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$^{40}Ar/^{39}Ar$ DATING OF MICAS AND AMPHIBOLES FROM METAMORPHIC ROCKS OF THE COBUÉ GROUP, NORTH-WESTERN MOZAMBIQUE

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Introduction

The results of 14 Ar-Ar measurements on micas and amphiboles from 12 rock samples of the north-westernmost part of Mozambique, near the borders with Malawi and Tanzania, are presented. The area is especially important because it is located in a key region within the southern portion of the East African Orogen, that shall not be very far from the position of the main suture generated by the supposed continental collision between East and West Gondwana, during the Neoproterozoic Pan-African orogeny. Therefore, the understanding of the regional tectonothermal evolution is crucial, and Ar-Ar analyses are especially suitable to deal with the final cooling of the orogen.

The studied region is located at ca. 200 km NW of Lichinga, and belongs to the Ngoo quadrangle. It includes an area of ca. 50 km long and 5-10 km wide, at the SW end of the Cadeia de Cobué, which forms a structural horst of the East African rift, between the eastern shore of Lake Niassa and the western border of the Maniamba Graben.

Rock types

The pre-Carboniferous basement rocks exposed in the Ngoo quadrangle were affected by successive structural deformations, and show evidence of polimetamorphism, generated by at least two and possibly more metamorphic events. Following the systematic terminology used by Afonso et al. (1998), the lower grade units (greenschist to amphibolite) make up the Neoproterozoic Katangan/Pan-African Cobué Group, and the higher grade rocks (granulite facies) are considered to be basement inliers, generally included within the Paleoproterozoic (?) Unango Group.

Most of the studied rocks are high-grade gneisses and granulites, with a metamorphic mineralogy including two pyroxenes, garnet, quartz and feldspars, together with hornblende and micas. Low-grade retrogression is evident in many of the samples by the presence of epidote, sericite and chlorite. A few Sm-Nd T_{DM} model ages between 2.64 and 3.24 Ga showed that a great deal of Archean material makes up the protoliths of these high-grade rocks. Moreover, their last deformational event is attributed to the Pan-African orogeny. Similar rock types, most likely bearing an analogous tectonic evolution, are described by Maboko (1995), Muhongo et al.(2001) and Sommer at al. (2003) from Tanzania, about 800 km to the northeast. In that area, Nd isotopic analyses, as well as zircon geochronology, demonstrated that old crustal material (up to Archean in age) was structurally reworked during a high-grade Pan-African event, whose age of ca. 640 Ma was shown clearly by dating of metamorphic zircon. Moreover, in southern Malawi, about 200 km to the south, similar high-grade gneisses, affected by the Pan-African orogeny, are also found (Kröner et al., 2001). However, in Malawi the peak of granulite facies metamorphism is younger, between 570 and 540 Ma, and the rocks exhibit a quite distinct tectonic evolution, their protoliths being largely formed by Meso to Neoproterozoic juvenile material, without significant proportion of Archean or Paleoproterozoic crustal material.

Results and discussion

The $^{40}Ar/^{39}Ar$ measurements were carried out at the Geochronology Research Center of the USP, following the procedures described by Vasconcelos et al. (2002). All mineral samples were analysed in triplicate, by means of incremental heating steps. Most of the grains yielded good quality spectra, well-defined plateaus, and calculated ages with errors (2σ) of the order of 0.5%.

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Six biotites were analysed. The best control on the physical significance of the measurements is given by the concordant Ar-Ar ages given by eight individual analyses of biotite grains from samples 174, 205 and 212 (all garnet-bearing schists), whose outcrops are located very close together (12.46 lat S & 34.71 long E). All ^{40}Ar-^{39}Ar spectra of these samples are of excellent quality, with clear plateau ages and no indication of excess argon 40. Therefore, their apparent ages (average close to 447 Ma) can be interpreted as related to the closing temperature for argon retention during the last regional cooling. A biotite from the muscovite-biotite gneiss 239, located about 6 km to the East (12.47 & 34.76), yielded an older apparent age of 466 Ma. Taking into account that the analytical quality of this measurement is equally good, we attribute the discrepancy to a differential exhumation time. A concordant apparent age of 467 Ma was obtained from a similar muscovite-biotite gneiss, sample 256, located near Cobué (12.19 & 34.73).

The biotite apparent age of 676 Ma for the pyroxene-gneiss 065 is much older. Two of the analysed grains from this sample yielded concordant results, while the third yielded a very irregular age spectrum that was discarded. Excess argon was not detected, and the significance of this anomalously old age can not be adequately interpreted at this moment.

Four muscovites were analysed. Two of them, from the garnet-gneiss 223 (12.47 & 34.74) and the mica-schist 269 (12.07 & 34.88) yielded somewhat irregular age spectra, with some indication of excess argon in the high temperature steps. Their apparent ages were a little above 490 Ma. The two other, from the same samples 239 and 256 whose biotite ages were reported above, yielded good plateau ages, close to 475 Ma.

Three hornblendes and one low-grade amphibole (tremolite/actinolite?) were also analysed. The 3 grains of the latter, from the low-grade schist 247 (12.20 & 34.77), yielded very good concordant and very precise plateau ages of 466 ± 1 Ma. In contrast, the $^{40}Ar/^{39}Ar$ measurements of the hornblende grains were usually somewhat irregular. Two of them, from the pyroxene-hornblende gneiss 070 (12.42 & 34.75) and from the amphibolite 126 (12.34 & 34.75), showed clear indications of excess argon, especially in the low temperature steps. They yielded less precise apparent ages of 477±7 and 504±8 Ma, respectively, of debatable interpretation. The third hornblende sample, from the pyroxene-amphibolite 218 (12.48 & 34.76), yielded a better constrained plateau age of ca. 522 Ma.

Even if K-Ar and Ar-Ar closure temperatures are still subjected to controversy, and may vary in dependence of many factors, such as grain size, fluid phases, etc., we may attempt, with our results, to produce a crude estimate of the regional cooling path for the Cobué region. Using the fixed values of 350°C and 300°C for argon closure temperatures of muscovite and biotite, and using the apparent ages of samples 239 and 256, a cooling rate of about 6 °C/Ma is obtained. Moreover, if we consider the apparently more reliable of the hornblende ages (sample 218, 522 Ma) and a fixed closure temperature of 500 °C for hornblende, a slow integrated regional cooling of about 3.5 °C/Ma is obtained for the final tectono-thermal evolution of the Pan-African orogeny in northern Mozambique.

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