Rapid melting of small planetesimals

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The presence of highly non-radiogenic ^{182}W in Fe meteorites has been used to estimate that rapid formation of Fe meteorites took place in < 1.5 Ma of formation of solar system [1]. The timing of formation of solar system is determined from $^{207}Pb/^{206}Pb$ ages of constituents of primitive meteorites the Cal-Al-rich Inclusions (CAIs) [e.g., 2]. The CAIs have some of the highest observed abundance of short lived radionuclide Al^{26} (half-life ~ 0.7 Ma) which decays to Mg^{26}, with $^{26}Al/^{27}Al \sim 5\times10^{-5}$ [3]. The early melting and differentiation of planetary bodies is attributed to the decay of heat generating ^{26}Al [4, 5]. The ability of ^{26}Al to melt an object will be determined by its abundance and the size of the planetary body [6]. Bodies with radii < 20km will not undergo complete melting; however a part of the inner core temperatures may exceed the solidus (~ 1200^oC) when radius > 5km [6]. The radii of parent bodies of Fe-meteorites range from 3-165km [7]. Melting of a small planetary body with ~ 3 km radius and chondritic composition cannot be easily explained. Furthermore, based on ^{26}Al abundance a hiatus of ~ 2 Ma is estimated between formation of CAIs and chondrules [e.g., 8]. If CAIs formed at a rapid rate they would have experienced gas drag resulting in their spiralling in to the early Sun [9]. The two possible mechanisms suggested to preserve CAIs is turbulent flow or rapid accretion of CAIs into small bodies. We report preliminary results of thermal evolution of small planetary bodies with CAI abundance greater than chondritic bodies resulting in higher than normal Al abundance. This will increase the ^{26}Al content per unit mass of the body, resulting in higher energy generation due its radioactive decay. In our calculations we observe that if the CAI content is varied between ~25% and 50% in a 3 km (radius) body, ~66% and 76% of the inner core of the body will respectively exceed solidus resulting in large scale differentiation and formation of Fe-cores. Bodies with very high CAI were recently reported [10]. The early sequestration of CAIs may be responsible for early formation of Fe-meteorites and angrites [1, 11].

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An investigation of basalts from the Central Indian Ocean Basin

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Basalts were recovered along with manganese nodules and encrustations from the Central Indian Ocean Basin (CIOB). The basalts are from the oceanic crusts and from a few seamounts, the latter being the manifestations of propagative fractures that formed from the ancient conjugate crusts of the South East and Central Indian Ridges. Magnetic anomalies (A26-A22) suggest the crust of the CIOB to be 60-52 Ma**.** Petrologically, the basalts are aphyric to moderately porphyritic with plagioclase forming a dominance of phenocrysts and microphenocrysts embedded in a glassy groundmass. Pyroxene and olivine occur in lesser amount together with a few opaque minerals.

Bulk-rock analyses indicate that the basalts from the CIOB are mainly hypersthene normative (3 – 19% hypersthene). Major element of the CIOB basalts show a wide range of variation of SiO_2 (~46 – 51 wt%) and MgO (~2.8 – 7.14 wt%). FeO (~9 to 17 wt%), TiO_2 (1.27 to 4 wt%) and Na_2O (2.43 to 4.26 wt%) exhibit an increase for a given MgO concentration. The concentrations of K_2O (0.24-1.6 wt%) and P_2O_5 (0.09-0.31 wt%) in the CIOB basalts are relatively high than the general MORB and relatively lower than the K-P type basalts indicating a slight enrichment of K and P, similar to ferrobasaltic melts. The CIOB basalts typically have high incompatible contents (TiO_2, La = 2.7-16.31 ppm, Rb > 6 ppm) and moderate LREE concentration.

A quantitative major and trace element modeling indicate that most of the variations are attributable to low-pressure fractional crystallisation under low f_{O2} condition of olivine, pyroxene and Ca-plagioclase. This plausibly led to the formation of Fe-Ti-rich basalt in the CIOB. The decreasing CaO/Al_2O_3 ratios and relatively constant Sc abundance with decreasing Mg# (55 to 31), supports the above view. The incompatible element ratios (Zr/Nb= 25-166; Y/Nb= 7-63; $(La/Sm)_N$= 0.58-1.46) are similar to ‘normal’ or ‘enriched normal’ mid-oceanic ridge basalt.

The above investigation of basalts from the CIOB indicates a similar formation history of magmas from different source regions or alternatively a single magmatic source followed a similar elemental enrichment trend prior to eruption from the ancient South East and Central Indian Ridges.