Thermal History of Mercury with enstatite chondritic composition

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Mariner10 discovered the intrinsic magnetic field of Mercury. This indicates that the convection exists in the liquid outer core. Stevenson et al. (1983) presented a thermal history model to explain the liquid core. In this model, however, the compositions of Mercury's mantle and core are assumed to be similar to those of Earth.

Mercury, the nearest planet from the Sun, may consist of reduced materials like enstatite chondrite (Wasson 1988). Also, the reflection spectra of Mercury show the absence of colored minerals in the surface of Mercury, indicating that Mercury consists of reduced material. Here we calculated thermal history of Mercury with enstatite chondritic composition.

The model parameters are given below. The weight fraction of light element is adopted 13 wt% to have the same composition to the metal-silicate components of enstatite chondrite. This may reduce the melting point of iron significantly and therefore may prevent the inner core growth. The viscosity of the dry terrestrial mantle is about 100 times larger than that of the wet mantle (Karato and Wu 1993), and the viscosity of enstatite is 10 times at 1773 K and 101.5 times at 1673 K larger than that of olivine (Mackwell 1991). Therefore the viscosity of Mercury's mantle, which may be dry and assumed to consist of enstatite, is adopted to meet the conditions showed above. The other parameter values such as coefficient of thermal expansion, the specific heat and the thermal diffusivity is adopted the same values of enstatite, respectively. Under these assumptions, we calculated Mercury's thermal history with the parameterized convection theory.

Stevenson et al. (1983) showed that the inner core growth began after 2.3 Gyr and inner core radius was about 1760 km after 46 Gyr. However, our result suggests that the inner core of Mercury does not grow. The value of the heat flux from the core is 2.38 mWm-2.

Because the heat flux necessary for thermal convection in liquid core is 11 mWm-2 (Stevenson et al. 1983), the liquid core of enstatite chondritic Mercury may not convect thermally. To explain the magnetic field, the liquid core has to convect for other reason. It may be chemical convection caused by excluding light-alloying material with inner core growth. But inner core does not grow in our model. If the viscosity is 1/3700 times smaller, the inner core can grow. Unknown mechanism that reduces the mantle viscosity seems to be required to reconcile the generation of magnetic field and enstatite chondritic composition of Mercury.