Minor Nonmetals

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ASPHALT (NATIVE)[1]

Native asphalt was produced in 1978-79 by six companies in four States. Leading States were Texas and Utah. Output increased 37% in 1978 to 1.7 million tons and decreased 5% in 1979 to 1.6 million tons while value increased 39% in 1978 to $19.3 million and 33% in 1979 to $25.6 million.

Bituminous limestone was produced by Whites Uvalde Mines and by Uvalde Rock Asphalt Co. in Uvalde County, Tex.; by Southern Stone Co. in Colbert, Ala.; and by Barton County Rock Asphalt Co. in Barton County, Mo. The product was used mainly in street and road repair.

Gilsonite was produced by American Gilsonite Co. in Uinta County, Utah, and by Ziegler Chemical and Mineral Corp. in Weber County, Utah. This material was used for purposes other than road repair.

GREENSAND[2]

Greensand (glauconite) was produced in 1978-79 only by the Inversand Co., a subsidiary of Hungerford and Terry Inc., near Clayton, N.J. Production and sales information is withheld to avoid disclosing company proprietary data.

Raw greensand produced by the company was sold for agricultural use as a soil conditioner. It contains both potassium and phosphorus. Processed greensand was sold as a filter media for the removal of manganese, iron, sulfide, and other elements from water.

IODINE[3]

U.S. demand for crude iodine in 1978 and 1979 was satisfied in part by increased domestic production and withdrawals from the surplus world supply accumulated in prior years. By 1979, however, the iodine market was becoming unbalanced with demand exceeding supply. During the 2-year period, the quoted price of crude product was raised five times, and reached $4.54 per pound by yearend 1979. Faced with rising prices and the possibility of shortages, U.S. chemical companies stockpiled iodine supplies in 1978 for consumption in 1979 and future years.

The two U.S. producers of crude iodine increased output to record high levels, but U.S. capacity was less than one-fourth of domestic requirements. Japan, which was by far the largest producer of iodine, and Chile were the major sources of supply to U.S. and world markets; however, difficulties with subsidence, drought, inflation of costs, and the weakness of the U.S. dollar relative to the yen had a detrimental effect on Japanese iodine production. Japanese plants were operating substantially below theoretical capacity. Although Chilean output increased in 1978 and 1979, Chilean capacity was insufficient to maintain the balance in supply and demand.

Legislation and Government Programs.—On December 31, 1978 and 1979, the U.S. Government strategic stockpile showed an inventory of 8,010,000 pounds of crude iodine. The stockpile inventory goal was established at 3,333,000 pounds in 1976. None of the excess of 4,677,000 pounds has been authorized for disposal.

The depletion allowance for iodine remained at 14% of gross income, and may not exceed 50% of net income without the depletion deduction.

Domestic Production.—In 1978, its second year of production, Woodward Iodine Operations of Woodward, Okla., increased output and sales 75%. In 1979, output and sales increased 7%. Woodward Iodine is a joint venture between Amoco Production Co. (49%) and PPG Industries, Inc. (51%). The operation is unique in comparison with iodine operations in Michigan, Chile, and Japan because iodine is the only commercial product. Amoco operates wells that pump brines and natural gas to the PPG plant where iodine of greater than 99.9% purity is recovered by the conventional vapor stripping process with incorporated proprietary refinements. To date, iodine output has not approached the design capacity of 2 million pounds per year. In 1979, strong demand and some operational difficulties that limited output forced PPG, which also markets iodine, to allocate supplies to customers. PPG introduced a United States Pharmacopeia (U.S.P.) grade product to the market in 1979, but sales were minimal because most of its iodine production was needed to supply crude iodine customers.

The Dow Chemical Co. recovered iodine as a coproduct of bromine, calcium and magnesium compounds, and potash from subterranean brines at Midland, Mich. Dow's iodine production increased in 1978 and also in 1979. Reported capacity for iodine extraction was 500,000 pounds.[4] Most, if not all, of the Dow product was retained for captive use.

Consumption and Uses.—According to the Bureau of Mines canvass for 1978, crude iodine was consumed by 30 plants in 14 States. Seventeen of the plants, which were located in the leading consumer States of Missouri, Georgia, Pennsylvania, New Jersey, and California (in decreasing magnitude of consumption), accounted for 80% of the total reported iodine consumption.

The 1979 Bureau of Mines canvass indicated a decline in crude iodine consumed in 31 plants in 14 States. Eighteen of these plants, which were located in the leading consumer States of Missouri, Pennsylvania, New Jersey, California, and Georgia (in decreasing magnitude of consumption), accounted for 86% of the total reported iodine consumption. Comparison of the 1979 canvass with 1978 figures showed a decrease in consumption of crude iodine for making both organic and inorganic iodine compounds and resublimed iodine.

While the canvass information indicates a general consumption pattern, establishing an accurate pattern of demand by end use is difficult because iodine is frequently converted into intermediate compounds and marketed as such before reaching its ultimate end use. Moreover, iodine and iodides used in catalytic and other dissipative processes are not well covered. This situation has been revealed consistently in recent years by import figures that exceeded reported consumption figures; in 1978 and 1979, crude iodine imports exceeded reported consumption by 437,000 pounds and 301,000 pounds, respectively. Combining imports with domestic production, estimated exports, and consumer inventory accumulations, apparent consumption in 1978 was about 8.1 million pounds. In 1979, despite fewer iodine imports, apparent consumption rose to 8.7 million pounds. Substantial withdrawals from consumer company inventories and greater domestic production were responsible for the increase in apparent consumption.

The major downstream uses for iodine in 1978 were estimated as follows: Catalysts (for synthetic rubber, stabilized rosin, tall oil, and other uses), estimated at 21%; animal feed supplements (mainly for cattle), 21%; inks and colorants, 16%; stabilizers (as in nylon precursors), 14%; pharmaceuticals, 12%; sanitary and industrial disinfectants, 7%; photographic film, 4%; and other uses, 5%. Other uses includes the making of high-purity metals, motor fuels, iodized salt, smog inhibitors, and lubricants. Iodine also has application in cloud seeding and radiopaque diagnosis in medicine. The end uses for iodine that appeared to have experi-

Table 1.—Crude iodine consumed in the United States

Products	1977			1978			1979		
	Number of plants	Consumption		Number of plants	Consumption		Number of plants	Consumption	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Reported consumption:									
Resublimed iodine	6	506	9	9	639	10	12	635	11
Potassium iodide	7	1,237	21	11	1,279	20	9	1,155	19
Sodium iodide	4	77	1	4	117	2	4	113	2
Other inorganic compounds	14	1,705	29	11	2,052	32	18	1,791	30
Organic compounds	20	2,376	40	14	2,315	36	15	2,235	38
Total	[1]31	[2]5,900	100	[1]30	[2]6,400	100	[1]31	[2]5,900	100
Apparent consumption	XX	8,600	XX	XX	8,100	XX	XX	8,700	XX

XX Not applicable.
[1]Nonadditive total because some plants produce more than one product.
[2]Data may not add to total shown because of independent rounding.

enced significant growth in 1978 were animal feed supplements and inks and colorants.

The major downstream uses for iodine in 1979 were estimated as follows: Catalysts (25%), animal feed additives (21%), pharmaceuticals (15%), sanitary preparations (11%), stabilizers (10%), inks and colorants (7%), photography (4%), and other (7%). Use of iodine for sanitation purposes increased rapidly. Although most categories of consumption continued to grow in 1979, a dramatic decrease in demand for crude iodine occurred in the inks and colorants category as rising iodine prices increased the attractiveness of substitute chemicals.

Prices.—The quoted price at the beginning of 1978 of $2.31 per pound of crude iodine was raised twice during the year, first to $2.59, then to $3.10. Additional increases to $3.63, $4.03, and $4.54 followed in 1979. In one instance in 1979, the major marketer of U.S.-produced iodine, PPG Industries, initiated the price increase. This was a departure from past price changes, which have traditionally been announced first by the Japanese Iodine Exporters Association.

Rising demand and production costs, and the deteriorating relationship of the dollar to the yen were significant factors affecting price in 1978-79, although the dollar-yen situation improved in 1979. Discounted sales prices for quantity purchases increased also. As the leading vendor of crude iodine in world markets, Japan exemplified this upward trend in discount prices. Exports of Japanese iodine had an average value of $2.20 per pound in 1978 and $3.04 per pound in 1979. Owing to the availability of improved information, the 1978 figure was revised from a previously reported figure.

Table 2.—Quoted prices of elemental iodine and selected iodine compounds[1]

	Value per pound, Dec. 31	
	1978	1979
Iodine, crude, drums	[2]$3.10	$4.54
Resublimed iodine, U.S.P., granular, 100-pound drums, works	5.86	7.24
Calcium iodate, drums, delivered	3.32	3.32
Calcium iodide, 35-pound drums, works	5.98	5.98
Potassium iodide, U.S.P., granular, crystals, drums, 1,000-pound lots, delivered	4.18	5.32
Sodium iodide, U.S.P., crystals, 300- to 500-pound lots, drums, freight equalized	6.16	7.41
Iodoform, N.F., 300-pound drums, f.o.b. works	$7.75-14.30	$7.75-14.30

[1]Conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and/or somewhat different price quotations.
[2]Chemical Marketing Reporter, V. 214, No. 21, Nov. 20, 1978, p. 24.

Source: Chemical Marketing Reporter, v. 215, No. 1, Jan. 1, 1979, pp. 46-55, and V. 216, No. 27, Dec. 31, 1979, pp. 26-35.

Foreign Trade.—The quantity of U.S. imports of crude iodine in 1979 was less than imports in 1978, while the total value was higher. The increase in the average U.S. Customs declared value from $2.14 per pound in 1978 to $2.98 per pound in 1979 reflected the growth in iodine prices. Imports of Japanese iodine declined from 1978 to 1979, whereas imports of Chilean iodine increased. In addition, small quantities of iodine were imported in 1979 from nontraditional sources.

Imports of resublimed iodine, mostly from Japan, amounted to 83,613 pounds in 1978 and 21,773 pounds in 1979.

Tariff rates were 8 cents per pound on resublimed iodine and 12 cents per pound on potassium iodide. Crude iodine enters the United States duty free.

Table 3.—U.S. imports for consumption of crude iodine, by country

(Thousand pounds and thousand dollars)

Country	1977		1978		1979	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	7	4	--	--	--	--
Chile	1,543	2,860	1,102	2,425	1,342	4,314
Indonesia	--	--	--	--	13	40
Japan	5,390	r10,968	5,734	12,208	4,838	14,073
Mexico	--	--	--	--	1	2
United Kingdom	--	--	--	--	7	25
Total[1]	6,940	13,831	6,837	14,633	6,201	18,454

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

Source: U.S. Department of Commerce, Bureau of the Census.

World Review.—Iodine producing nations include Japan, Chile, the United States, the U.S.S.R., China, and Indonesia.

Chile.—Although the 1978 devaluation of the Chilean peso with respect to the U.S. dollar placed the Chilean iodine producer in a more secure position than that of Japanese producers, price increases initiated by Japanese marketers were followed by Chilean marketers.

Iodine is a byproduct of potassium and sodium nitrates extracted from Chile's caliche deposits. The Government-owned mining concern, Sociedad Quimica y Minera de Chile S.A. (SOQUIMICH), produced nitrates and iodine from three mines and plants: Pedro de Valdivia, Maria Elena, and Victoria. According to a SOQUIMICH spokesman, iodine production goals for 1979 were 2.6 million pounds at Pedro de Valdivia, 1.2 million pounds at Maria Elena, and 170 thousand pounds at Victoria.[5] Through programs designed by Saline Processors, a U.S. consulting firm, SOQUIMICH's plans to apply new technology in the production of iodine and nitrates are expected to be realized in part in the construction of an iodine plant at Maria Elena. Production was planned to begin in 1980.

Iceland.—One of the world's largest seaweed drying plants is now in operation in Iceland.[6] Rockweed, dulse, and kelp are harvested and processed for industrial and veterinary uses and human consumption. Areas of kelp containing high iodine concentrations have been located and production of an extract concentrate is underway.

Indonesia.—The iodine plant of the state-owned pharmaceutical concern, P.T. Kimia Farma, at Mojokerto, East Java, is the only crude iodine producer in Indonesia. Indonesia has traditionally exported about half of its iodine output and used the balance for the manufacture of pharmaceuticals.

Japan.—Production of crude iodine in Japan, the largest producer for the world market, was affected by environmental and economic difficulties. Output in 1978-79 remained well below the 1972 record of 16.5 million pounds. Strong world demand for Japanese iodine reduced inventories to below adequate reserve levels.

Ise Chemical Industries, Ltd., which produces about half of Japan's iodine, and the

Table 4.—Crude iodine: World production, by country

(Thousand pounds)

Country[1]	1976	1977	1978[p]	1979[e]
Chile	3,137	4,092	4,237	4,800
China, Mainland[e]	800	800	1,000	1,000
Indonesia	60	45	16	20
Japan	15,331	13,448	13,227	13,800
United States	W	W	W	W
U.S.S.R.[e]	5,000	5,000	5,000	5,000
World total[2]	24,000	23,000	23,000	25,000

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data.

[1]In addition to the countries listed, the Federal Republic of Germany is known to have produced elemental iodine in 1976 and may have continued to do so during 1977-1979, but output is not officially reported and available information is inadequate for formulations of reliable estimates of output levels.

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

other five producers operated near Tokyo on the Chiba Peninsula, where problems with subsidence have increased in recent years. Other problems for iodine producers in 1978, besides subsidence, were related to a drought and a lack of profitability in iodine production which was exacerbated by the weakness of the U.S. dollar.[7] Ise has developed additional resources at Miyazaki and Niigata, but continuing internal difficulties have delayed the company's expansion plans. The Miyazaki plant was reportedly not operating during part of 1978 and the Niigata plant cut back production by 50%. Although the dollar strengthened in relation to the yen in 1979, the situation had not improved sufficiently to encourage expansion of capacity. The Miyazaki operation remained at about one-fourth of its design capacity of 4.4 million pounds. The Niigata facility produced about 1.5 million pounds.

Japanese exports of crude iodine increased about 10% in 1978. Export values averaged $2.20 per pound (revised from a previously published figure). Exports to the United States amounted to 43% of the total of 13.3 million pounds of iodine shipped to 43 countries. The countries of the European Community represented another 36%, and other markets included India (7%), Canada (3%), and Poland (3%).[8]

In 1979, exports of Japanese iodine declined 8% to 12.2 million pounds. Export values increased to an average $3.04 per pound. Japan exported iodine to 30 countries, of which the United States accounted for 40%; the European Community, 41%; India, 4%; Canada, 4%; and Poland, 2%.[9]

Technology.—The U.S. Department of Energy published a report on methods to analyze oilfield brines for iodide and fluoride using selective ion electrodes.[10] Knowledge of the concentrations of these ions is needed in enhanced oil recovery research, environmental impact studies, and in locating recoverable chemicals. The laboratory technique was reported to be more accurate and faster than the previously used titration method and to cover a wider range of iodide concentrations. The detection limit was 10 milligrams per liter.

General Atomics Co. has reportedly solved most of the problems caused by side reactions in its experimental process to produce hydrogen from a thermochemical sulfur-iodine water splitting cycle.[11] The potential for hydrogen to emerge as the preferred way to deliver energy in the twenty-first century and the long-term requirement for a replacement for natural gas as a hydrogen source make water a logical future source of hydrogen energy. The Sagami Chemical Research Center in Japan, where similar research is being conducted, has developed a catalyst which it claims to be effective in the production of hydrogen from a hydrogen iodide recycle process.[12] The catalyst is composed of fine platinum particles scattered on a fluoride resin carrier. Early experiments have shown that at a temperature of 200° C the catalyst decomposed about 40% of the hydrogen iodide in 100 minutes. The catalyst, which does not react with hydrogen iodide, remained active for 200-300 hours.

Using computer simulation, researchers at the Marshall Space Flight Center, Huntsville, Ala., concluded that disposal in space is feasible for radioactive iodine waste from nuclear power reactors.[13] The space transportation system utilized would rely on the space shuttle, a liquid hydrogen-liquid oxygen orbit transfer vehicle, and a solid propellant final stage. The iodine was assumed to be in the form of either an iodide or an iodate, and calculations were based on the assumption that the final destination would be either solar orbit or solar system escape.

Study of the health effects on users of drinking water purified with iodine indicated no ill effects during a 15-year pilot project comprising a Florida prison community of 750 men and women.[14] Of primary interest were the possible effects of iodinated water on the thyroid function of adults and of infants born to female prisoners. The research was supported by Calabrian International, the Medical Research Service of the Veterans Administration, and the National Institutes of Health General Clinical Research Center grant RR-82.

West Design Chemical Group, a division of West Agro-Chemical, Inc., has announced a technological innovation in utilizing the microbiocidal properties of iodine.[15] Compared with current products, the invention reportedly accelerates iodine's rate of disinfecting while requiring less iodine and complexing agents. A spokesman for West-Agro, which holds patent technology on iodophors (iodine complexed by surfactants or polyvinyl pyrrolidine), believes that this discovery will enable the production of finished iodophor formulations at lower cost, reduced potential for iodine skin absorption in animals and humans, and reduced potential for iodine contamination of food and environment.

A 3-year follow-up study is underway to confirm the results of the National Oceanic and Atmospheric Administration's weather modification experiment in south Florida.[16] Preliminary results indicated that cloud seeding with silver iodide could increase rainfall by 20%.

MEERSCHAUM[17]

Crude meerschaum was not imported in 1979; however, meerschaum imported for consumption in 1978 was 14,055 pounds, compared with only 485 pounds in 1977. Somalia (78%) and the Federal Republic of Germany (22%) were the import sources in 1978. Somalia meerschaum imports totaled 11,244 pounds, and had not been imported by the United States since 1975. Customs declared value of all imported meerschaum in 1978 was $35,405, or $2.52 per pound. The crude material was used by companies in New York and Ohio for the manufacture of smokers' pipes.

QUARTZ CRYSTAL[18]

Cultured quartz crystal production in 1978 was 329,000 pounds, a decrease of 44% from that in 1977; however, in 1979, the industry rebounded, increasing production 75% to 575,000 pounds. Consumption of cultured quartz for 1978 and 1979 was 237,000 pounds and 269,000 pounds, respectively. Consumption of natural electronic/optical grade quartz crystal continued its downward trend, decreasing 57% to 24,000 pounds in 1978, and further decreasing 38% to 15,000 pounds in 1979. Production of finished crystal units during the 1978-79 period remained near the 1977 level of 74 million units. Imports of natural quartz crystal (electronic/optical grade and lasca) for 1978 and 1979 were 165,000 pounds and 427,500 pounds, respectively. Exports of natural and cultured quartz crystal were not available for the 1978-79 period.

Legislation and Government Programs.—At yearend 1979, the total Defense Materials Inventory was 2.4 million pounds of natural quartz crystal. During 1978 and through September 1979, the stockpile goal for electronic grade crystal remained at zero, making the entire quartz crystal stockpile excess material. However, in September 1979, a provisional goal of 600,000 pounds of quartz crystal was established pending possible re-evaluation of requirements. Stockpile sales of quartz for 1978 and 1979 totaled 63,000 pounds and 272,000 pounds, respectively. Currently, there is no provision for a stockpile of cultured quartz crystal.

Table 5.—Salient electronic and optical grade quartz crystal statistics

(Thousand pounds and thousand dollars unless otherwise noted)

	1975	1976	1977	1978	1979
Production:					
Mine[1]	30	513	606	317	e314
Cultured quartz	724	849	583	329	575
Imports of natural quartz crystal[2]:					
Quantity	585	187	265	165	428
Value	$885	$183	$394	$459	$216
Exports of electronic and optical grade quartz crystal:					
Quantity	486	645	502	NA	NA
Value	$5,713	$10,908	$4,005	NA	NA
Natural:					
Quantity	313	188	370	NA	NA
Value	$1,656	$1,626	$1,371	NA	NA
Cultured:					
Quantity	173	457	133	NA	NA
Value	$4,057	$9,282	$2,634	NA	NA
Consumption of quartz crystal	239	349	280	261	284
Natural (electronic and optical grade)	90	159	56	24	15
Cultured	149	190	224	237	269
Production of finished crystal units, number thousands	39,545	82,730	r73,617	74,825	73,729

eEstimate. rRevised. NA Not available.

[1]Includes lasca, and some specimen and jewelry material.

[2]Includes electronic grade, optical grade, and lasca (a feedstock for growing cultured quartz).

Domestic Production.—Three companies were reported to have produced 317,000 pounds of various grades of natural quartz in Arkansas in 1978. These companies were: The Quartz Processing Co., Hot Springs, Ark., 301,000 pounds; Ocus Stanley, Mt. Ida, Ark., 16,000 pounds; and Terry Mining Co. of Midwest, Okla., 329 pounds. The production from Terry Mining Co. was in Garland County, Ark.[19] It was reported that some of the production of The Quartz Processing Co. was used as lasca[20] in both the U.S. and overseas cultured quartz industry. During the latter part of 1978, The Quartz Processing Co. ceased production and processing of quartz material; expiration of the mining lease was the reason cited for the stoppage of operations. No future activity by the company is planned at that site.

Reported domestic production of natural quartz during 1979 occurred in the Hot Springs, Ark., area, as follows: Ocus Stanley, 14,000 pounds and Terry Mining Co., 75 pounds.[19] In addition, an estimated 300,000 pounds of lasca, used in the U.S. cultured quartz industry, was produced by Coleman Crystal Inc., Jessieville, Ark.

In 1978, eight companies, with headquarters in five States, reported production of cultured quartz for use in the quartz-cutting industry. The companies were Motorola, Inc., Chicago, Ill.; Electro Dynamics Corp., and Thermo Dynamics Corp., both in Shawnee-Mission, Kans.; Western Electric Co., Inc., North Andover, Mass.; Bliley Electric Co., Cortland, Ohio; Crystal Systems, Inc., Chardon, Ohio; Sawyer Research Products, Inc., Eastlake, Ohio; and P. R. Hoffman Co., Carlisle, Pa. In 1979, Sawyer Research purchased Crystal Systems Inc., reducing the number of growers to seven.

Consumption and Uses.—Lasca consumption reported by the eight growers in 1978 totaled 444,000 pounds, while consumption in 1979 by seven growers totaled 815,000 pounds.

Consumption of electronic/optical grade quartz crystal totaled 261,000 pounds in 1978, a 7% decrease from that in 1977. Of the 1978 total, cultured quartz increased 6% to 237,000 pounds, while natural quartz decreased 57% to 24,000 pounds. Consumption in 1979 totaled 284,000 pounds; cultured crystal consumption, 269,000 pounds, increased 14% while natural crystal continued its downward trend, decreasing 38% to 15,000 pounds. Substitution of cultured quartz for natural quartz was the reason for the large decline in the use of natural material.

In 1978, 41 companies in 16 States reported consumption of quartz crystal. Of the total, 26 consumed cultured quartz, 2 consumed natural, and 13 consumed both natural and cultured crystal. During 1979, 36 companies in 14 States reported crystal consumption with 26 consuming cultured, 1 consuming natural, and 9 consuming both natural and cultured quartz.

Fifty-nine operations in 18 States reported production of about 75 million finished crystal units in 1978. In 1979, 52 operations in 17 States reported production of approximately 74 million crystal units. Oscillators (i.e. television, CB radio, watches, clocks, etc.) accounted for 81% of the total crystal

units manufactured during the 1978-79 period. Filter plates and telephone resonators accounted for 15% and 3% of production, respectively, during the period. Other uses, which included some optical units, made up the remaining 1% of crystal unit production.

Stocks.—Total reported yearend stocks of quartz crystal (cultured and natural electronic/optical grade) for 1978 totaled about 289,000 pounds. Of this total, approximately 100,000 pounds was natural quartz and 189,000 pounds was cultured quartz. By yearend 1979, natural crystal stocks had dropped to 88,000 pounds while cultured crystal increased to 218,000 pounds.

Prices.—The average reported value per pound for cultured quartz crystal for 1978 was $25.18. The average value in 1979 rose 8% to $27.16 per pound. Natural electronic/optical grade quartz had an average reported value of $16.53 per pound in 1978; value increased 45% to $23.94 per pound in 1979. Cultured quartz crystal has replaced natural quartz crystal in most applications, and the high increase in value of natural quartz in 1979 appeared to reflect the restriction of natural quartz crystal to high precision electronic and optical applications requiring high-quality natural material. The average reported value for lasca in 1978 was $0.43 per pound; this increased 28% in 1979 to $0.55 per pound. Reported average value of finished crystal units was not meaningful because of diverse end use applications and values.

Foreign Trade.—Due to a reclassification and combination of categories, export data for quartz crystal (lasca, natural electronic/optical grade, and cultured quartz) were not available for the 1978-79 period.

U.S. imports of natural quartz were designated as "Crude Brazilian Pebble;" this category included lasca, electronic grade, and optical grade quartz. The Bureau of the Census advised that imports from Mexico were not correctly classified for 1978; therefore, Mexican imports were eliminated from the statistics. Imports of natural quartz for 1978 totaled 184,000 pounds valued at $463,000. Higher grade natural quartz material imports (electronic/optical grade and lasca) were estimated to be 165,000 pounds valued at $459,000; of this, Brazil supplied 120,000 pounds valued at $63,000. The average customs value ($0.53 per pound) would indicate that most of the quartz crystal imported from Brazil was lasca. Average customs values for natural quartz material imported from Brazil ranged from $0.45 per pound to $2.47 per pound. Other import sources in 1978 were Canada, 44,000 pounds valued at $388,000; Japan, 1,000 pounds valued at $3,800; and the Federal Republic of Germany, 154 pounds valued at $3,800. The remaining lower grade quartz material, totaling 19,000 pounds and valued at $4,000, was imported from the Netherlands; however, the end use was not available.

U.S. imports of natural quartz crystal in 1979 totaled 427,500 pounds valued at $216,000; of this, Brazil supplied 364,900 pounds valued at $182,000. The average customs value, $0.50 per pound, and the range of customs values, $0.34 to $1.49 per pound, indicated that the Brazilian material was lasca. Other import sources for 1979 were Canada, 80 pounds valued at $363; Mexico, 20 pounds valued at $2,565; and Spain, 62,500 pounds valued at $30,800.

World Review.—*Brazil.*—The leading U.S. source for electronic grade, optical grade, and lasca grade quartz continued to be Brazil.

Japan.—Nihon Dempa Kogyo Co., a major Japanese crystal supplier, sold quartz crystal manufacturing equipment to Timex for use in its Singapore plant.[21]

The formation of a new expanded crystal association, The National Crystal Oscillatory Industry Association, having juridical status, was announced in 1979; membership was to be comprised of about 47 companies. One of the purposes of the group was to streamline the crystal industry which was hard hit by the large drop in CB radio business, problems in the watch crystal industry, and associated price declines.[22]

Madagascar.—Production of electronic (piezoelectric) grade quartz crystal in 1978 was 165 pounds valued at $814, or $4.93 per pound.[23] Production was located in the Fianarantsoa area and was exported primarily to Japan and France.[24]

STAUROLITE[25]

Staurolite is a naturally occurring, complex, hydrated aluminosilicate of iron having a variable but uncertain composition. Its formula can be generalized as $Fe_2Al_9Si_4O_{22}(OH)_2$. The mineral most commonly occurs as opaque reddish-brown to black crystals with specific gravity ranging from 3.74 to 3.83 and Moh's hardness between 7 and 8.

A limited rock-shop trade in cruciform-

twinned staurolite crystals ("fairy crosses") exists, notably from deposits in Georgia, North Carolina, and Virginia. Staurolite in the United States was produced commercially in 1979 by E. I. du Pont de Nemours and Co. and by Titanium Enterprises, Inc. This staurolite is a byproduct of heavy-mineral concentrates recovered from a glacial age beach sand in Clay County, north-central Florida. The staurolite is removed by means of electrical and magnetic separation after the concentrates have been scrubbed and chemically washed with caustic, rinsed, and dried. The resulting fraction produced is comprised of about 77% clean, rounded, and uniformly-sized grains of staurolite, with minor proportions of tourmaline, ilmenite and other titanium minerals, kyanite, zircon, and quartz. A nominal composition of this staurolite sand is 45% Al_2O_3 (min.), 18% Fe_2O_3 (max.), 3% ZrO_2 (max.), 5% TiO_2 (max), and 5% SiO_2.

Although originally marketed only as an ingredient in some portland cement formulations, staurolite is now marketed as a specialty sand under the trade name "Biasill" for use as a molding material in iron and nonferrous foundries, owing to its low rate of thermal expansion, high rate of thermal conductivity and high melting point. It is also used as an abrasive for impact finishing metals and sandblasting buildings under the trade names "Starblast" (80 mesh) and "Biasill" (90 mesh), as well as a course grade (55 mesh).

Quantitative production data are not released for publication, but the 1978 output of staurolite decreased 14% from that of 1977; shipments increased 51% in tonnage and 15% in price per ton from 1977. Output in 1979 increased 43% compared with 1978; shipments decreased 1% in tonnage and increased 26% in value compared with 1978. Domestic productive capacity is 135,000 tons to 160,000 tons per year.

Staurolite is also produced in India in small quantities and sometimes by other nations as well.

STRONTIUM[26]

Domestic consumption of strontium on a carbonate basis was an estimated 30,000 tons in 1978, representing a 3% increase over that of 1977, and an estimated 32,000 tons in 1979, or a 7% increase over the previous year. Imports of strontium minerals were 41,289 tons in 1978 and 43,956 tons in 1979. Imports of various strontium compounds were 4,133 tons in 1978 and 5,861 tons in 1979.

Legislation and Government Programs.—Government stockpiles contained 14,408 tons of nonstockpile-grade celestite (strontium sulfate) at yearend 1978, unchanged from that of 1977. This material was available for disposal throughout 1978, but no sales were made. After 1,000 tons were sold in 1979, Government stockpiles contained 13,408 tons at yearend 1979.

Domestic Production.—Strontium minerals have not been produced commercially in the United States since 1959. However, a number of firms produced strontium compounds from imported celestite.

Table 6.—Major producers of strontium compounds, 1978-79

Company	Location	Compounds
Baker, J. T. Chemical Co	Phillipsburg, N. J	Various.
Barium and Chemicals, Inc	Steubenville, Ohio	Do.
C-E Minerals (Div. of Combustion Engineering, Inc.)	King of Prussia, Pa	Sulfate.
Chemical Products Corp	Cartersville, Ga	Carbonate.
FMC Corp	Modesto, Calif	Carbonate, nitrate.
Mallinckrodt Chemical Works	St. Louis, Mo	Various.
Milwhite Co., Inc	Houston, Tex	Sulfate.

Consumption and Uses.—Domestic consumption of strontium in the manufacture of various strontium compounds increased 3% to 30,000 tons in 1978 on a strontium carbonate basis, of which 68% was consumed as strontium carbonate, 17% as strontium nitrate, and the balance almost all as strontium sulfate or processed celestite. In terms of end use in 1978, 66% of the total was consumed in television picture tubes, 17% in pyrotechnics, 5% in ferrites, 3% in purifying electrolytic zinc, and the balance in other uses. Domestic consumption of strontium increased 7% to 32,000 tons in 1979, of which 68% was consumed as strontium carbonate, 16% as strontium nitrate, and the balance almost all as strontium sulfate or processed celestite. In terms of

end use in 1979, 64% of the total was consumed in television picture tubes, 16% in pyrotechnics, 5% in ferrites, 6% in purifying electrolytic zinc, and the balance in other uses. Additional amounts were consumed directly as crude celestite in both years, usually in pigments or in purifying electrolytic zinc. Although quantitative information concerning consumption is incomplete, sales of domestically produced strontium carbonate to manufacturers of glass for color television picture tube faceplates appeared to have declined slightly in 1978 and to have rebounded in 1979. Consumption of strontium carbonate in the manufacture of ferrite ceramic permanent magnets increased in 1978, as did strontium nitrate in the manufacture of pyrotechnics and signals. In 1979, use in pyrotechnics decreased and use in ferrites increased slightly. Miscellaneous uses included greases, plastics, toothpaste, pharmaceuticals, paint, electronic components, welding fluxes, and the making of electrolytic zinc metal. Small quantities of strontium metal were produced by research companies.

Prices.—At yearend, prices quoted in the Chemical Marketing Reporter[27] were as follows: Strontium carbonate—glass grade, bags, truckloads, works, 22 to 23 cents per pound in 1978 and 28 to 28.75 cents per pound in 1979; strontium nitrate—bags, carlots, works, $24 per 100 pounds in 1978 and 1979, unchanged from 1977. Prices for strontium minerals are usually determined by direct negotiations between buyer and seller and are seldom published. The average value of imported strontium minerals at foreign ports was $45.65 per ton in 1978, up $1.10 from 1977, and $53.12 per ton in 1979, up $7.47 from 1978.

Foreign Trade.—Imports of strontium minerals totaled 41,289 tons in 1978 and 43,956 tons in 1979. All the material was imported from Mexico in 1978, and almost all of it in 1979. Imports of various strontium compounds returned to approximately the level of those for the years 1973 to 1976, increasing to 4,133 tons in 1978 and 5,861 tons in 1979. The Federal Republic of Germany was again the principal source of compounds, exporting 3,459 tons to the United States in 1978, and 3,927 tons in 1979. Quantitative data on U.S. exports of strontium compounds were not available.

Table 7.—U.S. imports for consumption of strontium minerals,[1] by country

Country	1978		1979	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Canada	--	--	183	$8
Mexico	41,289	$1,885	43,406	2,304
Turkey	--	--	367	22
Total	41,289	1,885	43,956	[2]2,335

[1]Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.
[2]Data do not add to total shown because of independent rounding.

Table 8.—U.S. imports for consumption of strontium compounds, by country

Country	1978		1979	
	Pounds	Value	Pounds	Value
Strontium carbonate, not precipitated:				
Canada	--	--	1,500	$500
Germany, Federal Republic of	39,683	$6,233	79,366	14,765
Total	39,683	6,233	80,866	15,265
Strontium carbonate, precipitated:				
Canada	12,139	6,144	14,294	7,147
China, Mainland	--	--	2,205	565
Germany, Federal Republic of	6,521,008	1,190,818	7,682,615	1,498,128
United Kingdom	5	528	1	399
Total	6,533,152	1,197,490	7,699,115	1,506,239
Strontium chromate[1]:				
Canada	623,410	591,987	420,370	435,630
France	41,667	18,824	--	--
Germany, Federal Republic of	--	--	39,683	7,485
Total	665,077	610,811	460,053	443,115

See footnotes at end of table.

Table 8.—U.S. imports for consumption of strontium compounds, by country —Continued

Country	1978		1979	
	Pounds	Value	Pounds	Value
Strontium nitrate:				
Canada	--	--	425	$391
France	--	--	220	533
Germany, Federal Republic of	158,731	$49,591	1,872	4,326
Italy	513,672	128,278	3,085,558	792,467
Total[1]	672,403	177,869	3,088,075	797,717
Strontium compounds, n.s.p.f.:				
Canada	30,824	1,599	22,121	1,480
Germany, Federal Republic of	199,387	97,380	50,484	69,915
Hong Kong	960	475	--	--
Italy	79,366	17,631	276,899	65,419
Japan	44,383	22,295	44,489	28,544
United Kingdom	22	2,443	3	540
Total	354,942	141,823	393,996	165,898
Grand total	8,265,257	2,134,226	11,722,105	2,928,234

[1]Imported as strontium chromate pigment (TSUS 473.19).

World Review.—Deposits of strontium minerals are numerous throughout the world, but over three-quarters of known world production is usually from five major producing countries. In the 1976-79 time period, Canada dropped from the ranks of major producers and Iran rose into the ranks. Mexico, Turkey, Spain, and Algeria have continued as major producers. World production of these minerals has dropped since 1977.

Canada.—Kaiser Strontium Products, Ltd., which closed its Nova Scotia operation in 1976, auctioned off its plant equipment after unsuccessfully attempting to sell the facility in 1976-1977.[28]

Iran.—Nakhjir, a new celestite deposit located approximately 120 miles southeast of Tehran in the northwestern part of the Dasht-e-Kavir salt desert was announced. The deposit is operated by the Strontium Co., a wholly-owned subsidiary of the Simiran group of companies. Current production capacity is about 16,500 tons per year of hand-sorted celestite, the bulk of which is shipped to the U.S.S.R. and Japan. Proven reserves are 2.2 million tons of celestite, of which 518,000 tons outcrop.[29]

Turkey.—The largest producer, Barit Maden Turk, is expanding the plant capacity of its Sivas operation from 22,000 short tons per year to 44,000 tons per year by early 1980.[30]

Technology.—Manufacturers continued to look toward strontium hexaferrite derived from the carbonate as an alternative to barium ferrite magnets owing to its higher maximum energy and better temperature characteristics. Strontium-containing glazes on pottery have the advantages of nontoxicity, lower solubility, greater scratch resistance, and extended firing range without color change, over lead- and zinc-containing glazes.[31]

Table 9.—Strontium minerals: World production by country

(Short tons)

Country[1]	1976	1977	1978[p]	1979[e]
Algeria	[r]7,147	5,732	6,418	6,000
Argentina	2,264	924	990	1,000
Canada[e]	13,200	--	--	--
Iran[e 2]	[r]6,000	11,000	16,535	9,000
Italy[e]	770	770	770	770
Mexico	24,424	50,302	36,563	36,500
Pakistan	665	402	239	220
Spain[e]	8,300	8,300	8,000	8,000
Turkey[e]	7,000	18,300	19,300	20,000
United Kingdom	5,952	5,622	[e]5,500	5,500
Total	[r]75,722	101,352	94,315	86,990

[e]Estimate. [p]Preliminary. [r]Revised.

[1]In addition to the countries listed, the Federal Republic of Germany, Poland, and the U.S.S.R. produce strontium minerals, but output is not reported quantitatively and available information is inadequate for formulation of reliable estimates of output levels.

[2]Year beginning March 21 of that stated.

WOLLASTONITE[32]

Wollastonite is a natural calcium metasilicate, usually white or light-colored, and has a theoretical composition of $CaO \cdot SiO_2$, equivalent to 48.3% lime combined with 51.7% silica. The largest single use for wollastonite has been in ceramic mixes for floor and wall tile. The mineral is also used for glazes and enamels; as a pigment and extender for paints; as a filler for plastics, rubber, and asphalt products; and in other applications.

Wollastonite output in the United States in 1978 was 15% greater in quantity and 25% higher in value than in 1977. Estimated output of wollastonite in 1979 was about 5% less in quantity and value compared with 1978. Output data are withheld to avoid disclosing company proprietary data. The two producers both years were Interpace Corp., Essex County, N.Y., and R.T. Vanderbilt Co., Inc., Lewis County, N.Y.

Wollastonite markets were discussed in a paper given at an international conference sponsored by Industrial Minerals magazine. World demand was said to have gone from 35,000 tons in 1970 to 94,000 tons in 1977. The largest probable growth area for wollastonite along with other industrial minerals was given as a functional filler in plastic systems.[33]

Interpace Corp. announced in late 1979 the sale of its wollastonite operation at Willsboro, N.Y., to Processed Minerals, Inc., a wholly-owned subsidiary of Canadian Pacific Investments, Inc. at a price of $27.5 million.[34]

Chemical Marketing Reporter, December 25, 1978, quoted the price of wollastonite, fine paint grade, bagged, in carload lots, f.o.b. works, as $86 per ton; medium paint grade, $70 per ton. The December 24, 1979, issue of the same publication quoted 400-mesh material, bagged, in carload lots, f.o.b. works, as $92 per ton; 325-mesh, $76 per ton. Through the end of 1978, the American Paint & Coatings Journal quoted prices ranging from $70 to $90 per ton for paint grade wollastonite. Corresponding prices in the December 31, 1979, issue ranged from $76 to $98 per ton.

ZEOLITES[35]

Natural zeolite production in the United States in 1978 and 1979 was probably equal to 1977's 5,000 tons. There was still no clear emergence of sustained markets. Prices were unavailable, but would not be relevant because of the market development period that zeolites were still undergoing during the period. A promising market in Europe may open up; significant sales of experimental quantities have been made.

Several domestic companies continued their applications research to develop markets for natural zeolites with very encouraging but confidential results. They are privately predicting large markets for their zeolites in the near future. The "methane from landfill" (MFL) market keeps expanding. Getty Synthetic Fuels, Inc. under an agreement with Reserve Gas Co. will provide capital and operating funds for three new MFL plants. The plants, at Monterey Park, Calif., San Fernando Valley, Calif., and near Chicago, Ill., will have a total capacity of 7 to 8 million cubic feet per day and use chabazite for the gas separation. New Jersey's Public Service Electric and Gas Co. is planning to tap the Meadowlands waste dump near East Rutherford for an estimated billion cubic feet per day of methane.

The synthetic zeolite market appears to be continually growing. An example of this growth, fluidized cracking catalysts, is examined in detail in a 1978 article.[36] The author reported that Engelhard's Mineral and Chemical Division had just completed an $8.8-million expansion of its zeolite plant at Attapulgus, Ga. This was the second such expansion in 2 years and brought the capacity up to 100 to 150 tons per day depending on product. Engelhard hopes to capture a larger share of the 130,000 tons per year American market for cracking catalysts. At a nominal $1,000 per ton that is a $130-million market. The three largest manufacturers in the zeolite catalyst cracking field are the Davison Division of W. R. Grace & Co. with a probable 55% of the market, Fitrol Corp. which has had about 28%, and Engelhard which now feels that it has 20%. The article also contains a brief description of the different processes used by each to produce their catalyst.

In the Federal Republic of Germany, Degussa and Henkel plan to up their cur-

rent 30,000-metric-ton-per-year capacity to 80,000 for their HAB-30 zeolite for detergent. In France, Grand Paroisse is now making and marketing a mordenite-type zeolite.

Mobil Oil Corp. unveiled new capabilities of its ZSM-5 family of shape selective zeolite catalyst even as several plants to use the zeolites were in the planning stage. New research demonstrated that 90 to 96 octane gasoline could be made not only from methanol using these zeolites, but also from rubber latex, corn oil, castor oil, and jojoba oil. The United States and West German Governments will use the zeolite in a pilot plant to produce 100 barrels per day of gasoline from coal and the New Zealand Government is planning a 13,000-barrel-per-day plant using the Maui gas field as the methanol feed stock.

Among research reports issued during 1978 was one comparing washing efficiencies of detergents containing tripolyphosphate against those containing zeolites.[37] The conclusion was that a detergent containing 30% by weight zeolite Na and 20% sodium silicate had equivalent performance to one using 25% sodium tripolyphosphate and 10% sodium silicate. Another report indicates that Union Carbide Corp. had produced a zeolite that would selectively retain organic molecules and allow water to pass. It is reportedly the first hydrophobic zeolite. Union Carbide's Hy Siv Pressure Swing Absorption (PSA) process for hydrogen purification is being used at a Lingen, Germany refinery to produce 42 million cubic feet per day of 99.999% pure hydrogen. This is reportedly the world's largest PSA unit.

The environmental question about the possible connection of erionite with the high incidence rate of mesothelioma in two Turkish villages remains unanswered. As one scientist said, "The data are equivocal." There are simply not enough data to either rule out the connection or to confirm it.

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[2]Prepared by James P. Searls, physical scientist.

[3]Prepared by Sandra T. Absalom, physical scientist.

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[17]Prepared by A. C. Meisinger, industry economist.

[18]Prepared by Alvin B. Zlobik, physical scientist.

[19]Directory of Arkansas Mineral Producers and Production. Little Rock, Ark. Published annually in March by the Arkansas Geological Commission and the Federal Bureau of Mines.

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