Testing of feldspar cooling geospeedometer – Experimental study

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The composition of feldspar grains from igneous rocks is frequently altered by chemical diffusion. Therefore, the data on diffusion rates of cations in feldspars in the subsolidus may help to explain the T-t history of rocks.

Heating experiments were performed under dry conditions at atmospheric pressure and in the temperature range of 800 - 1000°C. The temperature was measured with Pt-PtRh thermocouples with a precision of ± 3 °C. As starting material were used K-feldspar (13.6-14.8 wt% K_2O) with albite exsolution lamellae (30mm) of composition 11.5-12.5 wt% Na_2O. Feldspar samples were packed in Pt-foil to avoid contact with the surrounding ceramic. In the experiments, diffusion was measured along several crystallographic orientations: normal to (001) and (010), parallel to (110). Diffusion profiles were measured on an electron microprobe with an ED system before and after heating. The step between measured points was 2 and 4 mm. Laser spots and BSE imaging were used for orientation in the sample studied.

Lamellar feldspars appear promising for the determination of cooling history. Diffusion profiles measured in identical spots before and after heating appear to be more suitable than statistically determined diffusion coefficients. An equation for a semi-infinite medium with a constant concentration on the surface (for elemental concentration at grain boundaries different from zero and assuming a constant temperature) were used for the determination of diffussion coefficients - see Crank (1975). Diffusion coefficients in K-feldspar at 1000 °C vary depending on crystallographic orientation: $D_{Na}(001) = 10^{-11.8}$; $D_{Na}(100) = 10^{-12.3}$ to $D_{Na}(010) = 10^{-13.2}$ cm^2s^{-1}. The most favourable direction for the determination of K-feldspar geospeedometer appears to be the direction [001].

Reference

Crank, J., (1975), The mathematics of diffusion. Oxford University Press, 414 pp.

Source and thermal evolution of High Himalayan rocks in the Makalu region interpreted from U-Pb and fission-track dating of zircon

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The complex of sillimanite-, kyanite- and cordierite-bearing gneisses, calc-silicates and amphibolites (“Barun gneisses) above the MCT zone in eastern Nepalese High Himalaya is intruded by protolith of migmatitic orthogneisses and overlain by the biotite-sillimanite paragneisses. The rocks have experienced a clockwise P-T evolution in response to crustal thickening during the collision (T_{max} = 800°C, P = 8-10 kbar) followed by decompression and crustal melting at P = 2-7 kbar. The biotite-sillimanite paragneisses in the upper part of the slab were intruded by tourmaline leucogranites of the Makalu massif in the early Miocene – late Oligocene times. We have studied the source of metasedimentary rocks and low-temperature history of the crystalline units in the upper part of the Barun Valley using laser ablation ICPMS U-Pb and fission-track (FT) dating of zircon grains.

The U-Pb ages of detrital zircon grains recovered from the biotite-sillimanite paragneiss range from 340 – 1700 Ma with several age maxima at ca 500, 700 and 900 – 1100 Ma. The U-Pb age data suggest the sedimentary sources of the studied gneisses in the northern part of the Indian plate. The dating also constrains the minimum deposition age of the protolith of the paragneisses to the early Carboniferous times.

Zircon grains from the biotite-sillimanite paragneiss, migmatitic orthogneiss and glacial river sediments from the elevation of 4600 - 5000 m were subject to FT analysis. The fission track lengths in all studied samples are characterized by broadly smooth unimodal distribution with a peak around 10 micrometers (1 sigma) and a positive skewness, interpreted as resulting from a steady slow cooling through the zircon partial annealing zone (PAZ, 230 – 310°C). The FT zircon cooling ages for the orthogneiss and paragneiss samples were 7.1 ± 1 Ma and 12.1 ± 1 Ma (1 sigma), respectively, corresponding to an average exhumation cooling rate of ca 26°C/Ma from the late - middle Miocene to the present time. The FT ages of zircons from the river sediments (10 ± 0.8 Ma and 9.7 ± 1 Ma, 1 sigma) represent a mixture of the FT zircon cooling ages of rocks exposed in the upper part of the Barun Valley and yield an average cooling rate of 25°C/Ma for the High Himalayan crystalline units in the Makalu region.