# SIDEROPHYLLITE FROM BROOKS MOUNTAIN, ALASKA*

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Abstract

A brittle, dark green mica (siderophyllite) from Brooks Mountain, Alaska, unusually high in divalent iron (30.16% FeO) and with almost no magnesia is described. The indices of refraction are: $\alpha=1.590$, $\beta=1.640$ and $\gamma=1.640$.

A specimen of mica from a granite pegmatite on Brooks Mountain, Seward Peninsula, Alaska, proved upon analysis to be siderophyllite, the rare high-ferrous member of the biotite group.

The name siderophyllite was given by Lewis,[1] in allusion to the large percentage of iron which it contains, "to a hard black mica" with "laminae very brittle" found in the neighborhood of Pike's Peak, Colorado.

As the feature that distinguishes his mica from previously described micas of high iron content is its large percentage of ferrous oxide (25.50%) and minor percentages only of ferric oxide (1.55%) and magnesia (1.14%), it can be inferred that Lewis intended to restrict the application of the name siderophyllite to micas having a similar composition. This restriction is here made explicit. The mica from Alaska described in this paper is therefore siderophyllite.

## Location and Mode of Occurrence

Brooks Mountain is in the central part of the York Mountains, in the northwestern part of the Seward Peninsula, Alaska. The siderophyllite occurs in a pegmatite sill which is associated with a stock of coarse-grained porphyritic alaskite about 2 miles in diameter, forming the southern part of Brooks Mountain. The pegmatite sill, intrusive into fine grained marble, is exposed in one of two small pits about 500 feet northwest of a small ruined cabin on the saddle between the headwaters of Mint River and those of Crystal Creek, a tributary of Lost River. The sill consists of glassy gray quartz one foot thick, cut by stringers of siderophyllite and greenish-yellow orthoclase, both without crystal form. On the upper margin of the sill are masses of siderophyllite up to two inches in thickness, individual plates of which are as much as three-fourths of an inch across. The masses of coarse siderophyllite are locally separated from the altered limestone by massive orthoclase. On the

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[1] Lewis, H. C., On siderophyllite—a new mineral: *Proc. Acad. Natural Sci., Philadelphia*, **32,** 254–255 (1880).

lower contact of the sill, the siderophyllite, orthoclase, and quartz are closely intergrown in a medium-grained allotriomorphic-granular aggregate.

In thin section the siderophyllite is pleochroic from dark green to pale straw yellow with a greenish tinge. Some plates of siderophyllite from the intergrowth on the lower contact are discontinuously rimmed by a thin shell of mica, pale blue in thin section, and with a double refraction of 0.028 and a 2V of 37°. No blue mica was observed, however, in the portion taken for analysis, which came from the coarse-grained siderophyllite in the upper margin of the sill. The orthoclase has been partly replaced by albite ($Ab_{97}$) in irregular perthitic veinlets and in small euhedral crystals along grain boundaries. The rock contains a few scattered grains of zircon and apatite.

The marble along the contact with the sill has been metasomatically altered for a thickness of three to five inches to a dark-green rock, cut by pinkish-brown irregular veinlets. Under the microscope the green rock is seen to consist principally of idocrase prisms about 2 mm. in diameter and scattered grains of green hornblende and magnetite. The idocrase encloses poikiloblastically very small anhedral grains of pleochroic hedenbergite ($Di_{30}He_{70}$) and euhedral colorless fluorite, and is replaced by hornblende, brownish green mica, and calcite. The veinlets are composed principally of garnet, with scattered grains of green hornblende and magnetite. The anhedral garnet grains, about 1 cm. in diameter, enclose poikiloblastically a little green hornblende and euhedral colorless fluorite, about 0.1 mm. in diameter. The sequence of formation appears to be hedenbergite, fluorite and idocrase; garnet, hornblende and magnetite; and calcite.

## Optical and Physical Properties

The masses of siderophyllite correspond closely in color to Ridgway 35'''''*m*, blackish green-gray. The cleavage flakes are brittle, unlike most mica—a fact commented on in the original description of siderophyllite.

The optical properties of the siderophyllite were determined on a part of the sample prepared for analysis. The greatest and least indices of refraction were measured in sodium light by oil immersion at room temperature. The optic angle was determined by Mallard's method, and $\beta$ estimated from this value and the values for the other two indices.

$$\alpha = 1.590 \pm 0.002$$
$$\beta = 1.640 \text{ (calc.)}$$
$$\gamma = 1.640 - 1.642 \pm 0.002$$
$$B = 0.050$$
$$2V = 6\text{–}8°$$

The birefringence was checked in thin section by means of a Berek compensator. The specific gravity is 3.121.

## Chemical Analysis

The chemical analysis of the Alaskan siderophyllite is given in the following table under *A*. Under *B* is given the analysis of the original material described by Lewis,[2] and under *C* an analysis of siderophyllite from Ireland, described by Nockolds and Ritchey.[3]

### Analyses of Siderophyllite

*A*. Siderophyllite from Brooks Mountain, Alaska; J. J. Fahey, *analyst*.
*B*. Siderophyllite from Pike's Peak, Colorado; H. C. Lewis and F. H. Genth, *analysts*.
*C*. Blue-green mica, Newcastle Co. Down, North Ireland, N. Sahlbom, *analyst*.

| | A | B | C |
|---|---|---|---|
| $SiO_2$ | 37.01 | 36.68 | 39.60 |
| $Al_2O_3$ | 15.89 | 20.41 | 22.80 |
| $Fe_2O_3$ | Trace | 1.55 | .79 |
| FeO | 30.16 | 25.50 | 20.98 |
| MgO | .22 | 1.14 | .46 |
| CaO | .10 | .81 | 1.52 |
| $Li_2O$ | 1.01 | .37 | None |
| $Na_2O$ | .58 | 1.09 | Trace |
| $K_2O$ | 9.02 | 9.20 | 8.95 |
| $Rb_2O$ | .19 | — | — |
| $Cs_2O$ | .12 | — | — |
| $H_2O-110°C$ | None | — | .24 |
| $H_2O+110°C$ | 1.92 | 1.01 | 2.93 |
| $TiO_2$ | .02 | — | .21 |
| MnO | 1.01 | 2.10 | .29 |
| BaO | — | — | None |
| SrO | — | — | None |
| F | 3.88 | — | 2.03 |
| Cl | .24 | — | — |
| | 101.37 | 99.86 | 100.80 |
| Less O | 1.68 | | .85 |
| | 99.69 | | 99.95 |
| Sp. gr. | 3.121 | 3.1 | 3.04 |
| $\alpha$ | 1.590 | — | 1.582 |
| $\beta$ | 1.640 | — | 1.625 |
| $\gamma$ | 1.640 | — | 1.625 |

[2] Lewis, H. C., On siderophyllite—a new mineral: *Proc. Acad. Natural Sci., Philadelphia*, **32**, 254–255 (1880).

[3] Nockolds, S. R., and Ritchey, J. E., Replacement veins in the Mourne Mountains granite, North Ireland: *Am. Jour. Sci.*, **237**, 27–47 (1939).

A sample was prepared for analysis by grinding the material in an agate mortar, sieving through a 60-mesh screen and discarding that portion passing a 100-mesh screen. A minor quantity of quartz was then removed by heavy-liquid separation (bromoform having a specific gravity 2.836). The sample was then washed well with acetone and dried at room temperature. The five alkalies were determined by the procedure published by Wells and Stevens,[4] silica and fluorine by the ferron colorimetric method,[5] and the remaining constituents by the methods recommended by Hillebrand and Lundell.[6]

From the analyses in the table it is seen that the percentage of ferrous oxide is higher (30.16%) and those of ferric oxide and magnesia lower (trace and 0.22%, respectively) in the Brooks Mountain mineral than in the sample described by Lewis. Other features of analysis *A* are the low CaO, the high $Li_2O$ and F, and the chlorine content.

The high-iron biotite (26.72% FeO and 2.87% $Fe_2O_3$) from Amelia, Virginia,[7] in which MgO was not determined may closely approach siderophyllite. The rastolyte of Shepard[8] with 38.25% total iron computed to FeO cannot be listed as siderophyllite because trivalent iron was not determined. The same is true of several other analyses of micas containing from 32 to 28 per cent of total iron expressed as FeO. The literature also presents other analyses of biotite containing more than 25% FeO, but these have 4 to 9 per cent $Fe_2O_3$ and therefore should be classed as lepidomelane. The Brooks Mountain biotite described in this paper is the third known occurrence of siderophyllite.

## Structural Classification and Formula

As the mineral is a mica there was little question that the atomic structure was one having the silicon atoms arranged in continuous sheets, but its peculiar composition made it interesting to derive the exact formula according to the modern method of *x*-ray classification. As a matter of fact the analysis shows that it has very nearly the composition of a pure end member.

The accompanying table shows the number of metallic atoms calculated for 10 atoms of oxygen.

[4] Wells, R. C., and Stevens, R. E , Determination of the common and rare alkalies in mineral analysis: *Ind. Eng. Chem., Anal. Ed.* **6**, 439–442 (1934).

[5] Fahey, J. J., Colorimetric determination of fluorine with ferron: *Ind. Eng. Chem., Anal. Ed.*, **11**, 362–363 (1939).

[6] Hillebrand, W. F., and Lundell, G. E. F., *Applied Inorganic Analysis.* John Wiley and Sons, Inc., New York (1929).

[7] Glass, Jewell J., The pegmatite minerals from near Amelia, Virginia: *Am. Mineral.*, **20**, 748 (1935).

[8] Dana, J. D., Fourth supplement to Dana's Mineralogy: *Am. Jour. Sci.*, **24**, 128 (1857).

| | A | | B | | C | |
|---|---|---|---|---|---|---|
| Si | 2.976 | 4.00=Z | 2.599 | 4.00=Z | 2.966 | 4.00=Z |
| Al | 1.024 | | 1.401 | | 1.034 | |
| | .482 | | .303 | | .978 | |
| $Fe^{III}$ | — | | .083 | | .044 | |
| $Fe^{II}$ | 2.028 | | 1.510 | | 1.313 | |
| Ti | — | 2.93=Y | — | 2.25=Y | .012 | 2.42=Y |
| Mn | .069 | | .126 | | .018 | |
| Li | .327 | | .106 | | — | |
| Mg | .027 | | .120 | | .051 | |
| Ca | .009 | | .061 | | .122 | |
| Na | .091 | | .150 | | — | |
| K | .925 | 1.04=X | .831 | 1.04=X | .855 | 0.98=X |
| Rb | .010 | | — | | — | |
| Cs | .004 | | — | | — | |
| OH | 1.029 | | .477 | | 1.463 | |
| F | .986 | 2.05 | — | 0.48 | .480 | 1.94 |
| Cl | .033 | | — | | — | |

As seen in the table the Brooks Mountain siderophyllite (*A*) approaches very closely to the theoretical octaphyllite molecule $XY_3Z_4O_{10}(OH, F)_2$ of the phlogopite and biotite micas, in which the value of Y is three. X is close to 1. $Y_3$ is very largely ferrous iron and Mg is only 0.027, which are the characteristic features for designating the mica as siderophyllite. The ratio of Si to Al in the Z group is very close to 3:1. If analysis *B* is correct, on the other hand, the Pike's Peak siderophyllite has less Al in the Y group than either of the other two.

The heptaphyllite molecule $XY_2Z_4O_{10}(OH, F)_2$ of muscovite in which Y=2, seems to predominate in the Pike's Peak mineral (*B*) in which Y=2.25, and in the sample from the Mourne Mountains (*C*) in which Y=2.42. The low figure (0.48) for the (OH, F) group in analysis *B* is due to the fact that fluorine was not determined and to the faulty method "moderate ignition" used for the determination of water.

That this analysis is incorrect, having a deficiency of anions, i.e. $O_{10}(OH)_{0.48}$, can further be shown by recomputing to a total of twelve oxygen atoms. This makes the value of X more than one (1.194) and the value of Y more than three (3.153), a condition that does not fit the structure of mica.

In addition to the type analysis (*B*) there has been published only the one complete analysis (*C*) of material that can be classified as siderophyllite. The Brooks Mountain siderophyllite (*A*) is nearer than the type material to what could be called the ultimate composition of siderophyllite, in which all of the aluminum in the octahedral position in muscovite is replaced by divalent iron, yielding the formula $KFe_3AlSi_3O_{10}(OH)_2$. Such a mineral would contain 42.12% FeO.