Solution of the first terrestrial Pb-isotope paradox by garnetite accumulation in the transition zone

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The first terrestrial Pb paradox requires the existence of Pb that plots significantly to the left of the meteorite isochron in a common Pb-isotope diagram.

Extinct radionuclide evidence from the ^{53}Mn-^{53}Cr and ^{107}Pd-^{107}Ag decay schemes imply early core formation. Metal segregation within less than 35 Ma is now also indicated by the latest W-isotope measurements of chondrites. These and other observations limit the potential of Pb hidden in the terrestrial core to explain the first paradox. At least one additional hidden reservoir within the silicate Earth whose Pb plots significantly to the left of the meteorite isochron is required.

Lower continental crust has long been suspected to contain unradiogenic Pb, either because of a low μ inherited from fractional crystallisation (i.e. plag-rich gabbro) or due to metamorphic U and Th-loss long after rock formation. However xenoliths from the lower crust shows that on average, lower crustal rocks plot to the right of the meteorite isochron. Unless this compilation is grossly non-representative of typical lower crust, the major unradiogenic Pb reservoir must be in the Earth's mantle.

If a mantle origin for that reservoir is accepted, it immediately follows that some volumes of mantle have withstood mixing for at least 2 Ga. Based on the observation that only rare alkaline volcanic melts, such as lamproites, have Pb isotopes that plot to the left of the meteorite isochron we postulate that their mantle source represents the hidden reservoir. Despite repeated claims for a lithospheric origin of such melts we note that Pb from lithospheric xenoliths plots to the right of the meteorite isochron. Based on our model developed for lamproites in which melts are derived from a source containing a component of deeply subducted continent-derived sediment that has remained isolated in the mantle for billions of years, we here propose that subducted oceanic crust and associated sediment represent the hidden Pb reservoir.

The low μ and relatively high κ of this reservoir is explained by the presence of K-hollandite, which is an attractive explanation for the high K content and low K/Na ratio of melts that plot to the left of the meteorite isochron. Available experiments indicate that K-hollandite is stable in the transition zone. We will discuss a model in which storage of oceanic garnetite slabs in the transition zone gradually builds a mechanically strong layer that has, over time, impeded lower mantle to upper mantle mass transfer, thereby explaining why portions of the lower mantle are at least partly undegassed.

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^{10}Be and ^{14}C during the last deglaciation

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Cosmogenic radionuclides (such as ^{10}Be, ^{36}Cl and ^{14}C) are produced by the galactic cosmic rays entering the atmosphere. The variable geomagnetic and heliomagnetic shielding of the galactic cosmic rays influences the production rates of cosmogenic radionuclides (Lal and Peters, 1967). Therefore, radionuclide records allow us to reconstruct the solar activity and the geomagnetic field in the past. Nevertheless, potential changes in the atmospheric transport or deposition of ^{10}Be or ^{36}Cl must be considered to obtain a reliable proxy for past changes in the cosmogenic radionuclide production rate. In contrast, the atmospheric ^{14}C concentration is influenced by changes in the carbon cycle.

For the period of the last ice age the comparison of the radionuclide flux to Summit (Central Greenland) with geomagnetic field records indicates that the ^{10}Be and ^{36}Cl records are dominated by changes in the production rate (Beer et al., 2002). This comparison can be extended to the last deglaciation and the Holocene. It indicates that potential climate induced changes in the ^{10}Be flux are smaller than 20%. Reconstructing the ^{14}C production based on the ^{10}Be data allows us to discuss potential changes in the carbon cycle and their influence on the atmospheric ^{14}C concentration. This analysis indicates that to explain the atmospheric ^{14}C concentration, changes in the carbon cycle - most probably due to varying ocean circulation - must be considered for the last deglaciation.

References

Lal D. and Peters B. (1967), Handbuch der Physik, Springer **46/2**, 551-612.

Beer, J., Muscheler R., Wagner W., Laj, C., Kissel, C., Kubik, P.W., and Synal H.-A., Quat. Sci. Rev. **21**, 1129-1139.