SCIENTIFIC COMMUNICATION

BARIUM FELDSPAR FROM PUKKIHARJU BASE-METAL MINERALIZATION, CENTRAL FINLAND

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Normal barium feldspars have not been described before from Finland. In an unpublished thesis, however, Mäkipää (1976) described strontium- and barium-rich potassium feldspars, containing 0.07 to 6.15% SrO and 0.39 to 7.73% BaO, from Korsnäs deposit. The exhausted galena deposit was associated with pegmatite and it also contained appreciable amounts of carbonates, apatite and other phosphates as well as rare earth elements, indicating that the mineralizing fluids had a carbonatitic origin (Frietsch *et al.* 1979).

Barium feldspars usually occur in association with manganese deposits (Deer *et al.* 1967), but it is noted that barium feldspars are also associated with the base-metal exhalative mineralization at Rosh Pinah in Namibia (Page and Watson 1976) and at Aberfeldy in Scotland (Coats *et al.* 1980). Analyses of barian mica are rare in the literature although Bauer and Berman (1933) have reported a muscovite from Franklin, New Jersey containing 9.89% BaO, and Fortey and Beddoe-Stephens (1982) have reported muscovites from Aberfeldy containing 3.9 to 8.3% BaO.

The origin of barium feldspars has been the subject of only a few studies. They have been described as contact-metamorphic minerals after baryte (Strandmark 1903), as minerals formed during the regional metamorphism of a barium-rich silica-alumina gel or a mixture of quartz and barium-zeolite (Coats *et al.* 1980) and as replacement minerals of authigenic baryte crystals during diagenesis (Björlykke and Griffin 1973). Further, some experiments have been conducted in ceramic systems in which heating of a kaolinite-baryte mixture, with carbon as the reducing agent, produced celsian

Table 1. The chemical composition of the barium-bearing minerals in boulder sample L2-UMV-78 from Pukkiharju base-metal mineralization. The microprobe analyses were done with a JEOL 733 superprobe at the Geological Survey of Finland.

	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	56.8	57.2	57.1	55.2	57.1	56.2	56.2	61.0	58.4	39.3	38.1	39.2
TiO_2	0.12	0.00	0.00	0.12	0.00	0.11	0.00	0.00	0.00	2.41	2.63	2.70
Al_2O_3	21.3	20.3	20.8	21.3	21.6	21.1	21.5	24.2	25.4	18.4	19.1	19.3
FeO	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.33	7.23	6.44
MnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.51	0.54
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.7	16.8	17.9
CaO	0.41	0.00	0.00	0.00	0.00	0.00	0.00	6.58	8.52	0.00	0.01	0.00
Na_2O	2.18	2.48	2.31	2.48	2.51	2.40	2.31	7.90	7.04	0.21	0.23	0.15
K_2O	7.90	8.18	8.68	8.12	8.80	8.30	8.76	0.11	0.08	8.68	8.21	8.71
BaO	11.5	12.4	11.6	12.6	11.4	12.1	11.5	0.16	0.15	3.11	5.61	3.25
SrO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.03
Total	100.32	100.56	100.49	99.82	101.41	100.21	100.27	99.95	99.59	97.74	98.55	98.22
Cn	23.4	24.2	22.6	24.6	21.7	23.7	22.3	0.3	0.3			
Or	52.3	51.9	55.0	51.5	54.6	52.9	55.4	0.3	0.2			
Ab	22.0	23.9	22.4	23.9	23.7	23.4	22.3	68.1	59.1			
An	2.3	–	–	–	–	–	–	31.3	40.4			

1– 7 Hyalophane
8– 9 Plagioclase
10–12 Barian phlogopite

(Segnit and Gelb 1970). Fortey and Beddoe-Stephens (1982) have proposed that on some occasions cymrite could possibly be a precursor mineral to celsian.

The Pukkiharju base-metal mineralization is located in the Rautalampi area, about 50 km SW of the town of Kuopio (62 41' N and 28 47' E). Outokumpu Exploration conducted a drilling programme in 1977–1982 supplemented by geological, geochemical and geophysical investigations, but no economic ore-grade mineralization has yet been found. The geology, geochemistry and origin of the Pukkiharju base-metal mineralization has been studied by Lahtinen (1986).

There are some high barium assays from the mineralized samples of Pukkiharju area, but no baryte has been detected. One sample containing 2.08% BaO, 1.89% Zn, 0.09% Cu and 0.09% Pb was selected for mineralogical study to identify the barium-bearing minerals. Electron-microprobe analyses of the barium-bearing minerals in the sample are presented in Table 1. Barium is concentrated in potassium feldspars and to a lesser extent in micas. According to X-ray diffraction the barium-rich potassium feldspar has an orthoclase structure and in chemical composition it is a hyalophane (cf. Deer *et al.* 1967). The chemical composition of the mica resembles that of a phlogopite and, hence it is a barian phlogopite.

The host-rock of the barium silicates discussed in the present study is a pyrrhotite- and sphalerite-bearing sillimanitecordierite gneiss. The rock is heterogeneous in texture and fine grained, and the sulphides occur in a breccia-like form. The main accessory minerals are rutile and apatite. The barian phlogopite resembles normal phlogopite, and pleochroism is light brown (Z= light brown, X= almost colourless). Hyalophane occurs as anhedral grains with inclusions of quartz, plagioclase and sulphides. It often has embayed grain boundaries, and the largest grains (2.5-3.0 mm Ø)

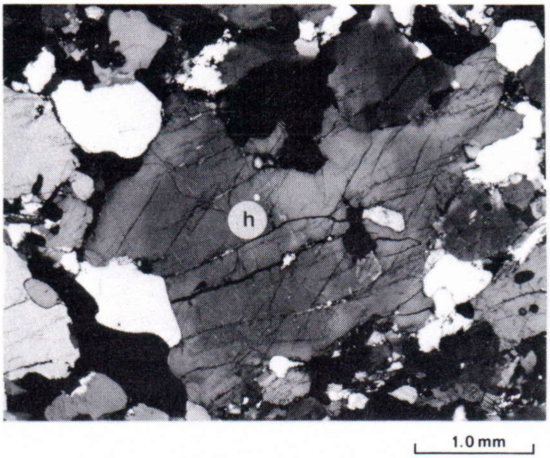

Fig. 1. A hyalophane porphyroblast (h) from boulder sample L2-UMV-78, Pukkiharju. Crossed nicols.

occur as porphyroblasts (Fig. 1). Hyalophane resembles orthoclase in polished thin section; it is untwinned and perthitic but shows anomalous bluish interference colours.

The perthite normally occurs as irregular flames or patches. The refractive indices of hyalophane are slightly lower than those of plagioclase (An 25–40) and so hyalophane is sometimes hard to distinguish from untwinned plagioclase. The rock has been subjected to brittle deformation, and sulphides have been mobilized into microcracks. The hyalophane has also been slightly altered around the grain boundaries and microcracks. It can be concluded from the texture of the hyalophane grains that they are secondary crystals that probably grew during metamorphism.

The Pukkiharju volcanic-sedimentary association is part of the Rautalampi block of the Savo schist belt (Korsman *et al.* 1984). The Rautalampi block has underwent granulite facies metamorphism during or before the intrusion of the hyperstene granitoids assigned an age of 1880 Ma by the U-Pb method (Korsman *et al.* 1984). The orebodies at Vihanti and Pyhäsalmi, as also the sulphide occurrences in the Pyhäsalmi – Pielavesi district, are part of the Vihanti Ore Zone of the Main Sulphide Ore Belt by Kahma (1973). The lead isotopic composition of the galenas from the Vihanti Ore Zone and the Pukkiharju base-metal mineralization form a group that points to a common origin for these leads (Vaasjoki 1981). The ores of the Vihanti Ore Zone are now generally considered to be volcanic-exhalative in origin (Helovuori 1979; Huhtala 1979); the same origin is proposed for the Pukkiharju base-metal mineralization (Lahtinen 1986).

The hyalophane of the present study is a metamorphic mineral, but the paucity of samples leaves the question of origin unanswered. Nevertheless, baryte is present as a gangue mineral in the zinc-rich ores of the Vihanti Ore Zone (Papunen 1967; Rouhunkoski 1968; Helovuori 1979; Huhtala 1979) and it is possible that baryte also occurs in the Pukkiharju base-metal mineralization. Being unstable under reducing conditions (Segnit and Gelb 1970; Björlykke and Griffin (1973), baryte could, as described by Björlykke and Griffin (1973), release barium, which could then be incorporated into growing potassium feldspars, under such conditions during or before metamorphism. Hyalophane might have been formed wherever the Ba/K ratio was high enough. However, there is a need for further mineralogical studies to test the validity of this assumption. It is also worth noting that baryte has not yet been found from the Pukkiharju area, and so there is still a chance that more of barium minerals will be found. Barium-rich minerals are not easily distinguished from their normal varieties, and it is possible that minerals of this type are more common in the barium-rich mineralizations of Finland than is at present realized.

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