# INTRODUCTION. ON THE HISTORY OF STUDY AND OPERATION OF THE VISHNEVYE MOUNTAINS MINERAL DEPOSITS


1. Geographical location of the Vishnevye Mountains.

**All specimens: Vishnevye Mountains, Vishnevogorskiy Massif, Kasli District, Chelyabinsk oblast, South Urals, Russia**

The Vishnevye Mountains (Vishnevye Gory Mountains), are situated at the eastern slope of the South Urals in the Kasli district, Chelyabinsk oblast, Russia (*Fig.* 1) 100 km NW of the town of Chelyabinsk and 18 km E of the Mauk station of the South Ural Railway.

This is a submeridional ridge approximately 15 km long and up to 4 km in width. The not very high mountains Mokhnataya, Karavay, Dolgaya, Vishennaya (Kobeleva, Kobelikha), Valezhnaya, Kurochkina, and Eremina are identified within the ridge from north to south. The Vishnevye Mountains (previously Vishennye) were named after the cherry bushes on Mt. Vishennaya as specified by Narkiz K. Chupin in his work (Chupin, 1873). The Vishnevye Mountains are separated from the Potaniny Mountains by the Mauk River Valley and the Kasli-Mauk road in the south and are bounded by depressions on the north, west and east. The urban-type settlement of Vishnevogorsk is situated in the northern part of the Vishnevye Mountains.

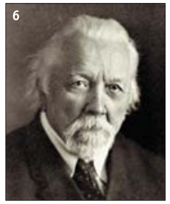
The Vishnevye Mountains are known for the discovery and exploitation of gold and zircon placers in the Bolshoi Mauk River and Gorkaya River valleys and with regard to the basement rocks, for the production of feldspar and zircon and especially mining of the Vishnevye Mountains niobium deposit.

The district geology, age relationships of rocks, petrography, localization, structure, and mineralogy of pegmatite bodies, carbonatites, and late hydrothermal and supergene assemblages are described in many publications.

2. View of the Vishnevye Mountains from the east. Photo: A.M. Kuznetsov.

3. Operated open pit at Mts. Dolgaya and Kobeleva. Photo: M.S. Zorin (Ekaterinburg).



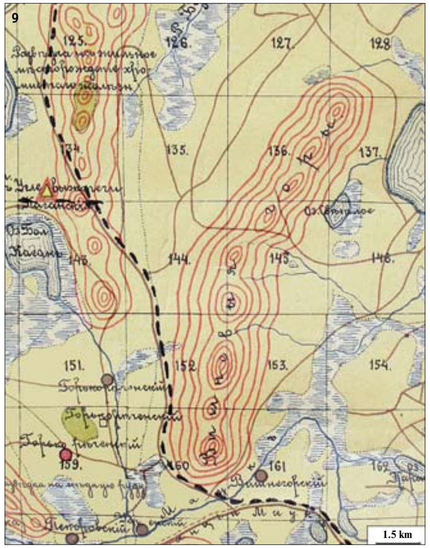


4–6. *Authors of the first publications about Vishnevye Mountains:*
4. Grigory Efimovich Shchurovsky.
5. Alexey Mikhailovich Zaitsev.
6. Alexander Petrovich Karpinsky.

7. Dmitry Stepanovich Belyankin, *discoverer of vishnevite.*

8. Vladimir Vasilievich Belov, *prospector of the Buldym vermiculite deposit.*

9. Fragment of geographical map of the Vishnevye Mountains with gold placer mines (brown circles) on the Mauk and Gorkaya Rivers (Zaitsev, 1884). Scale by V.I. Popova.




## Poetics of the first discoveries

Large zircon crystals from the Mauk River placer were mentioned for the first time by Grigory E. Shchurovsky in 1841 in his book "*Ural Range in Regard to Physiography, Geognosy, and Mineralogy*". Alexey M. Zaitsev (1884) complemented his "*Geological Essay of the Kyshtym and Kasli Dachas in the Central Urals*" with a detailed map and noted "granite-gneiss" with zircon in the Vishnevye Mountains. Alexander P. Karpinsky (1891) named this rock as miaskite by its similarity to nepheline syenite of the Ilmeny Mountains and briefly described for the first time the Vishnevye Mountains miaskite and gave its chemical composition in "*Guidebook for the Ural field trip, 17 International Geological Congress, 1897*".

Over the next 15 years, brief notes on the district geology (Sushchinsky, 1900; Nikolaev, 1902) were published and the first mineral list of the Vishnevye Mountains was published by A.V. Nikolaev (1912), who noted findings of zircon, ilmenite, and hydrobiotite. Then, there was a break in geological study due to the First World War in 1914–1918, revolutions, and Civil war in Russia.

## Feldspar raw material

In 1926 in the district of the Kurochkin Log (*log is wide and long ravine*), P.I. Sviridov, a Kasli citizen, found nepheline-feldspar veins, which became a basis for the further study and industrial development of the Vishnevye Mountains minerals. In 1928–1929, a geological crew supervised by Alexander S. Amelandov explored two large pegmatite bodies, described feldspar and miaskite as a ceramic and glass raw material, and noted "pyrochlore group minerals" (Amelandov, 1929; 1931*a*, 1931b). In 1932, a geological crew (for rare-metal) supervised by Fedor I. Rukavishnikov drilled several boreholes and encountered pegmatite bodies down to the depth of 72 m (Rukavishnikov, Tomeev, 1933*ofr*). A new mineral named vishnevite was found in the pegmatite lower lens (Belyankin, 1931, 1944).

*ofr* means open file report


10. Stela at the south entrance to Vishnevogorsk. Photo: M.S. Zorin.
11. Settlement in the Chuprunov Log. Photo: A.M. Kuznetsov.

*Figs. 12–13 on page 7*
12. Beginning of the new settlement at the SE-foothill of Mt. Karavay (white dumps of vein no. 5 on the left on the mountain slope). Photo: A.M. Kuznetsov.
13. Ruins of the zircon "factory". Photo: M.S. Zorin.

The Feldspar open pit (Feldspar Quarry) developed pegmatite bodies stated to operate in 1932. That time, women-workers manually with hammers separated feldspar pieces from "useless" nepheline. After 1944, these open pits were closed.

These open pits and dumps attract attention of researchers and mineral collectors so far. In 1968, the plant started to produce nepheline-feldspar concentrate (as a by-product of pyrochlore concentrate) and since 1993, OAO *Vishnevogorsky GOK* has produced only feldspar raw material for the vacuum, ceramic, electrode, and glass industry covering about 65% of market demands in Russia (Mostinets *et al.*, 2003). During a year, the Feldspar open pit (currently named as *Nadezhda*) at Mt. Dolgaya; (*Fig.* 3) produces 1.2 Mt of ore mass; after processing, 600 kt of nepheline-feldspar concentrate are shipped to customers (http://www.disclosure.ru/issuer/7409000147). The proved reserves of this raw material are sufficient for the 40-year operation of the enterprise under current mining and processing productivity.

## Vishnevye Mountains vermiculite

The petrographic map of the Vishnevye Mountains of 1:50000 scale was compiled for the first time in 1928 by Belyankin, and Sokolov, but they published only the map description (Belyankin, Sokolov, 1933). During geological survey in 1926–27, they examined part of the Buldym serpentinite massif with vermiculite occurrences while the deposit itself was studied later (Belov, 1936*ofr*; Amelandov and Ozerov, 1934).

Eleven vein-like vermiculite bodies were identified at the deposit and V.V. Belov (*Fig.* 8) in his manuscript of 1936 proved vermiculite suitability for technical purposes. In July 1943, the Mine for vermiculite was organized. The first barracks[1] for workers were built (mine administration was in the town of Kasli) and the settlement of Vermiculite was formed at the foot of Mt. Karavay. This settlement was named soon Rudnik (Mine) and in 1949, it became the urban-type settlement named Vishnevogorsk (*Figs.* 10–12).

In 1944, a processing plant was built on the vermiculite open pit and later the Vermiculite pit. Two near-parallel sublatitudinal ore bodies (nos. 1 and 2) 650 m long and from 0.5 to 25 m thick were the largest; other bodies were up to 30 m long along strike and up to 1–5 m thick. The highest quality vermiculite was present down to the depth of 6–7 m and the largest plates up to 40–50 cm (occasionally up to 1–1.5 m) were manually mined. More than 170 thousand cubic meters (about 350 kt) of vermiculite were produced during the exploitation of the deposit; Vladimir S. Samkov noted that noise- and thermal-insulation material in Russia was produced only at this deposit until 1956; in the early 1960s it was completely exhausted (Levin *et al.*, 1997).

## Zircon "boom"

Amelandov (1929) and Rukavishnikov and Tomeev (1933*ofr*)) studied the nepheline-feldspar pegmatites at Mt. Karavay found by prospectors in 1926. Researchers documented three veins (later generalized to be described as a single vein, the no. 5) with large crystals of ilmenite (up to 0.5 m), zircon (up to 10 cm), pyrochlore (up to 3.5 cm), and apatite (up to 20 cm). Ilarion I. Shafranovsky (1933) and Ekaterina E. Kostyleva (Kostyleva, Vladimirova, 1934) described the morphology and chemical composition of the local zircon for the first time. In 1937–39, a geological crew of the Institute of Geology and

1) barracks is a lightly constructed wooden building intended for temporary housing



Geochemistry, Ural Branch, Academy of Sciences of the USSR supervised by Mikhail G. Isakov, explored vein no. 5 for zircon and pyrochlore by trench and three adits (Isakov, 1940*ofr*, 1942*ofr*) and zircon placers along western slope of the Vishnevye Mountains.

Small integrated mining and processing facilities (factories) were built almost at each placer, producing zircon (*Fig.* 13); ruins of their basements or buildings are found in the forest. A zircon processing and finishing plant was at the western shores of the Svetloe Lake nearly in front of Kurochkin Log. In 1961, we (Vladimir A. Popov, Valentina I. Popova (Poroshina), and classmates) as students of the Sverdlovsk Mining Institute could observed the ruins of the basement of this plant and abundant zircon specimens in the retained dump, but the best zircon crystals were found in vein no. 5 (*Fig.* 13).

In 1940–50s, E.M. Bonshtedt, I.B. Borovsky, E.Z. Bur'yanova, M.A. Bukhman, G.N. Vertushkov, K.I. Viscont, M.E. Vladimirova, O.A. Vorobiova, A.V. Vtorushin, A.I. Zhilin, A.A. Ivanov, E.S. Iovchev, E.E. Kostyleva, V.S. Krasulin, S.M. Kurbatov, L.N. Ovchinnikov, A.K. Podnogin, V.I. Pyatnov, S.S. Slavinsky, Yu.M. Tolmachev, A.N. Filippov, V.V. Shcherbina, N.A. Yarosh, and other researchers studied the geology and mineralogy of the Vishnevye Mountains.

M.G. Isakov explored zircon veins and placers (*Fig.* 22); E.M. Bonshtedt-Kupletskaya (1951) (*Fig.* 23) generalized mineralogical information about alkaline pegmatites on the basis of her study in 1943–1947. In that monograph, pegmatites of Kurochkin Log, Mts. Eremina and Karavay, Chuprunov Log, vein no. 35 at Mt. Dolgaya, and some veins close to the Buldym Lake were described; 45 minerals were reported from these areas.

This book is still highly valuable for specialists.

## Ural niobium

Pyrochlore observed in nepheline-feldspar pegmatites of Kurochkin Log (Amelandov, 1929, 1931a,b) and Mt. Karavay (Rukavishnikov, Tomeev, 1933*ofr*; Shafranovsky, 1933) generated interest as a niobium source. During 1937–40, approximately 80 pyrochlore-bearing pegmatite veins were found, thirty of which were explored (Isakov, 1940*ofr*).

In 1941, the Vishnevogorsk Exploration Crew of *Uraltsvetmetrazvedka* Trust supervised by M.G. Isakov was organized and artisanal mining of pegmatite was started.

In 1941–44, a thematic crew supervised by Arkady A. Ivanov from the Mining and Geological Institute, Ural Branch of the AS USSR evaluated pegmatites for pyrochlore and niobium; several pyrochlore varieties were identified and minor Nb was measured in ilmenite, titanite, and zircon (Ivanov *et al.*, 1944*a*, 1944*b*).

In 1942, on the basis of proven pyrochlore reserves in vein nos. 29, 30, 36, 37, and some others, the Vishnevogorsk Mine Group was organized for niobium ores production; at the first by artisans, who provided 82% of production in 1948 and 1949, but the proportion of the state production soon reached 31.8 % (Isakov *et al.*, 1950*ofr*). In 1950, the artisanal pyrochlore production was completed because the Vishnevogorsk Mine Group started mechanical mining of pyrochlore ores and the Korennaya processing plant in the lower Chupronov Log was organized.

In 1951, the Vishnevogorsk Crew found zone no. 140 of about 1770 m long along strike , which was a series of pyrochlore-bearing silicate-carbonate veinlets in miaskite of the Sedlovidnaya body between Glavny (Main) miaskite and Buldym ultramafic massifs. Zone no. 140 was accessed by the Glavny open pit and since 1967, by the Kapitalnaya underground Mine down to the

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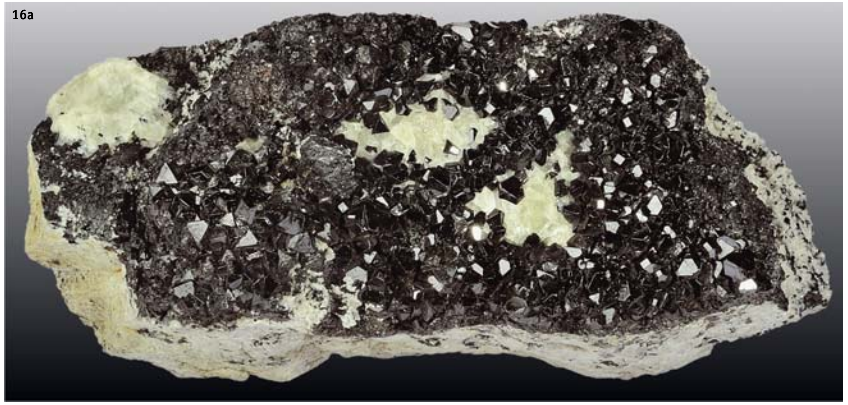

16b


14. **Zircon** (3.5 x 2.7 cm) with pyrochlore in microcline. Vein no. 5, Mt. Karavay. Specimen: I.V. Pekov.

15. **Chevkinite-(Ce)**. 1.8 x 1.1 cm. Specimen: I.V. Pekov.

**Photo 14, 15, 17–21: M.B. Leybov.**

16. **Pyrochlore**. Width about 40 cm. Specimen from mineral collection, Pierre and Marie Curie University, Paris, France. Photo was provided by Dr. Jean-Claude Boulliard, collection curator. (a) general view, (b) fragment.



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17. **Fluorite**, crystal fragment. 4 x 2.4 cm. Kapitalnaya Mine. Specimen: I.V. Pekov.

18. **Titanite** (crystal 5 x 2.5 cm). 8 x 8 cm. Svistunov Log. Natural Science Museum, Ilmeny State Reserve, #5997.

19. **Aegirine-augite** (crystal 3.5 x 2.8 cm) with feldspar, calcite, and quartz. 9 x 5 cm. Vein no. 125. Specimen: Ural Geological Museum, Ural State Mining University, #48325.

20. **Zircon** concentrate. Field of view: 14.5 x 11.5 cm. Specimen: Ural Geological Museum, Ural State Mining University.

21. **Ilmenite**, druse. 15 x 10 cm. Specimen: Ural Geological Museum, Ural State Mining University.

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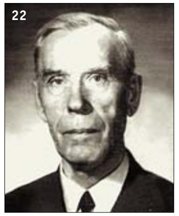



22. Mikhail Grigorievich Isakov, *prospector of zircon veins and placers of the Vishnevye Mountains.*
23. Elsa Maksimilianovna Bonshtedt-Kupletskaya, *a researcher of mineralogy of the Vishnevye Mountains pegmatites.*

24–26. *Researchers of the Vishnevye Mountains deposit mineralogy:*
24. Boris Valentinovich Chesnokov.
25. Evdokiya Mikhailovna Es'kova.
26. Arkady Grigorievich Zhabin.

depth of 500 m (*Figs*. 29–30). The processing plant produced pyrochlore concentrate from the ores of this zone and pyrochlore and nepheline-feldspar concentrates since 1968.

In 1953, Boris V. Chesnokov, geologist of the Vishnevogorsk Crew and Vasily D. Vodop'yanov, mine surveyor (who soon became a chief geologist of the Vishnevogorsk Mine Group) discovered the largest ore zone (later no. 147) about 20 km long along western and eastern contacts of the Glavny miaskite massif and followed it toward south in the Potaniny Mts. Pyrochlore mineralization in zone no. 147 occurs as veinlet net with predominant feldspars and nepheline; near the massif contact, the veinlet net becomes denser with increasing carbonate proportion, mainly calcite. In the contact zone of miaskites and phengites, the rocks are brecciated and cemented by calcite with fine pyrochlore. Due to refractoriness, the zone no. 147 ores were not mined further. Other zones were partly operated and then were mothballed.

During 1956–63, the Institute of Mineralogy, Geochemistry, Crystal Chemistry of Rare Elements (IMGRE, Moscow) continued to study alkaline rocks, stages of mineral formation, location of known and newly found rare-metal minerals and their paragenetic assemblages, and distribution of rare elements in the Vishnevogorskiy alkaline massif. Evdokiya M. Es'kova, Arkady G. Zhabin, and German N. Mukhitdinov completed a comprehensive body of work; E.B. Khalezova, V.A. Khvostova, and local geologists V.F. Antonov. N.E. Vlasko-Vlasenko, N.G. Klimov, A.A. Samoilov, and Yu.P. Zubov also participated in this study (Es'kova *et al.*, 1964). B.V. Chesnokov (1961*a*, 1961*b*, 1963), E.Z. Bur'yanova and P.V. Kalinin (1964), M.E. Kazakova, N.S. Samsonova, and N.V. Svyazhin (1966) continued to study some minerals. Slavinsky with colleagues (Slavinsky *et al.*, 1957*ofr*) evaluated geological and technological perspectives of the Vishnevye Mountains niobium deposit.

In the late 1950s, a thematic crew of the All-Union Geological Institute in Leningrad (Russian Geological Research Institute (VSEGEI)) tried to prove the metasomatic origin of alkaline rocks of the Vishnevogorskiy massif which was confirmed for the fenites later. In the same years, the researchers from the Moscow Institute for Geological Prospecting (MGRI) investigated the geology, mineralogy, and geochemistry of rare metal mineralization of the Vishnevogorskiy alkaline massif. During nearly 30 years, geological mapping combined with the study of pegmatites and pyrochlore-carbonate ores was carried out first under the supervision of Pavel V. Kalinin and then of Boris M. Ronenson (Ilmenev, 1958; Dobrokhotova, 1969; Kalinin, 1964; Ronenson, 1959, 1966; Ronenson *et al.*, 1995). Problems of miaskite genesis were also discussed taking into account isotope data (Kononova *et al.*, 1979). Viktor Y. Levin with colleagues and in collaboration with Ronenson's group, geologists of the Vishnevye Mountains Industrial Complex, Central Geological Expedition (N.G. Klimov and other), and Exploration Crew studied petrology and mineralization of the Vishnevogorskiy miaskite massif; the main results are published in the monographs "*Alkaline Province of the Ilmeny-Vishnevogorskiy Complex*" (Levin, 1974) and "*Alkaline-Carbonatite Complexes of the Urals*" (Levin *et al.*, 1997).

27. View from Mt. Karavay to the processing plant in the lower reach of Chuprunov Log and the Sungul Lake. Photo: A.M. Kuznetsov.

*Photos 29–30 on page 11*
29. Kapitalnaya Mine.
Photo: M.S. Zorin.

30. Administrative building of the Kapitalnaya Mine. Photo: A.M. Kuznetsov.



28. Researchers of geology, petrology, and ores of the Vishnevye Mountains *(left to right):*
Nikolai Grigorievich Klimov, Boris Mikhailovich Ronenson, Viktor Yakovlevich Levin, and Irina Leonidovna Nedosekova.

From the mid 1970s, the Chelyabinsk Expedition of the *Uralgeologiya* Production Geological Association surveyed in depth the Ilmeny-Vishnevye Mountains Complex: a geological map on a scale of 1 : 50000 of this complex was compiled; a new stratigraphic scheme was developed; new granitoid types were identified in the Urals; and much data on mineralogy and chemistry of the rock complexes were obtained (Yuretsky *et al.*, 1982*ofr*); M.M. Novikova carried out mineralogical and petrographic study of the mineralization.

From the 1980s, a group from the Ilmeny State Reserve and later from the Institute of Mineralogy and Institute of Geology and Geochemistry, Ural Branch RAS studied the northern part of the Vishnevye Mountains (Nikandrov, 1983; Chesnokov *et al.*, 1982, 1984; Popov *et al.*, 1986; Nikandrov, Makagonov, 1988; Nedosekova, 1993; Nedosekova, Murzin, 2007; Nedosekova *et al.*, 2009, 2012, 2014, 2016, 2019). Various types of mineralization were studied in mines of the Kapitalnaya underground Mine (Nikandrov, 1987, 1988*a*, 1988*b*), in the cores from some structure boreholes (E.P. Makagonov, V.A. Popov, T.P. Nishanbaev, V.I. Popova), and in the open pit at Mt. Dolgaya (Popova *et al.*, 2003). A list (Inventory) of minerals of the Vishnevye and Potaniny Mountains identified to the end of 20th century was published (Kobyashev *et al.*, 1998) as well as new data on minerals and rocks of the Vishnevye Mountains (Pekov *et al.*, 1996; Popov *et al.*, 2016; Popov, Nishanbaev, 1993, 2008, 2010; Makagonov, Muftakhov, 2016; Popova *et al.*, 2003*a*, 2015, 2018, 2019*a-c*, 2020).


31. Authors (left to right):
Valentina Ivanovna Popova,
Vladimir Anatolievich Popov,
Eugene Pavlovich Makagonov,
Sergey Nikolaevich Nikandrov,
Anatoly Vitalievich Kasatkin,
and Alexey Mikhailovich Kuznetsov.

The rocks of the Vishnevogorskiy miaskite-carbonatite massif were considered to be crystallization products of fluid-saturated alkaline magmas (Nedosekova *et al.*, 2009; Nedosekova, Pribavkin, 2014); the composition and relationships of rock-forming minerals from carbonatite veins and veinlets (Popov *et al.*, 2015) and cancrinite-sodalite pegmatites (Nishanbaev *et al.*, 2016) were described; syntactic intergrowths of silicates in alkaline pegmatites are characterized (Popov *et al.*, 2016); and some other issues of structure and mineralogy of the rocks and pegmatites were elaborated.

Over the years we studied and started targeted mineralogical study of alkaline pegmatites, vein carbonatites, carbonatite-pegmatites, and late hydrothermal and supergene associations in 1980. To date, 234 minerals (including 85 minerals which we identified for the first time in this alkaline massif) are found in veins of the Vishnevye Mountains. They are characterized to varying degree in publications of various researchers, including our papers. The material for the description of the minerals and their relationships given in this studies were largely collected and investigated by us (*Fig.* 31).

In our work we used mineral and rock samples from collections of Alexander V. Donskov, Boris V. Chesnokov, Svyatoslav Y. Kryukov, Sergey G. Epanchintsev, Tursyn P. Nishanbaev, and Oleg B. Ustinov, and samples kindly donated us for investigation by geologists Vladimir F. Kurkin, Vitaly G. Markov, Alexander S. Midri, Anatoly G. Menshikov, and Nadezhda M. Nekrasova. Electron microprobe study was performed using scanning electron microscopes Tescan Vega 3 equipped with EDS (analysts Ivan A. Blinov and Mikhail A. Rassomakhin) and REMMA-202M (analyst Vasily Al.h Kotlyarov) at the Institute of Mineralogy Ural Branch RAS (since 2020, Institute of Mineralogy, division of the South Urals Federal Research Center of Mineralogy and Geo-ecology of the Urals Branch of the RAS) and CamScan 4D (analyst A.V. Kasatkin) at the Fersman Mineralogical Museum (Moscow), as well as, a Cameca SX-100 electron microprobe at the Masaryk University, Brno, Czechia (analysts Radek Škoda and A.V. Kasatkin). The powder X-ray diffraction patterns of minerals were obtained using an RKD-57.3 camera and DRON-2.0 diffractometer (analysts Vladimir F. Zhdanov and Pavel V. Khvorov, Ilmeny State Reserve and Institute of Mineralogy of the South Urals Federal Research Center of Mineralogy and Geo-ecology of the Urals Branch of the RAS, Miass and Sergey G. Sustavov, Ural State Mining University, Ekaterinburg); the single crystal X-ray studies were carried out by Fabrizio Nestola, Padova, Italy and Anatoly V. Kasatkin, Moscow.

The administration of the *Vishnevye Mountains Industrial Complex*, and *Exploration Crew*, Vyacheslav E. Akhlyustin (geologist of the Vishnevye Mountains Exploration Crew and Chief geologist of the Vishnevye Mountains Industrial Complex,) and Alexander A. Sviridov (*Chelyabinsknedra*) assisted in preparation of material on the history of the prospecting of the Vishnevye Mountains in various years.

We are cordially grateful to all these persons.