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SPECIAL COLLECTION: BUILDING PLANETS: THE DYNAMICS AND GEOCHEMISTRY OF CORE FORMATION

The accretion and differentiation of Earth under oxidizing conditions†

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ABSTRACT

We present a new approach to model planetary accretion and continuous core formation, and discuss the implications if Earth accreted under conditions initially more oxidized than the modern day mantle. The modified model uses the same partitioning data that were previously used to model accretion under reducing conditions, however, changing the partitioning between accreting metal and silicate mantle means that reducing conditions fail to meet expected core/mantle values. Instead, the model requires conditions more oxidized than the modern day mantle to converge and to yield expected elemental core/mantle distribution values for moderately siderophile elements. The initial oxygen fugacity required to provide the crucial level of oxidation is approximately ΔIW ~ –1.2 to –1.7 and thus is in the range of carbonaceous and ordinary chondrites. The range of peak pressures for metal silicate partitioning is 60–6 GPa and oxygen fugacity must decrease to meet modern FeO mantle contents as accretion continues. Core formation under oxidizing conditions bears some interesting consequences for the terrestrial Si budget. Although the presented partitioning model can produce a Si content in the core of 5.2 wt%, oxidizing accretion may limit this to a maximum of ~3.0 to 2.2 wt%, depending on the initial f_{O_2} in BSE, which places bulk earth Mg/Si ratio between 0.98–1.0. In addition, under oxidizing conditions, Si starts partitioning late during accretion, e.g., when model earth reached >60% of total mass. As a consequence, the high *P-T* regime reduces the accompanied isotope fractionation considerably, to 0.07‰ for 5.2 wt% Si in the core. The isotope fractionation is considerably less, when a maximum of 3.0 wt% in the core is applied. Under oxidizing conditions it becomes difficult to ascertain that the Si isotope composition of BSE is due to core-formation only. Bulk Earth's Si isotope composition is then not chondritic and may have been inherited from Earth's precursor material.

Keywords: Terrestrial accretion, core formation, Si isotopes, terrestrial building blocks