**Thermal models for the planetary differentiation of planetesimals and asteroids with $^{26}$Al and $^{60}$Fe as the heat sources.** S. Sahijpal, Department of Physics, Panjab University, Chandigarh, India (sandeep@pu.ac.in)

Planetary differentiation of planetesimals in the early solar system resulted in a wide range of differentiated parent bodies of the iron, stony-iron meteorites and achondrites [1]. Based on the $^{182}$Hf-$^{182}$W systematics in iron meteorites, and the $^{26}$Al-$^{26}$Mg and $^{53}$Mn-$^{53}$Cr systematics in eucrites and angrites, the planetary differentiation occurred quite early in the solar system, perhaps within the initial few million years. The radiogenic decay energies of the short-lived nuclei $^{26}$Al and $^{60}$Fe have been considered as the plausible heat sources for the melting and differentiation of planetesimals [2, 3]. A number of thermal models have been developed earlier to explain the thermal evolution of planetesimals with $^{26}$Al as the heat source [4-6]. We are making efforts to numerically simulate the various proposed differentiation scenarios of the planetesimals in a realistic manner by numerically incorporating the various physico-chemical processes involved in planetary differentiation [7-11].

We have numerically modeled four distinct scenarios of the differentiation of planetesimals; labeled A, B, C and D. The heat conduction partial differential equation for a spherically symmetric planetesimal with $^{26}$Al and $^{60}$Fe as heat sources was solved using the finite difference method with classical explicit approximation. The numerical simulations have been performed for the linearly accreting planetesimals of sizes 26, 65, 130 and 351 km, with varied chondritic compositions, starting from planetary embryos of an initial radii of 0.3 km. These models include the plausible thermal evolution of the 4 Vesta asteroid. Accretion of the planetesimals were started at the chosen time of 1-5 Myr. (Myr., million years) from the formation of CAIs (calcium aluminium rich inclusions) and continued for a period of time 0.001-1 Myr. The planetesimal surface temperature of 250 K was maintained through out the simulations. Subsequent to the sintering (compaction) at ~700 K, the planetesimals acquired their final radii of 20, 50, 100, 270 km for the different set of simulations. The temperature dependence of thermal diffusivity and specific heat were incorporated. The melting of the Fe-FeS and silicate were carried out at 1213-1233 K and 1450-1850 K, respectively. We have modeled the gradual growth of the $(Fe\text{-}Ni)_{metal}$-FeS core and the basaltic melt extrusion for the first time.

The four differentiation models; A, B, C and D are distinct in the temporal sequence of the growth of $(Fe\text{-}Ni)_{metal}$-FeS core with respect to the silicate melting and the extrusion of the basaltic melt to form the crust. In A simulations, the initiation of the segregation of $(Fe\text{-}Ni)_{metal}$-FeS melt to form the core has been considered in the temperature range 1213-1233 K prior to the silicate melting. This is followed by the silicate melting at higher temperature and the extrusion of the basaltic melt at 0.2 fraction of silicate melting to form the crust. In B simulations, the initiation of the segregation of the $(Fe\text{-}Ni)_{metal}$-FeS melt has been considered at higher temperature, at 0.4 fraction of the silicate melting. No crust-mantle differentiation has been considered in this scenario. The initiation of the core-mantle differentiation in the models, labeled C and D, was triggered subsequent to 0.4 fraction of silicate melting as in the case of model B. However, the two models differ significantly in the mantle-crust differentiation. In the model C, the basaltic melt was generated during the 20% partial melting of the silicate and the melt was moved to the surface to form the crust. In model D, the magma ocean generated after the segregation of $(Fe\text{-}Ni)_{metal}$-FeS melt was cooled isothermally. The residual melt left subsequent to the equilibrium crystallization in the magma ocean was consider to be the source of basalts in this model. In order to imitate the effect of thermal convection in the molten $(Fe\text{-}Ni)_{metal}$-FeS core and the magma ocean, separately, the thermal diffusivity of Fe-FeS melt and the magma ocean was raised by three orders of magnitude as compared to the sintered rock.

Based on our varied simulations we can now make concluding assessments regarding the various differentiation scenarios along with their implications on the origin of differentiated meteorite parent bodies. The essential aim is to understand the dependence of the core-mantle and the mantle-crust differentiation on the onset time of the planetesimals accretion subsequent to the condensation of CAIs, the duration of the planetesimals accretion, the abundance of the radionuclides and the distinct planetary differentiation criteria.

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