# Mining and Quarrying Trends in the Metal and Nonmetal Industries

By Franklin D. Cooper[1]

The value of nonfuel raw mineral production in the United States for 1977 increased over that of 1976 by 5%, from $16.7 billion to $17.5 billion. Metals declined by 5% from $6.1 billion to $5.8 billion, chiefly because of strikes in the iron ore industry and a depressed copper market. Subsidization of mining industries in some foreign countries accounted in part for the excess of copper and some other metals on world markets. Weak metal markets and continued slowdowns in the world economy were the main reasons of the virtual absence of new mine projects.

Increasing domestic governmental involvement affecting mineral industry activities, such as pricing controls, public land withdrawals, and the Surface Mining Control and Reclamation Act, effective August 3, continued to be controversial and to be criticized by various segments of the industry.

Large capital outlay and the long lead time to attain production from a new facility were also of concern. Because of increasing costs and depletion of higher-grade reserves, the mining industry relied heavily on technology to develop more efficient mining and processing methods.

The use of raise- and shaft-boring was popular, compared with former development practices, because less completion time was required. Mine ventilation was improved and less maintenance was needed after the boring was completed. Four U.S. companies produced raise-boring machines, one of which could produce a 350,000-foot-pound torque and a 2-million-pound thrust. One manufacturer patented a "taper-lock" removable stem to eliminate the replacement of entire boring heads up to 20 feet in diameter when only the stem is broken.

Although pneumatic drill rigs dominated in most underground mines, hydraulic percussion drills with one single moving part gained favor because of faster penetration and less noise while requiring less energy and maintenance.

A twin-boom tunneling jumbo equipped with a dry dust collector met the strict requirements of environmental inspectors in an underground limestone mine.

The Bureau's continuous spiral drill-and-blast concept, when tested in the White Pine Copper mine, indicated advance rates four times that of conventional drill-and-blast methods.

Explosives manufacturers introduced a new plastic connector, the Safe-T-Tube, to prevent premature detonation of detonating cord. Two new explosives were made available for underground blasting.

Diesel-powered haulage continued to increase in noncoal underground mines.

A roof-support system using 14- to 18-foot-long fiberglass beams permitted a continuous mining operation, as demonstrated in a Pennsylvania mine, to advance 20 feet farther than with steel beams previously used. The Bureau of Mines developed an improved method for anchoring roof bolts, using a cartridge containing quick-setting portland-gypsum cement and microencapsulated water.

Tungsten-halogen lighting was initially introduced in underground mines as were two new designs of roof bolts.

In the surface mining sector, trends in new equipment were diversified. A 16-cubic-yard hydraulic-type shovel was being tested

by Reserve Mining Co. Ten of these units were reportedly sold to the U.S.S.R. However, for sizes larger than 11.5 cubic yards, cable operated shovels, according to operators' statistics, tend to be more reliable, have a longer life, and are cheaper to operate. A new small walking dragline capable of using a 10- to 16-cubic-yard bucket on a 140- to 200-foot boom was introduced. The modular design of the machine permitted it to be assembled in 124 hours, using an experienced 6-worker crew. Disassembly required 76 hours by the same crew. A new front-end-loader weighing system was introduced that recorded single and cumulative load weights for inventory control and productivity measurements. Two new 6-ton-capacity load-haul-dump (LHD) machines were introduced. One featured two loading buckets; the other had a 21,000-pound breakout force.

Drilling and blasting practices continued to change because of increasing governmental regulations limiting noise and surface vibration. In a joint effort with the Engineering Contractors' Association of South Florida, the Bureau of Mines developed an explosive-loading technique that can eliminate the often dangerous "kelly-bar" stem loading method.

More rotary drilling was used in open pits as higher benches, wider spacing, and large-diameter holes became more commonplace.

Bulldozers continued to increase in size. Three new machines were introduced. Rated horsepower ranged from 620 to 720, or about 15% higher than for previous models. One manufacturer introduced a track-type tractor with shock-proof sprockets that support the tractor, above the track roller frames.

For practical reasons, most U.S. mine haulage trucks remained below 200-ton capacity. Reasons usually given were: Over 200-tons, electric-wheel trucks require tires that are not readily available; the trucks have high initial and operating costs; and they require special conditions to realize maximum efficiency. A new 100-ton rear-dump truck with an all-hydraulic braking system was undergoing preproduction testing. The truck was said to be readily teamed with front-end loaders and loading shovels currently in use.

In operations handling large tonnages, the greater depth and steeper grades in some pits increased the expense of truck haulage. It was found advantageous in Duval Corp.'s Sierrita mine to replace 12 trucks by a $30.6 million conveyor haulage system. To provide continuous ore flow by preventing bridging problems in Duval's 6,540-ton-per-hour system, each of two 60-inch-diameter gyratory crushers was provided with a boom-mounted, 20,000-foot-pound hydraulic hammer delivering 400 to 500 blows per minute.

Growing use of computers was made for mine planning and production and haulage-truck assignments.

Progress in beneficiation and processing was highlighted by; automation of crushing and grinding circuits, process control using radioisotopic probes, onstream particle measurements, 1,000-cubic-foot flotation cells, new flotation reagents, smaller dimensioned but more efficient thickeners, and new ion exchange resins for absorption of precious and noble metals.

One company used a steel reinforced polyurethane medium to eliminate vibrating screen blinding.

Because of improved engineering and construction procedures, earth-bottom thickeners were increasingly used in porphyry-copper operations and for countercurrent decantation.

A spiral, inductive magnetic separation technique was developed that could produce a single-stage iron ore concentrate having the same metal content as normally recovered in two drum-type separators.

The Bureau of Mines developed economic methods for producing concentrates containing 28% to 31% $P_2O_5$ at 60% to 70% recovery from complex western phosphate rock.

The use of analog loop instrumentation increased the productivity of a uranium mill from 1,800 tons per day to 2,700 and a similar control system monitored the grinding circuit of a lead-zinc mill.

In one plant a controller, in conjunction with sensors evaluating the reflectance and scattering of 2,950-nanometer-wave-length light, kept the moisture content of green iron ore pellets at the required level.

Autogenous and semiautogenous grinding units continued to increase in number. A new mill liner system, with a reputed 15% to 20% reduction of energy consumption, was introduced. This system has liners of square cross section instead of the conventional wave pattern.

**Magnitude of the Mining Industry.**—The number of metal and nonmetal mines

decreased from 15,279 in 1976 to 14,784 in 1977. Eight additional metal mines were added and 503 nonmetal mines discontinued operations.

In 1977, 25 of nonfuel mines produced more than 10 million tons of crude ore, the same as in 1976. The principal commodities produced in these mines were copper (11 mines), phosphate rock (7), iron ore (4), stone (1), sand and gravel (1), and other (1). Heading the list of metal mines in output of crude copper ore were the Utah Copper mine of Kennecott Copper Corp. and the Sierrita mine of Duval Sierrita Corp. The Minntac mine of United States Steel Corp. and the Peter Mitchell mine of Reserve Mining Co. were the leading iron ore producers, while the largest producer of molybdenum ore was Climax Molybdenum Co., a division of AMAX, Inc. The leading producers of crude nonmetal ore were three Florida phosphate rock mines - Suwanee of Occidental Petroleum Corp., and the Noralyn and Kingsford mines of International Minerals & Chemicals Corp.

The Utah Copper mine of Kennecott Copper Corp. was the leading metal mine in total materials handled, followed by the Sierrita mine of Duval Sierrita Corp. The Kingsford and Noralyn phosphate mines were the leading nonmetal mines in total materials handled.

The 25 leading metal mines, on the basis of crude ore produced, included copper (11), iron ore (9), and titanium (2), while phosphate rock (17) and stone (7) comprised the majority of the 25 largest nonmetal crude ore producers.

**Materials Handled.**—The U.S. mineral-producing industry, excluding fuels, handled a total of 4.3 billion tons of crude ore and waste, a decrease of 2% compared with that of 1976. Of the total materials handled, crude ore comprised 64%. In 1977, total materials handled decreased 300 million tons for metal mines and increased 200 million tons for nonmetal mines, compared with those of 1976. The largest decrease in metals occurred in copper mining; in nonmetal mining the largest increase was in phosphate rock.

The amount of waste handled in 1977 totaled 1,520 million tons compared with 1,510 million tons in 1972, and 1,030 million tons in 1967.

In 1977, more than 100 million tons of materials were handled in each of 9 States, compared with 10 States in 1976. Arizona was the leading State followed by Florida and New Mexico. These three States handled 29% of the U.S. total.

**Value of Principal Mineral Products.**—The values shown in table 4 represent crude ore treated or, in the case of some nonmetals, crude ore shipped.

The average value for all commodities including byproducts increased 2% compared with that of 1976. Of the metal commodities and byproducts, approximately 60% showed an increase in value and the average value increased 10%. The metals showing the greatest increases were silver, mercury, and lead with zinc showing the greatest decrease. For the nonmetal commodities including byproducts, 56% showed an increase in average value. The overall average of the nonmetals increased 5% compared with that of 1976. Among the nonmetals, talc, soapstone, and pyrophyllite, pumice, natural sodium carbonate showed the largest increases in average value, with barite showing the largest decrease.

Byproducts were responsible for increasing the average value of all but five of the metal mine products and all but five of the nonmetal products, as shown in table 4. The largest addition to average value by byproducts occurred in ores of fluorspar, 30%, and gypsum, 22%.

The value of byproducts in 1977 from underground metal mine ores averaged 7% of the total value of ores from which they were produced, while byproduct value averaged 8% of the total value of surface mined metal ores. Byproducts from all nonmetal mines, excluding stone, and sand and gravel, contributed about 2% of the total value of the nonmetal ores.

**Ratio of Treated Ore to Marketable Product.**—The number of tons of crude ore treated to obtain a unit of marketable product in the metals, varied from a high of 826 for uranium to a low of 0.1 for silver. For most nonmetals, the ratio generally is 1:1.

**Comparison of Production From Surface and Underground Mines.**—In 1977, surface mines produced 94% of the total ore and accounted for 96% of the total materials handled by the U.S. mineral industry, the same as in 1972. The respective figures for 1967 were 94% and 95%.

Crude iron ore (31%) and copper ore (47%) comprised 78% of the total crude ores produced in metal mines. Iron ore and

copper mining together accounted for 76% of the total materials moved in 1977 in surface metal mines.

In nonmetal surface mining, phosphate rock (20%), sand and gravel (36%), and crushed and broken stone (39%), accounted for approximately 95% of all nonmetal materials handled in 1977.

The production of 9 metallic crude ores and 18 nonmetal ores came entirely from surface mines. Underground mines accounted for all production of potassium salts, and natural sodium carbonate.

**Exploration and Development.**—Total reported footage for development work performed in the United States in 1977 increased 151% while the total reported exploration footage increased 46% compared with 1976. Metal mine exploration work increased 54% while nonmetal exploration work decreased 60%.

Metal mining accounted for 84% of the total development footage and 99% of the exploration footage. The major portion of the metals development footage was in uranium, copper, and zinc. The majority of the nonmetals development footage was in phosphate rock and fluorspar.

Exploration drilling and trenching for uranium, gold, and bauxite accounted for 91% of the metals exploration footage. Exploration drilling and trenching for fluorspar and phosphate rock accounted for 71% of the total nonmetals exploration footage.

Of the total reported exploration footage of 21.2 million feet, the distribution was: Uranium, 67%; bauxite, 3%; lead, 2%; and zinc, 2%. Drilling and trenching for copper, molybdenum, tungsten, iron ore, and silver totaled 817,000 feet.

Of the total 162 million short tons of ores and wastes handled in mine development projects, 92% came from stripping. Of this total, uranium, 42%; iron ore, 31%; and copper, 7% accounted for most of the materials produced in development work. Leading States on the basis of materials produced in development work were: Wyoming, 40%; Minnesota, 19%; and Michigan, 11%.

U.S. mineral exploration in 1977 resulted in only a few announcements of new discoveries, some of which resulted from exploration started 3 to 10 years earlier. New exploration-related equipment resulted from modifications of the past art rather than major technological breakthroughs. Some large mining firms seriously examined the cost and usefulness of their exploration programs.

On a regional basis, Alaska, Arizona, Wisconsin, Michigan, and Maine had the most active exploration programs during 1977.

Exploration companies spent approximately $40 million in Alaska. Many of the more than 13,000 new claims recorded in the State were in the Delong Mountains of the Brooks Range.

In the contiguous United States the southern extension of the "Viburnum trend "in Missouri, and the Tennessee-Kentucky zinc district were explored by base metal mining companies. A significant discovery of massive sulfide was made near Ashland, Maine.

West of the Mississippi River, a large porphyry copper deposit was found at Francisco Grande, Ariz. A deposit of porphyry-type molybdenum was found in southern Utah. Estimates of molybdenite mineralization near Crested Butte, Colo., were raised to 165 million tons. An aeromagnetic survey of Idaho's Coeur d'Alene District indicated the existence of a deeply buried intrusion east of Mullan. Underground workings were completed to permit diamond drilling beneath the Twin Buttes open pit copper mine in Arizona. Fifteen major shafts totaling 8,100 feet of depth were completed at a uranium operation near Uravan, Colo.

Most uranium exploration was designed to locate lateral and vertical extensions of ore in Wyoming, Colorado Plateau, Ambrosia Lake, and the Texas Coastal Plain. There was also an intense interest in "porphyry" uranium deposits in conglomerates in the North Central States, in Triassic basins in the East and Southwest, and in the Nevada-Oregon intermontane basins. No major discoveries of interest were reported from these areas.

The largest expenditures for exploration in 1977 included those by the U.S. Department of Energy, Exxon Co. U.S.A., Wyoming Mineral Corp., Gulf Mineral Resources Co., Kerr-McGee Corp., the Tennessee Valley Authority, Getty Oil Co., and a West German consortium. Many smaller groups spent sums in the $1 to $3 million range.

Governmental and private industry exploration programs for uranium exploration amounted to $258 million, but overall it was not a very productive year.

No breakthroughs in ore-finding techniques were announced in 1977. Newmont Mining Corp. advocated the use of a ground search system, called electromagnetic-pulse (EMP), for massive sulfide exploration. The developer of this instrument stated that the practical limit of the system is near and that few additional advances can be expected.

Landsat imagery data and its interpretation was used on ore bodies that lie at, or near, lineament intersections.

Despite its relatively high cost, side-looking-radar was proven to be useful for rapid structural interpretations in thickly forested or deeply weathered terrain.

An improved drill hole logging system, using neutron-activation analysis, was announced. Core drilling may be unnecessary because sufficient data may be obtained by lowering the instrument through a percussion- or rotary-drilled borehole for quick results onsite.

A process was developed at Stanford University to efficiently sort particles as small as 1.7 millimeters and to detect fluorescent minerals. Photometric sorting was used elsewhere on gold, uranium, and copper ores.

Major diamond drilling contractors estimated that the average depth of drill holes for base metals was increasing about 5% annually.

Many base metals exploration groups switched emphasis from general exploration to exploration for massive sulfides.

There was some shift to exploration on private lands, particularly in the Eastern States in areas not under control of the U.S. Forest Service.

**Explosives.**—Apparent consumption of industrial explosives in the United States during 1977 increased 11.4% compared with that of 1976 to a record high of 3.7 billion pounds. This is the third successive year that the total surpassed 3 billion pounds. Bulk blasting agent consumption rose 15%, water gels and slurries declined 6.5%, permissible explosives rose 9.5%, and other high explosives declined 7.2% compared with 1976.

Nearly two-thirds (65.4%) of the total weight of explosives and blasting agents was used in coal mining. This total consisted of 95.4% of all permissible explosives and 62.5% of cylindrically packaged blasting agents and bulk blasting agents consumed. Quarrying, (33.9%) and construction, (27.6%) consumed the majority of all other high explosives. Metal mining used the majority (48.8%) of the water gels and slurries.

Seven States, namely Kentucky, Pennsylvania, Alabama, Ohio, Virginia, West Virginia, and Arizona, consumed 58.8% of all explosives and blasting agents used in the United States in 1977.

The apparent differences in 1977 consumption shown in tables 17-18, compared with prior years, are due to a change in category classification made by the Institute of Makers of Explosives (IME). In the change, processed blasting agents were added to the cylindrically packaged blasting agent category and the other processed blasting agent category now includes only unprocessed ammonium nitrate.

More detailed explosives information is published in the annual Explosive issue of Mineral Industry Surveys, prepared by the Division of Nonmetallic Minerals, Bureau of Mines.

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## Table 1.—Material handled at surface and underground mines in the United States, by type

(Million short tons)

| Type and year | Surface | | | Underground | | | All mines[1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Crude ore | Waste | Total[1] | Crude ore | Waste | Total[1] | Crude ore | Waste | Total |
| Metals: | | | | | | | | | |
| 1972 | 491 | 1,080 | 1,570 | 86 | 5 | 91 | 576 | 1,080 | 1,660 |
| 1973 | 574 | 1,280 | 1,860 | 82 | 9 | 91 | 655 | 1,290 | 1,950 |
| 1974 | 547 | 1,210 | 1,760 | 80 | 11 | 91 | 627 | 1,220 | 1,850 |
| 1975 | 535 | 1,170 | 1,700 | 74 | 13 | 87 | 609 | 1,180 | 1,790 |
| 1976 | 573 | 1,250 | 1,820 | 73 | 15 | 87 | 646 | 1,260 | 1,910 |
| 1977 | 490 | 1,030 | 1,530 | 74 | 12 | 87 | 564 | 1,050 | 1,610 |
| Nonmetals: | | | | | | | | | |
| 1972 | 2,020 | 415 | 2,430 | 77 | 5 | 82 | 2,100 | 420 | 2,520 |
| 1973 | 2,240 | 418 | 2,650 | 82 | 1 | 83 | 2,320 | 419 | 2,740 |
| 1974 | 2,220 | 418 | 2,640 | 82 | 5 | 87 | 2,300 | 423 | 2,720 |
| 1975 | 1,910 | 372 | 2,290 | 79 | 6 | 84 | 1,990 | 378 | 2,370 |
| 1976 | 2,000 | 393 | 2,390 | 80 | 6 | 86 | 2,080 | 399 | 2,480 |
| 1977 | 2,120 | 472 | 2,590 | 80 | 6 | 86 | 2,200 | 478 | 2,680 |
| Total metals and nonmetals:[1] | | | | | | | | | |
| 1972 | 2,500 | 1,500 | 4,000 | 163 | 10 | 173 | 2,670 | 1,510 | 4,180 |
| 1973 | 2,810 | 1,700 | 4,510 | 163 | 11 | 174 | 2,970 | 1,710 | 4,680 |
| 1974 | 2,760 | 1,630 | 4,390 | 162 | 16 | 178 | 2,930 | 1,650 | 4,570 |
| 1975 | 2,450 | 1,540 | 3,990 | 153 | 18 | 171 | 2,600 | 1,560 | 4,160 |
| 1976 | 2,570 | 1,640 | 4,210 | 153 | 21 | 174 | 2,720 | 1,660 | 4,390 |
| 1977 | 2,610 | 1,510 | 4,120 | 155 | 18 | 173 | 2,760 | 1,520 | 4,290 |

[1]Data may not add to totals shown because of independent rounding.

## Table 2.—Material handled at surface and underground mines in 1977, by commodity[1]

(Thousand short tons)

| Commodity | Surface | | | Underground | | | All mines[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Crude ore | Waste | Total[2] | Crude ore | Waste | Total[2] | Crude ore | Waste | Total |
| **METALS** | | | | | | | | | |
| Bauxite | 3,980 | 15,200 | 19,100 | -- | -- | -- | 3,980 | 15,200 | 19,100 |
| Copper | 240,000 | 594,000 | 834,000 | 25,700 | 1,500 | 27,200 | 266,000 | 596,000 | 861,000 |
| Gold: | | | | | | | | | |
| Lode | 2,890 | 14,400 | 17,200 | 1,670 | 236 | 1,910 | 4,560 | 14,600 | 19,200 |
| Placer | 3,150 | 762 | 3,920 | -- | (3) | (3) | 3,150 | 762 | 3,920 |
| Iron ore | 170,000 | 154,000 | 324,000 | 7,990 | 757 | 7,840 | 177,000 | 155,000 | 332,000 |
| Lead | 3 | 10 | 13 | 9,840 | 2,230 | 12,100 | 9,840 | 2,230 | 12,100 |
| Mercury | 215 | 900 | 1,120 | -- | -- | -- | 215 | 900 | 1,120 |
| Silver | 553 | 608 | 1,160 | 928 | 501 | 1,430 | 1,480 | 1,110 | 2,590 |
| Titanium, ilmenite | 37,500 | 356 | 37,900 | -- | -- | -- | 37,500 | 356 | 37,900 |
| Tungsten | 1,000 | 10 | 1,010 | 748 | 444 | 1,190 | 1,750 | 454 | 2,210 |
| Uranium | 16,800 | 227,000 | 244,000 | 5,110 | 4,420 | 9,530 | 21,900 | 232,000 | 253,000 |
| Zinc | W | W | W | 8,560 | 1,740 | 10,300 | 8,560 | 1,740 | 10,300 |
| Other[4] | 14,000 | 28,000 | 42,000 | 14,700 | 547 | 15,200 | 28,700 | 28,500 | 57,200 |
| Total metals[2] | 490,000 | 1,030,000 | 1,530,000 | 74,300 | 12,400 | 86,700 | 564,000 | 1,050,000 | 1,610,000 |
| **NONMETALS** | | | | | | | | | |
| Abrasives[5] | 348 | 377 | 725 | 78 | -- | 78 | 426 | 377 | 803 |
| Asbestos | 2,550 | 3,880 | 6,430 | W | W | W | 2,550 | 3,880 | 6,430 |
| Barite | 3,770 | 645 | 4,410 | W | W | W | 3,770 | 645 | 4,410 |
| Clays | 47,800 | e41,500 | 89,300 | 753 | e11 | 764 | 48,600 | 41,500 | 90,100 |
| Diatomite | 1,790 | 4,890 | 6,680 | -- | -- | -- | 1,790 | 4,890 | 6,680 |
| Feldspar | 1,480 | 145 | 1,620 | W | -- | W | 1,480 | 145 | 1,620 |
| Fluorspar | 56 | 55 | 111 | 542 | 42 | 584 | 598 | 97 | 695 |
| Gypsum | 11,500 | 9,960 | 21,500 | 2,450 | -- | 2,450 | 14,000 | 9,960 | 23,900 |
| Mica (scrap) | 986 | 343 | 1,330 | -- | -- | -- | 986 | 343 | 1,330 |
| Perlite | 778 | 202 | 980 | -- | -- | -- | 778 | 202 | 980 |
| Phosphate rock | 182,000 | 328,000 | 510,000 | W | W | W | 182,000 | 328,000 | 510,000 |
| Potassium salts | -- | -- | -- | 19,000 | 165 | 19,200 | 19,000 | 165 | 19,200 |
| Pumice | 4,110 | 331 | 4,440 | -- | -- | -- | 4,110 | 331 | 4,440 |
| Salt | 624 | -- | 624 | 14,500 | 699 | 15,200 | 15,100 | 699 | 15,800 |
| Sand and gravel | 929,000 | -- | 929,000 | -- | -- | -- | 929,000 | -- | 929,000 |
| Sodium carbonate (natural) | -- | -- | -- | 11,300 | 5,000 | 16,300 | 11,300 | 5,000 | 16,300 |
| Stone: | | | | | | | | | |
| Crushed and broken | 922,000 | e75,800 | 998,000 | 31,000 | e200 | 31,200 | 953,000 | 76,000 | 1,030,000 |
| Dimension | e3,070 | e1,620 | 4,690 | 17 | -- | 17 | 3,080 | 1,620 | 4,700 |

See footnotes at end of table.

**Table 2.—Material handled at surface and underground mines in 1977, by commodity[1] —Continued**

(Thousand short tons)

| Commodity | Surface | | | Underground | | | All mines[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Crude ore | Waste | Total[2] | Crude ore | Waste | Total[2] | Crude ore | Waste | Total |
| NONMETALS —Continued | | | | | | | | | |
| Talc, soapstone, pyrophyllite | 935 | 2,440 | 3,380 | 267 | 116 | 383 | 1,200 | 2,560 | 3,760 |
| Other[6] | 7,890 | 1,490 | 9,380 | 327 | 22 | 348 | 8,220 | 1,510 | 9,730 |
| Total nonmetals[2] | 2,120,000 | 472,000 | 2,590,000 | 80,200 | 6,050 | 86,500 | 2,200,000 | 478,000 | 2,680,000 |
| Grand total[2] | 2,610,000 | 1,510,000 | 4,120,000 | 155,000 | 18,400 | 173,000 | 2,760,000 | 1,520,000 | 4,290,000 |

[e]Estimate. W Withheld to avoid disclosing company proprietary data; included in "Other."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Antimony, beryllium, manganiferous ore, molybdenum, nickel, rare-earth metals, vanadium, zinc, and quantity of metal items indicated by symbol W.
[5]Emery, garnet, and tripoli.
[6]Aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, millstones, olivine, tube-mill liners, vermiculite, wollastonite, and quantity of nonmetal items indicated by symbol W.

**Table 3.—Material handled at surface and underground mines (including sand and gravel and stone) in 1977, by State[1]**

(Thousand short tons)

| State | Surface | | | Underground | | | All mines[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Crude ore | Waste | Total[2] | Crude ore | Waste | Total[2] | Crude ore | Waste | Total |
| Alabama | 42,700 | 827 | 43,500 | W | -- | W | 42,700 | 827 | 43,500 |
| Alaska | 73,600 | 750 | 74,300 | (3) | -- | (3) | 73,600 | 750 | 74,300 |
| Arizona | 175,000 | 327,000 | 502,000 | 20,600 | 1,200 | 21,800 | 195,000 | 328,000 | 523,000 |
| Arkansas | 38,700 | 15,300 | 54,000 | 417 | 2 | 418 | 39,100 | 15,300 | 54,400 |
| California | 164,000 | 46,600 | 211,000 | 1,130 | 274 | 1,400 | 165,000 | 46,800 | 212,000 |
| Colorado | 36,600 | 15,200 | 51,800 | 16,300 | 2,840 | 19,100 | 52,800 | 18,000 | 70,900 |
| Connecticut | 15,800 | 15 | 15,800 | -- | -- | -- | 15,800 | 15 | 15,800 |
| Delaware | 1,360 | -- | 1,360 | -- | -- | -- | 1,360 | -- | 1,360 |
| Florida | 261,000 | 245,000 | 506,000 | -- | -- | -- | 261,000 | 245,000 | 506,000 |
| Georgia | 51,600 | 1,540 | 53,100 | 652 | -- | 652 | 52,300 | 1,540 | 53,800 |
| Hawaii | 6,790 | -- | 6,790 | -- | -- | -- | 6,790 | -- | 6,790 |
| Idaho | 17,600 | 30,800 | 48,400 | 1,330 | 408 | 1,740 | 19,000 | 31,200 | 50,200 |
| Illinois | 93,300 | 10 | 93,300 | 2,810 | 36 | 2,840 | 96,100 | 46 | 96,200 |
| Indiana | 53,800 | -- | 53,800 | 1,730 | -- | 1,730 | 55,500 | -- | 55,500 |
| Iowa | 46,000 | 418 | 46,400 | 2,040 | -- | 2,040 | 48,000 | 418 | 48,500 |
| Kansas | 30,400 | -- | 30,400 | 2,690 | -- | 2,690 | 33,100 | -- | 33,100 |
| Kentucky | 39,000 | 45 | 39,000 | 7,660 | 6 | 7,670 | 46,600 | 51 | 46,700 |
| Louisiana | 32,600 | -- | 32,600 | 5,900 | 236 | 6,130 | 38,500 | 236 | 38,700 |
| Maine | 11,900 | -- | 11,900 | W | W | W | 11,900 | -- | 11,900 |
| Maryland | 29,200 | -- | 29,200 | W | -- | W | 29,200 | -- | 29,200 |
| Massachusetts | 24,900 | -- | 24,900 | -- | -- | -- | 24,900 | -- | 24,900 |
| Michigan | 124,000 | 31,100 | 155,000 | 6,210 | 37 | 6,250 | 130,000 | 31,100 | 162,000 |
| Minnesota | 148,000 | 66,900 | 215,000 | -- | -- | -- | 148,000 | 66,900 | 215,000 |
| Mississippi | 17,300 | -- | 17,300 | -- | -- | -- | 17,300 | -- | 17,300 |
| Missouri | 62,400 | 344 | 62,700 | 16,700 | 2,330 | 19,000 | 79,000 | 2,670 | 81,700 |
| Montana | 26,000 | 42,500 | 68,600 | 381 | 88 | 469 | 26,400 | 42,500 | 69,100 |
| Nebraska | 21,000 | -- | 21,000 | W | -- | W | 21,000 | -- | 21,000 |
| Nevada | 43,800 | 45,100 | 88,800 | 281 | 379 | 660 | 44,000 | 45,400 | 89,500 |
| New Hampshire | 7,640 | -- | 7,640 | -- | -- | -- | 7,640 | -- | 7,640 |
| New Jersey | 33,000 | -- | 33,000 | W | -- | W | 33,000 | -- | 33,000 |
| New Mexico | 51,500 | 157,000 | 208,000 | 22,800 | 1,910 | 24,700 | 74,200 | 158,000 | 233,000 |
| New York | 62,900 | 1,910 | 64,800 | 5,690 | 130 | 5,820 | 68,600 | 2,040 | 70,700 |
| North Carolina | 54,300 | 31,900 | 86,200 | -- | -- | -- | 54,300 | 31,900 | 86,200 |
| North Dakota | 5,890 | -- | 5,890 | -- | -- | -- | 5,890 | -- | 5,890 |
| Ohio | 94,200 | -- | 94,200 | 3,720 | 456 | 4,180 | 97,900 | 456 | 98,400 |
| Oklahoma | 35,600 | 13 | 35,600 | W | -- | W | 35,600 | 13 | 35,600 |
| Oregon | 38,200 | 1,660 | 39,800 | 2 | 4 | 6 | 38,200 | 1,670 | 39,800 |
| Pennsylvania | 81,400 | -- | 81,400 | 4,830 | 358 | 5,190 | 86,200 | 358 | 86,600 |
| Rhode Island | 3,150 | -- | 3,150 | -- | -- | -- | 3,150 | -- | 3,150 |
| South Carolina | 25,200 | -- | 25,200 | -- | -- | -- | 25,200 | -- | 25,200 |
| South Dakota | 9,780 | -- | 9,780 | W | W | W | 9,780 | -- | 9,780 |
| Tennessee | 57,000 | 11,000 | 68,000 | 7,840 | 1,300 | 9,140 | 64,800 | 12,300 | 77,100 |

See footnotes at end of table.

**Table 3.—Material handled at surface and underground mines (including sand and gravel and stone) in 1977, by State[1] —Continued**

(Thousand short tons)

| State | Surface | | | Underground | | | All mines[2] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Crude ore | Waste | Total[2] | Crude ore | Waste | Total[2] | Crude ore | Waste | Total |
| Texas | 131,000 | 7,920 | 139,000 | 941 | -- | 941 | 132,000 | 7,920 | 140,000 |
| Utah | 53,700 | 123,000 | 176,000 | 1,280 | 833 | 2,110 | 55,000 | 123,000 | 178,000 |
| Vermont | 6,770 | 683 | 7,450 | W | -- | W | 6,770 | 683 | 6,770 |
| Virginia | 52,100 | 24 | 52,100 | 1,680 | 19 | 1,700 | 53,700 | 43 | 53,800 |
| Washington | 31,300 | 12,600 | 43,900 | 212 | 49 | 261 | 31,600 | 12,700 | 44,200 |
| West Virginia | 14,000 | -- | 14,000 | 2,270 | -- | 2,270 | 16,300 | -- | 16,300 |
| Wisconsin | 53,500 | 7,270 | 60,700 | W | W | W | 53,500 | 7,270 | 60,700 |
| Wyoming | 20,100 | 165,000 | 185,000 | 12,100 | 5,330 | 17,400 | 32,100 | 170,000 | 202,000 |
| Undistributed[4] | 1,670 | 119,000 | 121,000 | 4,540 | 426 | 5,000 | 6,210 | 119,000 | 126,000 |
| Total[2] | 2,610,000 | 1,510,000 | 4,120,000 | 155,000 | 18,400 | 173,000 | 2,760,000 | 1,520,000 | 4,290,000 |

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes estimated data in table 2.

**Table 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1977**

(Value per ton)

| Ore | Surface | | | Underground | | | All mines | | |
|---|---|---|---|---|---|---|---|---|---|
| | Principal mineral product | By-product | Total | Principal mineral product | By-product | Total | Principal mineral product | By-product | Total |
| **METALS** | | | | | | | | | |
| Bauxite | $7.65 | $7.92 | $15.57 | -- | -- | -- | $7.65 | $7.92 | $15.57 |
| Copper | 7.26 | 1.03 | 8.29 | $10.01 | $1.06 | $11.07 | 7.57 | 1.04 | 8.61 |
| Gold: | | | | | | | | | |
| Lode | 14.97 | .27 | 15.24 | 29.99 | 1.03 | 31.02 | 20.62 | .55 | 21.17 |
| Placer | 1.26 | -- | 1.26 | -- | -- | -- | 1.26 | -- | 1.26 |
| Iron ore | 7.71 | -- | 7.71 | 16.36 | .32 | 16.68 | 8.05 | .01 | 8.06 |
| Lead | 15.72 | 10.24 | 25.96 | 33.53 | 12.42 | 45.95 | 33.52 | 12.42 | 45.94 |
| Mercury | 17.71 | -- | 17.71 | -- | -- | -- | 17.71 | -- | 17.71 |
| Silver | 10.52 | 4.75 | 15.27 | 73.21 | 13.53 | 86.74 | 54.26 | 10.88 | 65.14 |
| Titanium, ilmenite | .67 | .57 | 1.24 | -- | -- | -- | .67 | .57 | 1.24 |
| Uranium | 47.81 | -- | 47.81 | 49.73 | 5.72 | 55.45 | 48.76 | 2.84 | 51.60 |
| Zinc | W | W | W | 24.61 | 6.34 | 30.95 | 24.61 | 6.34 | 30.95 |
| Average[1] | 7.78 | .66 | 8.44 | 18.75 | 3.30 | 22.05 | 9.37 | 1.05 | 10.42 |
| **NONMETALS** | | | | | | | | | |
| Asbestos | 9.64 | -- | 9.64 | W | -- | W | 9.64 | -- | 9.64 |
| Barite | 7.86 | .01 | 7.87 | W | -- | W | 7.86 | .01 | 7.87 |
| Clays | 11.11 | -- | 11.11 | 12.29 | -- | 12.29 | 11.13 | -- | 11.13 |
| Diatomite | 36.65 | -- | 36.65 | -- | -- | -- | 36.65 | -- | 36.65 |
| Feldspar | 10.37 | .79 | 11.16 | W | -- | W | 10.37 | .79 | 11.16 |
| Fluorspar | 20.49 | -- | 20.49 | 30.87 | 7.35 | 38.22 | 29.47 | 6.36 | 35.83 |
| Gypsum | 4.91 | .13 | 5.04 | 6.44 | -- | 6.44 | 5.17 | .11 | 5.28 |
| Mica (scrap) | 5.84 | 1.15 | 6.99 | -- | -- | -- | 5.84 | 1.15 | 6.99 |
| Perlite | 13.89 | -- | 13.89 | -- | -- | -- | 13.89 | -- | 13.89 |
| Phosphate rock | 4.50 | .06 | 4.56 | W | -- | W | 4.50 | .06 | 4.56 |
| Potassium salts | 63.99 | -- | 63.99 | 8.83 | .06 | 8.89 | 8.86 | .06 | 8.92 |
| Pumice | 2.95 | -- | 2.95 | -- | -- | -- | 2.95 | -- | 2.95 |
| Salt | 3.29 | -- | 3.29 | 9.02 | 1.53 | 10.55 | 8.78 | 1.47 | 10.25 |
| Sand and gravel | 2.18 | -- | 2.18 | -- | -- | -- | 2.18 | -- | 2.18 |
| Sodium carbonate (natural) | -- | -- | -- | 28.07 | -- | 28.07 | 28.07 | -- | 28.07 |
| Stone: | | | | | | | | | |
| Crushed and broken | 2.43 | .01 | 2.44 | 3.15 | .01 | 3.16 | 2.46 | .01 | 2.47 |
| Dimension | 71.81 | -- | 71.81 | 204.03 | -- | 204.03 | 73.38 | -- | 73.38 |
| Talc, soapstone, pyrophyllite | 10.48 | -- | 10.48 | 11.74 | -- | 11.74 | 10.76 | -- | 10.76 |
| Average[1] | 2.95 | .03 | 2.98 | 9.60 | .34 | 9.94 | 3.20 | .04 | 3.24 |
| Average, metals and nonmetals[1] | 3.83 | .14 | 3.97 | 14.15 | 1.82 | 15.97 | 4.43 | .24 | 4.67 |
| Average, nonmetals (excluding stone and sand and gravel)[1] | 7.06 | .18 | 7.24 | 13.54 | .56 | 14.10 | 8.08 | .24 | 8.32 |
| Average, metals and nonmetals, (excluding stone and sand and gravel)[1] | 7.52 | .49 | 8.01 | 16.75 | 2.25 | 19.00 | 8.90 | .75 | 9.65 |

W Withheld to avoid disclosing company proprietary data; included in "Average."
[1]Includes withheld data.

**Table 5.—Crude ore and total material handled at surface and underground mines in 1977, by commodity**

(Percent)

| Commodity | Crude ore | | Total material | |
|---|---|---|---|---|
| | Surface | Underground | Surface | Underground |
| **METALS** | | | | |
| Antimony | W | [1]100.0 | W | [1]100.0 |
| Bauxite | 100.0 | -- | 100.0 | -- |
| Beryllium | 100.0 | -- | 100.0 | -- |
| Copper | 90.3 | 9.7 | 96.8 | 3.2 |
| Gold: | | | | |
| Lode | 63.4 | 36.6 | 90.0 | 10.0 |
| Placer | 100.0 | -- | 100.0 | -- |
| Iron ore | 96.0 | 4.0 | 97.6 | 2.4 |
| Lead | -- | 100.0 | -- | 100.0 |
| Manganiferous ore | 100.0 | -- | 100.0 | -- |
| Mercury | 100.0 | -- | 100.0 | -- |
| Molybdenum | 39.1 | 60.9 | 69.5 | 30.5 |
| Nickel | 100.0 | -- | 100.0 | -- |
| Rare-earth metals | 100.0 | -- | 100.0 | -- |
| Silver | 37.4 | 62.6 | 45.1 | 54.9 |
| Titanium, ilmenite | 100.0 | -- | 100.0 | -- |
| Tungsten | 57.3 | 42.7 | 46.2 | 53.8 |
| Uranium | 76.5 | 23.5 | 96.2 | 3.8 |
| Vanadium | 100.0 | -- | 100.0 | -- |
| Zinc | W | [1]100.0 | W | [1]100.0 |
| Total metals | 86.8 | 13.2 | 94.6 | 5.4 |
| **NONMETALS** | | | | |
| Aplite | 100.0 | -- | 100.0 | -- |
| Asbestos | [1]100.0 | W | [1]100.0 | W |
| Barite | [1]100.0 | W | [1]100.0 | W |
| Boron minerals | 100.0 | -- | 100.0 | -- |
| Clays | 98.4 | 1.6 | 98.4 | 1.6 |
| Diatomite | 100.0 | -- | 100.0 | -- |
| Emery | 100.0 | -- | 100.0 | -- |
| Feldspar | [1]100.0 | W | [1]100.0 | W |
| Fluorspar | 9.4 | 90.6 | 16.0 | 84.0 |
| Garnet | 100.0 | -- | 100.0 | -- |
| Graphite | 100.0 | -- | 100.0 | -- |
| Greensand marl | 100.0 | -- | 100.0 | -- |
| Gypsum | 82.4 | 17.6 | 89.7 | 10.3 |
| Iron oxide pigments (crude) | 100.0 | -- | 100.0 | -- |
| Kyanite | 100.0 | -- | 100.0 | -- |
| Lithium minerals | 100.0 | -- | 100.0 | -- |
| Magnesite | 100.0 | -- | 100.0 | -- |
| Mica (scrap) | 100.0 | -- | 100.0 | -- |
| Millstones | 100.0 | -- | 100.0 | -- |
| Olivine | 100.0 | -- | 100.0 | -- |
| Perlite | 100.0 | -- | 100.0 | -- |
| Phosphate rock | [1]100.0 | W | [1]100.0 | W |
| Potassium salts | -- | 100.0 | -- | 100.0 |
| Pumice | 100.0 | -- | 100.0 | -- |
| Salt | 4.1 | 95.9 | 3.9 | 96.1 |
| Sand and gravel | 100.0 | -- | 100.0 | -- |
| Sodium carbonate (natural) | -- | 100.0 | -- | 100.0 |
| Stone: | | | | |
| Crushed and broken | 96.7 | 3.3 | 96.7 | 3.3 |
| Dimension | 98.8 | 1.2 | 98.8 | 1.2 |
| Talc, soapstone, pyrophyllite | 77.8 | 22.2 | 89.8 | 10.2 |
| Tripoli | 42.6 | 57.4 | 47.5 | 52.5 |
| Vermiculite | 100.0 | -- | 100.0 | -- |
| Wollastonite | -- | 100.0 | -- | 100.0 |
| Total nonmetals | 96.4 | 3.6 | 96.6 | 3.4 |
| Grand total | 94.4 | 5.6 | 95.9 | 4.1 |

W Withheld to avoid disclosing company proprietary data; included with "Underground or Surface."
[1]Includes surface or underground; the Bureau of Mines is not at liberty to publish separately.

**Table 6.—Crude ore and total material handled at surface and underground mines in 1977, by State**

(Percent)

| State | Crude ore | | Total material | |
|---|---|---|---|---|
| | Surface | Underground | Surface | Underground |
| Alabama | [1]100 | W | [1]100 | W |
| Alaska | 100 | -- | 100 | -- |
| Arizona | 89 | 11 | 96 | 4 |
| Arkansas | 99 | 1 | 99 | 1 |
| California | 99 | 1 | 99 | 1 |
| Colorado | 69 | 31 | 73 | 27 |
| Connecticut | 100 | -- | 100 | -- |
| Delaware | 100 | -- | 100 | -- |
| Florida | 100 | -- | 100 | -- |
| Georgia | 99 | 1 | 99 | 1 |
| Hawaii | 100 | -- | 100 | -- |
| Idaho | 93 | 7 | 97 | 3 |
| Illinois | 97 | 3 | 97 | 3 |
| Indiana | 97 | 3 | 97 | 3 |
| Iowa | 96 | 4 | 96 | 4 |
| Kansas | 92 | 8 | 92 | 8 |
| Kentucky | 84 | 16 | 84 | 16 |
| Louisiana | 85 | 15 | 84 | 16 |
| Maine | [1]100 | W | [1]100 | W |
| Maryland | [1]100 | W | [1]100 | W |
| Massachusetts | 100 | -- | 100 | -- |
| Michigan | 95 | 5 | 96 | 4 |
| Minnesota | 100 | -- | 100 | -- |
| Mississippi | 100 | -- | 100 | -- |
| Missouri | 79 | 21 | 77 | 23 |
| Montana | 99 | 1 | 99 | 1 |
| Nebraska | [1]100 | W | [1]100 | W |
| Nevada | 99 | 1 | 99 | 1 |
| New Hampshire | 100 | -- | 100 | -- |
| New Jersey | 99 | 1 | 99 | 1 |
| New Mexico | 69 | 31 | 89 | 11 |
| New York | 92 | 8 | 92 | 8 |
| North Carolina | 100 | -- | 100 | -- |
| North Dakota | 100 | -- | 100 | -- |
| Ohio | 96 | 4 | 96 | 4 |
| Oklahoma | 97 | 3 | 97 | 3 |
| Oregon | 100 | -- | 100 | -- |
| Pennsylvania | 94 | 6 | 94 | 6 |
| Rhode Island | 100 | -- | 100 | -- |
| South Carolina | 100 | -- | 100 | -- |
| South Dakota | [1]100 | W | [1]100 | W |
| Tennessee | 88 | 12 | 88 | 12 |
| Texas | 99 | 1 | 99 | 1 |
| Utah | 98 | 2 | 99 | 1 |
| Vermont | [1]100 | W | [1]100 | W |
| Virginia | 97 | 3 | 97 | 3 |
| Washington | 99 | 1 | 99 | 1 |
| West Virginia | 86 | 14 | 86 | 14 |
| Wisconsin | [1]100 | W | [1]100 | W |
| Wyoming | 62 | 38 | 91 | 9 |
| Total | 94 | 6 | 96 | 4 |

W Withheld to avoid disclosing company proprietary data; included with "Surface."
[1]Includes underground; the Bureau of Mines is not at liberty to publish separately.

**Table 7.—Number of domestic metal and nonmetal mines in 1977, by commodity and magnitude of crude ore production[1]**

| Commodity | Total number of mines | Less than 1,000 tons | 1,000 to 10,000 tons | 10,000 to 100,000 tons | 100,000 to 1,000,000 tons | 1,000,000 to 10,000,000 tons | More than 10,000,000 tons |
|---|---|---|---|---|---|---|---|
| METALS | | | | | | | |
| Bauxite | 12 | -- | -- | 5 | 7 | -- | -- |
| Copper | 42 | 2 | -- | 2 | 7 | 20 | 11 |
| Gold: | | | | | | | |
| Lode | 43 | 25 | 7 | 5 | 4 | 2 | -- |
| Placer | 32 | 8 | 10 | 11 | 2 | 1 | -- |
| Iron ore | 53 | -- | 3 | 7 | 16 | 23 | 4 |
| Lead | 35 | 16 | 7 | -- | 7 | 5 | -- |
| Mercury | 5 | 4 | -- | -- | 1 | -- | -- |
| Silver | 43 | 24 | 6 | 8 | 5 | -- | -- |
| Titanium, ilmenite | 7 | -- | -- | -- | 1 | 6 | -- |
| Tungsten | 79 | 60 | 13 | 4 | 2 | -- | -- |
| Uranium | 236 | 50 | 99 | 64 | 20 | 3 | -- |
| Zinc | 32 | 2 | 4 | 3 | 22 | 1 | -- |
| Other[2] | 13 | 1 | 1 | 4 | 3 | 3 | 1 |
| Total metals | 632 | 192 | 150 | 113 | 97 | 64 | 16 |
| NONMETALS | | | | | | | |
| Abrasives[3] | 12 | -- | 5 | 6 | 1 | -- | -- |
| Asbestos | 4 | -- | -- | 1 | 2 | 1 | -- |
| Barite | 33 | 1 | 3 | 20 | 9 | -- | -- |
| Boron minerals | 3 | -- | -- | -- | 2 | 1 | -- |
| Clays | 1,075 | 52 | 270 | 620 | 133 | -- | -- |
| Diatomite | 13 | -- | 5 | 2 | 6 | -- | -- |
| Feldspar | 20 | -- | 7 | 8 | 5 | -- | -- |
| Fluorspar | 7 | -- | 3 | 2 | 2 | -- | -- |
| Gypsum | 69 | 3 | 5 | 17 | 44 | -- | -- |
| Mica (scrap) | 20 | 3 | 4 | 11 | 2 | -- | -- |
| Perlite | 12 | 1 | 3 | 6 | 2 | -- | -- |
| Phosphate rock | 44 | -- | 6 | 1 | 12 | 18 | 7 |
| Potassium salts | 8 | -- | -- | -- | 1 | 7 | -- |
| Pumice | 131 | 26 | 48 | 49 | 8 | -- | -- |
| Salt | 18 | -- | 1 | 2 | 8 | 7 | -- |
| Sand and gravel | 7,349 | 217 | 1,326 | 3,574 | 2,147 | 84 | 1 |
| Sodium carbonate (natural) | 4 | -- | -- | -- | 1 | 3 | -- |
| Stone: | | | | | | | |
| Crushed and broken | 4,840 | 446 | 815 | 1,696 | 1,725 | 157 | 1 |
| Dimension | 406 | 190 | 184 | 32 | -- | -- | -- |
| Talc, soapstone, pyrophyllite | 49 | 9 | 22 | 17 | 1 | -- | -- |
| Other[4] | 35 | 9 | 8 | 11 | 6 | 1 | -- |
| Total nonmetals | 14,152 | 957 | 2,715 | 6,075 | 4,117 | 279 | 9 |
| Grand total | 14,784 | 1,149 | 2,865 | 6,188 | 4,214 | 343 | 25 |

[1]Excludes wells, ponds, or pumping operations.
[2]Antimony, beryllium, manganiferous ore, molybdenum, nickel, rare-earth metals, and vanadium.
[3]Emery, garnet, and tripoli.
[4]Aplite, graphite, greensand marl, crude iron oxide pigments, kyanite, lithium minerals, magnesite, millstones, olivine, tube-mill liners, vermiculite, and wollastonite.

**Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1977, in order of output of crude ore**

| Mine | State | Operator | Commodity | Mining method |
|---|---|---|---|---|
| | | METALS | | |
| Utah Copper | Utah | Kennecott Copper Corp | Copper | Open pit. |
| Sierrita | Arizona | Duval Sierrita Corp | do | Do. |
| Minntac | Minnesota | United States Steel Corp | Iron ore | Do. |
| San Manuel | Arizona | Magma Copper Co | Copper | Do. |
| Climax | Colorado | Climax Molybdenum Co., a division of AMAX Inc. | Molybdenum | Caving and open pit. |
| Peter Mitchell | Minnesota | Reserve Mining Co | Iron ore | Open pit. |
| Morenci | Arizona | Phelps Dodge Corp | Copper | Do. |
| Berkeley Pit | Montana | The Anaconda Company | do | Do. |
| Erie Commercial | Minnesota | Pickands Mather & Co | Iron ore | Do. |
| Tyrone | New Mexico | Phelps Dodge Corp | Copper | Do. |
| Pima | Arizona | Cyprus Pima Mining Co | do | Do. |
| Pinto Valley | do | Cities Service Co | do | Do. |
| Empire | Michigan | Cleveland-Cliffs Iron Co | Iron ore | Do. |
| Twin Buttes | Arizona | Anamax Mining Co | Copper | Do. |
| Copper Canyon | Nevada | Pennzoil Co | do | Do. |
| Ray Pit | Arizona | Kennecott Copper Corp | do | Do. |
| Metcalf | do | Phelps Dodge Corp | do | Do. |
| St. Anthony | New Mexico | United Nuclear Corp | Uranium | Do. |
| Thunderbird | Minnesota | Oglebay Norton Co | Iron ore | Do. |
| Butler Project | do | Hanna Mining Co | do | Do. |
| Hibbing Taconite | do | Pickands Mather & Co | do | Do. |
| Eagle Mountain | California | Kaiser Steel Corp | do | Do. |
| Tilden | Michigan | Cleveland-Cliffs Iron Co | do | Do. |
| Trail Ridge | Florida | E. I. du Pont de Nemours & Co. | Titanium | Dredging. |
| Highland | do | do | do | Do. |
| | | NONMETALS | | |
| Suwannee | Florida | Occidental Petroleum Corp | Phosphate rock. | Open pit. |
| Noralyn | do | International Minerals & Chemical Corp. | do | Do. |
| Kingsford | do | do | do | Do. |
| Ft. Green | do | Continental Oil Co | do | Do. |
| Calcite | Michigan | United States Steel Corp | Stone | Open quarry. |
| Ft. Meade | Florida | Mobil Oil Corp | Phosphate rock. | Open pit. |
| Haynsworth | do | Brewster Phosphates | do | Do. |
| Payne Creek | do | Continental Oil Co | do | Do. |
| Clear Spring | do | International Minerals & Chemical Corp. | do | Do. |
| Thornton | Illinois | General Dynamics Corp | Stone | Open quarry. |
| Tampa Agricultural Chemical Operations. | Florida | Gardinier, Inc | Phosphate rock. | Open pit. |
| Hookers | do | W. R. Grace & Co | do | Do. |
| Rockland | do | United States Steel Corp | do | Do. |
| Feld | Texas | Texas Crushed Stone Co | Stone | Open quarry. |
| Lee Creek | North Carolina | Texasgulf Inc | Phosphate rock. | Open pit. |
| Bonny Lake | Florida | W. R. Grace & Co | do | Do. |
| Stoneport | Michigan | Presque Isle Corp | Stone | Open quarry. |
| Silver City | Florida | Swift Agricultural Chemicals Corp. | Phosphate rock. | Open pit. |
| Nichols | do | Mobil Oil Corp | do | Do. |
| Pennsuco | do | Maule Industries, Inc | Stone | Dredging. |
| International | New Mexico | International Minerals & Chemical Corp. | Potassium salts. | Open stopes. |
| Westvaco | Wyoming | FMC Corp | Sodium carbonate. | Artificial stopes. |
| Watson | Florida | Swift Agricultural Chemicals Corp. | Phosphate rock. | Open pit. |
| Beckman | Texas | McDonough Bros., Inc. | Stone | Open quarry. |
| McCook | Illinois | Vulcan Material Co | do | Do. |

[1]Brines and materials from wells excepted.

**Table 9.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1977, in order of output of total materials handled**

| Mine | State | Operator | Commodity | Mining method |
|---|---|---|---|---|
| | | METALS | | |
| Utah Copper | Utah | Kennecott Copper Corp | Copper | Open pit. |
| Sierrita | Arizona | Duval Sierrita Corp | do | Do. |
| Tyrone | New Mexico | Phelps Dodge Corp | do | Do. |
| Twin Buttes | Arizona | Anamax Mining Co | do | Do. |
| Berkeley Pit | Montana | The Anaconda Company | do | Do. |
| Eagle Mountain | California | Kaiser Steel Corp | Iron ore | Do. |
| Shirley Basin | Wyoming | Utah International Inc | Uranium | Do. |
| Morenci | Arizona | Phelps Dodge Corp | Copper | Do. |
| Pinto Valley | do | Cities Service Co | do | Do. |
| Ray Pit | do | Kennecott Copper Corp | do | Do. |
| Highland | Wyoming | Exxon Corp | Uranium | Do. |
| Pima | Arizona | Cyprus Pima Mining Co | Copper | Do. |
| Chino | New Mexico | Kennecott Copper Corp | do | Do. |
| Bagdad | Arizona | Cyprus Bagdad Copper Co | do | Do. |
| Bear Creek | Wyoming | Rocky Mountain Energy Co | Uranium | Do. |
| Climax | Colorado | Climax Molybdenum Co., a division of AMAX Inc. | Molybdenum | Caving and open pit. |
| Jackpile-Paquate | New Mexico | The Anaconda Company | Uranium | Open pit. |
| Hibbing Taconite | Minnesota | Pickands Mather & Co | Iron ore | Do. |
| Shirley Basin | Wyoming | Getty Oil Co | Uranium | Do. |
| Erie Commercial | Minnesota | Pickands Mather & Co | Iron ore | Do. |
| Minntac | do | United States Steel Corp | do | Do. |
| Metcalf | Arizona | Phelps Dodge Corp | Copper | Do. |
| Mitchell Pit | Minnesota | Reserve Mining Co | Iron ore | Do. |
| Empire | Michigan | Cleveland-Cliffs Iron Co | do | Do. |
| Ruth | Nevada | Kennecott Copper Corp | Copper | Do. |
| | | NONMETALS | | |
| Kingsford | Florida | International Minerals & Chemical Corp. | Phosphate rock. | Open pit. |
| Noralyn | do | do | do | Do. |
| Ft. Green | do | Continental Oil Co | do | Do. |
| Lee Creek | North Carolina | Texasgulf Inc | do | Do. |
| Payne Creek | Florida | Continental Oil Co | do | Do. |
| Haynsworth | do | Brewster Phosphates | do | Do. |
| Rockland | do | United States Steel Corp | do | Do. |
| Bonny Lake | do | W. R. Grace & Co | do | Do. |
| Ft. Meade | do | Mobil Oil Corp | do | Do. |
| Clear Spring | do | International Minerals & Chemical Corp. | do | Do. |
| Suwanee | do | Occidental Chemical Co | do | Do. |
| Lonesome | do | Brewster Phosphates | do | Do. |
| Tampa Agricultural Chemical Operations. | do | Gardinier, Inc | do | Do. |
| Hookers | do | W. R. Grace & Co | do | Do. |
| Nichols | do | Mobil Oil Corp | do | Do. |
| Silver City | do | Swift Agricultural Chemicals Corp. | do | Do. |
| Calcite | Michigan | United States Steel Corp | Stone | Open quarry. |
| Watson | Florida | Swift Agricultural Chemicals Corp. | Phosphate rock. | Open pit. |
| Conda | Idaho | J. R. Simplot Co | do | Do. |
| Westvaco | Wyoming | FMC Corp | Sodium carbonate. | Artificial stopes. |
| Gay | Idaho | J. R. Simplot Co | Phosphate rock. | Open pit. |
| Thornton | Illinois | General Dynamics Corp | Stone | Open quarry. |
| Vernal | Utah | Stauffer Chemical Co | Phosphate rock. | Do. |
| Wooley Valley | Idaho | do | do | Open pit. |
| Feld | Texas | Texas Crushed Stone Co | Stone | Open quarry. |

[1]Brines and materials from wells excepted.

**Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States in 1977, by commodity**

| Commodity | Unit of marketable product | Surface | | | Underground | | | Total[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ore treated (thousand short tons) | Marketable product (units) | Ratio of units of ore to units of marketable product | Ore treated (thousand short tons) | Marketable product (units) | Ratio of units of ore to units of marketable product | Ore treated (thousand short tons) | Marketable product (units) | Ratio of units of ore to units of marketable product |
| **METALS** | | | | | | | | | | |
| Bauxite | thousand long tons | 3,660 | 1,980 | 1.9:1 | -- | -- | -- | 3,660 | 1,980 | 1.9:1 |
| Copper | thousand short tons | 233,000 | 1,260 | 184.1:1 | 29,300 | 220 | 133.4:1 | 262,000 | 1,480 | 176.6:1 |
| Gold: | | | | | | | | | | |
| Lode | thousand troy ounces | 2,760 | 278 | 9.9:1 | 1,660 | 336 | 5.0:1 | 4,420 | 614 | 7.2:1 |
| Placer | do | 2,720 | 23 | 117.3:1 | -- | -- | -- | 2,720 | 23 | 117.3:1 |
| Iron ore | thousand long tons | 169,000 | 50,100 | 3.4:1 | 6,860 | 3,520 | 2.0:1 | 176,000 | 53,600 | 3.3:1 |
| Lead | thousand short tons | 5 | (2) | 39.0:1 | 9,870 | 539 | 18.3:1 | 9,870 | 539 | 18.3:1 |
| Mercury | thousand flasks | 216 | 28 | 7.7:1 | -- | -- | -- | 216 | 28 | 7.7:1 |
| Silver | thousand troy ounces | 406 | 926 | 0.4:1 | 938 | 14,900 | 0.1:1 | 1,340 | 15,800 | 0.1:1 |
| Titanium, ilmenite | thousand short tons | 37,400 | 542 | 68.9:1 | -- | -- | -- | 37,400 | 542 | 68.9:1 |
| Uranium | do | 6,020 | 7 | 826.2:1 | 5,930 | 7 | 794.3:1 | 11,900 | 15 | 810.1:1 |
| Zinc | do | W | W | W | 9,290 | 332 | 28.0:1 | 9,290 | 332 | 28.0:1 |
| **NONMETALS** | | | | | | | | | | |
| Asbestos | do | 2,570 | 101 | 25.4:1 | W | W | W | 2,570 | 101 | 25.4:1 |
| Barite | do | 3,770 | 1,480 | 2.5:1 | W | W | W | 3,770 | 1,480 | 2.5:1 |
| Clays | do | 47,800 | 47,800 | 1.0:1 | 753 | 753 | 1.0:1 | 48,600 | 48,600 | 1.0:1 |
| Diatomite | do | 1,740 | 648 | 2.7:1 | -- | -- | -- | 1,740 | 648 | 2.7:1 |
| Feldspar | do | 1,450 | 657 | 2.2:1 | W | W | W | 1,450 | 657 | 2.2:1 |
| Fluorspar | do | 76 | 26 | 2.9:1 | 484 | 143 | 3.4:1 | 559 | 169 | 3.3:1 |
| Gypsum | do | 11,900 | 10,800 | 1.1:1 | 2,450 | 2,590 | 1.0:1 | 14,400 | 13,400 | 1.1:1 |
| Mica (scrap) | do | 966 | 142 | 6.8:1 | -- | -- | -- | 966 | 142 | 6.8:1 |
| Perlite | do | 774 | 597 | 1.3:1 | -- | -- | -- | 774 | 597 | 1.3:1 |
| Phosphate rock | do | 182,000 | 51,900 | 3.5:1 | W | W | W | 182,000 | 51,900 | 3.5:1 |
| Potassium salts | do | W | W | W | 19,100 | 2,080 | 9.2:1 | 19,100 | 2,080 | 9.2:1 |
| Pumice | do | 4,060 | 4,010 | 1.0:1 | -- | -- | -- | 4,060 | 4,010 | 1.0:1 |
| Salt | do | 628 | 455 | 1.4:1 | 14,900 | 14,800 | 1.0:1 | 15,600 | 15,200 | 1.0:1 |
| Sand and gravel | do | 929,000 | 929,000 | 1.0:1 | -- | -- | -- | 929,000 | 929,000 | 1.0:1 |
| Sodium carbonate (natural) | do | -- | -- | -- | 11,400 | 5,960 | 1.9:1 | 11,400 | 5,960 | 1.9:1 |
| Stone: | | | | | | | | | | |
| Crushed and broken | do | 926,000 | 921,000 | 1.0:1 | 31,000 | 31,400 | 1.0:1 | 957,000 | 953,000 | 1.0:1 |
| Dimension | do | e3,070 | 1,400 | 2.2:1 | 17 | 17 | 1.0:1 | 3,090 | 1,420 | 2.2:1 |
| Talc, soapstone, pyrophyllite | do | 949 | 937 | 1.0:1 | 268 | 267 | 1.0:1 | 1,220 | 1,210 | 1.0:1 |

[e]Estimate. W Withheld to avoid disclosing company proprietary data.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

**Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States in 1977, by commodity**

| Commodity | Unit of marketable product | Surface | | | Underground | | | Total[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total material handled[2] (thousand short tons) | Marketable product (units) | Ratio of units of material handled to units of marketable product[3] | Total material handled[2] (thousand short tons) | Marketable product (units) | Ratio of units of material handled to units of marketable product[3] | Total material handled[2] (thousand short tons) | Marketable product (units) | Ratio of units of material handled to units of marketable product[3] |
| METALS | | | | | | | | | | |
| Bauxite | thousand long tons | 19,100 | 1,980 | 9.5:1 | -- | -- | -- | 19,100 | 1,980 | 9.5:1 |
| Copper | thousand short tons | 834,000 | 1,260 | 652.3:1 | 27,200 | 220 | 118.1:1 | 861,000 | 1,480 | 573.1:1 |
| Gold: | | | | | | | | | | |
| Lode | thousand troy ounces | 17,200 | 278 | 59.2:1 | 1,910 | 336 | 5.1:1 | 19,200 | 614 | 29.6:1 |
| Placer | do | 3,920 | 23 | 159.6:1 | (4) | -- | 0.0:1 | 3,920 | 23 | 159.6:1 |
| Iron ore | thousand long tons | 324,000 | 50,100 | 5.5:1 | 7,840 | 3,520 | 2.1:1 | 332,000 | 53,600 | 5.3:1 |
| Lead | thousand short tons | 3 | (4) | 24.8:1 | 12,100 | 539 | 19.1:1 | 12,100 | 539 | 19.1:1 |
| Mercury | thousand flasks | 1,120 | 28 | 39.6:1 | -- | -- | -- | 1,120 | 28 | 39.6:1 |
| Silver | thousand troy ounces | 1,170 | 926 | 0.6:1 | 1,430 | 14,900 | 0.1:1 | 2,600 | 15,800 | 0.1:1 |
| Titanium, ilmenite | thousand short tons | 37,900 | 542 | 69.8:1 | -- | -- | -- | 37,900 | 542 | 69.8:1 |
| Uranium | do | 244,000 | 7 | 24,386.6:1 | 9,570 | 7 | 1,006.6:1 | 253,000 | 15 | 12,553.9:1 |
| Zinc | do | W | W | W | 10,300 | 332 | 26.8:1 | 10,300 | 332 | 26.8:1 |
| NONMETALS | | | | | | | | | | |
| Asbestos | do | 6,430 | 101 | 32.0:1 | W | W | W | 6,430 | 101 | 32.0:1 |
| Barite | do | 4,410 | 1,480 | 3.0:1 | W | W | W | 4,410 | 1,480 | 3.0:1 |
| Clays | do | e89,300 | 47,800 | 1.9:1 | e764 | 753 | 1.0:1 | 90,100 | 48,600 | 1.9:1 |
| Diatomite | do | 6,680 | 648 | 10.3:1 | -- | -- | -- | 6,680 | 648 | 10.3:1 |
| Feldspar | do | 1,620 | 657 | 2.5:1 | W | W | W | 1,620 | 657 | 2.5:1 |
| Fluorspar | do | 111 | 26 | 4.3:1 | 584 | 143 | 3.8:1 | 695 | 169 | 3.9:1 |
| Gypsum | do | 21,500 | 10,800 | 1.4:1 | 2,450 | 2,590 | 1.0:1 | 23,900 | 13,400 | 1.3:1 |
| Mica (scrap) | do | 1,330 | 142 | 8.9:1 | -- | -- | -- | 1,330 | 142 | 8.9:1 |
| Perlite | do | 980 | 597 | 1.6:1 | -- | -- | -- | 980 | 597 | 1.6:1 |
| Phosphate rock | do | 510,000 | 51,900 | 9.6:1 | 182 | 162 | 1.0:1 | 510,000 | 52,100 | 9.6:1 |
| Potassium salts | do | -- | W | W | 19,200 | 2,080 | 9.2:1 | 19,200 | 2,080 | 9.2:1 |
| Pumice | do | 4,440 | 4,010 | 1.1:1 | -- | -- | -- | 4,440 | 4,010 | 1.1:1 |
| Salt | do | 624 | 455 | 1.4:1 | 15,200 | 14,800 | 1.0:1 | 15,800 | 15,200 | 1.0:1 |
| Sand and gravel | do | 929,000 | 929,000 | 1.0:1 | -- | -- | -- | 929,000 | 929,000 | 1.0:1 |
| Sodium carbonate (natural) | do | -- | -- | -- | 16,300 | 5,960 | 1.9:1 | 16,300 | 5,960 | 1.9:1 |
| Stone: | | | | | | | | | | |
| Crushed and broken | do | e998,000 | 921,000 | 1.1:1 | e31,200 | 31,400 | 1.0:1 | 1,030,000 | 953,000 | 1.1:1 |
| Dimension | do | e4,690 | 1,400 | 3.4:1 | 17 | 17 | 1.0:1 | 4,700 | 1,420 | 3.3:1 |
| Talc, soapstone, pyrophyllite | do | 3,380 | 937 | 3.4:1 | 383 | 267 | 1.4:1 | 3,760 | 1,210 | 3.0:1 |

e Estimate. W Withheld to avoid disclosing company proprietary data.
[1] Data may not add to totals shown because of independent rounding.
[2] Includes material from development and exploration activities.
[3] Material from development and exploration activities is excluded from the ratio calculation.
[4] Less than 1/2 unit.

**Table 12.—Mining methods used in open pit mining in 1977, by commodity**

(Percent)

| Commodity | Total material handled | |
|---|---|---|
| | Preceded by drilling and blasting | Not preceded by drilling and blasting[1] |
| **METALS** | | |
| Antimony | -- | 100 |
| Bauxite | 80 | 20 |
| Copper | 94 | 6 |
| Gold: | | |
| Lode | 100 | -- |
| Placer | -- | 100 |
| Iron ore | 91 | 9 |
| Lead | -- | 100 |
| Manganiferous ore | 98 | 2 |
| Mercury | -- | 100 |
| Molybdenum | 100 | -- |
| Nickel | 16 | 84 |
| Rare-earth metals | 100 | -- |
| Silver | 95 | 5 |
| Titanium, ilmenite | 2 | 98 |
| Tungsten | 2 | 98 |
| Uranium | 59 | 41 |
| Vanadium | 50 | 50 |
| Zinc | 100 | -- |
| **NONMETALS** | | |
| Aplite | 17 | 83 |
| Asbestos | 95 | 5 |
| Barite | 22 | 78 |
| Boron minerals | 100 | -- |
| Clays | -- | 100 |
| Diatomite | -- | 100 |
| Emery | 100 | -- |
| Feldspar | 84 | 16 |
| Fluorspar | 8 | 92 |
| Garnet | 92 | 8 |
| Graphite | -- | 100 |
| Greensand marl | -- | 100 |
| Gypsum | 87 | 13 |
| Iron oxide pigments (crude) | -- | 100 |
| Kyanite | 55 | 45 |
| Lithium minerals | 100 | -- |
| Magnesite | 100 | -- |
| Mica (scrap) | 29 | 71 |
| Millstones | 73 | 27 |
| Olivine | 63 | 37 |
| Perlite | 49 | 51 |
| Phosphate rock | 4 | 96 |
| Pumice | 3 | 97 |
| Salt | 100 | -- |
| Sand and gravel | -- | 100 |
| Stone: | | |
| Crushed and broken | 97 | 3 |
| Dimension | -- | 100 |
| Talc, soapstone, pyrophyllite | 79 | 21 |
| Tripoli | 100 | -- |
| Vermiculite | -- | 100 |
| Total | 55 | 45 |

[1]Includes drilling or cutting without blasting, dredging, mechanical excavation and nonfloat washing, and other surface mining methods.

**Table 13.—Exploration and development activity in the United States in 1977, by method**

| Method | Metals | | Nonmetals | | Total[1] | |
|---|---|---|---|---|---|---|
| | Feet | Percent of total[2] | Feet | Percent of total[2] | Feet | Percent of total[2] |
| DEVELOPMENT | | | | | | |
| Shaft and winze sinking | 19,400 | 0.6 | 125 | (3) | 19,500 | 0.5 |
| Raising | 131,000 | 3.9 | 1,310 | 0.2 | 132,000 | 3.3 |
| Drifting, crosscutting, or tunneling | 958,000 | 28.7 | 629,000 | 99.8 | 1,590,000 | 40.0 |
| Solution mining | 2,220,000 | 66.8 | -- | -- | 2,220,000 | 56.2 |
| Total[1] | 3,330,000 | 100.0 | 630,000 | 100.0 | 3,960,000 | 100.0 |
| EXPLORATION | | | | | | |
| Diamond drilling | 1,470,000 | 7.0 | 196,000 | 53.8 | 1,660,000 | 7.8 |
| Churn drilling | 116,000 | .6 | 20,000 | 5.5 | 136,000 | .6 |
| Rotary drilling | 13,200,000 | 63.0 | 140,000 | 38.3 | 13,300,000 | 62.6 |
| Percussion drilling | 5,330,000 | 25.5 | 7,370 | 2.0 | 5,330,000 | 25.1 |
| Other drilling | 755,000 | 3.6 | 745 | .2 | 756,000 | 3.6 |
| Trenching | 52,900 | .3 | 900 | .2 | 53,800 | .3 |
| Total[1] | 20,900,000 | 100.0 | 365,000 | 100.0 | 21,200,000 | 100.0 |
| Grand total[1] | 24,200,000 | XX | 995,000 | XX | 25,200,000 | XX |

XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Based on unrounded footage.
[3]Less than 1/2 of 1%.

**Table 14.—Exploration and development in 1977, by method and selected metals and nonmetals**

(Feet)

| Commodity | Development | | | | | Exploration | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Solution mining | Shaft and winze sinking | Raising | Drifting, cross-cutting, or tunneling | Total[1] | Diamond drilling | Churn drilling | Rotary drilling | Percussion drilling | Other drilling | Trenching | Total[1] |
| **METALS** | | | | | | | | | | | | |
| Bauxite | -- | -- | -- | -- | -- | -- | 28,300 | 425,000 | -- | 262,000 | -- | 716,000 |
| Copper | W | 6,710 | 49,100 | 96,600 | 153,000 | 326,000 | 8,000 | 52,800 | 12,600 | 38,100 | 4,050 | 442,000 |
| Gold | -- | 1,000 | 11,800 | 52,800 | 65,600 | 93,500 | 3,400 | 37,600 | 4,080,000 | 47,200 | 37,800 | 4,290,000 |
| Iron ore | -- | 106 | 80 | 28,700 | 28,800 | 45,600 | -- | 13,100 | 26,100 | 379 | -- | 85,100 |
| Lead | -- | 174 | 6,480 | 53,300 | 59,900 | 197,000 | 76,200 | 22,700 | 67,100 | 117,000 | -- | 480,000 |
| Molybdenum | -- | -- | W | W | W | 145,000 | -- | 2,250 | -- | -- | -- | 147,000 |
| Nickel | -- | -- | -- | -- | -- | 8,060 | 225 | -- | -- | -- | -- | 8,280 |
| Silver | -- | 186 | 7,380 | 43,200 | 50,800 | 35,300 | -- | 11,100 | 11,500 | 2,930 | 5,560 | 66,400 |
| Tungsten | -- | 777 | 4,970 | 24,100 | 29,800 | 37,900 | -- | 24,900 | 6,860 | 5,430 | 2,310 | 77,400 |
| Uranium | 870,000 | 7,780 | 28,300 | 492,000 | 1,400,000 | 291,000 | -- | 12,500,000 | 991,000 | 270,000 | 3,150 | 14,100,000 |
| Zinc | -- | 2,670 | 12,700 | 104,000 | 119,000 | 285,000 | -- | 48,400 | 134,000 | 9,790 | -- | 476,000 |
| Other[2] | 1,350,000 | -- | 10,000 | 62,500 | 1,420,000 | -- | -- | 8,860 | 1,650 | 1,800 | -- | 12,300 |
| Total[1] | 2,220,000 | 19,400 | 131,000 | 958,000 | 3,330,000 | 1,470,000 | 116,000 | 13,200,000 | 5,330,000 | 755,000 | 52,900 | 20,900,000 |
| **NONMETALS** | | | | | | | | | | | | |
| Barite | -- | -- | -- | -- | -- | 300 | 20,000 | 2,700 | 4,520 | -- | 900 | 28,400 |
| Fluorspar | -- | 125 | 950 | 3,170 | 4,250 | 179,000 | -- | 200 | 300 | -- | -- | 180,000 |
| Phosphate rock | -- | -- | -- | 7,290 | 7,290 | 726 | -- | 79,500 | -- | 15 | -- | 80,200 |
| Talc, soapstone, pyrophyllite | -- | -- | 237 | 197 | 434 | -- | -- | -- | W | W | -- | W |
| Other[3] | -- | -- | 120 | 618,000 | 618,000 | 16,100 | -- | 57,600 | 2,650 | 730 | -- | 77,000 |
| Total[1] | -- | 125 | 1,310 | 629,000 | 630,000 | 196,000 | 20,000 | 140,000 | 7,470 | 745 | 900 | 365,000 |
| Grand total[1] | 2,220,000 | 19,500 | 132,000 | 1,590,000 | 3,960,000 | 1,660,000 | 136,000 | 13,300,000 | 5,330,000 | 756,000 | 53,800 | 21,200,000 |

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.
[2]Antimony, beryllium, molybdenum, and platinum group metals.
[3]Asbestos, boron, diatomite, gypsum, millstones, potassium salts, pumice, salt, (natural) sodium carbonate, and (crushed and broken) stone.

## Table 15.—Exploration and development in 1977, by method and State

(Feet)

| State | Development | | | | | Exploration | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Solution mining | Shaft and winze sinking | Raising | Drifting, cross-cutting, or tunneling | Total[1] | Diamond drilling | Churn drilling | Rotary drilling | Percussion drilling | Other drilling | Trenching | Total[1] |
| Alaska | -- | 800 | -- | -- | 800 | 25,900 | 3,220 | -- | -- | 120 | 4,770 | 34,000 |
| Arizona | W | 1,270 | 47,600 | 85,800 | 135,000 | 116,000 | 8,000 | 115,000 | 11,600 | 39,700 | 6,100 | 296,000 |
| California | -- | 223 | 3,630 | 10,600 | 14,500 | 10,900 | 20,200 | 29,400 | 2,250 | 12,300 | 1,880 | 77,000 |
| Colorado | -- | 4,180 | 18,500 | 170,000 | 193,000 | 332,000 | -- | 1,590,000 | 290,000 | 613 | 155 | 2,210,000 |
| Florida | -- | -- | -- | -- | -- | -- | -- | 38,200 | -- | 15 | -- | 38,200 |
| Georgia | -- | -- | -- | -- | -- | 1,930 | -- | 3,540 | -- | 55,000 | -- | 60,500 |
| Idaho | -- | 388 | 11,000 | 31,100 | 42,500 | 38,000 | -- | 14,500 | 12,000 | 2,800 | 1,160 | 68,400 |
| Maine | -- | -- | -- | W | W | 25,700 | -- | -- | -- | -- | -- | 25,700 |
| Michigan | -- | -- | -- | 4,540 | 4,540 | 9,610 | -- | -- | -- | -- | -- | 9,610 |
| Minnesota | -- | -- | -- | -- | -- | 7,680 | -- | -- | -- | -- | -- | 7,680 |
| Missouri | -- | -- | 448 | 50,000 | 50,500 | 144,000 | 76,200 | 8,070 | 26,100 | 117,000 | -- | 372,000 |
| Montana | -- | 127 | 35 | 12,000 | 12,200 | 52,000 | -- | 55,300 | 5,110 | -- | 5,130 | 118,000 |
| Nevada | -- | 760 | 1,870 | 24,100 | 26,700 | 48,900 | -- | 63,200 | 103,000 | 50,000 | 29,100 | 294,000 |
| New Mexico | -- | 3,620 | 14,300 | 302,000 | 320,000 | 91,700 | 170 | 3,660,000 | 614,000 | 259,000 | 2,300 | 4,620,000 |
| New York | -- | -- | 7,040 | 42,800 | 49,800 | W | -- | -- | -- | -- | -- | W |
| North Dakota | -- | -- | -- | -- | -- | -- | -- | 35,400 | -- | -- | -- | 35,400 |
| Oregon | -- | 5 | 200 | 710 | 915 | 12,000 | -- | -- | 40 | 700 | 65 | 12,800 |
| South Dakota | -- | -- | W | W | W | 74,700 | -- | 919,000 | 3,970,000 | -- | -- | 4,970,000 |
| Tennessee | -- | 2,480 | 1,260 | 41,400 | 45,100 | 133,000 | -- | 33,500 | 92,800 | -- | -- | 259,000 |
| Texas | W | -- | -- | -- | W | 2,410 | -- | 1,120,000 | -- | -- | -- | 1,120,000 |
| Utah | -- | 5,460 | 6,150 | 66,600 | 78,200 | 83,800 | -- | 769,000 | 149,000 | 1,700 | 2,650 | 1,010,000 |
| Washington | -- | -- | 343 | 1,080 | 1,430 | 59,900 | -- | 7,440 | 14,700 | -- | -- | 82,000 |
| Wisconsin | -- | -- | -- | W | W | 28,900 | -- | -- | -- | 9,790 | -- | 38,700 |
| Wyoming | W | -- | 4,070 | 654,000 | 660,000 | 11,800 | -- | 2,820,000 | 1,200 | -- | 502 | 2,840,000 |
| Undistributed[2] | 2,220,000 | 231 | 15,000 | 84,900 | 2,320,000 | 351,000 | 28,200 | 2,010,000 | 38,600 | 207,000 | -- | 2,630,000 |
| Total[1] | 2,220,000 | 19,500 | 132,000 | 1,590,000 | 3,960,000 | 1,660,000 | 136,000 | 13,300,000 | 5,330,000 | 756,000 | 53,800 | 21,200,000 |

W Withheld to avoid disclosing company proprietary data; included in "Undistributed."

[1]Data may not add to totals shown because of independent rounding.

[2]Alabama, Arkansas, Illinois, Kansas, Kentucky, Louisiana, New Hampshire, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Virginia, and items indicated by symbol W.

**Table 16.—Total material (ore and waste) produced by mine development in the United States in 1977, by commodity and State**

(Thousand short tons)

| | Shaft and winze sinking | Raising | Drifting, crosscutting, or tunneling | Stripping | Total[1] |
|---|---|---|---|---|---|
| **COMMODITY** | | | | | |
| METALS | | | | | |
| Copper | 245 | 100 | 1,010 | 10,300 | 11,600 |
| Gold: | | | | | |
| Lode | 1 | 43 | 168 | 795 | 1,010 |
| Placer | (2) | -- | (2) | 272 | 272 |
| Iron ore | 4 | (2) | 437 | 49,300 | 49,700 |
| Lead | 2 | 20 | 1,790 | (2) | 1,810 |
| Silver | 1 | 41 | 178 | 606 | 825 |
| Tungsten | 2 | 14 | 242 | (2) | 258 |
| Uranium | 57 | 94 | 1,930 | 66,300 | 68,400 |
| Zinc | 41 | 19 | 1,330 | 95 | 1,490 |
| Other[3] | -- | 29 | 545 | 292 | 866 |
| Total metals[1] | 352 | 358 | 7,620 | 128,000 | 136,000 |
| NONMETALS | | | | | |
| Fluorspar | 2 | 4 | 34 | -- | 40 |
| Gypsum | -- | -- | -- | 6,790 | 6,790 |
| Phosphate rock | -- | -- | 20 | 10,200 | 10,200 |
| Pumice | -- | -- | -- | 195 | 195 |
| Salt | -- | -- | 151 | -- | 151 |
| Talc, soapstone, pyrophyllite | -- | 1 | 1 | 196 | 198 |
| Other[4] | -- | (2) | 5,000 | 3,300 | 8,300 |
| Total nonmetals[1] | 2 | 7 | 5,240 | 20,700 | 25,900 |
| Grand total[1] | 354 | 365 | 12,800 | 149,000 | 162,000 |
| **STATE** | | | | | |
| Alabama | -- | -- | -- | W | W |
| Alaska | -- | -- | -- | 251 | 251 |
| Arizona | 45 | 93 | 912 | 7,010 | 8,060 |
| California | 1 | 10 | 70 | 4,630 | 4,710 |
| Colorado | 28 | 53 | 991 | 105 | 1,180 |
| Idaho | 3 | 55 | 205 | 4,260 | 4,530 |
| Illinois | W | W | W | -- | W |
| Iowa | -- | -- | -- | W | W |
| Kentucky | W | -- | W | -- | W |
| Louisiana | -- | -- | W | -- | W |
| Maine | -- | -- | W | -- | W |
| Michigan | -- | -- | 37 | 17,500 | 17,500 |
| Minnesota | -- | -- | -- | 30,800 | 30,800 |
| Missouri | -- | 3 | 1,960 | -- | 1,960 |
| Montana | 1 | (2) | 52 | 641 | 694 |
| Nevada | 2 | 7 | 255 | 3,610 | 3,880 |
| New Mexico | 38 | 57 | 1,140 | 2,620 | 3,850 |
| New York | -- | 3 | 127 | 1,550 | 1,680 |
| Ohio | -- | -- | W | -- | W |
| Oklahoma | -- | -- | -- | W | W |
| Oregon | (2) | 1 | 3 | 59 | 63 |
| Pennsylvania | W | W | W | -- | W |
| South Dakota | -- | W | W | -- | W |
| Tennessee | 39 | 4 | 1,060 | 66 | 1,170 |
| Texas | -- | -- | -- | 4,180 | 4,180 |
| Utah | 191 | 22 | 347 | 4,530 | 5,090 |
| Virginia | -- | W | W | W | W |
| Washington | -- | 1 | 23 | 5,990 | 6,020 |
| Wisconsin | -- | -- | W | -- | W |
| Wyoming | -- | 6 | 5,220 | 60,070 | 65,300 |
| Undistributed | 10 | 50 | 423 | 733 | 1,210 |
| Total[1] | 354 | 365 | 12,800 | 149,000 | 162,000 |

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Antimony, bauxite, beryllium, and molybdenum.
[4]Asbestos, barite, garnet, mica (scrap), perlite, natural sodium carbonate, tripoli, and tube-mill liners.

## Table 17.—U.S. industrial consumption of explosives

(Thousand pounds)

| Year | Coal mining | Metal mining | Quarrying and nonmetal mining | Total mineral industry | Other | Total industrial |
|---|---|---|---|---|---|---|
| 1972 | 1,212,585 | 430,686 | 493,677 | 2,136,948 | 532,841 | 2,669,789 |
| 1973 | 1,177,062 | 495,879 | 643,292 | 2,316,233 | 438,713 | 2,754,946 |
| 1974 | 1,186,614 | 465,490 | 551,380 | 2,203,484 | 558,806 | 2,762,290 |
| 1975 | 1,652,251 | 449,271 | 493,125 | 2,594,647 | 524,380 | 3,119,027 |
| 1976 | 1,798,873 | 488,653 | 493,656 | 2,781,182 | 547,347 | 3,328,529 |
| 1977 | [1]2,093,312 | 446,406 | 522,678 | [1]3,062,396 | 647,354 | 3,709,750 |

[1]Data not comparable to prior years due to change in reporting by the Institute of Makers of Explosives.

## Table 18.—U.S. consumption of explosives in the minerals industry

(Thousand pounds)

| Year | Coal mining | Metal mining | Quarrying and nonmetal mining | Total |
|---|---|---|---|---|
| PERMISSIBLE EXPLOSIVES | | | | |
| 1975 | 41,996 | 241 | 1,083 | 43,320 |
| 1976 | 41,123 | 204 | 1,090 | 42,417 |
| 1977 | 46,663 | 225 | 694 | 47,582 |
| OTHER HIGH EXPLOSIVES | | | | |
| 1975 | 36,875 | 25,118 | 74,796 | 136,789 |
| 1976 | 34,521 | 24,265 | 65,891 | 124,677 |
| 1977 | 34,407 | 25,174 | 63,378 | 122,959 |
| CYLINDRICALLY PACKED BLASTING AGENTS | | | | |
| 1975 | 286,608 | 4,845 | 28,551 | 320,004 |
| 1976 | 269,778 | 3,471 | 65,922 | 339,171 |
| 1977 | 634,283 | 59,059 | 189,266 | [1]882,608 |
| PACKAGED AND BULK WATER GELS AND SLURRIES | | | | |
| 1975 | 24,118 | 181,809 | 73,872 | 279,799 |
| 1976 | 30,871 | 205,429 | 74,176 | 310,476 |
| 1977 | 42,406 | 154,704 | 75,062 | 272,172 |
| OTHER PROCESSED BLASTING AGENTS AND UNPROCESSED AMMONIUM NITRATE | | | | |
| 1975 | 1,262,654 | 237,258 | 314,823 | 1,814,735 |
| 1976 | 1,422,580 | 255,284 | 286,577 | 1,964,441 |
| 1977 | 1,335,553 | 207,244 | 194,278 | [1]1,737,075 |
| TOTAL EXPLOSIVES | | | | |
| 1975 | 1,652,251 | 449,271 | 493,125 | 2,594,647 |
| 1976 | 1,798,873 | 488,653 | 493,656 | 2,781,182 |
| 1977 | 2,093,312 | 446,406 | 522,678 | [1]3,062,396 |

[1]Data not comparable to prior years due to change in reporting by the Institute of Makers of Explosives.