Evidence for polyphase deformation in the mylonitic zones bounding the Chester and Athens Domes, in southeastern Vermont, from $40Ar/39Ar$ geochronology

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Abstract

The Chester and Athens Domes are a composite mantled gneiss in southeast Vermont. The deformation is recorded in the mechanisms of dome formation, most workers consider the domes to have formed during the Acadian Orogeny. This study integrates results of $40Ar/39Ar$ step-heating of single muscovite grains, or small multigrain aliquots, with data from microstructural analyses of samples collected in multiple transects across the dome-bounding shear zone(s) in order to understand the relationship between metamorphism and deformation. Results from the shear zones along the north and south transects are presented from west to east. In the north, hornblende from the Barnard Gneiss yielded a weighted mean age of 366 Ma from a plateau-like segment and biotite yielded a weighted mean age of 344 Ma. Muscovite from a second sample of the Barnard gneiss yielded a weighted mean age of 388 Ma for a plateau-like segment and biotite yielded a plateau age of 334 Ma. One analysis of biotite from the Devonian Walk River Formation yielded a plateau age of 403 Ma, and muscovite yielded a plateau age of 362 Ma, consistent with microstructural evidence of muscovite growing at the expense of biotite. In this transect, the deformation ages inferred for the samples include 388 Ma in association with upper greenschist to lower amphibolite-facies metamorphism, and 362 Ma in association with greenschist-facies metamorphism. In the south, muscovite from the basement cover contact yielded a weighted mean age of 365 Ma. Biotite from this sample yielded a weighted mean age of 359 Ma. A hornblende from the Mississippian Formation yielded a weighted mean age of 392 Ma. Muscovite from another sample of the Mississippian Formation yielded a weighted mean age of 365 Ma and biotite yielded a weighted mean age of 406 Ma. Along this southern transect, two sets of oriented thin sections were observed in thin section, an older S is preserved in the microcline of a younger, more dominant foliation. The dominant age signals in the integrated data from both transects are c. 406 Ma, 388 Ma, 383 Ma, 344 Ma and 362 Ma. The geochronology, along with the local preservation of an older S foliation in thin section, indicates that the samples experienced multiple phases of deformation. We also analyzed muscovite from a biotecrustatic Acadian dike that crosses the dominant penetrative foliation along the W margin of the Dome. Muscovite from this sample yielded a plateau age of 344 Ma. While all samples within the attenuated mantling units appeared to exhibit a single dominant deformation in the field, the results of this study suggest a complex history of deformation based on the microstructural analysis, the variety of plateau/weighted mean ages obtained, and the complexity of the strain parameters in the individual age spectra.

Geologic Overview

- These domes are core by Middle Proterozoic Grenvillian Basement and are separated from the metamorphic Silurian Ots Devosian-aged rocks of the Connecticut Valley Trough by the mylonitic shear zones (Karabinos, 1999; Karabinos et al., 2010, Doll et al., 1961).
- The faults surrounding the domes are now interpreted to be low-angle normal faults (Karabinos et al., 2010) that formed during the Acadian orogeny (Vance and Holland, 1993).
- Previous work involving $40Ar/39Ar$ and K-Ar geochronology has been completed in New England in an effort to determine and understand the timing of deformation.
- However, despite all of the geochronological data in the region, there are very limited data that exist for the Chester and Athens Domes. Work completed by McWilliams (2008) has suggested the domes experienced a polyphase tectonic history rather than a single experience of Acadian deformation. For example, deformation may have involved two folding stages including recumbent folds developing due to a nappe stage which observed thinning, followed by a doming phase (Heburn et al., 1984).
- In contrast, Karabinos et al. (2010) suggested extension occurred across the shear zone between the nappe stage and the doming stage.
- Resolving between the various hypotheses and constraining the timing of the deformation, particularly the formation of the dome bounding shear zones, has yet to be completed.