Insights on the protracted evolution of the deep crust of the Arabo-Nubian Shield.

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The Arabian-Nubian Shield (ANS) represents a mosaic of more than 15 Neoproterozoic juvenile island-arc terranes (850-600 Ma) formed in the Mozambique ocean realm. In spite of amalgamation events that subsequently led to accretion of the ANS, most exposed terranes are characterized by low- to moderate metamorphic overprint, greenschist-facies rocks being prevalent in the shield. It is thus difficult to examine how and when the lower crust of the ANS formed since it is mostly inaccessible. In this study, we analysed 3 gneisses from Zabargad Island (Egypt) corresponding to lower crustal units exposed at surface level during the Oligo-Miocene thinning of the ANS lithosphere related to the Red Sea rifting. Zircons from a felsic granulite have both low and high Th/U ratios (0.3 and 0.07), but yield undistinguishable ages of 652 ± 10 Ma, which we interpret as dating the age of the protolith and its conversion to granulite. Some zircons however yield low Th/U ratios and a significantly younger age of 597 ± 4 Ma, reflecting a second metamorphic event, possibly related to collision between island arc terranes of the ANS and the Saharan craton on the West. Monazites from a granulitic gneiss yield a much younger age of 497 ± 2 Ma which may reflect far-field stress associated to the latest stages of amalgamation of eastern Gondwana. Lastly, zircons extracted from a granulitic gneiss sampled at the contact with the Northern peridotite massif yield an age of 25.1 ± 0.4 Ma related to contact metamorphism during juxtaposition of the hot peridotite and lower crustal units. Gneisses from Zabargad island constitute a unique window to look at the polymetamorphic evolution of high-grade lower crustal units of the ANS.

Micro-fracturing induced by radioactivity of minerals: consequences on the permeability of rocks.

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Some rocks may contain radioactive (U-Th) minerals ranging from micrometric to millimetric sizes. These minerals are submitted to intense self-irradiation (α-decay of U and Th chains) that can lead to amorphization and also modify their environment by irradiating the host minerals. Amorphization induces volume increase, leading to the formation of cracks which eventually connected into a network through the rock. This fracturing allows fluid circulation, and promotes alteration of source minerals and dispersion of elements (e.g. Pb and U). These observations highlight the importance of understanding the impact of radiation damage on radioactive transport by fluids passing through such fractured rocks. The aim of this study is, through the caracterization of natural samples, to explore the consequences of such fracturing on the ability of rocks to transfer radioactive elements within fluid phases. The study was made up of imaging, laboratory measurements and numerical modelling.

First, the permeability of natural rocks with high-level of radioactivity, was measured. Such low permeability needs the use of specific gaz-permeameter. In agreement with the Klinkenberg effect, permeability of the samples can be obtained.

In a second step, these results were compared with those from numerical modelling. For that, the geometry of a micro-fracture network was used after SEM image processing. The model simulates both the flow in the fractures and the reactive transport associated with the dissolution of the radioactive minerals and helped us to evaluate the flow and the transport heterogeneity in a natural sample, induced by this local fracturation surrounding radioactive minerals.

For a better understanting of this process, the use of X-ray CT-scan is necessary to develop a 3D model.

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