# Microstructural controls on intragranular argon diffusion in naturally deformed muscovites

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Micas are commonly used in 40Ar/39Ar thermochronological studies of variably deformed rocks yet the physical basis by which deformation may affect radiogenic argon retention in mica is poorly constrained. This study examines the relationship between deformation and deformation-induced microstructures on radiogenic argon retention in muscovite. A combination of furnace step-heating, high spatial resolution in situ ultraviolet (UV) laser ablation 40Ar/39Ar analyses and transmission electron microscopy (TEM) observations are reported for pre-Alpine deformed muscovites sampled from a granitic pegmatite vein within the Siviez-Mischabel Nappe, western Swiss Alps (Peninnic domain, Briançonnais unit).
The geological significance of the geochronological data depends on the ability of the considered mineral to retain the radiogenic daughter product after crystallization. The radiogenic daughter product mobility within the lattice is generally governed by a volume diffusion process. Volume diffusion assumes the solute mobility occurs between regularly spaced sites of a perfect lattice following to Fick's second law. However the volume diffusion process is perturbed in the case where microstructural defects are introduced in the mineral because they constitute new sites influencing solute mobility. Plastic deformation of a solid is known to introduce dislocations in the mineral lattice (dislocation glide process) but their role on solute diffusion in mineralogy is still debated.
This work focuses on argon diffusion within natural muscovites mainly deformed by dislocation glide. These samples reveal a strong intragranular argon diffusion component that is incompatible with a volume diffusion process in a sample free of intracrystalline defects causing a physical grain size reduction. TEM observations highlighted different kinds of microstructural defects and among these, stacking faults are the most prominent and clearly related to deformation.
Two-dimensional defects, such as stacking faults, are known to modify the mechanical behavior or diffusion in ionic crystals. Of particular interest for argon diffusion is the net dilatation that partial dislocations contolling the stacking faults are able to generate in a muscovite. Numerical modeling of diffusion along the stacking faults was performed to estimate the diffusivity ratio of volume diffusion to defect-enhanced diffusion and results are comparable with diffusivity ratios for other materials, as for instance in metals.
In the absence of defects causing physical grain reduction (e.g. kink bands or subgrain boundaries), stacking faults are potentially the main defects in the medium controlling intragranular argon diffusion. Their significance as a high diffusivity component on the bulk diffusivity is especially significant when considering that volume diffusion is slower than commonly admitted. Stacking fault-enhanced argon diffusion differs from pipe diffusion whose significance on the bulk diffusion depends on a high dislocation density because of the low volume fraction of the dislocations. In contrast to pipe diffusion, the linked occurrence of a dislocation network and stacking faults constitute an enhanced diffusion process for which a high dislocation density is notrequired for a significant argon lost.