DIFFERENTIATION WITHOUT CORE FORMATION: S-ASTEROIDS AND STONY-IRON METEORITES. G. Jeffrey Taylor, Planetary Geosciences Division, Dept. of Geol. and Geophys., SOEST, Univ. of Hawaii, 2525 Correa Rd., Honolulu, HI 96822

Cores did not form in asteroid-sized bodies unless the silicate assemblage was >70% molten (1). This is due to two factors: (a) the high interfacial energies between metallic melts and silicates (1-3), which prevent a metallic melt from forming an interconnected network; and (b) the high yield strength of silicate mushes (4). Calculations (Fig. 1) show that even if metallic masses could coarsen to 10 cm in radius, >70% melting of silicates is required to sink in bodies 250 km in radius. In spite of the large amount of melting needed, cores did form in some asteroids (M-asteroids and the parent bodies of magmatic iron meteorites). Considering this and the fact that other asteroids did not melt at all (C, P, and D asteroids and the parent bodies of chondrites), it seems inescapable that many asteroids melted to varying extents, but not enough to form a core. They would thus be composed of metallic masses in a differentiated silicate matrix. The extent of differentiation can be calculated and predictions made about the properties as a function of the amount of melting. As previously suggested, S-asteroids (5-7) and some stony-iron meteorites and iron meteorites with silicate inclusions (8-11) might be the products of such partial differentiation.

Equilibrium partial melting of chondrites: possible products

I have used a program developed by John Longhi (e.g., ref 12) to calculate the melt and residual solid compositions during equilibrium partial melting calculations of H- and L-chondrites. The calculations keep track of variations during melting of the forsterite (Fo) content of olivine, and the ratio of olivine to olivine + pyroxene in the solid. In addition, assuming silicate melt migrates, I also calculated by simple mass balances how the abundance of metallic iron increases during melting. Results are shown in Figs. 2-4. For a starting composition like H-chondrites (Fig. 2), the calculations show that as the percentage of melting increases (decreasing crystal fraction), the ol/(ol+pyx) ratio in the solid increases, reaching 1 at a crystal fraction of 0.6. Fo in olivine also increases, rising from 80 to 92; Fo is 85 at the point where pyroxene is used up. Results for both H- and L-chondrite compositions are summarized in Fig. 3. As Fo in olivine increases, the ol/(ol+pyx) ratio also increases. Furthermore, as melting increases, the amount of metal relative to residual solid silicate increases. For example, an initial volume fraction of metal of 0.2 would rise to 0.3 at 40% melting and to 0.6 at 80% melting.

Predictions for S-asteroids

If the silicate melt migrates to the surface and is subsequently lost by impacts, the products of this process (possibly S-asteroids) should have predictable, observable properties: ol/(ol+pyx) ratio should increase with both the Fo content of olivine and the metal/silicate ratios. These predictions are greatly oversimplified because of a number of factors: The silicate melt might have been produced by fractional partial melting or it might not have migrated to the surface. Asteroids probably varied in initial composition and, thus, could lie between the paths in Fig. 3, or be more magnesian than H-chondrites or less magnesian L-chondrites. Impacts could have jumbled magmatic products produced at different degrees of melting. Finally, differential erosion stemming from the greater strength of metal might have led to an increase in the amount of metal on asteroid surfaces.

Metal-rich and related meteorites

There are meteorites with fractionated silicates that might be explained by partial melting without core formation. *Pallasites*: Except for one case, pallasites do not contain pyroxene. The bodies in which they formed, therefore, must have melted to >40%. This is consistent with their formation at the core-mantle boundary because core formation requires >70% melting (Fig. 1). Their olivine compositions (main-group pallasites have Fo_{90}) are also consistent, indicating about 70% melting if the body was of H-group composition; (2) reached the same con-

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ent, indicating about 70% melting if the body was of H-group composition; (2) reached the same conclusion based on experiments. *IIE iron meteorites*: (8) suggested that these iron meterorites formed in a silicate matrix, not in a core. As noted by (9), the globular inclusions in these iron meteorites bulk chemical compositions characteristic of low-melting fractions of ultramafic assemblages. Calculations indicate that about 15% melting of an H-chondrite produces melts like those in IIE irons. Thus, IIE irons represent a case where metal masses trapped some silicate liquid (but apparently not the residual solids), but did not form a core. *IAB and IIICD irons and related silicate metorites*: These meteorites formed when chondritic materials melted to small amounts. The unfractionated bulk compositions of the silicates indicates that the melts did not migrate (10,11). However, the inclusions are angular, so impact processes were also at work.

Conclusion: S-asteroids are partial differentiates

Many S-asteroids are partially differentiated bodies in which metallic cores did not form. Such asteroids formed when chondritic bodies partially melted and the silicate melt percolated upwards, leaving behind the solid silicate residue that contained metallic masses. This hypothesis is testable by appropriate observations; specifically, as Fo in olivine increases, olivine/pyroxene and metal/silicate decrease.

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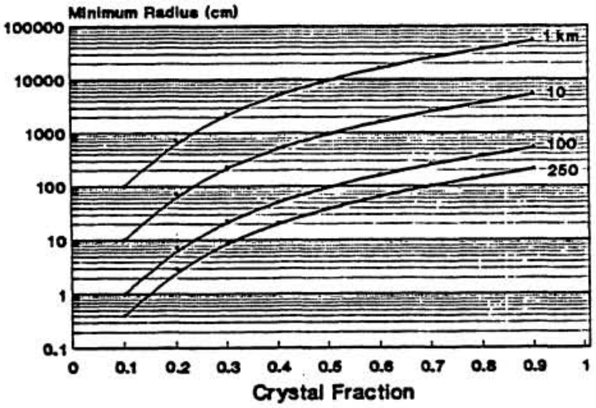

Fig. 1

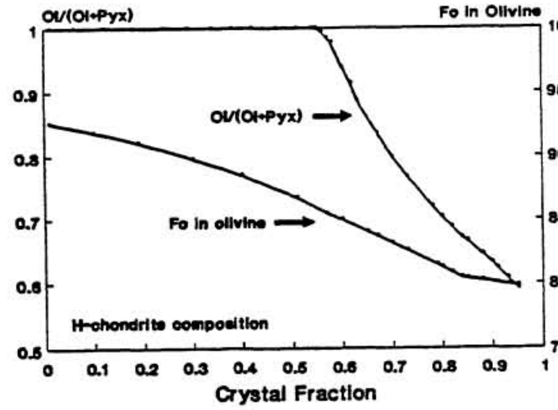

Fig. 2

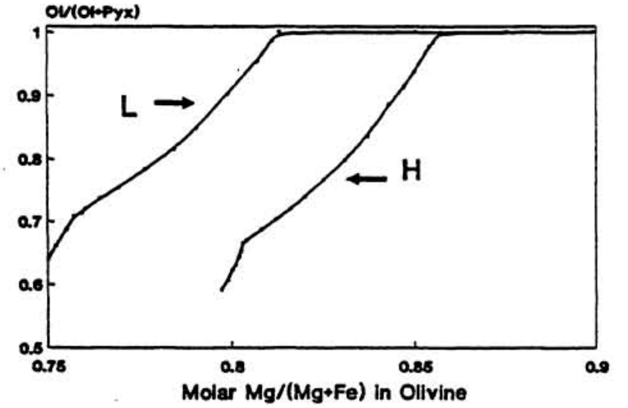

Fig. 3

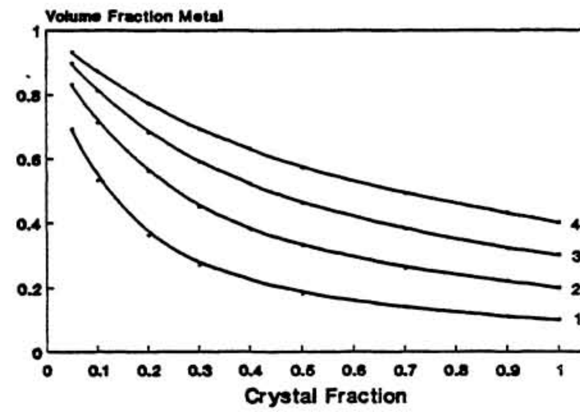

Fig. 4

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