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The effect of neutron irradiation on the diffusion of Ar in alkali feldspar

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Knowledge of the thermal histories of rocks is useful when investigating geologic processes such as exhumation. Some research suggests that thermal histories between ~350-150 ˚C can be constrained using ^{40}Ar/^{39}Ar data derived from step-wise heating of alkali feldspar [e.g. 1]. However, this requires that sample preparation and analysis do not alter the diffusion properties of alkali feldspar. Several studies suggest that this assumption is not valid [e.g. 2, 3; 4; 5; 6]. Horn et al. [2] demonstrated that neutron irradiation (primarily used to generate ^{39}Ar from reactions on ^{39}K) changes the diffusion properties of plagioclase, while Foland [3] indicated that it may affect the diffusion properties of alkali feldspar and suggested that this problem needs careful examination. We aim to observe how neutron irradiation affects the diffusion properties of Ar in alkali feldspar by performing repetitive step-heating experiments with unirradiated and irradiated 1 mm cubes of gem-quality alkali feldspar from Itrongay (Madagascar), which were dissected from a single crystal using a diamond thread saw.

Our preliminary results indicate that neutron irradiation has a profound effect on the diffusion properties of Itrongay feldspar. Step-wise degassing of the unirradiated sample yielded an Arrhenius trajectory which is consistent with the presence of multiple domains, and which is characteristic of commonly occurring alkali feldspar [e.g. 1], i.e. where $log(D/r^2)$ for a given temperature decreases with progressive heating. On the contrary, step-wise degassing of the irradiated sample (52 hours irradiation; Oregon State University, TRIGA, ICIT, F12 position) yielded an Arrhenius trajectory where $log(D/r^2)$values for short-time initial heating steps plot significantly lower than those for longer-time repeated heating steps at the same temperature. $log(D/r^2)$ values for repeated steps in both experiments are similar, although $log(D/r^2)$ values for the irradiated sample are systematically lower than for the unirradiated one.

The causes of these variations in degassing are currently unclear. However, clearly the effect of neutron irradiation can be significant and requires a better understanding before step-heating ^{40}Ar/^{39}Ar data from alkali feldspar is used to constrain the thermal histories of rocks. This work is ongoing, and further step-heating experiments will be conducted with feldspars with varying duration of neutron irradiation. Heating of irradiated samples in air and their subsequent characterisation using electron microscopy will be used to identify the changes they undergo during step-heating.

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