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Origin of Siberian Traps and their relation to the Permo-Triassic mass extinction

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The Large Igneous Provinces (LIPs) are known for their production of up to several million km^3 of magma in less than a few million years. They are likely associated with dramatic thinning of the lithosphere and they are often related to global environmental catastrophes. Despite the obvious importance of understanding the origin of LIPs, controversy surrounds even the basic idea that LIPs form through melting in the heads of thermal mantle plumes. The classic example of the "origin-problematic" LIP is the Permo-Triassic Siberian Traps, the largest continental LIP synchronized with the largest known mass-extinction event. It was erupted at a thick cratonic lithosphere, but there was no lithospheric stretching and pre-magmatic uplift, expected above the mantle plume head. It is also commonly believed that CO2 magma degassing from the Siberian Traps was not enough to trigger climatic crises.

Here 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, thus maintaining almost neutral buoyancy in the 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 heterogeneous delamination of the thick cratonic lithosphere over a few hundred thousand years. Degassing of CO2 and HCl stored in the recycled crust within the plume was likely much more extensive than previously proposed. The predicted quantity of released CO2 (120-150 10^{12} tones) and isotopic composition of C (δ^{13}C=-12 promille) is consistent with data on isotopic excursions for C and Ca at Permo-Triassic boundary (Payne et al., PNAS, 2010) and was probably enough to trigger the Permo-Triassic mass-extinction event.

According to our model, the main mass extinction event must have happened <u>before</u> the main phase of flood basalt extrusion. In contrast, the CO2 from the heating of carbon-rich sediments that was recently suggested as a trigger for the mass extinction (Ganino and Arndt, Geology, 2009; Svenson et al., EPSL, 2009) should be released <u>during</u> the main phase of magmatism, when the largest magmatic heat input is expected. The new precise U/Pb dating of the magmatic units of the Siberian traps is required to choose between these two hypotheses. However, the existing few high-quality U/Pb datings (Kamo et al., EPSL, 2003; Svenson et al., EPSL, 2009) indeed suggest that the major mass-extinction event at 252.3 Ma (Mundil et al., GS London SP, 2010) predated the main phase of magmatism, that may be common for other LIPs as well (Wignall, ES Rev.,2001). Additional large amounts of gases released from the heating of coal-rich sediments during the main phase of the Siberian Traps may have been the reason for a number of C excursion pulses during the late phases of the biotic crises.