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Characteristics of surface and interior of Mercury derived from its origin and evolution models

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Origin and evolution models of Mercury adequately modified from the previous models are presented to discuss characteristics of surface elemental composition, geomorphology, and inner structure of Mercury. That point has importance in setting the key objectives of .future missions such as Messenger and Bepi Colombo, and constraints of those missions on origin and evolution study are briefly discussed.

Since it was formed at the nearest region from the Sun, Mercury was made of materials that were condensed or coagulated in that hot region or undergone chemical fractionation process by collision during evolution from dusts to planets. Average density of the planet is dense relative to its size, which implies enrichment of iron. Existence of intrinsic magnetic field was found during fly-by observation by Mariner 10. Dynamo effect by fluid-dynamics inside the liquid core is a candidate for its generation. However, planet of Mercury's size generally tends to cool rapidly so that no liquid core remains. Majority of surface is occupied by crater-chronologically old plains, and there are found many lineated ridges and scarps that might be formed by thermal shrinkage when the planet cooled down.

In this study, three modified models to explain how to build a dense planet are discussed, that is selective accretion, evaporation, and giant impact. In the selective accretion model, Mercury is formed from heterogeneously accreted planetesimals, since the higher sticking probability of metals than that of silicates are likely. Silicate fragments should be rejected away from proximity of Mercury's orbit. Assumption is that iron is dominantly in metal phase (high magnesium number). Bulk composition of ancient mantle may be like enstatite chondrite. In the evaporation model, evolved proto-planet was heated up by solar activity or surrounding nebula gas so that the crust and upper mantle were lost by evaporation. The more volatile elements are thus expected more depleted. And in the giant impact model, one or more proto-planets were collided to the ancient Mercury and the uppermost layers were ejected away. Then the depleted, mantle-like, surface may be exposed.

Thermal history and core structure of Mercury is discussed to account for existence of intrinsic magnetic field. When assumed are consistent average density and moment of inertia, the inner structure is constrained in large core enriched in light element and mantle with large Mg-number (or thick crust), pure small core and mantle with small Mg-number (or thin crust), and their intermediate case. Elemental composition of core is determined by the origin of Mercury. Numerical simulation shows that current thickness of liquid core highly depends on amount of impurity in the core. If intrinsic magnetic field is driven in the liquid core, structure of magnetic field is related at inner structure of Mercury.

Major elemental composition and gravity anomaly mapping is required in order to estimate the density of crust and mantle, and improved moment of inertia and direct seismometry is necessary for core and mantle density and size. In addition to those observations, structure of magnetic field, libration, and high-resolution imagery, and heat flow will be measured by Messenger and Bepi Colombo missions. When those data is successfully obtained, much progress will be achieved in understanding the origin and evolution of Mercury.