Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)
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MIS22-P09 Room:Convention Hall Time:May 23 13:45-15:15

Dynamic role of the weak continental margin on the stability of continental lithosphere: A 3D mantle convection model

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It is still difficult to find the conditions which allow both stable cratonic lithosphere and plate tectonics in the numerical modeling of mantle convection (e.g., Yoshida, 2010, Yoshida and Santosh, 2011). A three-dimensional (3D) numerical model presented herein makes it possible to model the cratonic lithosphere that survives for a geologically long period of time, i.e., over ten billion years (Yoshida, 2012). In the present model, the lateral side of the highly viscous cratonic lithosphere (CL) is surrounded by the weak (low-viscosity) continental margin (WCM), such as the tectonically mobile (orogenic) regions.

Numerical results show that 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 the WCM. The WCM protects the cratonic lithosphere from being stretched by the surrounding convection force. In addition to the presence of the WCM, the higher viscosity of the cratonic lithosphere itself effectively contributes to the stability of the cratonic lithosphere, as suggested by the previous numerical modeling. However, the results of the present study suggest that the WCM plays a primary role in the longevity of cratonic lithosphere, even if the viscosity contrast between the cratonic and oceanic lithospheres is quite high, 10^3, and the high-viscosity of cratonic lithosphere may play a secondary role in the longevity of cratonic lithosphere. The combination of the presence of a WCM and the high-viscosity of cratonic lithosphere may realize the longevity of cratonic lithosphere that survives for over two billion years.

Future studies based on numerical modeling must address the geodynamic mechanisms of (1) the origin and growth of the continental crust, (2) the episodic growth of continental crust, and (3) the creation and destruction of continental crust related to subduction zone processes. In particular, the mechanism of crust production and growth should be incorporated in a future numerical model in order to investigate the hypothesis that plate tectonics creates and destroys continental crust over time. Such a study would test whether the geologically suggested episodic emergence of supercontinents are realized in the numerical model (e.g., Yoshida and Santosh, 2011).

References:
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Keywords: continental lithosphere, continental margin, craton, viscosity, mantle convection, numerical simulation