Geophysical Research Abstracts
Vol. 14, EGU2012-5144, 2012
EGU General Assembly 2012

Does numerical modelling of apparent partial loss Ar/Ar age spectra of hornblende give the correct thermal history of terranes? Insights from the Palaeoproterozoic Lapland-Kola orogen (Russia)

K. de Jong
School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea (keuntie@snu.ac.kr)

We investigate the validity of numerical modelling of hornblende ^{40}Ar/^{39}Ar age spectra obtained from the same sample by step-heating with: 1) a defocused laser on 1.5 mm diameter discs micro-sampled from polished petrographic thin sections with a microscope-mounted drill, and 2) a resistance-heated furnace using handpicked mineral separate. Micro-sampling enables to obtain parts of mineral grains without zoning or included phases from targeted sites. Three samples were analysed: a tonalitic gneiss and a biotite-bearing amphibolite, from the same outcrop-1, and a biotite-free amphibolite from neighbouring outcrop-2. The material is from the Neoarchaean Murmansk terrane in the Palaeoproterozoic Lapland-Kola collisional belt along the northern margin of the Fennoscandian (Baltic) Shield.

Hornblendes from the biotite-bearing gneiss and amphibolite (outcrop-1) yielded ^{40}Ar/^{39}Ar age spectra with progressively increasing step ages, whereas the biotite-free amphibole (outcrop-2) gave flat age spectra for both drilled disc and separate. These so-called staircase-type age spectra have been classically interpreted by partial loss of radiogenic argon by diffusion processes during younger thermal reworking. We applied numerical modelling tools (Double-Pulse, MacArgon) based on diffusion theory and that assume thermally activated loss of radiogenic Ar from so-called lower retentive lattice sites by solid-state volume diffusion. Modelling results suggest that staircase-shaped age spectra of our Neoarchaean hornblende are due to argon losses of 40-50% during reheating to 450 $\pm$ 25˚C in Palaeoproterozoic time, and that flat spectra imply a thermally undisturbed Neoarchaean isotope system. These results would imply that neighbouring samples would have experienced sharply contrasting thermal histories.

Hornblende with apparent partial loss age spectra is exclusively obtained from samples in which $<100\ \mu$m diameter crystals of greenish biotite locally replace the amphibole along grain boundaries, cleavages, fractures and other defects. Biotite from the matrix of such samples exclusively yielded Palaeoproterozoic ^{40}Ar/^{39}Ar ages. A key sample is the hornblende that yielded an apparent partial loss spectrum of progressively increasing step ages for the separate, not shown by the age spectrum of the drilled grain free of biotite. Apparently, drilling of discs from carefully selected parts of hornblende grains in thin sections permitted to minimise the effects of contaminant biotite inclusions. Apparent loss age spectra, thus, result from differential gas release of hornblende and an included earlier degassing minor contamination of much younger biotite, which had apparently not been completely eliminated from the amphibole separate, despite careful handpicking. This is confirmed by the $^{37}Ar_{Ca}/^{39}Ar_{K}$ spectra of hornblende that show a constant Ca/K for drilled biotite-free hornblende grains, but an initially low ratio for amphibole separates. The hornblende disc and separate from the biotite-free amphibolite with the flat age spectra also have flat Ca/K ratio spectra, confirming the role of biotite. Consequently, numerical modelling gave conflicting and unrealistic results regarding the thermal history of terranes in the Lapland-Kola belt. Our results imply that the low retentive sites in numerical models for hornblende may in fact be an artifact related to inclusions of earlier degassing biotite in natural hornblende.