Fluid inclusion $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology of andalusite from syntectonic quartz veins: perspectives on dating regional deformation and metamorphism events

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A long-lasting orogenic process often generates vast complexity of deformation and metamorphism. Understanding the time scales of these processes is essential for the reconstruction of the finite architecture of a fossil orogenic belt, which, nevertheless, is not always straightforward. This is because multiple episodes of tectonic events would lead to multiple growth periods of accessory minerals and deformation of rock-forming minerals, which brings challenges for conventional dating methods such as U–Pb, K/Ar, and $^{40}\text{Ar}/^{39}\text{Ar}$ step-heating. Fortunately, the emplacement of syn-tectonic quartz veins witness the deformation process and potentially, the associated metamorphism. They, therefore, have the potential to provide vital age information for regional crustal evolution. These veins, especially those in metapelitic terranes, usually contain andalusite, a fluid inclusion bearing K-poor pure aluminosilicate, which stands a good chance for directly dating syn-tectonic veining events by the fluid inclusion $^{40}\text{Ar}/^{39}\text{Ar}$ stepwise crushing technique.

Combined with detailed petro-structural investigation, this study applies the fluid inclusion $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology, for the first time, on andalusite minerals in syn-tectonic quartz veins from the Chinese Altai Orogenic Belt, Central Asia, to explore a new way for dating deformation and metamorphism. $^{40}\text{Ar}/^{39}\text{Ar}$ stepwise crushing on three andalusite samples yielded well-defined Early Permian ages of 282–274 Ma. These ages are consistent with previously published emplacement ages of regional syn-tectonic leucosome/pegmatite/granite veins and metamorphic ages for local and regional schist/gneiss from the same metamorphic series. These results collectively suggest that the fluid inclusion $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology of andalusite in syn-tectonic quartz veins has the potential to constrain the timing of fluid-present deformation and potentially contemporaneous metamorphism. This work, therefore, provides a novel way for the age constraints of regional tectonic-thermal evolution of metapelitic terranes in general.
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