Geophysical Research Abstracts
Vol. 13, EGU2011-13208-3, 2011
EGU General Assembly 2011

How to destroy thick cratonic lithosphere?

Stephan Sobolev (1) and Alexander Sobolev (2)
(1) GFZ, Potsdam, Germany (stephan@gfz-potsdam.de), (2) ISTerre, Grenoble, France

The cratonic lithosphere is known to be thick, chemically distinct and tectonically stable. However there are natural examples when large areas of such lithosphere are flooded by a huge volume of basalts comprising Large Igneous Provinces (LIPs). The examples of LIPs that were extruded at initially thick Archean or Proterozoic lithosphere, are numerous, i.e. Siberian Traps, Central Atlantic Province, Karoo, Parana, North-Atlantic Province etc. Lithosphere thinning is required by any model of origin of such LIPs because only when the source ascends to shallow level can normal mantle peridotite produce a large amount of melt. In addition, composition of most flood basalts needs a quite shallow (less than 70-80 km thick) and thus garnet free mantle source.

Despite the obvious importance of understanding the origin of such LIPs, controversy surrounds even the basic idea that LIPs form through melting in the heads of thermal mantle plumes. From compositions of melts, in many cases there is evidence for unusually high mantle temperatures over vast areas, which is indicative for mantle plume heads. However, for many LIPs there is no evidence for kilometer-scale uplift predicted by the plume head model. Another problem is that classical mechanism of lithospheric thinning, e.g. stretching, cannot be a sole mechanism for lithospheric destruction during formation of many LIPs, which are known to operate for only 1 mln years or less.

Here, we investigate the origin of the Siberian Traps as a type example of the “origin-problematic” continental LIPs using synergy of petrology and thermomechanical modeling and discuss possible extension of our model for the problem of destruction of the cratonic lithosphere in general. We present a numerical finite element thermomechanical model and supporting petrological data implying a large amount (ca. 15 Wt%) of recycled oceanic crust within the head of a hot mantle plume beneath the cratonic lithosphere. Model and data suggest that the Siberian Traps originated from the melting of the head of a mantle plume with a potential temperature of about 1600C, that contained about as much dense recycled oceanic crust as it could carry maintaining almost neutral buoyancy in the upper mantle. Because of the low buoyancy of the plume, no pre-magmatic uplift was produced. The large amount of melt generated from this plume was responsible for the delamination of the cratonic lithosphere, with initial thickness of thermal boundary layer of 160 km and chemical boundary layer of 130 km, in less than 1 mln years.

We will also present modeling results investigating sensitivity of the lithosphere destruction process on composition, temperature and volume of plume, as well as on degree of depletion and thickness of lithosphere. In general we suggest that large and variable content of recycled crust within plumes is crucial for the dynamics of their interaction with lithosphere.