Kuliginite, a new hydroxychloride mineral from the Udachnaya kimberlite pipe, Yakutia: Implications for low-temperature hydrothermal alteration of the kimberlites

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Abstract

Kuliginite is a new iron-magnesium hydroxychloride mineral with the ideal formula Fe₃Mg(OH)₂Cl₂ from the Udachnaya East kimberlite, Yakutia, Russia. It occurs as green prismatic-bipyramidal crystals (0.2–0.5 mm) and fills cavities and veins in several units of kimberlites together with iowaite, gypsum, calcite, halite, barite, and celestine. It is trigonal, with R₃ space group. Kuliginite has imperfect cleavage on {1011}. The spinel-like crystal structure of kuliginite is also typical for several copper minerals of the atacamite group with common formula Cu₃M(OH)₂Cl₂; kuliginite can be regarded as a Fe₂⁺ analog of tondite [Cu₃Mg(OH)₂Cl₂].

The occurrence of the kuliginite + iowaite + gypsum assemblage has implications for the interpretation of low-temperature (below 100°C) hydrothermal processes and alteration of kimberlite by hydrothermal fluids/brines, as well as for transport of metals in Cl-bearing solutions. This secondary hydrothermal mineral assemblage formed much later than the kimberlite groundmass minerals. Kuliginite contains inclusions of iowaite indicating their simultaneous crystallization.

Keywords: New mineral, kuliginite, crystal structure, kimberlite, atacamite group, hydroxychloride; Dynamics of Magmatic Processes

Introduction

The Paleozoic Udachnaya kimberlite pipe is the world’s largest diamond deposit, and it is located in the Yakutsk diamond province in the central Siberian craton. It has a complex structure (Kharkiv et al. 1998), with several distinct “volcanoclastic units” and “coherent” kimberlite in each pipe (Fig. 1), according to the modern model (Smith et al. 2013).

Na-K-Cl-bearing minerals were found in various assemblages from different units of the Udachnaya East kimberlite, but the source of Na and Cl in these units remains poorly constrained. Melt inclusion studies (Golovin et al. 2003, 2007, 2017; Kamenetsky et al. 2004, 2006, 2007b, 2009, 2014; Mernagh et al. 2011), as well as Sr, Nd, and Pb isotopes (Maas et al. 2005; Kamenetsky et al. 2009, 2014) and sulfur isotope data (Kitayama et al. 2017) on the Udachnaya-East rocks provide solid proofs for magmatic mantle origin of the Na-K-Cl component in two non-serpentinized ultra-fresh units of the Udachnaya East kimberlite. Thus, the discovery of these two compositionally unusual units offers a unique opportunity to study the composition and evolution of kimberlitic magma (Golovin et al. 2017; Kamenetsky et al. 2007b, 2012, 2014; Kitayama et al. 2017). On the other hand, some authors argue that any assemblage with chlorides larger than 1 cm in any unit of the Udachnaya East kimberlite from the depths of 410–640 m may be evaporatic or xenoliths coming from the host sediments (Kopylova et al. 2016).

This paper presents new data on mineral assemblages containing chlorides in voids from several types of kimberlites originated at the depths of 560–640 m in the Udachnaya East pipe, where a new hydroxychloride mineral, kuliginite, was found. Kuliginite is a new iron-magnesium hydroxychloride (IMA 2016-049) that belongs to the atacamite group (Hålenius et al. 2016) and was named after Sergey Semenovich Kuligin, Russian geologist and researcher (1961–2014), who for years studied Yakutian kimberlites, xenoliths, and alluvial diamond deposits all over Yakutia in search for unknown kimberlite pipes. S.S. Kuligin, together with his colleagues from the Sobolev Institute of Geology and Mineralogy (IGM, Novosibirsk, Russia), discovered the Nicka diamondiferous placer along the Tyung River (Yakutia). The holotype sample of kimberlite with abundant kuliginite is stored in the collection of the Central Siberian Geological Museum of IGM under the number VI-53/1.

Analytical techniques

Mineral chemistry of kuliginite (40 chemical analyses, Table 1), iowaite, celestine, and calcite were determined in IGM using a JEOL JXA-8100 electron microprobe operated at 20 kV acceleration voltage, 5 μm beam diameter, 50 nA focused beam current, and 20–30 s counting time; TESCAN MIRA 3 LMU JSM 6510LV equipped with an Oxford Instruments INCA energy-dispersive detector was used for chemical mapping at the operating conditions 20 kV, 1 nA, with an interval of 0.78 s for each spot. Raman spectra in the range from 50 to 4000 cm⁻¹ were collected with a Horiba Jobin Yvon LabRam HR800 Laser Raman spectrometer, using a 532 nm laser, at...