Geophysical Research Abstracts
Vol. 16, EGU2014-6207, 2014
EGU General Assembly 2014

Laboratory convection experiments with internal, noncontact, microwave generated heating, applied to Earth's mantle dynamics

Angela Limare (1), Emanoil Surducan (2), Erika di Giuseppe (1), Vasile Surducan (2), Camelia Neamtu (2), Kenny Vilella (1), Loic Fourel (1), Cinzia Farnetani (1), Edouard Kaminski (1), and Claude Jaupart (1)

(1) IPGP, Paris, France (limare@ipgp.fr), (2) INCDTIM, Cluj-Napoca, Romania (emanoil.surducan@itim-cj.ro)

The thermal evolution of terrestrial planets is controlled by secular cooling and internal heating due to the decay of radiogenic isotopes, two processes which are equivalent from the standpoint of convection dynamics. Few studies have been devoted to the intrinsic characteristics of this form of convection, which are dominated by instabilities of a single boundary layer and which involve a non-isentropic interior thermal structure. Laboratory studies of such convection have been plagued by considerable technical difficulties and have been mostly restricted to aqueous solutions with moderate values of the Prandtl number, contrary to planetary mantles. Here, we describe a new laboratory setup to generate internal heating in controlled conditions based on microwave (MW) absorption. The advantages of our technique include, but are not limited to: (1) a volumetric heat source that can be localized or distributed in space, (2) selectively heating part of the volume with time varying intensity and space distribution.

Our tank prototype had horizontal dimensions of 30 cm $\times$ 30 cm and 5 cm height. A uniform and constant temperature was maintained at the upper boundary by an aluminium heat exchanger and adiabatic conditions were imposed at the tank base. Experimental fluids were hydroxyethylcellulose - water mixtures whose viscosities were varied within a wide range depending on concentration. Experimental Prandtl numbers were set at values larger than 100. Thermochromic Liquid Crystals (TLC) were used to visualize the temperature field, and the velocity field was determined using Particle Image Velocimetry (PIV). The Rayleigh-Roberts number was varied from 10^5 to 10^7. We also conducted numerical simulations in 3D cartesian geometry using Stag-3D (Tackley 1993) to reproduce the experimental conditions, including the tank aspect ratio and the temperature dependence of physical properties. We observed that convection is driven by cold descending plumes generated at the upper boundary that induce a diffuse upward return flow. Within experimental error, excellent agreement was found between calculated and observed vertical profiles of the horizontally-averaged temperature. Calculations and experiments led to the same velocity field characteristics including the number of instabilities in the upper boundary layer and root mean square velocity values.

P. J. Tackley, Geophys. Res. Lett. 20, 2187–2190 (1993).