Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18635

Cooling or Fluids: A Multi-Proxy and Multi-Technique Approach to Investigate the 40Ar/39Ar Geochronology of the Agly Massif, Southern France

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The $^{40}Ar/^{39}Ar$ dating method is a powerful tool for reconstructing cooling paths of metamorphic terranes. A key assumption in defining such cooling paths is that $^{40}Ar/^{39}Ar$ dates reflect mineral-specific 'closure temperatures', formulated according to Dodson's equation of isotopic closure by thermally activated volume diffusion. However, deformation and fluid-assisted recrystallization are alternative processes that may reset the $^{40}Ar/^{39}Ar$ system at temperatures lower than the closure temperature. If unrecognized, $^{40}Ar/^{39}Ar$ dates may be erroneously linked to closure temperatures and therefore lead to the generation of inaccurate cooling paths.

The Agly Massif, southern France, is an excellent example of a Variscan metamorphic terrane where the interpretation of the $^{40}Ar/^{39}Ar$ data should be re-examined. $^{40}Ar/^{39}Ar$ biotite and muscovite ages from this terrane, as well as U-Pb apatite and U-Pb monazites ages, are unambiguously linked to Cretaceous (~110-100 Ma) exhumation, but despite these geochronological constraints, it is still unclear what is actually being dated: closure temperatures, deformation, or retrograde metamorphism?

Here we investigate what processes governed the ^{40}Ar loss from micas in the Agly Massif and how these processes can be identified through a multi-technique and multi-mineral approach. We combine in-situ and single-grain fusion $^{40}Ar/^{39}Ar$ dating of biotite and muscovite grains from six representative samples with EPMA and trace element analyses, detailed petrography, and numerical diffusion modelling. Preliminary results indicate that muscovite and biotite dates define a range between ~115-95 Ma. This range cannot be replicated through modelling the diffusive loss of ^{40}Ar expected for proposed PT paths after Variscan metamorphism. Petrographic observations and associated geochemistry further reveal the presence of numerous reaction textures involving both feldspars and micas; fluid-mediated reactions either grew new mica populations, or recrystallized older populations. The data suggest that retrograde metamorphism and associated deformation strongly affected the 40Ar/39Ar systematics of the Agly Massif and that thermally activated volume diffusion and associated $^{40}Ar/^{39}Ar$ 'cooling ages' may not be an appropriate tool to reconstruct the cooling path of this poli-metamorphic terrane. We stress the importance of a multi-technique and multi-mineral approach when interpreting $^{40}Ar/^{39}Ar$ dates from metamorphic rocks.