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Formation of phreatomagmatic pipes in the Tunguska Basin (Siberia, Russia) during the end-Permian

Alexander Polozov (1,2), Henrik Svensen (2), Sverre Planke (3,2)

(1) Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry RAS, Moscow, Russian Federation (a.g.polozov@mail.ru), (2) Physics of Geological Processes, University of Oslo, Oslo, Norway (henrik.svensen@matnat.uio.no), (3) Volcanic Basin Petroleum Research, Oslo Research Park, Oslo, Norway (planke@vbpr.no)

We recently proposed that numerous pipes piercing sedimentary rocks of Tunguska Basin triggered the Permian-Triassic mass extinction (Svensen et al., 2009). Large amounts of greenhouse and poisonous gases were released through the pipes and into P-Tr atmosphere, partly formed by heating of petroleum-bearing evaporites.
The sub-volcanic part of the Siberian Traps was emplaced in the Tunguska Basin sedimentary sequences, which includes Pre-Cambrian source rocks, Early Cambrian evaporites, and Paleozoic terrigenous and coal-bearing rocks. Spectacular breccia pipes are numerous in the evaporate-parts of the basin, and are filled with volcaniclastic rocks and commercial magnetite mineralization. Although these pipes have been intensively studied in order to understand the iron ore formation, the origin and formation of the pipes is poorly understood. Many researchers emphasize that magma-sediments interaction as a key reason of pipe formation, whereas phreatomagmatic hypothesis are also proposed.
In order to improve the understanding of pipe formation and ore-deposition, we have studied a basalt-rich breccia pipe piercing Cambrian evaporates at the Nepa locality in East Siberia. Textural features of the volcanic fragments in the breccias include lapilli, Pele's hear, glassy basalt and dolerite clasts, blocks of tuffs in addition to sedimentary rocks. Calcite and halite are the most common types of cement.
We have studied minerals from the breccia cement and from reaction rims around clasts in order to understand the hydrothermal system that developed after the pipe formed. Calcite and dolomite are the dominating carbonates, and two types of anhydrite is present. Biotite, Cl-Fe-bearing amphibole (hastingsite), and Cl-F-apatite are amongst early hydrothermal minerals covering magmatic clast and lapillies. Our new data confirm (i) the phreatomagmatic nature of breccia filling in the Tunguska Basin pipes and (ii) the key role of sedimentary brine and petroleum involved in the process of magma-sediment interactions.