Mantle composition constraints on different planet formation scenarios

S. A. JACOBSON[1,2], D. C. RUBIE[1], A. MORBIDELLI[2], A. IZIDORO[3] AND S.N. RAYMOND[3]

[1]University of Bayreuth, Bayreuth Germany
[2]Observatoire de la Côte d'Azur, Nice, France
[3]Université de Bordeaux, Pessac, France

Terrestrial planet formation has been focused on creating scenarios that match the orbits and masses of the inner planets and the distribution of masses and orbits in the asteroid belt [1,2]. However, differences between planet formation scenarios also has a consequence for the composition of the final terrestrial planets.

In order to track the mantle compositions of each simulated planet, we follow the process described in [3]. A number of different numerical N-body simulations for each planet formation scenario were chosen based on their ability to match the orbits and masses of the terrestrial planets. Then in each of these simulations, initial compositions were assigned to each of the starting planetesimals and planetary embryos according to heliocentric gradients in the disk. The odixation gradient is the most significant volatility gradient in the disk and responsible for driving significant changes in the differentiation state of the initial bodies as a function of semi-major axis as well as the final planets. As these bodies grow from accretion of one another, the projectile cores from each collision equilibrate with portions of the target mantle. How much of each body participates in equilibration is determined by laboratory and numerical fluid experiments. Furthermore, the equilibrated mantle composition is set by partitioning coefficients determined by high pressure laboratory experiments.

We experimented with three different planet formation scenarios: the Grand Tack scenario, the eccentric Jupiter and Saturn scenario and the Truncated Disk scenario. In each of these scenarios, we vary the oxidation gradient in the terrestrial disk so as to find a best fit disk that best reproduces the final mantle composition of the Earth-like planet. We measure the quality of the fits using a chi square statistic focused on 11 different species of varying siderophility.

Early results indicate that the best fit Earth-like planets require an oxidation gradient in the disk so that the growing Earth-like planet's accretion chemistry transitions from reducing to oxidizing conditions throughout planet formation.

References: [1] Raymond S. N. et al. (2009) *Icarus,* 203, 644–662. [2] Walsh K. J. et al. (2011) *Nature*, 475, 206–209. [3] Rubie D. C. et al. (2015) *Icarus*, 248 89–108.