Geochronology and P-T-t paths of the Berlengas Archipelago rocks, W Portugal

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The Berlengas Islands, located 10 miles off-shore from the Portuguese mainland, are the westernmost emerged exposure of continental crystalline rocks in the Iberian Peninsula. The main Berlenga Group is composed of biotite- granite with a U-Pb ID-TIMS age of 307.4 ± 0.8 Ma (concordant zircon and monazite). The Farilhões Islets (10 km NW of the main Berlenga Group) contain a metamorphic complex with parag-neisses, gneissic granitoids and migmatites. Preliminary dating of a deformed, two-mica granite has provided 3 overlapping monazite fractions with an age of 377 ± 1 Ma and 1 zircon fraction with an age of 483 ± 1 Ma (ID-TIMS U-Pb ages).

The migmatites from Farilhões Islets range from slightly peraluminous to metaluminous. The metaluminous rocks present an M_1 prograde metamorphic paragenesis that define P-T conditions consistent with the baric peak (P = 8.6 ± 1 kbar and T = 915 ± 50 °C), followed by an M_2 paragenesis representative of the establishment of the metamorphic peak temperature at T = 950 ± 50 °C during decompression to P = 6 ± 1 kbar. After reaching metamorphic peak conditions, the migmatites underwent progressive retrogression with decompression, cooling, and reequilibration to lower P and T. Subsequent M_3 assemblages show T ≈ 720 °C and P ≈ 5 kbar. Continuous exhumation and thermal readjustment followed to T ≈ 630 °C and P ≈ 3.5 kbar. The peraluminous rocks present a metamorphic peak of T ≈ 720 °C and P ≈ 5.5 kbar and a retrogressive stage of T ≈ 600 °C and P ≈ 4.5 kbar, very close results to the M_3 metamorphic stage of the metaluminous rocks.

The peraluminous rocks underwent lower P-T conditions than the metaluminous rocks and were probably put together during the M_3 metamorphic stage at 377 Ma. The age of the granulite event is uncertain. Conditions reaching the amphibole-dehydration melting curve indicate an abnormal geothermal gradient with input from an external heat source (magma underplating, upwelling of asthenospheric mantle?).

Osmium isotopes in aubrites

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Aubrites, or enstatite achondrites are a group of highly reduced, differentiated meteorites which share several geochemical properties with enstatite chondrites. Here we present the first comprehensive characterization of aubrites in terms of Os isotopic composition.

Osmium and Re concentrations vary over several orders of magnitude. Osmium concentrations range between 0.3 ppb (Bustee, Pena Blanca Spring) and 425 ppb (Shallowater). Rhenium concentrations cover a narrower range, between 0.13 ppb (Norton County) and 16.6 ppb (Shallowater). The majority of aubrites have present-day $^{187}Os/^{188}Os$ which overlap with those displayed by enstatite chondrites, with some notable exceptions. Mayo Belwa and LAR04316 show distinctly low $^{187}Os/^{188}Os$ around 0.120, whereas the low-Os aubrites Bishopville, Bustee, Norton County and Khor Temiki have radiogenic $^{187}Os/^{188}Os$, up to a value of 0.226 in Bustee. The Re/Os ratios are mostly suprachondritic up to values of 2.8 (Bishopville); notably the unradiogenic Mayo Belwa samples have high Re/Os as well. Elevated Re/Os coupled with broadly chondritic or subchondritic $^{187}Os/^{188}Os$ suggests post-accretionary perturbation of the Re-Os isotope system, and rules out an unmodified nebular origin for the aubrites, as suggested by early studies.

Past age estimates for aubrites range from 3.5 Ga to 4.5 Ga. Initial $^{187}Os/^{188}Os$ based on these estimates support a chondritic evolution for most aubrites, with values around the 4.5 Ga chondritic values of 0.097. Unreasonably low or even negative initial values are obtained for high Re/Os samples, suggesting late Re addition during parent body processing and supporting younger ages of aubrite formation.

In terms of highly siderophile elements primarily hosted in metal phases, aubrites can be interpreted as heterogeneous mixtures of a high-Os enstatite chondritic component and a low-Os component bearing a radiogenic $^{187}Os/^{188}Os$ signature, consistent with their brecciated nature. Results for the majority of samples are inconsistent with aubrites representing mantle residues from partial melting of a parent body similar to the enstatite chondrite parent body. Instead, several samples show high Re/Os signatures similar to those shown by basalts as terrestrial partial mantle melts.