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Basin-scale distribution of sill intrusions in the Tunguska Basin, East Siberia, and the implications for the end-Permian environmental crisis

Henrik H. Svensen (1), Sergei Frolov (2), Grigorii G. Akhmanov (2), Alexander G. Polozov (1,3), Sverre Planke (1,4)

(1) Center for Earth Evolution and Dynamics (CEED), University of Oslo, 0316 Blindern, Norway (henrik.svensen@mn.uio.no), (2) Institute of Geology, Moscow State University, Leninskie Gory, 119991 Moscow, Russia, (3) Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Russian Academy of Sciences (IGEM RAS), 119017 Moscow, Russia, (4) Volcanic Basin Petroleum Research AS (VBPR), 0349 Oslo, Norway

The emplacement of the Siberian Traps Large igneous province through the Tunguska Basin is regarded as the main processes behind the end-Permian environmental crisis. Still, the lack of data from the Tunguska Basin represents one of the main uncertainties in understanding this link. Degassing from contact metamorphic aureoles in evaporites is suggested as key to the continental mass extinction, but very little is known about the actual distribution of sills within these lithologies. We present results from a unique borehole database with more than 700 boreholes, where 293 boreholes are studied in detail and presented here. The boreholes cover large parts of the basin, from Norilsk in the north (N69) to Bratsk in the south (N55), with a bias towards petroleum-bearing regions. In total, 93.5% of the selected boreholes contain sill intrusions. The sill thicknesses vary considerably from kilometer-scale intrusive complexes to individual thin sills of a few tens of meters. Locally, thick sills (up to 900 meters in thickness) occur in the upper part of the sedimentary succession, affecting the coal-rich Tunguska Series sediments. However, on average, the thickest sills in the basin are emplaced within the vast Cambrian salt formations, with average thicknesses in the 115-130 meter range. Accompanying petrographic investigations of metamorphic sediments demonstrate that widespread high temperature devolatilization took place. Degassing to the atmosphere took place via explosive pipe degassing and seepage. We show that depending on the specific location within the province and the emplacement depth, the potential for degassing of both greenhouse gases (CH4, CO_2), aerosols (SO_2), and ozone destructive gases (CH3Cl, CH3Br) was substantial and can explain the end-Permian mass extinction.