# DIAMOND COLLECTION IN THE FERSMAN MINERALOGICAL MUSEUM OF THE RUSSIAN ACADEMY OF SCIENCES: SHORT HISTORICAL REVIEW

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Historical review on development of diamond collection of Fersman Mineralogical Museum is presented. Several chronological stages were outlined according to the history of exploration and study of new worlds diamondiferous provinces. Yu.L. Orlov's contribution to diamond studies and collection replenishment with diamond of various genesis and morphology was shown as well as his diamond classification. Several varieties of diamonds are described.
6 figures, 11 references.
Keywords: diamond, mineralogical collection, diamond genetic classification, Yu.L. Orlov.

Diamond collection of Fersman Mineralogical museum contains more than 1200 diamond crystals from placer and bedrock deposits from Russia, Brazil, Namibia, South Africa, Indonesia, USA and Australia. Its almost a century long history covers periods of discoveries and studies of Russian and foreign deposits and carries names of people who contributed to the collection.

The oldest diamond discoveries were done from placers and were made almost always by accident. It is known that bondman Pavel Popov, found the first Russian and European diamond in the basin of Koiva River near Krestovozdvizhensky gold workings in Perm government on the western slope of Ural mountains (now village Promysla of Gornozavodsk district in Perm region) on 4$^{th}$ of July, 1829 (Kharkiv *et al*., 1997). There are several crystals (sample FMM #25684) from those workings that came to the museums by the merit of Pavel Vladimirovich Eremeev (1830–1899), professor of mineralogy and crystallography of the Petersburg Mining Institute.

Significant donations of diamonds came to the museum in 1912–1916 period. They derived from foreign deposits: crystals from placers in Indonesia (Kalimantan and Borneo islands), Brazil, Namibia, Australia (Bingara); Middle Urals and also bedrock diamonds from South Africa (Kimberly and Jagersfontain pipes).

The diamond findings from Kalimantan and other regions of Indonesia were known from ancient times and were dated to VI–X centuries. Those are the second oldest diamond placers after India (Smith, 1980).

The specimens from Borneo (Kalimantan) island are connected to Georgiy Prokof'evich Chernik (1865–1942), major general of the Russian Army, who was professionally involved in gathering and studying of minerals. He handed more than 300 samples of various minerals to the museum within 30 years starting from 1903 (Mokhova, Generalov, 2007). Those samples included diamonds from Kalimantan placers (samples FMM #11273 and FMM #11304).

Diamond deposits in Brazil were discovered in the 18$^{th}$ century (Smith, 1980). The worlds center of diamond mining moved from Indonesia to South America for almost one century till the discovery of bedrock deposits in South Africa. Brazil is famous by unique green colored diamonds. Black cryptocrystalline aggregates, so-called carbonados, were also found there (Orlov, 1984). Uniqueness of the black diamonds was in their origin from environment that was not suitable for typical diamond formation as kimberlitic pipes. Brazilian black diamonds were found in young sedimentary rocks, in spite to their isotopic age that was calculated to be 3 bln. years old (Mal'kov, Askhabov, 2010).

Kimberly pipe (South Africa) was discovered in 1871 and was the first bedrock body containing diamonds. That is why the diamondiferous rock was named kimberlite. Kimberly pipe was mined out by 1914 (Smith, 1980). 14.5 mln. carats of diamonds were mined during its exploitation. Diamond mining is still active in South Africa, but located in other territories and depths. Thus, studies of diamonds from historical mines and ones that are still operational at larger depths are useful to compare diamond characteristics from various deposits and trace change in their properties with depth.

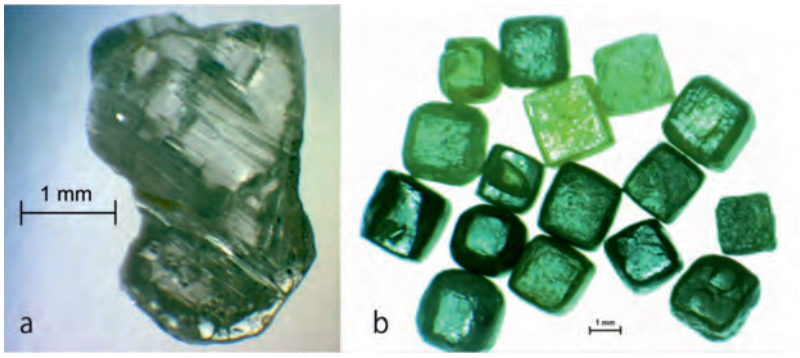



*Fig. 1. Diamonds from South Africa: a — fragment, sample FMM #3; b — cubs of II, II and IV variety; sample FMM #64771. Donor: Ministry of Finance of the USSR.*

South African crystals from the collection have various morphology: octahedral, cubical, combination forms, fragments and other. There are many colored stones and often are as large as around 1 carat and bigger. So-called "coated diamonds" (or diamond in diamond — *translator*) need to be mentioned as they are well presented in the collection. They belong to the IV variety according to Yu.L. Orlov classification. Referring of any diamond to a variety marked with Latinic digits in the article below was done according to this classification. "Coated" crystals represent octahedrons and cubes with dominating cubes (Fig. 1). The sample on the figure 1a is a flat fragment of indefinite shape weighed 0.4 ct. It is colorless, transparent with small dark inclusions. It fits to the variety I. Glide lines are well defined in one direction on the whole surface. South African cubic crystals of 3.48 ct total mass are shown on figure 1b demonstrating II, III and IV varieties. All of them are characterized with substantial degree of dissolution and slightly distorted shape. The crystals classify by the color into yellow, grey, black and crystals with yellow and green tint. All the cubes are dull due to the rough surface sculpture, so inclusions cannot be observed. Yellow and yellow-green specimens have etch channels on the surface.

The museums main fund is replenished from various sources. Most part of samples comes from scientific expeditions, from exchange with private people and organizations and from donations. The museum management always considered acquisition of private collections that have high historical, scientific and cultural value as a very important method to expand funds.

Academicians V.I. Vernadsky and A.E. Fersman and also the museum associate and later director of the museum V.I. Kryzhanovsky made significant contribution to the museums replenishing. Unique collection of prince Petr Arkadyevich Kochubey (1825—1892) was purchased hundred years ago, in 1913 on the initiative of Vernadsky and Fersman. The collection contained 2700 samples of minerals from Russian and foreign deposits, including fine assortment of diamond crystals from Brazil and South Africa.

The museum purchased a big mineral collection from Ilya Nikolayevich Kryzhanovsky in 1912. The gathering contained placer diamonds from Bobrovka River near Nizhniy Tagil in the Middle part of the Ural (sample FMM #22911). Those samples of museum funds were assigned to the diamond collection in 1927.

I.P. Balashovs' collection containing Brazilian diamonds was acquired with A.E. Fersman involvement in 1919.

Discoveries of numerous diamond placers mostly in Africa were made in 1920s (Kharkiv *et al.,* 1997). The largest coastal marine placers in Namibia have the highest grades of gem grade diamonds. Namibian diamonds in the collection are small (lighter than 0.3 ct) and most of them are fragments of greenish-yellow crystals with well-defined surface sculpture and dark inclusions (Fig. 2). Greenish-yellow 0.17 ct crystal of complex shape is shown on figure 2a. This diamond has medium resorption degree. One side of the sample has "lollypop" surface sculpture, which shows mechanic abrasion in the coastal zone (Posukhova, 2003). The crystal is transparent with dark inclusions. Fragment of combination shape (octahedroid) 0.26 ct crystal is shown in figure 2b. It has yellow color with smooth polished surface and deep etch channels and a negative cavern. The whole crystal is cut with dark and light fractures.

Active exploration for bedrock diamond deposits started in Siberia in 1930—40s. V.I. Vernadsky was the first who predicted possibility of kimberlite discovery in Siberia region. He recommended revising of diamond prospects

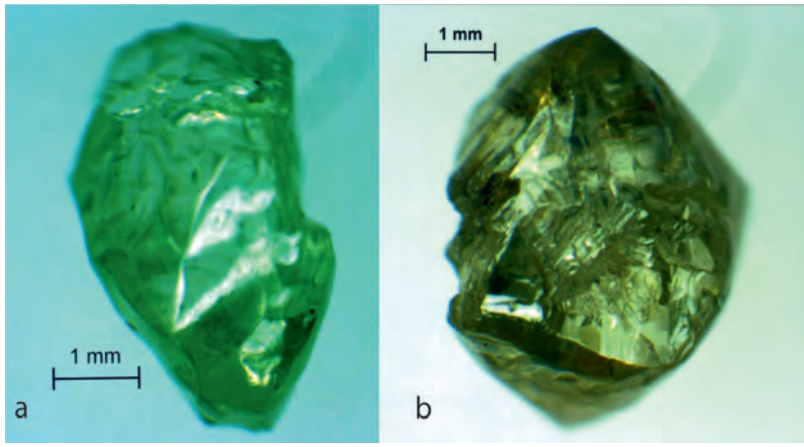



*Fig. 2. Placer diamonds from Namibia: a — fragment with "lollipop" sculpture, sample FMM #999 (A.E. Fersman); b — octahedroid fragment, sample FMM #1054. (A.E. Fersman).*

of the Russia's North according to results of new studies of South African deposits as early as in 1914. Diamond crystal (FMM #37711) found in the vicinity of Melnichnaya River near Eniseysk in 1897 came to the collection in 1938. It is established fact that this sample was the first diamond fount in Eastern Siberia. Vera Arsenyevna Balandina (1871—1943), a known educator, scientist and public person of her time gifted this sample to the museum.

Irkutsk Geological Survey carried out exploration in the north of Irkutsk Region, in Krasnoyarsk Territory and Yakutia. Diamond expedition of All-Union Geological Institute (VSEGEI, in Leningrad) explored foothills of Sayan Mountains. The predictions for diamond discoveries in Siberia in that period were based on geological and structural similarity with largest diamondiferous region of South Africa. Diamonds were actually found soon in terrace and riverbed sediments of Nizhnyaya Tunguska tributaries and middle reach of Angara river. Diamonds were subsequently discovered in sediments of Vilyuy and Malaya Botuobiya rivers. Those findings pointed to presence of a large diamondiferous province in Eastern Siberia.

The collection replenishes not only with Siberian diamonds during this period. The State Research Institute of Mining and Chemical Resources (GIGKhS) presented diamonds from Brazil (Minas Gerais, Diamantina, Villa Rica) and South Africa. State Archives of Ministry of Internal Affairs of the USSR gifted a collection of placer diamonds from Urals.

Part of the diamond collection was received from private donors. O.M. Shikhova passed diamonds from SAR in 1938. N.V. Kazakova donated diamonds also from South Africa in 1940. V.Ya. Burdakov handed over diamonds from Zhuravlik River area in the Middle Urals in 1941.


*Fig. 3. Places of discoveries of some diamonds from the Ural mountains in the collection of Fersman Mineralogical Museum:*
*1 — Bobrovka river, Nizhniy Tagil, Middle Ural mountains, sample FMM #22911 (I.N. Kryzhanovskiy);*
*2 — Zhuravlik river, the Is river tributary, Ural mountains, sample FMM #43171 (V.Ya. Burdakov);*
*3 — Krestovozdvizhensky mines to northeast of Bisersk, the Middle Urals, sample FMM #25684 (P.V. Eremeev).*

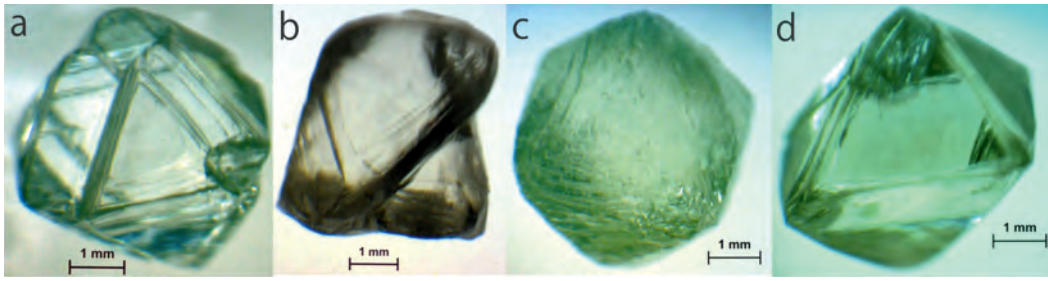



*Fig. 4. Diamonds from Ayhal pipe, Yakutiya: a, c, d – octahedra with various resorption degree, sample FMM ##64723, 64726, 64725 accordingly; b – intergrowth of two crystals, sample FMM #64724. Donor: Ministry of Finance of the USSR.*

Localities of placer diamonds from the Urals in the collection of the museum are marked on a map on figure 3.

Center of diamond exploration in our country moved to Yakutiya in 1950s. The work advanced with a great success very soon in 1953 when pipes Zarnitsa (1954), Mir (1955) and Udachnaya (1955) were discovered in very short period of time. These pipes are currently the biggest operating deposits in the country (Kharkiv *et al.*, 1997).

Russia has the worlds biggest proven diamond reserves as a result of big exploration efforts. The major diamondiferous territories are Yakutiya and Arkhangelsk region. Yakutiya diamond province has about 1000 known kimberlite pipes, 150 of which are diamond bearing and 20 are economical. Arkhangelsk deposits are now in mine developing stage. M.V. Lomonosov deposit is in pilot production since 2000. Industrial operations of diamond placers in Perm Region in the Urals started in 1955, but showed very high operation costs per carat exceeding by several times Yakutiyan diamonds.

Diamond exploration and mining boom in Eastern Siberia gave start to growth of the museums funds. Large amount of diamonds from Russian deposits came to the museum in the second half of the 20$^{th}$ century. Diamonds from Aykhal, Mir and Udachnaya pipes bedrock deposits in Yakutiya compose the main part of the collection. The crystals are mostly octahedral in shape with insignificant resorption. The diamonds have high color and clarity characteristics and there are some of lower quality including brown, black and crystals with inclusions (Fig. 4, 5).

Samples from Aykhal pipe are shown on figure 4. One of them is colorless gem quality octahedral crystal of I variety (Fig. 4a). The crystal weighs 0.36 ct and has sharp steps on its faces and deep negative apexes at fourfold crystal axes. Sharp stepped surface of the faces makes difficult observation of internal structure of the crystal. Only one dark inclusion can be spotted. Colorless 0.14 ct spinel twin crystal with slight brownish tone from a thin color coat of unclear origin on the surface is depicted on figure 4b. The crystal has flat-rounded faces with medium signs of resorption. One small light inclusion is observed. Figure 4c demonstrates a 0.58 ct crystal of I variety with yellow hue. It has combination shape with dodecahedroid faces originated from stepped growth. The crystal is strongly resorbed and the faces are covered with etched trigons pits. The surface sculpture hides from view the internal structure of the diamond. Colorless 0.51 ct octahedron with brownish hue and no inclusions on figure 4d belongs to I category. Medium degree of resorption, small microlayers, etch trigons and a channel are present of the faces. Fractures are observed near tip.

Samples from Mir pipe are shown on figure 5. All of them belong to the I variety. Transparent 0.12 ct octahedron with yellowish tone and no inclusions is shown on figure 5a. The faces are flat and fully covered with pattern of small trigon etch pits that dull the crystal. Colorless 0.17 ct spinel twin crystal is shown on Fig. 5b. It is transparent and has characteristic twin seam. Small brownish diamond grown on one face of the twin. Rounded stepped 0.3 ct octahedron with little resorption is shown on figure 5c. There is significant size smaller diamond grown on an apex. Micro layers and pits are well observed on the faces of the crystal. Many black inclusions are seen and a tension zone manifested with rainbow.

Collection has also placer diamonds from Prilenskaya region in Yakutya (Motorchuna, Molodo, Irelyakh rivers). These crystals are dodecahedroids, rounded octahedrons, fragments and intergrowths. Their outlook and surface morphology are different from placer diamonds from the Urals. The last ones have characteristic shape thet allowed to distin-

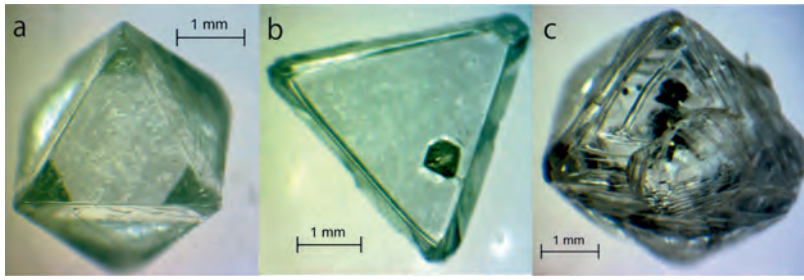



*Fig. 5. Diamonds from Mir pipe, Yakutiya: a — flattened octahedron, sample FMM #74398; b — flattened spinel twin crystal with intergrown crystal, sample FMM #74398, c — rounded stepped octahedron with intergrown crystal, sample FMM #74398. Donor: Centrakademsnab.*

guish a specific "Ural type dodecahedroid" which is dodecahedron with smooth faces presenting a final resorption shape (Palyanov, 1997).

Diamonds in Yakutiya placer showings are usually rounded crystals with convex crystal faces and rarely have flat surfaces. They also are larger and rounded, have rough sculpture with signs of mechanical attrition typical for placer diamonds. Surface features make the stones dull and do not allow observation of their internal structure. Placer diamonds of "Urals type" from Yakutiya are shown on figure 6 (a, b) and have residual (etch — *transl.*) relief pattern on the surface.

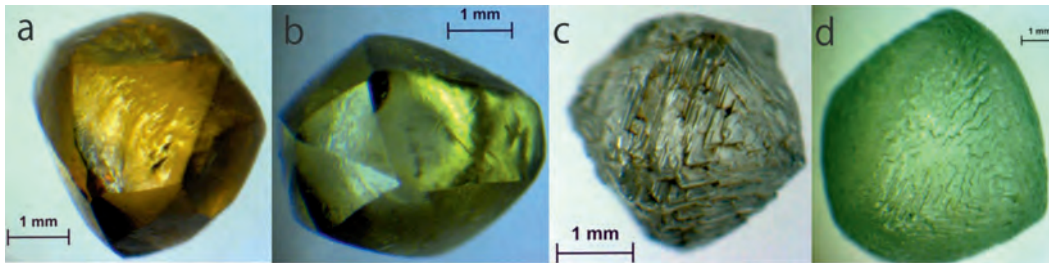
Figure 6a illustrates large 0.23 ct single dodecahedroid crystal of saturated yellow-brown color. Droplet shaped surface relief and intensive color assigns it to the II category. The crystal is semi-transparent due to surface roughness. Similar 0.07 ct dodecahedroid is documented on figure 6b. It is also yellow but less intensive with cool greenish tint, has no inclusions and was classified as I variety. Colorless 0.15 ct octahedral crystal with polynucleation facet growth is shown on figure 6c. The crystal has well defined stepped facet surface with ferrous stains on the surface features visible with stereoscope. Colorless 1.03 ct dodecahedroid with rough relief and tegular etch texture. Resorption degree of the crystal is high and thus internal features cannot be observed.

The short description of bedrock and placer diamonds of two genetic types: of Yakutiya and the Urals diamondiferous provinces from the museum collection gives an idea on morphologic features of the crystals.

Two sources of the museum collection replenishing were mentioned above. The government and various organizations: Yakutalmaz, Centracademnab, Gokhran, Institute of Experimental Mineralogy (IEM RAN) played a big role donating significant amount of samples to the museums funds. Some diamonds were received from private collections of research mineralogists: A.A. Arsenyev (samples FMM ##57215 −57218), M.E. Yakovleva (FMM ##62181 −62184), V.I. Stepanov (sample FMM #87470), E.M. Spiridonov (sample FMM #92005).

Yury Leonidovich Orlov (1926−1980), the most prominent expert in diamond mineralogy, made exclusively significant contribution to the collection. He gathered unique field specimens of the Urals diamonds as early as in 1953. He was hired as a junior researcher at the Fersman Mineralogical Museum in 1956 and continued studying diamonds, then he became the director of the museum in 1976 (Pavlova, 2011). He investigated immense amount of crystals from placers in republics of Soviet Union, South Africa, Kongo, Brazil, bedrock deposits of Yakutiya and other countries. The museums collection of diamonds and precious stones increased greatly by the efforts of Yu.L. Orlov.

*Fig. 6. Placer diamonds from Russia: a, b — dodecahedron of the Ural type, Yakutiya, Molodo River, sample FMM #74404 (Donor: Centrakademsnab); c — octahedron with polynucleation character of facet growth and sharp stepping, Yakutiya, Motorchuna River, sample FMM #74405. Donor: Centrakademsnab; d — spongy dodecahedroid of Yakutian type, the Urals, sample FMM #64776. Donor: Ministry of Finance of the USSR.*



Orlov's main interests were associated with diamond genesis and morphology. Yuriy Leonidovich had opportunity to collect samples from industrial concentrators and had most typical samples in the museums collection, which became the basis of his famous genetic classification. Every variety in the classification has its own typical features: forms of growth, mechanism of facet growth, color, visual transparency and other physical properties of the mineral such as light absorption in IR, visible and UV spectral range, luminescence in UV light, presence of typical color centers. All these features reflect conditions of diamond formation. Total of 11 varieties were determined and can be categorized into two groups: singular crystals – from I to V variety and polycrystalline aggregates – from VI to X variety. XI variety was distinguished separately and includes impact diamonds.

Orlovs's classification was the first well thought-out genetic diamond classification. All diamond experts in Russia use it. It is important to mention that discovery of new deposits reveals new genetic types of crystals which is hard to fit into a definite variety. Origin of diamonds of some varieties is questionable, for example V variety (Afanas'ev, 2000; Solodova *et al.,* 2008; Kriulina, 2012). Disparity between modern observations and limitations of varieties the classification surfaced nowadays. The cause of it, without going into scientific details, lays in the development of instrumental methods of mineralogical studies from 1970s when the classification was created and methods of modern micro mineralogy utilizing electron microscopy and microprobe analysis, Raman spectroscopy, methods local trace element composition and so forth. Contemporary research methods can be used to solve questionable issues and also support introduction of new genetic types developing Orlov's classification.

Description of morphological features of crystals from bedrock and placer deposits from various regions of the world, history of their exploration and information about people offered samples to the museum give an idea on the content of diamond collection of the Fersman Mineralogical Museum, its scientific and historic value.

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