How unradiogenic is Pb in the core? No limits to core-mantle exchange

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Interpretation of modern mantle melts with high $^{186}Os/^{188}Os$ and $^{107}Ag/^{109}Ag$ ratios as having a core-derived component is met by scepticism by those who expect the core to contain very unradiogenic Pb. Here we test in how far the paradigm of the core as a major reservoir of unradiogenic terrestrial Pb is supported by the latest constraints and data on core formation.

Two related issues need to be considered. Firstly, how much Pb is the core likely to contain and secondly, is the Pb really unradiogenic? With regard to the first question, we note that postulation of a Pb-rich core was based on the assumption that the Earth accreted with an U/Pb ratio similar to carbonaceous chondrites (CC). Estimates of CC U/Pb ratios from direct measurements and by inference of Pb-isotopes indicate that the bulk Earth should have a present-day $^{206}Pb/^{204}Pb$ ratio below 12. Mass balance would thus require that a large proportion (>75%) of the terrestrial Pb resides in the core or was lost during hydrodynamic escape. However, it is now widely agreed that the composition of the bulk Earth cannot be approximated by that of a single class of meteorite. It is significant that all other types of chondrites contain substantially more radiogenic Pb than CC. It will be shown that this radiogenic Pb is not an artefact of terrestrial contamination but an original feature of these meteorites. Because the inferred U/Pb of most ordinary and enstatite chondrites is similar to that of the silicate Earth there is no a priori reason to suspect the core to be particularly enriched in Pb.

The low terrestrial U/Pb paradigm was further cemented with the view that core formation provided a solution to the first terrestrial Pb-isotope paradox, because, as will be demonstrated, only very low bulk Earth U/Pb permit mean core formation times of <200 Ma. However, our new W-isotope data for the Allende CC show that core formation and accretion were very rapid processes (<40 Ma). Hence, core pumping even in a low U/Pb Earth does not provide a valid solution to the first Pb-isotope paradox nor does it help to constrain the bulk Earth U/Pb.

Published and new measurements of Pb-isotope ratios and Pb content in iron meteorites demonstrate that many contain substantial proportions of radiogenic Pb and that the Pb content is too low to support substantial fractionation of Pb during silicate/metal segregation. Although much of the radiogenic Pb appears to be unsupported by U and Th, the possibility remains that at least the outer core could contain relatively radiogenic Pb.

In summary, the lack of unradiogenic Pb cannot be quoted as evidence against a core component in the source of mantle melts with high $^{186}Os/^{188}Os$ and $^{107}Ag/^{109}Ag$.

Melt immiscibility in granite: a “missing link” in magmatic-hydrothermal transition

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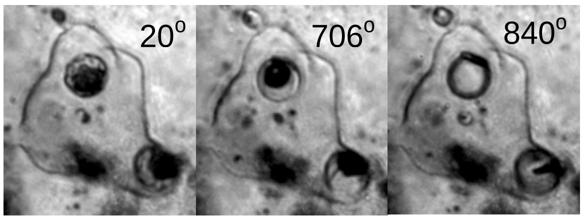
Magmatic-hydrothermal transition is commonly regarded as a separation of metal-bearing fluid phases from crystallising felsic magmas. However, the geological record of these fluid phases is extremely poor due to their transient nature resulting from continuous dissipation or evolution towards typical hydrothermal solutions. Constraints on the nature of the “missing link” in the orthomagmatic processes are derived from the study of primary melt inclusions in quartz from the Omsukchan granite (Industrialnoe Sn-deposit, NE Russia).

Recrystallised melt inclusions at room temperature show two major coexisting types: aluminosilicate inclusions composed of crystal aggregates, deformed vapour bubble(s) ± cubic mineral (halite), and brine (“salt” melt) inclusions consisting of 3-5 translucent crystals, large vapour bubble, interstitial aqueous solution ± opaque phase. Brine inclusions are usually smaller in size (<20 μm) and have spherical shape. Heating of silicate melt inclusions results in formation of homogeneous glass and bubble dissolution at 850-950ºC. In a significant number of silicate melt inclusions the melting reveals the presence of numerous spherical segregations (globules) that may or may not coalesce at high temperatures. When quenched these globules appear to be similar to salt melt inclusions. Their behaviour during heating is also similar: first melting occurs at 150-200ºC, last crystal disappears at 680-800ºC, and they homogenise by bubble dissolution at 790-900ºC (figure shows heating of salt globules in previously heated silicate melt inclusion).



This study suggests that at final stage of the evolution of the granitic magma immiscibility between silicate melt and essentially non-silicate, volatile-enriched salt melt happened. Both melts were coexisting in the magma chamber and were trapped in crystallising quartz as individual phases and as their mixture. As the granite-derived salt melt has low viscosity and remains unsolidified at granite subsolidus temperatures and well beyond, it may escape the waning magmatic system and act as a parent to syn- and postmagmatic hydrothermal fluids.