Re-Os isotope and HSE systematics of 3.5 Ga Barberton komatiites

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Studies of the highly siderophile element (HSE) systematics in komatiites provide invaluable information that may have far-reaching implications for the models of thermal and chemical evolution of the Earth. We present high-precision Re-Os isotope and HSE abundance data for the komatiites from the Schapenburg Greenstone Remnant (SGR), which contains supracrustal sequences equivalent to the lowermost formations of the Onverwacht Group in the Barberton greenstone belt. The SGR komatiites are characterized by a long-term depletion in LREE (εNd(T) = +2.4 ±0.2) and are also depleted in HREE. The komatiite lava upon emplacement has been estimated to contain 28% MgO, 1.1 ppb Os, 0.84 ppb Ir, 2.8 ppb Ru, and 3.5 ppb Pt. Most major, minor elements, and HSEs, except for Re and Pd, were immobile during alteration. The concentrations of the HSE in the emplaced lava are a factor of 2 (Os) to 3 (Pt) lower than in other Archean komatiites with a comparable MgO content. During the lava differentiation, all HSEs were incompatible with the fractionating assemblage, indicating that the melting that produced the lavas did not leave any sulfide in the mantle source. The Re-Os data yield a precise isochron with an age of 3588±76 Ma and an initial γOs = +4.1±0.1. This age is consistent with the emplacement age of the Onverwacht Group. The age, along with the fact that Os was immobile during lava alteration, provide evidence that the source of the SGR komatiite was radiogenic, indicating that it evolved with a time-integrated suprachondritic Re/Os ratio. The most plausible mechanism for producing such an enrichment in the SGR komatiite source would be addition of subducted oceanic crust. The ancient age and high-MgO content of the komatiite allow us to place strict constraints on the proportion of this component and its residence time in the mantle. Our modeling shows that 20 to 25% komatiite-basalt crustal component aged for 700 Ma in the mantle is required to account for the enriched Os isotopic signature. Deep (>200 km) mantle melting in the garnet stability field can explain the Al-depleted nature of this komatiite and the low PGE contents in the magma resulting from the diluting effect of the olivine going into the melt in addition to the incorporation of the mafic crustal component. This would require a mantle plume model as a primary mechanism for the origin of the Barberton komatiites and plate tectonics to operate very early in Earth history.

In search of the Archaean atmosphere in fluid inclusions trapped in 3.52 Ga quartz (Pilbara Drilling Project)

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The isotopic signatures of noble gases in the Present-day mantle and in the atmosphere permit exceptional insight into the evolution of these reservoirs through time ([1]). However, related exchange models are under-constrained and would require direct measurements of the atmospheric composition long ago, e.g., in the Archaean.

Drilling in the the 3.525 Ga chert-barite [2] of the Dresser formation, North Pole, Pilbara craton (Australia), led to recovery of exceptionally fresh samples preserving primary fluid inclusions unaffected by surface weathering. The chemical composition of primary fluid inclusions trapped in hydrothermal quartz from vacuolar komatiitic basalt sampled 110 m under surface by synchrotron X-ray microfluorescence (ESRF, Grenoble, France) shows that fluids are relatively homogenous and originated from hydrothermalism. The isotopic composition of xenon trapped in these fluids was measured by mass spectrometry following vacuum crushing. The Xe isotopic trends indicate mixing between two end-members. The first one is enriched in Xe isotopes produced by secondary nucleogenic reactions with halogens, Ba or/and Te, and fission of U and Pu. The second one contains less radiogenic isotopes than the Present-day atmosphere, and could represent a remnant of the Archaean atmosphere. However, we are also investigating another theory: $\beta\beta$-decay of ^{130}Te to produce ^{130}Xe.

[1] Staudacher T. & Allègre C.J. (1982) *EPSL* **60**, 389-406.
[2] Van Kranendonk *et al.* (2001) *R.-G. Surv. W. A.*, 134.