Evolution of sulfur concentrations in magma oceans during Earth's accretion.

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Sulfur contents of Earth's mantle and core are considered to be 200-250 ppm and 1.7-2.0 wt% respectively. Here we determine how these concentrations originated using a combined N-body accretion/core formation model that enables the evolution of mantle and core compositions for the terrestrial planets to be determined [1]. We assume that concentrations of S that became incorporated into planetesimals and planetary embryos of the protoplanetary disk after condensing in the solar nebula increased systematically with decreasing temperature and increasing heliocentric distance. Fully-oxidized bodies that formed beyond 6-7 AU are assumed to contain the full complement of S (corresponding to 5.35 wt% in a CI composition) with concentrations decreasing along a linear gradient towards the Sun. During each metal-silicate equilibration event that is associated with an accretional collision, the S contents of equilibrated metallic and silicate liquids are determined from a recent partitioning model [2].

Our results show that the S concentrations of Earth's mantle and core cannot be achieved through metal-silicate equilibration in magma oceans during core formation. Such equilibration results in final mantle and core concentrations of ~0.75 wt% and ~0.36 wt% respectively. Concentrations of ~0.75 wt% in a deep magma ocean far exceed SCSS (sulfur concentrations at sulfide saturation) values [3] as crystallization temperatures are approached during cooling. Consequently, exsolution and segregation of FeS liquid occurred during magma ocean cooling – an event that led to the formation of a sulfide-rich layer - the Hadean matte [4]. S concentrations in Earth's core and mantle are reproduced quantitatively by modelling FeS exsolution/segregation both as a single and a multistage event.

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