Implications of quantified noble gas partition coefficients for Ar-Ar dating

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Since Ar-Ar dating was established as an isotopic dating technique [1], one of the fundamental assumptions has been that, “The radiogenic argon measured in a sample was produced by in situ decay of ^{40}K in the interval since the rock crystallized or was recrystallized”. However, the earliest Ar-Ar studies [2] also demonstrated that the assumption is occasionally invalid, and exesses of radiogenic argon are responsible for many anomalously old ages some of which have been reported as real ages. The assumption was reformulated by Dodson [3] as exchange between a cooling mineral with a theoretically infinite reservoir. Given that argon diffusion in silicate melt and in grain boundary networks is not infinitely fast, and neither are those reservoirs infinitely large, the occurrence of annomalously old Ar-Ar ages is not unexpected.

Experimental studies over the last decade have quantified the fundamental diffusion and solubility parameters for argon in mineral phases, demonstrating that there are several orders of magnitude difference in solubility even within the amphibole family of minerals [4]. That must make a difference to their behaviour and reliability as Ar-Ar mineral chronometers. Thus it is possible to address the zero contamination assumption in many natural systems. This allows us to assess the limits of the Ar-Ar technique, quantify the likely contamination, and even to use the additional argon to understand noble gas and volatile movements in the crust and mantle.

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