Geophysical Research Abstracts
Vol. 17, EGU2015-3551, 2015
EGU General Assembly 2015

Petrological-thermomechanical modeling of Precambrian continental collision: geodynamical effects of subcontinental lithospheric mantle thickness

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The Precambrian collision and orogeny remains enigmatic and contentious. Different tectonic styles of orogeny in the Precambrian compared to modern Earth are suggested by interpretations of geological, petrological and geochemical observations from Proterozoic and Archean orogenic belts. Here, we present results of 2D petrological-thermomechanical numerical modeling of continental collision at crustal thickness of 35 km and convergence rate of 5 cm/year with variable thickness of subcontinental lithospheric mantle (SCLM). The numerical experiments cover the range of SCLM thickness from 65 km to 165 km, the upper mantle temperature exceeded the modern temperature by 150 oC, and the radiogenic heat production of continental crust is 1.5 times higher than that at present.

The numerical modeling has shown that in the case of SCLM thickness of 65 to 125 km the subduction terminates with slab break-off followed by the formation of a large igneous province in between the two continents instead of an orogenic belt. The time and the place of the slab break-off depend on SCLM thickness. The thinner it is, the earlier and the closer to the surface the slab breaks-off. For instance, the slab is detached in 10.3 m.y. at the depth 150 km when the model with SCLM of 115 km, whereas in the case of SCLM of 65 km the slab detaches in 5.1 m.y. almost near the very surface. In the latter case, the magmatic province is very large due to development at the both sides of the oceanic slab (instead of one side provinces in the other experiments). Continental collision with a very thick SCLM (of 165 km and more) proceeds without slab break-off and rather limited volcanism.

This work was supported by the Russian Foundation for Basic Research, grant 13-05-01033 and by the Supercomputing Centre of Lomonosov Moscow State University.