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Bacterial sulphate- and iron reduction in a Siberian Traps crater lake during the end-Permian crisis

Henrik H. Svensen (1), Timm John (2), Stefan Weyer (3), Kirsten E. Fristad (4), Alexander G. Polozov (5), Manon Bajard (1), Morgan Jones (1), Sverre Planke (1,6)

(1) Centre for Earth Evolution and Dynamics (CEED), University of Oslo, Norway (hensven@geo.uio.no), (2) Institute of Geological Sciences, Free University Berlin, Germany, (3) Institute of Mineralogy, Leibniz University Hannover, Germany, (4) Western Washington University, USA, (5) Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry of Russian Academy of Sciences (IGEM RAS), Moscow, Russia, (6) Volcanic Basin Petroleum Research (VBPR), Oslo Research Park, 0349 Oslo, Norway

In the Siberian Traps Large igneous province (LIP), the emplacement of magma in sedimentary strata led to explosive release of volatiles and the formation of large pipe structures with explosion craters. Of the hundreds of pipes present, several are overlain by lacustrine sedimentary rocks that were deposited in the craters. These craters represent the only known end-Permian sedimentary archive proximal to the Siberian Traps.
Previous studies from the S26 core drilled through the centre of the October pipe, located west of Bratsk, have shown that the lake was saline, stratified and anoxic/euxinic, with a high organic content (up to 4 wt.% TOC) and abundant framboidal pyrite. The sediments are dominated by sandstone and siltstone, sourced from the material ejected during the pipe formation, and have not experienced heating above ca. 50 C. The basal deposits are coarse and contain reworked magnetite-apatite ore that originally precipitated from hydrothermal fluids within the upper parts of the pipe. The sediments are calcite-cemented and the volcanic minerals altered to clays and zeolites, with occasional oxidized zones showing that the water level fluctuated, in accordance with rapid subsidence resulting from dissolution of deeper-seated Cambrian evaporites.

The S26 core contains 505 meters of sediments and in order to investigate the geochemical processes in the lake and the possible role of brine influx from the breccia pipe, we have analysed d34S and d56Fe in pyrite (14 samples) and d56Fe in magnetite (12 samples) from the breccia pipe and crater sediments. In addition, reference samples from two other breccia pipes and relevant sedimentary strata from the Tunguska Basin were analysed for comparison.

The results show a marked shift in both isotope systems from the breccia pipe and into the basal lake deposits. The d34S shifts from normal sedimentary values (+20-30 permil) in the pipe breccia, to -7-0 permil in the lower half of the lake sediments followed by an increase to +20 permil towards the top of the lake. The trend is evident in the d56Fe in magnetite as well, with a 0.4 permil negative shift from the breccia and into the lake sediments, followed by an upward increase in the stratigraphy. We suggest that basinal brines rich in iron and sulphate were partly reduced by bacteria in the stratified lake, leading to pyrite precipitation and isotope fractionation. The data shows the interplay between lake processes and fluid seepage from a hydrothermal system, making these deposits unique for understanding the consequences of LIP formation.