Towards a Model for the Pb-Isotope Evolution of Bulk Silicate Earth

KLAUS MEZGER[1], ALESSANDRO MALTESE[1]

[1]Institut für Geologie, Universität Bern, Baltzerstrasse 1+3, 3012 Bern, Switzerland
([*]correspondence: klaus.mezger@geo.unibe.ch)

The evolution of the ^{176}Lu-^{176}Hf and ^{147}Sm-^{143}Nd system in bulk silicate Earth (BSE) is quite well constrained due to the chondritic relative abundance of these elements in the Earth. Both isotope systems include only refractory and strongly lithophile element pairs, whose ratios are unaffected by accretionary processes and later planetary core formation. Thus, BSE maintained an essentially chondritic relative abundance of these elements. However, this is not the case for the U-Th-Pb system that has highly refractory parent elements and a daughter element that is volatile and chalcophile. Thus, the U-Th/Pb ratio in BSE is the result of multiple differentiation processes that started during condensation of the elements and formation of solids, and continued during accretion of planetesimals to the differentiation of the Earth into a core and mantle. The resulting non-chondritic abundances of U-Th-Pb in BSE make it difficult to model the evolution of Pb-isotopes in the Earth over time. The concentration of the refractory to moderately volatile lithophile elements in the bulk silicate Earth can be modelled as a mixture of two distinct components: a major component consisting of material that is strongly depleted in volatile elements and possibly highly reduced (ca. 85 %), with chondritic relative abundances of the refractory lithophile elements; and a second, minor component consisting of material that was relatively undepleted in volatile elements and more oxidized (ca. 15 %). Accretion of the major component was accompanied by a first core formation that produced a metallic core and depleted the silicate portion in siderophile elements. Addition of the second, volatile rich and oxidized component caused a second core formation event by segregation of a sulphide melt and depletion of the mantle in chalcophile elements including Pb. Using these constraints and BSE literature estimates as target values, the model yields an age of 4.50 Ga for mixing of the two components. This age is consistent with the time for the giant impact that led to the final accretion of the Earth and the formation of the Moon. An isotope evolution curve constructed using the derived perimeters reproduces well the Pb-isotope composition of ancient galenas from stratiform lead ore deposits. In addition the U-Th-Pb evolution of the bulk silicate Earth can be modelled without invoking modifications of the isotope system after accretion was completed.