Geophysical Research Abstracts,
Vol. 11, EGU2009-4710, 2009
EGU General Assembly 2009

Thermal Evolution of Mercury: Investigation of the Initial Conditions

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Because of its close proximity to the Sun, the innermost planet of our solar system, Mercury, cannot be studied from the Earth against the dark sky. Among the terrestrial planets Mercury is not only the smallest, but also the densest (after correction for self–compression), has the oldest surface and is the least explored. Understanding this 'end member' among the earth–like planets seems to be crucial to improve the understanding of the formation of the solar system and the history of the Earth.

For a long time only one spacecraft has visited Mercury up to now: MARINER 10. It imaged only about half of the planet's surface, while any details of the other hemisphere of Mercury have never been seen so far. Lately MESSENGER was launched and had two flybys on Mercury already, revealing a greater portion of the hermean surface and collecting more data. The BEPICOLOMBO spacecraft will be launched in 2014, arriving in 2020. Although MESSENGER will enter its orbit in 2011 already, the data basis remains relatively poor until then. We can therefore prepare ourselves for the upcoming results and perform test that allow some anticipation of the measured data. Because no material is available, which could have been analysed in a laboratory, numerical models are the most promising tool at the moment.

Due to the poor data basis it is not easy to pick the correct initial conditions for a numerical model. Since these might have a substantial influence on the final results they have to be carefully investigated in order to avoid false conculsions on the thermal history of Mercury. In this paper we show the first results for thermal evolution models of Mercury, obtained with a fully three dimensional spherical shell convection code. We present results that show dramatic differences in the convection structures according to the chosen intial conditions. The most striking feature is the massive core, which takes about 75 percent of the planet's radius. A large core like that is a significant energy source, providing a 'heating from below' as the dominant heat source, although the decay of radioactive heat sources is included too. The convection is generally driven by the energy release from the core and confined to the thin shell of the silicate mantle. The convection structures are relatively stable throughout the evolution. Choosing different initial conditions can therefore lead to completely different convection patterns, which then drive the full thermal evolution. We also present results obtained with a reasonable set of intial conditions, which are consistent with results from a different code, using similar initial conditions.