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22. MYRMEKITE AND K-FELDSPAR AUGEN IN THE PONAGANSET GNEISS, RHODE ISLAND, CONNECTICUT, AND MASSACHUSETTS, USA

Lorence G. Collins

email: lorencecollins@gmail.com

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Introduction

Along the Connecticut and Rhode Island boundary and extending into Massachusetts is the Hope Valley shear zone (Fig.1). On opposite sides are two distinct late-Precambrian Avalonian terranes, the Esmond-Dedham terrane containing the Ponaganset gneiss to the east, and the Hope Valley terrane containing the Hope Valley alaskite to the west (Moore, 1964; Quinn, 1971; Gromet and O'Hara, 1985; O'Hara and Gromet, 1985; Hermes and Zartman, 1985). The Devonian Scituate granite intrudes the Ponaganset gneiss in the southeastern part of the area. The Ponaganset gneiss mostly ranges from granite to tonalite, but small lenticular bodies of diorite and gabbro also occur. Locally, layers of augen gneiss are separated by narrow lenses of amphibolite.

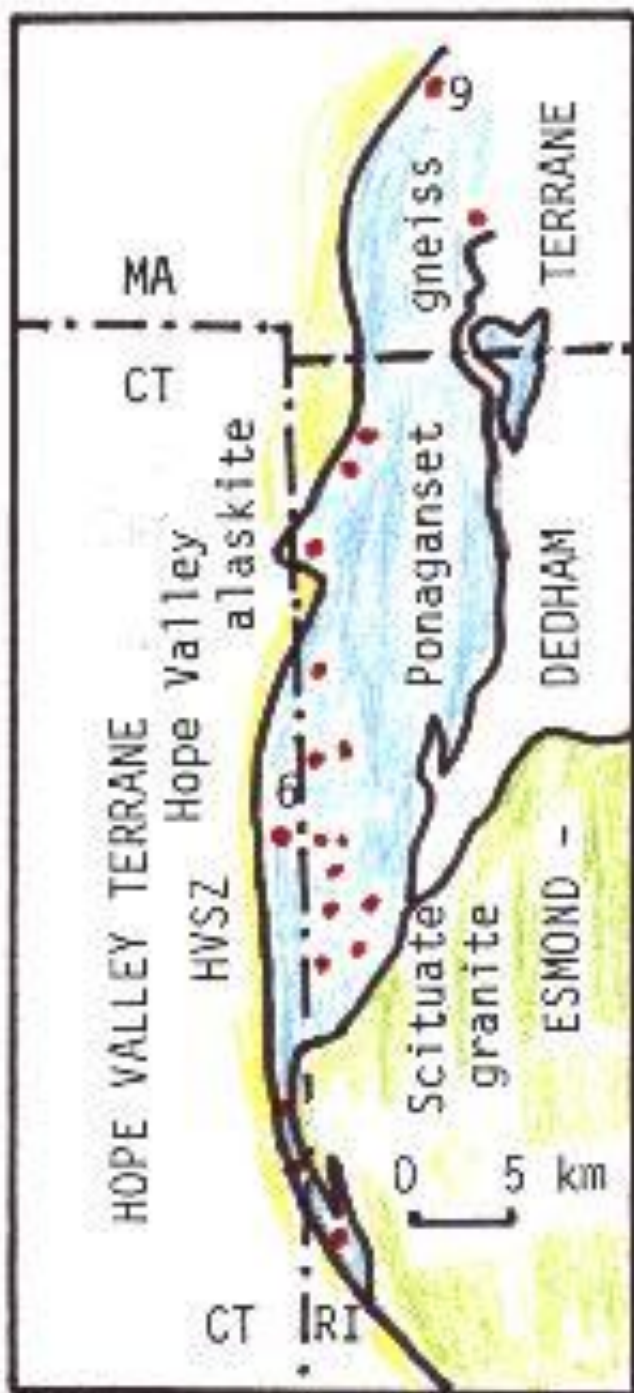


Fig. 1. Location of Hope Valley shear zone (HVSZ) near Connecticut-Rhode Island border, Ponaganset gneiss (blue), Scituate granite (green), and Hope Valley alaskite (yellow). Modified after map by Gromet and O'Hara (1985). Red dots indicate multiple samples examined in this presentation and their general locations. Numbers 6 and 9 indicate field trip stops in Gromet and O'Hara (1985).

In the shear zone both the Ponaganset gneiss and the Scituate granite contain K-feldspar augen and asymmetric quartz fabrics (Gromet and O'Hara, 1985). Simpson and Wintsch (1989) used the presence of myrmekite on the K-feldspar augen as one of their examples to support a model for the origin of myrmekite by Ca- and Na-replacement; see also presentation number 12 in this web site. These investigators argued that the myrmekite was created only on the highly-strained surfaces, but not at the ends of the K-feldspar augen in low-strain regions. In their model the K-feldspar is assumed to be primary and magmatic in origin. Field and thin-section examinations of the Ponaganset gneiss were made in transects from the shear zone eastward to test this assumption.

Distribution of K-feldspar augen

K-feldspar augen in the Ponaganset gneiss are restricted to a 1-4 km-wide strip centered along the Hope Valley shear zone, and these augen diminish in size and disappear with increasing distances eastward and westward from the shear zone. The augen are generally 1-2 cm long (Fig. 2, Fig. 3, Fig. 4, Fig. 5) but locally are as long as 7 cm in the narrowed, southern extension of the gneiss where it wraps around the Scituate granite (Fig. 1; Quinn, 1971). The augen are absent in coexisting amphibolite (Fig. 4), tonalite, diorite, and gabbro.



Fig. 2. Road-cut exposure of lineated Ponaganset augen gneiss near Rhode Island-Connecticut border on Route 6 West. This exposure is described in Stop 6 by Gromet and O'Hara (1985). Flat horizontal surface in center of photo shows a strong lineation projecting into the outcrop. White to light-pink K-feldspar augen vary from 1 to 2 cm long.



Fig. 3. Close-up picture of Ponaganset augen gneiss in same locality as shown in Fig. 2. U. S. dime is shown for scale.



Fig. 4. A narrow lens of amphibolite (black)) separates pinkish-brown (top) and gray (bottom) Ponaganset gneiss in a dynamited outcrop along Route 146 North in Massachusetts. This outcrop is described in Stop 9 by Gromet and O`Hara (1985). Drill-core traces are shown cutting through the gneiss.



Fig. 5. Close-up picture of gray Ponaganset augen gneiss in same locality as shown in Fig. 4

Formation of K-feldspar augen in the Ponaganset gneiss

Exposures of the Ponaganset gneiss are sparse, but samples were collected from scattered outcrops in southern Rhode Island, far-eastern Connecticut, and northward to southern Massachusetts (Fig. 1). Outcrops east and southeast of Stop 6 (Fig. 1) show that the augen diminish in size and disappear eastward as the gneiss becomes less deformed. The augen gneiss becomes massive, generally lacks strong foliation, and changes composition to become a biotite-rich tonalite, containing minor amounts of hornblende and no K-feldspar augen. From this tonalite westward toward the Hope Valley shear zone, the first appearance of K-

feldspar occurs in the interiors of deformed and fractured plagioclase crystals in biotite-hornblende tonalite (Fig. 6). Myrmekite locally borders this K-feldspar.

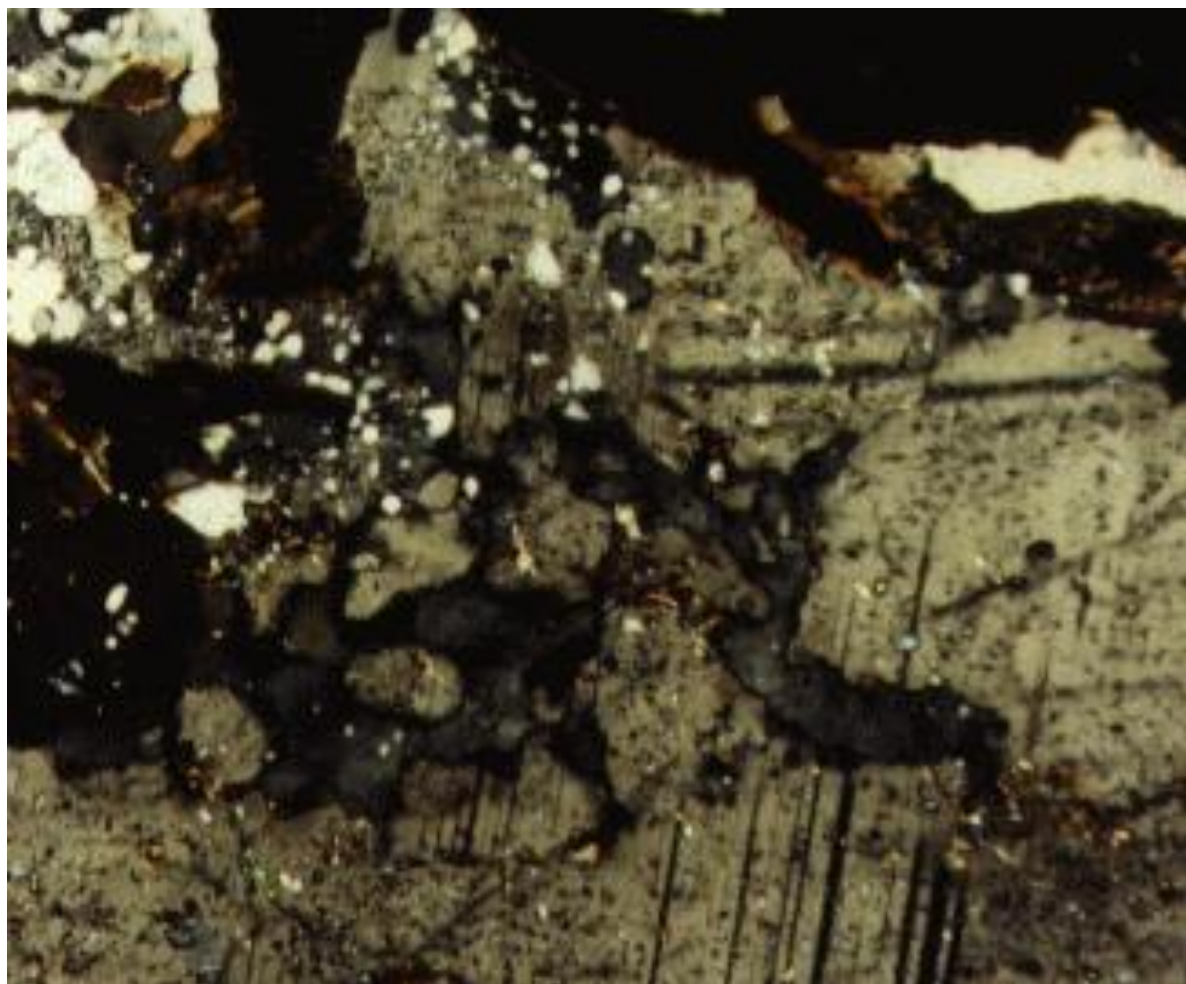


Fig. 6. Fractured, albite-twinned plagioclase (tan) in which the fractures are filled by K-feldspar (dark gray). Adjacent plagioclase is locally myrmekitic, containing quartz ovals (white). Biotite (brown).

Farther west toward the Hope Valley shear zone, where the replacement of plagioclase is more extensive, interiors of deformed plagioclase crystals contain irregular islands of K-feldspar (Fig. 7).

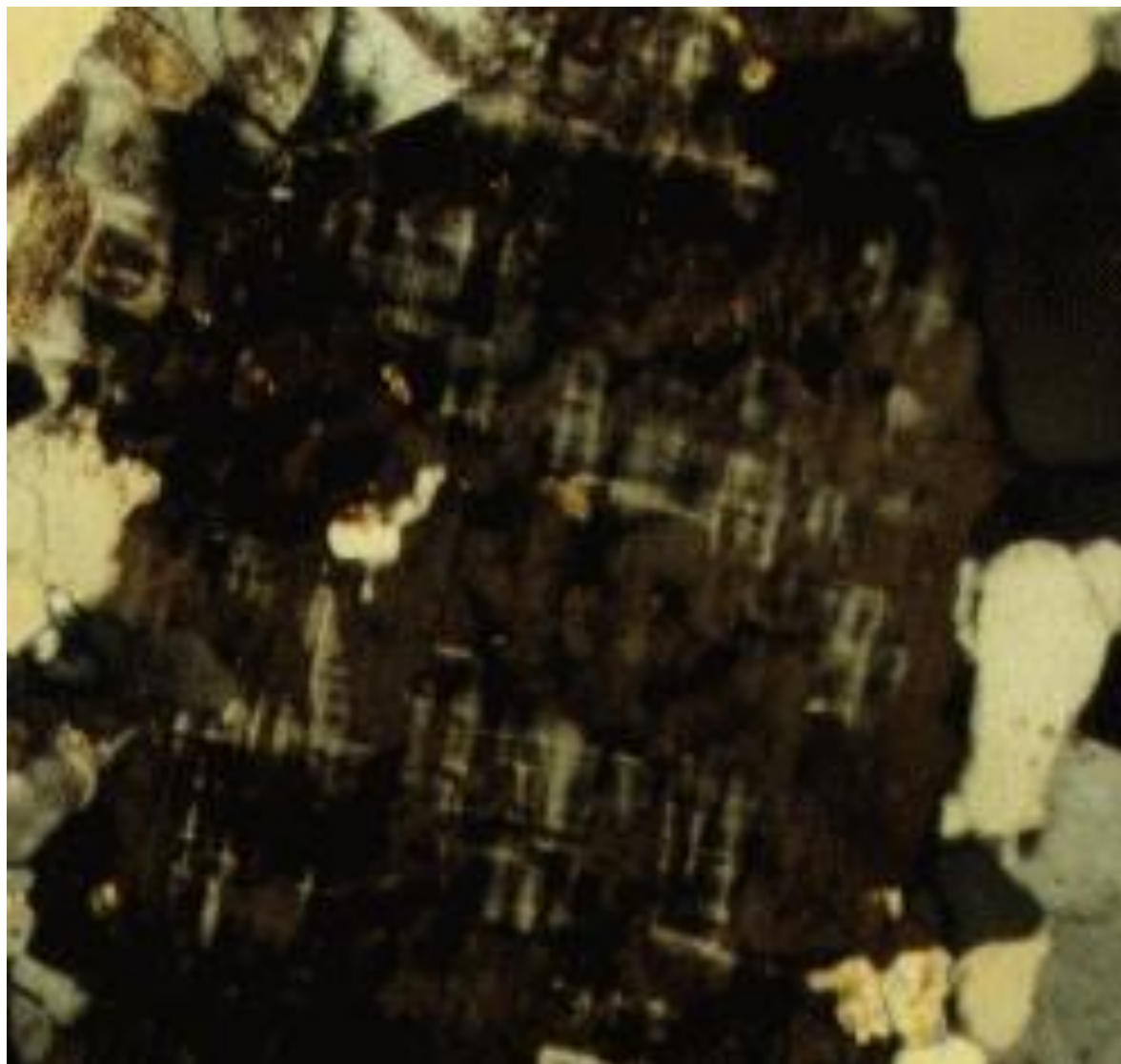


Fig. 7. Deformed, albite-twinned plagioclase (dark tan) with irregular islands of K-feldspar (microcline, black and white, grid-twinned). Feldspars are surrounded by quartz grains (cream, white, gray, and black).

Finally, where the K-feldspar augen appear in hand specimen and grow in size in the shear zone, many, if not most, plagioclase crystals are completely or nearly completely replaced by K-feldspar. These augen are bordered by myrmekite, enclose myrmekite grains, and/or contain ghost myrmekite (Fig. 8 and Fig. 9). The maximum diameter of the quartz vermicules is intermediate in size; see presentation number one in this web site. Coexisting biotite commonly shows quartz sieve textures (Fig. 10). In some places the biotite is associated with granular sphene.

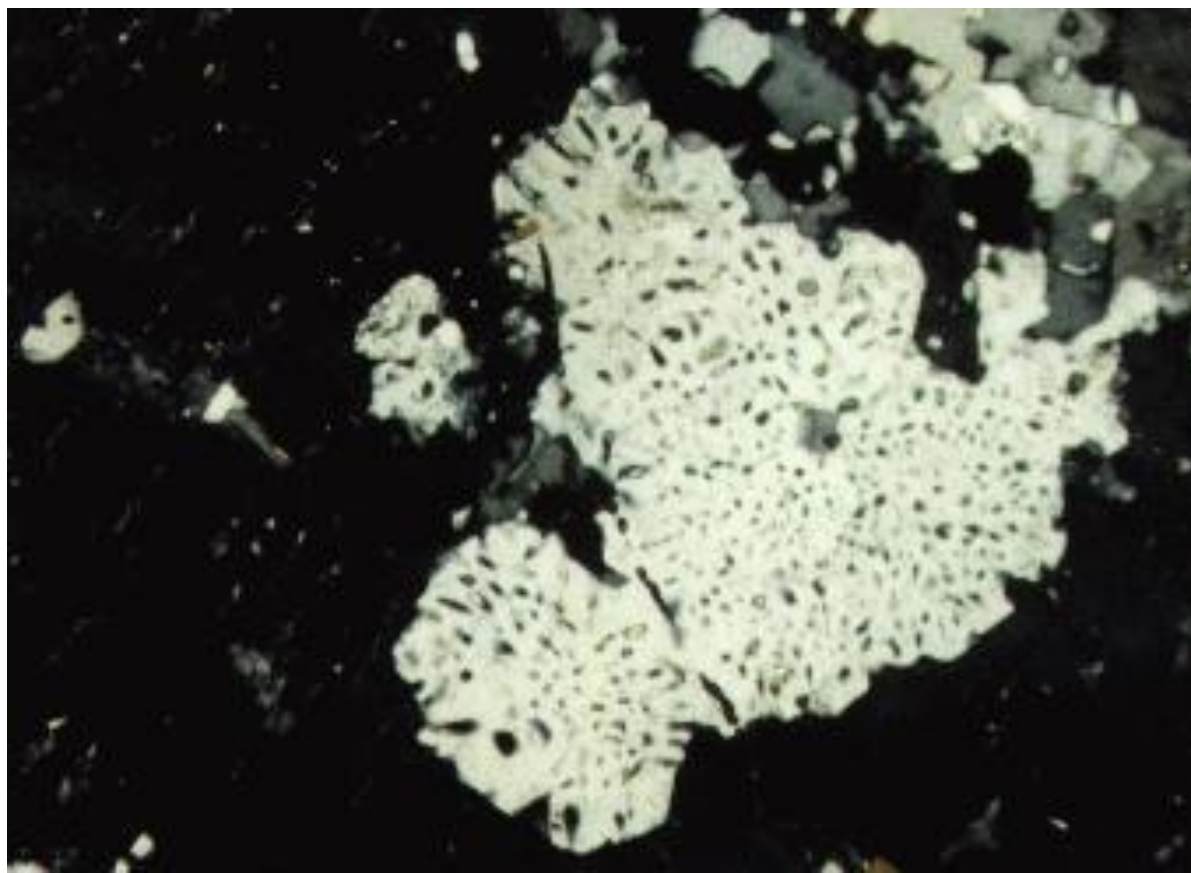


Fig. 8. Islands of myrmekite (white, with black quartz vermicules) in K-feldspar (microcline, black).



Fig. 9. K-feldspar (black) bordered by aggregate myrmekite grains (gray, white). Stringers of quartz ovules in ghost myrmekite extend through the K-feldspar.

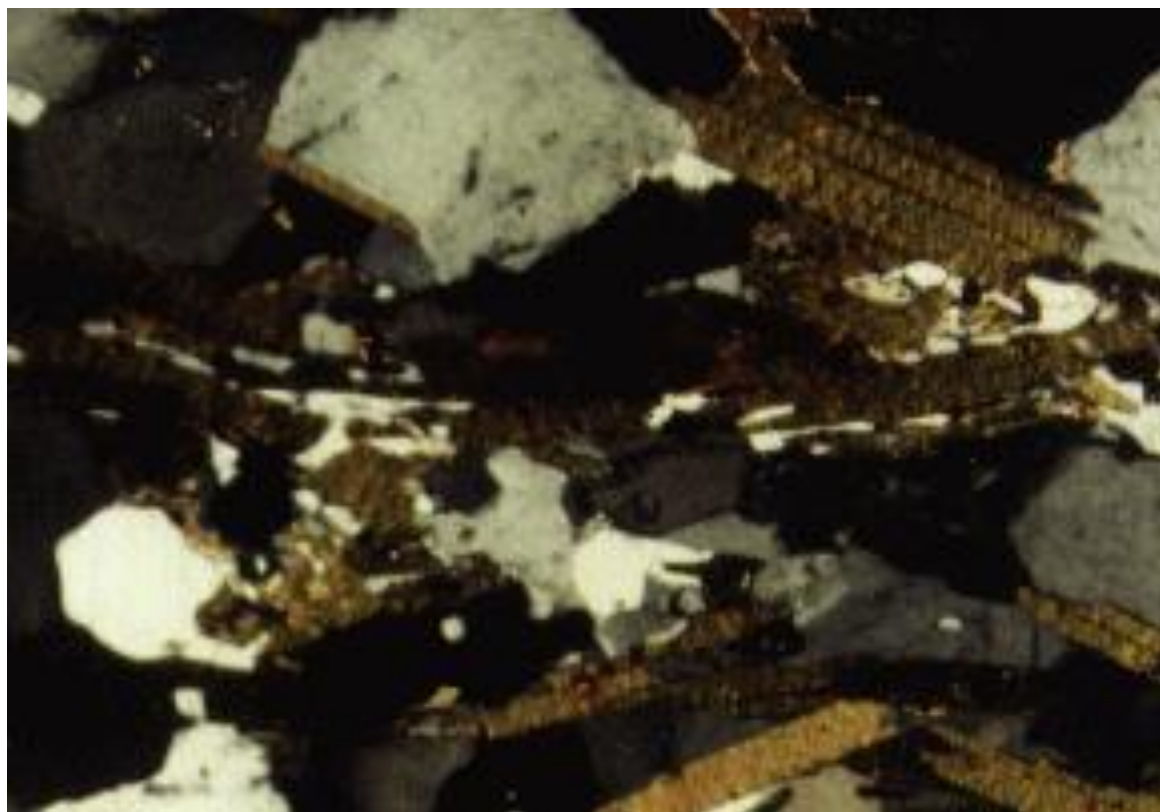


Fig. 10. Biotite (brown) locally contains quartz (white) in a sieve texture. Plagioclase, K-feldspar, and quartz coexist with the biotite.

Discussion

The field and thin-section relationships suggest (1) that the rocks that are now K-feldspar augen gneiss were originally interlayered, massive tonalite, diorite, and gabbro and (2) that those igneous rocks which were biotite-rich were easily and thoroughly deformed in the Hope Valley shear zone, whereas those rocks which were hornblende- or pyroxene-rich tended to be less sheared and preserved as lenticular layers, sandwiched between augen gneiss layers (e.g., the amphibolite lens, Fig. 4).

The restriction of the K-feldspar augen to the shear zone strongly suggests that the augen are secondary minerals whose existence and size are controlled by the degree of shearing and openness of the system for K-metasomatism. This hypothesis is supported by the gradual appearance of K-feldspar in fractured plagioclase crystals (Fig. 6 and Fig. 7).

Because the volume of myrmekite, where it first appears (Fig. 6), is about equal to the volume of adjacent K-feldspar, it is clear that the myrmekite cannot have been formed by exsolution from primary, high-temperature K-feldspar. The tiny volumes of K-feldspar would have contained insufficient dissolved Ca and Na to produce the plagioclase in the adjacent myrmekite. Furthermore, the myrmekite is most unlikely to have formed by replacement of the K-feldspar augen by solutions carrying Ca and Na ions, as proposed by Simpson and Wintsch (1989), because the K-feldspar is observed in its earliest stage of formation to be a secondary mineral replacing the plagioclase. The Ca and Na ions would have been displaced from the system by K rather than been introduced. In any case, the breakdown and replacement of biotite by quartz in zones of deformation would release the K to produce the K-feldspar augen.

The maximum sizes of the quartz vermicules in the myrmekite that occurs in the augen gneiss vary from place to place. Where the undeformed adjacent rock is tonalite with relatively sodic plagioclase, the quartz vermicules are relatively tiny, but where the undeformed adjacent rock is tonalite or diorite with relatively more-calcic plagioclase, then the quartz vermicules are coarser but still intermediate in size. At any rate, the maximum thicknesses of the quartz vermicules correlate with the An-content of the plagioclase in the Ponaganset gneiss (Quinn, 1971) which is what is expected and predicted by a metasomatic model (Collins, 1988; Hunt, et al., 1992).

Conclusion

It is clear from the field and thin section evidence (1) that the K-feldspar augen are secondary porphyroblasts and *not* porphyroclasts of former K-feldspar phenocrysts and (2) that the myrmekite is formed simultaneous with the appearance and growth of the K-feldspar augen.

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