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# The Influence of Metamorphic History on Intragrain Argon Isotope Variations in Metamorphic White Mica Mapped by in situ UV Laser Ablation $^{40}Ar/^{39}Ar$ Geochronology

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*In situ* $^{40}Ar/^{39}Ar$ age distributions have been determined by high spatial resolution ultraviolet laser (UV) ablation in white micas sampled from a variety of metamorphic rocks. The *in situ* UV-laser ablation analyses are performed using a pulsed excimer (KrF) UV laser on irradiated polished rock disks approximately 18mm in diameter and 200µm in thickness. The size and depth of the ablation pit are regulated to maximize the signal strength while minimizing the spot size. Several examples from geologically diverse settings are presented that underscore the variability and complexity of argon isotope distributions at the intragrain scale. Depending on the geological context, the intragrain $^{40}Ar/^{39}Ar$ age distributions can be related to one or more variables such as variations in mineral composition, metamorphic pressure and temperature conditions, degree of deformation and/or metamorphic cooling history.

Samples of ultra high pressure (UHP) phengite from the Sulu terrain, China record compositionally dependent intragrain distributions consistent with the preservation of inherited argon. Intragrain $^{40}Ar/^{39}Ar$ dates have a range of up to 700m.y. and are positively correlated with Fe/Mg ratios of the phengite, consistent with argon entrapment during periods of UHP crystallization or retrograde recrystallization. Petrographic relationships, argon concentrations in coexisting UHP phases and the lack of evidence for peak or retrograde stable isotopic exchange involving metamorphic fluids collectively support an interpretation of inherited argon surviving UHP metamorphism.

Samples of large (~6mm) muscovite from a basement gneiss of the Swiss Alps yield *in situ*intragrain $^{40}Ar/^{39}Ar$ age variations consistent with a polymetamorphic history with dates ranging from the time of high grade Variscan metamorphism (~330Ma) to the time of low grade Alpine overprinting. A statistical analysis of the dates reveals trends that are subparallel to the extensional fabric preserved in the sample and highlight the importance of deformational microstructures controlling argon retentivity. Modelling of these data is consistent with volume diffusion at the grain scale, however the youngest apparent ages occur in areas within the grains with the highest defect and/or dislocation density, consistent with argon loss at a smaller scale by microstructurally controlled fast diffusion pathways.

The *in situ* $^{40}Ar/^{39}Ar$ analysis of micas forming metamorphic foliations generally requires analysis of micas perpendicular to their c crystallographic axis, which precludes straightforward modelling of $^{40}Ar/^{39}Ar$ data in terms of cooling gradients. Samples from variably deformed rocks of the Southern Alps and the Western Carpathian Alps dated in such a way yield lesser, but nonetheless significant intragrain variations in muscovite. The interpretation of these data remains equivocal, however on the basis of petrologic and field observations they probably reflect slow cooling through their blocking temperatures following high temperature metamorphism. The somewhat larger range in dates preserved in the more strongly deformed rocks from Southern Alps perhaps indicates a greater influence of crystallographic defects on argon loss than from the lesser deformed rocks of the Carpathian Alps. These examples show that individual white mica grains from metamorphic rocks can be expected to record a range of apparent $^{40}Ar/^{39}Ar$ ages and the specific geological conditions dictate the kind of intragrain variations preserved. While conventional step-heating of single grains or multiple grains are more precise, they will obscure such intragrain variations. For the particular case of strongly deformed rocks such *in situ* analysis can yield insight into the interpretation of otherwise complex geochronological data.