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THE EFFECT OF CHEMICAL AND ISOTOPIC EXCHANGE ON MICA RB-SR AGES IN SLOWLY COOLED ROCKS.

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The determination of cooling and exhumation rates of metamorphic terranes depends on knowing closure temperatures for different geochronological systems. Ages measured for geochronological systems are plotted against their closure temperatures to produce cooling curves. If a geothermal gradient is assumed the exhumation rate can be calculated, telling us about the tectonic behaviour of metamorphic rocks. Closure temperatures have conventionally been assumed to relate to the effective cessation of isotopic exchange (for example, Sr isotopes in the Rb-Sr system) during cooling. However, we suggest that the down-temperature chemical exchange of elements involved in dating schemes may also be important in controlling the closure temperatures of radiometric systems.

JENKIN et al. (1995) have suggested down-temperature exchange of Sr isotopes among minerals and this has been shown in JENKIN *et al.* (2001). In geochronological systems there is the potential for both isotopic (^{87}Sr with ^{86}Sr, investigated in this study using laser ablation ICP-MS) and chemical (Rb with K or Sr with Ca, investigated using an ion microprobe) exchange as the rock cools that will cause variations in measured ages. Understanding what these variations mean will give better constraints on closure temperature ages and therefore, the cooling and exhumation rates of mountain belts.

Simple calcite marbles, containing mica bands were used in this study. Two point phlogopite-calcite isochrons of samples from Lago del Narèt, Central Swiss Alps (where the metamorphic peak was attained at 25 Ma, after Steiner, 1984) produce ages of 17-18 Ma ($^{87}Sr/^{86}Sr \sim 0.8$ and $^{87}Rb/^{86}Sr \sim 290$). These ages suggest 7 Ma of ^{87}Sr has been lost from the phlogopites during cooling, indicating isotopic exchange. Stable isotope data suggests no fluid flow has occurred during cooling, implying exchange via grain boundary and volume diffusion.

Laser ablation ICP-MS results suggest ^{87}Sr lost from the mica has entered the surrounding calcite, giving increased $^{87}Sr/^{86}Sr$ ratios in the calcite near the mica band, which decrease over a distance of a few centimetres (which varies with grain size, mineral mode and Sr concentration). Modelling of these results suggests a combination of grain boundary and volume diffusion is a suitable mechanism for the exchange.

The results of the ion microprobe study indicate chemical exchange is occurring among grains within this rock sample. Sr concentration profiles across calcite and K-feldspar grains show that K-feldspar is gaining and calcite is losing Sr at the rims of grains. The phlogopite in these samples has low total strontium concentrations and the Sr profiles are inconclusive.

The ion probe traverses, in conjunction with laser ablation ICP-MS results, show that both elements and isotopes of those elements are mobile during cooling. Strontium isotopic exchange occurs between the mica and the calcite with ^{87}Sr diffusing from the mica into the carbonate. However, the ion microprobe traverses suggest Sr chemical exchange occurs in the opposite sense, with net strontium movement out of the calcite and into other minerals, such as K-feldspar. This implies other Sr isotopes are mobile during cooling, a factor not previously considered in closure temperature models.

Combining the effects of both isotopic and chemical exchange, measured ages will decrease and the closure temperatures will be lowered compared to those calculated for only strontium isotopic exchange. Models of the chemical exchange suggest if Rb is increased in phlogopite, the measured ages will decrease and the closure temperature will be lowered compared to those calculated without chemical exchange, enhancing the mode effect (described in this paper and JENKIN et al. 1995). Using the Sr isotope traverse modelling, it may be possible to develop an independent method of estimating the cooling rate.

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