The geochemical attributes of the amazonitic microcline at the Morefield NYF-type pegmatite, Amelia district, Virginia

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ABSTRACT

In light of growing significance of amazonite as a petrogenetic indicator of the evolved granitic pegmatite-forming melts of the NYF affiliation, the amazonitic K-dominant feldspar form the Morefield pegmatite was examined by microanalytical techniques. The geochemical data collected showed strong enrichment in Pb, Rb, Cs, and Tl. The formation of the granitic magma enriched in these incompatible elements may well have been induced by crustal anatexis, but the crust presumably was fertilized from below prior to this event.

Keywords: *amazonitic K-feldspar, granitic pegmatites, NYF type, Morefield, Virginia.*

INTRODUCTION

The Morefield pegmatite, located in the Amelia district of central Virginia, is one of the classic examples of granitic pegmatites related to an anorogenic extensional tectonic setting. Being generally enriched in niobium, yttrium, and fluorine, these pegmatites are known as NYF-type granitic pegmatites, according to the classification of Černý (1991). Amazonitic K-feldspar, famous for its blue to green color, is typical of NYF pegmatites; it commonly constitutes a significant part of a pegmatitic body. Our goal in this paper is to give a geochemical portrait of amazonite from the Morefield mine and to discuss applications of the data collected to answer important petrological questions concerning the origin of this specific locality and other granitic pegmatites of the NYF affiliation.

GEOLOGICAL SETTING AND BRIEF DESCRIPTION OF THE MOREFIELD PEGMATITE

The Amelia pegmatite district lies within the Goochland terrane, an isolated block of multiply deformed granulite-facies metamorphic rocks of Grenvillian age (Farrar, 1984, Owens & Samson, 2004) overprinted by an amphibolite-facies retrograde metamorphism during the Late Paleozoic (Alleghanian) tectonomagmatic episode. Numerous granitic pegmatites cross-cut the pre-existing foliation of the surrounding biotite-garnet and biotite-hornblende granitic gneisses and schists (Lemke et al., 1952). They were likely injected along fractures during a period of crustal extension at the final stages of the Paleozoic event. Although granitic intrusions are widespread within the area, no pluton shows an obvious petrogenetic link to the pegmatites. This fact and the extensional setting favor a hypothesis of an anatectic origin of the Amelia pegmatites.

The Morefield rare-element granitic pegmatite is the largest and mineralogically most complex zoned pegmatitic dykes in the Amelia district. The dyke, more than 600 m in length and up to 10 m in width (Kearns, 1993b), intrudes discordantly the host gneiss and is cut by Triassic diabase dykes. The distinct mineralogical and textural zonation, documented in numerous studies (e.g. Glass, 1935, Lemke et al., 1952), reflects a degree of evolution of the granitic magma and the complex history of its crystallization.

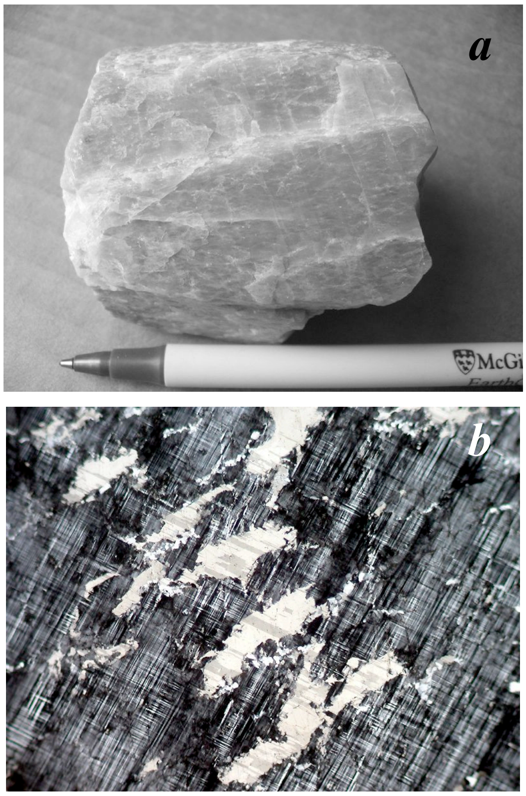

FIGURE 1. Photograph (*a*) and photomicrographs (*b*) of amazonitic perthite from the Morefield mine, Amelia Co., Virginia. (*a*) Hand specimen of turquoise-blue perthite; sample MF1. (*b*) Blebby perthite decorated by veinlets of late albite; sample MF4, section perpendicular to (001).

The pegmatite has four symmetrical zones, which record the progressive inward crystallization: a narrow fine-grained biotite-quartz border zone followed by a thicker, coarse-grained albite-rich wall zone, an intermediate zone of blocky perthitic microcline, and an innermost zone, the core of massive smoky quartz. The central part of the pegmatite body, adjacent to the core, hosts crystals of amazonite, beryl, topaz, manganotantalite, phenakite, zinnwaldite, and the rare aluminofluoride mineralization represented mainly by cryolite and prosopite (Kearns, 1993a). The presence of these minerals indicates the progressive enrichment of the residual pegmatite-forming melt in Be, F, Li, Nb, Ta, and Pb.

The Morefield amazonite forms blocky masses and, less commonly, well-developed crystals, and is characterized by a pale to deep turquoise-green color and a microperthitic texture (Fig. 1a). In oxidized zones, the amazonite loses its translucency and uniformity of color, and becomes “a white ground mottled with patches of green” (Glass, 1935). The coexisting lamellae have irregular “ragged” margins decorated by grains of late albite (Fig. 1b). Although possibly exsolution-induced, these lamellae have recrystallized and coarsened, which implies that microcline and albite, though in structural equilibrium, may not be truly equilibrated geochemically.

GEOCHEMICAL OBSERVATIONS

Two samples of turquoise-blue perthite (MF1 and MF4) and a chip of patchy pale greenish blue (MF2) amazonite from an oxidized zone have been characterized by electron microprobe and laser-ablation ICP-MS analyses. The analytical results of this study (Table 1) show that the amazonitic microcline is strongly enriched in Rb, Cs, Tl, Pb, and Ga. Bleaching effects deplete the first three, but locally concentrate Pb, Ba, and Sr. The different patterns of behavior of trace elements can be explained by a higher degree of mobility of Rb, Cs, and Tl. Being monovalent and more incompatible than Pb, Ba, and Sr, those elements can be more easily removed from the feldspar structure by percolating aqueous solutions in an oxidized zone. The perthite lamellae are composed of nearly pure albite.

TABLE 1. Representative compositions of amazonitic microcline and albite lamellae from the Morefield pegmatite.

	K-feldspar matrix			Albite lamellae		
	MF 1	**MF 4**	**MF 2**	**MF 1**	**MF 4**	**MF 2**
SiO2 wt.%	65.20	63.59	64.26	69.20	68.62	68.35
Al2O3	17.86	17.68	17.73	19.71	19.44	19.57
Fe2O3	bdl	bdl	bdl	bdl	bdl	bdl
CaO	bdl	bdl	bdl	bdl	bdl	bdl
Na2O	0.60	0.43	0.60	11.69	11.66	11.77
K2O	15.71	16.16	15.80	0.09	0.12	0.09
BaO	bdl	bdl	bdl	bdl	bdl	bdl
SrO	bdl	bdl	bdl	bdl	bdl	bdl
PbO	0.10	bdl	0.06	bdl	bdl	bdl
Rb2O	0.65	0.57	0.25	bdl	bdl	bdl
Total	**100.12**	**98.43**	**98.70**	**100.69**	**99.84**	**99.78**
T site						
Si	3.02	3.00	3.01	3.00	3.00	2.99
Al	0.97	0.98	0.98	1.01	1.00	1.01
SUM	**3.99**	**3.98**	**3.99**	**4.01**	**4.00**	**4.00**
M site						
Na	0.05	0.04	0.05	0.98	0.99	1.00
K	0.93	0.97	0.95	0.01	0.01	0.01
SUM	**0.98**	**1.01**	**1.00**	**0.99**	**1.00**	**1.01**
Ba ppm	4.3	4.1	18.7	1.1	0.7	bdl
Be	9.9	10.6	10.4	4.2	4.5	5.0
Cs	212	241	59.3	8.2	1.9	0.2
Cu	0.8	bdl	0.6	2.0	2.0	2.3
Ga	173	176	99.7	223	199	117
Li	1.9	2.3	3.1	bdl	bdl	3.3
Nb	bdl	bdl	bdl	bdl	bdl	bdl
Ta	bdl	bdl	bdl	bdl	bdl	bdl
Pb	463	416	535	82.3	51.0	31.4
Rb	4634	4854	2512	31.0	13.6	1.4
Sr	2.5	2.6	8.5	2.7	3.4	1.9
Th	bdl	1.6	bdl	bdl	bdl	bdl
Tl	37.6	61.1	28.4	1.0	0.5	bdl
U	bdl	bdl	bdl	bdl	bdl	bdl
Y	bdl	bdl	bdl	bdl	bdl	bdl
La	bdl	bdl	0.1	bdl	bdl	bdl
Ce	bdl	bdl	0.1	bdl	bdl	bdl
Eu	bdl	bdl	bdl	bdl	bdl	bdl

Notes: analytical data were acquired by electron microprobe and laser ablation ICP-MS; cation proportions are calculated on the basis of eight oxygen atoms; averages for trace elements were calculated on the basis of 6-10 analyses; bdl: below detection limit.

DISCUSSION

Two essential facts are known about amazonite: it is distinctly enriched in Pb and typically occurs in the evolved granitic pegmatites of the NYF type. The Morefield locality provides a supportive evidence for these statements. Ionizing radiation attributed to the presence of Th- and U-bearing accessory minerals and the elevated amounts of Pb (416-535 ppm) induced the greenish coloration of the K-dominant feldspar. Being confined to most evolved part of the Morefield dyke, at the interface of the quartz core and the intermediate zone, amazonitic microcline marks the final stages of the crystallization of the granitic pegmatite-forming melt. NYF pegmatite of anatectic origin may well arise by the melting of sialic crust that has been metasomatized by HFSE- and LILE-bearing fluids accompanying the underplating of the lower crust by basaltic magmas during the distensive stage after a major orogenic pulse.

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