Rb/Sr record of fluid-rock interaction in eclogites, Bergen Arcs, Norway

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Metamorphic reactions in the deep crust are either fluid-catalyzed, or require fluids as a reaction component. Fluid-induced rock transformations affect orogenic processes, as transformation relates to rock weakening and petrophysical changes. Isotopic dating of fluid-rock interaction therefore is a key aspect for understanding orogen dynamics. Isochron methods, in particular Rb/Sr, can provide precise ages of fluid-induced metamorphism, if, after crystallization of an equilibrated assemblage, closed system behaviour prevails.

Modally controlled closed system behaviour is presumed if shortly after equilibration fluid disappears from a rock. In a dry rock, intermineral isotope redistribution processes are drastically slowed down, and the local mode controls isotope mobility. For example a mica crystal will remain as a closed system up to very high temperatures if it is surrounded by phases with low Sr diffusivities, like garnet and omphacite. We propose that in dry rocks, Rb/Sr mineral systematics date the last metamorphic reactions rather than e.g. cooling.

The dry, granulite-facies rocks of the Lindås nappe, Bergen Arcs, Norway, were subducted to mantle depths during the Caledonian orogeny. However, eclogitization occurred only locally when fluids entered the rocks at eclogite facies conditions, at about 16-19 kbar / 650 - 750°C. Eclogite facies fluid activity resulted in metamorphic veins, surrounded by eclogitization aureolas. Overall fluid deficiency caused drying out of the eclogites shortly after the eclogitization reactions. From well-preserved vein precipi-tates and eclogites we obtained six Rb/Sr multimineral isochron ages, concordant at 425.2 ± 3.5 Ma, in agreement with a Sm/Nd mineral isochron age of 422 ± 10 Ma.

A second type of metamorphic veins with reaction aureolas is related to fluid infiltration during exhumation, at amphibolite facies conditions of about 8-10 kbar / 600°C. Rb/Sr multimineral isochron ages (n = 6) for this fluid infiltration event cluster around 412.9 ± 4.4 Ma.

The new age data, in combination with P,T conditions of metamorphism for eclogitization and retrogressive amphibo-litization, allow to calculate an average exhumation rate of 2.4 mm/a in the time frame between ~425 and ~413 Ma, at a cooling rate of about 8°C/Ma. These rate estimates are independent from vague assumptions on closure temperatures and isotope diffusion parameters. The approach of dating assemblages with modally controlled closed system behaviour avoids the pitfalls of the theory of cooling ages.

Sayh al Uhaymir 094 – a new martian meteorite from the Oman desert

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Sayh al Uhaymir 094 is a 223.3 g, partially crusted, strongly to very strongly shocked melanocratic olivine-porphyric rock of the shergottite group showing a microgabbroic texture. The rock consists of pyroxene (52.0 - 58.2 vol%) - dominantly prismatic pigeonite ($En_{60-68}Fs_{20-27}Wo_{7-9}$) associated with minor augite ($En_{46-49}Fs_{15-16}Wo_{28-31}$) - brown (shock-oxidized) olivine (Fo_{65-69}; 22.1 - 31%), completely isotropic interstitial plagioclase glass (maskelynite; $An_{50-64}Or_{0.3-0.9}$, 8.6 - 13.0%), chromite and titanian magnesian chromite (0.9 - 1.0%), traces of ilmenite (Ilm_{80-86}), pyrrhotite (Fe_{92-100}; 0.1 - 0.2%), merrillite (<< 0.1%), and pockets (4.8 - 6.7%) consisting of green basaltic to basaltic andesitic shock glass that is partially devitrified into a brown to black product along boundaries with the primary minerals. The average maximum dimensions of minerals are: olivine (1.5 mm), pyroxene (0.3 mm) and maskelynite (0.3 mm). Primary melt inclusions in olivine and chromite are common and account for 0.1 - 0.6% of the rock. X-ray tomography revealed that the specimen contains approximately 0.4 vol% of shock-melt associated vesicles, up to 3 mm in size, which show a preferred orientation. Fluidization of the maskelynite, melting and recrystallization of pyroxene, olivine and pyrrhotite indicate shock stage S6. Minor terrestrial weathering resulted in calcite-veining and minor oxidation of sulfides. The meteorite is interpreted as paired with SaU 005/008/051. The modal composition is similar to Dar al Gani 476/489/670/735/876, with the exception that neither mesostasis nor titanomagnetite nor apatite are present and that all phases show little zonation. The restricted mineral composition, predominance of chromite among the oxides, and abundance of olivine indicate affinities to the lherzolitic shergottites.

^{39}Ar-^{40}Ar dating of maskelynite suggests that SaU094 was produced during the same late Amazonian volcanic event as the other Martian shergottites Shergotty, Zagami, Los Angeles and EETA79001.