Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06194, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06194
EGU General Assembly 2008

Multi phase model of planetary evolution

Y. Ricard, O. Sramek and F. Dubuffet

Université de Lyon, Laboratoire des Sciences de la Terre, 2 rue Raphael Dubois, 69622, Villeurbanne, France

In various situations, the dynamics of planets involves various phases. For example the simultaneous presence of solid and melted silicates, that of metallic and silicated components in a still undifferentiated planet or even more complex, the presence of metallic and silicated components, both partially melted in a magma ocean. We will discuss the volume averaged equations that can be derived to simulate some of these situations and will present a model of the formation of the core during Hadean time during which the Earth was simultaneously growing by accretion and ongoing core segregation. Although in the first millions of years after the condensation of the first solids, radioactivities now extinct were heating the planet, the major source of heat came somewhat later, deposited near the surface by meteoritic impacts. The surface heating became important when gravity was itself important (say for a planet larger than 1000 km). A classical scenario of core-mantle segregation assumes that a hot shallow layer was formed, in which the iron (or the undifferentiated material) was melted. In this layer, the iron separated from the silicates, and formed metallic pounds on top of a still undifferentiated deeper and colder mantle. This metallic layer underwent an instability and sank into the deeper mantle as a diapir. To test this scenario we developed this code based on the two phase formalism of Bercovici et al. (2001). As the melting temperature of iron is lower than that of silicates we assume that iron can be present in both solid or liquid phases while silicates remain solid. When the metal is solid, the metal and the silicates are locked together and we treat their mixture as a single phase fluid where density is function of temperature and composition (iron/silicate proportions). When metal is liquid, it can separate from the silicates and the two phases interact through shear stress (e.g., Darcy flow) and normal stress. The evolution of the volume proportion of liquid iron (the porosity) is controlled by

the difference of pressure between the two phases. The heat equation accounts for the release of potential energy that occurs during segregation. The model predicts an evolution significantly different from the simple original scenario. The increase of temperature due to segregation (release of gravitational energy) is comparable to the initial heat delivered by the impact so that the process of segregation, once started, is more or less self maintained. The first diapir that crosses the mantle leaves a cusp-like trail that connects the protocore to the near surface silicates across the undifferentiated material. Melting occurs continuously both in the shallow and in the deep mantle. The sinking of metallic diapirs is very fast (of order of 100 kyrs) as instead of deforming the surrounding material as in a usual Stokes flow, the undifferentiated material desegregates on the bottom side of the diapir, the silicates cross the metallic phase, and accumulate behind the sinking diapir. The first impact that melts the iron phase is therefore potentially able to trigger the whole core-mantle segregation.