

Mercury : A Reduced Planet and its Evolution Process

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Mercury is a small-sized terrestrial planet but it should be noted that it was formed and evolved under a reduced condition as well. In this study, we construct an internal structure model of Mercury originated from reduced source materials and investigate it by the surface features found on the planet. The affect of source materials is briefly discussed in comparison with other terrestrial planet.

Mercury is larger than Moon but smaller than Mars, Venus, and Earth. Most simple assumption is that the planetary evolution depends on its size, but the affect of surface materials should be also considered especially in crust formation and igneous processes. The overall surface profile of Mercury resembles that of the Moon but there found many different features such as the regional variation of reflectance. Typical reflectance of the highlands is 0.12, similar to the lunar highlands, but that of the plains is 0.16, twice higher than the lunar maria. Impact melts found inside Caloris basin show about the same albedo as the surrounding area, which is again a different case with the basaltic melt at lunar Orientale basin. Mercury is so dense and has intrinsic magnetic field, indicating its large metallic core whose outer shell is molten.

Some models have been proposed to explain how to form the dense planet, including selective accretion, surface evaporation, and giant impact. In this study, we chose selective accretion, which depends on the selective growth mechanism of metal-rich bodies that ductile metals tend to stick together but brittle stones tend to break during hypervelocity impact, followed by accretion of those bodies to form planet. The degree of metal selection of Mercury is only 1.8 to 2.5 times compared with that of the Earth if Mercury has the core with $2/3$ to $3/4$ of planetary radius. The process requires coexistence of silicates and metals in the same bodies under the reduced solar nebula. Such candidates are E- or H-chondrites, but not C-chondrites.

Here we assumed the source material as E- and H-chondrite, and calculated the planetary surface and internal structure by adjusting the metal and silicate mixture ratio to account for the density of Mercury.

Result shows that E-chondrite forms enstatite crust and mantle and large metallic core. The core can be molten due to sufficient content of sulfur. Partial melting is not likely in the mantle but component materials such as anorthosite can form the crust. Plains formed by giant impacts expose the enstatite mantle, indicating high albedo. Impact melt is basically the same composition as the surroundings. Although the case with H-chondrite is similar to that of the lunar evolution and needs another explanation to the surface features.

Our simple calculation suggests the Mercury has been formed from reduced source materials such as E-chondrite, which evidently shows regional variation of albedo and absence of volcanic activity. It should be noted that the planetary evolution process highly depends on its oxidized and reduced condition and abundance of water as well as planetary size. In addition, innermost area of the solar system should have been under highly reduced condition, as indicated as asteroid taxonomy.