Control of accretion and early differentiation process on the diversity of volatile inventory of rocky Solar System objects

R. DASGUPTA[1*], D. S. GREWAL[1], K. TSUNO[1]

[1]Department of Earth, Environmental and Planetary Sciences, Rice University, Houston, TX, USA (*rd6@rice.edu)

Inventory of volatile elements such as carbon, hydrogen, nitrogen, and sulfur in the rocky reservoirs of inner Solar System objects is critical for their possible evolution towards establishing habitable surface conditions. However, the undifferentiated feedstock materials can undergo early differentiation in a number of different ways that lead to significantly different budgets of C, H, N, S in the early silicate reservoirs of various planets, planetary embryos, and planetesimals and primitive achondrites.

Here we will use laboratory experimental constraints on the fate of C, H, N, S during accretion and differentiation (e.g., core formation and atmospheric loss) of rocky bodies, guided by compositions sampled in our own Solar System. The key parameters we will use are partition coefficients of C, N, S, and H between core forming alloy/sulfide melts and silicate melts, solubility constants of volatile gas species in silicate melts (magma oceans), and *P*-*T*-dependent solubility of C and N in core forming alloy melt. We will show how with difference in the conditions of core-mantle fractionation (such as depth, temperature, composition, and redox state of alloy-silicate equilibration) and styles of differentiation such as internal differentiation versus magma ocean, low-temperature sulfide segregation, different planetary silicate reservoirs acquire different inventories of C, H, N, S. We will also evaluate how the volatile abundance pattern resulting from early differentiation scenarios involving core-mantle equilibration that may be expected for planets' gradual growth via accretion of undifferentiated planetesimals may differ from those where rocky planets experience punctuated and protracted growth via near-disequilibrium merger of differentiated planetary embryo(s). We will forward model expected volatile inventory of primtive achondrites, and non-metalic portions of Mercury, Mars, Earth, and asterioid 4 Vesta. If the accretion is modeled from a similarly depleted, chondritic reservoir, Mars and Vesta being accreted and differentiated at relatively oxidized conditions, likely achieved a subchondritic C/N and C/S ratio in their silicate reservoirs. Bulk silicate Mercury on the other hand could have achieved a superchodritic C/N ratio. Estimated superchondritic C/N and chondritic C/S for the BSE require contributions from an unsampled silicate reservoir.