

Polymetamorphism and Disequilibrium in the Bronson Hill Terrane, New England

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Abstract

The Bronson Hill Terrane in northern Connecticut provides an opportunity to study the overprinting effects of the Acadian and Alleghanian Orogenies on rocks originally deposited during the Taconian Orogeny. Though the rocks of New England have been studied for over a century, the relationship between the Taconian (Ordovician), Acadian (Devonian) and Alleghanian (Permian-Pennsylvanian) orogenies is not well understood. An attempt to use the Holland and Blundy (1994) hornblende-plagioclase thermometer to define the extent of the Alleghanian overprint produced results that reflect disequilibrium.

One of the samples studied was located within the Ellington quadrangle of Connecticut and is an amphibole + plagioclase + quartz + epidote + minor allanite schist. The sample is located within the amphibolite of the Bronson Hill, which is believed to have been extruded during the Taconian Orogeny (Tucker and Robinson, 1990). Backscatter imaging (BSE) reveals that the allanite is composed of two distinct parts. One part has sharp oscillatory zoning that outlines euhedral crystal growth and we believe to be igneous in origin. The second portion of the allanite is an anhedral overgrowth, which we conclude to be metamorphic. The overgrowth is non-centered around the igneous core and fingers into the surrounding epidote. Preliminary analysis of the allanite has revealed that the metamorphic and igneous portions of the crystal have different chemical compositions. In the igneous core, the moles of lanthanum, cesium, thorium, and niobium are lower than in the metamorphic overgrowth. The igneous levels of silica, aluminum, and calcium are higher than the metamorphic portion of the allanite.

Boyd et al. (1993) used ⁴⁰Ar/³⁹Ar to determine the cooling ages of muscovite and amphibole within the Bronson Hill Terrane. At a similar latitude to the allanite-bearing amphibolite sample, the muscovite cooling age was ~250 Ma and the amphibole ~300 Ma. These ages are indicative of cooling from a Permian (Alleghanian) loading event (Goeke et al., 2000).

The presence of the igneous core within the metamorphic core is evidence that the sample never reached a state of equilibrium during either the Acadian or Alleghanian orogenies. This could be an explanation as to why the amphibole-plagioclase thermometry produced outcomes that are indicative of disequilibrium.

Introduction

The bedrock of New England consists of a series of north-south trending lithotectonic terranes (Fig. 1) that were formed during three major orogenies: the Taconian (Ordovician), the Acadian (Devonian), and the Alleghanian (Pennsylvanian-Permian). Overprinting effects of the various orogenies have been recognized, but they are poorly understood. K/Ar and ⁴⁰Ar/³⁹Ar cooling age studies of whole rock, hornblende, muscovite and biotite have identified areas deformed during the various orogenies and have recognized several overprinting relationships (Fig. 2 and 3). The goal of this study is to petrologically quantify the overprinting effect seen in the cooling age studies.

Geologic Setting

The Bronson Hill is a north-south trending terrane (Fig. 1), which formed as an island arc over the east-dipping subduction of Laurentia under the Iapetus Ocean. The arc collided during the Taconian orogeny and was later metamorphosed during the Acadian and Alleghanian orogenies.

Amphibolite within the Bronson Hill contains predominantly amphibole + plagioclase + quartz and subordinate garnet, epidote, and biotite. This mineral assemblage was chosen for use with the Holland and Blundy (1994) hornblende-plagioclase thermometer.

Holland and Blundy (1994) Thermometers

Two thermometers were developed by Holland and Blundy (1994): a silica-saturated and a silica-undersaturated thermometer. For rocks that were silica-saturated during hornblende-plagioclase growth, the two thermometers should calculate the same temperatures. In contrast, silica-undersaturated rocks will produce two different calculated temperatures. In cases of equilibrium, the silica-undersaturated temperatures would be lower than the silica-saturated results. If the converse is true, Holland and Blundy (1994) conclude disequilibrium must have existed between the amphibole and plagioclase.

Thermometry Results

Plagioclase and amphibole compositions were analyzed for a series of samples within the Bronson Hill (Fig. 4). Thermometry using the Holland and Blundy (1994) Hb-Pl program produced results concordant with silica-undersaturation for all of the samples (Fig. 5-8). Three types of results occurred: 1. The silica-saturated temperatures were consistently lower than the undersaturated data (Fig. 5); 2. The silica-saturated and undersaturated temperature lines crossed at some pressure between 0 and 15 kbar (Fig. 6 and 7); 3. Calculated silica-saturated temperatures were always higher than silica-undersaturated temperatures. Disregarding the disequilibrium results, no discernable pattern can be identified on a north-south plot of the calculated temperatures for either 5 or 10 kbar (Fig. 12 and 13).

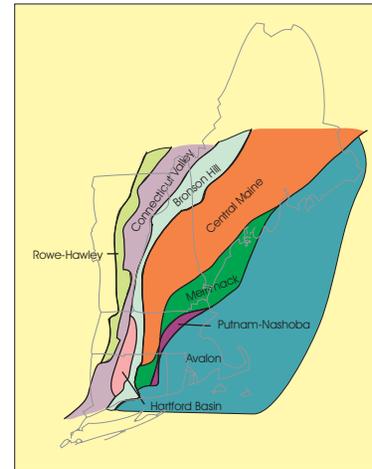


Figure 1. The terranes of New England. Based on Wintsch and Yi (2001).

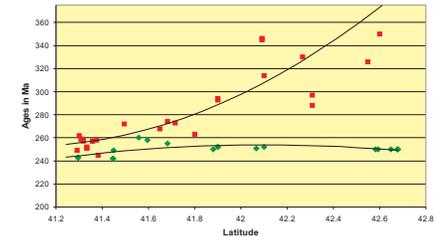


Figure 3. Hornblende (red squares) and muscovite (green diamonds) ⁴⁰Ar/³⁹Ar dates from Boyd et al. (1993). The difference in ages has been explained due to differential heating of the Bronson Hill terrane during the Alleghanian Orogeny. Hornblende in northern Connecticut and Massachusetts was not reset during the Alleghanian Orogeny, but the amphiboles in southern and middle Connecticut were. All of the muscovite was reset due to Permian heating.

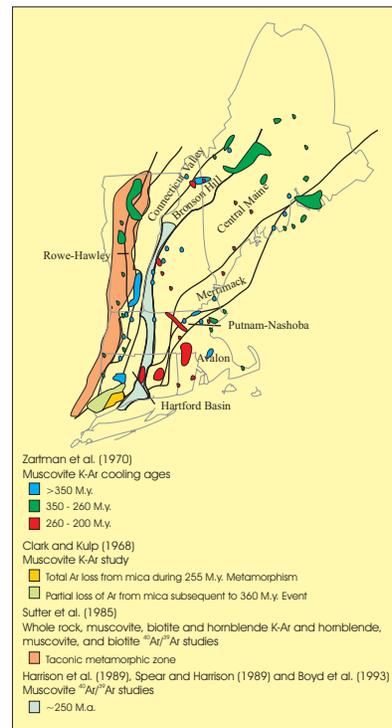


Figure 2. Summary of K-Ar and ⁴⁰Ar/³⁹Ar dating of New England rocks.

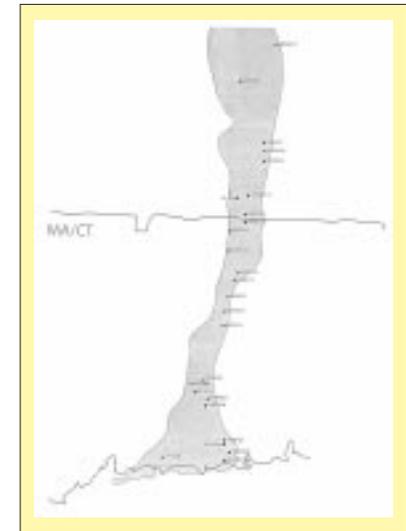


Figure 4. Sample map for rocks collected and used in this study. Dark area is the Bronson Hill.

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