Tracing Earth's volatile delivery with tin

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The history of Earth's volatile element depletion compared to primitive meteorites is debated, namely whether (1) volatile elements were delivered during the main phase of Earth's accretion and were subsequently lost by volatilization, or (2) Earth accreted from material devoid of volatiles with later addition of volatile-rich material [1,2]. The elemental and isotopic abundances of volatile siderophile elements in the Earth's mantle can be used to discriminate between these models, as they can be affected differently by core-mantle differentiation and volatility processes [3]. Tin is a moderately volatile siderophile element, and is well-suited to track the history of volatiles during Earth's formation [4]. However, little is known about its metal-silicate partitioning behavior, and even less about its isotopic behavior during such processes. High pressure and temperature metal-silicate experiments were performed in piston-cylinder and multi-anvil presses from 2 to 20 GPa and 1700 to 2600 K, to study the behavior of Sn, including the influence of fO_2, and metal and silicate compositions. We find that Sn siderophility decreases with temperature and increases with pressure. Core formation modelling was used to follow the evolution of Sn partitioning throughout Earth's differentiation. We find that Earth's primitive mantle Sn content can only be obtained if the volatiles are brought during the last stages of Earth's accretion and core formation. Such a scenario is further supported by the behaviors of S and Cu [5,6,7]. Isotopic results from the experiments indicate that a core-mantle equilibration temperature ~3000K could generate mantle Sn that is isotopically lighter than the core by 150-200 ppm per amu. The bulk silicate Earth Sn isotopic composition overlaps with the isotopic composition of chondrites [4], in good agreement with a scenario of late delivery of Sn and a partial equilibrium that would not be sufficient to create an isotopic fractionation of Sn between Earth's core and mantle.

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