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Timing of strain localization in high-pressure low-temperature shear zones: The argon isotopic record

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The complex interplay between rheology, temperature and deformation profoundly influences how crustal-scale shear zones form and then evolve across a deforming lithosphere. Understanding early exhumation processes in subduction zones requires quantitative age constraints on the timing of strain localization within high-pressure shear zones. Using both the in situ laser ablation and conventional step-heating 40Ar/39Ar dating (on phengite single grains and populations) methods, this study aims at quantifying the duration of ductile deformation and the timing of strain localization within HP-LT shear zones of the Cycladic Blueschist Unit (CBU, Greece). The rate of this progressive strain localization is unknown, and in general, poorly known in similar geological contexts. Critical to retrieve realistic estimates of rates of strain localization during exhumation, dense 40Ar/39Ar age transects were sampled along shear zones recently identified on Syros and Sifnos islands. There, field observations suggest that deformation progressively localized downward in the CBU during exhumation. In parallel, these shear zones are characterized by different degrees of retrogression from blueschist-facies to greenschist-facies P-T conditions overprinting eclogite-facies record throughout the CBU. Results show straightforward correlations between the degree of retrogression, the finite strain intensity and 40Ar/39Ar ages; the most ductilely deformed and retrograded rocks yielded the youngest 40Ar/39Ar ages. The possible effects of strain localization during exhumation on the record of the argon isotopic system in HP-LT shear zones are addressed. Our results show that strain has localized in shear zones over a $\sim$30 Ma long period and that individual shear zones evolve during $\sim$7-15 Ma. We also discuss these results at small-scale to see whether deformation and fluid circulations, channelled within shear bands, can homogenize chemical compositions and reset the 40Ar/39Ar isotopic record. This study brings new perspective on the process of strain localization through the dating of structures along strain gradients, especially on possible variation of rates of localisation through the entire exhumation history.