Systematic variations in argon diffusion in feldspars

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Feldspars are commonly used in $^{40}Ar/^{39}Ar$ studies to constrain the thermal evolution of meteorites, mountain belts, intrusive magmatic bodies, and a host of other Earth and planetary processes. Although the kinetics of Ar diffusion in K-feldspars have been extensively researched, comparably little work has been published on plagioclase feldspars, despite their being the primary host of potassium in most chondritic, lunar, and Martian meteorites and many terrestrial igneous bodies. Similarly, little is known of the potential effects of composition and structural state on Ar diffusion kinetics, or the extent to which diffusion might be anisotropic.

In this study, ~100 step-heating diffusion experiments were conducted on feldspars that range in composition from nearly pure orthoclase to nearly pure anorthite, with the bulk of the samples being plagioclase feldspars. These experiments reveal systematic variations in diffusive behavior that appear to be closely related to composition and microstructure. For example, plagioclase crystals having compositions between An_{50} and An_{90} typically yield Arrhenius arrays with pronounced upward curvature between 600 and 800 °C, the opposite of that commonly observed on Arrhenius plots from K-feldspars inferred to have multiple diffusion domains. Plagioclase crystals with compositions $<An_{50}$ yield linear Arrhenius arrays that give way to downward curvature between 600 and 1000 °C, where the temperatures at which linearity ceases appear to depend on the composition of the sample and the heating schedule. Brecciated and microstructurally complex plagioclase crystals exhibit Arrhenius arrays consistent with multiple diffusion domains. Preliminary experiments on cleavage flakes indicate that diffusion may be faster in the [001] crystallographic direction than [010], and additional experiments are underway to confirm this finding. Activation energies for plagioclase and K-feldspars span a large range, from ~160-300 kJ/mole.

Arrhenius plots for Ar diffusion in plagioclase appear to reflect a confluence of intrinsic diffusion kinetics and structural ordering-disordering that occurs during prolonged step-heating. These data indicate that Ar diffusivity is intimately related to composition and microstructure in plagioclase. As such, there is no broadly applicable set of diffusion parameters that can be utilized in thermal modeling. Sample-specific data are required.

Tracking the magmatic evolution of an island arc volcano: Insights from a high-precision Pb isotope record of Montserrat, Lesser Antilles

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It is rare to have a chance to examine the magmatic evolution of an island arc volcano over a period of millions of years. The volcanic succession exposed on Montserrat provides such an opportunity, extending from the 2 Ma andesites of the Silver Hills complex through to the youngest dome collapse of the Soufrière Hills volcano (February 2010). In this study we present new trace element, Sr, Nd and high-precision double spike Pb isotope data taken through Montserrat's time sequence. As well as from subaerial locations, we have collected samples from marine sediment cores, as significant volumes of pyroclastic material have ended up in the Caribbean Sea.

Each of Montserrat's volcanic groups; South Soufrière Hills (SSH), Soufrière Hills, Centre Hills and Silver Hills, can be clearly discriminated using trace element and isotopic parameters. Furthermore, the SSH can be divided into two suites: A and B, combining trace elements and Pb isotopes.

The trends in trace elements and isotopes suggest some variability in fluid and sediment addition over time. The SSH in particular has a greater slab fluid signature as indicated by elevated Pb/Ce, but less sediment addition than the other volcanic centres. $^{206/204}Pb$ against $\Delta 7/4$ and $\Delta 8/4$ diagrams show that Montserrat falls along two differing trends, one defined by the SSH volcanic region and the second trend defined by the other volcanic regions on Montserrat (Silver Hills, Centre Hills and Soufrière Hills). Furthermore, the SSH volcanic centre differs noticeably in trace elements and isotope ratios. This demonstrates that the source which generated the SSH magmas is different to the source of the other volcanics on Montserrat. Both isotopic trends point to an enriched mantle source underneath Montserrat. Samples from the current period of activity will be discussed including the presence of mafic enclaves within the current eruption.