The relationship between metamorphic evolution and argon isotope records in white mica: constraints from the Variscan basement of Sardinia (Italy)

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The basement of Sardinia represents a nearly complete section of a segment of the Variscan chain which experienced a polyphase tectono-metamorphic evolution and is characterised by Barrovian metamorphism. In northern Sardinia the metamorphic grade increases to the northeast over a relatively short distance; the transition from low- (chlorite zone) to high-grade zones with migmatites (sillimanite + K-feldspar zone) occurs in about 50km. Potassic white mica (PWM) occurs in the pelitic and quartz-feldspathic metamorphic rocks throughout the whole northern Sardinia. We performed a detailed microtextural, microchemical and in situ ^{40}Ar-^{39}Ar laser investigation on samples from the different metamorphic zones along a north-south transect. Samples up to the deeper garnet zones (maximum T up to 500-550°C) have two texturally and chemically resolvable generations of PWM: (1) deformed phengite flakes, locally with muscovite rims, defining a relic S1 foliation preserved in the main S2 foliation or within rotated plagioclase porphyroblasts; (2) muscovite flakes along the main S2 foliation. The S1 foliation developed earlier and at deeper crustal level than the attainment of the thermal peak. From the staurolite zone (T up to 600-630°C) to sillimanite + K-feldspar zone, PWM is nearly uniform in composition (muscovite) and is predominantly aligned along the S2 foliation or it is of later crystallisation (e.g. in the sillimanite + K-feldspar zone). In situ ^{40}Ar-^{39}Ar laser analyses on PWM yielded ages in the range of ~340-310Ma in the garnet zone, ~320-305Ma in the staurolite zone and, ~315-300Ma in the sillimanite + K-feldspar zone. In the garnet zone, ages of 340-330Ma were chiefly detected where PWM defines the early S1 foliation. These ages agree with the previously inferred estimates for the thickening stage in the study area (350-330Ma). Results highlight a close link between textures and structure-forming major elements, and argon isotope records in PWM. The largest age range and the oldest dates were only detected in samples where different PWM generations did not texturally and chemically re-equilibrate. This study suggests that PWM retained argon isotope records pertaining to an earlier metamorphic stage which survived a later event at temperatures of 500-550°C.

Carbon in the Earth's mantle : neither Primordial nor Recycled but simply "Mantle"-derived

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The origin of the carbon in the Earth's mantle is a chicken-and-egg problem. As shown by the constancy of $\delta^{13}C$-values - over nearly 3.5 Gy - in both sediments (organic matter, carbonates) and mantle-derived samples (diamonds, carbonatites, carbonates from kimberlite), carbon is in a steady state. The most appropriate word to describe carbon is therefore "mantle" as opposed to "recycled" or "primordial" (note that primordial and mantle are often used under the same meaning whereas it should not be). The mantle mean $\delta^{13}C$-value remained constant being around –4±1‰.

The detection of any large/small scale anomaly or evolution through time in either the concentration of carbon and/or its stable isotopic composition would be fundamental for our knowledge of the Earth's structure and evolution. Many authors describe discoveries of some carbon isotopic *heterogeneity* through some low $\delta^{13}C$-values in basalts or diamonds. However, for MORB and OIB, degassing produces both lower C-contents and $\delta^{13}C$-value and the detection of any heterogeneity requires very strong controls on the amount and type of degassing (i.e. closed and open-system). Also, fluids associated with diamonds growth can undergo strong evolution prior to diamond crystallisation and thus display low $\delta^{13}C$-values which again do not reflect any source heterogeneity but rather geological processes.

In this framework, rare gases, hydrogen and nitrogen isotopes play a fundamental role in better constraining the origin and the presence of any heterogeneity (i.e. tracing either primordial or recycled carbon etc...). Because of the great difference between mantle (mostly negative $\delta^{15}N$) and surface reservoirs (positive $\delta^{15}N$), nitrogen is one of the most promising tracers of source heterogeneity. However, like carbon, nitrogen is also strongly affected by degassing (the melt being enriched in ^{15}N). So positive $\delta^{15}N$-values (0 to +4‰) can either reflect source heterogeneity or degassing processes; mantle fluid evolution also produces diamonds having positive $\delta^{15}N$-values.

Available data point towards a homogeneous carbon source for MORB. Contrasting with rare gases and H-isotopes studies, OIB do not require a distinct carbon isotopic source from MORB, the recorded variations being again the result of degassing. OIB samples for which the degassing history can be somewhat constrained are presently lacking N-isotope data. New data obtained for OIB will be discussed more thoroughly at the conference together with available data for MORB and diamonds.