Earth's Missing Pb is in the Mantle

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The isotope composition of lead (Pb) in the silicate Earth appears to be far too radiogenic for evolution from chondritic (primitive solar system) material over 4.57 billion years, the so-called 'Pb paradox'. Loss of Pb to the core, storage in the lower continental crust, or arrival in a late veneer, have all been proposed as mechanisms to account for this imbalance, but each remains problematic. Recently, it has been suggested that the mantle itself may provide a complementary reservoir of unradiogenic Pb, but it is unclear why this material is not sampled by oceanic basalts. Modelling and experimental work, however, indicates that magma storage and transport in the crust is controlled by the chemistry of the underlying mantle. Melts from enriched rock types (such as pyroxenite), retain a higher melt fraction during cooling, while those from depleted rocks (such as peridotite) crystallise in the lower oceanic crust, thus the chemistry of erupted basalts is biased towards enriched mantle compositions.

Here we present high-precision Pb isotope data for primitive megacrysts commonly found in MORB (FAMOUS ridge segment) and gabbroic minerals from the lower oceanic crust (Atlantis Bank core complex). Megacrysts commonly preserve unradiogenic Pb compositions compared to host MORB glass, indicating crystallisation from depleted melts, in the lower crust or mantle. Likewise minerals from Atlantis bank core (ODP Hole 735B) indicate stratification of the crust, shallow MORB and gabbros are derived from enriched sources (with radiogenic Pb compositions), whereas deeper intrusive rocks originate from depleted mantle lithologies (with unradiogenic Pb isotope compositions). Therefore, not only are the melts delivered to the base of the crust derived from isotopically distinct sources, but they also traverse the crust while maintaining a high degree of chemical integrity. These results indicate not only that mantle rock types control the accretion of the oceanic crust, but that the resulting stratification masks the actual variability of the underlying mantle, which may be substantially more depleted than previously considered. In this case, there is no 'Pb paradox'.