Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT040-P09 Room:Convention Hall Time:May 23 10:30-13:00

A numerical model of three-dimensional mantle convection with long-lived cratonic lithosphere

Masaki Yoshida[1]*

[1]IFREE, JAMSTEC

The continental lithospheric mantle assists in the long-term survival of continental crust at Earth's surface and has a thick root or keel that extends hundreds of kilometers into the upper mantle. Geochemical and geochronological studies have revealed that some old cratons have survived at the Earth's surface for periods of more than three billion years despite later tectonic disturbances. The cratons are the keel of the continental lithosphere, and continental assemblages referred to as supercontinents have probably cyclically formed several times during Earth's history (see Yoshida and Santosh, 2011, Earth-Science Reviews).

However, in the numerical modeling of mantle convection, it is a challenging task to construct a numerical model to realize the longevity of cratonic lithosphere. Here, the dynamic role of a weak (low-viscosity) boundary zone (WBZ) between cratonic and oceanic lithospheres in the longevity of the cratonic lithosphere is investigated. The WBZ is assumed to consist of weak materials, deforming with time by mantle convection force. The three-dimensional numerical model presented herein makes it possible to model the cratonic lithosphere that survives for a sufficiently long geological timescale. An important factor in the longevity of cratonic lithosphere is the localized rheological (viscosity) contrast between the cratonic and oceanic lithospheres, i.e., the presence of a weak (low-viscosity) boundary zone (WBZ) that surrounds the cratonic lithosphere. The WBZ protects the cratonic lithosphere from being stretched by the surrounding convection force. This implies that the mechanical contrast between floating cratonic and oceanic lithospheres has played a significant role in the longevity of cratonic lithosphere itself throughout Earth's history. In addition to the presence of a WBZ, the higher viscosity of the cratonic lithosphere itself effectively contributes to the stability of the cratonic lithosphere.

There appears to be a relationship between the horizontal size and longevity of the cratonic lithosphere. The results of the present study are consistent with the fact that there are no Archean cratons of sizes larger than the scale of mantle convection in present-day Earth. Cratons that are sufficiently smaller than the convection scale are likely stable over the long geologic timescale, even if the continental keel is extensively eroded by younger magmatic and subduction-erosion processes.

Keywords: mantle convection, numerical simulation, cratonic lithosphere, supercontinent, plate motion, rheology