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Testing some assumptions behind $^{40}Ar/^{39}Ar$ thermochronology

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The $^{40}Ar/^{39}Ar$ method applied to K-feldspars and muscovite has been frequently used to construct continuous thermal history paths between ~150 – 600°C[1], which are usually applied to structural and tectonic questions in many varied geological settings. However, other authors contest the use of $^{40}Ar/^{39}Ar$ thermochronology because they argue that the assumptions are rarely valid. Here we evaluate the key assumptions, which are that i) ^{40}Ar is dominantly redistributed in K-feldspars and muscovite by thermally driven volume diffusion, and ii) laboratory experiments (high temperatures and short time scales) can accurately recover intrinsic diffusion parameters that apply to geological settings (lower temperatures over longer time scales). Case studies are presented from Itrongay (gem quality K-feldspar), Shap (UK) and Mt. Isa (Australia). Studies do not entirely negate the application of diffusion theory to recover thermal histories, although they reveal the paramount importance of first accounting for fluid interaction and secondary reaction products via a detailed textural study of single crystals[2-5]. Furthermore, an expanding database of experimental evidence shows that laboratory step-heating can induce structural and textural changes, and thus extreme caution must be made when extrapolating laboratory derived rate loss constants to the geological past. We conclude with a set of recommendations that include minimum sample characterisation prior to degassing, an assessment of mineralogical transformations during degassing and the use of in situ dating.

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