Geophysical Research Abstracts,
Vol. 11, EGU2009-4623, 2009
EGU General Assembly 2009

Formation and evolution of a lunar core from ilmenite-rich magma ocean cumulates

J. de Vries (1,2), A.P. van den Berg (1), and W. van Westrenen (2)

(1) Earth Sciences, Faculty of Geosciences, Utrecht University, Utrecht, Netherlands, (2) Petrology, Faculty of Earth and Life Sciences, VU University Amsterdam, Amsterdam, Netherlands

The size and composition of the lunar core are still debated. There are indications that at present, (part of) the lunar core is liquid. If this is indeed the case, this puts constraints on the composition and temperature of the core. It has been suggested that a dense ilmenite-rich layer, which originally crystallized near the top of the lunar magma ocean, may have sunk to the center of the moon to form either a complete lunar core or an outer core surrounding a metallic inner core.

Using a 2-D cylindrical numerical thermo-chemical convection model, we have investigated the formation, gravitational stability and thermal evolution of both an ilmenite-rich outer core and a full ilmenite-rich core.

Most planetary convection models assume a constant gravity acceleration in the planetary mantles. However, in the Moon, gravity acceleration decreases quickly with depth due to the much smaller core mass fraction for the Moon, $X_c \approx 0.01$–0.04 versus $X_c = 0.315$ for Earth. Since the gravity acceleration directly influences the buoyancy of materials, the low gravity acceleration near the centre was explicitly taken into account.

We have investigated core formation and evolution by varying two parameters, the density and the internal heating of the ilmenite-rich layer. Varying these parameters changes the compositional and thermal buoyancy of the dense layer. These two effects counteract and are therefore studied seperately. The density of the ilmenite-rich layer is varied, by varying the Mg# of the minerals between 20 and 40. The density decreases with increasing Mg#. The internal heat production due to the decay of radioactive isotopes of K, U and Th is used as a free parameter. The concentration of radioactive elements as a function of depth in the Moon is not well constrained. Two contrasting models are used, varying the heat production in the crust and in the ilmenite-rich layer, while keeping the total heat production of the models constant.

Results from this study show that a stable ilmenite-rich (outer) core may indeed have formed in the lunar interior. The size and density of this core depend on the internal heating in and the Mg# of the ilmenite-rich layer. Furthermore, the sharpness of the core-mantle boundary depends on the internal heating in the ilmenite-rich material. A last interesting result is that the temperature of a fluid inner core between models varies about 700 degrees maximum (around 2 Gyr after the start of the models), but only about 300 degrees after 4.5 Gyr. Further narrowing of the range of internal heating values is essential for a better determination of the present day core temperature and physical state.