

NUMERICAL SIMULATIONS OF THE PLANETARY DIFFERENTIATION OF PLANETESIMALS. S. Sahijpal, Dept. of Physics, Panjab University, Chandigarh, India (sandeep@pu.ac.in).

Introduction: We have attempted numerical simulations of the planetary differentiation of planetesimal undergoing accretional growth with ^{26}Al and ^{60}Fe as the heat sources [1]. In the present work, we have modified the numerical code developed earlier [1]. We have now explored the feasibility of the formation of a FeS core prior to significant segregation of $(\text{Fe-Ni})_{\text{metal}}$. In addition, we have tried comparatively higher melt percolation velocity for ascend of ^{26}Al -rich eucritic melt compared to our previous work [1].

Methodology: An identical numerical approach was followed for the accretional growth and the radiogenic heating of a H-chondrite parent body of radius 100 km [1]. Due to the uncertainty involved in the melting and the segregation of $(\text{Fe-Ni})_{\text{metal}}$ -FeS from the bulk chondrite [2-5], we considered the melting and the segregation of the entire FeS content of the bulk chondrite [6] to commence within 1213-1233 K. This was accompanied by varied proportion of $(\text{Fe+Ni})_{\text{metal}}$ segregation. Here we present results for two different extents of $(\text{Fe-Ni})_{\text{metal}}$ segregation. In most of the simulations, the entire Fe_{metal} and Ni_{metal} contents of the bulk chondrite [6], i.e., ~16% and ~1.7%, respectively, were segregated along with FeS to form a $[\text{FeS+Fe}(16\%)]$ core. In an alternative set of simulations, $(\text{Fe-Ni})_{\text{metal}}$ ~2% of the bulk chondrite was segregated along with FeS to form a $[\text{FeS+Fe}(2\%)]$ core. The remaining $(\text{Fe-Ni})_{\text{metal}}$ contents were retained by the silicate matrix until its melting. The silicate matrix in both sets of simulations retained the FeO content along with a proportionate amount of ^{60}Fe .

During the initial 15% melting of the silicate, ^{26}Al was removed from the silicate matrix. Ascend of the ^{26}Al -rich eucritic melt was parametrically modeled [1]. Here we present results for a melt percolation velocity of $(10-25) \text{ m yr}^{-1}$. The simulations can be performed for varied melt percolation velocities.

Results and discussions: The time required to initiate the formation of a $[(\text{Fe-Ni})_{\text{metal}}\text{-FeS}]$ core of a planetesimal of radius 100 km is graphically presented in fig. 1. In order to have substantial melting of FeS-Fe for planetary differentiation, the initiation of the formation of planetesimal should commence within the initial couple of million years in the early solar system. The temporal growth of the $[(\text{Fe-Ni})_{\text{metal}}\text{-FeS}]$ core along with the initiation of the eucritic melt for a representative set of simulations is presented in fig. 2. The simu-

lations were performed for a wide-range of initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratios and varied proportions of $(\text{Fe+Ni})_{\text{metal}}$ segregation during the segregation of FeS.

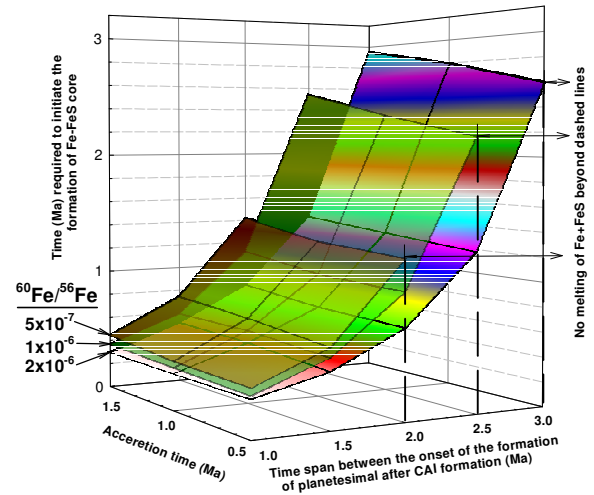


Figure 1. Time (in million years) required to initiate the formation of a $[(\text{Fe-Ni})_{\text{metal}}\text{-FeS}]$ core subsequent to the onset of the formation of planetesimal for a set of initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratios and different accretion timescales. For a given $^{60}\text{Fe}/^{56}\text{Fe}$ ratio, the melting of FeS-Fe is not feasible beyond the marked (dash) vertical lines. A value of 5×10^{-5} was considered for the initial $^{26}\text{Al}/^{27}\text{Al}$.

The growth of the $[(\text{Fe-Ni})_{\text{metal}}\text{-FeS}]$ core depends upon the onset time of the formation of a planetesimal, the accretion rate and the initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratio (fig. 2). Some of salient features of the simulations are:

- i) The growth of the core occurs rapidly in the simulation C even prior to the initiation of the eucritic melt. The accretion of the planetesimals over longer timescales results in the prolongation of the growth over longer timescales.
- ii) Major differences were not observed in the simulations with temperature independent specific heat and thermal diffusivity compared to the simulations with temperature dependent thermal properties. The former resulted in comparatively rapid thermal processing compared to the latter.
- iii) In the case of simulations M and N, the growth of the sulfur-rich core commences prior to silicate melting. Substantial segregation of $(\text{Fe-Ni})_{\text{metal}}$ may occur during the initiation of silicate melting. However, in the present work the two simulations were terminated just above the silicate melting due to the increase in the numerical complexities. A realistic

model may involve growth of a Fe-S core, subsequently followed by $(\text{Fe-Ni})_{\text{metal}}$ segregation along with silicate melting. This model is beyond the scope of present work.

The silicate melting was not observed in the simulation O. This simulation would result in the formation of a Fe-S core alone.

iv) In order to have a substantial silicate melt, the accretion of a planetesimal should commence within the initial couple of million years. Based on the accretion scenario and the initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratio,

cretion scenario and the initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratio, the initiation of the silicate melt can occur within the initial ~6 Ma and the melting can persist for a few million years.

References: [1] Sahijpal & Soni (2005) *LPSC XXXVI* Abstract # 1296 (CD-ROM). [2] Ghosh & McSween (1998) *Icarus* **134**, 187. [3] Taylor (1993) *Meteoritics* **28**, 34. [4] Rushmer et al. (2005) *LPSC XXXVI* Abstract # 1320 (CD-ROM). [5] Humayun et al. (2005) *LPSC XXXVI* Abstract # 2208 (CD-ROM). [6] Jarosewich (1990) *Meteoritics* **25**, 323.

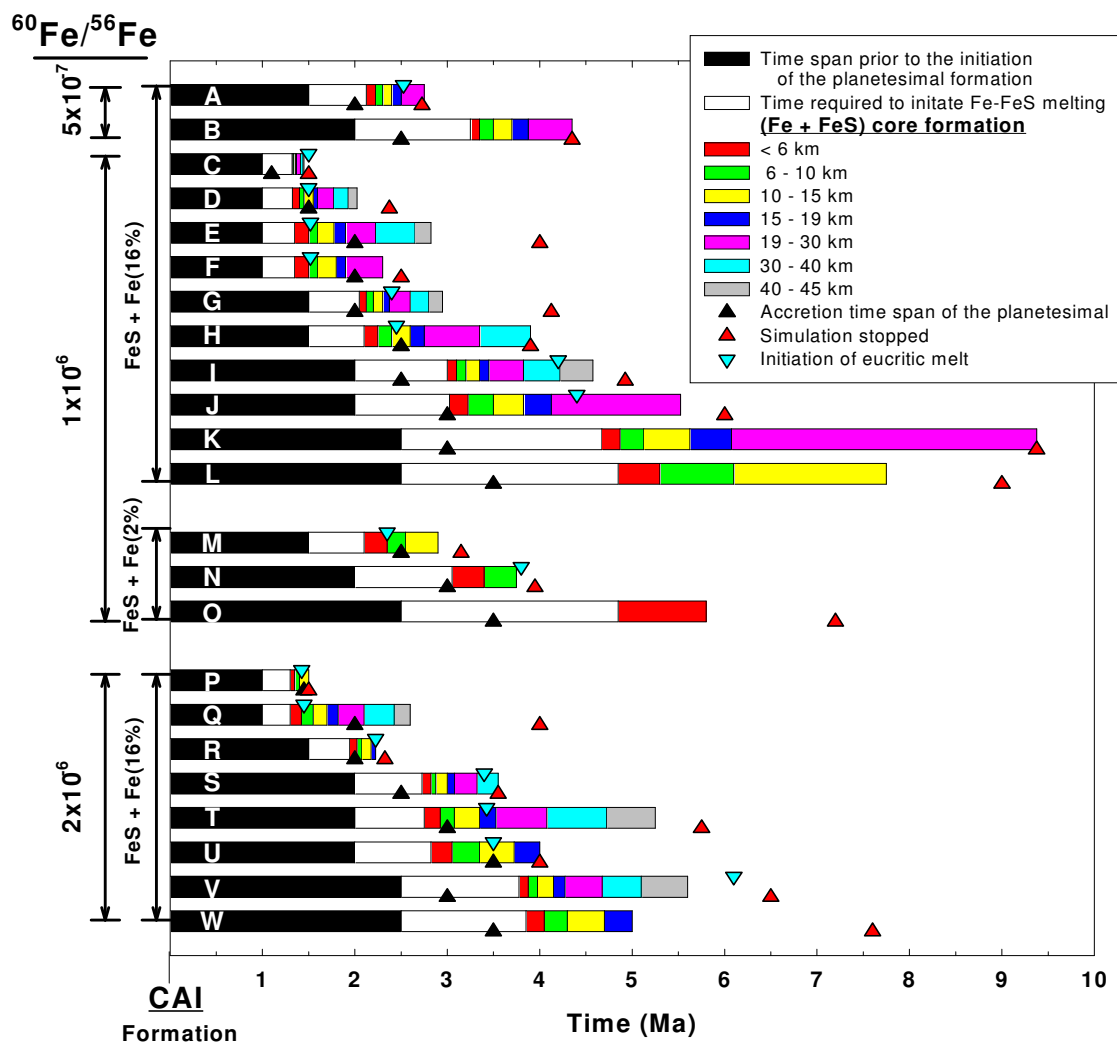


Figure 2. The temporal growth of a [Fe+FeS] core for a wide-range of simulation parameters. The black bars mark the time prior to the initiation of the formation of a planetesimal of radius 100 km. The symbol (\blacktriangle) indicates the termination of the accretion growth of the planetesimal. The multi-colored stacked bars (red through grey) represent the temporal growth of the [Fe+FeS] core size. The growth within a single color bar need not be linear with time. The symbol (\blacktriangledown) represents the time of the initiation of the silicate melt. The simulations were terminated at the time marked by the symbol (\blacktriangle).