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Crystal forms of natural microdiamonds

Victor Kvasnytsya *

Institute of Geochemistry, Mineralogy and Ore Formation, National Academy of Sciences of Ukraine, Palladin Ave., 34, 03680 Kyiv-142, Ukraine

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ABSTRACT

Geometrical crystallographic features of rare diamond micro-crystals (0.3–0.5 mm in diameter) from kimberlites having different complex flat and smooth faces are described. Such polyhedrons of microdiamonds are typically composed of two or more combinations of seven different crystal forms belonging to hexoctahedral symmetry class: octahedron, cube, rhombic dodecahedron, trisoctahedron, trapezohedron, tetrahexahedron and hexoctahedron. Many of them are not yet known for macro-crystals of this mineral. All these forms are found as small faces on the octahedral crystals. Both flat and smooth faces of octahedron and cube on such crystals have their own growth sectors. Flat faces of rhombic dodecahedron, different trisoctahedrons, trapezohedrons and hexoctahedrons occur as so-called faces of degeneration of octahedral growth planes. Nature of tetrahexahedron flat faces is not clear. An investigation of the complex diamond polyhedrons should give a new idea on crystal morphology of diamond, make more precise its symmetry and be important for the explanation of the nature of diamond on the whole.

1. Introduction

For a long time the amount of established growth forms (simple forms) of natural diamond crystals was restricted and based on the results of researches carried out by e.g. Romé de l'Isle, Bournon, Haüy, Rose and Sadebeck, Yeremeyev and others (e.g., [1,2]). At the initial period of diamond crystallography research in the 18th–19th century, symbols were often ascribed to the forms related not to flat faces, but to rounded surfaces. Later, diamond crystallography has been sufficiently developed due to the investigations of Fersman and Goldschmidt [1,2], Shafranovsky [3], Kukharenko [4], Tolansky [5], Bartoshinsky [6], Kalb [7], Moore [8] and other researchers, who provided detailed characterization of the general geometry of natural diamond crystals (mainly, the degree of roundness) and sculptures on their surface.

Critical consideration of simple crystal forms of diamond was performed by Fersman and Goldschmidt [1,2]. They revealed and designated the typical forms and the pseudo-forms. Flat-faceted forms of growth – usually octahedron and rarely cube formed by blunting of octahedron's apexes – were attributed to typical forms. Rhombic dodecahedron, composed of the edges of octahedral plates of growth, and cube, composed of the apexes of the same plates of growth, were attributed to pseudo-forms. Fersman and Goldschmidt separated all diamond forms known at that time into authentic and apocryphal ones. The authentic growth forms include octahedron, cube, rhombic dodecahedron, trisoctahedrons {331}, {332}, {221}, and trapezohedrons {211}, {322}. All these forms, except for the octahedron, were identified on some South-African diamond crystals where they had a minor significance in faceting of octahedral diamond macro-crystals. Examples of two more possible types of simple forms, tetrahexahedron and hexoctahedron, were included into a series of apocryphal forms characterizing rounded surfaces of diamond crystals. The tetrahexahedron and hexoctahedron on diamond crystals as growth forms have not been described.

Unusual morphology of diamond micro-crystals was noticed by Tolansky (reference in Moore [9]) who found that about 1% of the well-shaped diamond micro-crystals (0.5–1.0 mm in diameter) from Premier mine were cube-octahedrons with smooth and flat cube faces [9]. The first detailed investigations [10] of diamond micro-crystals (less than 0.2–0.5 mm in diameter) from Ukrainian placers have already shown that many of them developed flat faces of all simple forms of hexoctahedral class of symmetry. In addition Varshavsky and Bulanova [11] indicated even habital hexoctahedrons among micro-crystals of Yakutian diamonds. Later the rare diamond micro-crystals with numerous flat faces were found among diamonds from kimberlites of various provinces of the world and metamorphic rocks of Kumdy-Kol deposit in Kazakhstan [12–14].

The present paper is a detailed crystallographic investigation of rare diamond crystals from kimberlites with complex morphology.

2. Samples and analytical techniques

Unresorbed octahedral diamond micro-crystals from Yakutian kimberlites (Russia) have been investigated. The surfaces of these crystals show flat faces. The crystal size varies from approximately 0.3 to 0.5 mm, very rarely up to 0.7–0.9 mm in diameter. These small crystals were selected among a few thousand microdiamonds from Udachnaya, Mir and Yubileinaya pipes.

* Tel.: +380 44 424 05 40; fax: +380 44 424 12 70.
E-mail address: vmkvas@hotmail.com.

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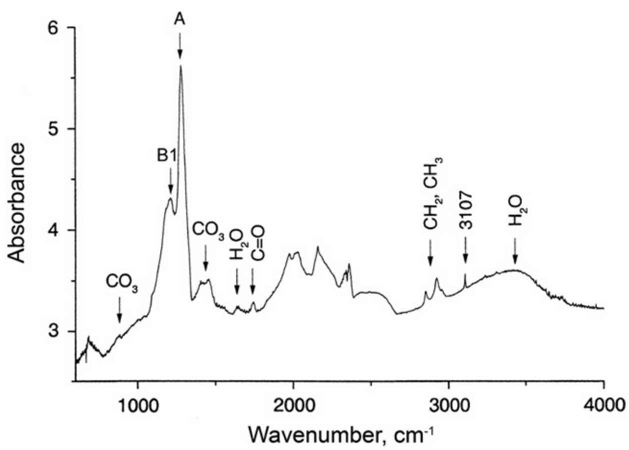

Fig. 1. FTIR-spectrum of microdiamond shown in Figs. 9e, 10.

For goniometric investigation of the crystals a two-circle goniometer GD-1 was used. The deviations of measured face coordinates from their theoretical values did not exceeded $\pm 2°$. Scanning electron microscopy (SEM) investigations were carried out on a REMMA-102 (SELMI, Ukraine) in National Academy of Sciences of Ukraine, Kyiv. The procedure of SEM analyses: carbon coating of diamonds was applied, the operation conditions were accelerating voltage 5 and 15 kV, probe current 5×10^{-10} A. A goniometry and SEM study were undertaken on 80 diamond micro-crystals.

Nitrogen is the main impurity in diamond crystals from kimberlites. The studied complex diamond micro-crystals also contain nitrogen in various amounts [15,16]. There are the "nitrogen-free" complex diamond micro-crystals. Also the unique crystal diamond with spiral growth according to spectroscopic study in the infrared region (Fig. 1) is a IaA type of physical classification: the content of nitrogen in the A form (band 1282 cm^{-1}) does not exceed 330 ppm and in the B1 form (band 1175 cm^{-1}) — 20 ppm.

3. Results

Goniometric measurements (Fig. 2) established that many flat faces on the investigated octahedral diamond micro-crystals represent cube, rhombic dodecahedron, trisoctahedrons, trapezohedrons, tetrahexahedrons and hexoctahedrons forms. As individual small flat faces, they complicate apexes and edges of the predominant octahedron. The studied crystals often combine some or even all of these forms on the same crystal displacing octahedron faces.

The most frequently occurring form is *cube* (Fig. 3). Compared with the other crystal forms it has the mostly developed surfaces and is often in a holohedral form. Flat faces of cube may have ideal smooth surface, or be complicated by single or multiple tetragonal cavities. Contours of the faces are clear rectangular or somewhat rounded; the edges of the faces are sharp or rounded. The goniometer reflections of the cube faces are sharp or, sometimes, slightly eroded.

Rhombic dodecahedron is represented by rare and particularly non-holohedral forms (Fig. 4). It may be seen as narrow strips of

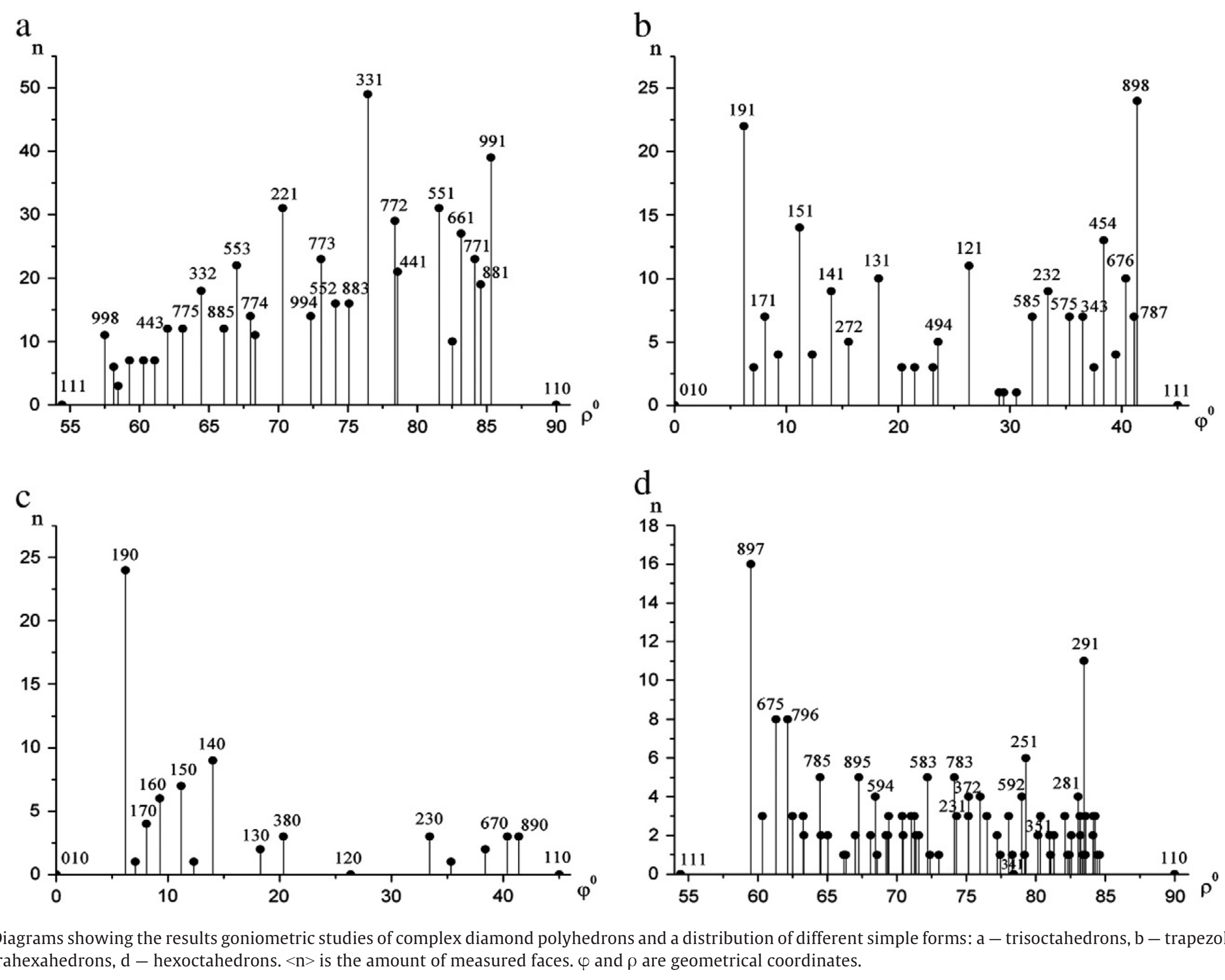

Fig. 2. Diagrams showing the results goniometric studies of complex diamond polyhedrons and a distribution of different simple forms: a — trisoctahedrons, b — trapezohedrons, c — tetrahexahedrons, d — hexoctahedrons. <n> is the amount of measured faces. φ and ρ are geometrical coordinates.