The hidden history of mantle depletion: Os isotopes reveal a link between mantle depletion and crustal growth

S.W. PARMAN, D.G. PEARSON AND G.M. NOWELL

Dept. of Earth Sciences, Durham University, South Road, Durham DH1 3LE, (stephen.parman@durham.ac.uk, d.g.pearson@durham.ac.uk, g.m.nowell@durham.ac.uk)

Two recent studies [1, 2] have provided new arguments in favor of pulsed growth of the continental crust (CC), with the main growth periods at 1.2, 1.9, 2.7 and 3.3 Ga. These CC growth pulses should be recorded as melt-depletion events in the mantle, but are not seen in the isotopic systems most commonly used to study the mantle (Sr, Nd, Pb). It is likely that the depletion history of the mantle is 'hidden' from these systems due to the subduction of enriched oceanic crust. Osmium, on the other hand, is compatible during mantle melting, and is a robust recorder of the timing of mantle depletion [e.g. 3].

Here we present over 400 new Os isotopic analyses (by laser-ablation multi-collector inductively coupled mass spectrometry: LA-MC-ICPMS) of osmiridium grains from three locations (Urals, Tasmania and Tibet). The data show a recurring peak at a $^{187}Os/^{188}Os$ value of 0.12±0.01, corresponding to a mantle depletion age of 1.2±0.1 Ga, and matching the youngest of the proposed CC growth events. The 1.2 Ga peak is also present in published data on osmiridiums from Oregon, USA [4] and from whole rock analyses of abyssal peridotites. Mixing models confirm the position of the 1.2 Ga peak in all datasets, and Monte Carlo simulations indicate that the probability that this repetition is the result of random chance is less than 1 in 100,000.

The older events, at 1.9 and 2.7 Ga, also appear to be recorded in the Os data, though the number of data points is small. In sum, the Os isotopic composition of the mantle records global melting events that correspond to peaks in CC age distributions, confirming the episodic model of CC growth and planetary differentiation.

References

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Irradiation of organic matter by uranium and thorium: From mineral deposits to extraterrestrial environments

J. PARNELL[1] AND R.W. COURT[2]

[1]Dept. of Geology & Petroleum Geology, University of Aberdeen, Aberdeen AB24 3UE, UK (J.Parnell@abdn.ac.uk)
[2]Dept. of Earth Science & Engineering, Imperial College, London SW7 2BP, UK

Many occurrences of solid organic matter in ore deposits are directly related to the distribution of uranium and thorium minerals. This relationship reflects a mutual precipitation: irradiation from the minerals causes polymerization and solidification of fluid hydrocarbons, and the organic matter can cause the concentration of uranium to the scale of an ore deposit. Irradiation progressively alters the organic matter, by dehydrogenation, oxidation, and increasing aromaticity, and also causes fractionation of carbon isotopes. Studies of this alteration in samples from mineral deposits are contributing to an understanding of how organic matter is processed by irradiation in a range of other environments, from hydrocarbon reservoirs to interstellar space.

Data from mineral deposits show two opposite trends of carbon isotope fractionation with irradiation. New experimental data explains this in terms of two distinct mechanisms: (1) a decrease in alkylation and increase in oxygenated compounds related to reactions of complex hydrocarbon mixtures with free radicals, and (2) increase in polyaromatic hydrocarbon (PAH) size and alkylation due to polymerization from a methane-rich source. Both processes are expected to occur similarly in hydrocarbon reservoirs. The data also support a model for extraterrestrial PAH formation due to cosmic irradiation of simple hydrocarbons in interstellar ices, and more widely an improved understanding of the response of organic matter to irradiation will help interpret the organic compositions of carbonaceous meteorites, cometary ices, and icy moons such as Titan. As irradiation can result in increased molecular complexity and the precipitation of heavy compounds, it is possible that it played a role in the prebiotic chemistry essential as a prelude to the evolution of life.

On Mars, mineral radioactivity is relatively low but would still cause long-term damage to any microbial spores. Other forms of irradiation (solar, cosmic, UV) have a greater effect in the near-surface, and would severely alter or destroy any organic matter down to 3m depth.

References

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