions to conduct Maglev feasibility and other related studies. The U.S. Department of Transportation will designate one project as being eligible for $950 million. The Federal Railroad Administration planned to solicit proposals for 1998 and to designate five projects for further study next year. Several Maglev projects received renewed interest as a result of the funding in California, Maryland, and Florida. Preliminary projects in New York, Pennsylvania, Georgia, and Tennessee are under way.

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

	Production—all forms		Reserves[7]	Reserve base[7]
	1997	1998[e]		
United States	1,190	1,200	40,000	80,000
Argentina	270	270	2,000	9,000
Bolivia	5	5	4,000	19,000
Chile	150	150	8,000	41,000
China	140	140	27,000	36,000
Iran	1	1	1,000	1,000
Kazakhstan	7	7	14,000	15,000
Peru	40	40	4,000	22,000
Russia	13	13	40,000	100,000
Turkey	1,250	1,250	30,000	150,000
World total (rounded)	3,070	3,080	170,000	470,000

World Resources: Large domestic reserves of boron materials occur in California, chiefly in sediments and their contained brines. Extensive resources also occur in Turkey. Small deposits are being mined in South America. World resources are adequate, at current levels of consumption, 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 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 Market Reporter.
[3]Stocks data are not available and are assumed to be zero for net import reliance and apparent consumption calculations.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]Gross weight of ore in thousand metric tons.
[7]See Appendix D 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 $226 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 uses were as 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:	1994	1995	1996	1997	1998[e]
Production[1]	195	218	227	247	234
Imports for consumption, elemental bromine and compounds[2]	18	14	14	11	11
Exports, elemental bromine and compounds	24	10	16	14	10
Consumption, apparent[3]	197	206	225	244	235
Price, cents per kilogram, bulk, purified bromine	79.5	85.3	66.0	80.2	96.8
Stocks, producer, yearend, elemental bromine[e]	—	—	—	—	—
Employment, number	1,600	1,600	1,700	1,700	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 (1994-97): Israel, 89%; United Kingdom, 4%; Netherlands, 3%; Belgium, 2%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
Bromine	2801.30.2000	5.9% 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	14.2% 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	0.8% ad val.	25% ad val.
Potassium bromate	2829.90.0500	0.6% ad val.	25% ad val.
Potassium or sodium bromide	2827.51.0000	Free	22¢/kg.
Sodium bromate	2829.90.2500	0.7% ad val.	25% ad val.
Tetrabromobisphenol A	2908.10.2500	0.9¢/kg + 13.8% ad val.	15.4¢/kg + 62% ad val.
Vinyl bromide, methyl	2903.30.1520	Free	25% ad val.

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

Government Stockpile: None.

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BROMINE

Events, Trends, and Issues: Three bromine companies accounted for more than 75% of world production. Two of these companies are located in the United States and accounted for about 50% of production. Legislation during the 1970's and 1980's reduced the traditional demand for bromine as a gasoline additive and in agriculture, but new end uses in specialized flame retardant chemicals have demanded increasing amounts of bromine. In the fourth quarter of 1998, the first new domestic bromine plant built since 1976 is expected to begin production in Manistee, MI. Production capacity was expected to be 9,000 tons per year of elemental bromine and brominated salts.

Israel is the second largest producer of bromine in the world and the largest producer of elemental bromine. Approximately 90% of production was for export, accounting for about 60% of international trade in bromine and bromine compounds to more than 100 countries. A company produced bromine from Dead Sea bromine rich brines after production of potash. Exports of elemental bromine are produced into compounds at a wholly owned plant in the Netherlands.

The financial crisis in Asia adversely affected exports of brominated materials. Some employees in the United States were laid off as a direct result of the decrease in exports.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States[1]	247.0	234.0	11,000	11,000
Azerbaijan	2.0	2.0	300	300
China	31.0	31.0	NA	NA
France	2.0	2.0	1,600	1,600
India	1.5	1.5	([7])	([7])
Israel	135	135	([8])	([8])
Italy	0.3	0.3	([7])	([7])
Japan	20.0	20.0	([9])	([9])
Spain	0.1	0.1	1,400	1,400
Turkmenistan	0.1	0.1	700	700
Ukraine	3.0	3.0	400	400
United Kingdom	28.0	28.0	([7])	([7])
World total (rounded)	470	457	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. E Net exporter. NA Not available.
[1]Sold or used by U.S. producers.
[2]Imports calculated from items shown in tariff section.
[3]Includes recycled product.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix D for definitions.
[7]From waste bitterns associated with solar salt.
[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 Use: Primary cadmium in the United States is produced by two companies as a byproduct of beneficiating and refining zinc metal from sulfide ore concentrates. Secondary cadmium is recovered from spent nickel-cadmium (Ni-Cd) batteries by one company. Based on the average New York dealer price, the combined output of primary and secondary metal in 1998 was valued at about $3.5 million. About 69% of total apparent cadmium consumption was for batteries. The remaining 31% was distributed as follows: pigments, 13%; coatings and plating, 8%; stabilizers for plastics, 7%; nonferrous alloys, 2%; and other uses, 1%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, refinery[1]	1,010	1,270	1,530	2,060	2,100
Imports for consumption, metal	1,110	848	843	790	650
Exports of metal, alloys, and scrap	1,450	1,050	201	554	300
Shipments from Government stockpile excesses	210	220	230	161	130
Consumption, apparent	1,040	1,160	2,250	2,510	2,650
Price, metal, dollars per pound[2]	1.13	1.84	1.24	.51	.30
Stocks, yearend, producer and distributor	423	990	1,140	1,090	1,020
Employment, smelter and refinery, number	125	125	145	150	150
Net import reliance[3] as a percent of apparent consumption	3	E	32	16	21

Recycling: To date, cadmium recycling has been practical only for Ni-Cd batteries, some alloys, and dust from electric arc furnaces (EAF). The exact amount of recycled cadmium is not known. In 1998, the U.S. steel industry generated more than 0.6 million ton of EAF dust, typically containing 0.003% to 0.07% cadmium. At least nine States required collection of rechargeable Ni-Cd batteries.

Import Sources (1994-97): Metal: Canada, 63%; Australia, 17%; Belgium, 15%; Mexico, 3%; and other, 2%.

Tariff: Item	Number	Canada and Mexico 12/31/98	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
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—9-30-98[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Cadmium	1,753	2	1,753	544	119

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CADMIUM

Events, Trends, and Issues: Japan is the largest producer and the largest net importer of refined cadmium metal. More than 60% of the cadmium consumed by Western countries goes into batteries, of which about 75% are for cellular telephones and other cordless electronic equipment. The remaining 25% is used for industrial purposes, such as emergency power supplies for telephone exchanges and hospital operating rooms. Because of environmental concerns about cadmium, some of the Ni-Cd batteries in electronic equipment are being replaced by lithium-ion batteries; the latter have already captured about a 30% share of Japan's rechargeable battery market. The current consumption pattern is expected to change as the manufacture of electric vehicles accelerates in the United States, the European Union, and Japan. If this market develops as expected, recycling of Ni-Cd batteries on a large scale will be required, both for environmental reasons and to assure an adequate supply of cadmium metal.

Additional inducements for recycling will come from a new U.S. law entitled *"The Mercury-Containing and Rechargeable Battery Management Act of 1996*" (Public Law 104-142) that became effective in May 1998. Title I of the act establishes uniform national labeling requirements and provides for the streamlining of regulations governing battery collection and recycling.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States	2,060	2,100	90,000	270,000
Australia	632	640	120,000	350,000
Belgium	1,600	1,600	—	—
Canada	2,380	2,300	55,000	155,000
China	1,600	1,600	13,000	35,000
Germany	1,140	1,140	6,000	8,000
Japan	2,460	2,400	10,000	15,000
Kazakhstan	1,200	1,100	25,000	40,000
Mexico	800	800	35,000	40,000
Russia	790	750	16,000	30,000
Other countries	5,300	5,450	230,000	275,000
World total (may be rounded)	20,000	19,900	600,000	1,200,000

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

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

[e]Estimated. 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.

[6]See Appendix D for definitions.

CEMENT

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

Domestic Production and Use: In 1998, nearly 82 million tons of portland cement and 3.7 million tons of masonry cement were produced at a total of 116 plants, spread among 37 States, by 1 State agency and 41 companies. In addition, there were two cement plants in Puerto Rico. The ex-plant value of production, excluding Puerto Rico, was about $6.5 billion, and the dominant portland cement component was used to make concrete worth at least $27 billion. Total domestic cement consumption (sales) were again at record levels, exceeding 100 million tons for the first time. There were 108 plants making clinker—the main intermediate product in cement manufacture—with a total calculated annual production capacity of about 83 million tons. Together with eight other cement plants that were just grinding facilities for clinker produced elsewhere, total finish grinding capacity at yearend amounted to about 96 million tons. If Puerto Rico is included, the clinker and grinding capacities become about 85 million tons and 98 million tons, respectively. The top 5 cement companies together accounted for about 43% 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; 10% to producers of concrete products, such as block, pipe, and precast slabs; 10% to contractors (largely for roadpaving); 5% to building material dealers; and 5% to miscellaneous users, including Government and other contractors.

Salient Statistics—United States:[2]	**1994**	**1995**	**1996**	**1997**	**1998**[e]
Production, portland and masonry[3]	77,948	76,906	79,266	82,582	85,500
Shipments to final customers, including exports	85,934	86,561	91,438	96,801	101,500
Imports for consumption[4]	9,074	10,969	11,566	14,523	18,000
Exports	633	759	803	791	800
Consumption, apparent[5]	86,476	86,003	90,355	96,018	103,000
Price, average mill value, dollars per ton	61.26	67.87	71.19	73.49	75.00
Stocks, mill yearend	4,701	5,814	5,488	5,784	5,500
Employment, mine and mill, number[e]	17,900	17,800	17,900	17,900	17,800
Net import reliance[6] as a percent of apparent consumption	10	12	12	14	17

Recycling: None for cement; there is a small amount of recycling of concrete for use as aggregate.

Import Sources (1994-97):[7] Canada, 35%; Spain, 11%; Venezuela, 10%; Greece, 9%; and other, 35%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR**[8] **12/31/98**
Cement clinker	2523.10.0000	Free	$1.32/t.
White portland cement	2523.21.0000	4¢/t	$1.76/t.
Other portland cement	2523.29.0000	Free	$1.32/t.
Aluminous cement	2523.30.0000	Free	$1.32/t.
Other hydraulic cement	2523.90.0000	Free	$1.32/t.

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

Government Stockpile: None.

Events, Trends, and Issues: A strong construction market in 1998 generated record consumption levels for cement. Demand growth in 1998 was met through increased production and a large increase in imports. Passage of a major transportation infrastructure spending bill in 1998 augured well for higher U.S. consumption levels in 1999, although demand growth was expected to be tempered by spillover effects of economic problems in Southeast Asia and in Latin America. One new cement plant was expected to come online in 1999 and several other plants continued to be engaged in projects to upgrade their capacities.

There continued to be concern over the environmental impact of cement manufacture, particularly the emissions of carbon dioxide and cement kiln dust (CKD). A yearend 1997 accord was reached in Kyoto, Japan, that would have so-called developed countries, including the United States, reduce their carbon dioxide emissions to levels below those in 1990. This accord had yet to be signed or ratified by the U.S. Government. There was much debate as to how this reduction was to be achieved and what its cost would be to the economy. The Environmental Protection

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CEMENT

Agency has released proposed, but not yet final, guidelines on CKD emissions, and it has, as yet, to designate 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, tempered by administrative constraints, appears to be towards increased use of waste fuels. A number of environmental issues, such as restrictions on silica in dust, 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 which, in the presence of free lime, have hydraulic cementitious properties; 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 unit 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	
	1997	1998[e]	1997[e]	1998[e]
United States (includes Puerto Rico)	84,255	87,200	83,147	83,700
Brazil	38,096	39,000	38,500	39,000
China	492,600	495,000	410,000	420,000
France	[e]19,000	19,000	24,000	24,000
Germany	[e]37,000	37,000	41,900	42,000
India	[e]80,000	85,000	72,000	75,000
Indonesia	[e]26,000	23,000	26,000	27,000
Italy	33,721	33,500	45,700	46,000
Japan	91,938	91,000	95,949	95,500
Korea, Republic of	59,796	59,000	55,800	57,000
Mexico	27,548	28,000	43,000	43,000
Russia	26,600	25,000	63,000	63,000
Spain	27,632	28,000	33,800	34,000
Taiwan	21,522	22,000	24,000	24,000
Thailand	[e]36,000	34,000	40,000	40,000
Turkey	36,035	37,000	28,600	28,600
Other countries	[e]379,000	357,000	336,000	340,000
World total (rounded)	[e]1,515,000	1,500,000	1,440,000	1,470,000

World Resources: Although individual company reserves are subject to exhaustion, cement raw materials, especially limestone, are geologically widespread and abundant and overall shortages are unlikely in the foreseeable future. Local shortages generally can be met through 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 moderate but growing use in the United States of pozzolans as partial or complete substitutes for portland cement for some concrete applications.

[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]Hydraulic cement and clinker.
[8]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 believed that at least one domestic company manufactured cesium products from imported pollucite ore. Cesium, usually in the form of chemical compounds, was used in research and development and commercially in electronic, photoelectric, and medical applications.

Salient Statistics—United States: Salient statistics, such as production, consumption, imports, and exports, are not available. The cesium market is very small, with annual consumption probably amounting to only a few thousand kilograms. As a result, there is no active trading of the metal and, therefore, no official market price. However, several companies publish prices for cesium and cesium compounds. These prices remain relatively stable for several years. The per-unit price for the metal or compounds purchased from these companies varies inversely with the quantity of material purchased. For example, in 1998, one company offered 1-gram ampoules of 99.98% grade cesium metal at $60.90. The price for 100 grams of the same material from this company was $919.00, or $9.19 per gram. At another company, the price for a 2-gram ampoule of 99.95% pure cesium was $89.00, or $44.50 per gram.

Recycling: None.

Import Sources (1994-97): The United States is 100% import reliant. Canada is the major source of cesium ores. Other possible sources of cesium-bearing material include Germany and the United Kingdom.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[1] 12/31/98
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, and data on resources are sketchy. The estimates of reserves and of the reserve base are based on occurrences of the cesium aluminosilicate mineral pollucite, found in zoned pegmatites in association with the lithium minerals lepidolite and petalite. Pollucite is mined as a byproduct with other pegmatite minerals; commercial concentrates of pollucite contain about 20% cesium by weight.

	Reserves[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 have not been estimated.

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

NA Not available.
[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 13% 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, 76%; full-alloy steel, 8%; superalloys, 2%; and others, 14%. The value of chromium material consumption was about $412 million.

Salient Statistics—United States:[1]	1994	1995	1996	1997	1998[e]
Production: Mine	—	—	—	—	—
Secondary	99	112	98	120	111
Imports for consumption	273	416	362	350	418
Exports	33	27	51	30	57
Government stockpile releases	49	44	52	47	37
Consumption: Reported (excludes secondary)	310	298	277	345	296
Apparent[2] (includes secondary)	390	565	467	488	520
Price, chromite, yearend:					
South African, dollars per metric ton, South Africa	55	61	75	73	68
Turkish, dollars per metric ton, Turkey	108	144	225	180	145
Stocks, industry, yearend	101	80	74	72	60
Net import reliance[3] as a percent of apparent consumption	75	80	79	75	79

Recycling: In 1998, chromium contained in purchased stainless steel scrap accounted for 21% of apparent consumption.

Import Sources (1994-97): Chromium contained in chromite ore and chromium ferroalloys and metal: South Africa, 39%; Russia, 16%; Turkey, 11%; Zimbabwe, 8%; Kazakhstan, 6%; and other, 20%.

Tariff:[4] Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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 1999 in February 1998. In addition to the stockpile-grade uncommitted inventory listed below, the stockpile contains the following nonstockpile-grade uncommitted inventory, in thousand metric tons: 36.6, metallurgical chromite ore; 0.6, high-carbon ferrochromium; 10.4, low-carbon ferrochromium; and 1.24, ferrochromium-silicon.

Stockpile Status—9-30-98[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998	Average chromium content
Chromite ore:						
Chemical-grade	162	48.2	132	90.7	—	28.6%
Metallurgical-grade	319	95.4	319	227	45.8	28.6%
Refractory-grade	202	85.2	58.0	90.7	5.44	[e]23.9%
Chromium ferroalloys:						
Ferrochromium:						
High-carbon	645	15.2	91.8	35.2	35.2	71.4%
Low-carbon	276	3.32	276	6.87	6.87	71.4%
Ferrochromium-silicon	49.4	1.78	49.4	3.26	3.26	42.9%
Chromium metal	7.72	—	—	—	—	[e]100%

Events, Trends, and Issues: Chromite ore is not produced in the United States, Canada, or Mexico. Chromite ore is produced in the Western Hemisphere only in Brazil and Cuba. Most of Brazilian production is consumed in Brazil; some is exported to Norway. Cuban production is relatively small. The largest chromite ore producing countries, accounting for about eighty percent of world production, are India, Kazakhstan, South Africa, and Turkey. South

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CHROMIUM

Africa alone accounts for nearly one-half of world production and has been the major supplier of chromium in the form of chromite ore and ferrochromium to Western industrialized countries. Stainless steel, the major end use market for chromium, has shown long term growth equivalent to about one or two new ferrochromium furnaces annually. To meet this demand, South African plants were built or expanded. Production capacity expansion continues to be achieved through the addition of furnaces; however, the emphasis has shifted to expansion through plant enhancements that improve recovery and reduce cost, such as agglomeration and pre-heating of furnace feed and recovery from slag. South African chromite ore and ferrochromium producers financed these process changes through joint ventures with stainless steel producers in Asia. By financing capacity growth and production efficiency, consumers lower their cost and secure their supply; producers secure market share and stabilize production rates.

Economic and political reorganization in the countries of the Commonwealth of Independent States resulted in reduced demand in those countries. This reduction may eventually be followed by strong growth-driven demand resulting from the institution of reforms in those countries. The economic slowdown that started with the Asian financial crisis in 1997 resulted in reduced demand for stainless steel in Asia and forced Asian produced stainless steel prices down, which resulted in pressure to lower the price of stainless steel produced in North America and Europe. Oversupply of stainless steel in the world market was expected to result in slowed or negative production growth which, in turn, would be reflected in reduced demand for ferrochromium.

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

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1997	1998[e]	(shipping grade)[8]	
United States	—	—	—	10,000
Brazil	330	300	14,000	17,000
Finland	611	600	41,000	120,000
India	1,360	1,400	27,000	67,000
Iran	200	200	2,400	2,400
Kazakhstan	1,000	1,000	410,000	410,000
Russia	150	130	4,000	460,000
South Africa	5,780	6,000	3,000,000	5,500,000
Turkey	1,750	1,700	8,000	20,000
Zimbabwe	680	670	140,000	930,000
Other countries	639	600	35,000	43,000
World total (may be rounded)	12,500	12,600	3,700,000	7,600,000

World Resources: World resources exceed 11 billion tons of shipping-grade chromite, sufficient to meet conceivable demand for centuries. About 95% of chromium resources are geographically concentrated in southern Africa. Reserves and reserve base are geographically concentrated in southern Africa and Kazakhstan. 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 largest end use, or for chromium in superalloys, the major strategic end use. Chromium-containing scrap can substitute for ferrochromium in metallurgical uses. Substitutes for chromium-containing alloys, chromium chemicals, and chromite refractories generally increase cost or limit performance. 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]See Appendix C for definitions.
[7]See Appendix D for definitions. Reserves and reserve base data are rounded to no more than two significant figures.
[8]Shipping-grade chromite ore is deposit quantity and grade normalized to 45% Cr_2O_3.

CLAYS

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 1998, clays were produced in most States except Alaska, Delaware, Hawaii, Idaho, New Hampshire, Rhode Island, Vermont, and Wisconsin. The leading 21 firms supplied 50% of the tonnage, and 219 firms provided the remainder. Together, these firms operated approximately 766 mines. The estimated value of all marketable clay produced was about $2.14 billion. Major domestic uses for specific clays were estimated as follows: ball clay—30% floor and wall tile, 21% sanitaryware, 10% pottery, and 39% other uses; bentonite—26% foundry sand bond, 23% drilling mud, 17% pet waste absorbent, 15% iron ore pelletizing, and 9% other uses; common clay—52% brick, 23% cement, and 16% lightweight aggregate; fire clay—53% refractories and 47% other uses; fuller's earth—75% absorbent uses, 8% insecticide dispersant, and 17% other uses; and kaolin—56% paper, 14% refractories, 7% fiberglass, 5% paint, and 18% other uses.

Salient Statistics—United States:[1]	**1994**	**1995**	**1996**	**1997**	**1998**[e]
Production, mine:					
Ball clay	1,050	993	935	1,040	1,130
Bentonite	3,290	3,820	3,740	4,020	4,030
Common clay	25,900	25,600	26,200	24,500	24,900
Fire clay[2]	458	583	505	649	604
Fuller's earth	2,640	2,640	2,600	2,370	2,500
Kaolin	8,770	9,480	9,180	9,410	9,770
Total[3]	42,000	43,100	43,100	42,000	43,000
Imports for consumption	36	35	45	64	75
Exports	4,620	4,680	4,830	5,080	5,100
Consumption, apparent	37,600	38,500	38,300	37,000	38,000
Price, average, dollars per ton:					
Ball clay	43	46	44	46	46
Bentonite	41	36	36	42	40
Common clay	5	6	5	6	8
Fire clay	25	22	21	15	19
Fuller's earth	92	101	106	107	110
Kaolin	116	117	120	120	120
Stocks, yearend[4]	NA	NA	NA	NA	NA
Employment, number:[e] Mine	4,500	3,950	4,900	4,900	4,800
Mill	9,000	9,000	9,000	9,000	8,900
Net import reliance[5] as a percent of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1994-97): Mexico, 33%; United Kingdom, 19%; Canada, 9%; China, 8%; and other, 31%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
Kaolin and other kaolinitic clays, whether or not calcined	2507.00.0000	6.5¢/t	$2.46/t.
Bentonite	2508.10.0000	7.9¢/t	$3.20/t.
Fuller's and decolorizing earths	2508.20.0000	4.9¢/t	$1.48/t.
Fire clay	2508.30.0000	9.8¢/t	$1.97/t.
Common blue and other ball clays	2508.40.0010	9.4¢/t	$1.97/t.
Other clays	2508.40.0050	9.4¢/t	$1.97/t.
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	1% 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).

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CLAYS

Government Stockpile: None.

Events, Trends, and Issues: The total tonnage of clays sold or used by domestic producers increased slightly in 1998. There was an increase in sales and/or use for ball clay, bentonite, common clay, fuller's earth, and kaolin. Imports for consumption increased to 75,000 tons. Mexico and the United Kingdom were the major sources for imported clays. Exports increased to 5.1 million tons. Canada, Finland, Japan, and the Netherlands were major markets for exported clays. U.S. apparent consumption was estimated to be 38 million tons.

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

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

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

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

COBALT

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

Domestic Production and Use: With the exception of negligible amounts of byproduct cobalt produced as intermediate products from some mining operations, the United States did not mine or refine cobalt in 1998. U.S. supply was comprised of imports, stock releases, and secondary sources such as superalloy scrap, cemented carbide scrap, and spent catalysts. There were two domestic producers of extra-fine cobalt powder: One produced powder from imported primary metal, and another produced powder from recycled materials. In addition to the powder producers, 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 82% of U.S. consumption of cobalt was in five major end uses. Superalloys, used mainly in aircraft gas turbine engines, accounted for about 48% of U.S. demand; catalysts, cemented carbides, and magnetic alloys each accounted for about 9%; paint driers, about 7%; and other, 18%. The total estimated value of cobalt consumed in 1998 was $450 million.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Mine	—	—	—	—	—
Secondary	1,660	1,640	2,000	2,530	2,500
Imports for consumption	6,780	6,440	6,710	8,430	8,000
Exports	1,360	1,300	1,660	1,570	1,600
Shipments from Government stockpile excesses	1,500	1,550	2,050	1,620	2,000
Consumption:					
Reported (includes secondary)	7,110	7,140	7,470	8,400	8,400
Apparent (includes secondary)	8,560	8,740	9,130	11,000	10,800
Price, average annual spot for cathodes, dollars per pound	24.66	29.21	25.50	23.34	22.50
Stocks, industry, yearend	1,490	1,080	1,050	1,060	1,160
Net import reliance[1] as a percent of apparent consumption	81	81	78	77	77

Recycling: About 2,500 tons of cobalt was recycled from purchased scrap in 1998. This represented about 30% of estimated reported consumption for the year.

Import Sources (1994-97): Cobalt contained in metal, oxide, and salts: Norway, 22%; Finland, 18%; Zambia, 15%; Canada, 13%; and other, 32%. Since 1991, imports from Congo (Kinshasa) and Zambia have decreased, while imports from Finland, Norway, and Russia have increased.

Tariff: Item	Number	Normal Trade Relations (NTR)[2] 12/31/98	Non-NTR[3] 12/31/98
Unwrought cobalt, alloys	8105.10.3000	4.6% 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	4.1% 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 Annual Materials Plan includes a cobalt disposal limit of 2,720 tons (6.0 million pounds) during fiscal year 1999.

Stockpile Status—9-30-98[4]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Cobalt	14,700	199	14,700	2,720	2,510

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COBALT

Events, Trends, and Issues: World cobalt production is expected to continue to increase during the next 5 years with the opening of new nickel-cobalt, copper-cobalt, and primary cobalt mines, and the startup of projects to recover cobalt from stockpiled tailings, slags, and concentrates. Cobalt supply during this period will also include cobalt in recycled scrap and sales from the U.S. Government's National Defense Stockpile.

Demand for cobalt in any given year will depend on world economic conditions. In the near to medium term, various industry sectors are expected to increase their consumption of cobalt. In particular, increases from the superalloy industry, which consumes the most cobalt of any industry sector, and the rechargeable battery industry, which has been using cobalt at a rapidly increasing rate in recent years, are anticipated to contribute to an overall growth in cobalt demand of 3% to 6% per year.

In the medium to long term, cobalt supply is expected to grow faster than demand. The general trend in cobalt prices would be downward in response to a growing market surplus. In 1998, the free market price for cobalt cathode experienced a nearly steady decrease from approximately $26 per pound in January to $20 per pound in September. In early October, the price rapidly dropped to $17 to $18 per pound. Market analysts attributed this rapid decrease in price to various factors, ranging from supply-demand fundamentals to an intentional effort to lower prices.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1997	1998[e]		
United States	—	—	—	860,000
Australia	3,000	3,400	430,000	840,000
Canada	5,700	6,200	45,000	260,000
Congo (Kinshasa)	3,500	5,000	2,000,000	2,500,000
Cuba	2,080	2,100	1,000,000	1,800,000
New Caledonia[6]	800	800	230,000	860,000
Philippines	—	—	—	400,000
Russia	3,300	2,800	140,000	230,000
Zambia	6,100	7,500	360,000	540,000
Other countries	2,490	2,500	90,000	1,200,000
World total (may be rounded)	27,000	30,300	4,300,000	9,500,000

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 Congo (Kinshasa) and Zambia. In addition, millions of tons of hypothetical and speculative cobalt resources exist in manganese nodules and crusts on the ocean floor.

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

COLUMBIUM (NIOBIUM)

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

Domestic Production and Use: There has been no significant domestic columbium-mining industry since 1959. Domestic columbium resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Most metal, ferrocolumbium, other alloys, and compounds were produced by six companies 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 1998 was more than $70 million. Major end-use distribution of reported columbium consumption was as follows: carbon steels, 32%; superalloys, 27%; high-strength low-alloy steels, 16%; stainless and heat-resisting steels, 13%; alloy steels, 11%; and other, 1%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
Concentrates, tin slags, and other[1]	NA	NA	NA	NA	NA
Ferrocolumbium[e]	2,590	3,580	2,970	4,260	4,900
Exports, concentrate, metal, and alloys[e]	320	370	190	70	50
Consumption, reported:					
Raw material	NA	NA	NA	NA	NA
Ferrocolumbium[e 2]	2,750	2,900	3,370	3,780	3,800
Consumption, apparent	3,700	3,800	3,800	3,900	4,000
Price: Columbite, dollars per pound[3]	2.60	2.97	3.00	3.00	3.00
Pyrochlore, dollars per pound[4]	NA	NA	NA	NA	NA
Stocks, industry, processor and consumer, yearend	NA	NA	NA	NA	NA
Employment	NA	NA	NA	NA	NA
Net import reliance[5] as a percent of apparent consumption	100	100	100	100	100

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

Import Sources (1994-97): Brazil, 70%; Canada, 17%; Germany, 4%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
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	4.3% ad val.	45% ad val.

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

Government Stockpile: Sales of National Defense Stockpile (NDS) ferrocolumbium began in March 1997. According to the Defense Logistics Agency's (DLA) Annual Materials Plan (AMP) for fiscal year (FY) 1998, the maximum amount of ferrocolumbium that could be sold would be about 91 tons of columbium contained in ferrocolumbium. For the first quarter of FY 1998 (October 1, 1997 through December 31, 1997), the DLA sold about 90 tons of columbium contained in ferrocolumbium valued at about $1.25 million. The sales effectively exhausted DLA's authority for ferrocolumbium disposals under the AMP in FY 1998. For FY 1999, the Department of Defense (DOD) planned to dispose of about 181 tons of columbium contained in ferrocolumbium. Also, the DOD proposed to dispose of about 10 tons of columbium contained in columbium carbide, about 91 tons of columbium contained in columbium concentrates, and about 9 tons of columbium contained in columbium metal ingots. The NDS uncommitted inventories shown below include about 343 tons of columbium contained in nonstockpile-grade concentrates and about 148 tons of columbium contained in nonstockpile-grade ferrocolumbium.

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COLUMBIUM (NIOBIUM)

Stockpile Status—9-30-98[7]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Columbium:					
Carbide powder	10	—	—	—	—
Concentrates	760	—	—	—	—
Ferrocolumbium	409	5	295	91	90
Metal	73	—	—	—	—

Events, Trends, and Issues: For the first one-half year, domestic demand for columbium ferroalloys was strengthened by a 7% increase in raw steel production compared with that of the previous year. Additionally, demand for columbium in superalloys was up significantly, affected by a strong aerospace market. For the same period, overall columbium imports rose by about 7%, owing to the increased volume of ferrocolumbium imports from Brazil. Brazil was the leading supplier, providing about 80% of total imports. U.S. exports continued to decline.

In early 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 a range of $6.75 to $7 per pound of contained columbium, and high-purity ferrocolumbium was quoted at a range of $17.50 to $18 per pound of contained columbium. Industry sources indicated that nickel columbium sold at about $19 per pound of contained columbium, and that columbium metal ingots sold in the range of about $25 to $35 per pound.

It is estimated that in 1999 domestic columbium mine production will be zero and U.S. apparent consumption will be about 4,000 tons. The majority of total U.S. demand will be met by columbium imports in upgraded forms.

World Mine Production, Reserves, and Reserve Base:

	Mine production 1997	Mine production 1998	Reserves[8]	Reserve base[8]
United States	—	—	—	Negligible
Australia	125	130	9,000	NA
Brazil	18,100	18,000	3,300,000	5,000,000
Canada	2,300	2,300	140,000	410,000
Congo (Kinshasa)[9]	—	—	32,000	91,000
Nigeria	13	10	64,000	91,000
Other countries[10]	—	—	NA	NA
World total (rounded)	20,600	20,400	3,500,000	5,600,000

World Resources: Most of the world's identified resources of columbium are outside the United States and occur mainly as pyrochlore in carbonatite deposits. On a worldwide basis, resources are more than adequate to supply projected needs. The United States has approximately 150,000 tons of columbium resources in identified deposits, all of which were considered uneconomic at 1998 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]Metal, alloys, synthetic concentrates, and columbium oxide.
[2]Includes nickel columbium.
[3]Average value, contained pentoxides for material having a Nb_2O_5 to Ta_2O_5 ratio of 10 to 1.
[4]Average value, contained pentoxide.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B.
[7]See Appendix C for definitions.
[8]See Appendix D for definitions.
[9]Formerly Zaire.
[10]Bolivia, China, Russia, and Zambia also produce, or are believed to produce columbium, but available information is inadequate to make reliable estimates of output levels.

COPPER

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

Domestic Production and Use: Domestic mine production in 1998 declined to 1.85 million metric tons and was valued at about $3.3 billion. The five principal mining States, in descending order, Arizona, Utah, New Mexico, Nevada, and Montana, accounted for 99% of domestic production; copper was also recovered at mines in three other States. While copper was recovered at about 35 mines operating in the United States, 15 mines accounted for about 97% of production. Seven primary and 3 secondary smelters, 7 electrolytic and 6 fire refineries, and 15 solvent extraction-electrowinning facilities were operating at yearend. Refined copper and direct melt scrap were consumed at about 35 brass mills; 13 rod mills; and 600 foundries, chemical plants, and miscellaneous consumers. Copper and copper alloy products were consumed[1] in building construction, 42%; electric and electronic products, 25%; industrial machinery and equipment, 11%; transportation equipment, 13%; and consumer and general products, 9%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Mine	1,850	1,850	1,920	1,940	1,850
Refinery: Primary[2]	1,840	1,930	2,010	2,060	2,140
Secondary[3]	392	352	345	383	290
Copper from all old scrap	500	442	428	496	410
Imports for consumption:					
Ores and concentrates	82	127	72	44	110
Refined	470	429	543	647	720
Unmanufactured	763	825	961	978	1,130
Exports: Ores and concentrates	261	239	195	128	40
Refined	157	217	169	93	100
Unmanufactured	752	894	683	618	450
Consumption: Reported refined	2,680	2,530	2,610	2,790	2,920
Apparent unmanufactured[4]	2,690	2,540	2,830	2,950	3,030
Price, average, cents per pound:					
Domestic producer, cathode	111.0	138.3	109.0	106.9	80
London Metal Exchange, high-grade	104.6	133.1	104.0	103.2	76
Stocks, yearend, refined[5]	119	163	146	314	450
Employment, mine and mill, thousands	13.1	13.8	13.3	13.2	13.0
Net import reliance[6] as a percent of apparent consumption	13	7	14	13	16

Recycling: Old scrap, converted to refined metal and alloys, provided 410,000 tons of copper, equivalent to 14% of apparent consumption. Purchased new scrap, derived from copper fabricating operations, yielded 950,000 tons of contained copper; 80% of the copper contained in new scrap was consumed at brass mills. Of the total copper recovered from scrap, copper smelters and refiners recovered 23%; ingot makers, 10%; brass mills, 63%; and miscellaneous manufacturers, foundries, and chemical plants, 4%. Copper in all old and new, refined or remelted scrap contributed 34% of the U.S. copper supply.

Import Sources (1994-97): Unmanufactured: Canada, 47%; Chile, 23%; Mexico, 13%; and other, 17%. Refined copper accounted for 60% of imports of unwrought copper.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Canada and Mexico 12/31/98	Non-NTR[7] 12/31/98
Unrefined copper; anodes	7402.00.0000	0.2% ad val.[8]	Free	6% ad val.[8]
Refined and alloys; unwrought	7403.00.0000	1% ad val.	Free	6% ad val.
Copper powder	7406.10.0000	1.1% ad val.	Free	49% ad val.
Copper wire (bare)	7408.11.6000	3.2% ad val.	Free	28% ad val.

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

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

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COPPER

Events, Trends, and Issues: World mine production of copper continued its 4-year-long upward trend, rising about 4% in 1998. Most of the increase in production came from South America and Indonesia, where an estimated 700,000 tons of new capacity came on-stream. In the United States, mine production declined by an estimated 90,000 tons. In response to sustained lower copper prices, a number of companies cut back production and deferred development of previously announced projects. One mine in Arizona completely curtailed its copper sulfide concentrate operations, and several others reduced production. One mine in New Mexico revised its mine plan to reduce electrowon production over a 3-year period. At yearend, further cutbacks were announced for 1999. The growth in world refined production lagged behind that of mine production owing to reduced secondary refined production. In the United States, an increase in primary refined production from the renovated Utah smelter/refinery complex was partially offset by reduced secondary refined production, cutbacks in electrowon production, and anode feed shortages.

The global production of refined copper during 1998 exceeded consumption, and reported world-wide inventories of copper rose during the second half of the year. With sustained high inventories, copper prices remained low throughout 1998. By July, prices, in constant dollar terms, had fallen to their lowest level since the Great Depression. A large shift in global inventories to U.S. London Metal Exchange (LME) warehouses in California had industry concerned that incentives offered by the warehouse operators, coupled with other market factors, had led to a distorted market. In September, the LME announced plans to limit further stock accumulations in California.

Domestic refined copper demand grew by about 5% in 1998 owing to demand for wire mill products and substitution of refined copper for scrap at brass mills. In June, a new wire-rod mill was commissioned in Texas. Worldwide, consumption grew by only about 2% in 1998 owing to the economic crises in Asia. In 1999, continued low global demand growth and a projected increase in mine production of more than 700,000 tons is expected to generate a surplus of refined copper.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[9]	Reserve base[9]
	1997	1998[e]		
United States	1,940	1,850	45,000	90,000
Australia	545	600	7,000	23,000
Canada	657	710	10,000	23,000
Chile	3,390	3,660	88,000	160,000
China	414	440	18,000	37,000
Indonesia	529	750	19,000	25,000
Kazakhstan	316	340	14,000	20,000
Mexico	391	400	15,000	27,000
Peru	491	450	19,000	40,000
Poland	414	420	20,000	36,000
Russia	505	450	20,000	30,000
Zambia	353	280	12,000	34,000
Other countries	1,450	1,550	50,000	105,000
World total (rounded)	11,400	11,900	340,000	650,000

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, 1997.
[2]From both domestic and 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, COMEX, and London Metal Exchange warehouses in the United States.
[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 D for definitions.

DIAMOND (INDUSTRIAL)

(Data in million carats, unless otherwise noted)

Domestic Production and Use: In 1998, production reached a record high for the second consecutive year and the United States remained the world's largest market for industrial diamond. Virtually all output was synthetic grit and powder. Two firms, one in New Jersey and the other in Ohio, accounted for all of the production. Nine other firms produced polycrystalline diamond from diamond powder. Three companies recovered used industrial diamond as one of their principal operations. Most consumption was accounted for by the following industry sectors: abrasive industries, construction, machinery manufacturing, mineral services, stone and ceramic production, and transportation equipment manufacturing. Mineral services, primarily drilling, accounted for most industrial stone consumption.

Salient Statistics—United States:[1]	1994	1995	1996	1997	1998[e]
Bort, grit, and powder and dust; natural and synthetic:					
Production: Manufactured diamond	104	115	114	125	130
Secondary	16.0	26.1	20	10	10
Imports for consumption	174	188	218	254	250
Exports[2]	150	98	105	126	102
Sales from Government stockpile excesses	2.0	.2	1	.7	—
Consumption, apparent	146	231	248	264	288
Price, value of imports, dollars per carat	.51	.43	.46	.43	.42
Net import reliance[3] as a percent of apparent consumption	16	39	46	49	51
Stones, natural:					
Production: Mine	—	—	([4])	([4])	([4])
Secondary	.1	.3	.4	.5	.5
Imports for consumption[5]	2.8	4.1	2.9	2.8	3.8
Exports[2]	.5	.5	.5	.6	.9
Sales from Government stockpile excesses	3.1	.3	.5	1.2	.4
Consumption, apparent	5.5	4.2	3.3	3.9	3.8
Price, value of imports, dollars per carat	9.41	6.62	7.54	7.69	5.32
Net import reliance[3] as a percent of apparent consumption	98	86	88	87	87

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

Import Sources (1994-97): Bort, grit, and powder and dust; natural and synthetic: Ireland, 53%; China, 13%; Russia, 10%; and other, 24%. Stone, primarily natural: United Kingdom, 31%; Belgium, 19%; Congo (Kinshasa)[6], 12%; and other, 38%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[7] 12/31/98
Miners' diamond, carbonados	7102.21.1010	Free	Free.
Other	7102.21.1020	Free	Free.
Industrial diamond, natural advanced	7102.21.3000	1% 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:

Stockpile Status—9-30-98[8]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Crushing bort	0.0620	—	0.0620	1.0	—
Industrial stones	3.10	0.105	.965	1.0	0.664

Events, Trends, and Issues: The United States will continue to be the largest market for industrial diamond through the remainder of this decade. A new diamond mine in Colorado, the first in the United States in almost a century, could become a domestic source of natural industrial stones.

World and U.S. 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 technology becomes more cost-effective; the decline is even more likely if competition from low-cost producers in China and Russia increases.

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

	Mine production		Reserves[10]	Reserve base[10]
	1997	1998[e]		
United States	([4])	([4])	—	Unknown
Australia	22.1	22.0	90	230
Botswana	5.0	5.0	130	200
Brazil	.6	.6	5	15
China	.9	.9	10	20
Congo (Kinshasa)[6]	12.5	13.0	150	350
Russia	9.6	10.0	40	65
South Africa	5.8	6.0	70	150
Other countries	1.2	1.0	80	200
World total (may be rounded)	57.7	59.0	580	1,200

World Resources: Natural diamond resources have been discovered in more than 35 countries. Nevertheless, nearly all industrial diamond is synthetic. At least 15 countries have the technology to produce synthetic diamond.

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

[e]Estimated. NA Not available.
[1]Some data revised to correspond with new information published in the USGS Mineral Industry Surveys annual review of industrial diamond for 1997.
[2]Reexports no longer are combined with exports as in previous Mineral Commodity Summaries because growing volumes of U.S. reexports obscure apparent consumption rates.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]Less than ½ unit.
[5]May include synthetic miners diamond.
[6]Formerly Zaire.
[7]See Appendix B.
[8]See Appendix C for definitions.
[9]Natural industrial diamond only. Note, however, that synthetic diamond production far exceeds natural industrial diamond output. Worldwide production of manufactured industrial diamond totaled at least 500 million carats in 1998; the largest producers included Ireland, Russia, South Africa, and the United States.
[10]See Appendix D 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 $182 million in 1998. Production was from 6 companies with 12 processing facilities in 4 States. Three companies produced more than 75% of the total. California and Nevada were the principal producing States. Estimated end uses of diatomite were filter aids, 64%; absorbents, 13%; fillers, 12%; and other (mostly cement manufacture), 11%.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production[1]	646	722	729	773	767
Imports for consumption	([2])	([2])	2	2	2
Exports	157	144	143	140	140
Consumption, apparent	489	578	588	635	629
Price, average value, dollars per ton, f.o.b. plant	236	238	242	244	237
Stocks, producer, yearend	36	36	36	36	36
Employment, mine and plant, number[e]	1,000	1,000	1,000	1,000	1,000
Net import reliance[3] as a percent of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (1994-97): France, 85%; Mexico, 5%; and other, 10%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[4] 12/31/98**
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 about 70 countries, primarily for filtration use.

In the United States, diatomite use in filtration applications appears to be stabilizing with cost a factor in preventing further growth of ceramic, polymeric, and carbon membrane technologies. Applications as an absorbent continue to grow.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1997	1998[e]		
United States[1]	773	767	250,000	500,000
China	150	150		NA
Denmark[6]	96	95		NA
France	85	85	Other	2,000
Germany	50	50	countries:	NA
Japan	194	200	550,000	NA
Korea, Republic of	70	70		NA
Mexico	50	50		2,000
Spain	40	40		NA
Former Soviet Union[7]	90	90		NA
Other countries	200	200		NA
World total (may be rounded)	1,800	1,800	800,000	Large

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

Substitutes: Many materials can be substituted for diatomite. However, the unique properties of diatomite assure its continuing use for many applications. Expanded perlite, and silica sand compete for filtration purposes, other filtration technologies 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 various clays and special brick, mineral wool, expanded perlite, and exfoliated vermiculite can be used.

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

FELDSPAR

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: U.S. feldspar production (including aplite) in 1998 had an estimated value of $40 million. The three largest producers accounted for almost two-thirds of the output, with eight other companies supplying the remainder. Operations in North Carolina provided about 46% 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 30 States and to foreign destinations, including Canada and Mexico. In ceramics and glass, feldspar functions as a flux. Estimated 1998 end-use distribution of domestic feldspar was glass, 70%, and pottery and other, 30%.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production, marketable	765	880	890	[e]900	800
Imports for consumption	7	9	7	9	7
Exports	17	15	10	7	18
Consumption, apparent	755	874	887	[e]900	789
Price, average value, marketable production, dollars per ton	40.78	42.50	44.27	[e]47.22	50.00
Stocks, producer, yearend[1]	NA	NA	NA	NA	NA
Employment, mine and preparation plant, number	400	400	400	400	400
Net import reliance[2] as a percent of apparent consumption	E	E	E	([3])	E

Recycling: Insignificant.

Import Sources (1994-97): Mexico, 96%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[4] 12/31/98**
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: Glass containers are a major end use of feldspar, including flint (clear), green, and amber glass. The glass container recycling rate in the United States was an estimated 35% in 1997 (latest available). The recycling rates for amber and green glass are considerably higher than for flint glass, even though flint glass accounts for around 60% of total U.S. container production. Recycled glass (cullet) adds a certain level of impurities to a glass manufacturing batch, in spite of efforts to remove metal caps, ceramics, and other contaminants in the cullet. This places demands on mineral suppliers for higher quality minerals, as flint glass requires more demanding specifications, such as iron content, than colored glass, according to a nongovernment source.

Whiteware, such as sanitaryware, is another major end use of feldspar. Usage of sanitaryware is reflected by activity in the construction market. In western Europe, some countries have had negative growth during this decade. Also, sanitaryware is one of the most labor intensive sectors of ceramics. As a result, there has been investment and relocation of manufacturing sites to eastern Europe where wages are lower and market consumption appears to have potential, according to a nongovernment source.

Turkish output of feldspar has increased from 139,000 tons in 1989 to approximately 1,000,000 tons in 1996 (latest available). Export tonnages made up a major portion, increasing from 49,000 tons in 1989 to 742,000 tons in 1996. Much of the exported material went to ceramic industries in Spain and Italy, although another market area is North Africa, including Egypt, Algeria, and Tunisia, according to a nongovernment source. Other markets are the Middle East, especially Israel, Jordan, and Saudi Arabia, and the Far East, including Indonesia, Malaysia, Taiwan, and the Philippines.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	1997	1998[e]	
United States	[e]900	800	Significant in the United States and assumed to be similar in other countries.
Brazil	225	230	
Columbia	60	60	
France	550	560	
Germany	360	370	
India	90	90	
Italy	2,300	2,400	
Japan	55	60	
Korea, Republic of	320	330	
Mexico	143	150	
Norway	75	75	
Russia	45	50	
Spain	350	350	
Thailand	660	660	
Turkey	1,000	1,000	
Uzbekistan	70	70	
Venezuela	150	160	
Other countries	697	685	
World total (may be rounded)	8,050	8,100	

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]Negligible.
[4]See Appendix B.
[5]See Appendix D for definitions.

FLUORSPAR

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: There was no domestic mine production of fluorspar in 1998. There was some recovery of byproduct calcium fluoride from industrial waste streams, although it is not included in the data shown below. Material purchased from the National Defense Stockpile or imported was screened and dried for resale to customers. An estimated 90% of U.S. reported fluorspar consumption went into the production of hydrofluoric acid (HF) in Louisiana and Texas and aluminum fluoride in Texas. HF is the primary feedstock for the manufacture of virtually all organic and inorganic fluorine-bearing chemicals, and is also a key ingredient in the processing of aluminum and uranium. The remaining estimated 10% of the reported fluorspar consumption was consumed as a flux in steelmaking, in iron and steel foundries, primary aluminum production, glass manufacture, enamels, welding rod coatings, and other uses or products. To supplement domestic fluorine supplies, about 67,000 tons of fluorosilicic acid (equivalent to 118,000 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:	1994	1995	1996	1997	1998[e]
Production: Finished, all grades[e 1]	[2]49	[2]51	8	—	—
Fluorspar equivalent from phosphate rock	97	98	119	121	118
Imports for consumption:					
Acid grade	434	470	474	485	433
Metallurgical grade	59	88	39	51	58
Fluorspar equivalent from hydrofluoric acid plus cryolite	108	114	131	175	207
Exports[3]	24	42	62	62	48
Shipments from Government stockpile	13	74	287	97	93
Consumption: Apparent[4]	556	599	719	551	522
Reported	486	534	527	491	510
Stocks, yearend, consumer and dealer[5]	284	405	234	375	457
Employment, mine and mill, number	130	130	5	—	—
Net import reliance[6] as a percent of apparent consumption	91	91	99	100	100

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

Import Sources (1994-97): China, 64%; South Africa, 21%; Mexico, 13%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[7] 12/31/98
Acid grade (more than 97% CaF_2)	2529.22.0000	\$0.41/t or free[8]	\$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: The Defense National Stockpile Center (DNSC) sold 137,000 tons (151,000 short dry tons) of acid grade and 45,000 tons (50,000 short dry tons) of metallurgical grade. Under the proposed fiscal year 1999 Annual Materials Plan, the DNSC will be authorized to sell 91,000 tons (100,000 short dry tons) of acid grade and 45,000 tons (50,000 short dry tons) of metallurgical grade. During fiscal year 1999, it is expected that the DNSC will be able to sell all remaining stockpiled acid grade authorized for disposal.

Stockpile Status—9-30-98[9]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Acid grade	95	280	95	163	136
Metallurgical grade	191	25	191	45	45

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FLUORSPAR

Events, Trends, and Issues: On July 20, 1998, the Chinese Government suspended the export quotas on fluorspar through the end of the year. This allowed the unlimited export of fluorspar by any of the 200 to 300 authorized fluorspar traders for a flat rate export fee of about $27 per ton. This fee was about $2 to $5 per ton higher than the original export license fees established in the initial export license bidding process.[10]

The Kyoto conference on the United Nations Framework Convention on Climate Change included hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride in the list of greenhouse gases for which emission-reduction targets were established. Under the terms of the Kyoto Protocol, the United States would be obligated to cut emissions of these gases by 7%, from the base year level of 1995, by the year 2012. Followup talks were held in Buenos Aires, Argentina, in November to discuss procedures for reaching the targets. These discussions included setting up an international emissions trading system and a clean development mechanism enabling industrialized countries to finance emissions-avoiding projects in developing countries and to receive credit for doing so. A major U.S. concern was the unwillingness of many developing countries to agree to formal commitments that would put an upper limit on their emissions. An item on “voluntary” commitments by developing countries was included in the agenda of the Buenos Aires conference.[11] On a related issue, the U.S. Environmental Protection Agency issued proposed rules extending a ban on venting chlorofluorocarbons and hydrochlorofluorocarbons to include hydrofluorocarbons and perfluorocarbons because of their potential to contribute to global warming. The proposed rule was issued under authority of Title VI of the Clean Air Act, but chemical companies challenged the legal basis of the proposed rule, pointing out that Title VI only addresses the problem of stratospheric ozone-depletion, not global warming.[12]

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[13 14]	Reserve base[13 14]
	1997	1998[e]		
United States	—	—	—	6,000
Brazil	60	60	W	W
China	2,400	2,400	23,000	94,000
France	110	110	10,000	14,000
Kenya	90	90	2,000	3,000
Mexico	553	550	32,000	40,000
Morocco	104	104	W	W
South Africa	217	217	30,000	36,000
Spain	120	120	6,000	8,000
United Kingdom	67	65	2,000	3,000
Other countries	899	824	[15]110,000	[15]170,000
World total (rounded)	4,620	4,540	220,000	370,000

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., Illinois.
[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]Free in the case of Canada, Mexico, and designated countries under the Generalized System of Preferences, Caribbean Basin Economic Recovery Act, U.S./Israel Free Trade Area, and the Andean Trade Preference Act.
[9]See Appendix C for definitions.
[10]Industrial Minerals, 1998, Fluorspar export quotas dropped: Industrial Minerals, no. 372, September, p. 17.
[11]United Nations Climate Change Secretariat, 1998, Kyoto Protocol talks in Buenos Aires to promote emissions cuts: Bonn, United Nations Climate Change Secretariat advance press release, 2 p.
[12]Hess, Glenn, 1998, Industry challenges EPA under Clean Air Act Title VI: Chemical Market Reporter, v. 254, no. 16, p. 19.
[13]See Appendix D for definitions.
[14]Measured as 100% calcium fluoride.
[15]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 1998. 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 $9.2 million. Gallium arsenide (GaAs) components represented about 95% of domestic gallium consumption. About 44% 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 51% of gallium demand. The remaining 5% 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:	1994	1995	1996	1997	1998[e]
Production, primary	—	—	—	—	—
Imports for consumption	16,900	18,100	30,000	19,100	23,000
Exports	NA	NA	NA	NA	NA
Consumption: Reported	15,500	16,900	21,900	23,600	23,000
Consumption: Apparent	NA	NA	NA	NA	NA
Price, yearend, dollars per kilogram, 99.99999%-pure	395	425	425	425	595
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, refinery, number[e]	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 (1994-97): France, 55%; Russia, 21%; Canada, 8%; Germany, 3%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[2] 12/31/98
Gallium metal	8112.91.1000	3.1% 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: Notwithstanding the economic crisis in Asia, which has affected many U.S. “high-tech” industries, most U.S. publicly owned firms that are predominately dedicated to GaAs manufacturing reported increased revenues in the first half of 1998. Most of the increase in revenues resulted from increased shipments of GaAs devices to the wireless communications sector. GaAs manufacturers continued to introduce new devices for this market and expand capacity to meet the growing demand. A new GaAs heterojunction bipolar transistor facility opened in North Carolina in June, which uses proprietary technology to produce these devices on 4-inch wafers for commercial wireless applications. One Massachusetts-based firm announced plans to double its monolithic microwave integrated circuit production capabilities, again for use in the wireless communications market.

Japanese demand for gallium was estimated to be 107 tons in 1997, with 6 tons of domestic production, 53 tons of imports; recycled material provided the remaining demand. Kazakhstan (34%), France (22%), Russia (15%) and China (12%) were the principal import sources. The 1997 demand was a 16% increase from that of 1996 and was attributed to recovery in the LED and cellular telephone markets. Japanese gallium demand was expected to level off or decline slightly in 1998 as consumers reduced inventory levels that had increased at yearend 1997 and switched from liquid-phase-epitaxy processing methods to vapor-phase epitaxy, which uses less gallium.

Development of blue and purple laser diodes and LED’s based on gallium nitride is rapidly progressing to commercial application. From a level of sales of $190 million in 1997, some projections anticipate sales growth to $950 million by 2000, an average annual growth rate of 38%. Potential large-scale uses for the blue and purple devices are in high-density data storage, laser printing, communications and lighting.

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 1998, world primary production was estimated to be about 60,000 kilograms, with Australia, Kazakhstan, and Russia as the largest producers. Countries with smaller output were China, Hungary, Japan, and Slovakia. Refined gallium production was estimated to be about 55,000 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 was recycled from new scrap in Germany, Japan, the United Kingdom, and the United States.

Gallium occurs in very small concentrations in many rocks and 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 LED’s. 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 for industrial use was mined in 1998 by six firms, three in New York, two in Montana, and one in Idaho. Output of crude garnet was valued at more than $5 million, while refined material sold or used was valued at $14 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:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production (crude)[2]	44,700	46,300	60,900	64,900	57,000
Sold by producers[2]	45,600	45,400	52,200	59,600	55,000
Imports for consumption[e]	7,000	7,000	9,000	10,000	10,000
Exports[e]	9,000	8,000	12,000	12,000	10,000
Consumption, apparent	43,600	43,900	48,700	57,600	55,000
Price, range of value, dollars per ton[3]	50-1,500	50-1,500	50-2,000	50-2,000	50-2,000
Stocks, producer[e]	5,000	5,900	14,600	19,900	21,900
Employment, mine and mill, number	160	180	210	250	230
Net import reliance[4] as a percent of apparent consumption	E	E	E	E	—

Recycling: Relatively small amounts of garnet reportedly are recycled.

Import Sources (1994-97[e]): Australia, 90%; India, 5%; China, 5%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[5] 12/31/98**
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	0.1¢/kg.	2.2¢/kg.
Natural abrasives on woven textile	6805.10.0000	0.5% ad val.	20% ad val.
Natural abrasives on paper or paperboard	6805.20.0000	0.5% ad val.	20% ad val.
Natural abrasives sheets, strips, disks, belts, sleeves, or similar form	6805.30.1000	0.5% ad val.	20% ad val.

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

Government Stockpile: None.

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GARNET (INDUSTRIAL)

Events, Trends, and Issues: Two of the three garnet mines in the western half of the United States (both in Montana) were offered for sale in 1998. Although U.S. garnet sales declined during 1998, some forecasts indicate that domestic and foreign markets for industrial garnet will grow in the next several years. Markets for blasting media and water jet cutting are expected to lead the demand. China may join Australia, India, and the United States as an important garnet exporter early in the next decade.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States	64,900	57,000	5,000,000	25,000,000
Australia	60,000	60,000	1,000,000	7,000,000
China	30,000	30,000	Moderate to Large	Moderate to Large
India	50,000	50,000	500,000	20,000,000
Other countries	10,000	10,000	6,500,000	20,000,000
World total (rounded)	215,000	210,000	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. Significant domestic resources of garnet also occur in Idaho, Maine, Montana, New Hampshire, North Carolina, and Oregon. In addition to the United States, major garnet deposits exist in Australia, China, and India, where they are mined for foreign and domestic markets; deposits in Russia and Turkey also have been mined in recent years, primarily for internal markets. Additional garnet resources are located in Canada, the Czech Republic, Pakistan, and Ukraine; small mining operations have been reported in most of these areas.

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]Data revised to correspond with new information published in the USGS Mineral Industry Surveys annual review of industrial garnet for 1997.
[3]Includes both crude and refined garnet; most crude concentrate is \$50 to \$100 per ton, and most refined material is \$150 to \$400 per ton.
[4]Defined as imports - exports + adjustments for industry stock changes.
[5]See Appendix B.
[6]See Appendix D for definitions.

GEMSTONES[1]

(Data in million dollars, unless otherwise noted)

Domestic Production and Use: Total U.S. gemstone output has decreased in recent years because of declining foreign demand for freshwater shell, a major component of the domestic industry. Domestic gemstone production also included amber, agates, beryls, coral, garnet, jade, jasper, pearl, opal, quartz, sapphire, topaz, turquoise, and many other gem materials. Output of natural gemstones was primarily from Arizona, Arkansas, California, Nevada, Oregon, and Tennessee. Reported output of synthetic gemstones was from six firms in Arizona, California, Michigan, North Carolina, and New York. There was notable production of turquoise in Arizona; beryl in Maine; sapphire in Montana; opal in Nevada; ruby in North Carolina; and freshwater pearl in Tennessee. Major uses were jewelry, carvings, and gem/mineral collections.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production:[2] Natural[3]	50.5	48.7	43.6	25.0	23.0
Synthetic	22.2	26.0	24.0	21.6	30.0
Imports for consumption	6,440	6,540	7,240	8,380	9,600
Exports, including reexports[4]	2,240	2,520	2,660	2,760	2,600
Consumption, apparent[5]	4,270	4,100	4,650	5,670	7,100
Price	Variable, depending on size, type, and quality				
Employment, mine, number[e]	1,200	1,200	1,200	1,200	1,200
Net import reliance[6] as a percent of apparent consumption	99	98	98	99	99

Recycling: Insignificant.

Import Sources (1994-97 by value): Israel, 34%; Belgium, 22%; India, 21%; and other, 23%. Diamond imports accounted for 91% of the total value of gem imports.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[7] 12/31/98
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	12.6% 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 stones, cut but not set	7103.99.1000	0.4% ad val.	10% ad val.
Other precious stones, misc.	7103.99.5000	12.6% ad val.	50% ad val.
Imitation precious stones	7018.10.2000	0.6% ad val.	20% ad val.
Synthetic stones, cut but not set	7104.90.1000	0.6% ad val.	10% ad val.
Pearls, natural	7101.10.0000	Free	10% ad val.
Pearls, cultured	7101.21.0000	0.4% ad val.	10 % ad val.
Pearls, imitation not strung	7018.10.1000	4.8% 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 U.S. Department of Defense is currently selling some NDS materials that may be of gemstone quality.

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GEMSTONES

Events, Trends, and Issues: A Colorado diamond mine, the only commercial U.S. diamond producer in almost a century, was offered for sale in 1998. Canada's first commercial diamond mine was opened in 1998. The mine may account for about 5% of global output when fully operational. Additional Canadian mines are scheduled to open in the next few years and may increase national output to 15% of world production.

As the world's leading gem market, accounting for at least one-third of world demand and reaching sales totaling $6 billion, the United States is expected to dominate global gemstone consumption well into the next millennium. Synthetic gemstones will gain a larger share of domestic jewelry sales. China may emerge as a major new gem market in the next decade.

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

	Mine production		Reserves and reserve base[9]
	1997	1998[e]	
United States	([10])	([10])	World reserves and reserve base of gem diamond are substantial. No reserves or reserve base data are available for other gemstones.
Angola	1,110	1,000	
Australia	18,100	18,500	
Botswana	13,000	13,000	
Brazil	300	300	
Central African Republic	400	400	
China	230	230	
Congo (Kinshasa)[11]	2,500	2,500	
Namibia	1,500	1,500	
Russia	9,550	10,000	
South Africa	4,380	4,500	
Venezuela	350	350	
Other countries	780	750	
World total (may be rounded)	52,200	53,000	

World Resources: Natural gem-quality diamonds are among the world's rarest mineral materials. Most diamond-bearing ore bodies have a diamond content that ranges from less than 1 carat per ton to only about 6 carats per ton. The major gem diamond reserves are in southern Africa, Russia, and Western Australia; Canadian resources may prove to be significant as well. Estimation of a reserve base is difficult to determine because of the changing economic evaluation of near-gem materials and recent discoveries in Australia, Canada, and Russia.

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

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

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 1998 producer price, was more than $37 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 1998. 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 the mining companies supplied domestic and export markets with germanium-bearing materials generated from the mining of zinc ores. The major end uses for germanium, worldwide, were fiber-optic systems, 44%; polymerization catalysts, 22%; infrared optics, 11%; electronics/solar electrical applications, 17%; and other uses (phosphors, metallurgy, and chemotherapy), 6%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, refinery[e]	10,000	10,000	18,000	20,000	22,000
Total imports[1]	14,700	16,200	27,500	23,700	20,000
Exports	NA	NA	NA	NA	NA
Consumption[e]	25,000	27,000	25,000	28,000	28,000
Price, producer, yearend, dollars per kilogram:					
Zone refined	1,060	1,375	2,000	1,475	1,700
Dioxide, electronic grade	660	880	1,300	950	1,100
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant, number[e 2]	100	110	120	115	100
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. Worldwide, about 25% of the total germanium consumed was produced from recycled materials. As a result of the low unit use of germanium in various devices, little germanium returns as old scrap.

Import Sources (1994-97):[4] Russia, 35%; Belgium, 19%; United Kingdom, 15%; China, 14%; and other, 17%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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	2.8% ad val.	25% ad val.
Other	8112.30.9000	4.6% ad val.	45% ad val.

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

Government Stockpile:

Stockpile Status—9-30-98[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Germanium	55,500	1,990	27,300	8,000	8,010

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GERMANIUM

Events, Trends, and Issues: Zinc ore, and associated germanium, is mined in 46 countries and smelted and refined in 34 countries. Germanium-bearing material generated from zinc processing is refined in only nine countries. World refinery production of germanium decreased in 1998, with smaller amounts brought to market by Canada, China, and Russia. However, total supply increased owing to increases in scrap recycling and metal released from government stockpiles in the United States, Russia, and Ukraine. Slight decreases in world demand for optical fibers and polyethylene terephthalate (PET), resulted in a world oversupply. It is expected that fiber optics will continue to be the main growth sector for germanium in spite of sluggish demand in the sector for 1998. The use of germanium in solar cells is also expected to increase.

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[7]	Reserve base[7]
	1997	1998[e]		
United States	20,000	22,000	450,000	500,000
Other countries	43,000	34,000	NA	NA
World total	63,000	56,000	NA	NA

World Resources: The available resources of germanium are associated with certain zinc and lead-zinc-copper sulfide ores. Worldwide germanium resources would increase substantially if germanium were to be recovered from ash and flue dust generated in the burning of 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 than competing materials in some high-frequency and high-power electronics 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]Gross weight of unwrought germanium, and waste and scrap. Does not include imports of germanium dioxide and other germanium compounds for which data are not available.

[2]Employment related to primary germanium refining is indirectly related to zinc refining.

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

[4]Total imports from republics of the Former Soviet Union (Estonia, Lithuania, Russia, and Ukraine) account for 44% of the 1994-97 imports.

[5]See Appendix B.

[6]See Appendix C for definitions.

[7]See Appendix D for definitions.

GOLD

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

Domestic Production and Use: Gold was produced at about 70 major lode mines, a dozen or more large placer mines, nearly all in Alaska, and numerous smaller placer mines, mostly in Alaska and in the Western States. In addition, a small amount of domestic gold was recovered as a byproduct of processing base metals, chiefly copper. Thirty mines yielded about 90% of the gold produced in the United States. The value of 1998 mine production was about $4 billion. Commercial-grade refined gold came from about two dozen producers. A few dozen companies, out of several thousand companies and artisans, dominated the fabrication of gold into commercial products. U.S. jewelry manufacturing was heavily concentrated in the New York, NY, and Providence, RI, areas with lesser concentrations in California, Florida, and Texas. Estimated uses were: jewelry and arts, 55%; other industrial, 38%; electronics, 4%; and dental, 3%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Mine	327	317	326	360	350
Refinery: Primary	241	([2])	([2])	270	260
Secondary (old scrap)	148	([2])	([2])	100	100
Imports[3]	114	126	159	209	340
Exports[3]	395	347	471	477	460
Consumption, reported 76	([2])	([2])	137	140	
Stocks, yearend, Treasury[4]	8,140	8,140	8,140	8,140	8,140
Price, dollars per ounce[5]	385	386	389	332	300
Employment, mine and mill, number[e]	14,100	14,700	16,900	16,300	16,000
Net import reliance[6] as a percent of apparent consumption	E	E	E	E	E

Recycling: 100 metric tons of old scrap was recycled in 1998 or 70% of the reported consumption as shown in the Salient Statistics subsection.

Import Sources (1994-97):[3] Canada, 55%; Brazil, 11%; Mexico, 8%; Chile, 6%; Colombia, 6%; and other, 14%.

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 1998 was estimated at slightly below the record level of 1997, 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 75% of the U.S. total. Between July 1997 and June 1998, six gold mines were closed, nine new gold mines were opened, and one gold mine was expanded in the United States. During this 12-month period, the average output per mine had increased, and companies merged creating fewer but larger gold mining operations in the United States. Most of the larger companies were successfully replacing their annual production with new reserves, but smaller companies were finding this more difficult. Estimates by an industry association indicate that worldwide gold exploration expenditures decreased in 1998, with 1997 marking the peak of exploration spending for the 1990's. The expenditures of U.S. gold producers continued to fall in 1998 owing to the declining gold price.

During the first 9 months of the year, the Engelhard Industries daily price of gold ranged from a low of about $275 per troy ounce, in August, to a high of nearly $315, in April. For most of 1998, this price range was below $298, the low price reported for all of 1997. The traditional role of gold as a store of value was not able to lift the price of gold out of its 18-year-low trading range. The market continued to be concerned about the future role of gold in the reserves of the European Central Bank (ECB), which will commence operation on January 1, 1999. It appears that gold will account for 10% to 15% of the Bank's foreign reserves. This would leave significant quantities of gold with the European Monetary Union (EMU) national central banks, and there is uncertainty about the degree of control those banks will retain over their reserves. The final make-up of the ECB and the determination of its relationship to the national central banks will influence the gold market far beyond the member countries of the EMU.

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GOLD

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1997	1998[e]		
United States	360	350	5,600	6,000
Australia	311	320	4,000	4,700
Brazil	59	60	800	1,200
Canada	169	155	1,500	3,500
China[e]	175	150	NA	NA
Russia	115	105	3,000	3,500
South Africa	492	465	18,500	38,000
Uzbekistan	75	100	2,000	3,000
Other countries	660	695	9,300	11,800
World total (may be rounded)	2,410	2,400	[8]45,000	[8]72,000

Of an estimated 125,000 tons of gold mined in historical times through 1998, about 15% is thought to have been lost, used in dissipative industrial uses, or otherwise unrecoverable or unaccounted for. Of the remaining 106,000 tons, an estimated 34,000 tons is official stocks held by central banks and about 72,000 tons is privately held as coin, bullion, and jewelry.

World Resources: Total world resources of gold are estimated at 89,000 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]Survey response not sufficiently complete for publication.
[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: 216.6 (1994), 243.9 (1995), 373.0 (1996), 142.8 (1997), and 215.3 (1998, estimated).

[4]Includes gold in Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.
[5]Englehard Industries average gold price quotation for the year.
[6]Defined as imports - exports + adjustments for Government and industry stock changes.
[7]See Appendix D for definitions.
[8]Excludes China and some other countries for which reliable data were not available.

GRAPHITE (NATURAL)

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Natural graphite was not produced domestically in 1998. Natural graphite was consumed by approximately 200 manufacturing firms, primarily in the Northeastern and Great Lakes regions. The major uses of natural graphite did not significantly vary from those of 1997. Refractory applications, once again, led the way in use categories with 33%; brake linings was second with 19%; lubricants, 6%; dressings and molds in foundry operations, 4%; and miscellaneous uses making up the remaining 38%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, mine	—	—	—	—	—
Imports for consumption	53	61	53	58	66
Exports	20	37	26	40	37
Consumption, apparent	33	24	27	18	29
Price, imports (average dollars per ton at foreign ports):					
Flake	629	658	699	622	700
Lump and chip (Sri Lankan)	709	610	675	1,010	1,000
Amorphous (Mexican)	138	143	134	153	150
Stocks, yearend	NA	NA	NA	NA	NA
Net import reliance[1] as a percent of apparent consumption	100	100	100	100	100

Recycling: Refractory brick and linings, as usual, led the way in recycling of graphite products. Primary recycling of refractory articles is growing with the recycled market being principally in less demanding service conditions, such as safety linings and thermal insulation.

Import Sources (1994-97): Mexico, 28%; Canada, 27%, China, 27%; Madagascar, 8%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[2] 12/31/98
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—9-30-98[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Sri Lanka, amorphous lump	5	—	—	—	—
Madagascar, crystalline flake	10	2	10	2	2
Other than Sri Lanka and Madagascar crystalline	([4])	—	([4])	—	—

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GRAPHITE (NATURAL)

Events, Trends, and Issues: Graphite was near to supply-demand balance in 1998. 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 because of increased efficiency by the iron and steel producers. Use of natural graphite in lubrication applications is also decreasing because of changes in requirements for lubricant compositions and in processing technologies.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1997	1998[e]		
United States	—	—	—	1,000
Brazil	36	40	460	1,000
China	190	200	5,300	310,000
India	120	120	620	620
Madagascar	16	15	960	960
Mexico	42	40	3,100	3,100
Other countries	171	190	5,300	43,800
World total (may be rounded)	575	605	16,000	360,000

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 oxidizing 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.
[4]Less than ½ unit.
[5]See Appendix D for definitions.

GYPSUM

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: In 1998, crude gypsum output exceeded 19 million tons valued at $135 million. The top producing States were Oklahoma, Texas, Iowa, Michigan, California, Nevada, and Indiana, which together accounted for 73% of total output. Overall, 29 companies produced gypsum at 60 mines in 19 States, and 10 companies calcined gypsum at 62 plants in 27 States. Most of domestic consumption, which totaled about 31 million tons, was accounted for by manufacturers of wallboard and plaster products. More than 4 million tons for cement production, almost 3 million tons for agricultural applications, and small amounts of high-purity gypsum for a wide range of industrial processes, such as smelting and glassmaking, accounted for remaining uses. Capacity at operating wallboard plants in the United States was 27 billion square feet per year while sales were more than 26 billion square feet, representing capacity utilization greater than 98%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Crude	17,200	16,600	17,500	18,600	19,000
Byproduct[1]	1,800	2,600	3,900	4,000	4,600
Calcined[2]	16,700	16,700	17,000	17,200	17,500
Wallboard products (million square feet)	22,500	24,000	23,700	24,400	26,500
Imports, crude, including anhydrite	8,470	8,160	8,050	8,400	8,500
Exports, crude, not ground or calcined	89	79	136	174	200
Consumption, apparent[3]	27,400	27,400	29,200	30,800	31,900
Price: Average crude, f.o.b. mine, dollars per ton	6.70	7.29	7.10	7.11	7.20
Average calcined, f.o.b. plant, dollars per ton	17.23	17.37	16.88	17.58	18.00
Stocks, producer, crude, yearend	1,200	1,100	1,200	1,200	1,200
Employment, mine and calcining plant, number[e]	6,700	6,500	6,300	6,000	6,000
Net import reliance[4] as a percent of apparent consumption	31	29	27	27	26

Recycling: A relatively small amount of gypsum wallboard is recycled.

Import Sources (1994-97): Canada, 69%; Mexico, 23%; Spain, 5%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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: Construction of new homes, commercial buildings, and office space continued to stimulate wallboard demand and boosted domestic consumption of gypsum. Some forecasts indicate that gypsum demand in North American markets will remain high for the next few years. This demand, however, will depend principally on the strength of the construction industry, particularly in the United States where more than 90% of the gypsum consumed is used for wallboard products, building plasters, and the manufacture of portland cement. Nevertheless, Federal funding authorized in 1998 for road building and repair through 2003 will help to spur gypsum consumption in the cement industry. Several large wallboard plants under construction and designed to use only byproduct gypsum will accelerate substitution significantly as they become operational within a few years.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1997	**1998[e]**		
United States	18,600	19,000	700,000	Large
Australia	2,100	2,200		
Canada	8,500	8,500	450,000	Large
China	7,800	8,000		
Egypt	2,000	2,000		
France	5,000	5,000		
India	2,500	2,500		
Iran	8,500	8,500		
Italy	2,000	2,000	Reserves and reserve base are large in major producing countries, but data are not available.	
Japan	5,500	5,500		
Mexico	5,900	5,900		
Poland	1,000	1,000		
Spain	7,400	7,400		
Thailand	8,600	8,600		
United Kingdom	2,000	2,000		
Other countries	16,600	17,000		
World total (rounded)	104,000	105,000	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, where large imports from Canada augment domestic supplies for wallboard manufacturing in large metropolitan markets. Large deposits occur in the Great Lakes region, midcontinental region, and California. Foreign resources are large and widely distributed; more than 90 countries produce gypsum.

Substitutes: Other construction materials may be substituted for gypsum, especially cement, lime, lumber, masonry, and steel. There is no practical substitute for gypsum in portland cement. Byproduct gypsum generated by various industrial processes is becoming more important as a substitute for mined gypsum in wallboard manufacturing, cement production, and agricultural applications.

[e]Estimated.
[1]Only byproduct reported as sold or used.
[2]From domestic crude.
[3]Defined as crude + total reported byproduct use + net import reliance.
[4]Defined as imports - exports + adjustments for industry stock changes.
[5]See Appendix B.
[6]See Appendix D for definitions.

HELIUM

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

Domestic Production and Use: During 1998, the estimated value of Grade-A (99.995% or better) helium extracted at the Bureau of Land Management's Exell Helium Plant was $4 million; the estimated value of Grade-A helium extracted by private industry was about $205 million. The total sales value for domestic consumption and exports was $209 million. Eleven private industry plants and one Government facility purified helium. Of the privately owned plants, four were in Kansas, three were in Texas, two were in Colorado, and one each was in Utah, Oklahoma, and Wyoming. Crude helium was extracted from natural gas by an additional eleven private industry plants, and this helium was either stored in the Government's crude helium pipeline system or purified by one of the purification plants. Six of these crude helium plants were in Kansas, one was in Oklahoma, and four were in Texas. The major uses of the 1998 estimated domestic consumption of 78.2 million cubic meters (2.8 billion cubic feet) were primarily for cryogenic applications, 24%; for pressurizing and purging, 20%; for welding cover gas, 18%; for controlled atmospheres, 16%; and other uses, 22%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Helium extracted from natural gas[2]	112	101	103	116	118
Withdrawn from storage[3]	(11.5)	(5.2)	(8.3)	(9.3)	(10)
Grade-A helium sales	100	96.1	94.7	107	108
Imports for consumption	—	—	—	—	—
Exports[4]	25.0	27.7	22.8	29.5	29.7
Consumption, apparent[4]	75.4	68.1	67.1	77.4	78.2
Employment, plant, number[e]	615	635	631	605	531
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 through March 1998, after which the facility stopped production. 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 $1.514 per cubic meter ($42 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 (1994-97): None.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
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 104-273. During 1998, Helium Operations accepted over 33 million cubic meters (1,202 million cubic feet) of private helium for storage and redelivered over 29 million cubic meters (1,060 million cubic feet) for a net increase in privately owned storage of more than 3.9 million cubic meters (142 million cubic feet). As of September 30, 1998, 132 million cubic meters (4.8 billion cubic feet) was owned by private firms, which is the largest amount to date.

Stockpile Status—9-30-98[7]
(in million cubic meters)

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Helium	832.4	16.6	832.4	—	7.4

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HELIUM

Events, Trends, and Issues: A Grade-A helium plant in the southeastern Texas Panhandle began production in September, and a Grade-A helium plant in eastern Colorado began production near yearend. Three Grade-A facilities stopped production—one in Texas, the Bureau of Land Management's Helium Operations, and two in Colorado. One crude helium plant in Kansas began production. Helium Operations stopped the production and sale of refined helium in April 1998, as mandated by the Helium Privatization Act of 1996. Other parts of the Helium Program, such as operation of the helium storage system for private companies, operation of the Government's helium conservation system, and collection of helium royalties and fees, will continue.

It is estimated that in 1999 domestic production of helium will be over 110 million cubic meters (3.97 billion cubic feet) and that U.S. apparent consumption will be more than 78 million cubic meters (2.8 billion cubic feet). Exports from the United States are expected to increase slowly because of economic uncertainties in the Asian markets.

World Production, Reserves, and Reserve Base:

	Production		Reserves[9]	Reserve base[9]
	1997	1998[e]		
United States	116	118	6,000	[10]11,100
Algeria	16	16	NA	2,100
Canada	NA	NA	NA	2,100
China	NA	NA	NA	1,100
Poland	1.4	1.4	40	280
Former Soviet Union[11]	4.2	4.2	1,700	6,700
Other countries	NA	NA	NA	2,800
World total (rounded)	138	140	NA	26,200

World Resources: The measured and indicated helium resources of the United States were estimated to be about 11.1 billion cubic meters (399 billion cubic feet) as of January 1, 1998. This includes 1 billion cubic meters (36 billion cubic feet) of helium stored in the Cliffside Field, 6 billion cubic meters (215 billion cubic feet) of helium in helium-rich natural gas (0.30% helium or more), and 4.1 billion cubic meters (148 billion cubic feet) in helium-lean natural gas (less than 0.30% helium). The Hugoton (Kansas, Texas, and Oklahoma), Panhandle West, Panoma, and Riley Ridge Fields are currently depleting gasfields and contain an estimated 4.5 billion cubic meters (163 billion cubic feet) of helium. Future supplies will probably come from known helium-rich natural gas with little fuel value and from helium-lean resources.

Helium resources of the world exclusive of the United States were estimated to be 15 billion cubic meters (540 billion cubic feet). The locations and volumes of the principal deposits, in billion cubic meters, are the Former Soviet Union, 6.7; Algeria, 2.1; Canada, 2.1; China, 1.1; and Poland, 0.8. As of January 1, 1998, Helium Operations had analyzed nearly 21,000 gas samples from 26 countries and the United States as part of 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 and other impurities).
[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]See appendix C for definitions.
[8]The author is Chief, Branch of Helium Resources, Bureau of Land Management, Amarillo Field Office (Helium Operations), Amarillo, TX.
[9]See Appendix D for definitions.
[10]All domestic measured and indicated helium resources in the United States.
[11] As constituted before December 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 Virginia, and one firm produced ilmenite in California as a byproduct of sand and gravel production. Domestic ilmenite production data was withheld to avoid revealing company proprietary data. Based on average prices, the value of U.S. ilmenite and titanium slag consumption in 1998 was about $334 million. Major coproducts of mining from heavy-mineral deposits are rutile and zircon. About 99% of the ilmenite and 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:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production	W	W	W	W	W
Imports for consumption[2]	584	586	641	651	605
Exports[e]	9	15	7	11	39
Consumption, reported[2]	W	1,010	1,010	1,060	1,120
Price, dollars per metric ton:					
Ilmenite, bulk, 54% TiO_2, f.o.b. Australian ports	77	83	87	83	77
Slag:[e]					
80% TiO_2, f.o.b. Sorel, Quebec	278	244	292	294	338
85% TiO_2, f.o.b. Richards Bay, South Africa	334	349	353	390	385
Stocks, mine, distributor and consumer, yearend[2]	208	137	267	234	248
Employment, mine and mill,[3] number	400	400	400	400	450
Net import reliance[4] as a percent of reported consumption	W	64%	50%	63%	49%

Recycling: None.

Import Sources (1994-97): South Africa, 54%; Australia, 31%; Canada, 5%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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.

Events, Trends, and Issues: Global production of total ilmenite and slag in 1998 is estimated to have increased 9% compared with that of 1997. Domestic consumption of ilmenite and titanium slag concentrates in 1998 was estimated to have increased 7% compared with that of 1997. Although the United States relies heavily on imports of ilmenite and titanium slag to satisfy most of its domestic needs for titanium mineral feedstock, 1998 imports of these concentrates decreased significantly.

In 1998, several projects to expand the availability of chloride-grade slag feedstock were underway. In Norway, the Tinfos slag operation was in the process of converting its ilmenite feedstock source material so as to allow for the production of chloride-grade slag. Shipments of chloride-grade slag from the upgraded slag plant at Sorel, Canada began in the first quarter 1998. In South Africa, an expansion project was underway at Namakwa to double capacity through the addition of a second slag furnace.

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ILMENITE

In Australia, two of the world largest mineral sands producers planned to merge their two companies. If completed, the merger would improve recovery rates and extend the mine life of some reserves by processing of minerals at more efficient plants. Operational difficulties at the newly commissioned operation at Beenup has resulted in limited production of ilmenite feedstock. In the first half of 1998, the Beenup operation produced less than 30% of its 600,000-ton-per-year nameplate capacity. Initially, ilmenite from Beenup was scheduled to supply one-half of the feedstock requirements for the Tinfos slag operation in Norway. The shortfall has been reported to have been met with material from India.

Exploration and development of titanium mineral deposits continued in 1998. In the United States, deposits under examination included Camden, TN, Escalante, UT, Powderhorn, CO, and Okefenokee, GA. Canadian deposits under investigation included Shubenacadie River Basin, Nova Scotia, and Pipestone Lake, Manitoba. In Australia, investigations were ongoing at Broken Hill, Spring Hill, and Twelve Mile, New South Wales; Goondicum, Western Queensland; Ouyen, Victoria; and a large portion of the Murray Basin in New South Wales, Victoria, and South Australia. South African exploration and development investigations were ongoing at Bothaville. In preparation of a full feasibility study, a metallurgical study was completed for the Kwale mineral sands project in Kenya.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States	W	W	13,000	59,000
Australia	1,270	1,400	[7]81,000	[7]118,000
Brazil	54	54	18,000	18,000
Canada (slag)	680	768	31,000	36,000
China	85	85	30,000	41,000
Egypt	—	—	—	1,700
Finland	—	—	1,400	1,400
India	162	178	30,000	38,000
Italy	—	—	—	2,200
Madagascar	—	—	—	19,000
Malaysia	92	92	—	1,000
Norway (ilmenite and slag)	338	338	40,000	40,000
South Africa (slag)	842	935	63,000	63,000
Sri Lanka	10	16	13,000	13,000
Ukraine	133	53	5,900	13,000
Other countries	5	5	1,000	1,000
World total (rounded)	[8]3,660	[8]4,000	327,000	460,000

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

Substitutes: Rutile and synthetic rutile were used extensively 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 D for definitions.
[7]Increased from 1997 based on data published by the Australian Bureau of Resource Sciences.
[8]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 1998. 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 1998. Several firms produced high-purity indium shapes, alloys, and compounds. Thin-film coatings, which are used in applications such as liquid crystal displays (LCD's) and electroluminescent lamps, continued to be the largest end use. Indium semiconductor compounds were used in infrared detectors, high-speed transistors, and high-efficiency photovoltaic devices. The estimated distribution of uses in 1998 was about the same as in 1997: coatings, 50%; solders and alloys, 33%; electrical components and semiconductors, 12%; and research and other, 5%. The estimated value of primary metal consumed in 1998, based on the annual average price, was $14.8 million.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, refinery	—	—	—	—	—
Imports for consumption	70.2	85.2	33.2	80	77
Exports	NA	NA	NA	NA	NA
Consumption[e]	40.0	43.0	45.0	50	50
Price, annual average, dollars per kilogram (99.97% indium)	138	375	370	309	296
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, becomes significant when the price is relatively high and/or increasing rapidly. This was not the case for 1998.

Import Sources (1994-97): Canada, 47%; Russia, 15%; China, 11%; France, 8%; and other, 19%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[2] 12/31/98
Unwrought, waste and scrap	8112.91.3000	Free	25% ad. val.

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

Government Stockpile:

Stockpile Status—9-30-98[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Indium	0.44	—	1.09	0.44	—

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INDIUM

Events, Trends, and Issues: Estimated domestic indium consumption remained steady at about 50 tons in 1998. The indium market appeared to be approaching long term stability. The last indium held by the Government Stockpile was offered for sale on December 10, 1998. In 1995, prices rose steadily over supply concerns and strong demand. In 1996, significant quantities of indium were recycled for the first time. This brought about a steady decrease in prices and significantly lower U.S. imports. In 1997, domestic prices fluctuated moderately, and in 1998 they were very steady. Although the production of LCD's was slightly lower in 1998 than it was in 1997, the long range outlook for the indium market remains promising.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production[e]		Reserves[4]	Reserve base[4]
	1997	1998		
United States	—	—	300	600
Belgium	12	15	([5])	([5])
Canada	50	40	700	2,000
China	45	50	400	1,000
France	45	50	([5])	([5])
Italy	12	12	([5])	([5])
Japan	40	40	100	150
Peru	4	4	100	150
Russia	20	25	200	300
Other countries	4	4	800	1,500
World total (may be rounded)	230	240	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. 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]See Appendix C for definitions.
[4]Estimate based on the indium content of zinc ores. See Appendix D for definitions.
[5]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 1998 from three companies operating in Oklahoma accounted for 100% of the elemental iodine value estimated at $24 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 and reopened a world-class plant that was closed in 1993 because of low market prices for iodine. A third company continued production at Vici, OK, for domestic use and export to Germany. Of the consumers that participate in the annual survey, 29 plants reported consumption of iodine in 1997. Major consumers were located in the Eastern United States. Prices of crude iodine in drums, published for October, ranged between $19.00 and $21.00 per kilogram. Imports of iodine through September averaged $16.45 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 in animal feed supplements, catalysts, inks and colorants, pharmaceuticals, photographic equipment, sanitary and industrial disinfectants, stabilizers, and other uses.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production	1,630	1,220	1,270	1,320	1,340
Imports for consumption, crude content	4,360	3,950	4,860	6,380	6,000
Exports	1,200	1,220	2,410	2,760	2,800
Shipments from Government stockpile excesses	218	133	—	204	291
Consumption:					
Apparent	4,780	3,540	3,700	5,140	4,800
Reported	3,690	3,680	3,920	4,500	NA
Price, average c.i.f. value, dollars per kilogram, crude	7.56	8.88	12.90	12.82	16.45
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, number	35	35	40	40	40
Net import reliance[1] as a percent of apparent consumption	66	90	66	74	72

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

Import Sources (1994-97): Chile, 52%; Japan, 46%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[2] 12/31/98
Iodine, crude	2801.20.0000	Free	Free.
Iodide, calcium or of copper	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—9-30-98[3]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Stockpile-grade	1,891	87	1,891	454	291

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IODINE

Events, Trends, and Issues: Chile was the largest producer of iodine in the world. Japan was the second largest producer of iodine in the world. Production was primarily from underground brines associated with natural gas production. Six U.S. companies operated 17 plants with a total capacity of 9,000 tons per year. Production capacity of the plants was dependent upon the availability of brines with high iodine concentrations.

In February, the Defense National Stockpile Center (DNSC) of the Department of Defense, announced the award of 204,117 kilograms of crude iodine for a current market value of $3.9 million. In April, the DNSC revised the Annual Materials Plan for fiscal 1998 from 204,117 kilograms to 453,593 kilograms. An industry meeting was held in June to discuss the impact of the increased amount on the market. In September, DNSC announced the award of 87,090 kilograms of stockpiled iodine to three companies for a current market value of $1.5 million. DNSC also issued a solicitation for 1,000,000 kilograms of iodine with quarterly sales not to exceed 113,398 kilograms.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1997	1998[e]		
United States	1,320	1,340	550,000	550,000
Azerbaijan	300	300	170,000	NA
Chile	5,000	5,600	900,000	1,200,000
China	500	500	400,000	400,000
Indonesia	80	80	100,000	100,000
Japan	5,500	5,500	4,000,000	7,000,000
Russia	150	150	NA	NA
Turkmenistan	260	260	170,000	NA
World total (rounded)	13,100	13,700	[5]6,300,000	NA

World Resources: In addition to the fields listed in the reserve base, seawater contains 0.05 part 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.
[4]See Appendix D for definitions.
[5]Sum excludes countries for which data are not available.

IRON ORE[1]

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

Domestic Production and Use: The value of usable ore shipped from mines in Minnesota, Michigan, and six other States in 1998 was estimated at $1.9 billion. Twelve iron ore production complexes with 12 mines, 10 concentration plants, and 10 pelletizing plants were in operation during the year. The mines included 11 open pits and 1 underground operation. Virtually all ore was concentrated before shipment. Nine mines operated by five companies accounted for 99.5% of production.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, usable	58.5	62.5	62.1	63.0	62.0
Shipments	57.8	61.1	62.2	62.8	62.0
Imports for consumption	17.5	17.6	18.4	18.6	18.5
Exports	5.0	5.3	6.3	6.3	6.4
Consumption: Reported (ore and total agglomerate)[3]	80.2	83.1	79.6	79.5	79.0
Apparent	71.0	72.7	72.0	73.0	74.3
Price,[4] U.S. dollars per metric ton	24.89	28.82	31.26	30.90	32.0
Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore	21.3	23.5	25.7	27.9	27.7
Employment, mine, concentrating and pelletizing plant, quarterly average, number	7,200	7,400	7,400	7,500	7,500
Net import reliance[5] as a percent of apparent consumption (iron in ore)	18	14	14	14	17

Recycling: Insignificant.

Import Sources (1994-97): Canada, 54%; Brazil, 26%; Venezuela, 13%; Australia, 4%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
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% (Domestic), 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Worldwide, nearly all iron ore is used in steelmaking. In the United States, steelmaking accounts for about 97% of iron ore consumption. Iron ore production and consumption are concentrated in a few countries. From 1993 through 1997, iron ore was produced in at least 50 countries; the 14 largest of these countries produced 94% of the world total and no other country had as much as a 1% share. Pig iron production, the most direct indicator of iron ore consumption, also takes place in at least 50 countries, but is less concentrated. In this case, the 21 largest producers accounted for 92% of world pig iron production, with all other countries having less than a 1% share. Domestic production of iron ore is generally about 75% of domestic consumption. Thus, the United States is a net importer and from 1993 to 1997 depended on imports to satisfy 14% of its demand for iron ore. The majority of U.S. iron ore trade involves Canada. Since 1990, about 54% of U.S. imports originated in Canada and 99% of U.S. exports were shipped there. The reasons for this are ownership and proximity. Canadian steel mills have partial ownership in three of the nine iron ore operations that produce 99.5% of U.S. ore. One U.S. steelmaker and one merchant iron ore company own part of one of the three Canadian iron ore producers. The proximity of the two countries, in particular in the Great Lakes region, means lower shipping costs for iron ore producers in both countries. Most of the iron ore trade between the United States and Canada is via the Great Lakes.

From 1993 through 1997, the United States ranked sixth in iron ore production and third in pig iron production. Although world pig iron production levels have changed little over the past 20 years, production by area changed considerably. Asia, Europe, the Commonwealth of Independent States (CIS), and North America accounted for 93% of that production. While world production increased by only 11% from 1977 through 1997, pig iron production fell in the CIS by 43%, in North America by 27%, and in Europe by 9%. Production in Asia increased by 91%, and its share

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IRON ORE

of world production increased from 26.3% in 1977 to 45.3% in 1997. This trend will probably continue, although it may be slowed by the present currency crisis.

Domestic iron ore production and consumption rates into the third quarter of the year exceeded those of 1997, but declined late in the year as the result of record imports of low-priced steel. At least two of the seven iron ore producers on the Mesabi iron range in northeastern Minnesota reduced production. In Australia, one producer ceased construction of an important new mine and another reduced production because of the financial crisis in southeast Asia. Steel consumption in the United States remained strong through most of the year, but a large portion of that consumption was satisfied by steel imports, which were cheaper for U.S. consumers partly because of the strength of the U.S. dollar against foreign currencies. In addition, foreign producers who could not sell steel products in their depressed economies increased their exports to the United States. Flat-rolled 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.

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 provided potential benefits to those companies providing alternatives to scrap. Because of concern over the availability of low residue scrap, investment in alternative iron-making 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 million to considerably more than 4 million metric tons per year.

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

	Mine production		Crude ore		Iron content	
	1997	1998[e]	Reserves	Reserve base	Reserves	Reserve base
United States	63	62	10,000	23,000	6,400	14,000
Australia	158	155	18,000	40,000	11,000	25,000
Brazil	183	180	7,600	17,000	4,800	11,000
Canada	37	37	1,700	3,900	1,100	2,500
China	243	240	25,000	50,000	7,800	15,000
India	67	65	2,800	6,200	1,800	3,900
Kazakhstan	14	14	8,300	19,000	4,500	10,000
Mauritania	12	12	700	1,500	400	1,000
Russia	71	70	20,000	45,000	11,000	25,000
South Africa	33	33	1,000	2,300	650	1,500
Sweden	22	22	3,500	7,800	2,200	5,000
Ukraine	53	50	22,000	50,000	12,000	28,000
Other countries	81	75	17,000	38,000	10,000	23,000
World total (may be rounded)	1,040	1,020	140,000	300,000	74,000	160,000

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

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

[e]Estimated.
[1]See also Iron and Steel Scrap.
[2]Agglomerates, concentrates, direct-shipping ore, and byproduct ore for consumption.
[3]Includes weight of lime, flue dust, and other additives used in producing sinter for blast furnaces. Consumption data are not entirely comparable to those of 1987 and earlier years owing to changes in data collection.
[4]Calculated value of ore at mines.
[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]See Appendix D 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 101 companies that produced raw steel at 143 locations, with combined raw steel production capability of about 126 million tons. Indiana accounted for about 21% of total raw steel production, followed by Ohio, 16%, and Pennsylvania, 8%. Pig iron was produced by 14 companies operating integrated steel mills, with about 39 blast furnaces in continuous operation. Integrated companies accounted for about 57% 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, 21%; transportation (predominantly for automotive production), 13%; construction, 14%; cans and containers, 4%; and others, 48%. Ferrous foundries, numbering about 1,100, continued to be importers of pig iron into the United States, mainly from Brazil and Russia.

Salient Statistics—United States:[1]	1994	1995	1996	1997	1998[e]
Pig iron production[2]	49.4	50.9	49.4	49.6	50.1
Steel production:	91.2	95.2	95.5	98.5	102
Basic oxygen furnaces, percent	60.7	59.6	57.4	56.2	55.3
Electric arc furnaces, percent	39.3	40.4	42.6	43.8	44.9
Continuously cast steel, percent	89.5	91.0	93.2	94.7	95.3
Shipments:					
Steel mill products	86.3	88.4	91.5	96.0	97.8
Steel castings[3]	1.0	1.1	1.2	1.2	1.2
Iron castings[3]	13.2	9.8	9.8	9.8	9.8
Imports of steel mill products	27.3	22.1	26.5	28.3	34.6
Exports of steel mill products	3.5	6.4	4.6	5.5	4.7
Apparent steel consumption[4]	104	102	108	114	113
Producer price index for steel mill products (1982=100)[5]	113.4	120.1	115.6	116.4	114
Steel mill product stocks at service centers yearend[6]	6.6	5.9	6.3	6.6	7.3
Total employment, average,[7] number					
Blast furnaces and steel mills	172,000	171,000	168,000	169,000	168,000
Iron and steel foundries	125,000	130,000	129,000	128,000	127,000
Net import reliance[8] as a percent of apparent consumption	22	21	20	20	18

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

Import Sources (1994-97): European Union, 27%; Canada, 16%; Japan, 9%; Brazil, 9%; and other, 39%.

Tariff:[9] Item	Number	Normal Trade Relations (NTR)[10] 12/31/98	Canada 12/31/98	Mexico 12/31/98	Non-NTR[11] 12/31/98
Pig iron	7201.10.0000	Free	Free	Free	$1.11/t.
Carbon steel:					
Semifinished	7207.12.0050	2.5%	Free	2.1%	20%.
Structural shapes	7216.33.0090	0.5%	Free	0.4%	2%.
Bars, hot-rolled	7213.20.0000	1.1%	Free	0.9%	5.5%.
Sheets, hot-rolled	7208.39.0030	2.9%	Free	2.4%	20%.
Hot-rolled, pickled	7208.27.0060	3.1%	Free	2.5%	0.4¢/kg+20%.
Cold-rolled	7209.18.2550	1.9%	Free	1.6%	20%.
Galvanized	7210.49.0090	3.9%	Free	3.2%	21.5%.
Stainless steel:					
Semifinished	7218.91.0015	3.1%	Free	2.6%	29%.
	7218.99.0015	3.1%	Free	2.6%	29%.
Bars, cold-finished	7222.20.0075	6.4%	Free	5.3%	29%.
Pipe and tube	7304.41.3045	4.6%	Free	Free	36%.
Cold-rolled sheets	7219.33.0035	6.1%	Free	5.0%	29%.

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IRON AND STEEL

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: Pig iron production and steel production and shipments continued to increase during 1998. The basic oxygen process used in integrated mills continued to decline in importance relative to the use of electric arc furnaces and continuous casting in minimills. Capital expenditures by integrated steelmakers was an estimated $2.2 billion in 1998, an increase of nearly 5% from that of 1997. Capital expenditures in minimills also increased to $1.4 billion, 16% more than that of 1997.

Although domestic demand for steel remained high during 1998 and domestic steelmaking capacity increased, pessimism in the industry grew as steel spot prices and exports declined while imports increased. July imports of relatively low-priced steel were 44% greater than imports during July 1997. Some minimalist and integrated mills responded by cutting production. Capacity utilization decreased below 80%. Some mills also reduced scrap inventories and laid off workers. Several big producers joined the United Steel Workers of America to file antidumping suits against Japanese, Russian, and Brazilian hot roll producers.

The United Steelworkers of America and the Made in the USA Foundation filed a lawsuit against the Federal Government charging that the North American Free Trade Agreement (NAFTA) is unconstitutional on the ground that it is a treaty that was not approved by two-thirds vote of the Senate. The Department of Labor determined that about 7,400 steelworker union members have been displaced as a result of NAFTA.

World Production:

	Pig iron		Raw steel	
	1997	1998[e]	1997	1998[e]
United States	49.6	50.1	98.5	102
Brazil	25.0	25.6	25.1	25.8
China	115	115	108	111
European Union	96.4	102	165	170
Japan	78.5	75.0	105	95.1
Korea, Republic of	22.7	23.5	42.6	41.1
Russia	37.3	35.4	48.4	42.8
Ukraine	20.0	21.6	25.6	24.8
Other countries	105	95.8	177	170
World total (may be rounded)	550	544	795	783

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.
[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]All tariff percentages are ad valorem.
[10]No tariff for Israel and certain Caribbean and Andean nations.
[11]See Appendix B.

IRON AND STEEL SCRAP[1]

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

Domestic Production and Use: Total value of 1998 domestic purchases (receipts of ferrous scrap by all domestic consumers from brokers, dealers, and other outside sources) and exports was estimated at $7.5 billion, down nearly 10% from that of 1997. Manufacturers of pig iron, raw steel, and steel castings accounted for nearly 80% of scrap consumption by the domestic steel industry, using scrap together with pig iron 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.

Raw steel production in 1998 was an estimated 101 million tons, nearly 3% more than that produced in 1997. Net shipments of steel mill products were estimated at about 98 million tons compared with 96.0 million tons for 1997. The domestic ferrous castings industry shipped an estimated 11 million tons of all types of iron castings in 1998 and an estimated 1.2 million tons of steel castings, including investment castings.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Home scrap	20	20	20	20	22
Purchased scrap[2]	58	59	57	59	54
Imports for consumption[3]	1.9	2.3	2.9	3	4
Exports[3]	9.0	10.5	9.1	9	7
Consumption: Reported	70	72	71	73	69
Price, average, dollars per metric ton delivered:					
No. 1 Heavy Melting composite price, Iron Age					
Average: Pittsburgh, Philadelphia, Chicago	124.58	131.29	126.0	126.02	120
Stocks, consumer, yearend	4.1	4.2	5.2	5.5	4.7
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 200 years. The automotive recycling industry alone recycles more than 11 million vehicles annually through more than 200 car shredders, supplies 37% of all ferrous scrap to scrap recyclers, and employs more than 40,000 people in more than 7,000 businesses. In the United States alone, about 69 million tons of steel apparently was recycled in steel mills and foundries in 1998. 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 32% home scrap (new recirculating scrap from current operations), 23% prompt scrap (produced in steel-product manufacturing plants), and 45% obsolete (old) scrap.

Import Sources (1994-97): Canada, 79%; Venezuela, 7%; Mexico, 6%; United Kingdom, 5%; and other, 3%.

Tariff: **Item**	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[6] 12/31/98**
Iron and steel waste and scrap:			
No. 1 bundles	7204.41.0020	Free	74¢/t.
No. 1 Heavy Melting	7204.49.0020	Free	74¢/t.
No. 2 Heavy Melting	7204.49.0040	Free	74¢/t.
Shredded	7204.49.0070	Free	74¢/t.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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IRON AND STEEL SCRAP

Events, Trends, and Issues: Scrap prices in the United States declined steadily throughout 1998 from the high levels of 1997. 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 $119 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 $668 per metric ton in 1998, which was significantly lower than the 1997 average price of $805 per metric ton. Exports of ferrous scrap declined from about 9 million tons in 1997 to 7 million tons in 1998, having an estimated value of about $1.3 billion.

The Asian financial crisis resulted in reduced consumption of U.S. steel products, and ferrous scrap consumption declined. Consumption of domestic scrap was also adversely affected by increasing imports into the United States of excess-capacity low-cost finished and semi-finished steel from Asia, Russia, and Brazil. U.S. imports of steel mill products set a new record high during August that was 78% above that of August 1997. Monthly imports during April through August 1998 were the highest in U.S. history. The domestic scrap supply beyond 1998 is difficult to predict. However, by late 1998, scrap collectors and distributors were beginning to refuse to trade at depressed price levels, and processing equipment was being temporarily idled with the hope that by yearend prices would stop falling.

In the United States, the primary source of obsolete steel scrap is the automobile. The recycling rates of automobiles, appliances, steel cans, and construction steel are about 98%, 80%, 60%, and 90%, respectively. The recycling rates of appliance, can, and construction steel are expected to increase not only in the United States, but also in emerging industrial countries. As environmental regulations increase, recycling becomes more profitable and convenient, and public interest in recycling continues to increase.

The problem of accidental meltings of radioactive sources continues to be a concern of steelmakers as radioactive scrap arrives with increasing frequency at their truck and rail gates. Materials causing the most concern are shielded radioactive devices used by about 6,000 licensees, designed for measuring and controlling the thickness, density, and other characteristics of materials during industrial and other processes. In addition to potential health risks, radioactive scrap threatens the economic survival of steel companies when mill shutdown costs for decontamination, disposing and storing radioactive electric furnace dust, and shutdown of steel production, can be as much as $500,000 per day. One mini-mill reported a clean-up cost of about $23 million. Monitoring of incoming ferrous scrap has prevented hundreds of accidental meltings of radioactive materials. Nevertheless, during the period 1983 to June 30, 1997, 18 meltings of radioactive material were reported by United States steel mills. In April 1998, the Nuclear Regulatory Commission (NRC) directed its staff to develop a proposed rule that would require a registration program for licensees possessing radioactive devices.

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

World Resources: Not applicable.

Substitutes: Nearly 1.7 million tons of direct-reduced iron was used in the United States in 1998 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 1998, approximately 20 million tons of iron and steel slags, valued at about $160 million[1] (f.o.b), were consumed. Of this, iron or blast furnace slag accounted for approximately 60% of the tonnage and was worth about $132 million. Steel slags, produced from open hearth[2], basic oxygen, and electric arc furnaces, accounted for the remainder. There were 15 slag-processing companies, operating either iron and steel or just steel facilities at about 100 locations: iron slags at about 30 sites in a dozen States and steel slags at about 90 sites in about 30 States. The North Central region (Illinois, Indiana, Michigan, Ohio) were the source of about 60% of total sales of slag of domestic origin. The major uses for iron slag were for asphaltic concrete aggregate and other concrete applications, 40%; road bases, 35%; and fill, 15%. Steel slags were mainly used for asphaltic concrete aggregate, 30%; fill, 30%; and road bases, 25%. Approximately 90% of iron and steel slag shipments were by truck, generally to customers within approximately 80 kilometers of the plant. Rail and waterway transport each accounted for about 5% of shipments, but these included destinations farther afield.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, marketed[3]	20,100	21,000	20,500	18,900	20,000
Imports for consumption	199	280	346	663	670
Exports	4	4	3	9	10
Consumption, apparent	20,300	21,300	20,800	19,600	20,700
Price average value, dollars per ton, f.o.b. plant	6.99	6.89	6.90	7.72	8.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, number[e]	2,500	2,500	2,500	2,500	2,700
Net import reliance[4] as a percent of reported consumption	1	1	2	3	3

Recycling: No longer regarded largely as waste, ferrous slags today are viewed as valuable coproducts of iron- and steelmaking 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 used internally—being recycled to the furnaces as ferrous and flux feed. Entrained metal, particularly in steel slag, is routinely recovered during slag processing for return to the furnaces. However, data for such furnace feed uses are unavailable.

Import Sources (1994-97): Not available. Year-to-year import data for ferrous slags show great variations in both tonnages and unit values; many of the data contain unresolved discrepancies. Slag was imported in 1995-96 mainly from Canada and South Africa; prior sources were mainly Canada and Japan. Data for 1997 only: Italy, 56%; Canada, 12%; South Africa, 10%; France, 9%; Mexico, 9%; other, 4%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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	5.9¢/ton	73.8¢/ton.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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IRON AND STEEL SLAG

<u>Events, Trends, and Issues</u>: Sales of iron and steel slags are increasing slowly but depend, to a large degree, on the price and availability of natural aggregates, which are 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 in the United States is likely to decline as existing blast furnaces are retired, given that no new blast furnaces are under construction or planned. It is unclear if imports will increase to compensate for the domestic decline. 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 thus far succeeded at keeping slag exempted from such regulation. No government regulation is anticipated in the near future.

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

<u>World Resources</u>: Not applicable.

<u>Substitutes</u>: 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]Sales of open hearth furnace steel slag were from stockpiles; there was no domestic open hearth steel production in 1998.
[3]Data for actual production of marketable slag are unavailable and the data shown are for sales. Production may be estimated as equivalent to 25% to 30% of crude (pig) iron production and 10% to 15% of crude steel output.
[4]Defined as imports - exports. Data are unavailable to allow adjustments for changes in stocks.
[5]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:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Mine	W	W	W	W	W
Synthetic mullite	W	W	W	W	W
Imports for consumption (andalusite)	8	3	11	8	11
Exports[e]	35	35	35	35	35
Shipments from Government stockpile excesses	—	—	—	1	—
Consumption, apparent	W	W	W	W	W
Price, average, dollars per metric ton:					
U.S. kyanite, raw	138	144	154	154	157
U.S. kyanite, calcined	239	248	262	262	267
Andalusite, Transvaal, South Africa, 57.5% Al_2O_3	170	190	190	190	190
Andalusite, Transvaal, South Africa, 59.5% Al_2O_3	190	210	230	230	230
Stocks, producer	NA	NA	NA	NA	NA
Employment, kyanite mine and plant, number[e]	150	150	150	150	150
Net import reliance[1] as a percent of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1994-97): South Africa, 100%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[2] 12/31/98**
Andalusite, kyanite, and sillimanite	2508.50.0000	Free	Free.
Mullite	2508.60.0000	1% ad val.	30% ad val.

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

Government Stockpile:

Stockpile Status—9-30-98[3]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 1998**	**Disposals FY 1998**
Kyanite, lump	0.1	—	0.1	—	—

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KYANITE AND RELATED MINERALS

Events, Trends, and Issues: Refractories continue to be the largest end use of kyanite and mullite. Based on recent years' data, overall refractory market value has increased at a higher rate than refractory tonnage, according to a non-Government source. Refractories are being developed that are higher quality and longer lasting.

A major growth area of refractories in general is projected to be monolithic refractories (those that are made or formed in one piece) and preformed shapes. The technology of refractories has continued to advance in response to the increasingly stringent requirements of the customers.

Over-capacity in refractories is said to still exist in the industrialized countries of Europe, Japan, and North America, according to another non-Government source. Corporate mergers and buyouts in the refractories industry have occurred and may continue. Major refractory companies are producing and selling more overseas and are establishing joint ventures in developing countries.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[4]
	1997	1998[e]	
United States	W	W	Large in the United States and South Africa; may be large in other countries.
France	45	45	
India	14	15	
South Africa[5]	220	220	
Other countries	8	10	
World total[6]	287	290	

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. E Net exporter. 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]See Appendix D for definitions.
[5]Production is mostly andalusite.
[6]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 1998, based on the average U.S. producer price, was $440 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 and a smelter in Montana. Of the 29 plants that produced secondary lead, 17 had annual capacities of 15,000 tons or more and accounted for more than 98% of secondary production. Lead was consumed at about 170 manufacturing plants. The transportation industries were the principal users of lead, consuming 76% of it for batteries, fuel tanks, solder, seals, and bearings. Electrical, electronic, communications uses (including batteries), ammunition, television glass, construction (including radiation shielding), and protective coatings accounted for approximately 20% 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:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Mine, lead in concentrates	370	394	436	459	460
Primary refinery:					
From domestic ore	328	374	326	343	330
From imported materials[1]	23	W	W	W	W
Secondary refinery, old scrap	877	963	1,030	1,040	1,030
Imports for consumption, lead in concentrates	1	3	7	18	25
Exports, lead in concentrates	39	66	60	42	20
Imports for consumption, refined metal, wrought and unwrought	237	271	278	272	310
Exports, refined metal, wrought and unwrought	54	57	61	53	30
Shipments from Government stockpile excesses, metal	65	34	39	26	45
Consumption: Reported	1,450	1,560	1,540	1,600	1,700
Apparent	1,490	1,570	1,630	1,610	1,720
Price, average, cents per pound:					
North American Producer	37.2	42.3	48.8	46.5	45
London Metal Exchange	24.8	28.6	35.1	28.3	25
Stocks, metal, producers, consumers, yearend	78	94	80	101	65
Employment: Mine and mill (peak), number	1,300	1,200	1,200	1,200	1,200
Primary smelter, refineries	600	600	500	450	450
Secondary smelters, refineries	1,800	1,800	1,800	1,800	1,800
Net import reliance[2] as a percent of apparent consumption	19	17	17	14	21

Recycling: About 1.1 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 1.0 million tons (equivalent to 58% of domestic lead consumption) was recovered from used batteries alone.

Import Sources (1994-97): Lead in concentrates: Australia, 24%; Canada, 19%; Mexico, 18%; Peru, 13%; and other, 26%. Metal, wrought and unwrought: Canada, 70%; Mexico, 21%; Peru, 7%; and other, 2%. Total lead content: Canada, 69%; Mexico, 21%; Peru, 7%; Australia, 1%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR)[3] 12/31/98	Non-NTR[4] 12/31/98
Unwrought (refined)	7801.10.0000	2.7% ad val.	10.0% ad val.

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

Government Stockpile:

Stockpile Status—9-30-98[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Lead	306	17	306	54	54

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LEAD

Events, Trends, and Issues: During 1998, the price for lead decreased 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 about 2% and 13%, respectively, below the averages for 1997. Despite a continued demand for lead in the North American and European markets, overall market softness remained during 1998 owing to increasing instability in the Asian economies. U.S. mine production remained unchanged from that of 1997, while primary and secondary refinery production declined by about 4% and 1%, respectively. Significant consolidation of the primary and secondary lead industries in the United States occurred during the year as a result of the sale of one company's primary lead business to its principal U.S. competitor and the sale of several secondary refineries and lead-acid battery manufacturing plants to existing U.S. lead companies. U.S. apparent consumption of lead increased, particularly owing to the increased demand for replacement batteries as warmer temperatures persisted, causing automotive-battery failures to increase during the summer months. In addition, demand for industrial-type stationary and traction batteries continued to grow.

Production and shipments of lead and zinc concentrates were begun during the year at new mines in Australia and Ireland, and production was resumed at a mine in Tunisia following its purchase by a Canadian mining company. A major Canadian mine, however, was forced to close temporarily as a result of low metal prices, and a recently opened lead-zinc mine in Spain was closed most of the year as a result of the failure of a tailings dam that flooded a significant portion of the neighboring land.

The International Lead and Zinc Study Group, at its 43rd Session in Marrakech, Morocco, in October, projected world demand for lead to increase by 0.5% to 6.05 million tons in 1998. European demand was expected to remain fairly steady while the demand for lead in China was anticipated to rise by about 4%. A moderate decline in refined lead production was expected to result in a relatively close balance between supply and demand for the year.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States	459	460	6,500	20,000
Australia	531	590	18,000	33,000
Canada	186	190	3,500	12,000
China	650	600	9,000	30,000
Kazakhstan	35	40	2,000	2,000
Mexico	175	170	1,000	2,000
Morocco	77	70	500	1,000
Peru	258	250	2,000	3,000
South Africa	84	90	2,000	3,000
Sweden	100	100	500	1,000
Other countries	455	520	21,000	33,000
World total	3,010	3,080	66,000	140,000

World Resources: In recent years, significant lead resources have been demonstrated in association with zinc and/or silver or copper in the United States (Alaska), Australia, Canada, China, 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, 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 Canada.
[4]See Appendix B.
[5]See Appendix C for definitions.
[6]See Appendix D for definitions.

LIME[1]

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

Domestic Production and Use: In 1998, lime producers at 114 plants in 35 States sold or used 20.4 million tons (22.5 million short tons) of lime valued at about $1.2 billion, an increase of about 700,000 tons (770,000 short tons) and an increase of about $10 million from 1997 levels. Ten companies, operating 46 plants, accounted for about 80% of the total output. Principal producing States, each with production over 1 million tons, were Alabama, Kentucky, Missouri, Ohio, Pennsylvania, and Texas. These six States produced about 11.3 million tons (12.5 million short tons) or 55% of the total output. Major markets for lime were steel, flue gas desulfurization, mining, construction, pulp and paper, precipitated calcium carbonate, and water treatment.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production[3]	17,400	18,500	19,200	19,700	20,400
Imports for consumption	204	289	262	274	250
Exports	74	72	50	80	70
Consumption, apparent[4]	17,500	18,700	19,300	19,900	20,600
Quicklime average value, dollars per ton at plant	56.43	56.77	56.68	57.80	56.40
Hydrate average value, dollars per ton at plant	67.71	72.09	79.64	80.20	73.00
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and plant, number	5,500	5,500	5,600	5,600	5,600
Net import reliance[5] as a percent of apparent consumption	—	—	1	1	1

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

Import Sources (1994-97): Canada, 91%; and Mexico, 9%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
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]
Calcined dolomite	2518.20.0000	3.6% ad. val.	30% ad. val.

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

Government Stockpile: None.

Events, Trends, and Issues: The lime industry experienced some major changes in company ownership in 1998. Dravo Lime Co. was acquired by Carmeuse Lime, Inc., in a deal made final in October.[8] Carmeuse Lime is part of the Carmeuse North America Group, which announced a joint venture merger of North American lime operations with Lafarge S.A. that was expected by the end of the year.[9] Carmeuse Lime, Inc., which will consist of the former lime operations of Marblehead Lime, Carmeuse Pennsylvania, Dravo Lime, and Lafarge, becomes the largest lime producer in the United States. Graymont Ltd., Canadian parent of Continental Lime Inc., acquired Bellefonte Lime Inc. of Pennsylvania and GenLime LP of Ohio. These operations will become part of Graymont's East Division Operations.[10] Oglebay Norton Co. of Cleveland, OH, acquired the Canadian based Global Stone Corp., which owns lime and stone operations in Canada and the United States, including lime plants in Michigan, Oklahoma, Tennessee, and Virginia.[11]

Passage of new Federal transportation legislation (Transportation Equity Act for the 21st Century) is expected to boost soil stabilization and asphalt markets. The new legislation budgets $167 billion over 6 years for highway construction, which is a 44% increase compared with previous years.

Lime sales continued to increase, continuing the growth trend that has now reached 7 years. Sales over that period have increased on average about 600,000 tons per year. The growth has been fueled mainly by increased demand for flue gas desulfurization, steel, and precipitated calcium carbonate.

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LIME

A surge in cheap steel imports beginning in the second quarter caused a decrease in domestic steel production and resulted in complaints by the U.S. steel industry and the steelworkers union of foreign dumping. At least two small steel producers were forced to declare bankruptcy, and others were forced to cut prices and production because of the record amounts of imports, which are blamed for causing prices to plummet and demand to weaken. Steel is the largest market for lime, and cuts in domestic steel production adversely affect lime sales.

Increased Federal regulation of hazardous air pollutants (such as mercury) and particulate matter is expected under existing Clean Air Act authority. Emissions of carbon dioxide and nitrous oxide may be regulated in the future in an attempt to control global greenhouse effects. Legislation does not currently exist to regulate these gases, but international discussions have been held as part of the United Nations Framework Convention on Climate Change to develop greenhouse gas reduction goals and international methods to achieve these goals. These discussions, and resulting commitments to proposed reductions (Kyoto Protocol), are being monitored very closely by the lime industry. Lime production produces carbon dioxide from the combustion of fuels (primarily coal) to fire the kilns and as a result of the calcination process, which dissociates calcium carbonate into calcium oxide (lime) and carbon dioxide. Any program regulating carbon dioxide emissions would have a direct impact on the lime industry.

World Lime Production and Limestone Reserves and Reserve Base:

	Production		Reserves and reserve base[12]
	1997	1998[e]	
United States	19,700	20,400	Adequate for all countries listed.
Belgium	1,800	1,800	
Brazil	5,700	5,700	
Canada	2,447	2,500	
China	20,500	21,000	
France	2,800	2,800	
Germany	8,000	8,000	
Italy[13]	3,500	3,500	
Japan (quicklime only)	7,850	7,800	
Mexico	6,600	6,600	
Poland	2,500	2,500	
Romania	1,750	1,750	
South Africa (sales)	1,585	1,600	
United Kingdom	2,500	2,500	
Other countries	32,800	33,000	
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]Dravo Corp., 1998, Dravo News: Dravo Corp. news release, October 26, 1 p.
[9]AFX News, 1998, Lafarge, Carmeuse merge North American lime operations: AFP-Extel News Ltd., July 7, 1 p.
[10]National Lime Association, 1998, Graymont Ltd. acquires Bellefonte Lime and GenLime: Limelites, v. 64. no. 3, p. 4.
[11]Global Stone Corp., 1998, Global Stone Signs Agreement with Oglebay Norton: Global Stone Corp. press release, April 15, 1 p.
[12]See Appendix D for definitions.
[13]Includes hydraulic lime.

LITHIUM

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

Domestic Production and Use: Chile was the largest lithium chemical producer in the world, followed by China, Russia, the United States, and Argentina, in descending order of production. Australia and Canada were major producers of lithium ore concentrates. The U.S. remained the leading consumer of lithium minerals and compounds and the leading producer of value-added lithium materials. Because only two companies produced lithium compounds for domestic consumption as well as for export to other countries, reported production and value of production data cannot be published. Estimation of value for the lithium mineral compounds produced in the United States is extremely difficult because of the large number of compounds used in a wide variety of end uses and the great variability of the prices for the different compounds.

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

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production	W	W	W	W	W
Imports for consumption	851	1,140	884	978	2,100
Exports	1,700	1,900	2,310	2,010	1,400
Consumption: Apparent	W	W	W	W	W
Estimated	2,500	2,600	2,700	2,800	2,900
Price, yearend, dollars per kilogram:					
Lithium carbonate	4.41	4.34	4.34	4.47	4.47
Lithium hydroxide, monohydrate	5.62	5.62	5.51	5.74	5.74
Stocks, producer, yearend	W	W	W	W	W
Employment, mine and mill, number[e]	230	230	230	230	100
Net import reliance[1] as a percent of apparent consumption	E	E	E	E	W

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

Import Sources (1994-97): Chile, 96%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[2] 12/31/98
Other alkali metals	2805.19.0000	5.7% 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: One U.S. lithium company closed its spodumene mine and lithium carbonate plant in North Carolina. As a result, the only active lithium carbonate plant remaining in the United States was at a brine operation in Nevada. The North Carolina operations were closed when the company's brine operation in Argentina was able to supply the lithium carbonate required for production of downstream lithium compounds and to meet customer requirements. Subsurface brines have become the dominant raw material for lithium carbonate production worldwide. Most of the lithium minerals mined in the world were used as ore concentrates rather than feedstock for lithium carbonate and other lithium compounds.

The U.S. company with lithium carbonate operations in Nevada and Chile sold all its lithium concerns to a German company. The German firm had been one the U.S. company's major lithium customers and a long-time producer and supplier of lithium chemicals in Europe.

The increased production in Argentina and Chile continued an oversupply situation that resulted in lower prices for lithium carbonate over the past two years, although company price lists do not reflect that trend. Actual prices paid may have been as much as 50% lower than list prices. Reprocessed lithium salts from battery recycling and lithium hydroxide monohydrate from former Department of Energy stocks also were available at discounted prices, causing further downward pressure on lithium prices. Lower prices may benefit the lithium industry in the long run by expanding the use of lithium materials into new high-volume, but price sensitive markets.

Interest in lithium batteries for electric vehicles (EV's) continued to grow and research was ongoing. Lithium batteries could power the majority of future EV's, but the precise battery type and the timetable for implementation was still in question.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	1997	1998[e]		
United States	W	W	38,000	410,000
Argentina[e]	8	1,000	NA	NA
Australia[e]	2,800	2,800	150,000	160,000
Bolivia	—	—	—	5,400,00
Brazil	32	30	910	NA
Canada	1,600	1,600	180,000	360,000
Chile	4,100	4,500	3,000,000	3,000,000
China	2,900	2,900	NA	NA
Namibia[e]	40	40	NA	NA
Portugal	180	160	NA	NA
Russia[e]	2,000	2,000	NA	NA
Zimbabwe	700	500	23,000	27,000
World total (may be rounded)	[4]14,000	[4]16,000	[5]3,400,000	[6]9,400,000

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

Substitutes: Substitutes for lithium compounds are possible in manufactured glass, ceramics, greases, and batteries. Examples are sodic and potassic fluxes in ceramics and glass manufacture; calcium and aluminum soaps as substitutes for stearates in greases; and zinc, magnesium, calcium, and mercury as anode material in primary batteries. Lithium carbonate is not considered 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]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix B.
[3]See Appendix D for definitions.
[4]Excludes U.S. production.
[5]Excludes Argentina, China, Namibia, Portugal, and Russia.
[6]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 74% 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 62% 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:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production	345	360	389	402	440
Imports for consumption	287	328	240	259	220
Exports	46	54	66	56	50
Consumption, apparent	586	634	563	605	610
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, plant, number[e]	650	600	600	600	600
Net import reliance[2] as a percent of apparent consumption	41	43	31	34	28

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

Import Sources (1994-97): China, 69%; Canada, 9%; Austria, 5%; Greece, 3%; and other, 14%.

Tariff:[3] Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Canada 12/31/98**	**Non-NTR[4] 12/31/98**
Crude magnesite	2519.10.0000	Free	Free	$10.33/ton.
Dead-burned and fused magnesia	2519.90.1000	0.1¢/kg	Free	1.7¢/kg.
Caustic-calcined magnesia	2519.90.2000	41¢/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: Because of the decline in imports of dead-burned magnesia from China, total U.S. production of magnesium compounds increased to meet the demand. Export licensing requirements for China reduced the maximum quantity of magnesia that the country could export to 1 million tons in 1998, one-half of the 1997 export volume of 2 million tons. In addition, U.S. production of magnesium hydroxide is expected to continue to increase because of the growing demand for the material in water treatment applications.

In the United States, a new operation was expected to open by yearend in Arizona to recover brucite from a deposit near Kingman. Brucite produced from the deposit will be targeted to flame retardant and smoke suppressant applications. One of the Michigan brine producers announced that it would double capacity for magnesium oxide and magnesium hydroxide at its Manistee facility by the end of 1999. Magnesium oxide produced at the facility is used by the rubber and plastics industry, and the magnesium hydroxide is used in pharmaceuticals.

In Australia, a new magnesite mine is planned to be developed in Tasmania by yearend 1999. In its initial stages of operation, crude magnesite from the mine is expected to be sold on as feed material for dead-burned and caustic-calcined magnesia throughout the Pacific Rim. The operating company is investigating the potential of using the magnesite as feed for a magnesium metal plant to be constructed near the mine. A contract to construct a magnesia plant in Jordan was scheduled to be awarded by yearend. The new plant will have an annual capacity of 50,000 tons of magnesia and 10,000 tons of specialty products; brine from the Dead Sea will be the plant's feed material. Completion is scheduled by mid-2000.

World Mine Production, Reserves, and Reserve Base:

	Magnesite production		Magnesite reserves and reserve base[5]	
	1997	1998[e]	Reserves	Reserve base
United States	W	W	10,000	15,000
Australia	71	75	NA	NA
Austria	187	190	15,000	20,000
Brazil	87	90	45,000	65,000
China[e]	576	580	750,000	1,000,000
Greece	187	190	30,000	30,000
India	108	100	30,000	45,000
Korea, North[e]	461	460	450,000	750,000
Russia[e]	173	170	650,000	730,000
Serbia and Montenegro	27	25	5,000	10,000
Slovakia[e]	288	290	20,000	30,000
Spain	130	130	10,000	30,000
Turkey	634	635	65,000	160,000
Other countries	99	100	420,000	480,000
World total (rounded)	[6]3,030	[6]3,040	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 D 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 1998 valued at approximately $374 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 50% 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 27% of U.S. consumption of primary metal; desulfurization of iron and steel, 12%; cathodic protection, 4%; reducing agent in nonferrous metals production, 3%; and other uses, 4%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Primary	128	142	133	125	117
Secondary (new and old scrap)	62	65	70	80	80
Imports for consumption	29	35	47	65	75
Exports	45	38	41	41	40
Consumption: Reported, primary	112	109	102	101	105
Apparent	149	171	162	185	177
Price, yearend:					
Metals Week, U.S. spot Western, dollars per pound, average	1.63	2.09	1.75	1.65	1.55
Metal Bulletin, free market, dollars per metric ton, average	3,125	4,138	2,525	2,525	1,900
Stocks, producer and consumer, yearend	19	21	26	21	27
Employment, number[e]	1,400	1,400	1,400	1,400	1,400
Net import reliance[2] as a percent of apparent consumption	E	E	E	16	16

Recycling: In 1998, about 31,000 tons of the secondary production was recovered from old scrap.

Import Sources (1994-97): Canada, 52%; Russia, 27%; China, 7%; Mexico, 3%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Canada and Mexico 12/31/98	Non-NTR[3] 12/31/98
Unwrought metal	8104.11.0000	8.0% ad val.	Free	100% ad val.
Unwrought alloys	8104.19.0000	6.5% ad val.	Free	60.5% ad val.
Wrought metal	8104.90.0000	14.8¢/kg on Mg content + 3.5% ad val.	Free	88¢/kg on Mg content + 20.0% andval.

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

Government Stockpile: None.

Events, Trends, and Issues: In November, the largest U.S. magnesium producer announced that it would close its 65,000-ton-per-year primary magnesium plant in Freeport, TX. Damage from summer storms was cited as the reason for the closure; the company had been producing magnesium for more than 80 years. As an oversupply of magnesium developed during the year, prices fell to their lowest level since the end of 1994. Part of the reason for the oversupply was additional magnesium from the new Israeli plant on the world market.

In a preliminary ruling from the Department of Commerce, the International Trade Administration (ITA) set the antidumping duties for pure magnesium from the largest Canadian magnesium producer at 0% ad valorem for the period August 1, 1996, to July 31, 1997. This is the third review in which the rate has been established at 0%. However, the ITA does not intend to revoke the antidumping order (which can be done after three consecutive 0% determinations) because it can not be assured that the company will not dump in the future. The ITA also issued results of the countervailing duty review for pure and alloy magnesium for calendar year 1996 from Canada; the duty was set at 2.78% ad valorem.

The Court of International Trade (CIT) has upheld a remand decision by the U.S. International Trade Commission (ITC) that the U.S. magnesium industry is not injured by imports of magnesium from Ukraine. In 1995, the ITC issued

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MAGNESIUM METAL

antidumping duties ranging from 79.87% to 104.27% ad valorem on pure magnesium from Ukraine. These duties were appealed to the CIT in 1997, and the Court's decision was a result of the 1997 appeal. If there are no further appeals by December 20, the duties should be revoked.

The European Commission (EC) imposed provisional antidumping duties on magnesium imported from China, effective May 15. The EC has set a floor price of about $3,100 per ton. The duty will be the difference between the floor price and the c.i.f. value of magnesium imported under tariff codes 8104.11.00 and 8104.19.00. With this action, the EC has set antidumping duties for magnesium imported from China, Russia, and Ukraine. China also has imposed a minimum floor price for magnesium for export of $1,950 per ton, f.o.b. China.

Predictions of strong growth in magnesium usage in automotive applications spurred several announcements of new magnesium projects around the world. In Australia, a preliminary study began for the construction of a 90,000-ton-per-year magnesium plant near Burnie, Tasmania, by 2003 using magnesite from a nearby deposit as feedstock. In the Netherlands, a 40,000- to 50,000-ton-per-year magnesium plant was proposed using magnesium chloride brines from the nearby magnesia operation as a feedstock. The company is looking for financing to develop the project, and several technologies for magnesium production are being evaluated.

In Canada, several companies are investigating new projects to recover magnesium from asbestos tailings. One firm is in the early stages of planning a project in northern British Columbia using tailings from a chrysotile mine as feed. In addition, another firm submitted a proposal to the Newfoundland government to extract magnesium from an asbestos tailings pile at the Baie Verte mine. Interest in recovering magnesium from asbestos tailings has been heightened by the new 58,000-ton-per-year magnesium plant in Canada that broke ground for construction on April 15, which would be the first commercial plant to produce magnesium from asbestos tailings.

The firm developing a 50,000-ton-per-year magnesium plant in Congo (Brazzaville) began the first phase of a prefeasibility study that should be completed by early 1999. In April, the owners of the proposed 90,000-ton-per-year Australian magnesium plant became a shareholder in the proposed Iceland magnesium plant with a 40% stake. A feasibility study for a 50,000-ton-per-year magnesium plant near Reykjanes was completed in 1998. Although a decision about plant construction was expected by yearend 1997, the company wanted to find a major shareholder (which it has done with the Australian firm) and decide on which production technology to use—one developed by the Australians or currently used Ukrainian technology.

World Primary Production, Reserves, and Reserve Base:

	Primary production	
	1997	**1998**[e]
United States	125	117
Brazil	9	9
Canada	58	55
China[e]	92	95
France	12	12
Israel	8	20
Kazakhstan[e]	9	10
Norway	28	25
Russia[e]	40	35
Serbia and Montenegro	3	3
Ukraine[e]	10	8
World total	392	389

Reserves and reserve base[4]

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

World Resources: Resources from which magnesium may be recovered range from large to virtually unlimited and are globally widespread. Resources of dolomite and magnesium-bearing evaporite minerals are enormous. Magnesium-bearing brines are estimated to constitute a resource in 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 D 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 1998. 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 in products for construction, machinery, and transportation, which were estimated to be 23%, 14%, and 11%, 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 $470 million.

Salient Statistics—United States:[1]	1994	1995	1996	1997	1998[e]
Production, mine[2]	—	—	—	—	—
Imports for consumption:					
Manganese ore	331	394	478	357	310
Ferromanganese	336	310	374	304	360
Silicomanganese[3]	273	305	323	306	395
Exports:					
Manganese ore	15	15	32	84	90
Ferromanganese	11	11	10	12	13
Shipments from Government stockpile excesses:[4]					
Manganese ore	134	115	128	115	95
Ferromanganese	9	18	(2)	31	25
Consumption, reported:[5]					
Manganese ore[6]	449	486	478	510	515
Ferromanganese	347	348	326	337	355
Consumption, apparent, manganese[7]	694	676	776	628	755
Price, average value, 46% to 48% Mn metallurgical ore, dollars per mtu cont. Mn, c.i.f. U.S. ports	2.40	2.40	2.55	2.44	2.40
Stocks, producer and consumer, yearend:					
Manganese ore[6]	269	309	319	275	235
Ferromanganese	36	33	27	21	15
Net import reliance[8] 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 (1994-97): Manganese ore: Gabon, 58%; Australia, 15%; Mexico, 14%; Brazil, 6%; and other, 7%. Ferromanganese: South Africa, 37%; France, 26%; Brazil, 10%; Australia, 9%; and other, 18%. Manganese contained in all manganese imports: South Africa, 27%; Gabon, 17%; Australia, 14%; France, 11%; and other, 31%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[9] 12/31/98
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: In addition to the data tabulated, the stockpile contained additional uncommitted inventories of nonstockpile-grade materials, as follows, in tons: natural battery ore, 16,800; chemical ore, 81; and metallurgical ore, 296,000. Disposals in FY 1998 also included 132,000 tons of nonstockpile-grade metallurgical ore.

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MANGANESE

Stockpile Status—9-30-98[10]

Material		Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Battery:	Natural ore	99	1	116	18	8
	Synthetic dioxide	3	—	3	3	—
Chemical ore		146	—	146	36	2
Metallurgical ore		685	141	981	227	90
Ferromanganese:					45	
High-carbon		908	15	856	XX	30
Medium-carbon		—	—	—	XX	13
Electrolytic metal		7	—	7	2	2

Events, Trends, and Issues: Domestic manganese demand was bolstered by increased raw steel production through at least the first one-half of the year. Ore price fell slightly to the level of 3 years earlier. Through September, U.S. prices increased moderately for high-carbon and medium-carbon ferromanganese but deteriorated for silicomanganese. In South Africa, the two Japanese-South African joint ventures for production of refined ferromanganese came on-stream. 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 (metal content):[11]

	Mine production 1997	Mine production 1998[e]	Reserves[12]	Reserve base[12]
United States	—	—	—	—
Australia	1,024	770	28,000	75,000
Brazil	[e]780	740	21,000	56,000
China	[e]1,400	1,400	40,000	100,000
Gabon	[e]878	890	45,000	150,000
India	[e]680	680	24,000	36,000
Mexico	[e]193	195	4,000	9,000
South Africa	[e]1,320	1,350	370,000	4,000,000
Ukraine	[e]1,030	920	135,000	520,000
Other countries	[e]377	410	Small	Small
World total (rounded)	[e]7,680	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 Commonwealth of Independent States (CIS) 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 CIS.

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

[e]Estimated. XX Not applicable.
[1]Manganese content typically ranges from 35% to 54% for manganese ore and from 74% to 95% for ferromanganese.
[2]Excludes insignificant quantities of low-grade manganiferous ore.
[3]Imports more nearly represent amount consumed than does reported consumption; internal evaluation indicates that reported consumption of silicomanganese is considerably understated.
[4]Net quantity 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]For 1996-98, exclusive of that at iron and steel plants.
[7]Thousand metric tons, manganese content; based on estimates of average content for all significant components except imports, for which content is reported.
[8]Defined as imports - exports + adjustments for Government and industry stock changes.
[9]See Appendix B.
[10]See Appendix C for definitions.
[11]Thousand metric tons, manganese content.
[12]See Appendix D for definitions.

MERCURY

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

Domestic Production and Use: Recovery of mercury from obsolete or worn out items remains the primary source of domestic mercury production. Several companies in the eastern and central United States recovered mercury from a variety of secondary sources such as batteries, chlor-alkali wastewater sludges, dental amalgams, electrical apparatus, fluorescent light tubes, and measuring instruments. Domestic mine production of mercury was limited to a very small quantity of byproduct production from fewer than 10 gold mines in California, Nevada, and Utah. The value of mercury used in the United States was estimated at approximately $2 million. It was estimated that approximately 35% of the mercury consumed domestically was used in the manufacture of chlorine and caustic soda and 30% for electrical and electronic applications. The remaining 35% was used for applications such as measuring and control instruments and dental amalgams.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Mine	W	W	W	W	W
Secondary, industrial	466	534	446	389	400
Imports for consumption	129	377	340	164	200
Exports	316	179	45	134	150
Shipments from Government stockpile excesses	86	—	—	—	—
Consumption: Reported	483	436	372	346	400
Apparent	W	W	W	W	W
Price, average value, dollars per flask,					
D.F. Goldsmith	194.45	247.40	261.65	NA	NA
Free market	NA	NA	NA	159.52	180.00
Stocks, industry, yearend[2]	469	321	446	203	200
Net import reliance[3] as a percent of apparent consumption	W	W	W	W	W

Recycling: About 400 tons of mercury was recovered from old scrap in 1998.

Import Sources (1994-97): Russia, 37%; Canada, 25%; Kyrgyzstan, 13%; Spain, 10%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
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—9-30-98[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Mercury	4,435	—	4,435	690	—

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MERCURY

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

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

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States	W	W	—	7,000
Algeria	370	300	2,000	3,000
Italy	—	—	—	69,000
Kyrgyzstan	611	600	7,500	13,000
Spain	1,000	1,000	76,000	90,000
Other countries	745	700	38,000	61,000
World total (may be rounded)	2,730	2,600	120,000	240,000

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

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

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

MICA (NATURAL), SCRAP AND FLAKE[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Scrap and flake mica production, excluding low-quality sericite, was estimated to be 81,000 metric tons in 1998. North Carolina accounted for about 52% 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 industrial sand beneficiation. The majority of domestic production was processed into small particle-size mica by either wet or dry grinding. Primary uses were joint compound, paint, roofing, oil well drilling additives, and rubber products. The value of 1998 scrap mica production was estimated at $9 million. Ground mica sales in 1997 were valued at $37 million. There were 10 domestic producers of scrap and flake mica.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production:[2 3] Mine	109	108	97	114	81
Ground	95	98	103	110	78
Imports, mica powder and mica waste	18	22	18	23	22
Exports, mica powder and mica waste	6	7	8	8	8
Consumption, apparent[4]	97	112	107	122	90
Price, average, dollars per ton, reported:					
Scrap and flake	66	52	81	83	112
Ground:					
Wet	1,007	974	1,032	1,080	1,000
Dry	151	174	182	176	180
Stocks, producer, yearend[e]	14	13	7	NA	NA
Employment, mine, number[e 5]	364	360	NA	NA	NA
Net import reliance[6] as a percent of apparent consumption	1	5	4	9	13

Recycling: None.

Import Sources (1994-97): Canada, 63%; India, 29%; Finland, 4%; Japan, 2%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[7] 12/31/98
Mica powder	2525.20.0000	0.5% 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: Domestic production of ground mica decreased in 1998. The decline was primarily the result of the closure of a lithium and mica mine in Bessemer City, NC. Part of the production shortfall from the North Carolina mine was offset by increased production from recently opened operations in Deep Step, GA, and Newell, SD. A dry and wet ground mica producer in Micaville, NC, was sold to a larger mining company with existing operations in Spruce Pine, NC. The United States remained a major world producer of scrap and flake mica. Imported mica scrap and flake is primarily used for making mica paper and as a filler and reinforcer in plastics.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	1997	1998[e]		
United States[2]	114	81	Large	Large
Brazil	7	7	Large	Large
Canada	18	18	Large	Large
India	1	1	Large	Large
Korea, Republic of	34	34	Large	Large
Russia	100	100	Large	Large
Other countries	41	40	Large	Large
World total	315	281	Large	Large

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

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

[e]Estimated. NA Not available.
[1]See also Mica (Natural), Sheet.
[2]Sold or used by producing companies.
[3]Excludes low-quality sericite used primarily for brick manufacturing.
[4]Based on ground mica.
[5]Total employment at mines and mills where mica was produced and processed, 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 D 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 1998, incidental to scrap and flake mica production and the mining of gemstone-bearing pegmatites. The domestic consuming industry was dependent on imports and shipments of U.S. Government stockpile excesses to meet demand for sheet mica. During 1998, an estimated 3,200 tons of unworked mica split block and mica splittings valued at $1.9 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 1,800 tons of imported worked mica valued at $13.3 million was also consumed.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, mine[e]	([2])	([2])	([2])	([2])	([2])
Imports, plates, sheets, and strips; worked mica; split block; splittings; other > $0.55/kg	2,610	4,230	6,330	5,760	5,000
Exports, plates, sheets, and strips; worked mica; crude and rifted into sheet or splittings > $0.55/kg	1,003	935	831	1,060	1,340
Shipments from Government stockpile excesses	134	511	1,110	326	414
Consumption, apparent	1,740	3,800	6,540	5,030	4,070
Price, average value, dollars per kilogram, muscovite and phlogopite mica, reported:					
Block	66	73	77	41	30
Splittings	1.72	1.86	1.75	1.51	1.50
Stocks, fabricator and trader, yearend	[e]503	NA	NA	NA	NA
Net import reliance[3] as a percent of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1994-97): India, 63%; Belgium, 13%; Germany, 8%; China, 5%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
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	3.2% ad val.	40% ad val.
Worked mica and articles of mica—other	6814.90.0000	3.1% ad val.	45% ad val.

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

Government Stockpile:

Stockpile Status—9-30-98[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Block:					
Muscovite	735	289	598	([6])	453
Phlogopite	59	—	—	—	—
Film, muscovite	9	([2])	9	([6])	9
Splittings:					
Muscovite	5,550	—	5,550	([6])	93
Phlogopite	264	—	264	([6])	1

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MICA (NATURAL), SHEET

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

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1997	1998[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 numerous electrical and electronic uses. Substitutes include acrylic, Benelex®, cellulose acetate, Delrin®, Duranel® N, fiberglass, fishpaper, Kapton®, Kel F®, Kydex®, Lexan®, Lucite®, Mylar®, nylon, nylatron, Nomex®, Noryl®, phenolics, Plexiglass®, polycarbonate, polyester, styrene, Teflon®, vinyl-PVC, and vulcanized fiber. Mica paper made from scrap mica can be substituted for sheet mica in electrical and insulation applications.

[e]Estimated. NA Not available.
[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.
[6]The total disposal plan for all categories of mica in the National Defense Stockpile, except phlogopite block, is undifferentiated at 1,025 metric tons (2,260,000 pounds).
[7]See Appendix D for definitions.

MOLYBDENUM

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

Domestic Production and Use: In 1998, molybdenum, valued at about $454 million (based on average oxide price), was produced by 11 mines. Molybdenum ore was produced at 3 mines in Colorado, New Mexico, and Idaho, whereas 8 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:	1994	1995	1996	1997	1998[e]
Production, mine	46,800	60,900	54,900	60,900	53,500
Imports for consumption	7,153	11,500	13,400	15,000	15,200
Exports, all primary forms	37,000	51,300	49,600	50,400	45,000
Consumption: Reported	19,100	19,900	20,900	20,000	20,000
Apparent	25,400	20,200	21,200	23,000	23,600
Price, average value, dollars per kilogram[1]	4.60	17.50	8.30	9.46	8.50
Stocks, mine and plant concentrates, product, and consumer materials	11,500	12,400	9,930	11,400	12,500
Employment, mine and plant, number	700	700	800	700	600
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. While molybdenum is not recovered from scrap steel, recycling of steel alloys is significant, and molybdenum content is reutilized. Data on the quantities of molybdenum recycled in this manner are not available.

Import Sources (1994-97): United Kingdom, 30%; Chile, 22%; China, 17%; Canada, 14%; and other, 17%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
Molybdenum ore and concentrates, roasted	2613.10.0000	13¢/kg + 1.8% ad val.	$1.10/kg + 15% ad val.
Molybdenum ore and concentrates, other	2613.90.0000	18.2¢/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	3824.90.3400	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	10.1¢/kg + 1.3% 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	8102.92.3000	6.6% ad val.	60% ad val.
Wire	8102.93.0000	4.8% ad val.	60% ad val.
Other	8102.99.0000	4.1% ad val.	45% ad val.

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MOLYBDENUM

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

Government Stockpile: None.

Events, Trends, and Issues: U.S. mine output of molybdenum in 1998 decreased to about the level of 1996, after rising nearly 11% in 1997. The decline reflected reduced prices. Reported consumption of molybdenum was about the same as in 1997, while exports decreased about 11%, and U.S. producer inventories increased about 10% above those of 1997.

The molybdenum industry was uneventful in 1998, and prices of concentrates and molybdenum products moderated toward the end of the year. The domestic price for technical-grade molybdic oxide averaged $8.50 per kilogram of contained molybdenum during 1998, a decline of 10% from that of 1997. Mine capacity utilization was 43%.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1997	1998[e]	(thousand metric tons)	
United States	60,900	53,500	2,700	5,400
Armenia	1,800	2,000	20	30
Canada	7,540	8,000	450	910
Chile	17,900	18,900	1,100	2,500
China	32,000	33,000	500	1,000
Iran	600	1,000	50	140
Kazakhstan	400	500	130	200
Mexico	4,300	4,000	90	230
Mongolia	1,992	2,000	30	50
Peru	3,835	4,000	140	230
Russia	8,500	8,500	240	360
Uzbekistan	500	500	60	150
Other countries	—	—	—	590
World total (rounded)	140,000	136,000	5,500	12,000

World Resources: Identified resources amount to about 5.5 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 D for definitions.

NICKEL

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

Domestic Production and Use: The only nickel smelter in the United States closed in April 1998 because of low nickel prices. The smelter, near Riddle, OR, had been producing ferronickel from ores imported from New Caledonia. The adjoining mine on Nickel Mountain has been idle since 1996. On a monthly or annual basis, 158 facilities reported nickel consumption. The principal consuming State was Pennsylvania, followed by West Virginia and Ohio. Approximately 44% of the primary nickel consumed went into stainless and alloy steel production, 38% into nonferrous alloys and superalloys, 14% into electroplating, and 4% into other uses. Ultimate end uses were as follows: transportation, 31%; chemical industry, 14%; electrical equipment, 11%; construction, 8%; fabricated metal products, 8%; petroleum, 7%; machinery, 7%; household appliances, 6%; and other, 8%. Total estimated value of apparent primary consumption was $740 million.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Mine	—	1,560	1,330	—	—
Plant	—	8,290	15,100	16,000	4,290
Imports: Ore	—	8,200	15,000	17,600	1,420
Primary[1]	127,000	149,000	142,000	147,000	155,000
Secondary[1]	6,070	7,930	8,060	11,000	9,780
Exports: Primary	7,420	9,750	13,100	16,400	8,940
Secondary	34,500	41,800	33,600	40,200	34,600
Consumption: Reported, primary	107,000	125,000	119,000	122,000	121,000
Reported, secondary	58,600	64,500	59,300	68,800	66,400
Apparent, primary	134,000	151,000	147,000	154,000	159,000
Price, average annual, London Metal Exchange:					
Cash, dollars per metric ton	6,340	8,228	7,501	6,927	4,648
Cash, dollars per pound	2.876	3.732	3.402	3.142	2.108
Stocks: Government, yearend	26,800	19,800	15,900	8,530	2,830
Consumer, yearend[2]	10,300	12,400	13,100	16,200	13,300
Producer, yearend[3]	10,200	12,700	13,300	12,600	12,500
Employment, yearend, number: Mine	1	17	8	7	—
Smelter	22	253	253	264	10
Port facility[4]	3	25	23	22	3
Net import reliance[5] as a percent of apparent consumption	64	60	59	56	65

Recycling: About 66,000 tons of nickel was recovered from purchased scrap in 1998. This represented about 35% of reported consumption for the year.

Import Sources (1994-97): Canada, 37%; Norway, 15%; Russia, 14%; Australia, 10%; and other, 24%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
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.

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

Government Stockpile:

Stockpile Status—9-30-98[7]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Nickel	1,960	805	1,960	9,070	1,830

Events, Trends, and Issues: Stainless steel accounts for 40% of primary nickel consumed in the United States and two-thirds of world primary consumption. U.S. production of nickel-bearing stainless steel was down 6% from 1997's near-record 1.36 million tons. Demand for nickel-free grades of stainless steel remained strong because of robust automotive sales, decreasing the nickel-bearing share of stainless steel production from 63% to 59%. Imports of stainless steel continued to grow and accounted for 33% of U.S. stainless steel consumption in 1997, which triggered a series of countervailing duty and antidumping investigations by the Federal Government.

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NICKEL

The world nickel supply grew faster than demand in 1998. In August, the London Metal Exchange (LME) cash price dropped below $4,300 per metric ton ($1.95 per pound)—the lowest level in more than a decade. A sharp rise in exports of cathode and stainless steel scrap from Russia to the European Union contributed to the oversupply situation and offset cutbacks in world ferronickel production. For the week ending November 20, 1998, the LME cash price for 99.8%-pure nickel averaged $4,163 per metric ton ($1.89 per pound). The oversupply situation is expected to continue for 4 or 5 years because of mine and smelter capacity additions in Australia, Canada, Indonesia, and Venezuela. The long-term outlook is more positive from a producer's standpoint. Since 1975, world demand for stainless steel has grown at an average rate of 4.5% per year. This growth rate is projected to continue for the next 20 years. Exploration teams have identified additional resources in the Canadian Shield since the discovery of the huge Voisey's Bay deposit in 1993. Most of these resources are in Labrador or on the Ungava Peninsula. The proposed mine and mill complex at Voisey's Bay is now scheduled to begin production in 2002. Authorities are holding hearings on the project's environmental impact, aboriginal land claims, and the issuance of mining leases.

Automotive manufacturers in the European Union, Japan, and the United States have begun mass producing electric vehicles powered by nickel-metal hydride, nickel-cadmium, or sodium metal-nickel batteries. At least one Japanese manufacturer is producing a hybrid automobile that uses an electric motor to power the vehicle in low-speed, stop-and-go city driving and switches to an internal combustion engine for higher speeds. Nickel metal powder production facilities in the United Kingdom are being expanded to meet growing demand from battery manufacturers.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[8]	Reserve base[8]
	1997	1998[e]		
United States	—	—	43,000	2,500,000
Australia	124,000	145,000	3,700,000	7,300,000
Botswana	20,157	21,300	780,000	830,000
Brazil	25,300	31,500	670,000	6,000,000
Canada	190,529	225,000	5,300,000	15,000,000
China	44,000	40,000	3,700,000	7,900,000
Colombia	31,230	31,800	560,000	1,100,000
Cuba	59,000	66,000	5,500,000	23,000,000
Dominican Republic	52,000	32,000	1,000,000	1,300,000
Greece	18,419	12,900	450,000	900,000
Indonesia	72,200	76,400	3,200,000	13,000,000
New Caledonia	137,068	137,000	4,500,000	15,000,000
Philippines	18,132	17,000	410,000	11,000,000
Russia	260,000	265,000	6,600,000	7,300,000
South Africa	34,830	34,700	2,500,000	11,800,000
Zimbabwe	11,000	11,600	240,000	260,000
Other countries	21,300	20,100	450,000	12,000,000
World total (may be rounded)	1,120,000	1,170,000	40,000,000	140,000,000

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

Substitutes: With few exceptions, substitutes for nickel would result in increased cost or some tradeoff in the economy or performance of the product. Aluminum, coated steels, and plastics can replace stainless steel to a limited extent in many construction and transportation applications. Nickel-free specialty steels are sometimes used in place of stainless steel within the power generating, petrochemical, and petroleum industries. Titanium alloys or specialty plastics can substitute for nickel metal or nickel-based superalloys in some highly corrosive chemical environments.

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

NITROGEN (FIXED)—AMMONIA

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

Domestic Production and Use: U.S. ammonia producers continued to operate slightly below rated capacity. Fifty-eight percent of total U.S. ammonia production capacity was centered in Louisiana, Oklahoma, and Texas because of their large reserves of natural gas, the dominant domestic feedstock. The United States remained the world's second largest ammonia producer and consumer following China. Urea, ammonium phosphates, ammonium nitrate, nitric acid, and ammonium sulfate were the major derivatives of ammonia in the United States, in descending order of importance.

Approximately 86% of U.S. apparent domestic ammonia consumption was for fertilizer use, including anhydrous ammonia for direct application, urea, ammonium nitrates, ammonium phosphates, and other nitrogen compounds. Ammonia was also used to produce plastics, synthetic fibers, and resins, explosives, and numerous other chemical compounds.

Salient Statistics—United States:[1]	1994	1995	1996	1997	1998[e]
Production[2]	13,300	13,000	13,200	13,200	13,000
Imports for consumption	3,450	2,630	3,390	3,530	3,600
Exports	215	319	435	395	400
Consumption, apparent	16,500	15,300	16,300	15,800	16,100
Stocks, producer, yearend	956	959	881	1,530	1,600
Price, dollars per ton, average, f.o.b. Gulf Coast[3]	211	212	190	173	125
Employment, plant, number[e]	2,500	2,500	2,500	2,500	2,500
Net import reliance[4] as a percent of apparent consumption	19	15	19	16	19

Recycling: None.

Import Sources (1994-97): Trinidad and Tobago, 46%; Canada, 37%; Mexico, 10%; Venezuela, 2%; and other, 5%. In addition, the United States imports significant quantities of ammonia from Russia and Ukraine, but the Bureau of the Census quantity data are suppressed, so these data are not included in the calculation of import sources.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
Ammonia, anhydrous	2814.10.0000	Free	Free.
Ammonia, aqueous	2814.20.0000	Free	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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NITROGEN (FIXED)—AMMONIA

Events, Trends, and Issues: U.S. ammonia producers operated at about 90% of installed capacity in 1998. Production decreased from the 1997 level as prices dropped throughout the year. The Asian financial crisis, coupled with a wet spring in the United States, had a negative effect on Gulf Coast ammonia prices. Ammonia prices continued the decline begun in 1997, and by November, the Gulf Coast ammonia price had dropped to $102 per short ton. With the addition of two new 650,000-ton-per-year ammonia plants that started operation in Trinidad in 1998 and debottlenecking and incremental additions to U.S. ammonia plants, ammonia was in oversupply during most of the year. U.S. farm exports also decreased in 1998 because of large world grain crops, a slowdown in Asian purchases, and the strength of the U.S. dollar.

In the United States, one ammonia producer with plants in Alaska, California, and Washington announced plans to sell its nitrogen operations in order to concentrate on its core energy business. Because of changing economic conditions, another ammonia producer decided not to proceed with construction of a 665,000-ton-per-year ammonia complex that was planned for Wells, NV. Planning continued for the development of new nitrogen projects around the world, particularly in Asia, Australia, and South America. But because of the depressed Asian economy, completion of several of the Asian projects was postponed.

World Ammonia Production, Reserves, and Reserve Base:

	Plant production		Reserves and reserve base[6]
	1997	1998[e]	
United States	13,200	13,000	Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries.
Canada	3,980	3,800	
China	24,000	25,000	
Germany	2,470	2,600	
India	8,600	9,300	
Indonesia	3,770	3,600	
Japan	1,570	1,400	
Mexico	1,450	1,600	
Netherlands	2,500	2,300	
Russia	7,150	5,000	
Trinidad and Tobago	1,800	2,000	
Ukraine	3,500	3,400	
Other countries	27,400	27,500	
World total (rounded)	101,000	101,000	

World Resources: The availability of nitrogen from the atmosphere for fixed nitrogen production is unlimited. Mineralized occurrences of sodium and potassium nitrates, found in the Atacama Desert of Chile, contribute minimally to global nitrogen 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 D 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 $16 million in 1998. Peat was harvested and processed by about 60 producers in 20 States; Florida, Michigan, and Minnesota were the largest producing States in order of importance. Reed-sedge peat accounted for about 60% of the total volume followed by sphagnum moss, 25%; humus and hypnum moss accounted for the remaining 15%.

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 municipal 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:	1994	1995	1996	1997	1998[e]
Production	574	589	549	661	550
Commercial sales	552	660	640	753	611
Imports for consumption	669	669	667	754	830
Exports	23	20	19	22	25
Consumption, apparent[2]	1,240	1,110	1,240	1,310	1,380
Price, average value, f.o.b. mine, dollars per ton	27.22	25.80	28.90	23.23	28.80
Stocks, producer, yearend	252	384	342	421	400
Employment, mine and plant, number[e]	650	800	800	800	800
Net import reliance[3] as a percent of apparent consumption	53	57	56	50	60

Recycling: None.

Import Sources (1994-97): Canada, 100%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
Peat	2703.00.0000	Free	Free.

Depletion Allowance: 5% (Domestic).

Government Stockpile: None.

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PEAT

Events, Trends, and Issues: Restrictions placed on wetlands development by Federal and State agencies have led to the closures of many peat bogs over the past five years. This has resulted in the Canadian sphagnum peat industry, with its large reserves, capturing a greater percentage of the domestic market. In 1998, shipments of peat from Canada were proceeding at a record annual rate of 830,000 tons.

A major U.S. peat producer acquired a brand of peat products from the major producer in Ireland. Under the agreement, the Irish company will mix and package peat products for the U.S. company for sale in Ireland and the United Kingdom. The U.S. producer also obtained preferential access to the other company's vast peat reserves in Ireland.

Estimated peat production from countries in the Former Soviet Union (FSU) accounts for a significant portion of global production. Because the quantity of peat produced in the FSU for agricultural purposes is not reported on a consistent and reliable basis, worthwhile estimates cannot be made; the quantity of peat produced in the FSU for agricultural purposes is not included in world production tabulations, even though the quantity produced is thought to be significant.

The outlook for the domestic peat industry likely will be influenced by several variables, including future regulations restricting the use of wetlands, the ability to permit new bogs, growth and competition from composted yard wastes and other organic materials, and Canadian competition.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[5]	Reserve base[5]
	1997	1998[e]		
United States	661	550	150,000	6,400,000
Belarus[e 6]	300	300	([7])	([7])
Canada	849	900	22,000	300,000,000
Estonia[e 6]	1,100	1,100	([7])	([7])
Finland	5,450	5,500	64,000	6,400,000
Germany	2,980	3,000	42,000	450,000
Ireland	7,300	7,300	160,000	820,000
Latvia[e 6]	442	450	([7])	([7])
Lithuania[e 6]	200	200	([7])	([7])
Russia[e 6]	2,500	2,500	([7])	([7])
Sweden	1,650	1,700	([7])	([7])
Ukraine[e 6]	1,000	1,000	([7])	([7])
United Kingdom[e]	550	550	([7])	([7])
Other countries	1,000	1,000	4,900,000	150,000,000
World total (rounded)	26,000	26,000	5,300,000	460,000,000

World Resources: World resources of peat were estimated to be 1.9 trillion tons, of which the FSU 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 D for definitions.
[6]Does not include agricultural peat production.
[7]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 1998 was $24.8 million. Crude ore production came from 10 mines operated by 8 companies in 6 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, 71%; horticultural aggregate, 10%; filter aid, 9%; fillers, 7%; and other, 3%.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production[1]	644	700	684	706	688
Imports for consumption[e]	70	84	125	135	140
Exports[e]	30	40	38	38	38
Consumption, apparent	684	744	771	803	790
Price, average value, dollars per ton, f.o.b. mine	30.03	27.93	28.25	33.04	35.99
Stocks, producer, yearend	NA	NA	NA	NA	NA
Employment, mine and mill	125	125	125	135	135
Net import reliance[2] as a percent of apparent consumption	6	6	11	12	13

Recycling: Not available.

Import Sources (1994-97): Greece, 100%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
Mineral substances, not specifically provided for	2530.10.0000	Free	Free.

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

Government Stockpile: None.

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PERLITE

Events, Trends, and Issues: A new perlite mine in Oregon continued operating but at less than planned capacity. The Idaho Department of Environmental Quality halted operations at a refurbished mine in Idaho, but an affiliated expanding plant remained operational. A company in Utah continued work towards bringing up to capacity a new mine near Kaysville. Closure and reclamation of a mine near Florence, CO, continued.

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 processing are used to reclaim the mined out areas, and, therefore, little waste is produced. Airborne dust is captured by baghouses, and there is practically no runoff that contributes to water pollution.

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]
	1997	1998[e]		
United States	706	688	50,000	200,000
Greece	425	450	50,000	300,000
Japan	200	200	([5])	([5])
Turkey	175	175	([5])	([5])
Other countries	334	360	600,000	1,500,000
World total (may be rounded)	1,840	1,870	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 D 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 44.6 million tons of marketable product valued at $1.14 billion f.o.b. mine. Florida and North Carolina accounted for 83% 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 were used as intermediates in the manufacture of granular and liquid ammonium phosphate fertilizers. More than 50% of the wet-process phosphoric acid produced was exported in the form of upgraded granular diammonium and monoammonium phosphate fertilizer, triple superphosphate fertilizer, and merchant grade phosphoric acid. Calcium phosphate animal feed supplements were manufactured from defluorinated phosphate rock and defluorinated phosphoric acid. Phosphate rock mined by two western companies was used as feedstock for elemental phosphorus production at two wholly owned electric furnace facilities in Idaho.
Elemental phosphorus was used to produce high-purity phosphoric acid and phosphorus compounds, which were used in a variety of industrial applications.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production[1]	41,100	43,500	45,400	45,900	44,600
Sold or used by producers	43,900	43,700	43,500	42,400	43,900
Imports for consumption	1,800	1,800	1,800	1,830	1,800
Exports	2,800	2,760	[2]1,570	[2]335	[2]300
Consumption[3]	42,900	42,700	43,700	43,900	46,300
Price, average value, dollars per ton, f.o.b. mine[4]	21.14	21.75	23.40	23.45	25.36
Stocks, producer, yearend	5,980	5,710	6,390	7,910	7,700
Employment, mine and beneficiation plant, number	5,000	5,000	5,000	5,000	5,000
Net import reliance[5] as a percent of apparent consumption	5	E	E	E	4

Recycling: None. Limited to phosphate rock conversion products.

Import Sources (1994-97): Morocco, 99%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[6] 12/31/98**
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: Exports of phosphate rock have dropped substantially over the past 2 years as domestic producers have switched to exporting higher value fertilizer materials, which increased owing to strong demand in Asia. Domestic fertilizer consumption grew as farmers planted more corn and soybeans to build inventories and to improve crop yields. Projections for 1999 indicated an increase in both acreage planted and crop yields, which coupled with a strong export market should result in a good year for phosphate producers.

Consolidation of the domestic industry continued in 1998. In Florida, a producer of phosphate rock purchased the fertilizer plant in Texas, which had been toll processing its ore. In Idaho, a fertilizer manufacturer purchased the mine that supplies its plant. Another company in Florida reopened its mine late in 1998 and its associated fertilizer plant was scheduled to resume production early in 1999; both have been idle since 1992. Two companies, one each in Florida and Idaho, purchased phosphate rock reserves adjacent to operating mines from firms no longer active in mining. Permitting procedures began for three new mines in Florida that were scheduled to open in the next 5 to 10 years, to replace currently operating mines after their reserves have been depleted.

Both world production and consumption of phosphate rock were expected to increase in 1998. Several major mine and fertilizer plant expansion projects were underway in Africa, Asia, and the Middle East. Demand for fertilizers, primarily diammonium phosphate, in China and India continued to be strong, with the United States as the major supplier.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1997	1998[e]		
United States	45,900	44,600	1,200,000	4,400,000
Brazil	3,850	3,900	330,000	370,000
China	20,000	22,000	210,000	210,000
Israel	4,050	4,000	180,000	180,000
Jordan	5,900	6,000	900,000	1,700,000
Kazakhstan	1,700	1,500	50,000	100,000
Morocco and Western Sahara	23,400	24,000	5,900,000	21,000,000
Russia	7,500	9,500	150,000	1,000,000
Senegal	1,540	1,600	50,000	160,000
South Africa	3,000	3,000	1,500,000	2,500,000
Togo	2,630	2,600	30,000	60,000
Tunisia	7,070	7,100	100,000	600,000
Other countries	11,500	11,500	1,000,000	2,500,000
World total (rounded)	138,000	141,000	12,000,000	35,000,000

World Resources: Reserve and reserve base figures for Jordan have been revised to reflect changes provided by the sole producer in the country. Reserve figures for Kazakhstan, Russia, Senegal, and Togo have been revised based on information obtained from other sources. Phosphate rock resources occur principally as sedimentary marine phosphates. 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 Ocean and the Pacific Ocean.

Substitutes: There are no substitutes for phosphorus in agriculture.

[e]Estimated. E Net exporter.
[1]Marketable.
[2]Source: Bureau of the Census.
[3]Defined as sold or used + imports - exports.
[4]Marketable phosphate rock, weighted value, all grades, domestic and export.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B.
[7]See Appendix D for definitions.

PLATINUM-GROUP METALS

(Platinum, palladium, rhodium, ruthenium, iridium, osmium)
(Data in kilograms, unless otherwise noted)

Domestic Production and Use: The United States has only one active platinum-group metals (PGM) mine. The mine, located near Nye, MT, processed about 430,000 metric tons of ore and recovered about 13,600 kilograms of PGM (primarily palladium) in 1998. Small quantities of PGM were also recovered as byproducts of copper refining by two companies in Texas and Utah. The automotive industry is the principal consumer of PGM as oxidation catalysts in catalytic converters to treat automobile exhaust emissions. Oxidation catalysts are also used in many air pollution abatement processes to remove organic vapors, odors, or carbon monoxide. Chemical uses include catalysts for organic synthesis, e.g., in hydrogenation, dehydrogenation, and isomerization. Platinum alloys, in cast or wrought form, are commonly used for jewelry. Platinum, palladium, and a variety of complex gold-silver-copper alloys are used as dental restorative materials. The primary medical use of PGM is in cancer chemotherapy. Other medical uses include platinum-iridium alloys in prosthetic and biomedical devices.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Mine production:[1] Platinum	1,960	1,590	1,840	2,610	3,500
Palladium	6,440	5,260	6,100	8,400	10,500
Imports for consumption, refined:					
Platinum	56,500	71,500	75,800	77,300	82,000
Palladium	92,500	124,000	146,000	148,000	151,000
Rhodium	7,820	9,600	9,650	14,400	8,600
Ruthenium	9,880	7,520	15,600	11,500	10,200
Iridium	926	1,450	1,810	1,860	1,000
Osmium	55	73	329	54	75
Exports, refined:					
Platinum	15,500	15,000	12,700	23,000	8,460
Palladium	29,900	26,000	26,700	43,800	37,400
Rhodium	791	741	187	282	898
Price[2], dollars per troy ounce:					
Platinum	411.30	425.36	397.97	396.58	406.00
Palladium	156.20	153.35	130.39	184.14	290.00
Rhodium	636.00	463.30	300.00	298.99	300.00
Employment, mine, number	445	500	500	550	600

Recycling: An estimated 65 metric tons of PGM was recovered from new and old scrap in 1998.

Import Sources (1994-97): Platinum: South Africa, 60%; United Kingdom, 12%; Germany, 6%; Russia, 6%; and other, 16%. Palladium: Russia, 46%; South Africa, 18%; Belgium, 10%; United Kingdom, 6%; and other, 20%.

Tariff: All unwrought and semimanufactured PGM can be imported duty free.

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

Government Stockpile:

Stockpile Status—9-30-98[3]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 1998**	**Disposals FY 1998**
Platinum	13,700	—	—	—	—
Palladium	38,800	—	—	—	—
Iridium	920	—	—	—	—

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PLATINUM-GROUP METALS

Events, Trends, and Issues: Short-term concerns about supplies from Russia pushed the price of palladium from $198 per troy ounce (ounce) at the beginning of the year to $417 per ounce on May 18, 1998, overtaking the price of platinum($407 per ounce) for the first time. The price surge was driven by the lack of imports from Russia, the world's largest producer, during the first 4 months of 1998. The sharp price increase was only temporary, falling to $285 per ounce on May 29, as Russian shipments began to reach the market. The price on September 30, 1997, was only $280 per ounce, but still significantly higher than at the beginning of the year.

The only domestic primary PGM mine produced a record 3,732 kilograms of palladium and platinum in the second quarter of 1998. This was 54% higher than second quarter 1997 production of 2,426 kilograms. Cash cost per ounce, $147 per ounce, was 22% lower than the 1997 cash costs or $189 per ounce. Production for the 6 months ending on June 30, 1998, was 6,843 kilograms of palladium and platinum, 40% more than the 4,883 kilograms of metal produced in the same period in 1997. In the third quarter of 1998, a tunnel-boring machine was put into operation as part of an expansion project that is scheduled for completion in 2002 and expected to be at full capacity of about 15,600 kilograms of PGM annually by 2003.

World supplies of PGM are expected to increase substantially in the next 5 years, according to plans laid out by major non-South African PGM mining companies. About 62,200 kilograms of additional output could come from projects under development in Canada, the United States, and Zimbabwe. All were either expanding production or developing new mines.

World Mine Production, Reserves, and Reserve Base:

	Mine production				PGM	
	Platinum		Palladium		Reserves[4]	Reserve base[4]
	1997	1998[e]	1997	1998[e]		
United States[2]	2,610	3,500	8,400	10,500	730,000	810,000
Canada	7,550	7,300	4,810	4,800	310,000	380,000
Russia	17,000	17,500	47,000	47,000	6,200,000	6,600,000
South Africa	125,000	125,000	55,900	60,000	63,000,000	69,000,000
Other countries	1,840	2,000	2,890	3,500	700,000	750,000
World total (rounded)	154,000	155,000	119,000	125,000	71,000,000	78,000,000

World Resources: World resources of PGM in mineral concentrations currently or potentially economic to mine are estimated to be more than 100 million kilograms. The greatest reserves are in South Africa. Currently there are 10 producing mines in the Bushveld Complex. Of these, nine are producing from the Merensky Reef and UG2 Chromite Layer and one is producing from the Platreef, located on the northern limb of the Complex.

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.

Electronics consumers are reducing the average palladium content of the conductive pastes used to form the electrodes of multi-layer ceramic capacitors, substituting palladium materials with palladium-silver pastes containing up to 70% silver. Other substitution plans include using nickel and copper.

[e]Estimated.
[1]Estimates from published sources.
[2]Handy & Harman quotations.
[3]See Appendix C for definitions.
[4]See Appendix D for definitions.

POTASH

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

Domestic Production and Use: In 1998, the value of production of marketable potash, f.o.b. mine was about $320 million, owing to price increases over 1997. Domestic potash production was from Michigan, New Mexico, and Utah. The majority of the production was from southeastern New Mexico, where two companies operated five mines, two of which were connected underground. New Mexico potash ore was beneficiated by flotation, heavy media separation, dissolution-recrystallization, and washing, and provided more than 70% of the U.S. total producer sales.

In Utah, of the three potash operations, one company brought underground potash to the surface by solution mining. The potash was recovered from the brine by solar evaporation to crystals and flotation. Another Utah company collected subsurface brines from an interior basin for solar evaporation to crystals and flotation. The third Utah company collected lake brines for solar evaporation to crystals, flotation, and dissolution-recrystallization. In Michigan, a company used deep well solution mining and recovery by mechanical evaporation. The fertilizer industry used about 90% of the U.S. potash sales and the chemical industry used about 10%. More than 50% of the potash was produced as potassium chloride (muriate of potash). Potassium sulfate (sulfate of potash) and potassium magnesium sulfate (sulfate of potash-magnesia), required by certain crops and soils, were also sold.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, marketable	1,400	1,480	1,390	1,400	[1]1,300
Imports for consumption	4,800	4,820	4,940	5,490	4,500
Exports	464	409	481	466	450
Consumption, apparent	5,810	5,820	5,890	6,500	[2]5,300
Price, dollars per metric ton of K_2O, average, muriate, f.o.b. mine[3]	131	137	133	140	145
Stocks, producer, yearend	234	312	265	[1]200	[1]300
Employment, number: Mine	845	900	880	850	730
Employment, number: Mill	810	840	810	800	780
Net import reliance[4] as a percent of apparent consumption	76	75	77	[5]80	[5]80

Recycling: None.

Import Sources (1994-97): Canada, 93%; Russia, 4%; Belarus, 1%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
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's largest potash producers operated at reduced capacity for another year owing to potential oversupply. The Canadian potash industry operated for the first half of the year at about 75% of capacity, which was about 98% of "practical capacity," the capacity that is open and operating but not the mines that would take greater than 6 months to reopen. Other countries slightly increased production by returning to normal (shorter) summer maintenance closures. The world continued operating at reduced capacity as Asian economic problems caused a reduction of foodstuff trade, leading to lower grain prices, and grain storage problems in grain-producing and -exporting countries. Consequently, potash sales declined in the second half of 1998 as farmers reduced their purchases for fall potash application. In the United States, the potash price rose as the loss of two regional potash mines in 1997 maintained, or even caused increased prices during the year. The Pacific Basin potash buyers saw their prices rise along with North American consumers. European buyers saw a rather stable price.

French production decreased owing to the approaching end of mine life. Belarus, Canada, Germany, and Russia increased production by returning to normal summer maintenance closures.

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POTASH

The flooded potash mine and the accompanying mill near Sussex, New Brunswick, Canada was renamed and the mill was used for compacting standard (size) grade potash from New Brunswick and Saskatchewan to granular (size) grade. The other New Brunswick potash mine has been reported to have a saturated brine inflow at the rate of approximately 250 gallons per minute.

A consortium lead by the Israeli potash producer won a tender to purchase the remaining potash mines and mills in the Catalan province of Spain as the Spanish Government privatized certain companies.

A subsidiary of a Norwegian firm signed a memorandum of understanding (MOU) with a western Canadian firm concerning a proposed mine in Thailand. The MOU includes an off-take and marketing arrangement, with a to-be-agreed-upon investment into the mine operating company.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1997	1998[e]		
United States	1,400	[1]1,300	100,000	300,000
Azerbaijan[e]	5	5	NA	NA
Belarus	3,250	3,400	800,000	1,000,000
Brazil	243	300	50,000	600,000
Canada	9,301	9,400	4,400,000	9,700,000
Chile	240	200	10,000	50,000
China	115	100	320,000	320,000
France	665	500	3,000	NA
Germany	3,423	3,550	720,000	870,000
Israel	1,488	1,650	[8]40,000	[8]580,000
Jordan	849	840	[8]40,000	[8]580,000
Russia	3,400	3,700	1,800,000	2,200,000
Spain	640	550	20,000	35,000
Ukraine	100	100	25,000	30,000
United Kingdom	565	620	22,000	30,000
Other countries	—	—	50,000	140,000
World total (may be rounded)	25,700	24,900	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 large potash resource lies about 7,000 feet under central Michigan. The U.S. reserve figure above contains approximately 62 million tons of reserves in central Michigan. Estimated world resources total about 250 billion tons. The potash deposits in the Former Soviet Union contain large amounts of carnallite; it is not clear if this can be mined in a free market, competitive economy. 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]Estimated to the nearest 0.1 million tons to protect proprietary data.
[2]Estimated to the nearest 0.2 million tons to protect proprietary data.
[3]Average prices based on actual sales; excludes soluble and chemical muriates.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]Rounded to one significant digit to protect proprietary data.
[6]See Appendix B.
[7]See Appendix D for definitions.
[8]Total reserves and reserve base in the Dead Sea is equally divided between Israel and Jordan.

PUMICE AND PUMICITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: The estimated value of pumice and pumicite sold or used in 1998 was $15.1 million. Domestic output came from 14 producers in 6 States. The principal producing States were Idaho, New Mexico, and Oregon, with combined production accounting for about 77% of the national total. The remaining production was from Arizona, California, and Kansas. About 59% of the pumice was consumed for building blocks, and the remaining 41% was used in abrasives, concrete, laundries, and many other applications.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, mine[1]	490	529	612	577	616
Imports for consumption	143	238	215	265	306
Exports[e]	18	16	13	12	21
Consumption, apparent	615	728	814	830	901
Price, average value, dollars per ton, f.o.b. mine or mill	24.10	25.00	24.20	27.90	24.60
Stocks, yearend	NA	NA	NA	NA	NA
Employment, mine and mill, number	50	60	70	70	75
Net import reliance[2] as a percent of apparent consumption	20	30	25	30	32

Recycling: Not available.

Import Sources (1994-97): Greece, 87%; Ecuador, 6%; Turkey, 6%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
Crude or in irregular pieces, including crushed pumice	2513.11.0000	Free	Free.
Other	2513.19.0000	0.1¢/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 amount of pumice and pumicite sold or used in 1998 increased nearly 7% compared with that of 1997. Imports increased over 15% compared with that of 1997 as more Greek pumice was brought into the eastern half of the United States. Total consumption reached a 10-year high, at 901,000 tons. Consumption increased because of increased demand from lightweight-block producers. Laundry use of pumice continued to decline in 1998.

It is estimated that in 1999 domestic mine production of pumice and pumicite will be about 650,000 tons, with U.S. apparent consumption at approximately 950,000 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 costs 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 1998 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]
	1997	1998[e]		
United States[1]	577	616	Large	Large
Chile	450	475	NA	NA
France	450	450	NA	NA
Germany	600	600	NA	NA
Greece	1,200	1,200	NA	NA
Italy	5,100	5,100	NA	NA
Spain	600	600	NA	NA
Turkey	1,130	1,140	NA	NA
Other countries	1,090	1,100	NA	NA
World total (rounded)	11,200	11,300	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 D for definitions.

QUARTZ CRYSTAL (INDUSTRIAL)

(Data in metric tons, unless otherwise noted)

Domestic Production and Use: Domestic production of cultured quartz crystal has been relatively stable for the past few years. Lascas[1] mining and processing in Arkansas was stopped at the end of 1997 but four U.S. firms continued to produce cultured quartz crystals by using imported and stockpiled lascas as feed material. Electronic applications accounted for most industrial uses of quartz crystal; other uses included special optical applications.

Virtually all quartz crystal used for electronics was cultured rather than natural crystal. Electronic-grade quartz crystal was essential for making filters, frequency controls, and timers in electronic circuits employed for a wide range of products, such as communications equipment, computers, and many consumer goods (e.g., television receivers and electronic games).

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Mine[2]	544	435	435	450	—
Plant, cultured (as grown)	294	351	327	355	355
Imports for consumption:					
Lascas	NA	NA	NA	NA	NA
Cultured	19	47	42	63	63
Exports:					
Lascas	—	90	90	NA	NA
Natural electronic	NA	NA	NA	NA	NA
Cultured (mostly lumbered)	38	35	89	74	48
Consumption, apparent:					
Natural electronic	([3])	([3])	([3])	NA	NA
Cultured	275	363	280	343	370
Price, average value, dollars per kilogram:					
Lascas	1.20	1.20	1.20	1.20	—
Cultured (lumbered)	300	300	300	241	241
Stocks, producer, yearend:					
Lascas (for cultured crystal only)	150	190	190	250	250
Natural electronic	([3])	([3])	([3])	NA	NA
Cultured	200	200	200	200	200
Employment, mine, processing plant, number[e]	15	15	15	15	—
Net import reliance[4] as a percent of apparent consumption, lascas	NA	NA	NA	NA	100

Recycling: None.

Import Sources (1994-97): This information is no longer available.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[5] 12/31/98**
Sands:			
Other than natural	2506.10.0010	Free	Free.
Other	2506.10.0050	Free	Free.
Quartzite	2506.21.0000	Free	Free.
Piezo-electric quartz	7104.10.0000	3.6%	50%.

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QUARTZ CRYSTAL (INDUSTRIAL)

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

Government Stockpile:

Stockpile Status—9-30-98[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Quartz crystal	107	21	([3])	—	—

Events, Trends, and Issues: The only producer of lascas in the United States was closed down at yearend 1997. The U.S. is now totally dependent on imported lascas for the production of cultured quartz crystal. The switch to imported lascas was based on price differences between domestic and foreign suppliers.

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[7]	Reserve base[7]
	1997	1998[e]		
United States[e 2]	450	—	—	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 electronic 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.
[7]See Appendix D 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 1998. 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 $29 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 $600 million. The approximate distribution in 1997 by end use was as follows: automotive catalytic converters, 48%; petroleum refining catalysts, 17%; glass polishing and ceramics, 14%; permanent magnets, 12%; metallurgical additives and alloys, 7%; phosphors, 1%; and miscellaneous, <1%.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production:					
Bastnasite concentrates[2]	20,700	22,200	20,400	[e]20,000	10,000
Monazite concentrates	W	—	—	—	—
Imports:[3] Thorium ore (monazite)	—	22	56	11	—
Rare-earth metals, alloys	284	905	429	529	760
Cerium compounds	1,890	4,090	4,760	1,810	4,310
Mixed REO's	354	678	879	974	2,490
Rare-earth chlorides	2,410	1,250	1,070	1,450	1,730
Rare-earth oxide, compounds	5,140	6,500	10,300	7,070	3,990
Ferrocerium, alloys	92	78	86	121	123
Exports:[3] Thorium ore, monazite	27	—	—	—	—
Rare-earth metals, alloys	329	444	250	991	856
Cerium compounds	4,460	5,120	6,100	5,890	4,260
Other rare-earth compounds	2,420	1,550	2,210	1,660	1,850
Ferrocerium, alloys	3,020	3,470	4,410	3,830	2,520
Consumption, apparent[4]	17,800	W	W	19,400	14,000
Price, dollars per kilogram, yearend:					
Bastnasite concentrate, REO basis	2.87	2.87	2.87	2.87	2.87
Monazite concentrate, REO basis	0.46	0.44	0.48	0.73	0.73
Mischmetal, metal basis, metric ton quantity[5]	9-11	8-11	7-11	8-12	6-8
Stocks, producer and processor, yearend	W	W	W	W	W
Employment, mine and mill, number	NA	NA	NA	NA	NA
Net import reliance[4] as a percent of apparent consumption	E	6	18	E	29

Recycling: Small quantities, mostly permanent magnet scrap.

Import Sources (1994-97): Monazite: Australia, 75%; France, 25%; Rare-earth metals, compounds, etc.: China, 65%; France, 28%; Japan, 3%; United Kingdom, 1%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
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	5.8% 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.

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).

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RARE EARTHS

Government Stockpile: None.

Events, Trends, and Issues: Domestic demand for rare earths in 1998 was lower than in 1997. Imports increased for most rare-earth categories, however, domestic mine production was estimated to have decreased substantially. The decrease in domestic mine production and the temporary closure of the separation plant at Mountain Pass, CA, is primarily the result of a blocked underground effluent pipe. Significant delays have been encountered in obtaining governmental permitting to repair and install a new underground pipe. Exports of rare earths declined as demand in overseas markets, especially those in southeast Asia, declined. The overall trend in demand was for increased use of cerium and other rare earths in automotive catalytic converters and permanent magnets. The U.S. Department of Energy provided a research grant to develop rare-earth magnetic refrigeration for use in automobile air-conditioning systems. Use of the new technology would eliminate the need for chlorofluorocarbons and hydrofluorocarbons, the traditional coolants in compressor-type cooling systems.[7]

The *Rare Earths '98* conference was held in Freemantle, Western Australia, Australia, from October 25-30, 1998. The *22nd Rare-Earth Research Conference* is scheduled for July 11-15, 1999, in Argonne, IL.

World Mine Production, Reserves, and Reserve Base:

	Mine production[e]		Reserves[8]	Reserve base[8]
	1997	1998		
United States	20,000	10,000	13,000,000	14,000,000
Australia	—	—	5,200,000	5,800,000
Brazil	1,400	1,400	280,000	310,000
Canada	—	—	940,000	1,000,000
China	[9]53,300	50,000	43,000,000	48,000,000
Congo (Kinshasa)[10]	—	—	1,000	1,000
India	2,700	2,700	1,100,000	1,300,000
Malaysia	220	250	30,000	35,000
South Africa	—	—	390,000	400,000
Sri Lanka	120	120	12,000	13,000
Former Soviet Union[11]	2,000	2,000	19,000,000	21,000,000
Other countries	—	—	21,000,000	21,000,000
World total (rounded)	79,700	66,500	100,000,000	110,000,000

World Resources: Rare earths are relatively abundant in the Earth's crust, but discovered minable concentrations are less common than for most other ores. U.S. and world resources are contained primarily in bastnasite and monazite. Bastnasite deposits in China and the United States constitute the largest percentage of the world's rare-earth economic resources, while monazite deposits in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, and the United States constitute the second largest segment. Xenotime, rare-earth-bearing (ion adsorption) clays, loparite, phosphorites, apatite, eudialyte, secondary monazite, cheralite, and spent uranium solutions make up most of the remaining resources. Undiscovered resources are thought to be very large relative to expected demand.

Substitutes: Substitutes are available for many applications, but generally are less effective.

[e]Estimated. E Net exporter. 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.
[3]REO equivalent or contents of various materials were estimated. Data from U.S. Bureau of the Census.
[4]Monazite concentrate production was not included in the calculation of apparent domestic consumption and net import reliance. Net import reliance defined as imports - exports + adjustments for Government and industry stock changes.
[5]Price range from Elements - Rare Earths, Specialty Metals and Applied Technology, Trade Tech, Denver, CO.
[6]See Appendix B.
[7]Iowa State University, 1998, Cars may be first to benefit from magnetic refrigeration: Ames, Iowa, Iowa State University news release, October 12, 2 p.
[8]See Appendix D for definitions.
[9]Number reported in China Rare Earth Information, Baotou, Inner Mongolia, China.
[10]Formerly Zaire.
[11]As constituted before December 1991.

RHENIUM

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

Domestic Production and Use: During 1998, 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 20% 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 1998 was $35 million.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production[1]	15,500	17,000	14,000	15,400	16,000
Imports for consumption	8,200	12,800	20,800	15,100	20,000
Exports	NA	NA	NA	NA	NA
Consumption: Estimated	12,900	16,200	24,100	17,900	22,000
Consumption: Apparent	NA	NA	NA	NA	NA
Price, average value, dollars per kilogram:					
Metal powder, 99.99% pure	1,560	1,100	900	900	1,100
Ammonium perrhenate	1,100	700	500	300	700
Stocks, yearend, consumer, producer, dealer	NA	NA	NA	NA	NA
Employment, number			Small		
Net import reliance[2] as a percent of apparent consumption	NA	NA	NA	NA	NA

Recycling: Small amounts of molybdenum-rhenium and tungsten-rhenium scrap were processed during the past few years by several companies.

Import Sources (1994-97): Chile, 52%; Germany 18%; Kazakhstan, 8%; Netherlands, 6%; and other 16%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[3] 12/31/98**
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	3.3% ad val.	25% ad val.
Rhenium, etc., (metals) wrought; etc.	8112.99.0000	4.6% ad val.	45% ad val.

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

Government Stockpile: None.

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RHENIUM

Events, Trends, and Issues: During 1998, the average rhenium prices were $1,100 per kilogram for metal and $700 per kilogram for ammonium perrhenate, rises of 22% and 133%, respectively, over those of 1997. Imports of rhenium increased by about 32% for 1998 compared with those of 1997. Chile and Germany supplied the majority of the rhenium imported. The United States relies on imports for much of its supply of rhenium. The increased estimated consumption, was in the areas of catalysts for petroleum refining and superalloys for jet engines.

It is estimated that in 1999 U.S. consumption of rhenium will be about 30,000 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[4]	Reserve base[4]
	1997	1998		
United States	15,400	16,000	390,000	4,500,000
Armenia	NA	NA	95,000	120,000
Canada	—	—	—	1,500,000
Chile	11,400	13,600	1,300,000	2,500,000
Kazakhstan	1,800	2,400	190,000	250,000
Peru	2,000	2,300	45,000	550,000
Russia	NA	NA	310,000	400,000
Uzbekistan	NA	NA	59,000	400,000
Other countries	5,000	3,200	91,000	360,000
World total (may be rounded)	35,600	37,500	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 Kazakhstan, rhenium also exists in sedimentary copper deposits.

Substitutes: Substitutes for rhenium in platinum-rhenium catalysts are being evaluated continually. Iridium and tin have achieved commercial success in one such application. Other metals being evaluated for catalytic use include gallium, germanium, indium, selenium, silicon, tungsten, and vanadium. The use of these and other metals in bimetallic catalysts may decrease rhenium's share of the catalyst market. Materials that can substitute for rhenium in various end uses are as follows: cobalt and tungsten for coatings on copper X-ray targets, rhodium and rhodium-iridium for high-temperature thermocouples, tungsten and platinum-ruthenium for coatings on electrical contacts, and tungsten and tantalum for electron emitters.

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

RUBIDIUM

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

Domestic Production and Use: Although rubidium is not recovered from any domestically mined ores, at least one domestic company manufactured rubidium products from imported lepidolite ore. Small quantities of rubidium, usually in the form of chemical compounds, were used mainly in research and development. Rubidium also was used in electronic and medical applications.

Salient Statistics—United States: Salient statistics such as production, consumption, imports, and exports are not available. The domestic rubidium market is very small, with annual consumption probably amounting to only a few thousand kilograms. There is no active trading of the metal and, therefore, no market price. However, several companies publish prices for rubidium and rubidium compounds. These prices remain relatively stable for several years. The per-unit price for the metal or compounds purchased from these companies varies inversely with the quantity of material purchased. For example, in 1998, one company offered 1-gram ampoules of 99.8%-grade rubidium metal at $76.60. The price for 100 grams of the same material from this company was $960.00, or $9.60 per gram. At another company, the price for a 1-gram ampoule of 99.6% pure rubidium was $48.50.

Recycling: None.

Import Sources (1994-97): The United States is 100% import reliant. Although there is no information on the countries shipping rubidium-bearing material to the United States, Canada is thought to be the major source of this raw material.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[1] 12/31/98
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:[2] Rubidium forms no known minerals in which it is the predominant metallic element. Rather, it substitutes for potassium in a number of minerals, especially those that crystallize late in the formation of pegmatites. Lepidolite, a potassium lithium mica that may contain up to 3.15% rubidium, is the principle ore of rubidium. Pollucite, the cesium aluminosilicate mineral, may contain up to 1.35% rubidium. The rubidium-bearing minerals are mined as byproducts or coproducts with other pegmatite minerals.

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

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. Domestic rutile production data was withheld to avoid revealing company proprietary data. The value of U.S. rutile consumption in 1998, including synthetic rutile, was about $190 million. Two firms, with facilities in Nevada and Oregon, used titanium tetrachloride primarily made from rutile to manufacture titanium. Of 28 consuming firms, mainly in the Eastern United States, 5 companies used 93% of the rutile consumed to produce titanium dioxide (TiO_2) pigment. Welding-rod coatings and miscellaneous applications, which include fiberglass and titanium metal, consumed about 7%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production	W	W	W	W	W
Imports for consumption[2]	311	295	305	311	362
Exports[e]	4	6	3	5	16
Shipments from Government stockpile excesses	18	17	—	—	—
Consumption, reported[2]	478	439	365	383	410
Price, dollars per ton of rutile, yearend, bulk, f.o.b. Australian ports	420	600	563	530	500
Stocks, mine, distributor and consumer, yearend	141	52	77	80	70
Employment, mine and mill,[3] number	400	400	400	400	450
Net import reliance[4] as a percent of reported consumption	76	90	76	79	87

Recycling: None.

Import Sources (1994-97): Australia, 54%; South Africa, 37%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
Rutile concentrate	2614.00.6040	Free	Free.
Synthetic rutile	2614.00.3000	Free	30% ad val.

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

Government Stockpile: None.

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RUTILE

Events, Trends, and Issues: Domestic consumption of rutile concentrates was estimated to have increased 7% compared with 1997. In 1998, imports of all rutile concentrates were estimated to have increased 16% compared with 1997. However, although imports of natural rutile increased 31%, imports of synthetic rutile decreased 3% compared with 1997. Increased availability of rutile concentrates caused prices for natural rutile concentrates to decrease 6% compared with 1997.

In Australia, two of the world largest mineral sands producers planned to merge their two companies. If completed, the merger would improve recovery rates and extend the mine life of some reserves by processing of minerals at more efficient plants. The International Monetary Fund approved a $16 million loan to support the repair of mining operations in Sierra Leone. Prior to civil strife in 1995, the Sierra Leone operation had been the world's largest single producer of natural rutile.

Exploration and development of titanium mineral deposits continued in 1998. In the United States, deposits under examination included Camden, TN, Escalante, UT, Powderhorn, CO, and Okefenokee, GA. Canadian deposits under investigation included Shubenacadie River Basin, Nova Scotia, and Pipestone Lake, Manitoba. In Australia, investigations were ongoing at Broken Hill, Spring Hill, and Twelve Mile, New South Wales; Goondicum, Western Queensland; Ouyen, Victoria; and a large portion of the Murray Basin in New South Wales, Victoria, and South Australia. South African exploration and development investigations were ongoing at Bothaville. In preparation for a full feasibility study, a metallurgical study was completed for the Kwale mineral sands project in Kenya.

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]
	1997	1998[e]		
United States	W	W	700	1,800
Australia	171	190	[7]17,000	[7]51,000
Brazil	2	2	40	85,000
India	13	13	6,600	7,700
Italy	—	—	—	8,800
Sierra Leone	—	—	3,100	3,100
South Africa	108	108	8,300	8,300
Sri Lanka	3	2	4,800	4,800
Thailand	3	4	NA	NA
Ukraine	95	95	2,500	2,500
World total (may be rounded)	[8]395	[8]414	43,000	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. NA Not available. 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 D for definitions.
[7]Increase from 1997 based on data published by the Australian Bureau of Resource Sciences.
[8]Excludes U.S. production.

SALT

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Domestic production of salt increased in 1998, with total value estimated at $965 million. Twenty-eight companies operated 68 plants in 14 States. The estimated percentage of salt sold or used, by type, was salt in brine, 51%; rock salt, 31%; vacuum pan and solar salt, 9%, each.

The chemical industry consumed about 45% of total salt sales, with salt brine representing about 88% 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 30% of U.S. demand. The remaining markets for salt, in declining order, were distributors, 8%; industrial, 7%; agricultural, 4%; food, 3%; other combined with exports, 2%; and primary water treatment, 1%.

Salient Statistics—United States:[1]	1994	1995	1996	1997	1998[e]
Production	40,100	42,100	42,200	41,400	42,100
Sold or used by producers	39,700	40,800	42,900	40,600	40,700
Imports for consumption	9,630	7,090	10,600	9,160	9,300
Exports	742	670	869	748	800
Consumption: Reported	47,200	46,500	52,800	49,500	49,200
Apparent	48,600	47,200	52,600	49,000	49,200
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant:					
Vacuum and open pan salt	115.35	118.63	120.54	119.61	106.00
Solar salt	34.77	30.82	39.97	38.81	32.00
Rock salt	22.33	21.80	22.14	20.50	17.90
Salt from brine	5.40	6.91	6.72	6.67	6.00
Stocks, producer, yearend[e 2]	400	1,300	1,400	800	1,400
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	18	14	19	17	17

Recycling: None.

Import Sources (1994-97): Canada, 39%; Chile, 20%; Mexico, 20%; The Bahamas, 12%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
Iodized salt	2501.00.0000	Free	26% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: The winter of 1997-98 was relatively mild compared with that of previous years because of the El Niño weather phenomenon. As a result, consumer salt inventories were higher than normal and led to reduced salt sales in 1998. Severe rain storms attributed to El Niño also were responsible for destroying 1,200 solar salt operations in India and others in Kenya. In India, the bodies of 415 salt workers were recovered after a storm subsided. Salt from several countries had to be imported to meet the demand by the chloralkali and synthetic soda ash producers in India.

A major U.S. salt company was acquired early in the year by a large domestic fertilizer producer that owned a small byproduct salt operation in Hersey, MI, and salt operations in Canada. Aside from purchasing the domestic salt facilities, the sale also included the acquisition of other salt operations in Canada and England. Another U.S. salt company sold one of its solar salt facilities at Amboy, CA, to a calcium chloride producer. The salt company will continue to market the salt from the operation.

A rock salt mine in Detroit, MI, that was closed since the mid-1980's was purchased and reopened by a new salt company. The renovated mine will replace some of the production capacity lost when the Retsof, NY, mine closed in 1995. In addition, construction of a new rock salt mine began in November at Hampton Corners, NY. This project was the intended replacement mine for the flooded Retsof Mine but the original owner abandoned plans to develop it in 1996. First production was scheduled for late 1999.

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SALT

A large U.S. salt company celebrated its 150th anniversary of being in the salt business. The Chicago-based company began in 1848 as a sales agency for salt made at Lake Onondaga near Syracuse, NY. As the demand for salt grew, the company acquired other salt operations. Today, the company ranks among the top three U.S. salt producers.

Consumption of salt in 1999 is expected to be higher than that of 1998. Many weather forecasters were forecasting below-normal temperatures following the previous year's El Niño weather phenomenon, which increases the likelihood of adverse conditions requiring large quantities of deicing salt.

World Production, Reserves, and Reserve Base:

	Production		Reserves and reserve base[5]
	1997	1998[e]	
United States[1]	41,400	42,100	Large. Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans comprise an inexhaustible supply of salt.
Australia	8,722	8,800	
Brazil	5,520	5,700	
Canada	13,264	13,000	
China	29,300	30,000	
France	7,160	7,200	
Germany	15,700	15,000	
India	9,500	9,400	
Italy	3,600	3,600	
Mexico	7,933	7,900	
Poland	3,968	4,000	
Russia	1,400	1,300	
Spain	4,000	4,100	
Ukraine	2,500	2,400	
United Kingdom	6,600	6,600	
Other countries	40,433	38,900	
World total (may be rounded)	201,000	200,000	

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 produced and salt sold or used.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix D 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 $4.7 billion was produced by 3,642 companies from 5,288 operations in 50 States. Leading States, in order of volume, were California, Texas, Michigan, Ohio, Arizona, Washington, Utah, and Colorado, which combined accounted for about 47% of the total output. It is estimated that about 42% of the 1.02 billion metric tons of construction sand and gravel produced in 1998 was for unspecified uses. Of the remaining total, about 43% was used as concrete aggregates; 23% for road base and coverings and road stabilization; 13% as asphaltic concrete aggregates and other bituminous mixtures; 13% as construction fill; 2% for concrete products such as blocks, bricks, pipes, etc.; 2% for plaster and gunite sands; and the remainder for snow and ice control, railroad ballast, roofing granules, filtration, and other miscellaneous uses.

The estimated output of construction sand and gravel in the 48 conterminous States shipped for consumption in the first 9 months of 1998 was about 752 million tons, which represents an increase of 7.4% compared with the same period of 1997. 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:	1994	1995	1996[3]	1997	1998[e]
Production	891	907	914	952	1,020
Imports for consumption	1	1	1	2	2
Exports	1	1	1	2	2
Consumption, apparent	891	907	914	952	1,020
Price, average value, dollars per ton	4.20	4.30	4.38	4.47	4.63
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e]	42,500	42,500	42,500	42,500	42,500
Net import reliance[4] 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 (1994-97): Canada, 73%; The Bahamas, 15%; Mexico, 3%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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 7% in 1998. It is estimated that 1999 domestic production and U.S. apparent consumption will be about 1.07 billion tons each, a 4.9% increase. Aggregate consumption should see continued growth because of increased outlays for highway construction and maintenance provided by the Transportation Equity Act for the 21st Century (Public Law 105-178).

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[6]
	1997	1998[e]	
United States	952	1,020	The reserves and reserve base are controlled largely by land use and/or environmental constraints.
Other countries	NA	NA	
World total	NA	NA	

World Resources: Sand and gravel resources of the world are large. However, 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 choice 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]Excludes Hawaii.
[4]Defined as imports - exports + adjustments for Government and industry stock changes; changes in stocks not available and assumed to be zero.
[5]See Appendix B.
[6]See Appendix D 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 $532 million was produced by 80 companies from 141 operations in 36 States. Leading States, in order of volume, were Illinois, Michigan, California, Texas, and Wisconsin. Combined production from these States represented 45% of the national total. About 37% of the national tonnage was used as glassmaking sand, 23% as foundry sand, 6% as hydraulic fracturing sand, 5% as abrasive sand, and the remaining 29% for many other uses.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production	27,300	28,200	27,800	28,500	29,000
Imports for consumption	24	65	7	39	41
Exports	1,880	1,870	1,430	980	2,010
Consumption, apparent	25,400	26,400	26,400	27,600	27,000
Price, average value, dollars per ton	17.86	17.82	17.88	18.17	18.27
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e]	1,500	1,450	1,450	1,450	1,400
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 (1994-97): Australia, 66%; Canada, 11%; Mexico, 9%; Guyana, 7%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
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. Through September 1998, exports were estimated to have more than doubled compared with 1997. This large increase was mostly attributed to Mexico, which received more than the amount that was exported in 1997. 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 (e.g., very favorable freight rates).

The quantities of industrial sand and gravel sold or used increased about 1.6% in 1998 compared with that of 1997. It is estimated that 1999 domestic production and U.S. apparent consumption will be about 29.5 million tons and 27.5 million tons, respectively.

The industrial sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions in 1998. 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]
	1997	1998	
United States	28,500	29,000	
Australia	2,500	2,500	Large. Silica is abundant in the Earth's crust. The reserves and reserve base are determined by the location of population centers.
Austria	6,500	6,500	
Belgium	2,300	2,400	
Brazil	2,700	2,700	
Canada	1,590	1,600	
France	6,500	6,500	
Germany	6,000	6,200	
India	1,500	1,500	
Italy	3,000	3,000	
Japan	3,310	3,100	
Mexico	1,560	1,600	
Netherlands	24,000	24,000	
Paraguay	5,000	5,000	
South Africa	2,480	2,500	
Spain	2,800	2,800	
Sweden	500	750	
United Kingdom	4,800	4,800	
Other countries	13,500	13,500	
World total (rounded)	119,000	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 D for definitions.

SCANDIUM

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

Domestic Production and Use: Demand for scandium increased in 1998. Although scandium was not mined domestically in 1998, quantities sufficient to meet demand were available from domestic concentrates and tailings. Principal sources were imports from Russia and Ukraine. Companies that processed scandium ores, concentrates, and low-purity compounds to produce refined scandium products were located in Mead, CO; Urbana, IL; and Knoxville, TN. Capacity to produce ingot and distilled scandium metal was located in Phoenix, AZ; Urbana, IL; and Ames, IA. Scandium used in the United States was derived from both domestic and foreign sources. Principal uses for scandium in 1998 were aluminum alloys for sporting equipment, metallurgical research, high-intensity metal halide lamps, analytical standards, electronics, and laser research.

Salient Statistics—United States:	1994	1995	1996	1997	1998[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	1,600	1,500	1,400	1,400	1,100
Per kilogram, oxide, 99.9% purity	3,300	3,300	2,900	2,900	2,300
Per kilogram, oxide, 99.99% purity	5,200	5,100	4,400	4,400	3,400
Per kilogram, oxide, 99.999% purity	9,000	7,650	6,750	6,750	5,750
Per gram, powder, metal[1]	372.00	372.00	372.00	285.00	285.00
Per gram, sublimed, metal[2]	169.00	169.00	169.00	172.00	172.00
Per gram, scandium bromide, 99.99% purity[3]	80.00	80.00	80.00	90.00	90.00
Per gram, scandium chloride, 99.9% purity[3]	37.00	37.00	37.00	38.80	38.80
Per gram, scandium fluoride, 99.9% purity[3]	77.00	77.00	77.00	78.50	78.50
Per gram, scandium iodide, 99.999% purity[3]	78.00	78.00	78.00	148.00	148.00
Stocks	NA	NA	NA	NA	NA
Employment, processors, number	12	8	5	4	2
Net import reliance[4] as a percent of apparent consumption	NA	NA	NA	NA	NA

Recycling: Minor, recovered from laser crystal rods.

Import Sources (1994-97): Not available.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
Mineral substances not elsewhere specified or included: Including scandium ores	2530.90.0000	Free	0.3¢/kg.
Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed 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.

Events, Trends, and Issues: Nominal prices for domestically produced scandium compounds decreased from the previous year. The supply of domestic and foreign scandium remained strong despite increased demand. Although

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SCANDIUM

demand increased in 1998, the total market remained very small. Domestic increases in demand were primarily from recently developed applications in welding wire, scandium-aluminum baseball and softball bats, and scandium-aluminum bicycle frames.

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 1997, primarily to meet demand for alloying. Scandium's availability from the Former Soviet Union (FSU) 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, Kazakhstan, Ukraine, and Russia. Foreign mine production data were not available. No scandium was mined in the United States in 1998. 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 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, Kazakhstan, 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 Kazakhstan are in the Kola Peninsula apatites and in uranium-bearing deposits, respectively. Scandium in Madagascar is contained in pegmatites in the Befanomo area. Resources in Norway are dispersed in the thortveitite-rich pegmatites of the Iveland-Evje Region and a deposit in the northern area of Finnmark. An occurrence of the mineral thortveitite is reported for Kobe, Japan. Undiscovered scandium resources are thought to be very large.

Substitutes: In applications, such as lighting and lasers, it is generally not subject to substitution. In metallurgical applications, titanium and aluminum high-strength alloys and carbon fiber may substitute in sporting goods, especially bicycle frames.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Less than 250 micron, 99.9% purity, 1994 through 1998 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 ultradry powder from Alfa Aesar.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix D for definitions.

SELENIUM

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

Domestic Production and Use: Primary selenium was recovered from anode slimes generated in the electrolytic refining of copper. Two copper refineries, both in Texas, accounted for domestic production of primary selenium. Anode slimes from other primary electrolytic refiners were exported for processing. The estimated consumption of selenium by end use was as follows: glass manufacturing, 35%; chemicals and pigments, 20%; electronics, 15% (a decrease); and other, including agriculture and metallurgy, 30% (an increase). In glass manufacturing, selenium was used to decolor container glass and other soda-lime silica glasses and to reduce solar heat transmission in architectural plate glass. Cadmium sulfoselenide red pigments, which have good heat stability, were used in ceramics and plastics. Chemical uses included rubber compounding chemicals, gun bluing, catalysts, human dietary supplements, and antidandruff shampoos. Dietary supplementation for livestock was the largest agricultural use. Combinations of bismuth and selenium were added to brasses to replace lead in plumbing applications. Selenium was added to copper, lead, and steel alloys to improve their machinability. In electronics, high-purity selenium was used primarily as a photoreceptor on the drums of plain paper copiers; but this application has reached the replacement-only stage as selenium has been supplanted by newer materials in currently manufactured copiers.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, refinery	360	373	379	W	W
Imports for consumption, metal and dioxide	441	324	428	352	350
Exports, metal, waste and scrap	246	270	322	127	150
Consumption, apparent[1]	530	517	564	W	W
Price, dealers, average, dollars per pound, 100-pound lots, refined	4.90	4.89	4.00	2.94	2.50
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	31	31	38	W	W

Recycling: There was no domestic production of secondary selenium. Scrap xerographic materials were exported for recovery of the contained selenium. An estimated 45 tons of selenium metal recovered from scrap was imported in 1998.

Import Sources (1994-97): Canada, 36%; Philippines, 28%; Belgium, 13%; Japan, 9%; and other, 14%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
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 selenium consumption increased slightly in 1998. World selenium demand and production remained at about the 1997 level, so the oversupply situation was not eased significantly. The price continued the steady decline begun in 1996.

The use of selenium in glass remained strong. The use in copiers continued to decline, while the use in metallurgical additives increased. The use of selenium as an additive to no-lead, free-machining brasses for plumbing applications continued to increase as more stringent regulations on lead in drinking water take effect (ordinary free-machining brass contains up to 7% lead). Alloys with bismuth/selenium additions are dominating this new market. Selenium reduces the quantity of bismuth needed, without adverse effects on alloy properties.

Long-range research was continued to confirm the effectiveness of dietary selenium supplementation in cancer prevention. The dosage requirement for direct supplementation is likely to be small: 200 to 400 micrograms per day.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[4]	Reserve base[4]
	1997	1998[e]		
United States	W	W	10,000	19,000
Belgium	250	250	—	—
Canada	509	545	7,000	15,000
Chile	50	50	19,000	30,000
Finland	28	30	—	—
Germany	115	115	—	—
Japan	540	525	—	—
Peru	21	20	2,000	5,000
Philippines	40	40	2,000	3,000
Serbia and Montenegro	30	30	1,000	1,000
Sweden	20	20	—	—
Zambia	20	20	3,000	6,000
Other countries[5]	13	13	27,000	55,000
World total (rounded)	[6]1,640	[6]1,660	70,000	130,000

World Resources: In addition to the reserve base of selenium, which is contained in identified economic copper deposits, 2.5 times this quantity of selenium was estimated to exist in copper or other metal deposits that were undeveloped, of uneconomic grade, or as yet undiscovered. Coal contains an average of 1.5 parts per million of selenium, which is about 80 times the average for copper deposits, but recovery of selenium from coal appears unlikely in the foreseeable future.

Substitutes: High purity silicon has replaced selenium in high-voltage rectifiers and is the major substitute for selenium in low- and medium-voltage rectifiers. Other inorganic semiconductor materials, such as silicon, cadmium, tellurium, gallium, and arsenic, as well as organic photoconductors, substitute for selenium in photoelectric applications. Other substitutes include cerium oxide in glass manufacturing; tellurium in pigment and rubber compounding; bismuth, lead, and tellurium in free-machining alloys; and bismuth and tellurium in lead-free brasses.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[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 D for definitions.
[5]In addition to the countries listed, Australia, China, India, Kazakhstan, Russia, the United Kingdom, and Zimbabwe are known to produce refined selenium.
[6]Excludes U.S. production.

SILICON

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

Domestic Production and Use: Estimated value of silicon metal and alloys (excluding semiconductor-grade silicon) produced in the United States in 1998 was about $580 million. Ferrosilicon was produced by six companies in seven plants, and silicon metal was produced by five companies in eight plants. Three of the eight companies in the industry produced both products. 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. The semiconductor industry, which manufactures chips for computers from high-purity silicon, accounted for only a few percent of silicon demand.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production	390	396	412	430	433
Imports for consumption	255	250	227	256	250
Exports	32	47	44	50	50
Consumption, apparent	616	609	594	628	632
Price,[1] average, cents per pound Si:					
Ferrosilicon, 50% Si	43.9	57.9	64.0	54.8	52
Ferrosilicon, 75% Si	40.8	58.1	62.2	48.0	43
Silicon metal	64.1	69.5	89.7	81.4	71
Stocks, producer, yearend	45	35	35	44	45
Net import reliance[2] as a percent of apparent consumption	37	35	31	32	32

Recycling: Insignificant.

Import Sources (1994-97): Norway, 25%; Russia, 15%; Brazil, 12%; Canada, 11%; and other, 37%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
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:			
More than 2% Mg	7202.29.0010	Free	4.4¢/kg Si.
Other	7202.29.0050	Free	4.4¢/kg Si.
Silicon, more than 99.99% Si	2804.61.0000	0.7% 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	6.2% 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: Domestic apparent consumption of silicon for 1998 is projected as 3% greater than the average for 1994-97. Of the 1998 total, ferrosilicon is estimated to account for 56% and silicon metal 44%. Growth in demand for ferrosilicon is expected to be at an annual rate in the range of 1% to 2%, in line with long-term trends in domestic steel production, which was strong during the first three quarters of 1998. Growth in demand for silicon metal is expected to be greater, as the annual growth rate in demand from the aluminum industry has been about 3% and from the chemical industry about 8%. The chemical industry, principally silicones, may soon overtake the aluminum industry as the largest user of metal. Global economic uncertainties that surfaced during 1998, and a strike at one of the three major U.S. automobile producers, seemed liable to affect domestic demand for silicon metal more than for ferrosilicon.

In terms of contained silicon, domestic production continued on an upward course in 1998, mainly because of increased production of silicon metal. In line with a global trend to emphasize production of silicon metal, one domestic producer restarted a silicon metal furnace and another planned to add one.

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SILICON

Prices for silicon materials in the U.S. market showed decreases through at least the first three quarters of 1998. Prices as of the end of September versus those at the beginning of the year were lower by 2% for 50% ferrosilicon, 8% for 75% ferrosilicon, and 4% for silicon metal. As of the end of September, the range in dealer import price, in cents per pound of contained silicon, was 50 to 53 for 50% ferrosilicon, 41.25 to 42.75 for 75% ferrosilicon, and 65 to 73 for silicon metal.

The outcome of lawsuits and changes in the status of protective tariffs continued to claim the attention of the domestic industry. Settlements were reached in some of the lawsuits claiming damages from price fixing alleged to have occurred around 1990. Certain of the antidumping duties initially imposed in the early 1990's on imported ferrosilicon and/or silicon from China and various Latin American countries and republics of the Commonwealth of Independent States continued to be receiving annual review by the International Trade Administration of the U.S. Department of Commerce. In the latter part of the year, the U.S. International Trade Commission agreed to conduct a changed circumstances review of its determination regarding antidumping and countervailing duties on ferrosilicon but not silicon metal. This raised the possibility that such duties on imported ferrosilicon eventually might be negated.

World Production, Reserves, and Reserve Base:

	Production[e]	
	1997	**1998**
United States	430	433
Australia	29	29
Brazil	271	260
Canada	58	58
China	826	880
Egypt	26	26
France	157	160
Iceland	46	46
India	58	55
Kazakhstan	65	81
Macedonia	37	33
Norway	413	420
Poland	47	47
Russia	362	380
Slovakia	20	20
South Africa	115	120
Spain	34	34
Ukraine	195	195
Venezuela	39	39
Other countries	124	110
World total (rounded)	3,400	3,400

Reserves and reserve base[4]

The reserves and reserve base in most major producing countries are ample in relation to demand. Quantitative estimates are not available.

Production quantities given above are combined totals of estimated content for ferrosilicon and silicon metal, as applicable. For the world, ferrosilicon accounts for about four-fifths of the total. The leading countries for ferrosilicon were Brazil, China, Norway, Russia, Ukraine, and the United States, and for silicon metal Brazil, China, France, Norway, and the United States. China was by far the largest producer of ferrosilicon and may well have been the largest producer of silicon metal. China's production of silicon metal is not included in this tabulation because data are not available.

World Resources: World and domestic resources for making silicon metal and alloys are abundant, and, in most producing countries, adequate to supply world requirements for many decades. The source of the silicon is silica in various natural forms such as quartzite.

Substitutes: 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.
[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 D for definitions.

SILVER

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

Domestic Production and Use: Silver, produced by about 76 mines in 16 States, had an estimated value of $338 million in 1998. Nevada was the largest producer, followed by Alaska, Arizona, and Idaho. Precious metal ores accounted for approximately one-half of domestic silver production; the other one-half was recovered as a byproduct from processing of copper, lead, and zinc ores. There were 22 principal refiners of commercial-grade silver with an estimated output of approximately 3,600 tons. About 30 fabricators accounted for more than 90% of the silver consumed in arts and industry. The remainder was consumed mostly by small companies and artisans. Aesthetic uses of silver for decorative articles, jewelry, tableware, and coinage were overshadowed by industrial and technical uses. Industrial and technical uses include photographic materials, electrical products, catalysts, brazing alloys, dental amalgam, and bearings.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Mine	1,490	1,560	1,570	2,150	2,100
Refinery: Primary	1,810	NA	NA	2,200	1,900
Secondary	1,700	NA	NA	1,360	1,700
Imports for consumption[2]	2,600	3,250	3,010	2,540	2,600
Exports[2]	967	2,890	2,950	3,080	3,800
Shipments from Government stockpile excesses	186	220	232	109	250
Consumption, apparent	NA	NA	NA	4,980	5,240
Price, dollars per troy ounce[3]	5.29	5.15	5.19	4.89	5.10
Stocks, yearend: Treasury Department[4]	882	520	402	484	400
COMEX, CBT[5]	10,400	6,290	4,550	3,430	3,500
Department of Defense	15	13	10	—	—
Employment, mine and mill,[6] number	1,000	1,200	1,400	1,550	1,600
Net import reliance[7] as a percent of apparent consumption	NA	NA	NA	E	E

Recycling: About 1,700 tons of silver was recovered from old and new scrap in 1998.

Import Sources[2] (1994-97): Canada, 26%; Mexico, 24%; Germany, 9%; Peru, 8%; and other, 33%.

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

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

Government Stockpile:

Stockpile Status—9-30-98[8]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Silver	1,092	—	1,092	280	133

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SILVER

Events, Trends, and Issues: The price of silver increased sharply in the first quarter of 1998 following the disclosure that a U.S.-based investment firm had accumulated more than 4,000 tons of silver, the equivalent of 16% of world fabrication demand in 1997. The firm began purchasing large volumes of silver on July 25, 1997, when silver closed at $4.32 per ounce. Only 5 months later the price rose to a 9-year high of $6.27 per ounce. Thereafter, however, the price of silver began to fluctuate and the trend was down for the remainder of the 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 16 years, from 1982 through September 30, 1998, the Government has reduced the quantity of silver held in the Stockpile from nearly 4,300 tons to about 1,100 tons.

Photographic demand accounts for about 28% of total silver demand, and digital imaging is considered to be a potential threat to the silver market. In contrast to the use of silver halide film in conventional photography, digital technology converts images directly into electronic form, thereby avoiding the need for silver. Silver halide pictures may also be scanned into electronic form, which necessitates the use of silver in taking and printing the picture but eliminates the need for silver halide technology in further processing. The major advantage of using digital cameras is the ability to immediately capture a digital picture that can be manipulated on a personal computer using readily available software. The major disadvantage is that digital cameras are expensive and produce poorer picture quality compared to conventional cameras.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[9]	Reserve base[9]
	1997	1998[e]		
United States	2,150	2,100	33,000	72,000
Australia	1,106	1,100	29,000	33,000
Canada	1,222	1,200	37,000	47,000
Mexico	2,679	2,700	37,000	40,000
Peru	2,077	1,900	25,000	37,000
Other countries	7,170	7,200	120,000	190,000
World total (may be rounded)	16,400	16,200	280,000	420,000

World Resources: World reserves of minable silver at current prices total about 280,000 tons. Approximately two-thirds of world silver resources are associated with copper, lead, and zinc deposits, often at great depths. 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. Even though the price of silver and improved technology may appear to increase sharply the quantity of minable reserves, the extraction of silver from these resources will depend on the salability of the primary base metals.

Substitutes: Aluminum and rhodium can be substituted for silver in mirrors and other reflecting surfaces. Tantalum can be used in place of silver for surgical plates, pins, and sutures. Stainless steel is an alternate material used widely in the manufacture of table flatware. Nonsilver batteries being developed may replace silver batteries in some applications. Silverless black and white film, film with reduced silver content, and xerography are alternatives to some uses of silver in photography.

[e]Estimated. E Net exporter. NA Not available.
[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Refined bullion, plus silver content of ores, concentrates, precipitates, and doré; excludes coinage, waste, and scrap material.
[3]Handy & Harman quotations.
[4]Balance in Mint only.
[5]COMEX: Commodity Exchange Inc., New York. CBT: Chicago Board of Trade.
[6]Source: Mine Safety and Health Administration.
[7]Defined as imports - exports + adjustments for Government and industry stock changes.
[8]See Appendix C for definitions.
[9]Includes silver recoverable from base metal ores. See Appendix D 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 86% 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 1998 was $840 million.[1]

Based on final 1997 data, the estimated 1998 reported distribution of soda ash by end use was glass, 49%; chemicals, 26%; soap and detergents, 12%; distributors, 5%; flue gas desulfurization, 3%; pulp and paper and miscellaneous, 2% each; and water treatment, 1%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production[2]	9,320	10,100	10,200	10,700	10,300
Imports for consumption	79	83	107	101	75
Exports	3,230	3,570	3,840	4,190	3,800
Consumption: Reported	6,260	6,500	6,390	6,480	6,600
Apparent	6,240	6,510	6,470	6,670	6,600
Price: Quoted, yearend, soda ash, dense, bulk, f.o.b. Green River, WY, dollars per short ton	105.00	105.00	105.00	105.00	105.00
F.o.b. Searles Valley, CA, same basis	130.00	130.00	130.00	130.00	130.00
Average sales value (natural source), f.o.b. mine or plant, same basis	70.44	74.50	82.60	77.25	74.00
Stocks, producer, yearend	203	306	271	259	325
Employment, mine and plant, number	2,800	2,800	2,800	2,800	2,700
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 (1994-97): Canada, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
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: The economic problems in Asia that continued throughout 1998 severely reduced U.S. exports of soda ash. Shipments to Indonesia, the Republic of Korea, and Thailand decreased from 26% of total exports in 1996 to 16% of total in 1998. On the positive side, exports to Brazil, Chile, Japan, Mexico, and Taiwan increased from 32% to total exports in 1996 to 38% in 1998. An antidumping investigation of U.S. soda ash imported by Brazil that began in 1996 ended in March 1998 in favor of the U.S. soda ash export association. With the problems in the Asian economy, resumption of exports to Brazil provided some relief to the troubled export market.

The synthetic soda ash producer in England, which had previously purchased its rival soda ash plant in the Netherlands, was itself acquired by a group of U.S. investors, including a major bank.

A major domestic fertilizer company acquired the assets of the California soda ash producer early in the year, but was seeking to divest itself of all or part of the operation by yearend. Another U.S. soda ash producer remained for sale throughout the year.

A $400 million soda ash project in northwest Colorado was announced at midyear. The operation was scheduled to produce 900,000 tons of soda ash annually from nahcolite, which is naturally occurring sodium bicarbonate. A 26-kilometer pipeline would transport the solution mined material to a processing plant located near a rail line. Mining

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SODA ASH

could begin by 2000. A prospective sixth Wyoming soda ash producer constructed a soda ash pilot plant with a capacity of 5 tons per day. Startup of the demonstration plant that will test new technology was scheduled for January 1999.

A soda ash producer in Wyoming completed its 800,000-ton-per-year expansion at yearend. Because of the downturn in soda ash demand in several regions of the world, the company decided to integrate the new expansion while taking 900,000 tons of capacity out of service until market conditions improve. In the interim, the company plans to use the time to refurbish the older equipment to improve the operating efficiency.

The outlook for soda ash through 1999 is forecast to be similar to that of 1998. Despite the economic problems in certain regions, the overall world demand for soda ash is expected to grow 1.5% to 2% annually in the early part of the next century. Domestic demand should be slightly higher than in 1998 when a titanium dioxide producer comes completely on-stream with new technology that will convert byproduct liquid wastes into a marketable product by using more than 230,000 tons of soda ash annually.

World Production, Reserves, and Reserve Base:

	Production		Reserves[5 6]	Reserve base[6]
Natural:	1997	1998[e]		
United States	10,700	10,300	[7]23,000,000	[7]39,000,000
Botswana	170	160	400,000	NA
Kenya	220	200	7,000	NA
Mexico	—	—	200,000	450,000
Turkey	—	—	200,000	240,000
Uganda	NA	NA	20,000	NA
Other countries	—	—	260,000	220,000
World total, natural (rounded)	11,100	10,700	24,000,000	40,000,000
World total, synthetic (rounded)	21,100	20,300	—	—
World total (rounded)	32,100	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 and the 47 billion tons of interbedded or intermixed trona and halite that are in beds more than 1.2 meters thick. About 34 billion tons of reserve base soda ash could be obtained from the 36 billion tons of halite-free trona and the 25 billion tons of interbedded or intermixed trona and halite that are in beds more than 1.8 meters thick. Underground room-and-pillar mining, using a combination of conventional, continuous, and shortwall mining equipment, is the primary method of mining Wyoming trona ore. The method has an average 45% mining recovery, which is higher than the 30% average mining recovery from solution mining. Improved solution mining techniques, such as horizontal drilling to establish communication between well pairs, could increase this extraction rate and enable companies to develop some of the deeper economic trona. Wyoming trona resources are being depleted at the rate of about 15 million tons per year (8.3 million tons of soda ash). Searles Lake and Owens Lake in California contain an estimated 815 million tons of soda ash reserves. There are at least 62 identified natural sodium carbonate deposits in the world, some of which have been quantified. Although soda ash can be manufactured from salt and limestone, both of which are practically inexhaustible, synthetic soda ash is more costly to produce and generates environmentally deleterious wastes. 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 D 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 decreased an estimated 5% compared with that of 1997. Approximately 47% of total production was a byproduct from facilities that manufacture rayon and various chemicals. The total value of natural and synthetic sodium sulfate sold was an estimated $55 million.

Estimates of U.S. sodium sulfate consumption by end use were soap and detergents, 45%; textiles, 18%; pulp and paper, 13%; glass, 10%; and miscellaneous, 14%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production: Natural	298	327	306	318	290
Synthetic[1]	293	318	296	262	260
Total	591	645	602	580	550
Imports for consumption	190	206	177	150	140
Exports	65	66	86	86	85
Consumption, apparent (natural and synthetic)	724	803	690	636	598
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	81.25	84.55	88.90	109.13	100.00
Stocks, producer, yearend, natural	34	16	19	26	33
Employment, well and plant, number	240	240	240	240	240
Net import reliance[2] as a percent of apparent consumption	18	17	13	9	8

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 (1994-97): Canada, 95%; Mexico, 4%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[3] 12/31/98**
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: Economic problems in Asia reduced sodium sulfate exports to several countries in Asia and Australia. The decline in the domestic textile industry, with U.S. textile manufacturers moving overseas because of cheaper labor costs and imports of inexpensive clothing, resulted in a decrease in sodium sulfate consumption. Sodium sulfate production in Mexico increased slightly because of an increase in textile production and detergent manufacturing that consume large quantities of product.

In the United States, the use of sodium sulfate as a filler in powdered home laundry detergents remained the major consuming sector. About one-half of all detergents sold in the country are powdered and the remainder are liquid, which are growing at a faster rate than the powdered. Although some liquids contained some sodium sulfate in their formulations, automatic dishwasher liquid detergents are now competing with a tablet form of detergent that does not use any sodium sulfate.

The outlook for sodium sulfate in 1999 is forecast to be slightly lower than that for 1998, with detergents remaining the largest sodium sulfate-consuming sector. World production and consumption of sodium sulfate are expected to grow in the next few years, especially in Asia and South America.

World Production, Reserves, and Reserve Base:

	Production		Reserves[4]	Reserve base[4]
Natural:	1997	1998[e]		
United States	318	290	860,000	1,400,000
Argentina	15	15	NA	NA
Canada	305	290	84,000	270,000
China	1,450	1,500	NA	NA
Iran	280	280	NA	NA
Mexico	525	550	170,000	230,000
Spain	600	615	180,000	270,000
Turkey	300	290	100,000	NA
Turkmenistan[5]	100	75	NA	200
Other countries	97	50	100,000	200,000
World total, natural (may be rounded)	3,990	3,960	[6]3,300,000	[7]4,600,000
World total, synthetic (rounded)	1,530	1,600	—	—
World total (may be rounded)	5,520	5,600	—	—

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. 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 D 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, China, Iran, and Turkmenistan. Includes nonproducing nations.
[7]Excludes Argentina, China, 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 $8.8 billion was produced by 1,450 companies operating 3,400 active quarries in 48 States. Leading States, in order of production, were Pennsylvania, Texas, Ohio, Florida, Virginia, Missouri, Illinois, Georgia, North Carolina, Kentucky, and Tennessee, together accounting for about 50.3% of the total output. It is estimated that, of the 1.5 billion tons of crushed stone produced in 1998, about 43% 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 1998, about 71% was limestone and dolomite; 16%, granite; 7%, traprock; and the remaining 6%, was shared, in descending order of quantity, by sandstone and quartzite, miscellaneous stone, marble, slate, calcareous marl, 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 1998 was 1.1 billion tons, which represents an increase of about 6.5% compared with the same period of 1997. Additional production information by quarters for each State, geographic division, and the United States is published in the Quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production	1,230	1,260	1,330	1,420	1,500
Imports for consumption	9	11	11	12	12
Exports	5	6	3	4	4
Consumption, apparent	1,234	1,265	1,338	1,428	1,508
Price, average value, dollars per metric ton	5.39	5.36	5.40	5.66	5.75
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[e 3]	75,350	75,940	76,020	77,590	78,500
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 (1994-97): Canada, 62%; Mexico, 23%; The Bahamas, 7%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[5] 12/31/98
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 5.3% in 1998. It is estimated that 1999 domestic production and U.S. apparent consumption will be about 1.57 billion tons each, a 5.3% increase. The Transportation Equity Act for the 21st Century (Public Law 105-178) appropriates $205 billion through year 2003, a 44% increase compared to the previous Intermodal Surface Transportation Efficiency Act (ISTEA) legislation. The new law guarantees that $165 billion will be obligated for highways and $35 billion for transit work. The guaranteed amounts are linked to actual Highway Trust Fund receipts and can only be used for highways and highway safety programs. The States are also guaranteed a return of at least 90.5% of their contributions to the Highway Trust Fund. The legislation also established timetables for determining if States are complying with the Environmental Protection Agency's new air quality standards for particulate matter, also known as PM 2.5.

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]
	1997	1998[e]	
United States	1,420	1,500	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]Including office staff.
[4]Defined as imports - exports + adjustments for Government and industry stock changes. Changes in stocks were assumed to be zero in the net import reliance and apparent consumption calculations because data on stocks were not available.
[5]See Appendix B.
[6]See Appendix D for definitions.

STONE (DIMENSION)[1]

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Dimension stone totaling 1.08 million tons (1.19 million short tons) valued at $205 million was sold or used (herein considered to be production) in 1998 by 137 companies from 187 quarries in 33 States and Puerto Rico. By tonnage, the dimension stone sold or used was for rough blocks in building, 26%; rough blocks for monuments, 11%; ashlar (relatively small, thin dressed blocks), 11%; flagging, 11%; curbing, 10%; dressed monumental, 4%; and other, 27%. Leading producing States were Georgia, Indiana, Pennsylvania, Vermont, and Wisconsin, which combined accounted for more than 50% of the tonnage output. The portion of total tonnage attributed to granite was estimated to be about 40%; limestone, 30%; sandstone, 15%; marble, 3%; slate, 2%; and other, 10%.

Salient Statistics—United States:[2]	1994	1995	1996	1997	1998[e]
Production: Tonnage	1,190	1,160	1,150	1,180	1,080
Value, million dollars	218	233	234	225	205
Imports for consumption, value, million dollars	440	478	462	548	500
Exports, value, million dollars	53	52	50	55	52
Consumption, apparent, value, million dollars	605	659	646	718	653
Price	Variable, depending on type of product				
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[3]	3,000	3,000	3,000	3,000	3,000
Net import reliance[4] as a percent of apparent consumption (based on value)	64	64	64	69	69
Granite only:					
Production	499	495	501	444	420
Imports for consumption	NA	NA	NA	NA	NA
Exports (rough and finished)	170	158	137	166	154
Consumption, apparent	NA	NA	NA	NA	NA
Price	Variable, depending on type of product				
Stocks, yearend	NA	NA	NA	NA	NA
Employment, quarry and mill, number[3]	1,500	1,500	1,500	1,500	1,500
Net import reliance[4] as a percent of apparent consumption (based on tonnage)	NA	NA	NA	NA	NA

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

Import Sources (1994-97) (based on value): Dimension stone: Italy, 40%; India, 15%; Canada, 15%; Spain, 10%; and other, 20%. Granite only: Italy, 45%; Canada, 15%; India, 10%; Brazil, 10%; and other, 20%.

Tariff: Dimension stone tariffs ranged from free to 6.3% ad valorem for countries with normal trade relations (NTR, formerly most favored nation) in 1998 according to type, degree of preparation, shape, and size. Most crude or rough trimmed stone is imported for 3.6% ad valorem or less. Tariffs on stone from nations without normal trade relations (non-NTR) ranged up to 60% ad valorem.

Depletion Allowance: 14% (Domestic and Foreign); 5% if used for rubble and other nonbuilding purposes.

Government Stockpile: None.

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STONE (DIMENSION)

Events, Trends, and Issues: Domestic production has been trending downward for several years, but imports continue trending upward with a significant increase in 1997. Wider applications in residential markets; improved quarrying, finishing, and handling technology; and a greater variety of stone, as well as rising costs of alternative construction materials, are among the factors that indicate an increased demand for dimension stone during the next 5 to 10 years. Furthermore, current high commercial vacancy rates and increased competition have caused an increased use of stone to upgrade the appearance of buildings.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves and reserve base[5]
	1997	1998[e]	
United States	1,180	1,080	Adequate except for certain
Other countries	NA	NA	special types and local
World total	NA	NA	shortages.

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

Substitutes: In some applications, substitutes for dimension stone include concrete, steel, aluminum, resin agglomerated stone, plastics, and glass.

[e]Estimated. NA Not available.
[1]See also Stone (Crushed).
[2]Includes Puerto Rico.
[3]Excluding office staff.
[4]Defined as imports - exports + adjustments for Government and industry stock changes. Changes in stocks were assumed to be zero in the net import reliance and apparent consumption calculations because data on stocks were not available.
[5]See Appendix D 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, 76%; ferrite ceramic magnets, 10%; pyrotechnics and signals, 5%; and other applications, 9%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, strontium minerals	—	—	—	—	—
Imports for consumption:					
Strontium minerals	16,000	12,700	11,600	12,500	12,000
Strontium compounds	20,000	20,800	20,500	26,000	25,000
Exports, compounds	1,120	1,160	712	599	570
Shipments from Government stockpile excesses	—	—	—	—	—
Consumption, apparent, celestite and compounds	34,900	32,300	31,400	37,900	36,400
Price, average value of mineral imports at port of exportation, dollars per ton	68	71	67	72	60
Net import reliance[2] as a percent of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1994-97): Strontium minerals: Mexico, 100%. Strontium compounds: Mexico, 88%; Germany, 11%; and other, 1%. Total imports: Mexico, 93%; and Germany, 7%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Mexico 12/31/98	Non-NTR[3] 12/31/98
Celestite	2530.90.0010	Free	Free	0.3¢/kg.
Strontium metal	2805.22.1000	3.7% ad val.	Free	25% ad val.
Compounds:				
Strontium carbonate	2836.92.0000	4.2% ad val.	Free	25% ad val.
Strontium nitrate	2834.29.2000	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—9-30-98[4]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Celestite	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 1999 Annual Materials Plan, announced at the end of September 1998 by the Defense National Stockpile Center, did not list any quantity of celestite to be offered for disposal. Because the remaining material does not meet the quality specifications of celestite purchasers, it will be difficult to dispose of the material into the traditional markets. It might be attractive as a low-cost replacement for barite in drilling mud applications.

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

	Mine production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States	—	—	—	1,360,000
Algeria	5,400	5,400		
Argentina	4,000	4,000		
China	35,000	35,000		
Iran	20,000	20,000		
Mexico	145,000	145,000	Other:	Other:
Pakistan	2,000	2,000	6,800,000	10,600,000
Spain	100,000	100,000		
Tajikistan	NA	NA		
Turkey	30,000	30,000		
World total (may be rounded)	[7]340,000	[7]340,000	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.
[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]See Appendix C for definitions.
[5]Metric tons of strontium minerals.
[6]See Appendix D for definitions.
[7]Excludes Tajikistan.

SULFUR

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

Domestic Production and Use: In 1998, elemental sulfur and byproduct sulfuric acid were produced at 149 operations in 30 States, Puerto Rico, and the U.S. Virgin Islands. Total shipments were valued at about $450 million. Elemental sulfur production was 9.7 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 58 companies at 137 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 14% of sulfur in all forms, was recovered at 14 nonferrous smelters in 8 States by 10 companies. Domestic elemental sulfur provided 67% of domestic consumption and byproduct acid accounted for 11%. The remaining 22% of sulfur consumed was provided by imported sulfur and sulfuric acid. About 90% of sulfur was consumed in the form of sulfuric acid. Agricultural chemicals (primarily fertilizers) comprised 65% of reported sulfur demand; petroleum refining, 15%; chemicals, organic and inorganic, 7%; and metal mining, 7%. Other uses, accounting for 6% of demand, were widespread because a multitude of industrial products require sulfur in one form or another during some stage of their manufacture.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Frasch	[e]2,960	[e]3,150	[e]2,900	[e]2,820	2,000
Recovered elemental	7,160	7,250	7,480	7,650	7,700
Other forms	1,380	1,400	1,430	1,550	1,600
Total	11,500	11,800	11,800	12,000	11,300
Shipments, all forms	11,700	12,100	11,800	11,900	11,800
Imports for consumption:					
Recovered, elemental	1,650	2,510	1,960	2,060	2,400
Sulfuric acid, sulfur content	696	628	678	659	680
Exports:					
Frasch and recovered elemental	899	906	855	703	900
Sulfuric acid, sulfur content	46	56	38	39	50
Consumption, apparent, all forms	13,100	14,300	13,600	13,900	13,900
Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and/or plant	30.08	44.46	34.11	36.06	36.20
Stocks, producer, yearend	1,160	583	639	761	350
Employment, mine and/or plant, number	3,100	3,100	3,100	3,100	3,100
Net import reliance[1] as a percent of apparent consumption	12	21	13	13	18

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

Import Sources (1994-97): Elemental: Canada, 72%; Mexico, 24%; and other, 4%. Sulfuric acid: Canada, 80%; Germany, 7%; Mexico, 6%; Japan, 4%; and other, 3%. Total sulfur imports: Canada, 74%; Mexico, 20%; Germany, 3%; and other, 3%.

Tariff: **Item**	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[2] 12/31/98**
Sulfur, crude or unrefined	2503.00.0010	Free	Free.
Sulfur, all kinds, other	2503.00.0090	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: The single remaining domestic Frasch sulfur producer was spun off as an independent entity by its parent corporation early in the year. The newly formed company announced significant production cutbacks at both of its sulfur mines in an attempt to balance the market. The two Frasch mines operated in the Gulf of Mexico and in west Texas. Production at the offshore mine was also adversely affected by two hurricanes that hit the Gulf Coast region in September, during which the platform was evacuated and production ceased. Damage to the mine as a result of the second storm severely restricted production during the fourth quarter. Although the company planned to close the Texas mine in September, it continued to operate at a reduced rate in an effort to offset production lost in the Gulf. Recovered sulfur producers were also affected by the hurricanes, but damage was not extensive.

Because of production cutbacks at Frasch operations, total elemental sulfur production was 7% lower than in 1997. Shipments, however, were nearly the same as in the previous year because of an aggressive remelting program undertaken by the Frasch producer to meet its sales contract requirements. By yearend, total domestic producers' sulfur stocks were less than one-half of what they were at the end of 1997. In general, the domestic market was relatively tight, even with increased imports. Domestic prices were steady throughout the first three quarters of the year, with a small increase at yearend.

Domestic Frasch sulfur production is expected to level off at about 2 million tons after the Texas mine closes and the offshore mine recovers from its technical problems. Production should remain at that level throughout the lifetime of the mine. Production of recovered elemental sulfur will continue its steady growth, with most of the growth coming from petroleum refining. Recovered sulfur from natural gas processing is expected to stay relatively level. The amount of byproduct sulfuric acid produced will be closely tied to the performance of the copper industry. High levels of copper production will result in increased acid production. Apparent consumption of sulfur in all forms is projected to be steady at about at 13.9 million tons in 1999.

World Production, Reserves, and Reserve Base:

	Production—All forms		Reserves[3]	Reserve base[3]
	1997	1998[e]		
United States	12,000	11,300	140,000	230,000
Canada	10,200	10,200	160,000	330,000
China	6,750	6,500	100,000	250,000
France	1,110	1,100	10,000	20,000
Germany	1,130	1,110	NA	NA
Iran	900	900	NA	NA
Iraq	450	450	130,000	500,000
Japan	2,800	2,800	5,000	15,000
Kazakhstan	945	1,000	NA	NA
Mexico	924	925	75,000	120,000
Poland	1,820	1,800	130,000	300,000
Russia	3,750	3,750	NA	NA
Saudi Arabia	2,000	2,000	100,000	130,000
South Africa	570	570	NA	NA
Spain	761	750	50,000	300,000
Other countries	7,500	8,800	500,000	1,300,000
World total (may be rounded)	53,600	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. Elemental sulfur deposits have become marginal reserves unless the deposits are already developed. Sulfur from petroleum and metal sulfides may be recovered where they are refined, which may be in the country of origin or in an importing nation. The rate of sulfur recovery from refineries is dependent on the environmental regulations where refining is accomplished.

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.
[1]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix B.
[3]See Appendix D for definitions.

TALC AND PYROPHYLLITE

(Data in thousand metric tons, unless noted)

Domestic Production and Use: The total estimated crude ore value of 1998 domestic production was $30.2 million. There were 15 talc-producing mines in 7 States in 1998. Companies in Montana, New York, Texas, and Vermont accounted for most of the domestic production. Ground talc was consumed in ceramics, 29%; paper, 22%; paint, 18%; plastics, 7%; roofing, 5%; cosmetics, 3%; and other, 16%. Two firms in North Carolina accounted for all of domestic pyrophyllite production, which was unchanged from that of 1997. Consumption was in ceramics, refractories, and insecticides, in decreasing order of tonnage.

Salient Statistics—United States:[1]	1994	1995	1996	1997	1998[e]
Production, mine	935	1,060	994	1,050	958
Sold by producers	923	901	909	942	895
Imports for consumption	155	146	187	123	136
Exports	154	183	192	179	162
Shipments from Government stockpile excesses	—	—	—	([2])	1
Consumption, apparent	936	1,020	989	994	933
Price, average, processed, dollars per ton	126	111	111	118	116
Stocks, producer, yearend	80	80	NA	NA	NA
Employment, mine and mill[e]	750	750	750	750	700
Net import reliance[3] as a percent of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (1994-97): China, 40%; Japan, 21%; Canada, 18%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
Crude, not ground	2526.10.0000	0.01¢/kg	0.6¢/kg.
Ground, washed, powdered	2526.20.0000	0.5% 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—9-30-98[5]
(Metric tons)

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Talc, block and lump	911	—	911	907	1
Talc, ground	988	—	988	—	—

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TALC AND PYROPHYLLITE

Events, Trends, and Issues: Production, sales, and apparent consumption decreased from those of 1997. Imports increased and exports decreased from those of 1997. Canada was the major importer of U.S. talc. Canada and China supplied approximately 43% of the imported talc.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[6]	Reserve base[6]
	1997	1998[e]		
United States[1]	1,050	958	136,000	544,000
Brazil	625	625	14,000	54,000
China	2,350	2,350	Large	Large
India	610	620	4,000	9,000
Japan	1,010	1,000	132,000	200,000
Korea, Republic of	810	810	14,000	18,000
Other countries	2,015	2,040	Large	Large
World total (may be rounded)	8,470	8,400	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, mica, and silica in paint; calcium carbonate and kaolin in paper; clays, feldspar, mica, silica, and wollastonite in plastics; and calcium carbonate, kaolin, mica, 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.
[6]See Appendix D for definitions.

TANTALUM

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

Domestic Production and Use: There has been no significant domestic tantalum-mining industry since 1959. Domestic tantalum resources are of low grade, some mineralogically complex, and most are not commercially recoverable. Most metal, alloys, and compounds were produced by 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, approximately 60% of use, mainly in tantalum capacitors. The value of tantalum consumed in 1998 was estimated at around $160 million.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, mine	—	—	—	—	—
Imports for consumption, concentrate, tin slags, and other[1]	NA	NA	NA	NA	NA
Exports, concentrate, metal, alloys, waste, and scrap[e]	190	220	290	340	370
Consumption: Reported, raw material	NA	NA	NA	NA	NA
Consumption: Apparent	430	515	490	550	550
Price, tantalite, dollars per pound[2]	26.24	26.98	27.75	28.76	33.80
Stocks, industry, processor, yearend	NA	NA	NA	NA	NA
Employment	NA	NA	NA	NA	NA
Net import reliance[3] as a percent of apparent consumption	80	80	80	80	80

Recycling: Combined prompt industrial and obsolete scrap consumed represented about 20% of apparent consumption.

Import Sources (1994-97): Australia, 31%; Thailand, 15%; China, 10%; Brazil, 7%; and other, 37%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
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	2.7% ad val.	25% ad val.
Alloys and metal	8103.10.6090	2.7% ad val.	25% ad val.
Tantalum, wrought	8103.90.0000	4.6% ad val.	45% ad val.

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

Government Stockpile: For fiscal year (FY) 1998, ending September 30, 1998, the Defense Logistics Agency sold about 1 ton of tantalum contained in tantalum carbide valued at about $131,000, about 9 tons of tantalum contained in tantalum oxide valued at about $1.3 million, and about 45 tons of tantalum contained in tantalum minerals valued at about $6.2 million from the National Defense Stockpile (NDS). The sales exhausted the Annual Materials Plan quantity of tantalum carbide, tantalum oxide, and tantalum minerals for disposal in FY 1998. For FY 1999, the Department of Defense proposed to dispose of about 2 tons of tantalum contained in tantalum carbide, about 23 tons of tantalum contained in tantalum metal powder, about 18 tons of tantalum contained in tantalum metal ingots, about 91 tons of tantalum contained in tantalum minerals, and about 9 tons of tantalum contained in tantalum oxide. The NDS uncommitted inventories shown below include a small quantity in nonstockpile-grade tantalum capacitor-grade metal powder and about 454 tons of tantalum contained in nonstockpile-grade minerals.

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TANTALUM

Stockpile Status—9-30-98[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Tantalum:					
Carbide powder	11	—	1	1	1
Metal:					
Capacitor-grade	73	—	—	—	—
Ingots	111	—	—	—	—
Minerals	1,090	45	295	45	45
Oxide	56	—	—	9	9

Events, Trends, and Issues: Total consumption of tantalum in 1998 remained about the same as that in 1997, with somewhat of a slowdown in the second half of the year. The increase in tantalum consumption in 1997 was attributed to strong demand for tantalum capacitors in products such as portable telephones, pagers, video cameras, personal computers, and automotive electronics. U.S. sales of tantalum capacitors for the first one-half year increased by about 5% compared with that of the similar period in 1997. For the same period, imports for consumption of tantalum mineral concentrates were up, with Australia supplying almost 60% of quantity and about 70% of value. Exports continued to rise, with Hong Kong (mostly waste and scrap), Israel, Germany, and Brazil the major recipients of the tantalum materials. The published spot price for tantalite ore, which began the year at a range of $32 to $34 per pound of contained pentoxide, rose to $33 to $35 in March where it remained through early November. The most recent industry source on tantalum prices indicated the following (per pound of contained tantalum): capacitor-grade powder, $135 to $240; capacitor wire, $180 to $250; vacuum-grade metal, $75 to $95; 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 1999 domestic mine production will be zero, and U.S. apparent consumption will be less than 600 tons.

World Mine Production, Reserves, and Reserve Base:

	Mine production[6] 1997	Mine production[6] 1998	Reserves[7]	Reserve base[7]
United States	—	—	—	Negligible
Australia	302	300	11,000	NA
Brazil	55	55	900	1,400
Canada	54	55	1,800	2,300
Congo (Kinshasa)[8]	—	—	1,800	4,500
Nigeria	2	2	3,200	4,500
Other countries[9]	—	—	NA	NA
World total (may be rounded)	413	412	19,000	24,000

World Resources: Most of the world's resources of tantalum occur outside the United States. On a worldwide basis, identified resources of tantalum are considered adequate to meet projected needs. These resources are largely in Australia, Brazil, Canada, Congo (Kinshasa), and Nigeria. The United States has about 1,400 tons of tantalum resources in identified deposits, all of which were considered uneconomic at 1998 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]Metal, alloys, and synthetic concentrates; exclusive of waste and scrap.
[2]Average value, contained tantalum pentoxides, 60% basis.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.
[6]Excludes production of tantalum contained in tin slags.
[7]See Appendix D for definitions.
[8]Formerly Zaire.
[9]Bolivia, China, Russia, and Zambia also produce, or are believed to produce tantalum, but available information is inadequate to make reliable estimates of output levels.

TELLURIUM

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

Domestic Production and Use: Tellurium and tellurium dioxide of commercial grades were recovered in the United States at one copper refinery, principally from anode slimes, but also from lead refinery skimmings. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide. Tellurium was used mainly in the production of free-machining steels. It was used as a minor additive in copper and lead alloys and malleable cast iron, as an accelerator in rubber compounding, in thermoelectric applications, and as a semiconductor in thermal-imaging and photoelectric applications. Tellurium was added to selenium-base photoreceptor alloys to increase the photo speed. In 1998, the estimated distribution of uses, worldwide, was as follows: iron and steel products, 50%; catalysts and chemicals, 25%; additives to nonferrous alloys, 10%; photoreceptors and thermoelectric devices, 8%; and other uses, 7%.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production, refinery	W	W	W	W	W
Imports for consumption, unwrought, waste and scrap[1]	27	46	74	64	72
Exports	NA	NA	NA	NA	NA
Consumption, apparent	NA	NA	NA	NA	NA
Price, dollars per pound, 99.7% minimum[2]	26	23	21	19	18
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 (1994-97): United Kingdom, 31%; Canada, 16%; Philippines, 14%; Peru, 12%; and other, 27%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
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 remained about the same in 1998 as they were in 1997. World production also remained steady, resulting in little change in the oversupply. Detailed information on the world tellurium market was not available.

The most promising new application that would significantly affect tellurium demand is in Remote Area Power Supplies, mainly in developing countries, where the largest percentage increases in power consumption will occur in the next century. Cadmium telluride is one of the most promising thin-film photovoltaic (PV) module compounds for power generation, achieving some of the highest power conversion ratios yet obtained.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[5]	Reserve base[5]
	1997	1998[e]		
United States	W	W	3,000	6,000
Canada	40	40	700	1,500
Japan	24	25	—	—
Peru	25	25	500	1,600
Other countries[6]	NA	NA	16,000	29,000
World total (may be rounded)	[7]89	[7]90	20,000	38,000

World Resources: The figures shown for reserves and reserve base include only tellurium contained in economic copper deposits. In addition, significant quantities of tellurium are contained in economic gold and lead deposits, but currently none is recovered. Deposits of coal, copper, and other metals that are 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 Tariff Schedule; 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 D for definitions. Estimates include tellurium contained in copper resources only.
[6]In addition to the countries listed, Australia, Belgium, China, France, Germany, Kazakhstan, the Philippines, Russia, and the United Kingdom produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable production estimates.
[7]Excludes refinery production from the United States and "Other countries."

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 1998. Research and development in the use of thallium-base superconductor materials accounted for a significant portion of domestic consumption in 1998. Thallium also was used in electronics, alloys, glass manufacturing, and pharmaceuticals.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Imports for consumption[1]	630	1,180	166	168	NA
Exports	NA	NA	NA	NA	NA
Consumption[e]	630	700	300	300	NA
Price, metal, dollars per kilogram[2]	950	1,100	1,200	1,280	1,280
Net import reliance[3] as a percent of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (1994-97): Mexico, 33%; Belgium, 31%; Canada, 29%; and Germany, 7%.

Tariff: Item	Number	Normal Trade Relations (NTR)[4] 12/31/98	Non-NTR[5] 12/31/98
Unwrought; waste and scrap; powders	8112.91.6000	4.3% 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 1998 to improve and expand the use of thallium. In addition to a continued interest in thallium-containing materials for use as superconducting magnets in magnetic levitation transportation applications, there was a significant interest in the clinical application of thallium in cardiovascular imaging to detect coronary artery disease.

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. With regard to these toxicity concerns, Federal agencies issued either proposed or final rules during the year that further addressed the control of thallium levels in the environment. In one rule, a final universal treatment standard for nonwastewater forms of thallium was established. In another, the allowable concentration limit for thallium in bottled water was determined to be the same as the limit established in the national standard for primary drinking water.

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

	Mine production		Reserves[7]	Reserve base[7]
	1997	1998		
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 total 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 part per million.

Substitutes: While other light-sensitive materials can substitute for thallium and its compounds in specific electronic applications, ample supplies of thallium discourage development of substitute materials.

[e]Estimated. NA Not available.
[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]By the North American Free Trade Agreement, there is no tariff for Canada or Mexico.
[5]See Appendix B.
[6]Estimates, based on thallium content of zinc ores.
[7]See Appendix D 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: The primary source of the world's thorium is the rare-earth and thorium phosphate mineral, monazite. Monazite was not recovered as a salable product during processing of heavy mineral sands in 1998. Past production had been as a byproduct during processing for titanium and zirconium minerals and monazite was recovered for its rare-earth content. Essentially all thorium compounds and alloys consumed by the domestic industry were derived from imports, stocks of previously imported materials, or materials shipped from U.S. Government stockpiles. About eight companies processed or fabricated various forms of thorium for nonenergy uses, such as high-temperature ceramics, catalysts, and welding electrodes. The value of thorium metal, alloys, and compounds used by the domestic industry was estimated to be about $600,000.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	—	40	101	20	—
Thorium ore and concentrates (monazite), ThO_2 content	—	2.80	7.07	1.40	—
Thorium compounds (oxide, nitrate, etc.), gross weight	3.12	20.51	26.30	13.50	10.50
Thorium compounds (oxide, nitrate, etc), ThO_2 content	2.31	15.16	19.45	10.00	7.77
Exports:					
Thorium ore and concentrates (monazite), gross weight	33	—	2	—	—
Thorium ore and concentrates (monazite), ThO_2 content	2.31	—	.14	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	.01	.08	.06	.24	1.15
Thorium compounds (oxide, nitrate, etc.), ThO_2 content	.01	.06	.04	.18	.85
Shipments from Government stockpile excesses ($ThNO_3$)	—	—	—	.82	—
Consumption: Reported, (ThO_2 content[e])	3.6	5.4	4.9	13.0	5.0
Apparent	NA	NA	NA	33.6	6.9
Price, yearend, dollars per kilogram:					
Nitrate, welding-grade[2]	5.46	5.46	5.46	5.46	5.46
Nitrate, mantle-grade[3]	23.30	23.30	14.32	27.00	27.00
Oxide, yearend: 99.0% purity[4]	63.80	NA	64.45	65.55	65.55
99.9% purity[4]	NA	88.50	90.00	90.00	90.00
99.99% purity[4]	107.25	107.25	107.25	107.25	107.25
Stocks, industrial, yearend	NA	NA	35.2	12.8	NA
Net import reliance[5] as a percent of apparent consumption	NA	NA	NA	100	100

Recycling: None.

Import Sources (1994-97): Monazite: Australia, 50%; and France, 50%. Thorium compounds: France, 99%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[6] 12/31/98
Thorium ores and concentrates (monazite)	2612.20.0000	Free	Free.
Thorium compounds	2844.30.1000	6.0% 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—9-30-98[7]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Thorium nitrate (gross weight)	3,217	—	2,945	454	—

Events, Trends, and Issues: Domestic mine production of thorium-bearing monazite ceased at the end of 1994 as world demand for ores containing naturally occurring radioactive thorium declined. Imports and existing stocks supplied essentially all thorium consumed in the United States in 1998. Domestic demand for thorium ores, compounds, metals, and alloys has exhibited a long term declining trend. Thorium consumption in the United States increased in 1997 to 13.0 tons, however, most material was consumed in a nonrecurring application. Thorium consumption in 1998 is estimated to decrease. Based on data through July 1998, the average value of imported thorium compounds decreased to $23.00 per kilogram from the 1997 average of $42.46 per kilogram (gross weight).

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THORIUM

A theory developed by Italian physicist and past director of the European Laboratory for Particle Physics (CERN) to create a fuel cycle using subatomic particles and thorium gained support in Europe. The theory advanced that thorium should produce 140 times more energy than uranium using accelerated subatomic particles. The process would involve accelerating the subatomic particles to speeds of several million kilometers per hour in particle accelerators and then firing them at thorium.[8] Fission would occur based on a nuclear cascade generated by the particle accelerator instead of the conventional chain reaction generated from the neutron bombardment from uranium or plutonium fuel. Several European industrial companies were reportedly preparing to fund a prototype of the energy amplifier needed to demonstrate the process.[9]

The use of thorium in the United States has decreased significantly since the 1980's, when consumption averaged 45 tons per year. Increased costs to monitor and dispose of thorium have caused the domestic processors to switch to thorium-free materials. Real and potential costs related to compliance with State and Federal regulations, proper disposal, and monitoring of thorium's radioactivity have limited thorium's commercial value. It is forecast that thorium's use will continue to decline unless a low-cost disposal process is developed or new technology creates renewed demand.

World Refinery Production, Reserves, and Reserve Base:

	Refinery production		Reserves[10]	Reserve base[10]
	1997	1998		
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]Source: U.S. Department of Defense, Defense Logistics Agency. Based on sales from the National Defense Stockpile.
[3]Source: Rhône-Poulenc Basic Chemical Co., f.o.b. port of entry, duty paid, ThO_2 basis. Rhône-Poulenc Basic Chemicals Co., Shelton, CT, 1994-98.
[4]Source: Rhône-Poulenc Basic Chemicals Co., f.o.b. port of entry, duty paid.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B.
[7]See Appendix C for definitions.
[8]The Washington Post, Reuters, 1993, In theory, a new route to nuclear energy: November 24, p. A18.
[9]Sacks, Tony, 1997, Nuclear nirvana?: Electrical Review, v. 230 no. 12, June 10, p. 24-26.
[10]See Appendix D for definitions.

TIN

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

Domestic Production and Use: In 1998, 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 consumed in 1998, based on the New York composite price, was $325 million.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Mine	—	—	—	—	—
Secondary (old scrap)	7,400	7,720	7,710	7,830	7,900
Secondary (new scrap)	4,300	3,880	3,930	4,520	4,500
Imports for consumption, refined tin	32,400	33,200	30,200	40,600	39,000
Exports, refined tin	2,560	2,790	3,670	4,660	5,000
Shipments from Government stockpile excesses	5,620	11,500	11,800	11,700	11,000
Consumption reported: Primary	33,700	35,200	36,500	36,100	39,000
Secondary	8,530	10,800	8,180	8,250	9,000
Consumption, apparent	43,300	47,000	48,400	55,300	53,000
Price, average, cents per pound:					
New York market	255	295	288	264	260
New York composite	369	416	412	381	377
London	248	282	279	256	254
Kuala Lumpur	245	278	275	252	249
Stocks, consumer and dealer, yearend	10,400	11,700	10,900	11,100	11,000
Employment, mine and primary smelter, number[e]	—	—	—	—	—
Net import reliance[1] as a percent of apparent consumption	83	84	83	86	85

Recycling: About 12,000 tons of tin from old and new scrap was recycled in 1998. Of this, about 7,900 tons was recovered from old scrap at 7 detinning plants and 110 secondary nonferrous metal processing plants.

Import Sources (1994-97): Brazil, 26%; Indonesia, 21%; Bolivia, 20%; China, 12%; and other, 21%.

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—9-30-98[2]

Material	**Uncommitted inventory**	**Committed inventory**	**Authorized for disposal**	**Disposal plan FY 1998**	**Disposals FY 1998**
Pig tin	83,835	7,762	83,835	12,000	11,981

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TIN

Events, Trends, and Issues: The Defense Logistics Agency (DLA) tin sales program emphasized its long-term activity and had only a modest spot sales effort. DLA allocated 2,000 tons of tin to sell on the spot market at monthly sales. Two long-term sales were planned for fiscal year 1998, with one in the spring and one in the fall, about 5,000 tons each time.

DLA announced that its Annual Materials Plan for fiscal year 1998 called for sales of up to 12,000 tons of stockpile tin. Stockpile tin is warehoused at seven depots, with the largest holdings at Hammond, IN, and Anniston, AL.

The Steel Recycling Institute (SRI), Pittsburgh, PA, announced that the domestic steel can recycling rate reached 60% in 1997, compared with a 58% rate in 1996. SRI continued to emphasize the importance of aerosol can recycling. It noted that 200 million Americans had access to steel can recycling programs.

The world tin industry's major research and development laboratory, based in the United Kingdom, was in its fourth full year under its new structure. It is now privatized, with funding supplied by numerous major tin producing and consuming 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 tin foil capsule to replace lead foil capsules on wine bottles, and a new noncyanide-based electrolyte called "Stanzec" that yields a coating of tin and zinc, which 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]
	1997	1998[e]		
United States	—	—	20,000	40,000
Australia	10,000	9,000	210,000	600,000
Bolivia	15,000	16,000	450,000	900,000
Brazil	19,000	20,000	1,200,000	2,500,000
China	65,000	67,000	2,100,000	3,400,000
Indonesia	47,000	48,000	750,000	820,000
Malaysia	5,000	5,000	1,200,000	1,400,000
Peru	28,000	29,000	300,000	400,000
Portugal	4,000	4,000	70,000	80,000
Russia	8,000	8,000	300,000	350,000
Thailand	1,000	1,000	940,000	1,000,000
Other countries	9,000	9,000	180,000	200,000
World total (may be rounded)	211,000	216,000	7,700,000	12,000,000

World Resources: U.S. resources of tin, primarily in Alaska, were insignificant compared with those of the rest of the world. Sufficient world resources, principally in western Africa, southeastern Asia, Australia, Bolivia, Brazil, China, and Russia 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]Defined as imports - exports + adjustments for Government and industry stock changes.
[2]See Appendix C.
[3]See Appendix D 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 firms consume ingot to produce forged components, mill products, and castings. In 1998, 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 $316 million, assuming an average selling price of $9.70 per kilogram ($4.40 per pound).

In 1998, titanium dioxide (TiO_2) pigment, valued at about $3 billion, was produced by 5 companies at 11 plants in 9 States. TiO_2 was used in paint, varnishes, and lacquers, 50%; paper, 23%; plastics, 18%; and other, 9%. Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Titanium sponge metal:					
Production	W	W	W	W	W
Imports for consumption	6,470	7,560	10,100	16,100	13,200
Exports[2]	126	225	528	976	387
Shipments from Government stockpile excesses	—	—	—	227	1,140
Consumption, reported	17,200	21,500	28,400	32,000	32,600
Price, dollars per pound, yearend	4.00	4.40	4.40	4.40	4.40
Stocks, industry yearend[e]	5,570	5,270	4,390	5,470	10,400
Employment, number[e]	300	300	300	300	300
Net import reliance,[3] as a percent of reported consumption	21	36	37	47	28
Titanium dioxide:					
Production	1,250,000	1,250,000	1,230,000	1,340,000	1,360,000
Imports for consumption	176,000	183,000	167,000	194,000	198,000
Exports	352,000	342,000	332,000	405,000	430,000
Consumption, apparent	1,090,000	1,080,000	1,070,000	1,130,000	1,130,000
Price, rutile, list, dollars per pound, yearend	0.93	1.01	1.09	0.93	1.00
Stocks, producer, yearend	106,000	120,000	107,000	108,000	106,000
Employment, number[e]	4,600	4,600	4,600	4,600	4,600
Net import reliance[3] as a percent of apparent consumption	E	E	E	E	E

Recycling: New scrap metal recycled by the titanium industry was about 31,400 tons in 1998. In addition, estimated use of titanium as scrap and in the form of ferrotitanium made from scrap by the steel industry was about 4,700 tons; by the superalloy industry, 800 tons; and in other industries, 1,000 tons. Old scrap reclaimed was about 300 tons. Minor amounts of TiO_2 were recycled.

Import Sources (1994-97): Sponge metal: Russia, 55%; Japan, 32%; Kazakhstan, 5%; China, 4%; and other, 4%. Titanium dioxide pigment: Canada, 43%; Germany, 14%; France, 11%; Spain, 5%; and other, 27%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[4] 12/31/98
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	5.6% ad val.	30.0% ad val.

Depletion Allowance: Not applicable.

Government Stockpile:

Stockpile Status—9-30-98[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Titanium sponge	31,700	837	31,700	3,630	1,140

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TITANIUM AND TITANIUM DIOXIDE

Events, Trends, and Issues: In 1998, domestic production of titanium pigment reached 1.36 million tons, a slight increase compared with 1997. Although imports increased slightly, exports of titanium pigment increased 6% compared with 1997. Apparent consumption of titanium pigment was unchanged, and published prices of rutile-grade pigment increased 8%. Consumption of titanium sponge metal products was nearly unchanged in 1998 compared with 1997. Domestic production of titanium ingot and mill products was expected to reach 44,000 tons and 25,900 tons, respectively.

Trends in the titanium pigment industry in 1998 indicated a move toward consolidation of ownership and expansion of capacity. In the United States, the Hamilton, MS, pigment facility was in the process of increasing chloride-route capacity by 27,000 tons per year. Meanwhile, ownership of the Lake Charles, LA, pigment facility moved from a joint venture to a wholly owned venture by one of the joint-venture companies.

In the titanium metal industry, the cancellation of aircraft orders indicated a slowing in demand for titanium metal products. The International Trade Administration (ITA) issued a revocation of antidumping findings on titanium sponge from Russia, Kazakhstan, and Ukraine, and the antidumping duty order on titanium sponge from Japan. In its determination, the ITA concluded that these revocations are not likely to lead to a continuation or recurrence of material injury to an industry in the United States. The Defense National Stockpile Center continued to solicit offers for the sale of titanium sponge held in the Government stockpile. For fiscal year 1999, 4,540 tons of titanium sponge were being offered for sale.

World Sponge Metal Production and Sponge and Pigment Capacity:

	Sponge production		Capacity 1998[6]	
	1997	1998[e]	Sponge	Pigment
United States	W	W	21,600	1,491,000
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	21,100	24,000	25,800	326,000
Kazakhstan[e]	10,000	9,000	26,000	1,000
Russia[e]	18,000	17,000	30,000	20,000
Spain	—	—	—	65,000
Ukraine[e]	—	—	—	120,000
United Kingdom[e]	—	—	—	275,000
Other countries	—	—	—	585,000
World total (may be rounded)	[7]51,000	[7]52,000	110,000	4,000,000

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]Exports of sponge metal only. In previous reports all forms of metal exports were reported.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.
[6]Operating capacity.
[7]Excludes U.S. production.

TUNGSTEN

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

Domestic Production and Use: In 1998, little if any tungsten concentrate was produced from U.S. mines. Approximately 10 companies in the United States processed tungsten concentrates, ammonium paratungstate, tungsten oxide, and/or scrap to make tungsten powder, tungsten carbide powder, and/or tungsten chemicals. More than 70 industrial consumers were surveyed on a monthly or annual basis. Based on data reported by these consumers, approximately 75% of tungsten consumed in the United States went into making cemented carbide parts to be used as cutting and wear-resistant materials primarily in the metalworking, oil and gas drilling, mining, and construction industries. The remaining tungsten was consumed in making lamp filaments, electrodes, and other components for the electrical and electronics industries, 10%; other steels, superalloys, and wear-resistant alloys, 10%; tool steels, 4%; and chemicals for catalysts and pigments, 1%. The total estimated value of primary tungsten materials consumed in 1998 was $300 million.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production, mine shipments	W	W	W	W	W
Imports for consumption, concentrate	2,960	4,660	4,190	4,850	4,800
Exports, concentrate	44	20	72	40	50
Government stockpile shipments, concentrate	—	—	—	—	—
Consumption: Reported, concentrate	[1]3,630	5,890	5,260	6,590	5,300
Apparent, all forms	7,900	10,000	10,800	12,100	12,800
Price, concentrate, dollars per mtu WO_3,[2] average:					
U.S. spot market, Platt's Metals Week	45	62	66	64	52
European market, Metal Bulletin	42	64	53	47	45
Stocks, producer and consumer, yearend concentrate	955	671	613	702	900
Employment, mine and mill, number	35	46	58	58	50
Net import reliance[3] as a percent of apparent consumption	95	90	89	84	78

Recycling: During 1998, the tungsten content of scrap consumed by processors and consumers was estimated at 3,500 tons. This represented approximately 27% of apparent consumption of tungsten in all forms.

Import Sources (1994-97): China, 33%; Russia, 24%; Germany, 6%; Bolivia, 5%; and other, 32%.

Tariff: Item	Number	Normal Trade Relations (NTR)[4] 12/31/98	Non-NTR[5] 12/31/98
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	7.7% ad val.	58.0% ad val.
Ammonium tungstate	2841.80.0010	6.4% ad val.	49.5% ad val.
Tungsten carbide	2849.90.3000	8.5% ad val.	55.5% ad val.

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

Government Stockpile: In October, Congress passed and the President signed the Defense Authorization Act for fiscal year 1999. The act granted authority to dispose of all the tungsten materials in the National Defense Stockpile, but stated that disposals must not result in undue disruption of the usual markets of producers, processors, and consumers of the materials, or avoidable loss to the United States. The Annual Materials Plan for fiscal year 1999, which would specify the maximum quantity of each tungsten material that could be sold during the fiscal year, was being reviewed by the interagency Market Impact Committee in October and November. In addition to the data shown below, the stockpile contained the following quantities of nonstockpile-grade tungsten materials (tons of tungsten content): ores and concentrates, 7,010; ferrotungsten, 533; metal powder, 151; and carbide powder, 51.

Stockpile Status—9-30-98[6]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Carbide powder	871	—	—	—	—
Ferrotungsten	385	—	—	—	—
Metal powder	710	—	—	—	—
Ore and concentrate	27,600	—	—	—	—

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TUNGSTEN

Events, Trends, and Issues: World demand for tungsten was very strong through mid-1998, but was expected to be weaker during the second half of the year. World consumption remained higher than world mine production, with the shortfall being met from releases of stockpiled tungsten materials from Russia, Kazakhstan, and Eastern Europe. Prices of tungsten concentrates and ammonium paratungstate continued to decrease in 1998 and were expected to result in a further decrease in mine production from market economy countries. China remained the dominant supplier of tungsten to world markets.

Late in the year, the U.S. Congress authorized the sale of tungsten materials from the National Defense Stockpile. Tungsten was last sold by the U.S. Government in 1989.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[7]	Reserve base[7]
	1997	1998[e]		
United States	W	W	140,000	200,000
Australia	—	—	1,000	63,000
Austria	1,400	1,400	10,000	15,000
Bolivia	500	500	53,000	100,000
Brazil	170	150	20,000	20,000
Burma	280	280	15,000	34,000
Canada	—	—	260,000	490,000
China	25,000	25,500	870,000	1,200,000
France	—	—	20,000	20,000
Kazakhstan	200	200	NA	38,000
Korea, North	900	900	NA	35,000
Korea, Republic of	—	—	58,000	77,000
Portugal	1,036	900	25,000	25,000
Russia	3,000	3,000	250,000	420,000
Tajikistan	50	50	NA	23,000
Thailand	25	25	30,000	30,000
Turkmenistan	—	—	NA	10,000
Uzbekistan	250	250	NA	20,000
Other countries	618	378	280,000	360,000
World total (may be rounded)	33,400	33,500	2,000,000	3,200,000

World Resources: More than 90% of the world's estimated tungsten resources are outside the United States. Nearly 40% of these resources are in China, 15% are in Canada, and 13% are in Russia.

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. However, an electrodeless, nontungsten lamp is available for commercial and industrial use.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[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]Special tariff rates apply for Canada and Mexico.
[5]See Appendix B.
[6]See Appendix C for definitions.
[7]See Appendix D for definitions.

VANADIUM

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

Domestic Production and Use: Eight firms make up the U.S. vanadium industry. These firms process material such as ferrophosphorus slag, petroleum residues, spent catalysts, utility ash, and vanadium-bearing iron slag to produce ferrovanadium, vanadium pentoxide, vanadium metal, and vanadium-bearing chemicals or specialty alloys. Metallurgical use, primarily as an alloying agent for iron and steel, accounts for more than 95% of the vanadium consumed domestically. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts for the production of maleic anhydride and sulfuric acid. With regard to total domestic consumption, major end-use distribution was as follows: carbon steel, 38%; high-strength low-alloy steel, 20%; full alloy steel, 19%; tool steel, 10%; and other, 13%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production:					
Mine, mill	W	W	W	W	W
Petroleum residues, recovered basis	2,830	1,990	3,730	NA	NA
Imports for consumption:					
Ash, ore, residues, slag	1,900	2,530	2,270	2,950	5,000
Vanadium pentoxide, anhydride	294	547	485	711	1,000
Oxides and hydroxides, other	3	36	11	126	60
Aluminum-vanadium master alloys (gross weight)	38	36	2	11	50
Ferrovanadium	1,910	1,950	1,880	1,840	1,700
Exports:					
Vanadium pentoxide, anhydride	335	229	241	614	400
Oxides and hydroxides, other	1,050	1,010	2,670	385	100
Aluminum-vanadium master alloys (gross weight)	1,030	660	310	974	1,400
Ferrovanadium	374	340	479	446	500
Shipments from Government stockpile	—	416	201	260	—
Consumption: Reported	4,280	4,650	4,630	4,730	4,700
Apparent	W	W	W	W	W
Price, average, dollars per pound V_2O_5	2.95	2.80	3.19	3.90	4.00
Stocks, producer and consumer, yearend	1,110	1,100	1,070	1,000	300
Employment, mine and mill, number	400	390	390	400	400
Net import reliance[1] as a percent of apparent consumption	W	W	W	W	W

Recycling: Some tool steel scrap was recycled primarily for its vanadium content, and vanadium was recycled from spent chemical process catalysts, but these two sources together accounted for only a very small percentage of total vanadium used.

Import Sources (1994-97): Ferrovanadium: Canada, 40%; Russia, 18%; China, 12%; Czech Republic, 11%; and other, 19%. Vanadium pentoxide: South Africa, 89%; China, 6%; Russia, 4%; and other, 1%.

Tariff: Ash, residues, slag, and waste and scrap enter duty-free.

Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[2] 12/31/98
Vanadium pentoxide anhydride	2825.30.0010	12.8% ad val.	40% ad val.
Vanadium oxides and hydroxides, other	2825.30.0050	12.8% ad val.	40% ad val.
Vanadates	2841.90.1000	9.5% 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.

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

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VANADIUM

Government Stockpile: None.

Events, Trends, and Issues: Vanadium consumption in the United States in 1998 was essentially unchanged from that in 1997. Although total consumption was essentially unchanged, preliminary data indicated the following changes among the major uses for vanadium during the first 6 months of 1998: carbon steel increased 7%; full alloy steel increased 14%; high-strength low-alloy steel increased 5%; and tool steel decreased 37%.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[3]	Reserve base[3]
	1997	1998[e]		
United States	W	W	45,000	4,000,000
China	8,000	7,000	2,000,000	3,000,000
Russia	11,000	11,000	5,000,000	7,000,000
South Africa	17,000	16,000	3,000,000	12,000,000
Other countries	1,100	1,000	—	1,000,000
World total (may be rounded)	[4]37,100	[4]35,000	10,000,000	27,000,000

World Resources: World resources of vanadium exceed 63 million tons. Vanadium occurs in deposits of titaniferous magnetite, phosphate rock, and uraniferous sandstone and siltstone, in which it constitutes less than 2% of the host rock. Significant amounts are also present in bauxite and carboniferous materials, such as crude oil, coal, oil shale, and tar sands. Because vanadium is usually recovered as a byproduct or coproduct, demonstrated world resources of the element are not fully indicative of available supplies. While domestic resources are adequate to supply current domestic needs, a substantial part of U.S. demand is currently met by foreign material because of price advantages.

Substitutes: Steels containing various combinations of other alloying elements can be substituted for steels containing vanadium. 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. 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 D for definitions.
[4]Excludes U.S. mine production.

VERMICULITE

(Data in thousand metric tons, unless otherwise noted)

Domestic Production and Use: Two companies, with mining and processing facilities, produced vermiculite concentrate. One company had its operation in South Carolina, and the other company had an operation in Virginia and an operation in South Carolina run by its subsidiary company. Most of the vermiculite concentrate was shipped to 20 exfoliating plants in 11 States. The end uses for exfoliated vermiculite were estimated to be agriculture and insulation, 77%; lightweight concrete aggregates (including concrete, plaster, and cement premixes), 18%; and other, 5%.

Salient Statistics—United States:	1994	1995	1996	1997	1998[e]
Production[1]	177	171	W	W	W
Imports for consumption[e]	30	30	48	67	50
Exports[e]	7	6	8	8	7
Consumption, apparent, concentrate	200	195	W	W	W
Consumption, exfoliated	130	130	135	[e]155	150
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, number[e]	230	230	230	230	230
Net import reliance[2] as a percent of apparent consumption	11	12	W	W	W

Recycling: Insignificant.

Import Sources (1994-97):[e] South Africa, 84%; China, 12%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[3] 12/31/98
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	1% ad val.	30% ad val.

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

Government Stockpile: None.

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VERMICULITE

Events, Trends, and Issues: South Africa continued to be the largest producer of vermiculite, averaging about 210,000 tons per year during the past several years. In Australia, a relatively new company continued to develop export markets, including southeast Asia, Japan, and Europe, although its focus remained on domestic sales. Production was 10,000 tons in 1997 and was projected to increase to 16,000 tons in 1998, according to a nongovernment source.

In western Europe, the manufacture of building products is estimated to account for 70% to 80% of vermiculite consumption, according to another nongovernment source. An example is a company in Denmark that produces moler (diatomite) bricks and blocks, and calcium silicate and vermiculite insulating slabs and granules. A variety of vermiculite insulation materials are produced including boards and ready-mixed insulation castables based on a mix of moler and vermiculite. The principal export market for vermiculite insulation slabs is Germany, where they are used in place of glass and mineral wools.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1997	1998[e]		
United States	W	W	25,000	100,000
Russia	25	25	NA	NA
South Africa	211	210	20,000	80,000
Other countries[5]	44	45	5,000	20,000
World total	[6]280	[6]280	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 D for definitions.
[5]Excludes 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 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 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 abrasives, wear-resistant and corrosion-resistant cutting tools, seals and bearings, high-temperature refractories for continuous-casting nozzles, jet engine coatings, oxygen sensors in automobile engines, and simulant gemstones. In electronics, yttrium-iron-garnets were components in microwave radar to control high frequency signals. Yttrium was an important component in yttrium-aluminum garnet laser crystals used in industrial cutting and welding, medical and dental surgical procedures, temperature and distance sensing, photoluminescence, photochemistry, digital communications, and nonlinear optics. Yttrium was also used in heating-element alloys, superalloys, and high-temperature superconductors. The approximate distribution in 1997 by end use was as follows:
lamp and cathode ray tube phosphors, 41%; oxygen sensors, laser crystals, and miscellaneous, 38%, ceramics, 21%.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production, mine	W	—	—	—	—
Imports for consumption:					
In monazite (yttrium oxide content[e])	—	0.44	1.11	0.22	—
Yttrium compounds greater than 19% to less than 85% oxide equivalent (gross weight)	NA	NA	42.2	48.4	130
Exports, in ore and concentrate	NA	NA	NA	NA	NA
Consumption, estimated[2]	344	365	207	292	450
Price, dollars:					
Monazite concentrate, per metric ton[3]	233-272	222-259	244-285	400-400	400-400
Yttrium oxide, per kilogram, 99.0% to 99.99% purity[4]	20-116	17-110	17-85	17-85	22-85
Yttrium metal, per kilogram, 99.0% to 99.9% purity[4]	135-350	150-200	95-200	80-100	80-100
Stocks, processor, yearend	NA	NA	NA	NA	NA
Net import reliance[e 5] as a percent of apparent consumption	100	100	100	100	100

Recycling: Small quantities, primarily from laser crystals and synthetic garnets.

Import Sources (1997):[e] Yttrium compounds: China, 35%; France, 35%; United Kingdom, 23%; Belgium, 3%; and other, 4%.

Tariff: **Item**	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Non-NTR[6] 12/31/98**
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 1997 and continued strong in 1998 as prices increased. Yttrium markets continued to be competitive, although China was the source of most of the world's supply. The U.S. economy showed a slowdown in the first half of 1998, although imports of yttrium increased. The increase in domestic yttrium demand is primarily the result of U.S. dollar strength and the recessionary Asian economies minimizing inflation and undercutting commodity prices. 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[7]		Reserves[8]	Reserve base[8]
	1997	1998[e]		
United States	—	—	120,000	130,000
Australia	—	—	100,000	110,000
Brazil	15	15	400	1,500
Canada	—	—	3,300	4,000
China	2,200	2,200	220,000	240,000
Congo (Kinshasa)[9]	—	—	570	630
India	30	30	36,000	38,000
Malaysia	4	4	13,000	21,000
South Africa	—	—	4,400	5,000
Sri Lanka	2	2	240	260
Thailand	—	—	600	600
Former Soviet Union[10]	120	120	9,000	10,000
World total (rounded)	2,370	2,370	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, but is generally not as resilient.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]See also Rare Earths and Scandium.
[2]Essentially all yttrium consumed domestically was imported or refined from imported ores and concentrates.
[3]Monazite concentrate prices derived from Metals Bulletin (1994-96) and U.S. Bureau of the Census data (1997).
[4]Yttrium oxide and metal prices from Elements—Rare Earths, Specialty Metals and Applied Technology (a TradeTech publication), Denver, CO, and Rhodia, Inc., Shelton, CT.
[5]Defined as imports - exports + adjustments for Government and industry stock changes.
[6]See Appendix B.
[7]Includes yttrium contained in rare-earth ores.
[8]See Appendix D for definitions.
[9]Formerly Zaire.
[10]As constituted before December 1991.

ZINC

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

Domestic Production and Use: The value of zinc mined in 1998, based on contained zinc recoverable from concentrate, was about $840 million. It was produced in 7 States by 19 mines operated by 7 mining companies. Alaska, Tennessee, New York, and Missouri accounted for 95% of domestic mine output; Alaska alone accounted for more than 62%. Three primary and eight secondary smelters refined zinc metal of commercial grade in 1998. Of zinc metal consumed, about 75% was used in Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania, mostly by steel companies. Of the total zinc consumed, about 55% was used in galvanizing, 19% in zinc-base alloys, 13% in brass and bronze, and 13% in other uses. Zinc compounds and dust were used principally by the agriculture, chemical, paint, and rubber industries. Major coproducts of zinc mining and smelting, in decreasing order, were lead, sulfur, cadmium, silver, gold, and germanium.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Mine, recoverable[1]	570	614	598	605	655
Primary slab zinc	217	232	226	227	245
Secondary slab zinc	139	131	140	140	145
Imports for consumption:					
Ore and concentrate	27	10	15	50	30
Refined zinc 793	856	827	876	830	
Exports: Ore and concentrate	389	424	425	461	500
Refined zinc	6	3	2	4	2
Shipments from Government stockpile	39	14	15	32	25
Consumption: Apparent, refined zinc	1,180	1,230	1,210	1,260	1,290
Apparent, all forms	1,400	1,460	1,450	1,490	1,520
Price, average, cents per pound:					
Domestic producers[2]	49.3	55.8	51.1	64.6	52.0
London Metal Exchange, cash	45.3	46.8	46.5	59.7	47.0
Stocks, slab zinc, yearend	94	92	88	104	63
Employment: Mine and mill, number[e]	2,700	2,700	2,700	2,500	2,400
Smelter primary, number[e]	1,000	1,000	1,000	1,000	1,000
Net import reliance[3] as a percent of apparent consumption of:					
Refined zinc 70	71	70	71	70	
All forms of zinc	35	35	33	35	35

Recycling: In 1998, an estimated 375,000 tons of zinc was recovered from waste and scrap; more than one-third was recovered in the form of slab zinc and the remainder in alloys, oxide, and chemicals. Of the total amount of scrap recycled, 285,000 tons was derived from new scrap and 90,000 tons was derived from old scrap. About 28,000 tons of scrap was exported, mainly to Taiwan, and 26,000 tons imported, mainly from Canada.

Import Sources (1994-97): Ore and concentrate: Peru, 42%; Mexico, 35%; Australia, 19%; and other, 4%. Metal: Canada, 58%; Mexico, 11%; Spain, 10%; Peru, 3%; and other, 18%. Combined total: Canada, 56%; Mexico, 12%; Spain, 10%; Peru, 5%; and other, 17%.

Tariff: Item	**Number**	**Normal Trade Relations (NTR) 12/31/98**	**Canada 12/31/98**	**Mexico 12/31/98**	**Non-NTR[4] 12/31/98**
Ore and concentrate	2608.00.0030	0.3¢/kg on lead content	Free	Free	3.7¢/kg on zinc content.
Unwrought metal	7901.11.0000	1.5% ad val.	Free	Free	5.0% ad val.
Alloys, casting-grade	7901.12.1000	6.2% ad val.	Free	Free	45.0% ad val.
Alloys	7901.20.0000	6.2% ad val.	Free	Free	45.0% ad val.
Waste and scrap	7902.00.0000	Free	Free	Free	11.0% ad val.
Hard zinc spelter	2620.11.0000	0.3% ad val.	Free	0.7% 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—9-30-98[5]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Zinc	193	14	193	45	28

Events, Trends, and Issues: Despite closure of the Clinch Valley Mine in Tennessee, domestic mine production increased in 1998, mainly because of increased output at the Red Dog Mine in Alaska, the leading producer in the United States. Because most of the production from the Red Dog Mine is processed in Canada, exports of zinc concentrate increased in correspondence to increased production. The United States is the world's largest exporter of zinc concentrates; it is also the largest importer of zinc metal. The lack of refinery capacity will be partially rectified by expansion of the Clarksville, TN, refinery from 105,000 tons per year to 300,000 tons per year by the first quarter of 2001. With a small increase of capacity at Sauget, IL, primary annual capacity in the United States was 245,000 tons in 1998.

Domestic consumption of zinc metal continued to increase in 1998, mainly because of increased use of galvanized steel. The United States is the largest consumer of zinc and zinc products, but domestic metal production capacity, both primary and secondary, accounts for less than one-third of the quantity consumed. Canada and Mexico are the leading sources of zinc to the United States, because of their geographical proximity and because concentrate and metal imports can be imported from them duty-free.

After a high of more than 79 cents per pound in the summer of 1997, the domestic producer price during 1998 fluctuated between 50 cents and 55 cents per pound of zinc metal.

World Mine Production, Reserves, and Reserve Base:

	Mine production[6]		Reserves[7]	Reserve base[7]
	1997	1998[e]		
United States	632	730	25,000	80,000
Australia	1,040	1,100	36,000	90,000
Canada	1,060	1,100	14,000	39,000
China	1,200	1,250	33,000	80,000
Mexico	379	380	6,000	8,000
Peru	865	870	7,000	12,000
Other countries	2,290	2,370	72,000	130,000
World total (may be rounded)	7,460	7,800	190,000	440,000

World Resources: Identified zinc resources of the world are about 1.9 billion tons.

Substitutes: Aluminum, steel, and plastics substitute for galvanized sheet. Aluminum, plastics, and magnesium are major competitors as diecasting materials. Plastic coatings, paint, and cadmium and aluminum alloy coatings replace zinc for corrosion protection; aluminum alloys are used in place of brass. Many elements are substitutes for zinc in chemical, electronic, and pigment uses.

[e]Estimated.
[1]Zinc recoverable after smelting and refining.
[2]Platt's Metals Week price for North American Special High Grade zinc.
[3]Defined as imports - exports + adjustments for Government and industry stock changes.
[4]See Appendix B.
[5]See Appendix C for definitions.
[6]Zinc content of concentrate and direct shipping ore.
[7]See Appendix D for definitions.

ZIRCONIUM AND HAFNIUM

(Data in metric tons of zirconium oxide (ZrO_2) equivalent, unless otherwise noted)

Domestic Production and Use: Zircon sand was produced at two mines in Florida and one mine in Virginia. 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 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 an addition in superalloys.

Salient Statistics—United States:	**1994**	**1995**	**1996**	**1997**	**1998[e]**
Production: Zircon (ZrO_2 content)[1]	W	W	W	W	W
Imports:					
Zirconium, ores and concentrates (ZrO_2 content)	53,300	60,800	60,100	40,600	70,000
Zirconium, alloys, waste and scrap (ZrO_2 content)	837	884	836	929	1,400
Zirconium oxide (ZrO_2 content)[2]	2,400	4,370	5,240	4,220	4,000
Hafnium, unwrought, waste and scrap	5	5	9	8	13
Exports:					
Zirconium ores and concentrates (ZrO_2 content)	20,800	26,200	22,780	28,800	24,000
Zirconium, alloys, waste and scrap (ZrO_2 content)	301	221	184	188	200
Zirconium oxide (ZrO_2 content)[2]	1,220	1,680	1,480	1,970	1,700
Consumption, zirconium ores and concentrates, apparent (ZrO_2 content)	W	W	W	W	W
Prices:					
Zircon, dollars per metric ton (gross weight):					
Domestic[3]	306	352	462	462	462
Imported, f.o.b. U.S. east coast[4]	220	325	400	400	353
Zirconium sponge, dollars per kilogram[5]	20-26	20-26	20-26	20-26	20-26
Hafnium sponge, dollars per kilogram[5]	165-209	165-209	165-209	165-209	165-209
Net import reliance[6] as a percent of apparent consumption:					
Zirconium	W	W	W	W	W
Hafnium	NA	NA	NA	NA	NA

Recycling: Zirconium metal was recycled by four companies, one each in California, Michigan, New York, and Texas. 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 (1994-97): Zirconium ores and concentrates: Australia, 51%; South Africa, 48%; and other, 1%. Zirconium, wrought, unwrought, waste and scrap: France, 39%; Germany, 24%; Canada, 12%; Japan, 10%; and other, 15%. Hafnium, unwrought, waste and scrap: France, 69%; Australia, 21%; Germany, 8%; and United Kingdom, 2%.

Tariff: Item	Number	Normal Trade Relations (NTR) 12/31/98	Non-NTR[7] 12/31/98
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	4.1% 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 15,800 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—9-30-98[8]

Material	Uncommitted inventory	Committed inventory	Authorized for disposal	Disposal plan FY 1998	Disposals FY 1998
Baddeleyite	15,800	—	—	—	—

Events, Trends, and Issues: The global supply and demand of zirconium mineral concentrates was largely in balance in 1998 and this trend is expected to continue over the next few years. However, long term supply shortages may occur unless new production sources of zirconium concentrates are developed. U.S. imports of zirconium concentrates were estimated to have increased 73% while exports decreased 16% compared with 1997. A new mining operation at Stony Creek, VA, began production of zircon and other heavy minerals in 1998. Initial capacity was expected to include up to 30,000 tons per year of zircon. 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. Zirconium-clad fuel rods in nuclear reactors are hafnium-free to improve reactor efficiency because hafnium is a strong absorber of thermal neutrons. At the same time, hafnium is used in reactor control rods to regulate the fission process through neutron absorption.

World Refinery 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[9] (million metric tons, ZrO_2)	Reserve base[9]	Reserves[9] (thousand metric tons, HfO_2)	Reserve base[9]
	1997	1998[e]				
United States	W	W	3.4	5.3	68	97
Australia	424	500	9.1	29.8	182	596
Brazil	17	17	.4	.4	7	7
China[e]	15	15	.5	1.0	NA	NA
India	19	20	3.4	3.8	42	46
South Africa	360	265	14.3	14.3	259	259
Ukraine[e]	65	60	4.0	6.0	NA	NA
Other countries	26	30	.9	4.1	NA	NA
World total (rounded)	[10]926	[10]907	36	65	558	1,000

World Resources: Resources of zircon in the United States included about 14 million tons associated with titanium resources in heavy-mineral sand deposits. Phosphate and sand and gravel deposits have the potential to yield substantial amounts of zircon as a future byproduct. Eudialyte and gittinsite are zirconium silicate minerals that have a potential for zirconia production. Identified world resources of zircon exceed 60 million tons.

Resources of hafnium in the United States are estimated to be about 130,000 tons, available in the 14-million ton domestic resources of zircon. World resources of hafnium are associated with those of zircon and baddeleyite and exceed 1 million tons.

Substitutes: Chromite and olivine can be used instead of zircon for some foundry applications. Dolomite and spinel refractories can also substitute for zircon in certain high-temperature applications. Columbium (niobium), stainless steel, and tantalum provide limited substitution in nuclear applications, while titanium and synthetic materials may substitute in some chemical plant uses.

Silver-cadmium-indium control rods are used in lieu of hafnium at numerous nuclear powerplants. Zirconium can be used interchangeably with hafnium in certain superalloys; in others, only hafnium produces the desired or required grain boundary refinement.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Less than 250 micron, 99.9% purity, 1994 through 1998 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 ultradry powder from Alfa Aesar.
[4]Defined as imports - exports + adjustments for Government and industry stock changes.
[5]See Appendix B.
[6]See Appendix D for definitions.

APPENDIX A

Abbreviations and Units of Measure

1 carat (metric) (diamond)	= 200 milligrams
1 flask (fl)	= 76 pounds, avoirdupois
1 karat (gold)	= one twenty-fourth part
1 kilogram (kg)	= 2.2046 pounds, avoirdupois
1 long ton (lt)	= 2,240 pounds, avoirdupois
1 long ton unit (ltu)	= 1% of 1 long ton or 22.4 pounds avoirdupois
long calcined ton (lct)	= excludes water of hydration
long dry ton (ldt)	= excludes excess free moisture
Mcf	= 1,000 cubic feet
1 metric ton (t)	= 2,204.6 pounds, avoirdupois or 1,000 kilograms
1 metric ton (t)	= 1.1023 short ton
1 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-Normal-Trade-Relations Trade Areas

The countries or areas for which non-normal-trade-relations (Non-NTR) rates apply are the following:

Afghanistan
Cuba
Laos
North Korea
Vietnam

Normal trade relations (NTR), Non-NTR, 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

Terms Used for Materials in the National Defense Stockpile

Uncommitted inventory, as used by the Department of Defense, refers simply to material currently in the stockpile, whether stockpile-grade or nonstockpile-grade. In the tables for this report, only the stockpile-grade material is listed; nonstockpile-grade material, if any, is cited in the text.

Committed inventory refers to both stockpile-grade materials and nonstockpile-grade materials that have been sold or traded from the stockpile, either in the current fiscal year or in prior years, but not yet removed from stockpile facilities.

Authorized for disposal refers to quantities that are in excess of the stockpile goal for a material, and for which Congress has authorized disposal over the long term at rates designed to maximize revenue but avoid undue disruption of the usual markets and loss to the United States.

Disposal plan FY 1998 refers the Defense Logistics Agency's Annual Materials Plan for the fiscal year. Fiscal year 1998 is the period 10/1/97 through 9/30/98.

Disposals FY 1998 refers to material sold or traded from the stockpile in fiscal year 1998; it may or may not have been removed by the buyers.

APPENDIX D

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

[1]Based on U.S. Geological Survey 831, 1980.

(marginal reserves), and some of those that are currently subeconomic (subeconomic resources). The term "geologic reserve" has been applied by others generally to the reserve-base category, but it also may include the inferred-reserve-base category; it is not a part of this classification system.

Inferred Reserve Base.—The in-place part of an identified resource from which inferred reserves are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a deposit and for which there may be no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base, for which there is geologic evidence.

Reserves.—That part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

Marginal Reserves.—That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technological factors.

Economic.—This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Subeconomic Resources.—The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources.—Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. Undiscovered resources may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, undiscovered resources may be divided into two parts.

Hypothetical Resources.—Undiscovered resources that are similar to known mineral bodies and that may be reasonably expected to exist in the same producing district or region under analogous geologic conditions. If exploration confirms their existence and reveals enough information about their quality, grade, and quantity, they will be reclassified as identified resources.

Speculative Resources.—Undiscovered resources that may occur either in known types of deposits in favorable geologic settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources/Reserves.—That part of any resource/reserve category that is restricted from extraction by laws or regulations. For example, restricted reserves meet all the requirements of reserves except that they are restricted from extraction by laws or regulations.

Other Occurrences.—Materials that are too low grade or for other reasons are not considered potentially economic, in the same sense as the defined resource, may be recognized and their magnitude estimated, but they are not classified as resources. A separate category, labeled other occurrences, is included in figures 1 and 2. In figure 1, the boundary between subeconomic and other occurrences is limited by the concept of current or potential feasibility of economic production, which is required by the definition of a resource. The boundary is obviously uncertain, but limits may be specified in terms of grade, quality, thickness, depth, percent extractable, or other economic-feasibility variables.

Cumulative Production.—The amount of past cumulative production is not, by definition, a part of the resource. Nevertheless, a knowledge of what has been produced is important to an understanding of current resources, in terms of both the amount of past production and the amount of residual or remaining in-place resource. A separate space for cumulative production is shown in figure 1. Residual material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

FIGURE 1.--Major Elements of Mineral-Resource Classification, Excluding *Reserve Base* and *Inferred Reserve Base*

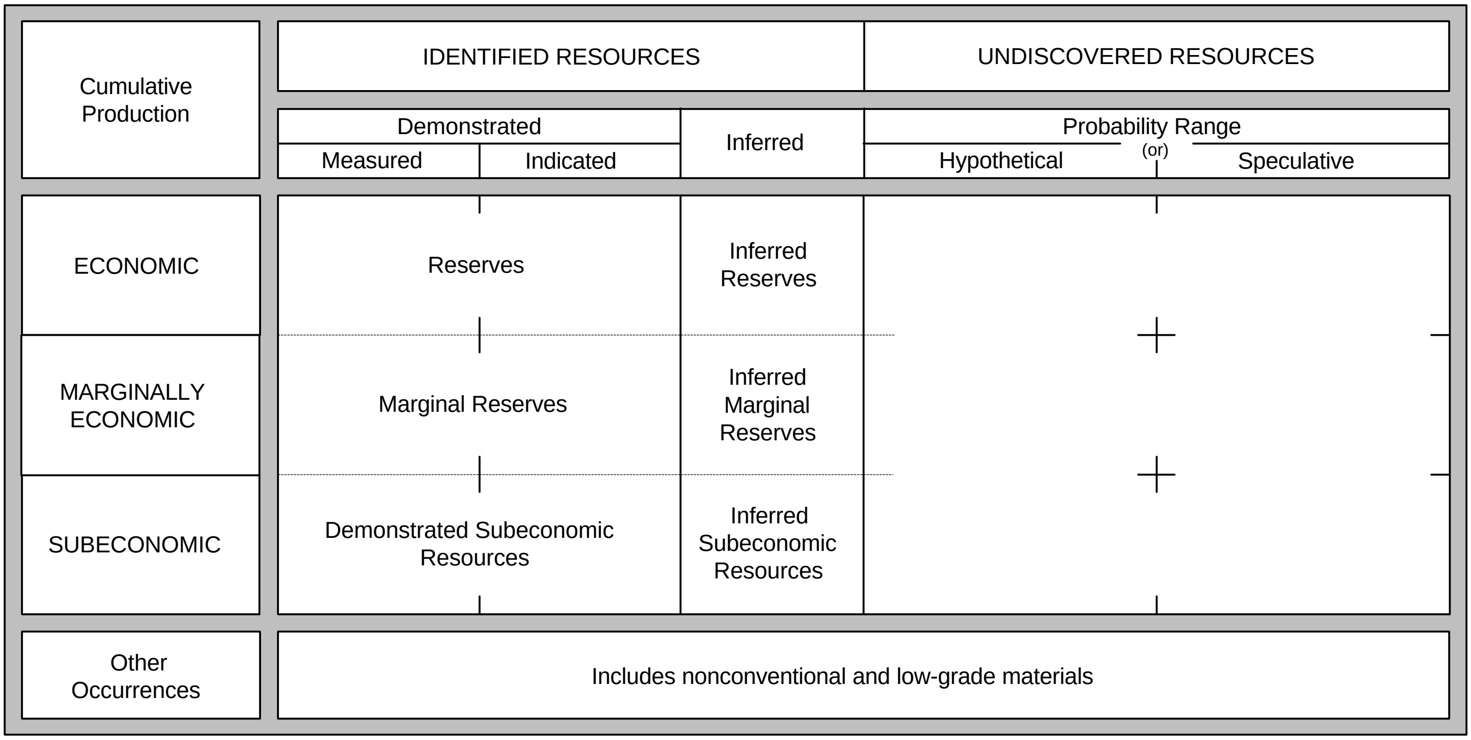

FIGURE 2.--*Reserve Base* and *Inferred Reserve Base* Classification Categories