TIME SCALES OF DUCTILE DEFORMATION AND FLUID FLOW: IN SITU UV-LASER $^{40}$Ar/$^{39}$Ar GEOCHRONOLOGY AND OXYGEN ISOTOPE GEOCHEMISTRY OF SYNTECTONIC MUSCOVITE FISH

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The duration of mylonitic deformation localized within shear zones is poorly known mainly because of the difficulty in resolving the age of different fabric elements within mylonitic fault rocks. Yet, the rates of deformation and the time scales over which ductile shear zones develop in the middle and lower crust are critical parameters for processes that govern the behaviour of the Earth’s crust and lithosphere. We present an integrated approach using texturally controlled in situ $^{40}$Ar/$^{39}$Ar geochronology and stable isotope geochemistry to establish the time scales and rates of extensional reactivation and fluid flow at the Porsgrunn-Kristiansand Shear Zone, Southern Norway. Neocrystallization of synkinematic muscovite fish in the hanging wall of the extensional shear zone was accompanied by infiltration of meteoric fluids as evidenced by low $\delta^{18}$O values for synkinematic muscovite and quartz. Element mapping of these muscovite fish indicates compositional changes within the highly strained tips of the muscovite fish consistent with a protracted history of muscovite growth and localized recrystallization during ductile deformation. When analyzed with the $^{40}$Ar/$^{39}$Ar UV-laser microprobe, individual muscovite fish record systematically younger $^{40}$Ar/$^{39}$Ar ages within the recrystallized tips than in the cores. Oxygen isotope thermometry data from the footwall mylonites ($T = 390 – 420^\circ$C) are consistent with deformation temperatures in the hanging wall below the closure temperature for diffusion of argon in white mica. The intra-grain age variation in the muscovite fish is interpreted to date synkinematic growth and subsequent crystal-plastic deformation of muscovite within
the mylonite. The observed ∼10 m.y. age difference between synkinematic muscovite cores and recrystallized muscovite tips demonstrates that mylonitization and meteoric fluid infiltration in the hanging wall occurred over a considerable time scale. Given a well-established structural and mineralogical context in situ $^{40}$Ar/$^{39}$Ar dating places constraints not only on the time scales over which deformation occurs but also on the strain rates associated with the deformation event. The in situ $^{40}$Ar/$^{39}$Ar data demonstrate that attributing a single "deformation age" to crustal scale brittle-viscous mylonite zones is inadequate given the longevity of mylonitization associated with crustal extension.