American Mineralogist, Volume 105, pages 498–509, 2020

Enigmatic diamonds from the Tolbachik volcano, Kamchatka

Erik M. Galimov[1], Felix V. Kaminsky[1,*], Svetlana N. Shilobreeva[1], Vyacheslav S. Sevastyanov[1], Sergei A. Voropaev[1], Galina K. Khachatryan[2], Richard Wirth[3], Anja Schreiber[3], Vladimir V. Saraykin[4], Gennady A. Karpov[5], and Leonid P. Anikin[5]

[1]Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygin Street 19, Moscow 119334, Russian Federation
[2]Central Research Institute of Geological Prospecting for Base and Precious Metals, Varshavskoye Shosse 129, Moscow 117545, Russian Federation
[3]Helmholtz Centre Potsdam, GFZ German Research Center for Geosciences, 3.5 Surface Geochemistry, Telegrafenberg, C120, D-14473 Potsdam, Germany
[4]Institute of Physical Problems, Zelenograd 124460, Russian Federation
[5]Institute of Volcanology and Seismology, Russian Academy of Sciences, Petropavlovsk–Kamchatskii 683006, Russian Federation

Abstract

Approximately 700 diamond crystals were identified in volcanic (mainly pyroclastic) rocks of the Tolbachik volcano, Kamchatka, Russia. They were studied with the use of SIMS, scanning and transmission electron microscopy, and utilization of electron energy loss spectroscopy and electron diffraction. Diamonds have cube-octahedral shape and extremely homogeneous internal structure. Two groups of impurity elements are distinguished by their distribution within the diamond. First group, N and H, the most common structural impurities in diamond, are distributed homogeneously. All other elements observed (Cl, F, O, S, Si, Al, Ca, and K) form local concentrations, implying the existence of inclusions, causing high concentrations of these elements. Most elements have concentrations 3–4 orders of magnitude less than chondritic values. Besides N and H, Si, F, Cl, and Na are relatively enriched because they are concentrated in micro- and nanoinclusions in diamond. Mineral inclusions in the studied diamonds are 70–450 nm in size, round- or oval-shaped. They are represented by two mineral groups: Mn-Ni alloys and silicides, with a wide range of concentrations for each group. Alloys vary in stoichiometry from MnNi to Mn_2Ni, with a minor admixture of Si from 0 to 5.20–5.60 at%. Silicides, usually coexisting with alloys, vary in composition from $(Mn,Ni)_4Si$ to $(Mn,Ni)_5Si_2$ and Mn_5Si_2, and further to MnSi, forming pure Mn-silicides. Mineral inclusions have nanometer-sized bubbles that contain a fluid or a gas phase (F and O). Carbon isotopic compositions in diamonds vary from –21 to –29‰ $\delta^{13}C_{VPDB}$ (avg. = –25.4). Nitrogen isotopic compositions in diamond from Tolbachik volcano are from –2.32 to –2.58‰ $\delta^{15}N_{Air}$. Geological, geochemical, and mineralogical data confirm the natural origin of studied Tolbachik diamonds from volcanic gases during the explosive stage of the eruption.

Keywords: Diamond, Kamchatka, cavitation, silicide, carbon isotope, nitrogen isotope, volcanic gases, volatiles