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Strontianite from the Korkodinskoye deposit of jewelery andradite (Middle Urals)

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Abstract

The relevance of the work is due to the need to study the mineralogy of the Ural gems, in this case deposits of jewelry andradite (demantoid and topazolite).

The purpose of the work – description and detailed instrumental study of strontianite from paragenesis with gem topazolite, which was established at the Korkodinskoye deposit.

Research methodology. Strontianite was studied at the Institute of Geology and Geochemistry named after academician A. N. Zavaritsky, Ural Branch of the Russian Academy of Sciences (Ekaterinburg), the Institute of Mineralogy of the Ural Branch of the Russian Academy of Sciences (Miass) and the Ural State Mining University (Ekaterinburg). For its study, the whole complex of modern research methods was used. Chemical, geochemical, X-ray and X-ray spectral studies were carried out, and the method of IR spectrometry was also used.

Results and conclusions. Carbonate was found in a fissure-vein zone in association with garnet (topazolite) among tectonized serpentinites at the Korkodinskoe deposit of gem andradite. According to the chemical composition, strontianite is extremely calcium. Crystal chemical formula of the carbonate: $(Sr_{0,48}Ca_{0,45}Ba_{0,04}Mg_{0,03})_{1,00}CO_3$. In terms of chemical composition, the carbonate of the Karkodinskoe deposit is very similar to the strontianite of the Buldymsky massif; apparently, this is a typochemical feature of all strontium carbonates from ultramafic bodies. For strontianite, the results of powder diffractometry and IR spectroscopy are given, which are very close to the reference data. Strontianite belongs to the post-garnet stage of mineral formation, and the source of strontium for carbonate was small bodies of quartz-plagioclase metasomatites occurring at the site. The results obtained do not agree with the latest model of the formation of the Korkodinsky ultramafic massif proposed by A. Yu. Kisin with co-authors. The discovery of strontianite in a fissure-vein zone with andradite (topazolite) is another evidence of the formation of demantoid-bearing bodies after the formation of gabbro and granitoid intrusions.

***Keywords*:** strontium, strontianite, serpentinites, quartz-plagioclase metasomatites, Korkodinsky massif, Middle Urals.

Introduction

Strontium is a chemical element uncharacteristic for rocks of ultramafic composition. From this, the finds of strontium minerals in ultramafic rocks deserve special attention. In the mid-80s of the last century, strontianite was found in dolomite veinlets in serpentinites of the Buldymsky massif of the Vishnovyye Mountains. This finding of strontianite was explained by the processes of carbonatite formation [1]. In 2000, strontianite was discovered in the Korkodinsky ultramafic massif in the south of the Middle Urals. Here, strontium carbonate is encountered in a fissure-vein zone with andradite among serpentinites at the Korkodinskoye deposit of topazolites, demantoids, and chromandradites. This discovery of strontianite was explained by the fact that strontium carbonate is one of the earliest minerals in the multistage process of serpentinite carbonatization [2]. Complementing the previously obtained data on strontianite from the Korkodinskoe deposit with the results of the latest studies of the Korkodinsky andradites [3, 4], the chemical composition of the rocks of the massif and its environment contributes to solving the problem of the genesis of the demantoid deposit of the Korkodinsky massif, in particular, and the Ural deposits of demantoid and topazolites, in general.

Research methodology

Strontianite was studied at the Institute of Geology and Geochemistry named after academician A. N. Zavaritsky, Ural Branch of the Russian Academy of Sciences (Ekaterinburg), the Institute of Mineralogy of the Ural Branch of the Russian Academy of Sciences (Miass) and the Ural State Mining University (Ekaterinburg).

X-ray spectral analysis of the strontium content in quartz-plagioclase metasomatites was carried out using SRM-18 and VRA-30 instruments (IGG Ural Branch of the Russian Academy of Sciences, analysts: L. A. Tatarinova, V. P. Vlasov, G. S. Neupokoeva, L. V. Fomina, N. P. Gorbunova).

The chemical composition of strontianite was determined by the method of complete quantitative chemical analysis. Determination of the content of oxides of elements was carried out: SrO – by the atomic absorption method; BaO – by the gravimetric method, by precipitation of barium sulfate; CaO – titrametrically; K_2O and Na_2O – by the flame photomet-

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ric method; Fe_2O_3 – by atomic absorption, FeO – by the titrametric bichromate method; CO_2 – by the titrametric method (USMU, analyst N. V. Penkina).

Analysis of the content of rare and trace elements in strontianite was carried out by the ICP-MS method (IGG Ural Branch of the Russian Academy of Sciences, analyst D. V. Kiseleva).

The IR spectra of strontianite were measured on a Specord instrument (IM Ural Branch of the Russian Academy of Sciences, analyst V. Ya. Eremyashev).

The interplanar distances of strontianite were measured by the method of diffraction patterns on a DRON-2.0 device, Cu-radiation, 20 mA, 30 kV, V = 1 deg/min. (USMU, analyst N. G. Sapozhnikova).

Brief geological description of the Korkodinskoye deposit area. The Korkodinskoye deposit of jewelry andradites is confined to the southern part of the hypermafic massif of the same name. In the same massif, a little more than seven kilometers southwest of the Korkodinskoye deposit, is the famous Poldnevskoye demantoid deposit. The Korkodinsky massif belongs to the ophiolite formation and is part of the Serov-Mauksky belt of hypermafic massifs tracing the Serov-Mauksky and the Main Ural (MUR) faults. According to new data, the Korkodinsky massif lies along the host fault of the same name, which is part of the MUR zone. In terms of kinematics, the Korkodinsky massif corresponds to a regional left-hand transpressional fault, presumably of Late Paleozoic age [5]. The Korkodinsky massif is located in the junction zone of the Tagil and Magnitogorsk geosynclinal troughs.

The age of the massif is Middle-Late Devonian [6]. It has a block structure and an irregular shape elongated in the submeridional direction. Size of the massif: 12 km long, 0,5 to 4,5–5 km wide. In the vertical section, the massif is a tectonically shattered plate pushed over the phyllites of the Central Ural uplift. The thickness of the plate varies from 50 m to 200–300 m [5, 7]. The Korkodinsky massif is interpreted as a remnant of the Ufaleysky serpentinite massif [7]. The latter is located 1.5 km southeast of the southern end of the Korkodinsky massif.

The Korkodinsky massif is composed of dunites, pyroxene-bearing dunites, massive and veined clinopyroxenites, harzburgites, wehrlites, and websterites. It is noteworthy that relatively large bodies of fine and medium-grained clinopyroxenites in the marginal parts are transformed from medium- and coarse-grained to giant-grained clinopyroxenites with diallag separation (diallagites). Small in terms of clinopyroxenite bodies, their vein varieties are, as a rule, completely recrystallized into diallagites. The rocks are serpentinized to varying degrees up to the formation of lizardite-antigorite, chrysotile-lizardite, lizardite, antigorite, and magnetite-antigorite serpentinites. At the base and in the marginal parts of the massif, serpentinites pass into talc-carbonate rocks [6, 8]. Serpentinites are confined to local zones of shearing and intense fracturing (serpentinite melange) of submeridional strike. In such zones, earlier tectonic faults in serpentinites and clinopyroxenites with steep dips to the northwest, north, south, and southwest are cut off by later gentle thrusts dipping to the east-southeast. The age of gentle thrusts is Cretaceous [8].

The ultramafic rocks of the massif are in contact with rocks of basic and acidic compositions. At the same time, in the northern and middle parts of the massif, small bodies of amphibolized gabbro break through it. In the area of the Poldnevskoye primary deposit of demantoids, plagioclase metasomatites develop along amphibolized gabbro at the junction of blocks of the massif in zones of intense fracturing of sublatitudinal strike.

No gabbro was found in the southern part of the massif. However, small bodies of plagiogranites and granodiorites are mapped here at the contact with serpentinites and near them [6]. At the Korkodinskoye deposit, 100–150 m southeast of the fissure-vein zones with demantoids at the contact with the serpentinites of the massif, a small body of metasomatically altered granitoid (presumably rhyodacite [8]) was uncovered by an exploration ditch. With distance from the contact of the massif, this rock was transformed into epidote–quartz–plagioclase and quartz–plagioclase metasomatites (fig. 1).

The host rocks in the area of the Poldnevskoye demantoid deposit, framing the massif from the east, are mainly represented by chlorite-sericite-quartz and sericite-chlorite schists

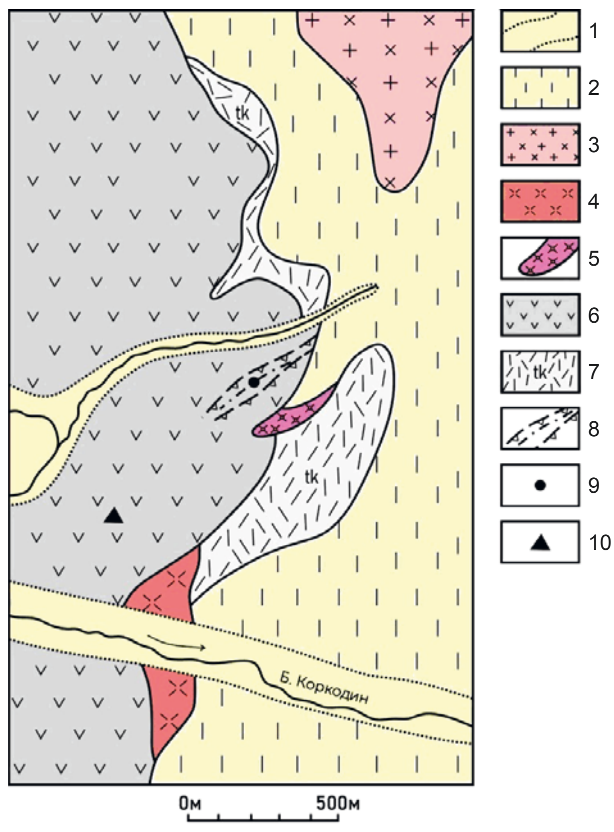

Figure 1. Geological map of the area of the Korkodinskoye jewelry andradite deposit [6] with the author's addition: *1* – Quaternary deposits; *2* – quartz-sericite schists; *3* – antigorite serpentinites; *4* – granodiorites; *5* – plagiogranites; *6* – quartz-plagioclase and epidote-quartz-plagioclase metasomatites; *7* – talc-carbonate rocks; *8* – local shear zone of serpentinites with gentle thrusts; *9* – primary manifestation of demantoids; *10* – manifestation of chromite ore

Рисунок 1. Геологическая карта района Коркодинского месторождения ювелирных андрадитов [6] с дополнением автора: *1* – четвертичные отложения; *2* – кварц-серицитовые сланцы; *3* – антигоритовые серпентиниты; *4* – гранодиориты; *5* – плагиограниты; *6* – кварц-плагиоклазовые и эпидот-кварц-плагиоклазовые метасоматиты; *7* – тальк-карбонатные породы; *8* – локальная зона смятия серпентинитов с пологими надвигами; *9* – коренное проявление демантоидов; *10* – проявление хромитовой руды with interlayers of carbonaceous-siliceous composition. At the Korkodinskoye deposit, the host rocks are mainly represented by quartz-sericite schists [6]. They belong to the Vyiskaya Formation (O_{2-3}) [6]. At the contact with the serpentinites of the massif and at a distance of about 100 m to the north of the hardrock outcrop of quartz-plagioclase metasomatites, an amphibolite lens, a few meters in size, was uncovered in shales. The rock consists of hornblende and plagioclase. In the same area, 100–150 m more to the north, in quartz-sericite schists, old pits were found from prospecting for hard rock gold with blocks of milky white quartz up to 20 cm thick and multiple imprints of crystals of pseudomorphs of limonite on pyrite in the form of a cube up to 10 mm along the edge. Similar blocks of quartz are found in the dumps of miners' pits in the upper reaches of the Zabitiy creek (the creek is unnamed in fig. 1).

Andradite mineralization at the Korkodinskoye deposit is controlled by non-extended crushing zones in serpentinites and diallagites. These are fissure-vein zones, in the formation of which both separation cracks and cleavage cracks take part. The strike of the fissure-vein zones is mainly southeast – 110°, the dip is subvertical to the north [9]. Some fissure-vein zones have a west-northwest (270–300 °C) strike and a subvertical dip to the south and southwest [4]. Strontianite was found among apodunitic serpentinite in one of such fissure-vein zones of sublatitudinal strike.

Research results and discussion

In addition to andradite, strontium carbonate in the fissure-vein zone is associated with two generations of clinochrysotile, lizardite, magnetite, calcite, and aragonite. There are two generations for strontianite. The first generation, strontianite-I, forms a microgranular, close to colomorphic aggregate of white and greenish-white color, which cements blocks of lizardite-clinochrysotile serpentinite (fig. 2). On the surface of the blocks, there are spherulite-like aggregates of clinochrysotile of the first generation (clinochrysotile-I), as well as intergrowths of round topazolite grains, up to 2 cm in size. Serpentinite contains magnetite in the form of isometric grains ranging in size from 0,1 to 2,5–3 mm. There is also magnetite in the form of irregularly shaped grains 3–5 mm in size. This magnetite is xenomorphic with respect to clinochrysotile-I.

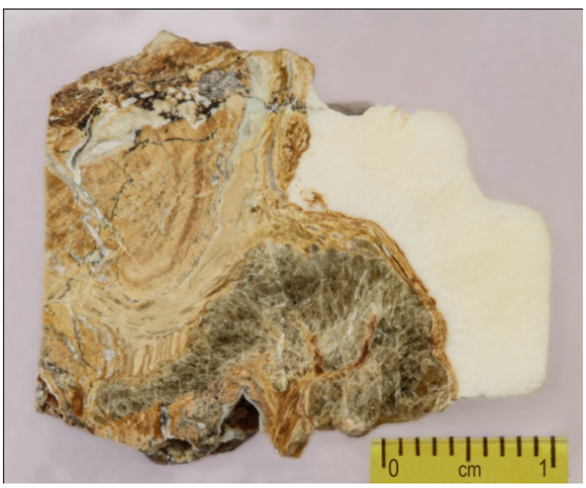

Figure 2. Strontianite of the first generation (white), growing on a spherocrystal intergrowth of topazolite
Рисунок 2. Стронцианит первой генерации (белый), нарастающий на сросток сферокристаллов топазолита

The second generation, strontianite-II, forms fusiform, columnar, and close to cylindrical individuals up to 2 cm in length. Separate individuals, as a rule, are surrounded by longitudinally fibrous clinochrysotile of the second generation (clinochrysotile II). With the latter, strontianite individuals are in close intergrowth. Strontianite-clinochrysotile aggregate of the second generation composes the central part of the mineralized fissure-vein zone. There is no garnet in it, and magnetite is represented only by dust-like dissemination.

The surface of separate strontianite individuals is smooth. In this case, the basal sections are rounded or oval. By elongation, individuals are often broken by transverse cracks, which are filled with clinochrysotile II. In parallel-columnar aggregates, the surface of strontianite individuals is inductive in the form of a rough transverse elongation of individuals by hatching. Basal sections of strontianite in such aggregates have a polygonal shape in the form of irregular hexagons or curved (with convex-concave sides) triangles.

The orientation of individuals and aggregates of strontianite-II is closely related to the orientation of clinochrysotile-II. In the pressure shadows of serpentinite blocks, strontianite-II individuals are often misoriented, located across the strike and dip of a mineralized fracture, together with clinochrysotile-II fibers randomly located between them. In areas of laminar arrangement of clinochrysotile-II fibers along the dip of a mineralized crack, strontianite has a parallel and consistent orientation with clinochrysotile-II. In this case, basal cracks of strontianite individuals healed by serpentine are much rarer. All this may indicate that the formation of late generations of strontianite and clinochrysotile occurred simultaneously. During growth, strontium carbonate individuals underwent brittle deformations, and the cracks formed transverse to elongation were filled with longitudinally fibrous clinochrysotile.

The color of strontianite-II is white, at the contact with serpentine it is light beige (fig. 3). Due to the heterogeneous microgranular structure, as well as the content of finely dispersed inclusions, a brownish-gray color appears. Under a microscope, strontianite has a radial-radiant structure. Strontianite-II is formed along the periphery of strontianite-I with the formation of a rim with a thickness of 1–5 mm. Often, these rims are overgrown with a parallel columnar carbonate microaggregate, presumably aragonite.

Calcite in the form of veinlets up to 3–5 mm thick cuts through strontianite-I, develops along serpentine at the contact of garnet grains with strontianite-clinochrysotile aggregate. In the form of microveinlets up to 0,12 mm thick, calcite cuts longitudinally fibrous clinochrysotile II and develops along lizardite with the formation of pulverized magnetite.

Inclusions in strontianite are mainly represented by thin needles of amphibole in optical properties corresponding to tremolite. Their length varies from 0,1 to 0,4 mm. The maximum number of inclusions of tremolite needles (up to 10–20% of the total mass) is contained in strontianite-I. In general, no orientation in the arrangement of tremolite needles is noted, although occasionally some of them form parallel series. It should be noted that similar tremolite individuals are present in lizardite-clinochrysotile serpentinite with garnet, where the percentage of tremolite approaches that in strontianite-I.

a *b*

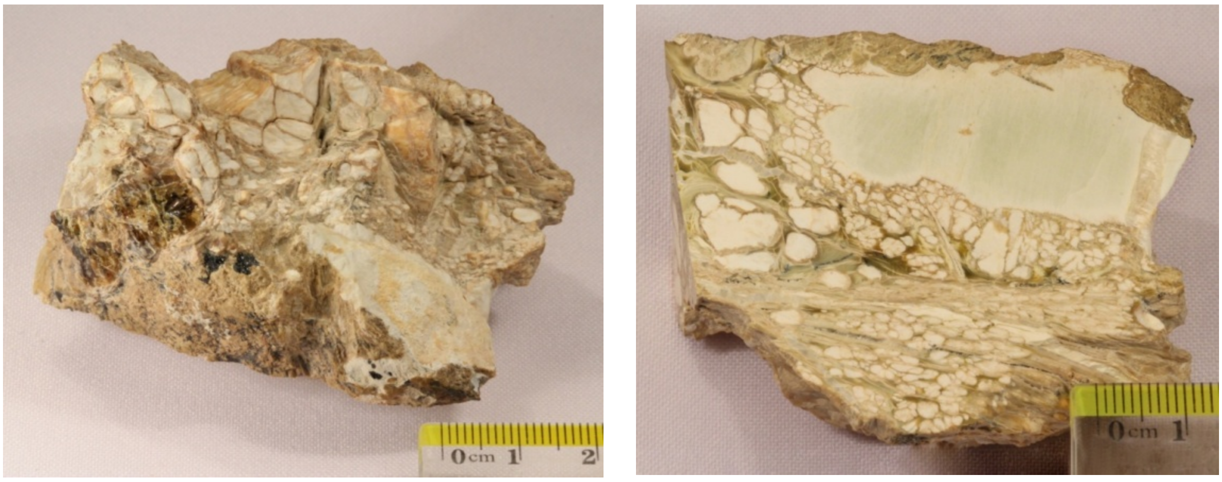

Figure 3. Strontianite-serpentine aggregate: *a* – crystals and intergrowths of strontianite-II in the middle and upper parts of the sample, serpentinite with inclusions of magnetite and topazolite in the lower part; *b* – the same sample on the reverse side, ground, light green – strontianite-I, white – strontianite-II

Рисунок 3. Стронцианит-серпентиновый агрегат: *а* – в средней и верхней частях образца кристаллы и сростки стронцианита-II, в нижней части – серпентинит с вкраплениями магнетита и топазолита; *б* – тот же образец, с обратной стороны пришлифованный, светло-зеленый – стронцианит-I, белый – стронцианит-II

Pulverized magnetite in the form of inclusions is presented in strontianite-II.

Topazolite, in the form of separate spherical grains and their intergrowths, is located among strontianite-I. In most cases, garnet is located at the contact of serpentinite and strontianite. At the same time, garnet grains immersed in a carbonate substrate are surrounded by a characteristic envelope, which includes: scaly serpentine, micro-acicular tremolite, and pulverized magnetite. Here, carbonate replaces serpentine minerals with the preservation of the relict texture of their aggregates.

The interplanar distances of the studied carbonate are close to calcium strontianite from Parbeck (England) [10] (table 1), as well as an analogue from the Buldymsky ultramafic massif in the Southern Urals [1].

The chemical composition of strontianite-II, wt. %: SiO_2 – 4,45; TiO_2 – 0,01; Fe_2O_3 – 0,10; Al_2O_3 – 0,05; PbO – 0,03; MnO – 0,01; FeO – 0,10; CaO – 19,40; MgO – 1,03; BaO – 4,50; SrO – 39,00; K_2O – 0,01; Na_2O – 0,06; P_2O_5 – 0,03; loss on ignition – 31,41 (of which CO_2 – 31,35); total – 100,19. Crystal chemical formula calculated without taking into account silica: $(Sr_{0,48}Ca_{0,45}Ba_{0,04}Mg_{0,03})_{1,00}CO_3$. According to the formula of the mineral, it can be attributed to the limiting calcium strontianite. It is interesting that the strontianite of the Buldymsky massif is also distinguished by a high admixture of calcium, most likely, these are the typochemical features of strontium carbonate from ultramafic bodies.

The trace element composition of strontianite-II of the Korkodinskoe deposit is given in table 2. High contents of strontium and barium in the studied sample confirm the data of chemical analysis. In addition, elevated contents of Ni, Mn, and Zn are found in strontianite. The contents of TR are distributed in such a way that elements of the yttrium subgroup mainly predominate in strontianite. At the same time, the total amount of light lanthanides is 13,5 times higher than heavy ones. This corresponds to the general tendency for the inclusion of elements of the Eu–La series into the group of strontium and barium minerals.

The IR spectra of strontianites of both generations contain the following absorption bands (cm^{-1}): 1) for strontianite-I – 3400, 1780, 1625, 1440, 1415, 1060, 1030, 960, 860, 850, 705, 620, 530, 505, 470; 2) for strontianite-II – 1450, 1420, 1110, 1090, 960, 860, 850, 705, 620, 540, 470. The main absorption band of $[CO^3]^{2-}$ -ion (1440–1450 cm^{-1}) in the spectra of the studied samples is shifted from the standard absorption band of strontianite (1461 cm^{-1}) towards witherite (1435 cm^{-1}) [11]. The narrow absorption band in the form of a doublet 850–860 cm^{-1} corresponds to the characteristic frequency range of the strontianite spectrum (841, 871 cm^{-1}) [11] and is closest to the spectrum of strontianite from the Buldymsky massif [1]. An intense narrow absorption band in the region of 705 cm^{-1} is characteristic of strontianite [11] and is present in the spectra of Korkodinsky carbonates. The main distinguishing feature of the IR spectrum of strontium carbonate of the first generation of the Korkodinskoye deposit is the presence of a wide absorption band in the region of 3400 cm^{-1}, which is characteristic of the spectra of aqueous carbonates [11].

High contents of Sr and Na in quartz-plagioclase metasomatite of the zone of contact with serpentinites of the massif at the Korkodinskoye deposit are noted by silicate and X-ray spectral analysis. In this case, the average (for three analyses) content of Sr is determined to be about 2803 ppm. The average (for three analyzes) content of Na is 7,8% (table 3). In the apogabbro plagioclasites of the area of the Poldnevskoye deposit, the average Sr content is 536 ppm (for three analyses). This is five times less than in the Korkodinsky quartz-plagioclase metasomatite. Apogabbro plagioclasite also contains less Na, averaging 2,25% (for three analyses). However, this rock contains more vanadium. This is probably why, in the early generation Poldnevsky andradites – melanites, an anom-

Table 1. Interplanar Distances and Unit Cell Parameters of Strontianite
Таблица 1. Межплоскостные расстояния и параметры элементарной ячейки стронцианита

Korkodinskoye deposit		$(Sr, Ca)CO_3$ [10]		
d/n	I	d/n	I	hkl
4,31	2	4,32	10	110
3,84	2	4,16	4	020
3,51	10	3,506	100	111
3,41	8	3,411	45	021
3,03	4	–	–	–
2,98	4	2,98	7	002
2,80	4	2,80	14	012
2,57	3	2,57	7	102
2,54	5	2,536	30	200
2,49	1	2,50	4	112
2,45	8	2,45	20	130
2,43	8	2,428	48	022
2,28	2	–	–	–
2,24	2	2,24	3	211
2,16	3	2,16	22	220
2,09	2	2,07	4	040
2,04	8	2,034	36	221
1,972	4	1,96	15	041
1,936	6	1,93	9	202
1,914	3	–	–	–
1,895	6	1,88	13	132
1,817	6	1,80	7	023
1,796	4	1,79	4	231
1,750	2	1,75	2	222
1,654	2	1,65	3	310
1,600	3	1,59	6	150
1,556	3	1,54	3	241
1,527	3	1,52	4	151
a_o = 5,050 ± 0,001 Å b_o = 8,302 ± 0,003 Å c_o = 6,051 ± 0,002 Å			a_o = 5,07 Å b_o = 8,28 Å c_o = 5,96 Å	

Table 2. The composition of trace elements in strontianite of the Korkodinskoye deposit, ppm
Таблица 2. Состав микроэлементов в стронцианите Коркодинского месторождения, г/т

Elements	Strontianite	Elements	Strontianite	Elements	Strontianite
Li	0,12	Cs	0,03	Ag	0,02
Sc	5,00	Ba	900	Cd	0,03
Ti	18,00	La	7,00	Sn	0,07
V	0,31	Ce	1,10	Sb	0,14
Cr	5,10	Pr	0,90	Pb	0,17
Mn	50,00	Nd	3,90	Te	5,00
Co	7,00	Sm	0,40	Th	0,01
Ni	120,00	Eu	0,46	U	0,002
Cu	8,00	Gd	0,31	Y	8,00
Zn	50,00	Tb	0,02	Zr	0,70
Ga	0,13	Dy	0,09	Nb	0,02
Ge	0,05	Ho	0,02	Mo	0,14
As	5,70	Er	0,04	Hf	0,014
Se	0,88	Tm	0,003	Ta	0,002
Rb	0,28	Yb	0,02	W	0,017
Sr	> 100 000	Lu	0,003	Tl	0,0008

alously high (up to 2900 ppm) content of vanadium is found. In the garnets of the same name of the Korkodinskoye deposit, the content of vanadium is up to 700 ppm [4].

Previously, it was established that strontium is a typomorphic microimpurity of the Korkodinskoye deposit garnets. Its maximum amount (14 ppm) is found in titanium-bearing andradite of early generation, with a decrease by several times (up to 5 ppm on average for three analyzes) in late topazolites [4]. Such Sr contents in the andradites of the Korkodinsky massif can be considered relatively high if we take into account that the melanite, demantoid, and topazolites of the Poldnevskoye primary deposit contain an order of magnitude less Sr than the Korkodinsky andradites.

Conclusions

As a result of the research, it can be concluded that the

Table 3. Chemical (wt. %) and trace element (ppm) composition of metasomatites
Таблица 3. Химический (вес. %) и микроэлементный (г/т) состав метасоматитов

Oxides and Elements	Samples					
	KGR-1.1	KGR-1.2	KGR-1.3	G-22.1	G-22.2	G-22.3
SiO_2	66,74	66,96	67,69	47,80	48,00	48,15
TiO_2	0,15	0,17	0,15	0,16	0,17	0,16
Al_2O_3	17,70	18,10	18,09	15,08	14,96	15,02
Fe_2O_3	1,38	0,65	1,00	2,52	3,20	3,96
FeO	0,36	1,08	0,72	5,74	5,03	4,31
MnO	0,06	0,06	0,05	0,15	0,11	0,14
CaO	2,86	2,85	2,84	11,25	11,29	11,23
MgO	0,89	0,83	0,79	11,30	10,98	11,11
K_2O	0,45	0,45	0,44	0,02	0,02	0,02
Na_2O	7,39	8,62	7,39	2,00	2,07	2,67
P_2O_5	0,12	0,11	0,11	0,01	0,01	0,01
V	0,004	0,007	0,003	0,005	0,005	0,005
Cr	0,003	0,003	0,004	0,025	0,024	0,025
Loss on ignition	0,37	–	0,29	2,42	2,53	2,29
Total	98,48	99,89	99,57	98,48	98,40	99,11
Sr	2797	2808	2803	532	538	539
Ce	l/r	l/r	l/r	59	< 50	26
La	13	< 10	< 10	14	10	11
Zr	15	11	19	< 5	< 5	5,5
Yb	l/r	l/r	l/r	< 3	< 3	< 3
Y	l/r	l/r	l/r	8,7	7,1	8,3
Sc	< 5	5,2	6	7,1	8,7	8,3
V	27	22	28	151	102	118
Co	l/r	l/r	l/r	50	32	46
Ni	13	15	16	191	209	200
Be	l/r	< 1	1,4	l/r	l/r	l/r

Note: 1) samples KGR-1.1, KGR-1.2, KGR-1.3 – quartz-plagioclase metasomatite of the Korkodinskoye deposit;
2) samples G-22.1, G-22.2, G-22.3 – apogabbro plagioclase metasomatite of the area of the Poldnevskoye deposit.
Примечание: 1) пробы КГР-1.1, КГР-1.2, КГР-1.3 – кварц-плагиоклазовый метасоматит Коркодинского месторождения;
2) пробы Г-22.1, Г-22.2, Г-22.3 – апогаббровый плагиоклазовый метасоматит района Полдневского месторождения.

strontianite of the Korkodinskoye jewelry andradite deposit belongs to the post-garnet stage of mineral formation. In association with clinochrysotile II, it is one of the late minerals at the final stage of the formation of serpentine minerals and, at the same time, one of the early minerals in the multistage process of carbonatization in the local shear zone and intense fracturing of serpentinites of the Korkodinsky massif. At the first stage of this process, serpentinite blocks are cemented with strontianite-I in mineralized fissure-vein zones with garnet with partial replacement of first-generation clinochrysotile. At the final stage of hypermafic serpentinization under conditions of a tectonically mobile zone of serpentinite melange, the chrysotilization process resumes with the formation of clinochrysotile-II and the transformation of strontianite-I into strontianite-II. This process ends with the formation of calcite, the early generation of which develops after strontianite of both generations. Among the late carbonates, aragonite is formed, which is part of the aragonite-calcite aggregate that fills late cracks in serpentinite.

The presence of microimpurities of strontium in the andradites of the Korkodinskoye deposit, along with the presence of strontium carbonate in the fracture-vein zone, indicate that the introduction of Sr into the ultramafic rocks of the local shear zone occurred both after and at the time of the formation of ruptures with demantoid and topazolite here. Considering that quartz-plagioclase metasomatites are the most probable source of strontium at the Korkodinskoye deposit, the influence of a small intrusion of granitoids on the formation of an area unusually rich in andradite content on a relatively small (a few hundred meters) area of the zone of increased fracturing and crushing of serpentinites becomes obvious. Such an interpretation of the process of the genesis of the deposit of jewelry andradites of the Korkodinsky massif fully corresponds to the conclusion about the conditions for the formation of demantoid as a result of superimposed low-grade metamorphism [12]. However, in the absence of certain structures at the points of contact of serpentinites with intrusions of acidic and basic compositions, demantoid is not formed [13, 14]. This testifies to the leading role of fissure tectonics in the formation of demantoids.

On the whole, no direct and ubiquitous connection between primary sources of demantoid and felsic intrusions has been established in the Korkodinsky massif. At the same time, ultramafic rocks, granitoids, and gabbro undergo metasomatic changes in tectonically weakened zones. At the same time, the presence of rocks of basic and acidic compositions in a particular deposit with their involvement in the process of medium and low temperature metasomatism determines the typomorphism of the microimpurity composition of garnets.

The results obtained do not agree with the new model of the formation of the Korkodinsky ultramafic massif [15]. The discovery of strontianite in a fissured-vein zone with topazolite is another evidence of the formation of demantoid-bearing bodies after the formation of gabbro and granitoids intrusions.

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Стронцианит из Коркодинского месторождения ювелирных андрадитов (Средний Урал)

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Аннотация

Актуальность работы обусловлена необходимостью изучения минералогии уральских драгоценных камней, в данном случае для месторождений ювелирного андрадита (демантоида и топазолита).

Цель работы – описание и детальное инструментальное исследование стронцианита из парагенезиса с ювелирным топазолитом, который был установлен на Коркодинском месторождении.

Методология исследования. Стронцианит изучался в Институте геологии и геохимии им. акад. А. Н. Заварицкого УрО РАН (г. Екатеринбург), Институте минералогии УрО РАН (г. Миасс) и Уральском государственном горном университете (г. Екатеринбург). Для его изучения применялся весь комплекс современных методов исследования. Проведены химические, геохимические, рентгенометрические и рентгеноспектральные исследования, а также применялся метод ИК-спектрометрии.

Результаты и выводы. Карбонат встречен в трещинно-жильной зоне в ассоциации с гранатом (топазолитом) среди тектонизированных серпентинитов на Коркодинском месторождении ювелирного андрадита. По данным химического состава стронцианит является предельно кальциевым. Кристаллохимическая формула карбоната: $(Sr_{0,48}Ca_{0,45}Ba_{0,04}Mg_{0,03})_{1,00}CO_3$. По химическому составу карбонат Коркодинского месторождения очень напоминает стронцианит Булдымского массива, по всей видимости, это является типохимической особенностью всех карбонатов стронция из гипербазитовых тел. Для стронцианита приведены результаты порошковой дифрактометрии и ИК-спектроскопии, которые очень близки к эталонным данным. Стронцианит относится к постгранатовой стадии минералообразования, а источником стронция для карбоната послужили встречающиеся на объекте небольшие тела кварц-плагиоклазовых метасоматитов. Полученные результаты не согласуются с последней моделью формирования Коркодинского ультрабазитового массива, предложенной А. Ю. Кисиным с соавторами. Находка стронцианита в трещинно-жильной зоне с андрадитом (топазолитом) служит очередным доказательством образования демантоидоносных тел после становления интрузий габбро и гранитоидов.

Ключевые слова: стронций, стронцианит, серпентиниты, кварц-плагиоклазовые метасоматиты, Коркодинский массив, Средний Урал.

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