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P–T paths that make it possible to consistently date high–pressure metamorphic mineral growth using argon geochronology

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Much can be learned as to the geodynamics underlying the evolution of metamorphic geology by constraining the timing of individual fabric forming events and/or individual mineral recrystallisation or growth events. The argon geochronological system is important in this regard because typically it is the potassium bearing minerals (e.g., muscovite or phengite) that are intimately involved in the fabric–forming process. In addition, it is these minerals that are also the most obviously affected during later (overprinting) shear zone movement, or by subsequent grain growth ± recrystallisation events during which microchemistry is modified. However, only if the dated minerals were retentive of argon under the pressures and temperatures involved would the ages obtained be able to directly time microstructural processes. Here we show that specific classes of P–T paths should make minerals such as white mica or K-feldspar considerably more retentive of argon, to the point that it would then be possible to consistently directly date high-pressure metamorphic mineral growth events, or the timing of other microstructural processes, using argon geochronology. In addition, since Arrhenius plots from step-heating experiments imply that phengitic white mica can be extremely retentive of argon, even at zero pressure, if these data can be extrapolated to the natural environment, it should become a matter of routine that ages obtained from phengitic white are interpreted as recording the timing of deformation and metamorphism after mineral growth, and not as cooling ages. This is demonstrated by considering new geochronology from porphyroblastic white mica grown in pressure-shadows around a large boudin caught in the Boulder Mélange Shear Zone in northern Syros, in the Cycladic eclogite–blueschist belt, Aegean Sea, Greece. Argon geochronology step-heating experiments are able to consistently date microstructural events in these metamorphic rocks. The age spectra depend on microstructure in a predictable and systematic way. Ages can be inferred by applying the method of asymptotes and limits. The results are consistent with previously published estimates for the timing of a sequence of distinct and discrete episodes of high–pressure metamorphic mineral growth observed regionally across this belt.