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Multiple replenishments in an evolving silicic magma chamber: The Vinalhaven intrusive complex, Maine, USA

R. A. WIEBE[1] AND D. P. HAWKINS[2]

[1] Franklin and Marshall College, Lancaster, USA
[2] Denison University, Granville, USA
(bwiebe@fandm.edu; Hawkins@Denison.edu)

The Vinalhaven intrusive complex (VIC) is equant, about 12 km in diameter, and located on Vinalhaven Island, Maine. It consists mainly of cg granite with areas of abundant, interlayered, inward-dipping gabbroic and hybrid sheets. Several irregular bodies of porphyry (0.2 to 0.5 km in diameter) occur in the cg granite, with which they have variably sharp, gradational, and/or commingled contacts. Some contain angular inclusions of cg granite. The porphyry bodies appear to represent replenishments into the VIC magma chamber. In one area, three porphyry bodies occur at increasing distances from the pluton margin. Each shows sharp contacts where it cuts cg granite closer to the margin of the intrusion and commingled, gradational contacts where it cuts cg granite toward the interior. Each of these exposed sections through a replenishment feeder appears to record the location of the transition from crystal-rich floor or wall of the magma chamber to the crystal-poor interior. This group of feeders may record the gradual inward solidification of the pluton. Most porphyry has an aphanitic to microgranophyric matrix that suggests rapid crystallization. Porphyry compositions are close to the granite minimum with major and trace element concentrations similar to cg granite. Because there is essentially no compositional contrast, the porphyry matrix probably quenched due to a rapid reduction of pressure that led to saturation in H_2O, possibly during emplacement of the replenishment into the chamber.

Enclaves of porphyry (30-120 cm) occur in many areas of cg granite. They have compositions, mineralogy and textures that closely match the more strongly quenched portions of porphyry in the replenishment feeders. Cylindrical schlieren are commonly visible in cg granite above the enclaves and connect downward with schlieren beneath them. These schlieren appear to record downward sinking of enclaves through a weak crystal mush at the base of a silicic magma chamber. Because the enclaves are molded around individual crystals in the cg granite, they must have come to rest before they were solid. Large numbers of enclaves and their associated schlieren commonly occur in restricted areas. We tentatively interpret these enclaves as fragments of the quenched outer portions of felsic replenishments that were carried upward into the crystal-poor chamber and then sank to the floor. Each cluster of enclaves and associated schlieren appear to define the floor of the chamber at time of a silicic replenishment.

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Gouldsboro Granite: Silicic replenishment of granite magma chambers

T.E. WAIGHT[1,2] AND R.A. WIEBE[3]

[1] Danish Lithosphere Centre, Øster Voldgade 10, 1350 Copenhagen K, Denmark
[2] Geological Institute, Øster Voldgade 10, 1350 Copenhagne K, Denmark (todw@geol.ku.dk)
[3] Department of Geosciences, Franklin and Marshall College, Lancaster PA 17604, U.S.A (bob.wiebe@fandm.edu)

The Gouldsboro Granite, Coastal Maine, is linked temporally and compositionally to abundant co-existing mafic magmas. The pluton is underlain by gabbro, with a transition upwards through a zone of chilled mafic sheets and pillows. The pluton contains both mafic microgranular enclaves and a suite of intermediate to felsic enclaves (65-71% SiO_2). Wiebe & Adams (1997) [1] suggested that these silicic enclaves represented quenched magma that was trapped rising through the mushy roof of the magma chamber. The felsic enclaves can be separated into high- and low-K varieties, with otherwise similar petrography and chemistry. Wiebe & Adams suggested the low-K felsic enclaves were the result of alkali exchange between a normal (high-K) felsic enclave magma and underlying basalt to produce alkali-poor felsic magmas.

As radiogenic isotopic compositions are affected by diffusive exchange at rates similar to the alkalis then the isotopic compositions of the felsic enclaves should be highly variable, correlated with alkali contents, and trend towards compositions of the mafic components. Instead, the felsic enclaves have higher $^{87}Sr/^{86}Sr_i$ and lower εNd_i than the host granite and mafic rocks and are invariant with respect to alkali content. These results are inconsistent with alkali exchange and indicative of the involvement of an additional felsic component during granite petrogenesis. The felsic enclaves have isotopic compositions similar to granitic dikes that cut the nearby Pleasant Bay Layered Intrusion and may represent pristine, least contaminated samples of the silicic magmas that originally fed and replenished the overlying granitic magma chambers. The granitic compositions preserved in the magma chamber bulk were subsequently modified by extended replenishment, fractionation and interactions with co-existing mafic magmas and are therefore provide little information on crustal sources. These results suggest that multiple replenishments of silicic magma were involved in generation of the Gouldsboro Granite, these were likely derived from multiple crustal sources and variably affected by interactions with other magmas.

References

[1] Wiebe R.A. and Adams S.D. (1997) *J. Geol.* **105,** 617-627.