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The origin of so-called "exceptionally fresh" kimberlite of the Udachnaya-East pipe

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The so-called "exceptionally fresh" kimberlite of the Udachnaya-East pipe was the subject of several recent publications. The kimberlite contains uncommonly abundant olivine microphenocrysts, no primary groundmass serpentine, and crystallizes alkali carbonates, gypsum, sodalite and chloride minerals in the groundmass. The composition of this kimberlite was proposed as an estimate of the deep kimberlite melt, uniquely rich in mantle chlorine and Na. We propose a different point of view on the Udachnaya–East kimberlite and show that it acquired the high Na- and Cl- contents due to assimilation of halite xenoliths and interaction with modern Na-Ca-Cl brines.
The Na- and Cl-rich kimberlite is intersected by drill holes at the Udachanaya East at depths of 400-500 m. The predominant kimberlite is fragmental, containing 1-30% xenoliths of country rocks, mantle xenoliths and early hypabyssal kimberlite. Country rock xenoliths are represented by limestones and halite- and hypsum-bearing evaporates (the last are scarce). The fragmental kimberlite is cut by dykes of late hypabyssal kimberlite. All varieties of the kimberlite at 400-500 m contain fresh, unserpentinizied olivine. The kimberlite is carbonatized; recrystallization of calcite makes it more coarse grained and forms monomineral calcite veins. Similar recrystallization affected limestone xenoliths. The Na- and Cl-rich kimberlite also shows late gypsum veining that include fine-grained veinlets along rock fractures as well as the coarse gypsum zones ranging in thickness from 10 to 20 m. The kimberlite and mantle xenoliths often host miarolitic cavities with carbonate-chloride minerals. Their presence suggests leaching and resorption of solid, fully-crystallized kimberlite and included mantle nodules.
The Udachanaya pipe is situated within the modern Daldyn-Markha criohydrogeological reservoir consisting of several aquifers. The aquifer at 400-500 m depth is characterized by anomalously high concentrations of Na and Cl (0.3 g/cm3).
The main trend in the major element composition of the kimberlite is the inverse correlation of CaO with SiO2 and MgO, typical of all worldwide kimberlites. The content of Na2O (0.07 3.1 wt %, 0.97 wt. % on average) is higher than that of a kimberlite reflecting high abundances of zemcorite, halite, shortite in the rock. The Na2O content does not correlate with any major element oxides, but in rocks with CO2 > 9 wt.% the Na2O content is relatively low (< 0.2 wt%). We ascribe this to the intensive carbonatization which «seals» the kimberlite to brine penetration.
The Sr isotope composition of the kimberlite ranges from 0.704 0.709. Sr ratios higher than 0.705 are typical of kimberlites contaminated by the crust. This contamination may have come as assimilated Cambrian carbonates and lagoon sulfate-chloride rocks (87Sr/86Sr =0.7082-0.7088), or as modern brines (87Sr/86Sr =0.7088-0.7090). The oxygen and carbon isotope ratios ([U+F064]18O and [U+F064] 13C) of the kimberlite are +15.4 - +18.2 ‰ and -2.2 - -3.1 ‰ respectively. Trace element composition of the kimberlite analyzed in this work provide evidence on the brine-kimberlite interaction.
We conclude that the source of chlorine and Na in the Udachnaya-East kimberlite is shallow sedimentary marine rather than the deep mantle. Chlorine and Na are added to the studied kimberlite as halite and gypsum deposited by present-day brines, and as assimilated evaporite xenoliths. The assimilation of evaporite xenoliths occurs at relatively high, magmatic temperatures causing capture of Cl-rich fluid inclusions in olivine fractures. The assimilation leads to crystallization of pseudo-primary, hybrid minerals such as alkali carbonates, gypsum, sodalite and chlorides. Addition of chloride components lowers the temperatures of kimberlite crystallization and makes water to escape rather than to form groundmass serpentine, typical of kimberlites worldwide. Lower content of deuteric hydrous vapor leaves the kimberlite olivine fresh and unserpentinized. A similar spacial relationship between unaltered kimberlite olivine and halite is also noticed the Internationalnaya kimberlite. In this kimberlite, few blocks of kimberlite with fresh olivine is restricted to deep mining horizons where the kimberlite contacts

with evaporite country rocks rich in halite.