Numerical simulation on the thermal evolution and differentiation of iron meteorites' parent body

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According to Hf-W chronometry, the parent bodies of iron meteorites had experienced silicate-metal separation within the first a few myr since CAI formation (*e.g.*, Markowski *et al.*, 2006). In this case short-lived radioisotopes such as ^{26}Al and ^{60}Fe may have been survived and played a key role in thermal history of parent body (Urey, 1955). However the thermal history and the mechanism of silicate-metal separation have been unclear so far. Thus, in this study, we developed a numerical model on the thermal evolution and differentiation of planetesimal-sized (from a few km to about 100km-sized) celestial body to clarify the timing and mechanism of the formation of metallic core, which is one of the most plausible candidate of the origin of iron meteorites.

Our model takes into account the internal heating due to short-lived radioisotopes, radiative cooling from the surface, the porosity effect on the thermal conductivity, sintering of silicate media (pores shrink due to the effect of pressure and temperature), and silicate-metal separation due to permeable flow of molten metal through silicate media. Since the melting temperature highly depends on the sulfur content, we also consider the change in sulfur content along the phase diagram in Fe-FeS system (Kullerud, 1967).

According to our numerical results, there are two conditions for the planetesimal-sized body to form a metallic core. At first, the parent body should form within the first 2 myr from CAI formation, otherwise it would have insufficient heat source. Next, the radius of the body should be larger than about 7 km, otherwise the body would be cooled rapidly. Once these conditions are satisfied, molten metal, into which sulfur preferentially dissolves, migrates toward the center of the body to form metallic core. Afterward, as the core cools down precipitation of pure iron takes place in accordance with the phase diagram in Fe-FeS system. Finally a pure iron 'inner core' forms at the center of the metallic core, which would be the origin of iron meteorites. Resulting cooling rate of metallic core at 800 K is slower than several 100 K/myr depending on the planetary size, which is consistent with the cooling rate of iron meteorites obtained from the analytical study, from 1 to 500 K/myr (*e.g.*, Wood, 1964).

References

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Syn-plutonic dykes and magma mingling: An example from the Alvand plutonic complex, Sanandaj-Sirjan metamorphic belt, Iran

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The Alvand plutonic complex is composed of various mafic to felsic plutonic rocks (gabbro-diorite-tonalite-granite) formed by repeated injections of magmas of crustal (anatectic) and mantle origin. Two extreme end-members of magmas in the complex include: 1) M-type magmas generating gabbro-diorite-tonalite suite and mafic-intermediate dykes and 2) crustal anatectic magmas generating S-type granites and related rocks. There are many NE-SW trending microdioritic-microtonalitic syn-plutonic dykes in the complex which in the some places they are disaggregated to mafic microgranular enclaves (MME). Their appearance, mineralogical and geochemical affinities are similar to other dioritic rocks of the complex but they are finer grained, richer in quartz-ocelli and mafic clots and they are more silicic than their coarse grained equivalents. Regarding to field, petrographic, mineralogical and geochemical features a suite of pure anatectic to hybrid and to mantle type plutonic rocks can be distinguished in the Alvand plutonic complex. The dioritic-tonalitic rocks are hornblende-rich (30-50 %) but anatectic monzogranites-granodiorites are hornblende-free. The evidence of hybridization due to magma mingling in the region is better understood by characteristics of mafic end member than felsic one. This is due to volumetric abundance of two original magmas so that felsic magma has been more abundant than mafic one at the time of hybridization, and therefore, the mafic magma has been surrounded by the felsic magma, so that, solidified parts of the felsic magma have been disintegrated into mafic magma. Since that the felsic magma has been near the end of its crystallization (solidification) history its mixing with mafic magma has been limited. The geochemical properties of both of the felsic and mafic rocks of the region have been slightly affected by hybridization process.