Revisiting the lower bound on the initial temperature of accreting moonlets

Vishal Goyal[1*], Sandeep Sahijpal[1]

[1]Department of Physics, Panjab University, Chandigarh, India

*Corresponding Author E-mail: goyalvishal4@gmail.com, vishalg@pu.ac.in

Presently, the most plausible hypothesis for lunar formation is the giant impact hypothesis. The giant impact simulations [2] suggest a duration of initial 200 years only, for lunar formation. Moreover, despite a low metallic content (1-1.5 wt%), several observations indicate core-mantle-crust structure for Moon [1]. These exceptional features make Moon a unique planetary body in the context of its formation. The initial temperature of accreting moonlets (T_{ini}) is an important constraint in context of the giant impact and lunar evolutionary models. Furthermore, it lies at the interface of both the models. Based on the lunar evolution modeling, Sahijpal and Goyal [3] proposed the lower bound on T_{ini} to > 1600 K. In order to incorporate physicochemical processes in a more realistic manner and to formulate novel improvised models, Goyal and Sahijpal [4] recently developed a novel numerical code in *Python*. The advancements in these models include the incorporation of local Rayleigh numbers, radially varying Stoke's flow, gravitational energy released, optical heat diffusion and modification of composition from modified H-chondrites to LPUM among several others. Local Rayleigh numbers are incorporated, perhaps for the first time, to study radially varying 1-D convection at full-scale planetary models. In the present study, we attempt to provide a revised lower bound on T_{ini}.

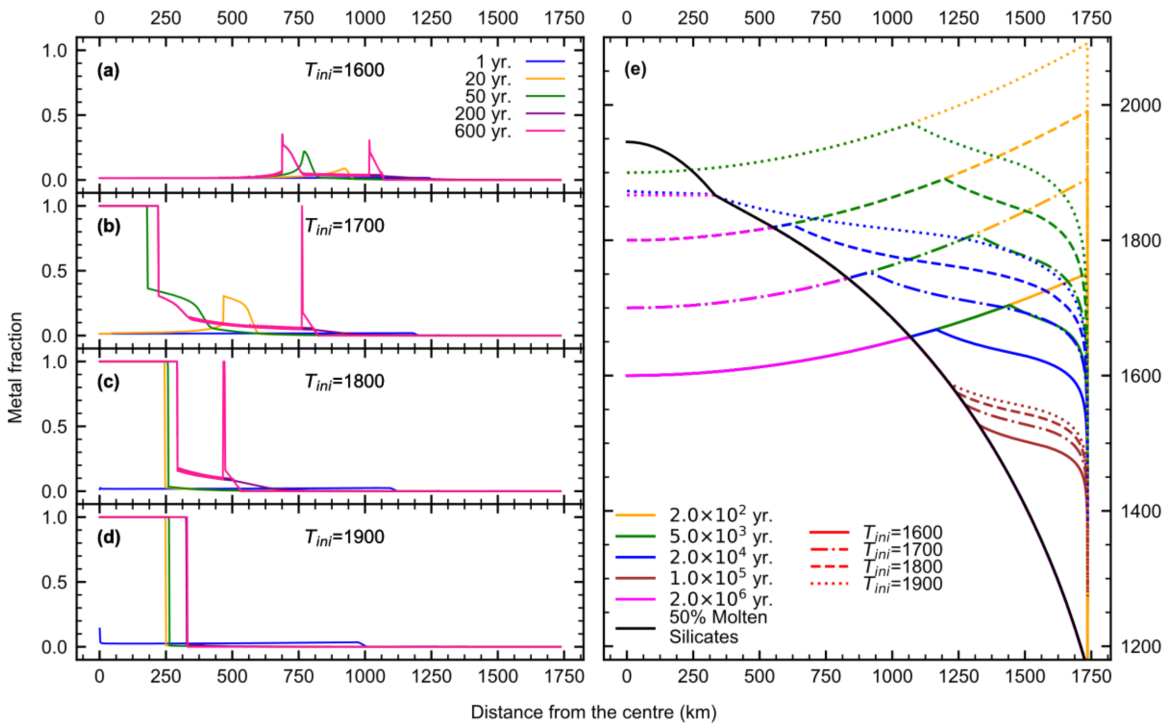

Figure 1: Core-formation and thermal evolution of the Moon. (**a-d)** temporal evolution of metallic content distribution, and (**e**) thermal evolution of Moon at various initial temperatures of accreting moonlets, T_{ini}.

Fig. **1a-d)** shows the temporal evolution of extent of core-formation at four distinct values of T_{ini}. Fig. **1e)** shows the thermal evolution of interiors of Moon. At T_{ini} = 1600 K, neither core nor metallic shell forms, however heterogeneity in mass distribution builds up (Fig **1a**). At T_{ini}

= 1700 K, partial core forms along with a metallic shell that is far away from center (Fig **1b**). At T_{ini} = 1800 K, core formation is more advanced and metallic shell is formed comparatively nearer to partially-formed core (Fig **1c**). At T_{ini} = 1900 K, core forms in its completeness (Fig **1d**). Within few hundred years, zones containing the metallic content cools below the rheological transition temperature, thus inhibit the Stoke's flow and further core-formation. Therefore, the formation of lunar core requires that that lower bound for T_{ini} should be around ~1800 K.

References: [1] Williams, J. G. et al. (2014) *JGR*, *119*, 1546–1578. [2] Salmon, J. and Canup, R. M. (2014) *Philos. Trans. R. Soc. A*, *372*. [3] Sahijpal, S. and Goyal, V. (2018) *MAPS*, *53*, 2193–2211. [4] Goyal, V. and Sahijpal, S. (2020) *Icarus*, (*submitted*).