Chemical constraints on the Grand Tack accretion model

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The Grand Tack model of planetary accretion has been very successful in reproducing the characteristics of the terrestrial planets of the solar system in terms of planetary mass and orbital characteristics [1]. In particular, the mass of Mars is well reproduced, in contrast to the results of earlier classical simulations. In order to provide further tests of the viability of accretion simulations as well as planetary differentiation processes, we are combining a multistage core-mantle differentiation model [2] with N-body accretion models. The core formation model combines rigorous mass balance with metal-silicate element partitioning data and requires that the bulk compositions of all starting embryos and planetesimals are defined as a function of their heliocentric distances of origin. To do this, we assume that non-volatile elements are present in solar system (CI) relative abundances in all bodies and that oxygen content is the main compositional variable. The primary constraint on the combined model is the calculated mantle composition of an Earth-like planet (i.e. located at ~1 AU and of 1 Earth mass) with secondary constraints being the FeO concentrations in the mantles of Mercury and Mars. The model is refined by least squares minimization using up to 4 fitting parameters that consist of the metal-silicate equilibrium pressure and 1-3 parameters that define the starting compositions of primitive bodies.

Investigations of a broad parameter space show that: (1) Accretion of Earth was heterogeneous and (2) Equilibration pressures increase as accretion progresses and are ~60% of core-mantle boundary pressures. Results are highly sensitive to the compositional model for starting bodies: acceptable fits are only obtained when bodies that originated close the Sun (<1-1.5 AU) are highly reduced and those from beyond this distance are increasingly oxidized [3].

[1] Walsh *et al.* (2011) *Nature* **475**, 206-209. [2] Rubie *et al.* (2011) *EPSL* **301**, 31-42. [3] Rubie *et al.* (2014) *LPSC* Abstract #1734.