MINOR NONMETALS: CARBON DIOXIDE, GRAPHITE, GREEN-SAND, KYANITE, LITHIUM MINERALS, MEERSCHAUM, MINERAL WOOL, MONAZITE, OLIVINE, STRONTIUM MINERALS, AND VERMICULITE

By Paul M. Tyler

SUMMARY OUTLINE

<table>
<thead>
<tr>
<th>Page</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>1209</td>
</tr>
<tr>
<td>Graphite</td>
<td>1301</td>
</tr>
<tr>
<td>Greensand</td>
<td>1301</td>
</tr>
<tr>
<td>Kyanite</td>
<td>1304</td>
</tr>
<tr>
<td>Lithium minerals</td>
<td>1307</td>
</tr>
<tr>
<td>Meerschaum</td>
<td>1309</td>
</tr>
</tbody>
</table>

CARBON DIOXIDE

Production of liquid carbon dioxide increased in the United States from 23,978 short tons valued at $2,345,743 in 1909 to 44,093 tons valued at $6,280,647 in 1929. Virtually no solid carbon dioxide was produced prior to about 1925, and it was commercially unimportant until about 1929 when production jumped to around 15,000 tons. For 1931 the Bureau of the Census reported 76,788 tons of carbon dioxide valued at $6,225,643, but of this about 40,000 tons were piped to dry-ice plants, and the total production of dry ice at 29 plants was reported as 42,477 tons having a value of $2,899,738. Even this industry felt the effects of the depression; production in 1933 dropped below the 1931 record, but by 1935 it was once more on the uptrend, 58 establishments reporting a production of 48,704 tons of commercial carbon dioxide of which 12,643 tons were piped to dry-ice plants. The total output of dry ice in 1935 was 82,562 tons valued at $3,245,692. Later figures are not yet available, but further growth undoubtedly will be reported for 1937. In seeking Federal Trade Commission approval of its trade-practice rules, the Carbon Dioxide Institute (75 East 45th St., New York, N. Y.) stated recently that the industry's invested capital is $25,000,000 and its estimated sales $10,000,000 annually.

Most of the carbon dioxide is obtained from coke ovens, limekilns, metallurgical plants, fermentation plants, and chemical works, but increasing quantities are being produced from natural gases. In the United States gas wells suitable for producing solid carbon dioxide are found in several States, and natural dry-ice plants have been built in California, Colorado, New Mexico, Utah, and Washington.

1 Figures on imports and exports compiled by M. B. Price, of the Bureau of Mines, from records of the Bureau of Foreign and Domestic Commerce.
The rated capacity of these plants, according to a letter from J. C. Miller of the Geological Survey, totals 80 to 100 tons daily, indicating an output of 6,000 to 10,000 tons a year. New Mexican resources and developments have recently been summarized in detail. Gas-bearing springs have been a source of carbon dioxide in several States, notably for carbonating beverages at Saratoga Springs, N. Y., and Manitou, Colo., but contributions from this source are not likely to be important at any time.

On the other hand byproduct gas from limekilns, cement mills, metallurgical works, and other mineral-processing plants may become of even greater importance as better methods are devised for capturing the waste gas economically. Since limestone contains roughly as much carbon dioxide as it does lime, fully 20 million tons of the gas are liberated in a normal year at American cement and lime-burning plants alone. Although probably only a small fraction of this quantity can ever be sold as dry ice, certain favorably situated plants may find that the solid carbon dioxide market offers attractive profit possibilities. A serious objection to the use of byproduct gas has been dilution, but one method of avoiding this difficulty is revealed in Canadian Patent 362594, issued December 15, 1936, to R. H. McKee and E. Wintern and assigned to the MacMar Corporation. For treating flue gas, this process employs a solution of potassium carbonate as an absorbing agent, forming a bicarbonate that subsequently reverts to the carbonate, when heated to higher temperatures, and liberates substantially pure CO2.

There are several methods of making solid carbon dioxide from purified gas, whether artificial or natural, but in most of them the liquid is made first in compressors, then partly converted to snow in an expansion chamber, and finally compacted in the same chamber by pressing. Ordinarily, only about 50 percent of the liquid is converted into snow, and a total of 20,000 to 25,000 cubic feet of carbon dioxide gas is required to manufacture 1 ton of dry ice.

In addition to being employed for carbonated beverages, liquid or bottled gas still finds some use in refrigerating machines and under the trade name Cardox is used increasingly in mining as a safe, slow-acting explosive. A novel application of the liquid gas to extinguish mine fires is described in a recent Bureau of Mines circular. Dry ice is consumed principally by makers of ice cream and secondly (though to a much less extent) in shipping perishable goods by truck or train; consequently it has a highly seasonal market. Attempts to build up stocks during the winter have been unsuccessful, not so much because of evaporation losses as because the product granulates when kept too long in storage. New industrial uses are being sought to increase demand during the winter season. As many as 2,000 possible applications have been enumerated, and an enormously expanded use, although still seasonal, would follow its adoption for household refrigerators, air-conditioning, and general cooling.

Solid carbon dioxide is formed into solid blocks or cubes 10 inches square and weighing 50 to 55 pounds. Each block is weighed and wrapped before packing in portable, insulated shipping containers.
specially designed for this service. Liquid gas in cylinders is sold in New York at 4 to 6 cents a pound and dry ice at $30 to $50 a ton, according to locality, the average in New York being under $50 a ton. However, the ultimate consumer generally pays 4 to 10 cents a pound. The relative refrigerating effect of dry ice and ordinary water ice at 32° F. is usually stated as in the ratio of 2 to 1 by weight, but Selater claims that 1 pound of solid carbon dioxide is almost as efficient as 14 pounds of water ice. However, the efficiency of dry ice varies considerably under different conditions.

GRAPHITE

A small amount of natural graphite was produced in the United States in 1937. The Carson Black Lead Co., Oakland, Calif., continued to mine amorphous graphite for paint from its mine at Carson, Nev., and Michigan graphite was drawn from stock by the Detroit Graphite Co., L'Anse, Mich., for use in its paint factory. The Southern Mining & Milling Co., Clarkesville, Ga., in 1937 began to recover a little graphite from kyanite schist which it treats by a special mulling operation. The overflow from the millers is dewatered and tabled to eliminate sand, and the resulting concentrate goes to a flotation cell which yields a froth concentrate of good flake graphite. Joe Porterfield, Royston, Ga., reported a small quantity of graphite produced for experimental purposes. The Texas Graphite Co., Llano, Tex., produced and shipped refined crystalline graphite for use in foundry facings. The Crystal Graphite Co., Dillon, Mont., again made sales from stock for local use. The machinery and equipment of the Annandale Graphite Corporation at Annandale, N. J., long idle, was sold at auction in December 1937 and the buildings were torn down later.

Domestic production of artificial graphite has been maintained steadily for many years. It is manufactured principally by the Acheson Graphite Corporation (30 East 42d St., New York, N. Y.) at Niagara Falls, N. Y., although minor quantities are made as a by-product of silicon carbide. The Acheson Graphite Corporation is also the leading manufacturer of graphitized electrodes, although these are also produced at St. Mary's, Pa., by several other concerns. Sales of artificial graphite were not pushed in 1937, because the demand for electrodes was so great that all available furnaces were used to manufacture them. Outside of the dry-battery business, which has never regained the importance it enjoyed in 1929 before the development of radios using 110-volt current, artificial graphite has not displaced natural graphite to any large extent, and in the battery field Mexican graphite has begun to get a fair foothold. Artificial graphite, however, seems to be used increasingly as colloidal graphite for an ever-expanding variety of uses, including special lubricants and for coating various surfaces. According to a recent technical bulletin issued by the Acheson Colloids Corporation, Huron, Mich., colloidal graphite can withstand temperatures of 3,000° C. in inert atmospheres and does not combine with oxygen below 600° C.; it has a low expansion coefficient, is a relatively good conductor of heat and electricity,

---

resists electron bombardment, absorbs light, is photoelectrically poor and radioinactive, exerts no vapor tension at ordinary temperatures, and is insoluble in acids or alkalis. Graphite films on metals are valuable chiefly because of their tunctionous and lubricating properties, but in the electrical and radio industry, in optics, and in various scientific apparatus they are used on numerous substances for decorative effects as well. Although the wider use of colloidal graphite has not balanced its diminished use for dry-battery making, the United States continues to be the leading producer of artificial graphite, supplying its own needs and some export business.

Detailed statistics on imports and exports of graphite during recent years were tabulated in Minerals Yearbook 1937 (p. 1442). In 1937 imports aggregated 29,593 short tons valued at $752,315 compared with 24,171 tons valued at $566,662 in 1936, and exports were 1,514 tons valued at $163,331 compared with 816 tons worth $114,847 in 1936. Imports of leading items in 1937 (1936 figures in parentheses) were: Artificial graphite, 802 tons valued at $31,562 (1,635 tons, $63,804); natural amorphous, 25,354 tons, $512,162 (20,160 tons, $344,499); Ceylon lump and chip, 482 tons, $41,499 (251 tons, $18,107); dust, 321 tons, $17,600 (68 tons, $4,090); and flake, 2,634 tons, $149,492 (2,057 tons, $136,162). All the artificial graphite was of Canadian origin. Mexico supplied 13,381 tons, Ceylon 7,063 tons, and Japan (Chosen) 2,987 tons of natural amorphous. As usual, most of the flake graphite was imported from Madagascar or France, but Canada's shipment rose to 272 tons, and small amounts were imported from Japan (Chosen) and Norway.

Further substantial increases in imports of natural graphite have brought the apparent consumption, or available new supply, back to 30,000 tons a year, or about what it was before the World War and almost three times what it was during the depression of the early 1930's. The actual recovery is by no means as complete as the tonnage figures indicate as the output was mainly low-priced amorphous graphite. Only a few decades ago the relatively expensive, crystalline graphites comprised two-thirds of the domestic consumption. During the World War such qualities soared into far greater prominence, and for a decade thereafter they were used in fully as large quantities as amorphous graphite, but during the last few years the proportionate use of crystalline varieties has aggregated scarcely more than 10 percent of the total. This shift in demand, shown graphically in Figure 1, has resulted in a great shrinkage of the dollar volume of natural-graphite business, thus reducing the incentive for recreating a domestic industry out of the collapse that followed the World War.

Mexican amorphous graphite, which carries 80 percent graphitic carbon, is now by far the leading factor in domestic consumption and costs $25 to $30 a ton delivered in New York. It comes in boxcars in bulk, and $14 of the delivered cost is the freight rate from the mines. Korean amorphous is a trifle cheaper than Mexican, and both grades can be bought finely powdered for not much over $40 a ton. Ceylon No. 1 lump, formerly used extensively in crucible making, is rarely sold now but is quoted at 6½ cents a pound crude. Soft carbon lump, 90 percent carbon, also from Ceylon, is worth only $50 to $70 a ton and is a more or less unique product that does not seem to be duplicated in domestic or other foreign mines. Madagascar No. 1 flake sells in carlots (minimum 25 tons) for $90 to $120 a ton; second
grades are a little cheaper, being priced about the same as in 1936 except for a slight increase due to rising freight rates which in 1937 were about $14 a short ton (55s. to 65s. a metric ton).

Domestic supplies of graphite are drawn principally from Ceylon, Madagascar, Mexico, and Chosen. All four countries produce ores that not only are richer in graphite but also are more acceptable to American users than domestic ores. Wages in these countries are much lower than in the United States, and although all but Mexico are far from our shores, transportation charges by water are not much more than the railroad freight from domestic sources to leading consuming centers in the East. Mexico, after a record output of 10,732 short tons in 1936, established a new record of 12,539 tons in 1937.

Canada, which also depends principally upon the American market, likewise reported increased shipments in 1937.

Throughout the nineteenth century and until after the outbreak of the World War Ceylon was the most important world source of graphite. Graphite was not discovered in Madagascar until 1912, and not until 1916 did that island begin to rival Ceylon as a world producer. Boom prices during the Boer War caused an increase in world production in 1901, to nearly 77,000 tons valued at approximately $3,920,000, a peak that was never exceeded except in 1917. Of this total Ceylon contributed 29 percent in quantity and 80 percent in value, but in later years Ceylon’s contributions have diminished at times to less than 10 percent of the world total in quantity, and even in value the relative importance of its production has been much reduced. Although Ceylon still ships some of the highest-priced grades of graphite that are produced anywhere, its production of
these grades has declined even more than its total output. The leading buyers of Ceylon graphite, or plumbago as it is called locally, are the United States, Japan, and the United Kingdom, in about the order named. A recent consular report emphasizes the differences in the average prices received for shipments to specified countries. For the first 5 months of 1937, for example, the averages, expressed in rupees per hundredweight (112 pounds) varied as follows: Australia, 3.15; United Kingdom, 4.49; United States, 5.30; Japan, 6.32; British India, 6.50; and Germany, 9.65. These figures show clearly that Germany, which has a large home production of low-grade graphite, buys mostly high-grade crucible lumps and chip and that Japan likewise buys chiefly the more costly kinds. On the other hand, Australia, and the United Kingdom buy almost exclusively the cheapest qualities, supplementing imports of Madagascar flake. The United States buys varying quantities of both, but its purchases of crucible and other expensive grades of Ceylon graphite have declined and those of amorphous and other cheaper qualities have increased notably during the last few years. Italian graphite, mined in the north of Italy chiefly by one company that also produces talc, was in demand in 1937, especially locally. Italy has a virtual monopoly of the world market for electrodes made from natural graphite. Graphitized electrodes, great quantities of which are produced in the United States and other countries, ordinarily contain no natural graphite. Norway’s output of natural graphite has been increasing lately.

GREENSAND

The best grade of greensand, screened and bagged, has been quoted in Engineering and Mining Journal Metal and Mineral Markets at $20 per short ton, f. o. b. cars in New Jersey, in carload lots. Production, recently reported by five companies, consists mostly of processed material used for water softening. The quantities consumed as fertilizer, formerly the leading use, have dwindled to insignificant proportions. Shipments of refined material in 1937 increased to 9,734 short tons valued at $210,974 compared with 8,368 tons valued at $177,835 in 1936; the average for the 1925–29 period was 12,715 tons valued at $197,187.

KYANITE

Demand for kyanite continues to increase slowly, and production and imports keep pace. Celilo Mines, leading domestic producer, has been treating 175 tons of crude ore daily on three shifts at its Burns-ville (N. C.) plant. The ore carries about 15 percent kyanite, 10 percent garnet, 30 percent mica, and some 5 percent of miscellaneous minerals. The latest flow sheet of this operation, recently published, includes crushing in hammer mills to pass a 16-mesh Ton-cap screen followed by Sutton, Steele, and Steele air tables, the kyanite concentrates from which are cleaned magnetically. The Exolon-Johnson magnetic separator, used on minus 28-plus 48-mesh material, makes garnet concentrates as well as kyanite concentrates, the latter being given a final cleaning on another air table. The prime objective in

---

crushing is to release the silica as much as possible without crushing the kyanite grains. All material under 48-mesh (about one-third of the mill feed) is discarded without attempting to separate it.

The mill on the former McLanahan-Watkins property near Pamplin, Va., was remodeled and started during the latter part of the year by the Phosphate Recovery Corporation. In Georgia the Southern Mining & Milling Co., Clarkesville, began building two new kyanite-mica mills in Habersham County, making a total of four plants in operation, of which three work on schists and one on a placer deposit. Roofing mica and a small quantity of graphite are recovered from the schists in addition to kyanite. Much of the latter is now ground to 20-mesh, but in the special milling operation very little kyanite is broken finer than 10-mesh. The kyanite is removed from the millers and screened to eliminate sand.

The Vitrefrax Corporation, which produces refractory products under the trade names “Argon” and “Durox,” has mined some 900 tons of kyanite annually at Ogilby, Calif. This ore, which carries roughly 30 to 35 percent kyanite, with quartz as the main accessory mineral, is crushed and processed by screening and grinding to a product of unusually low flux content, known as Standard Vitrox and sold for use in the manufacture of saggars and other ceramic bodies.

A considerable part of the kyanite produced is used at the company plant at Los Angeles in the manufacture of various products. Foremost among these, perhaps, is synthetic mullite, made by fusing a mixture of kyanite and pure alumina in electric arc furnaces. This product, known as “Durox,” is sold for use in spark-plug and other porcelains.

The Nonmetals Division of the Bureau of Mines has obtained samples of kyanite from large, low-grade deposits in various parts of the country for testing, chiefly by froth-flotation and agglomerate tabling concentration methods. The impurities in the different deposits vary, and all the concentration problems are not yet solved. Moreover, economic considerations have to be taken into account. Freight rates from some localities to consuming centers are such that a finished concentrate may be worth less than $10 a ton, f. o. b. mill, consequently ores that fail to yield a fairly high percentage of concentrate are not worth considering at present.

Allied to kyanite, particularly as regards their property of forming mullite in ceramic bodies, are andalusite, sillimanite, and dumortierite. The three minerals kyanite, sillimanite, and andalusite are identical in composition, having the formula Al₂O₃·SiO₂, but they differ in mode of crystallization. Andalusite and kyanite will revert to sillimanite between 1,350° and 1,400° C., whereas sillimanite is exceedingly refractory even at temperatures above 1,600° C. However, at 1,545° C. all four of these minerals break up into mullite, 3Al₂O₃·2SiO₂, and a liquid. The amount of liquid for all four minerals is small, however, and is least for dumortierite, which has a slightly higher Al₂O₃ content.

Andalusite is mined rather extensively from White Mountain, Mono County, Calif., and has also been produced, generally admixed with corundum, near Hawthorne, Mineral County, Nev., by the Tillotson Clay Products Co., Los Angeles, Calif. Dumortierite is found in commercial quantities near Oreana, Nev., and has been
mined by the Champion Sillimanite, Inc., which also controls the White Mountain deposit in California. Ceramic bodies containing

dumortierite alone gradually swell, overcoming any tendency of
andalusite to sag, so the company uses a mixture of the two for
making spark-plug cores and high-grade laboratory porcelain, which
it sells under the trade name "Champion" sillimanite.

Sillimanite occurs in gneisses, schists, slates, and hornfels, and is
probably produced in nature at higher temperatures than the other
minerals of the group but under essentially similar conditions of
metamorphism. Important deposits occur in India at Khasi Hills,
Assam, and at Pipra, Rewa. At the latter place the sillimanite is
associated with corundum in a schist which is surrounded by granitic
gneiss. Both deposits are too inaccessible at present to be mined
profitably, and the Bureau of Mines does not know of sillimanite being
produced commercially elsewhere. Seemingly the most promising
domestic source of this mineral is in New Mexico, where sillimanite
schists occur as brick-red seams in Ortega quartzite along the south side
of Arroyo Hondo in the N 1/2 sec. 25, T. 24 N., R. 11 E. Accompanying
the sillimanite are variable quantities of quartz, some muscovite and
talc, and a minor quantity of magnetite. The composition varies
somewhat, but it is reported that many thousands of tons of material
would merit exploitation if the quartz and magnetite could be eco-
nomically removed. The outcrops, about a mile long, have been
staked as mining claims, but so far no development beyond assessment
work has been done. West of these claims, in sec. 26, and elsewhere in
the State, quartz-kyanite veins have been found. Most of these are
small, but some years ago Philip S. Hoyt mined considerable kyanite
near Government Spring in the mountains west of Tres Piedras,
N. Mex.

Mullite is a common and exceedingly desirable constituent of re-
fractories but is rare in nature. In fact, the mineral was not identified
until the artificial compound was discovered in porcelain. The first
known occurrence is in buchites—fused argillaceous sediments present
as inclusions in the Western Isles of Scotland, including the Island of
Mull. Synthetic mullite refractories are made by the Corhart
Refractories Co., Louisville, Ky., by electric-furnace fusion of diaspore
and kaolin.

Increasing quantities of kyanite are being imported. During 1937
imports totaled 7,674 short tons valued at $79,410, all from British
India. Figures for earlier years are not available, being included with
those for a variety of other unspecified industrial minerals that are
entered free of duty under paragraph 1719 of the Tariff Act of 1930.
The average valuation (about $10.35 a short ton) is the declared value,
f. o. b. country of origin, and thus does not include freight which on
many commodities imported from India ranged around $5 or $6 a
ton. In India kyanite occurs in quartz-kyanite or kyanite schists and is
associated with muscovite schist. Dunn estimates reserves at
Lapsa Buru as at least 214,000 tons of kyanite. Smaller and less-
accessible deposits are located at Ghagidih (20,000 tons), Badia-

9 Just, E., Geology and Economic Features of the Pegmatites of Taos and Rio Arriba Counties, N. Mex.,
10 Dunn, J. A., Aluminous Refractory Materials, Kyanite, Sillimanite, and Corundum in Northern
Bakra (10,000 tons), and Kanyluka (8,000 tons) according to the same authority. Although kyanite has been reported in various other parts of the world, few deposits outside of the United States and India have actually been worked. Considerable experimental work has been reported on material found in the Urals, and firebrick have been made for 30 years at Clackline, Australia, using a kaolinized biotite schist. The latter deposits have been described by one of the Government geologists.11

Prices have always been the main deterrent to more widespread use of kyanite and allied refractory minerals. When first introduced, about 1923, kyanite sold for $100 a ton, but this quotation was soon reduced to $40 a ton and later decreased slowly but steadily. By the end of 1934 Celco Mines, Inc., was quoting $18 a short ton for 70- to 80-percent concentrates, grading up to $25 for 90-percent. An additional charge of $15 a ton was made for calcining. North Carolina and Georgia concentrates are still quoted at $18 to $22.50 a ton, but their purity has improved. Imported kyanite is nominally cheaper.

LITHIUM MINERALS

The demand for lithium minerals continues to advance moderately, and the output rose from 1,239 short tons valued at $25,273 in 1936 to 1,357 tons valued at $36,206 in 1937. By the end of 1935, according to Schaller,12 the total output of the various lithium minerals in the United States had been about 70,000 tons, worth around $1,300,000. Of this quantity South Dakota spodumene comprised 22,000 tons, South Dakota amblygonite about 4,000, California lepidolite (including a little amblygonite) 24,500 tons, and New Mexico lepidolite about 19,000 tons. Spodumene mining in the Black Hills was begun in 1898 and amblygonite production (in the same vicinity but mainly from different mines) in 1910. The Stewart mine at Pala, Calif., began commercial production of lepidolite about 1900, although considerable specimen material was shipped as early as 1892. The Harding lepidolite mine in Taos County, N. Mex., was worked mostly during the decade 1920–30. Since about 1930, production has come almost exclusively from South Dakota, as the demand for lepidolite has been small. Substantial reserves of this mineral, however, are available in California, and although the original ore shoot at the Harding mine may be worked out additional large supplies could doubtless be uncovered by a little systematic prospecting.13 The pegmatites near Pala, Calif., have yielded a variety of gem stones, including not only kunzite and other transparent varieties of spodumene but also green, pink, and colorless tourmaline. A brief history and description of the district and its minerals was published in 1936.14

Lepidolite also occurs in the Black Hills and has been produced in small but increasing quantities during the last year or two. The main production, however, has been spodumene, most of which has come from the Etta pegmatite near Keystone, S. Dak. A number of

---

pegmatite areas in the Black Hills region are lithium-bearing, and new deposits may be developed as concentrating methods are perfected. Smaller contributions of lithium ores have come from Maine, and the New England deposits seem to contain more spodumene than formerly was supposed.

Apparently the principal potential sources of lithium in the United States and probably in the world are the disseminated deposits in North Carolina. According to Hess 15 these deposits lie in a strip of the Piedmont running from Lincolnton through the town of King’s Mountain, almost on the South Carolina line. About 4½ miles from King’s Mountain, Philip S. Hoyt of the Southern Mining & Milling Co. erected an experimental kiln for concentrating the ore by the Ralston-Fraas decrystallization process but made no commercial production in 1937. Experiments with this process have been performed by other investigators working on samples from North Carolina and by the Black Hills Tin Co., Tinton, on South Dakota ore.

The lithium chloride process for dehumidifying air does not take any considerable amount of lithium, and, notwithstanding its great potentialities, does not seem to have expanded much in 1937. Research indicates a possible large demand for spodumene in tableware, as it imparts desirable properties when employed in both body and glaze. Lepidolite has been used principally in glassmaking. Relatively large quantities were utilized in opal or white glasses for a brief period beginning about 1920, but by about 1930 this was discontinued. It can also be used effectively, however, in clear glass, and an increase in this application was anticipated, although the cargoes shipped in 1937 seem to have been more or less for experimental purposes. Glassmakers want material with at least 4 percent Li₂O and are unwilling to pay a high price even for that. Amblygonite is the most readily decomposed mineral for making lithium salts, but Bureau of Mines laboratories have worked out methods that promise to reduce the cost of making salts from spodumene. 16

Domestic production in 1937 came from seven companies, all in South Dakota. Heidepriem and Wells (Custer, S. Dak.), Geo. V. Bland (Hill City, S. Dak.), Black Hills Tin Co. (1 North Lasalle St., Chicago, Ill.), and Consolidated Feldspar Co. (1403 Trenton Trust Bldg., Trenton, N. J.) produced only amblygonite; Maywood Chemical Works (Maywood, N. J.) and Denis Henault (Hill City, S. Dak.) produced only spodumene; and the Black Hills Keystone Corporation (Keystone, S. Dak.) produced mostly lepidolite, along with a little spodumene and amblygonite. Average values f. o. b. mines were $37.63 per ton for amblygonite and $55 for spodumene. Prices generally tended to be higher in 1937, but after the business recession only about $28 to $30 was being offered for spodumene at the Atlantic seaboard, although amblygonite was still around $50 delivered. Lepidolite continued to be quoted by Engineering and Mining Journal Metal and Mineral Markets nominally at $20 to $25 a ton.

In South-West Africa, during the first 9 months of 1937, 990 long tons of lepidolite (3.75 percent Li₂O) were produced compared with 852 tons during the calendar year 1936, as well as 110.7 long tons of

---

15 Hess, Frank L., Rare Metals and Minerals: Min. and Met., Vol. 19, No. 373, January 1938, p. 6
amblygonite, a mineral hitherto not mined in the Territory. A fairly extensive deposit of amblygonite seems to have been opened at Johann Albrechts Hoehe, District of Karibib. According to official reports the bulk of the South-West African lithium ores is exported to England, France, and Germany.

A lepidolite pegmatite in Bastar State, British India, is reported \(^{17}\) to be 30 feet wide and over 200 feet long. The lepidolite is confined to the center of the vein, and the yield is estimated at 15 tons of lepidolite (diluted with 90 tons of quartz) per foot of depth.

Lithium ore was produced commercially in Canada for the first time in 1937 at a property in southeastern Manitoba; it was exported for use in making chemicals.

Amblygonite is found principally in South Dakota, but other potential sources are Portugal, Australia, and South Africa; the total world production probably does not exceed 800 tons yearly, the greater part being used in Europe. A promising source of spodumene is in the State of San Luis, Argentina; these deposits carry large, high-grade crystals and thus resemble not the North Carolina deposits where the crystals are small but the South Dakota pegmatites where single well-defined crystals frequently measure 40 feet in length and weigh over 37 tons.\(^{18}\)

**MEERSCHAUM**

Meerschaum or sepiolite is a soft, somewhat claylike hydrous magnesium silicate used almost exclusively in smokers’ articles, although it is reported to have been employed in Spain as a light building material and elsewhere in place of soap. It has also been utilized as an ingredient of porcelain. A few scattered deposits occur in the United States, which has produced a total of perhaps 1,000 tons, chiefly from a mine near Sapillo Creek, N. Mex., which ceased to be worked about 1914. World supplies have come chiefly (and in recent years apparently exclusively) from Asia Minor. Meerschaum deposits near Eskishehur, Turkey, have been worked for centuries, possibly as early as 2,000 years ago, and have yielded most of the lump material that can be carved wet and subsequently hardened. Artificial meerschaum pipes may be made from meerschaum chips and dust compressed into blocks, but small pieces such as might be obtained by concentrating a disseminated deposit have never been readily salable.

World production, virtually all from Turkey, may have exceeded 10,000 boxes, weighing 30 to 35 kg each, in 1869, but it is reported that the average was 7,000 boxes annually when the World War paralyzed the industry of carving pipe bowls and cigar holders, long centered principally in Germany and Austria. Aside from the sporadic domestic production, much of which was unsalable, all meerschaum used in the United States has been imported. In 1914 the value of the imports of crude meerschaum was $102,803, but subsequently the maximum importation has been 16,646 pounds valued at $22,649 in 1924. In 1934 imports had dropped to 508 pounds worth $2,077. Statistics of imports since 1920 are summarized as follows:


Crude meerschaum imported for consumption in the United States, 1920–37

<table>
<thead>
<tr>
<th>Year</th>
<th>Pounds</th>
<th>Value</th>
<th>Year</th>
<th>Pounds</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Average per pound</td>
<td></td>
<td>Total</td>
<td>Average per pound</td>
</tr>
<tr>
<td>1920-24</td>
<td>7,707</td>
<td>$18,058</td>
<td>1935</td>
<td>936</td>
<td>$3,216</td>
</tr>
<tr>
<td>(ave.)</td>
<td>$2.35</td>
<td></td>
<td></td>
<td></td>
<td>$3.44</td>
</tr>
<tr>
<td>1925-29</td>
<td>5,776</td>
<td>13,327</td>
<td>1936</td>
<td>1,724</td>
<td>4,384</td>
</tr>
<tr>
<td>(ave.)</td>
<td>2.31</td>
<td></td>
<td></td>
<td></td>
<td>2.55</td>
</tr>
<tr>
<td>1930-34</td>
<td>1,324</td>
<td>3,672</td>
<td>1937</td>
<td>5,097</td>
<td>12,631</td>
</tr>
<tr>
<td>(ave.)</td>
<td>2.70</td>
<td></td>
<td></td>
<td></td>
<td>3.44</td>
</tr>
</tbody>
</table>

Market quotations apply to cases of standard size and vary according to the size of individual pieces in the box. The number of pieces per case may range from only 35 to several thousand. As long as the material is large enough to be made into pipe bowls, the variation in size is not as important as the quality, and for each size group there are as many as seven grades ranging in price from $155 to $335 a case. Small pieces sell as low as $30 a case. It seems impossible to translate these complicated quotations to a weight basis, but the average foreign-market prices per pound as declared for imports into the United States in recent years have ranged from a minimum of $1.36 in 1924 to a maximum of $4.09 in 1934.

MINERAL WOOL

In January 1938 the Bureau of Mines issued a 54-page mimeographed circular (Information Circ. 6984) by J. R. Thoenen summarizing the technique of mineral-wool manufacture and discussing various other aspects of the industry. Previous literature on the subject has been meager but it is of interest to note that Thoenen found manufacturing methods some producers apparently considered trade secrets often in use elsewhere or even improved. Mineral wool is reported to have been made in Wales as early as 1840, shortly thereafter in Germany, and at Cleveland, Ohio, in 1888, but the industry really began in Indiana in 1892. By 1928, however, it had grown to only 50,000 tons a year, whereas Thoenen estimates the domestic output only 3 years later, in 1936, as 500,000 tons. Rapid strides have been made in technical operation and control during the last decade, and Thoenen, in visiting 35 plants, was able to obtain much information that had never been available before. At least 50 companies, several of which operate more than one plant, are engaged in making wool from wool-rock, iron slag, lead slag, or miscellaneous materials in the United States. New plants were either built or contemplated during 1937 in California, Indiana, Iowa, Kansas, Missouri, and Texas. The National Association of Rock and Slag Wool Industries had only 16 members when it was first organized in 1933 to formulate an NRA code for the elimination of unfair trade practices. The Kansas Geological Survey has issued a report on rock-wool resources of that State, and the Oklahoma Geological Survey is engaged in a similar canvass of local possibilities.

Glass wool or glass silk is a mineral wool that usually has the composition of soda-lime glass, whereas ordinary mineral wool is composed principally of silicates of lime and alumina. The manufacture and varied uses of this interesting material were outlined briefly in the chapter of this series in Minerals Yearbook, 1936. A more detailed
account is found in the excellent review by Lamar and Fryling in the compendium on industrial minerals published by the American Institute of Mining and Metallurgical Engineers.19

Although by far the most outstanding use of mineral wool is in building insulation it has a number of industrial applications. A new and interesting use of mineral wool, however, was announced in 1937 by R. C. Allen, of Cornell, who discovered that blankets of glass wool can be employed to keep plants warm in winter. For delicate plants this new form of mulch is said to be much superior to straw, excelsior, and other opaque materials because it lets in enough light to keep the foliage green.

MONAZITE

No domestic production of monazite has been reported to the Bureau of Mines since 1925, although occasional specimens are found in feldspar mines and the question of reviving placer production in the Carolinas comes up now and then. British India has held the world market virtually for 20 years, although during the last few years Brazil shipments have been increasing. Brazil shipped an average of 4,500 short tons annually from 1902 to 1913, around 500 tons a year from 1913 to 1920, and a total of only 115 tons during the next 5 years. In 1926, 199 tons were shipped and in 1927, 200 tons, but this revival was followed by a drop to 15 tons in 1930 and to none in 1931. French buying accounted for a total of some 700 tons in 1932 and 1933, and 10 tons went to the United States from Brazil during 1933, but no exports have been reported for the period 1934 to 1937. Beach sands contain at least 50,000 tons and have the further advantage that they may yield ilmenite and zircon, but there are interior deposits that also might be utilized if the demand for monazite should increase sufficiently. Analyses and additional information on Brazil deposits are summarized in a consular report abstracted in Mineral Trade Notes.20

Imports of monazite into the United States decreased from 607 tons valued at $25,324 in 1936 to 336 short tons valued at $13,579 in 1937; price quotations, as reported in Engineering and Mining Journal Metal and Mineral Markets, have remained unchanged at $60 to $75 a ton for monazite carrying 8 percent thorium (ThO₂).

OLIVINE

Olivine, a natural magnesium silicate, is now a recognized refractory. Production on a small scale was begun in North Carolina about 1930. Sales for the past 6 years are estimated by Hubert O. DeBeck, of Burnsville, N. C., in a letter to the author, as follows: 1932, 720 short tons; 1933, 1,500; 1934, 3,000; 1935, 6,000; 1936, 5,000; and 1937, 4,000. The mineral has possibilities as a furnace refractory when employed alone, but the most rapidly growing application is for shaped refractories sold under the trade name “Forsterite,” in which it is blended with magnesite. Olivine as a refractory material was first described by Goldschmidt and Knudsen in 1926, although industrial use was largely developed in Germany from 1928 to 1931. Progress

---

reports on developments in the United States and Europe have appeared recently.\(^1\) Dunite deposits in North Carolina, Washington, and Norway yield material carrying up to 90 percent olivine, and experience in selecting material for refractories has made possible the mining of a greatly improved grade of rock. Although low-melting impurities may be reduced they cannot be eliminated, and the magnesia-enriching treatment seems essential for high-grade forsterite. In Europe serpentine also has been treated with magnesite to yield a forsterite material. Mixtures of magnesite and olivine may be added to chrome ore for refractory use; wide variations in relative proportions of these three materials are mentioned.

The Ukrainian Research Institute reports \(^2\) that Ural dunite containing 43 percent magnesia and only 8 percent iron oxides has greater thermal stability and resists basic open-hearth slag better than silica. According to this report olivine refractories may be utilized in the roofs of open-hearth and electric furnaces instead of silica brick.

The nominal price of olivine, as quoted by the Engineering and Mining Journal, remained unchanged during 1937 at $6 a ton, f. o. b. North Carolina mine shipping points.

**STRONTIUM MINERALS**

A general review of the strontium industry appeared in Minerals Yearbook, 1935 (p. 1232), and import statistics were tabulated in Minerals Yearbook, 1937 (p. 1450). No domestic production of strontium ore has been reported since 1918, and domestic needs are supplied by imports, which were as follows in 1937 (1936 figures are given in parentheses): Strontium minerals, 5,636,570 pounds valued at $20,877 (3,880,302 pounds, $14,537); strontium nitrate, 609,488 pounds, $40,240 (694,696 pounds, $39,820); and strontium carbonate and oxide, 44,579 pounds, $4,610 (52,311 pounds, $6,056).

**VERMICULITE**

Sales of vermiculite increased markedly in 1937 to 24,556 short tons valued at $235,164 compared with 16,933 tons valued at $185,787 (revised figures) in 1936. Virtually the entire output was cleaned and sized vermiculite shipped from western mines to calcining plants in various cities in the United States and to England, only small amounts being expanded or exfoliated by calcining at the mine. Sales of expanded vermiculite during the first half of 1937 exceeded those for all of 1936, and notwithstanding the decline that occurred later in the year business continued at a good rate until about November. Prices were unchanged. Most of the material continues to be used for house fill, but recent developments include a larger use in sponge rubber, in which the vermiculite is mixed with latex, and some new applications in the way of burned clay refractories.

The Zonolite Co. (5905 Second Blvd., Detroit, Mich.) and the Universal Insulation Co. (2601 West 107 St., Chicago, Ill.), both

---


\(^3\) Moveschevich, P. L., Novosti Tekhnikii: Vol. 12, 1936, pp. 7-8; Ceram. Abs., Vol. 17, No. 2, February 1938, p. 73.
operating near Libby, Mont., were still the leading producers, although much of the increase in production came from Colorado where substantial developments occurred on both sides of the Continental Divide. The Vermiculite Co. of America (459 Harding St. NE., Minneapolis, Minn.) and the General Vermiculite Co. (Guthrie, Colo.) operated in the general vicinity of Canon City, Colo.; the latter company succeeded the Colorado Vermiculite Co., mentioned in Minerals Yearbook 1937. The United States Vermiculite Co. (915 Metropolitan Bank Bldg., Minneapolis, Minn.) acquired the property in Gunnison County, Colo., leased from the Ute Indians by the Associated Minerals Co. Wyoming production was restricted because the mill of the Mikolite Co. (1317 Union Ave., Kansas City, Mo.) burned in June and was not rebuilt and ready to resume operations until February 1938. Earle H. Paine, after doing considerable development work, was preparing to lease his property, also near Encampment, Wyo., to J. T. Gregory and associates (1560 Gaylord St., Denver, Colo.). No new shipments were reported from North Carolina, although North Carolina vermiculite was burned at various places from stock at processing plants.

So long as the main use for vermiculite is as house fill, chiefly minus 3 plus 14-mesh, North Carolina material is at a disadvantage owing to the small yield of good, corklike pellets. This disadvantage is represented quantitatively by the difference in prices which, notwithstanding some freight advantage to certain important eastern consuming points, are $6 a ton f. o. b. North Carolina, compared with $11 to $15 f. o. b. Montana. Freight on raw material to the Atlantic seaboard from Libby, Mont., is around $13 a ton in carload lots (usually 43 tons), thus making the delivered cost of unexpanded material $24 or more a ton, to which must be added at least $6 for expanding and bagging so that the total cost, exclusive of shrinkage and loss in fines, works out to at least $30 a ton at eastern calcining plants. Rock wool, the leading competitor, can be bought wholesale in Washington, D. C., for $45, but this is the price for "commercial" grade; the granulated product sells for $53 to $60 a ton to dealers, while consumers pay 90 cents to $1.30 a bag. Bags nominally are equivalent to 4 cubic feet, and commercial wool runs 60 and granulated wool about 50 bags to the short ton. However, 4-cubic foot bags of vermiculite weigh only 24 or 25 pounds each, so run 80 to the ton. By selling these to dealers at 70 to 82 cents each, vermiculite manufacturers can get $56 to $65 a ton for the expanded product and still sell to consumers at about $1 a bag.

For house insulation, according to one manufacturer, a 4-cubic foot standard bag of properly expanded vermiculite will cover 27 square feet 2 inches deep and reduce attic heat loss by 75 percent; a 3-inch layer stops 85 percent and a 4-inch layer 92 percent of the loss. One 32-day test by Professor Gordon B. Wilkes in laboratories of the Massachusetts Institute of Technology indicated that "mica pellets" were a much better insulator than rock wool from the standpoint of condensation. On the other hand, some official tests tend to show that under certain circumstances rock wool is the better insulator. Evidently there is need for better methods of testing porous materials for heat conductivity, particularly under actual operating conditions. For mineral wool a volume factor of 10 pounds per cubic foot is gen-
erally recommended; but looser packing may give good results, and for
nodulated glass wool packing as loose as 3 pounds per cubic foot may
result in no appreciable settling and consequent lowering in efficiency.
For expanded vermiculite the standard volume ratio is 6 pounds per
cubic foot, but varieties that cannot meet this standard are likely to be
used increasingly, although perhaps not at the same price per ton or
even per bag.

Vermiculite is typically an American product. Not only is Montana
raw material being sent to London to be expanded there in a factory
affiliated with the F. E. Schundler Co. (Joliet, Ill., and Long Island,
City, N. Y.), but also substantial shipments of exfoliated vermiculite
are being exported to Continental Europe. Russian material has been
exploited, and although it was not well-liked in the United States it is
being used abroad, at least in the U. S. S. R. Recently the South
African Department of Mines announced that samples of vermiculite
from Palabora in the Leydsdorp area of northeastern Transvaal ex-
foliate satisfactorily and that samples from the Petersburg area,
although not so good, may have commercial possibilities. Occur-
rences also were noted near Messina, north Transvaal.