Integrated high-spatial resolution 40Ar/39Ar geochronology, stable isotope geochemistry, and structural analysis of extensional detachment systems: case studies from the Prosgrunn-Kristiansand shear zone (S-Norway) and the Shuswap metamorphic core complex (Canada)

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Reconstructing the tectonic and kinematic history of orogens and their major fault systems requires a quantitative understanding of the timing and duration over which these fault systems were active. This study aims at understanding the often complex 40Ar/39Ar geochronological data obtained from deformed mylonitic rocks and examines the relationship between deformation, recrystallization, and argon, oxygen, and hydrogen isotope exchange in muscovite and to some extent amphibole. Textures, as well as compositions and in situ UV-laser ablation and furnace step heating 40Ar/39Ar data from different extensional shear zones demonstrate that when combined with adequate sample characterization, cooling ages can be distinguished from neo- or recrystallization ages. Deformed muscovite porphyroclasts and recrystallized muscovite from the Pogallo Shear Zone (Ivrea Zone, southern Alps) reveal variable intra-grain 40Ar/39Ar ages with internal age variations of more than 60 m.y. The wide age range within compositionally homogeneous grains is consistent with diffusion-dominated argon loss controlled by observable intra-grain microstructures. In contrast, intra-grain 40Ar/39Ar ages of muscovite fish from Proterozoic mylonite of the Porsgrunn-Kristiansand Shear Zone (Southern Norway) and Eocene detachment mylonite of the Shuswap metamorphic core complex (British Columbia, Canada) display only minor age dispersion. Intra-grain recrystallization microstructures of compositionally-zoned, early syntectonic muscovite fish from extensional detachment mylonite at the Porsgrunn-Kristiansand Shear Zone record 40Ar/39Ar ages of deformation increments that bracket the duration of greenschist facies mylonitization. Texturally controlled in situ UV-laser 40Ar/39Ar dating of muscovite cores (891.9 2.9 Ma) and recrystallized rims (881.0 3.0 Ma) successfully resolves age variations between intra-grain deformation microstructures in muscovite fish and constrains the time scales of extensional detachment faulting to 10.9 5.9 m.y. Extensional detachment faulting and exhumation of lower crustal basement rocks along the Porsgrunn-Kristiansand Shear Zone hence occurred well after the main phase of Sveconorwegian high temperature thrusting and crustal shortening at ~1120-1100 Ma as determined by 40Ar/39Ar geochronology of amphibole. Spatially resolved sampling in mylonitic detachment quartzite of the Shuswap metamorphic core complex indicates that muscovite recrystallized between 49.0 - 47.9 Ma in the presence of meteoric water strongly depleted in deuterium. In situ 40Ar/39Ar geochronology reveals very homogeneous intra-grain 40Ar/39Ar distributions consistent with grain-scale recrystallization and synkinematic argon and hydrogen exchange. Several lines of evidence suggest that for at least 1-2 m.y. during the Early Eocene meteoric waters precipitated onto elevations of 4060 ± 250 m to 4320 ± 250 m some 1000 m higher than today's highest peaks in the area. The approach of combining X-ray element mapping and careful microstructural characterization with high-spatial resolution in situ UV-laser 40Ar/39Ar geochronology

and hydrogen and oxygen isotope geochemistry represents a significant advance in understanding 40Ar/39Ar data from shear zone minerals. The results of this thesis underline that this approach provides a widely applicable tool to establish the rates and time scales of tectonically controlled exhumation in eroding mountain belts and bears potential for determining the paleoelevation of eroded mountain ranges