University of Arizona
Bulletin

Mica
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The term mica refers to a group of minerals having similar physical characteristics, and related, through different, chemical structure. The most characteristic physical properties are a very perfect basal cleavage and flexible and elastic cleavage sheets. Chemically, micas are silicates of aluminum and potassium containing varying amounts of magnesium and iron, and in some varieties, sodium, lithium and other elements.

However, only two varieties of mica are used commercially to a great extent. These are muscovite, or potash mica, and phlogopite, or magnesia mica. Lepidolite, or lithia mica, has been used as a source of lithia. Muscovite is the most common mica, and is the only mica mined in the United States.

Mica is one of the most common minerals of the earth’s surface, occurring either as small grains or scales in many types of rocks, or as larger crystals in distinctive types of rocks. The principal mica producing countries of the world are India, the United States, Canada, German East Africa, and Brazil.

"In the United States the production of mica comes from a number of states, only a few of which, however, are regular producers. North Carolina has led in the production for years, and the output from the following states has varied in importance: New Hampshire, South Dakota, Idaho, New Mexico, Colorado, Virginia, South Carolina, Alabama and Georgia. Small outputs of mica from deposits which promise to be of future value have been reported from Wyoming, Utah, Nevada, Arizona, California, Washington, Maine, Connecticut, New York, Pennsylvania and Maryland."

In the United States mica occurs mostly in regions of highly metamorphic rocks, such as mica, garnet, kyanite, staurolite, hornblende, and granite gneisses and schists. A few deposits have been found in less altered granites and other igneous rocks.

Deposits of muscovite of commercial value are found only in pegmatite. This rock is variable in composition, but is commonly composed of feldspar and quartz, with or without mica and other minerals. It is allied to granite in composition. The texture grades from

*Dana, E. S. Textbook of Mineralogy.*
that of ordinary granite to masses in which the individual grains or minerals measure many feet across.

Pegmatites occur in irregular masses, sheets, lenses, and stocks or chimneys. These masses are at times conformable with the bedding of the country rock, and at times cut across the bedding at various angles.

THE MICA GROUP OF MINERALS

The minerals of the mica group are:
- Muscovite—Potassium mica.
- Phlogopite—Magnesia mica.
- Paragonite—Sodium mica.
- Lepidilite—Lithium mica.
- Zinnwaldite—Lithium iron mica.
- Biotite—Magnesium iron mica.
- Lepidomelane—Iron mica.

These minerals crystallize in the mono-clinic system, and are characterized by a very perfect basal cleavage, yielding very thin, tough and more or less elastic laminae.

"Chemically considered, the micas are silicates, and in most cases ortho-silicates, of aluminum with potassium and hydrogen, also, often magnesium, ferrous iron, and in certain cases ferric iron, sodium, lithium and, rarely, barium, manganese, and chromium. Fluorine is prominent in some species, and titanium is also sometimes present. Other elements, boron, etc., may be present in traces. All micas yield water upon ignition in consequence of the hydrogen (or hydroxy) which they contain."*

MUSCOVITE

Chem. Comp.: Muscovite is an acid potassium ortho-silicate, 
\[ \text{H}_2\text{KAl}_3\text{(SiO}_4\text{)}_8 \].

Form: Usually occurs in cleavages and scaly masses, and but rarely in well defined crystals. Scales are tough and elastic.

Color: Colorless, pale green, or pale brown to reddish. Thin sheets are transparent.

Hardness: Soft (2 to 2.5).

Weight: Light (Sp. Gr. 2.8).

Occurrence: 1. In granite pegmatites.

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*Mineral Resources, 1913. Pt. II.
2. Schists and gneisses.

Blowpipe Tests: Fusible on thin edges (5) and whitens. Gives water in closed tube. Insoluble in acids, and not decomposed by $\text{H}_2\text{SO}_4$. (Sulphuric acid.)

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PHLOGOPHITE

Chem. Comp.: Phlogophite is an acid potassium magnesium aluminium ortho-silicate, $\text{H}_2\text{K} \text{Mg}_2 \text{Al} (\text{SiO}_4)_3$. Also contains some iron and fluorine.

Form: Occurs in crystals, in disseminated scales, and in lamellar masses.

Color: Bronze, brown, yellow, green.

Hardness: Soft (2.5 to 3).

Weight: Light (Sp. Gr. 2.8).

Occurrence: 1. In crystalline limestones or dolomite.
2. Often associated with pyroxene, amphibole, penteine, etc.

Blowpipe Tests: Fusible on thin edges (5) and whitens. Gives water in closed tube on intense ignition. Easily decomposed by conc. $\text{H}_2\text{SO}_4$. (Sulphuric acid.)

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LEPIDOLITE

Chem. Comp.: Lepidolite is a lithium potassium aluminum fluoride meta-silicate, $\text{LiKAl}_2 (\text{OH}, \text{F}) (\text{SiO}_8)_3$.

Form: Usually in scaly masses, like the muscovite, but crystals are much smaller.

Color: Pale to deep lilac.

Hardness: Soft (2.5 to 3).

Weight: Light (Sp. Gr. 2.8).

Occurrence: In granite pegmatites and surrounding granites associated with tourmaline albite, muscovite, spodumene, amblygonite, etc.

Blowpipe Tests: Easily fusible (2) with swelling to white glass, coloring the flame purple. In closed tube on intense heat gives water an an acid reaction, due to HF. (Hydrofluoric acid.) Partially decomposed by HCl. (Hydrochloric acid.) After fusion gelatinizes with HCl.
FLOW SHEET FROM

*Average Record from a N*;

1,000 lbs. mine run mica goes to rifters, each rifter handling 200 lbs. per day.

- 400 lbs. thumb trimmed plate goes to cutters.
- 50 lbs. 2¾ inch washer stock goes to washer cutters.
- 60 lbs. 1¾ inch washer stock goes to washer cutters.
- 370 lbs. ¾ inch washer stock goes to washer cutters.
- 120 lbs. waste goes to grinding.

80 lbs. uncleaned goes to cleaners.
220 lbs. waste going.
100 lbs. electric quartz goes to cleaners.
40 lbs. uncleaned washer stock goes to washer sorters.
10 lbs. waste going.
45 lbs. uncleaned washer stock goes to washer sorters.
15 lbs. waste going.
92 lbs. uncleaned washer stock goes to washer sorters.
278 lbs. waste going.

Total

Total shrinkage in
A MICA MINE RUN

Hampshire Mica Mine

Ove mica

1. 60 lbs. finished stove mica @ $1.50 lb......................... $ 90.00
2. 20 lbs. thin split goes to tube (1500 tubes @ $10.00 per M) .... 15.00
   (5 lbs. waste goes to grinding.

Lity plate

1. 75 lbs. electric plate finished @ 50 cents per lb................ 37.50
2. 20 lbs. thin split goes to tube (1500 tubes @ $10.00 per M) .... 15.00
   (10 lbs. waste goes to grinding.

Hers goes

1. 30 lbs. finished washers @ 40 cents per lb..................... 12.00
2. 10 lbs. waste goes to grinding.

Washers

1. 35 lbs. washers @ 30 cents per lb............................. 10.50
2. 10 lbs. waste goes to grinding.

Hers goes

1. 65 lbs. washers goes to core department, making 650 cores @ 10c 65.00
2. 27 lbs. waste goes to grinding.

Waste, 705 lbs.

1. Makes 28 lbs. 200-160 mesh @ 2¾ cents................. 63
2. Makes 56 lbs. 160-120 mesh @ 2 cents............... 1.12
3. Makes 70 lbs. 120-80 mesh @ 1½ cents.............. 1.22
4. Makes 105 lbs. 80-40 mesh @ 1¼ cents.............. 1.57
5. Makes 423 lbs. 40-10 mesh @ 1½ cents............. 5.34

Total Value .................................................. $354.32
BIOTITE

Chem. Comp.: Biotite is an acid potassium magnesium-iron aluminium ortho-silicate \( (H,K)_2 (Mg, Fe)_2 Al_2 (SiO_4)_3 \).

Form: It occurs in embedded crystals, disseminated scales and lamellar or platy mass. Similar to muscovite.

Color: Black or dark brown. Thin sheets are translucent.

Hardness: Soft (2.5-3).

Weight: Light (Sp. Gr. 2.9).

Occurrence:
1. In many kinds of igneous rocks, but especially in granites, and in certain dike rocks.
2. In schists and gneisses. Biotite is often associated with muscovite.

Blowpipe Tests: Fusible on thin edges (5) and turns white. In the closed tube gives a little water on intense ignition. Decomposed by conc. \( H_2SO_4 \).

The other minerals of the mica group are of no importance commercially, and so no detailed description is offered in this bulletin.

USES OF MICA

Mica finds a wide variety of uses. Probably its principal use is as an insulation for electrical appliances. It is also used in stoves, as a lubricant, for paints, decorative purposes, as an adulterant in rubber goods, and, when mixed with other materials, as a heat insulation for steam pipes, boilers, etc.

In electrical apparatus and machinery, mica is used in the form of washers, discs, sheets, tubes, rings, etc. Flexible mica covered cloth and tape is also used in electrical machinery. As an insulator for electrical machinery the mica used is mostly muscovite. It should be very pure, as an impure product does not last nearly as long as the better grades. Thus, in spark plug use, mica containing iron oxide burns out very quickly.

Ground mica is used for decoration of wall papers, for the manufacture of lubricants, fancy paints, rubber goods, molded mica, roofing papers, and as covering for steam pipes. Finely ground mica is used to supply lustre and brightness to wall paper. Wet ground mica is used for this purpose, because the scales are cleaner and flatter than in the dry ground product.

When mixed with oil, ground mica forms an excellent lubricant, for axles and other bearings. Mixed with various pigments, mica is
used to produce many fancy paints. Ground mica mixed with shellac or plaster is used as "molded mica" for insulation of trolley wires.

The Westinghouse Electric and Manufacturing Company of Pittsburg, Pa., has placed on the market a new mica product called "micarta." This is intended to take the place of other insulators for electrical work. It is a tan-colored, hard, homogeneous material that can be sawed, milled, turned, and threaded. Thin sheets can be punched, and it is claimed that it will not warp, expand, or shrink beyond very small limits. "Bakelite" micarta is infusible, and resists heat to a point where carbonization takes place.

MINING AND TREATMENT

Mica is mined by various methods, its irregular occurrence making it impossible to lay down any set rules. If the pegmatite is in sheet-like bodies, and the mica content is not too variable, ordinary straight mining methods may be followed, such as mining by regular shafts, adits or tunnels, drifts and stopes; if the mica content is variable, the stopes and other workings are more irregular. Where the pegmatite is irregular in character, mining methods are, of course, irregular. If the pegmatite occurs in large masses, rich enough to be worked for mica, quarrying may be resorted to. This is quite common in New England.

Ordinary mine run mica consists of rough crystals and blocks ranging from small size to several feet across. These crystals have to be treated before the mica is ready for trade by cobbings, splitting, rough trimming, sorting, cutting into patterns, building up into large composite sheets, or grinding.

The rough mica crystals are cobbled and cleaned of adhering quartz, feldspar or dirt, by rapping with hammers. They are then split with knives or wedges into plates of about one-sixteenth of an inch or less in thickness. The rough edges are cut off these plates, and the mica is graded for size and quality. It is then ready for further splitting and trimming into desired patterns. Small sheets are commonly left with rough edges, and are used for making disks, washers, and other forms. "Thin splittings" are made from small mica. In making these, the edges of the plates are beveled, and these edges are pressed against a flat plate to open the cleavage. The mica is then split with thin knives. This product is built into mica board and flexible sheets.

Mica is trimmed into forms and patterns as desired by large shears
and punches. If shears are used, the mica is cut to shape around a templet of wood, metal, or composition. Mica punching machines are supplied with various dies for punching disks, washers, and other shapes.

Rough small mica, and the waste from sheet mica is ground. Two processes, wet grinding and dry grinding, are used, according to the uses to which the mica is to be put. There are several methods, but they are mostly kept secret.

A sheet showing how the product of a New Hampshire mica mine is handled is embodied in this bulletin.

THE MICA INDUSTRY

The total value of the mica product in the United States in 1913 was $436,060. The production was from eleven states—North Carolina, New Hampshire, Idaho, New Mexico, South Dakota, South Carolina, Alabama, Virginia, Pennsylvania, Colorado, and New York, named in the order of the value of their product. Alabama, Virginia, and Pennsylvania did not report any production in 1912. The value of the mica produced in 1913 exceeds that of 1912 by $104,164, and was the largest ever reported.

The production of sheet mica in 1913 was 1,700,677 pounds, valued at $353,517. The production of scrap mica was 5,322 short tons, valued at $82,543.

The imports of unmanufactured and trimmed sheet mica into the United States in 1913 were valued at $943,018, as compared with $748,973 in 1912. The amount of ground mica imported is small, a value of $4,765 being reported for 1913.

MICA DEPOSITS OF ARIZONA

There are several deposits of mica in Arizona, but none have been developed to any extent, and their value is therefore unknown.

Mica has been reported from Coconino County, on the north side of the Grand Canyon; in Maricopa County, in the White Horse Tank Mountains, southwest of Phoenix; in Yuma County, in the Mohawk Mountains; in Pima County, in the Santa Catalina Mountains.
GEOLOGICAL CONDITIONS AND ASSOCIATIONS

Most of the mica deposits of the United States occur in regions of highly metamorphic rocks, such as mica, garnet, kyanite fibrolite, staurolite, hornblende, and granite gneisses and schists. A few deposits have been found in less altered granites and other igneous rocks.

Deposits of muscovite mica of commercial value are confined to pegmatite. This rock is composed of feldspar and quartz, with or without mica and other minerals, and is allied to granite.

Ortho-clase and microcline are the most common varieties of feldspar found in pegmatite. In many places, however, a variety of plagioclase feldspar, either albite or orthoclase, makes up part or all of the feldspar component. The feldspar occurs in masses and rough crystals, some of which may be several feet thick.

Quartz occurs in several ways in pegmatite, either intermixed with feldspar and mica in granite texture, graphically intergrown with feldspar, or segregated into large separate masses. In the latter case the quartz may form sheets or veins in the interior or along the walls, or it may occur in irregularly shaped bodies through the pegmatite. This segregated quartz is massive and granular, sometimes showing a rough crystallization.

The mica occurs in various positions in the pegmatite, and no definite rule can be given as to where it may be expected to be found. In pegmatites containing quartz segregations, the mica is usually richest near the quartz. The mica may follow one or the other wall, or it may be either regularly or irregularly distributed through the pegmatite. The mica crystals or blocks are generally rough, and range in size from a fraction of an inch to several feet across.

Pegmatites have no regular form of occurrence, being found in irregular masses, stocks, pipes, chimneys, lenses, or sheets, and varying greatly in size. Forked or branched pegmatites are common, and, therefore, often contain “horses” or inclusions of wall rock.

The minerals most commonly associated with mica are, of course, quartz and feldspar. Other minerals are very numerous, and include garnets, beryls, tourmalines, and, more rarely, cassiterite, apatite, fluorite, topaz, spodumene, and many others.

The origin of pegmatites are undoubtedly intrusives, in certain cases. The more coarse grained pegmatites are probably the result of very slow cooling of granitic material injected in a pasty condition.
PRICES AND ECONOMIC CONSIDERATIONS

According to the U. S. Geological Survey, Mineral Resources for 1913, the average price of sheet mica during 1913 was 20.8 cents a pound, as compared with 33.4 cents in 1912, and 16.4 in 1911. The average price of sheet mica in North Carolina was 28.8 cents per pound; in New Hampshire, 8.8 cents per pound. In South Dakota 11.5 cents; in New Mexico, 42.8 cents; in South Carolina, 11.4 cents; in Virginia, nearly $1 per pound. The average price of scrap mica in 1913 was $15.51 a short ton.

The price of mica varies according to the grade and size. Large pieces of sheet mica bring a higher price per pound than small pieces. Good clear mica is more valuable than spotted and clay stained mica.

Economic considerations that apply to any mine would also apply, in a general way, to mica mining. That is, a suitable market must be found, transportation must be cheap, etc., etc. As a general rule, mica is made up into forms ready for the market at the mine. It is very seldom shipped any great distance in crude form.

Unless a large percentage of the deposit is good, clear mica, the project might as well be abandoned, for the market for spotted and stained mica is rather limited.

THE FUTURE OF THE MICA INDUSTRY

A glance at the figures on production and imports will show that there is quite a field for the development of the mica industry in the United States. With only eleven states reporting any production of mica, and most of these eastern states, it would seem as though the West should be able to break in.

Of course, the western states have laid more stress on metal mining than on non-metallics, but mining men should remember that other things besides gold, silver and copper are valuable.

With the vast quantities of granite and allied rocks that go to form the larger part of the West, prospects for good mica deposits are bright.

There is no question but what the demand for mica will increase and not decrease. Its use in electrical apparatus is wide, and necessary, due to its superior quality over other materials. In its minor uses, also, the demand is steady and increasing.