THE VALIDITY OF PARAGONITE AS A MINERAL SPECIES

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Abstract

The occurrence of paragonite at three localities has been verified by new analyses.

The validity of paragonite, as a separate species, distinct from muscovite, has been questioned by McCormick[1] who, on the basis of a partial analysis, showing 1.77 per cent Na_2O and 4.6 per cent K_2O, concludes "that the so-called paragonite schist of Pizzo Forno, Switzerland, is primarily a muscovite schist containing about 37 per cent of the paragonite molecule. Paragonite as a distinct mineral has not been found in nature, indicating that it probably is an unstable molecule of the mica group."

This conclusion apparently was verified by analyses of various micas which had been made in the Geological Survey, U. S. Department of the Interior, in which only minor substitutions of potassium by sodium are shown. Thus, in the series of 17 analyses of lepidolite made by Stevens,[2] the highest percentage of Na_2O is 1.27 (sample no. 2). All the other 16 analyses show less than 1 per cent of Na_2O. In a series of alkali determinations in various micas made by Stevens and as yet unpublished similar results were obtained. The highest content of Na_2O in 12 muscovites is 1.81 per cent; 10 samples contain less than 1 per cent. In 6 biotites, and in taeniolite, phlogopite, zinnwaldite, and vermiculite, the content of Na_2O is less than 1 per cent. Many of these samples were selected from specimens containing albite, where a sodium environment suggested that paragonite might be present. For example, in an intergrowth of albite (with 11.58 per cent Na_2O, 0.30 per cent K_2O, and 0.08 per cent CaO) from the Pala View mine, on the southern slope of Stewart Hill, Pala, San Diego County, California, the intergrown mica nevertheless was found to contain only 1.06 per cent Na_2O with 9.97 per cent K_2O (a content of soda comparable with that of nearly all muscovites).

Similarly, only minor quantities of soda are reported in a series of analyses of muscovites by other workers. For example, in the list of 25 analyses of muscovite given by Volk,[3] the highest percentage of Na_2O is 1.70 (sample no. 8). Out of a series of 10 analyses of muscovite given by

[1] McCormick, R. B., Paragonite from Pizzo Forno, Picino, Switzerland: *Am. Mineral.*, **19,** 431–432 (1934).

[2] Stevens, Rollin E., New analyses of lepidolites and their interpretation: *Am. Mineral.*, **23,** 615 (1938).

[3] Volk, G. W., Optical and chemical studies of muscovite: *Am. Mineral.*, **24,** 259 (1939).

Jakob,[4] one contains 3.77 per cent Na_2O (with 8.10 per cent of K_2O) whereas each of the others contains less than 2 per cent of Na_2O. In eleven additional analyses by Jakob,[5] the highest percentage of Na_2O is 2.21. From a third set[6] of eight analyses by Jakob the highest percentage of Na_2O is 2.08, and from a fourth set,[7] the highest percentage of Na_2O is 2.10 per cent.

Some of the recorded analyses of high-soda micas apparently are based on faulty analytical determinations. For example, the content of Na_2O in polylithionite from Kangerdluarsuk, Greenland, as given by Lorenzen,[8] namely 7.63 per cent Na_2O with 5.37 per cent K_2O, is much too high. On similar material Stevens[9] obtained 0.53 per cent Na_2O and 11.05 per cent K_2O. On polylithionite containing about 4 per cent of iron oxide from Narsarsuk, Greenland, Flink[10] likewise found but little soda, namely 1.61 per cent Na_2O with 11.05 per cent K_2O. The results obtained by Flink and Stevens confirm the conclusion that the percentage of Na_2O in polylithionite is not unusually high, as given by Lorenzen. The large quantity of lithia present in this mica probably accounts for the errors in the alkalies in Lorenzen's analysis.

The mica hallerite,[11] whose original analysis made on calcined material (the mineral contained 4.60 per cent "loss on ignition," fluorine absent) showed 1.26 per cent Li_2O, 7.63 per cent Na_2O and 3.12 per cent K_2O, was reanalyzed by Mallet[12] who obtained quite different results. Mallet's results on type material are: 0.36 per cent Li_2O, 3.04 per cent Na_2O, and 8.86 per cent K_2O. Hallerite, therefore, according to Mallet's results, is essentially muscovite with a relatively high content of sodium, equivalent to about 33 per cent of the paragonite molecule.

The recently described sericite[13] from Missouri "of unusual composi-

[4] Jakob, Johann, Beiträge zur chemischen Konstitution der Glimmer. II. Mitteilung: Die Muskovite der Pegmatite. I. Teil: *Zeits. Krist.*, **62**, 445 (1925).

[5] Jakob, Johann, Beiträge zur chemischer Konstitution der Glimmer. V. Mitteilung: Die Muskovite der Pegmatite. II. Teil: *Zeits. Krist.*, **69**, 404 (1929).

[6] Jakob, Johann, Beiträge zur chemischen Konstitution der Glimmer. VI. Mitteilung: Die nicht pegmatitischen Muskovite. I. Teil: *Zeits. Krist.*, **69**, 512 (1929).

[7] Jakob, Johann, Beiträge zur chemischen Konstitution der Glimmer. VII. Mitteilung: Die Muskovite der Pegmatite. III. Teil: *Zeits. Krist.*, **70**, 494 (1929).

[8] Lorenzen, J., *Meddelelser om Grønland*, **2**, 70–73 (1881). Analysis quoted in Dana's *System of Mineralogy*, p. 627, anal. no. 7.

[9] Stevens, R. E., *op. cit.*, p. 615, anal. no. 17.

[10] Flink, G., *Meddelelser om Grønland*, **24**, 110–115 (1901).

[11] Barbier, Ph., Sur un nouveau mica du group paragonite: *Compt. Rendu*, **146**, 1220 (1908).

[12] Mallet, J., Sur l'identite de la hallerite et de la muscovite lithinifere· *Bull. Soc. franc. Mineral.*, **61**, 209–211 (1938).

[13] Meyer, D. B., A sericite of unusual composition: *Am. Mineral.*, **20**, 385 (1935).

tion," with dominant soda, given as 5.27 per cent Na_2O with only 2.70 per cent K_2O, seemed to indicate a paragonite type of mica but these results could not be verified by us, as a redetermination of the alkalies (by Stevens) on a part of the original sample furnished by the late Prof. W. A. Tarr,[14] gave very different results, namely 1.82 per cent Na_2O and 7.60 per cent K_2O.

Apparently, then, McCormick's conclusion would seem to be justified and paragonite possibly should be placed among the doubtful species.

However, two recent analyses of micas made in the Geological Survey show a high content of sodium and indicate that McCormick's conclusion may not be correct. The alkalies in mica from a schist (the Gassetts schist of Richardson) in Vermont, were determined by Dr. R. C. Wells of the Geological Survey who found 5.4 per cent Na_2O and 3.1 per cent K_2O, and in a new analysis (by Schaller) of euphyllite from Corundum Hill, Pa., soda was found to be greatly in excess of potash, though in the analyses of euphyllite listed on page 623 of Dana's *System of Mineralogy*, soda and potash are given in nearly equal quantities, with the percentages of potash slightly in excess. Also, a recent analysis of paragonite (locality not given) by Koch[15] shows 5.47 per cent Na_2O with only 0.46 per cent K_2O.

There are also in the literature a number of analyses of mica (paragonites), not yet shown to be faulty, in which soda greatly predominates over potash. In the older literature[16] about a dozen analyses of paragonite, with high content of soda, are given.

There seems, therfore, to be considerable evidence of the existence of a sodium mica. On the basis of this apparently conflicting evidence, it seemed desirable to reexamine the question of the existence of paragonite.

Accordingly, the alkalies were redetermined on three samples of mica from Europe labeled paragonite, and on euphyllite from Pennsylvania. The three samples from Europe were obtained from the U. S. National Museum through the courtesy of Dr. W. F. Foshag. One of these, however, although labeled "paragonite (var. pregrattite)," from Pregratten, Pustherthal, Tyrol (U. S. Nat. Mus. Coll. R 4415) is muscovite[17] with 0.07 per cent Li_2O, 1.81 per cent Na_2O, and 8.89 per cent K_2O, with no

[14] In a personal communication to W. T. Schaller, Prof. Tarr wrote (April 9, 1937): "The crushed and powdered sample is material Mrs. Meyer used in her analyses."

[15] Koch, G., Chemische und physikalisch-optische Zusammenhänge innerhalb der Sprodglimmergruppe: *Chemie der Erde*, **9**, 463 (1935).

[16] As listed, for example, by Hintze, Carl, *Handbuch der Mineralogie*, **2**, pp. 648 and 649 (1897).

[17] The sample, of course, may not have been true pregrattite. Dana (*System*, p. 623, anal. no. 2) gives for pregrattite, 7.06 per cent Na_2O and 1.71 per cent K_2O.

Rb_2O and Cs_2O. The other two samples, Nos. 1 and 2 below, are paragonite.

No. 1 is labeled "paragonite (var. cossaite)," from Fenestrella, near Borgofranco, Valle-del Chisone, Piedmont, Italy (U. S. Nat. Mus. Coll. R 4416). It is very fine grained, compact, of typical sericitic pseudomorphic texture. Our analysis corresponds to analysis no. 5 as listed on p. 623 of Dana's *System of Mineralogy.*

No. 2 is labeled "paragonite," from Monte Campione, Switzerland (U. S. Nat. Mus. Coll. R 4414). The mica was separated from most of the associated quartz and kyanite with heavy solutions but the sample analyzed was estimated still to contain about 1 to 2 per cent of quartz and 2 to 3 per cent of kyanite. Our analysis corresponds to analysis no. 1 as listed on p. 623 of Dana's *System of Mineralogy.*

Both samples were carefully examined microscopically for the presence of any feldspar of which none could be seen.

No. 3 is euphyllite from Corundum Hill, Pa., obtained from the Brush type collection at Yale University by Dr. Michael Fleischer through the courtesy of Dean C. H. Warren. As far as can be ascertained this sample (Yale No. 3725) represents the type material analyzed by Smith and Brush, the results being published in 1853.[18] The specimen, a coarse aggregate of euphyllite and black tourmaline, was broken down by rolling on a steel plate, so as to crush finely the more brittle tourmaline and other associated minerals and leave much of the euphyllite in relatively large sheets. The material was then sieved, the large sheets of mica being retained. After further selection and purification, the mica was ground and analyzed.

The alkalies determined in these three samples of high soda micas are shown below.

ALKALIES IN PARAGONITES

[By R. E. Stevens]

	1[a] Fenestrella, Italy	2[b] Monte Campione, Switzerland	3[c] Pennsylvania	Calculated for paragonite
Na_2O	7.26	6.28	5.64	8.11
K_2O	1.01	2.17	1.71	—

[a] In addition, 0.13 per cent Li_2O, no rubidium or cesium.
[b] In addition, 0.08 per cent Li_2O, 0.12 per cent Rb_2O, no cesium.
[c] In addition, 0.73 per cent Li_2O, 0.11 per cent Rb_2O, no cesium.

[18] A new and complete analysis will be given and discussed in a later paper.

Paragonite, therefore, is a valid species and the conclusion of McCormick that "Paragonite as a distinct mineral has not yet been found in nature . . . " is incorrect. Three localities may be given with assurance: Fenestrella, Italy; Monte Campione, Switzerland; and Corundum Hill, Pa. Doubtless other localities will be added when the older analyses are verified.

Plotting selected analyses of muscovite and paragonite on the basis of their weight percentage composition of the two end members (M)$H_2KAl_3Si_3O_{12}$ with 11.82 per cent K_2O and (P)$H_2NaAl_3Si_3O_{12}$ with 8.11 per cent Na_2O, there is an almost continuous series from 95M, 5P to about 60M, 40P and from 30M, 70P to nearly 100P. The large gap from 60M, 40P, to 30M, 70P apparently has no representative.

It seems to be impossible to differentiate between muscovite and paragonite on the basis of their optical properties, those of paragonite lying within the variable range of the indices of refraction of the muscovites, for most of which both β and γ lie between 1.590 and 1.615, with a concentration of the values for γ from 1.598 to 1.604. Thus Koch gives: $\alpha=1.577$, $\beta=1.599$, and $\gamma=1.605$ for the paragonite analyzed by him. The paragonite from Fenestrella (no. 1) has $\beta=1.599$ and $\gamma=1.604$ and the paragonite from Monte Campione (no. 2) has $\beta=1.600$ and $\gamma=1.605$, with a few scales (possibly muscovite?) with both β and γ very slightly under 1.600. The euphyllite (no. 3) has about $\beta=1.605$ and $\gamma=1.609$, slightly variable.