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Dating slate belts using 40Ar/39Ar geochronology and zircon ages from crosscutting plutons: A case study from east-central Maine, USA

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Determining the tectonic significance of slate belts is a persistent problem in many orogenic belts because of the lack of time constraints on the age of deposition and the age(s) of cleavages. We have solved this problem in east-central Maine where the ages of the regional Acadian cleavage (S1) and local ductile fault zone cleavage (S2) were both constrained using 40Ar/39Ar geochronology and the ages of crosscutting plutons. Applying 40Ar/39Ar geochronology to rocks with multiple generations of muscovite was possible because each cleavage-forming muscovite records a crystallization age rather than a cooling age due to the low grade of regional metamorphism. Evidence for metamorphic crystallization in rocks dominated by regional Acadian cleavage (S1) comes from the truncations of detrital and authigenic muscovite and chlorite grains by new muscovite and chlorite grains that define the S1 foliation. In rocks that display two foliations, the evidence comes from the truncations of chlorite and muscovite grains defining all earlier fabrics by new muscovite grains in the younger folia (S2).

Step-heating experiments using the 40Ar/39Ar technique on twelve samples all yielded sigmoidal age spectra. The low-temperature steps produced a hump in the age spectra, indicating 39Ar recoil into adjacent interlayered chlorite grains, the latter interlayering confirmed by back-scattered electron imaging. Continuing steps climbed steadily from those with minimum apparent ages as young as ∼381 Ma to steps with maximum ages as old as 466 Ma. The samples with the lowest minimum apparent age steps are those in which the S2 cleavage-forming mica population dominates. In contrast, the oldest apparent age steps are from samples that have the highest modal abundance of detrital micas.

The Middle Ordovician age of the maximum age steps is interpreted to be the minimum cooling age of the detrital micas. The minimum 40Ar/39Ar age steps of muscovite in the samples that display only S1 cleavage constrain the age of the regional Acadian foliation to be younger than ∼411 Ma. These regionally metamorphosed slates and meta-sandstones are from the Madrid Formation and the overlying Devonian Carrabassett Formation that were intruded by the unfoliated granite of the Mattamiscontis Mountain pluton. Its 407 ± 4 Ma zircon crystallization age (Bradley et al. 2000) provides a minimum age of the regional Acadian deformation thus constrained to the range 411-407 Ma. The 40Ar/39Ar minimum age steps of slates that display S1 and S2 cleavages from the Chester shear zone constrain the age of a second cleavage to be younger than ∼381 Ma. The fabrics in some of the Chester shear zone rocks are overprinted by garnet porphyroblasts interpreted as the product of thermal metamorphism associated with the emplacement of the nearby Center Pond pluton (zircon crystallization age is 377 ± 3 Ma, Bradley et al. 2000). This constrains the age of S2 cleavage to be between 381-377 Ma. Thus, the combination of maximum crystallization ages analyzed in the slates and the minimum contact metamorphic ages around local plutons established narrow constraints on the ages of low-grade cleavages in the Central Maine-Aroostook-Matapedia slate belt.