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Geochronology of plagioclasite veins from the Lipovskoye pegmatite field (Middle Urals)

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Abstract

The relevance of the research is due to the need to improve the method of chemical dating as applied to high-thorium and high-uranium accessory minerals, which are difficult to date by isotopic research methods.
The purpose of the research is to study the chemical composition of monazite and uraninite from plagioclasite veins of the Lipovskoye pegmatite field and to determine their age.
Research Methodology: quantitative analysis of the chemical composition of monazite and uraninite was performed on an X-ray spectral electron probe microanalyzer CAMECA SX 100. Measurement conditions: accelerating voltage 15 kV, current strength 250 nA, electron beam diameter 2 μm. Sample chamber pressure $2 \cdot 10^{-4}$ Pa. The spectra were obtained on tilted wave spectrometers, the intensity was measured using analytical lines: Th M*a*, U M*b*, Pb M*a*, Y L*a*, Si K*a*, Ca K*a*, P K*a*, Ce L*a*, La L*a*, Pr L*b*, Nd L*a*, Sm L*b*, Dy L*a*, Gd L*b*. Age calculation was carried out according to well-known methods of foreign authors in addition to their own developments.
Results. According to the chemical composition, monazite belongs to the cerium variety and is characterized by high contents of ThO_2 up to 13,4 wt. %, UO_2 up to 0,8 wt. % and PbO up to 0,18 wt. %. According to chemical dating, monazite-(Ce) gives an age of 266 ± 17 Ma. In undeformed plagioclasites, uraninite contains impurities of ThO_2 up to 11,6 wt. % and PbO up to 3,0 wt. %, its calculated age is 258 ± 3 Ma. In tectonized plagioclasites, uraninite is characterized by impurities of ThO_2 from 26 up to 45 wt. % and PbO up to 2,4 wt. %. According to chemical dating data, two ages are calculated in these uraninites: 255 ± 10 Ma in the central part of the grains, and 244 ± 4 Ma in the marginal parts of the grains.
Conclusions. Microprobe data on the composition of these minerals have been obtained, and the complex geochronology of these rocks has been established by chemical dating. These plagioclasite bodies were formed after the Middle Permian quartz-potassium feldspar (topaz-beryl) granitic pegmatites, widely developed within the Lipovskoye field, and later underwent superimposed changes twice in the Upper Permian and Triassic times.

Keywords: monazite, uraninite, plagioclasites, geochronology, Lipovskoye vein field, Middle Urals.

Introduction

Granite pegmatites of the Lipovskoe vein field are located on the eastern slope of the Middle Urals (70 km northeast of Ekaterinburg and 5 km west of the village of Lipovskoye). The world-famous and fully developed deposit of pink tourmalines (rubellites) is associated with them. Pegmatites are confined to a gently sloping synclinal structure sandwiched between three large granite massifs – Murzinsky (from the northwest), Aduisky (from the southwest) and Sokolovsky (from the east). The syncline itself is composed of metamorphic rocks of the Proterozoic age, which are dominated by various gneisses, shales, and amphibolites [1, 2]. Separate bodies of serpentinites and marbles are also noted here, which are usually tectonically interspersed with each other in the melange zone. The well-known and fully developed Lipovskoye deposit of silicate-nickel ores is associated with karst marbles and weathering crusts of serpentinites. Granite vein bodies are widespread within the Lipovskoye pegmatite field and are usually represented by intragranite, lithium-bearing and plagioclasite (desilitic) types. Despite the abundance of plagioclasite veins in this area and their relatively good mineralogical knowledge [2, 3], it turned out that no age dating was given for the desilicated veins of the Lipovskoye pegmatite field.

Geological position of plagioclasite veins and their structure. Desilicated (plagioclasite) veins in their mineralogical features most closely correspond to pegmatites of the crossing line and are located exclusively in serpentinites. Visually, they resemble desilicated apogranite pegmatites of the Ural emerald mines, which are described in detail in the works of K. A. Vlasov and E. I. Kutukova [4].

When mapping plagioclasites in the Lipovskoye pegmatite field, we discovered a whole series of similar bodies (about

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Figure 1. Veins plagioclasite bodies of the Lipovskoye pegmatite field: *a* – quarry no. 6 (vein no. 42); *b* – quarry no. 7 (vein no. 61)

Рисунок 1. Жильные плагиоклазитовые тела Липовского пегматитового поля: *а* – карьер № 6 (жила № 42); *б* – карьер № 7 (жила № 61)

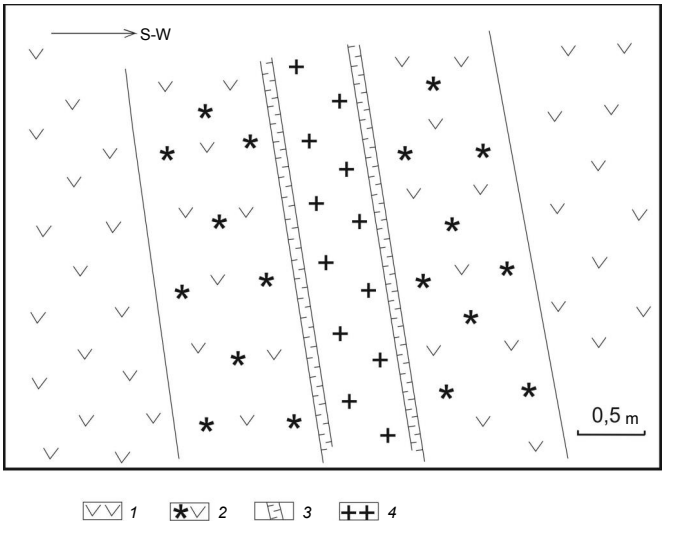

Figure 2. Schematic structure of plagioclasite vein no. 42 (vertical section): *1* – serpentinites; *2* – anthophyllitized serpentinites; *3* – chlorite zone after phlogopite; *4* – plagioclasite body with tourmaline crystals

Рисунок 2. Схематическое строение плагиоклазитовой жилы № 42 (вертикальный разрез): *1* – серпентиниты; *2* – антофиллитизированные серпентиниты; *3* – хлоритовая зона по флогопиту; *4* – тело плагиоклазита с кристаллами турмалина

20 veins) with their own characteristic features. Usually, they are extended thin veins from 0.2 to 1 m. The dip of the veins is from subvertical to subhorizontal (fig. 1); they consist mainly of plagioclase and black-blue tourmaline (a dravite composition with a high content of uvite minal). At the same time, plagioclasite bodies are fine-grained to giant-grained and are composed of anorthite (more rarely, andesine) aggregate with an admixture of calcite and muscovite-chlorite substance. The plagioclasite matrix contains inclusions of ore minerals (uraninite, ishikavaite, various pyrochlores, fersmite, ferrocolumbite, magnesiotantalite, cassiterite, and many others), tourmaline, zircon, barite, as well as chrysoberyl, phenakite, and Be-cordierite [2, 3, 5–7]. At the contact of these bodies with host serpentinites, a phlogopite (usually replaced by chlorite) carrack with the presence of an anthophyllite zone is constantly observed (fig. 2).

Research methods

Quantitative analysis of the chemical composition of monazite and uraninite was performed on an electron probe microanalyzer CAMECA SX 100 (IGG UB RAS, Ekaterinburg). Polished sections were made from pieces of rock, up to 0.5 cm in size, then they were sprayed with a thin layer of carbon. Measurement conditions: accelerating voltage 15 kV, current strength 250 nA, electron beam diameter 2 μm. The pressure in the sample chamber is $2 \cdot 10^{-4}$ Pa. The spectra were obtained on tilted wave spectrometers, the intensity was measured using analytical lines: Th *Ma*, U *Mb*, Pb *Ma*, Y *La*, Si *Ka*, Ca *Ka*, P *Ka*, Ce *La*, La *La*, Pr *Lb*, Nd *La*, Sm *Lb*, Dy *La*, Gd *Lb*. Standards used for calibration: thorium and uranium oxides, diopside, zircon, REE synthetic phosphates, $Pb_2P_2O_7$. When performing a quantitative analysis of monazite, the peak intensity measurement time (400 s for thorium, 400 s for lead, 400 s for uranium, 20 s for silicon, yttrium, and calcium, and 10 s for other elements) was two times longer than the background measurement time. For monazite, the following limits of detection have been achieved: Th – 110, U – 65 and Pb – 58 ppm. For uraninite, the intensity measurement time at the peak for Th, U, and Pb is 40 s each, for Y and Si, 20 s each, and for other elements, 10 s; in the background – two times less. The detection limits for Th, U, and Pb were about 930, 650, and 430 ppm. The oxygen content was determined under the assumption of the stoichiometry of the composition. The theoretical and practical substantiation of the chemical dating method using X-ray microprobe analysis is given in numerous publications on this topic [8, 9], including one of the authors

[10, 11]. The main condition of this method is that the mineral did not lose radiogenic lead during evolution (i. e., the Th–U–Pb system was closed), all lead in the mineral was formed due to the decay of thorium and uranium.

Results and discussion

For study and dating, we used monazite and uraninite, which form accessory dissemination in plagioclasite veins.

Monazite composes small (up to 50 μm in elongation) grains pulverized in some parts of plagioclasite veins. The shape of the grains is corroded, round or oval, sometimes with traces of faceting (fig. 3). According to the chemical composition, REE phosphate belongs to the cerium variety (table 1) and is characterized by high thorium contents. (ThO_2 up to 13.4 wt. %), uranium (UO_2 up to 0,8 wt. %) and lead (PbO up to 0,18 wt. %). It is known that for thorium and uranium impurities in monazite, the huttonite ($Th^{4+}(U^{4+}) + Si^{4+} \rightarrow REE^{3+} + P^{5+}$) and/or cheralite ($Th^{4+}(U^{4+}) + Ca^{2+}(Sr^{2+}, Ba^{2+}, Pb^{2+}) \rightarrow 2REE^{3+}$) type of isomorphism takes place. From the available analyzes of the chemical composition of monazite, it can be argued that both types of isomorphism take place in the phosphate matrix.

In the well-known work [12], the parameter β = (Si + Ca)/(Th + U + Pb), characterizing the degree of charge compensation of impurities of $Th^{4+}(U^{4+})$, considered as an indicator of closure Th–U–Pb-monazite system: when it is close to unity, the system is considered closed. For monazite from plagioclasite veins, the parameter β = 0,96–1,02, which indicates the closed nature of the system and means the possibility of a correct assessment of the age of the mineral.

When chemically dated (based on 23 analyses), monazite-(Ce) showed age variation from 252 to 282 Ma. The weighted average age of REE phosphate is 269.3 ± 7.8 Ma (fig. 4, *a*). When building a dependency ThO_2^*–PbO according to the set of analysis points, accessory monazites lie on one straight line (or isochron, according to [14]), which indicates their simultaneous formation. Here $ThO_2^* = (ThO_2 + UO_2^{eq})$, where UO_2^{eq} – the content of uranium converted to the equivalent content of thorium capable of producing the same amount of lead during the lifetime of the system, given equality U–Pb and Th–Pb-age values. Calculation of the age from the slope of the isochron gives a dating of 266 ± 17 Ma, MSWD = 0.79,

Table 1. Chemical composition of monazite from Lipovka plagioclasites, wt. %
Таблица 1. Химический состав монацита из плагиоклазитов Липовки, мас. %

Oxides	Analysis number											
	1	2	3	4	5	6	7	8	9	10	11	12
P_2O_5	26,91	27,01	27,07	27,33	27,07	27,44	27,16	27,12	27,22	27,50	27,79	27,46
ThO_2	12,71	12,65	13,40	13,26	12,34	12,20	12,86	12,26	12,78	13,15	11,83	12,41
UO_2	0,44	0,43	0,49	0,46	0,45	0,45	0,48	0,46	0,48	0,49	0,76	0,49
SiO_2	1,94	2,00	1,89	1,71	1,70	1,72	1,83	1,78	1,90	1,96	1,46	1,73
Ce_2O_3	20,04	19,92	19,51	19,53	19,88	19,84	19,90	20,56	20,10	19,80	19,87	19,73
La_2O_3	9,03	9,03	8,72	9,22	9,33	8,87	8,72	9,24	8,58	8,57	9,31	8,51
Nd_2O_3	12,72	12,60	12,56	11,66	12,23	12,82	12,85	12,51	12,96	12,92	12,52	12,93
Pr_2O_3	2,68	2,60	2,61	2,58	2,72	2,66	2,76	2,66	2,69	2,62	2,62	2,73
Sm_2O_3	4,78	4,70	4,60	4,55	4,65	4,56	4,80	4,62	4,73	4,61	4,57	4,69
Gd_2O_3	3,34	3,28	3,42	3,20	3,26	3,24	3,37	3,21	3,38	3,35	3,21	3,35
Dy_2O_3	0,77	0,72	0,70	0,72	0,68	0,69	0,71	0,72	0,72	0,71	0,73	0,74
Y_2O_3	2,30	2,11	2,22	2,20	2,23	2,31	2,22	2,26	2,27	2,27	2,26	2,28
PbO	0,16	0,16	0,17	0,17	0,15	0,15	0,16	0,15	0,17	0,17	0,16	0,16
CaO	0,89	0,90	1,19	1,37	1,02	1,04	1,08	1,02	1,06	1,27	1,39	1,18
Total	98,72	98,09	98,53	97,95	97,71	97,97	98,89	98,58	99,04	99,38	98,47	98,39

Oxides	Analysis number										
	13	14	15	16	17	18	19	20	21	22	23
P_2O_5	27,41	28,92	28,24	28,62	28,51	28,87	28,58	29,05	27,81	28,02	27,94
ThO_2	12,54	8,25	10,50	7,28	10,84	9,86	10,02	8,87	9,83	11,14	7,63
UO_2	0,48	0,69	1,26	0,80	1,27	1,31	1,30	1,03	0,38	0,47	0,40
SiO_2	1,66	1,02	1,32	0,87	1,43	1,20	1,16	0,92	1,14	1,32	0,96
Ce_2O_3	20,14	21,50	20,57	21,58	20,82	20,71	21,24	20,46	21,68	20,87	21,59
La_2O_3	9,14	10,42	9,92	11,02	9,97	9,73	9,74	9,96	10,25	10,14	9,92
Nd_2O_3	12,00	12,69	11,63	12,51	11,44	11,66	11,71	12,10	11,94	10,78	12,49
Pr_2O_3	2,57	2,91	2,56	2,79	2,51	2,71	2,68	2,76	2,68	2,50	2,73
Sm_2O_3	4,61	4,22	3,95	3,96	3,79	4,06	3,85	4,09	4,42	4,45	4,86
Gd_2O_3	3,30	3,15	3,32	2,95	3,09	3,28	3,16	3,47	3,12	2,88	3,29
Dy_2O_3	0,70	0,79	0,93	0,77	0,88	1,00	0,97	1,05	0,67	0,64	0,70
Y_2O_3	2,26	2,66	2,81	2,73	2,95	3,27	2,91	3,40	2,09	2,10	2,17
PbO	0,15	0,12	0,17	0,11	0,18	0,16	0,17	0,15	0,13	0,15	0,10
CaO	1,28	1,07	1,44	1,08	1,42	1,38	1,39	1,26	0,88	1,24	1,02
Total	98,22	98,42	98,64	97,09	99,09	99,20	98,87	98,55	97,01	96,71	95,81

Note: IGG UB RAS, microanalyzer CAMECA SX 100, analyst V. V. Khiller.

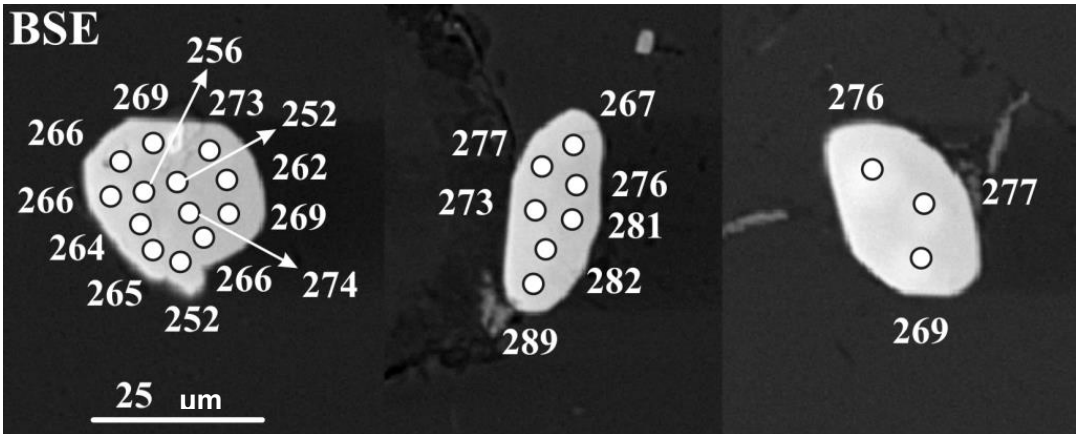

Figure 3. BSE-photo of monazite grains from desilicated veins with outlier dot dating. Microanalyzer CAMECA SX 100, analyst V. V. Khiller

Рисунок 3. BSE-фото зерен монацита из десилицированных жил с вынесенными точечными датировками. Микроанализатор CAMECA SX 100, аналитик В. В. Хиллер

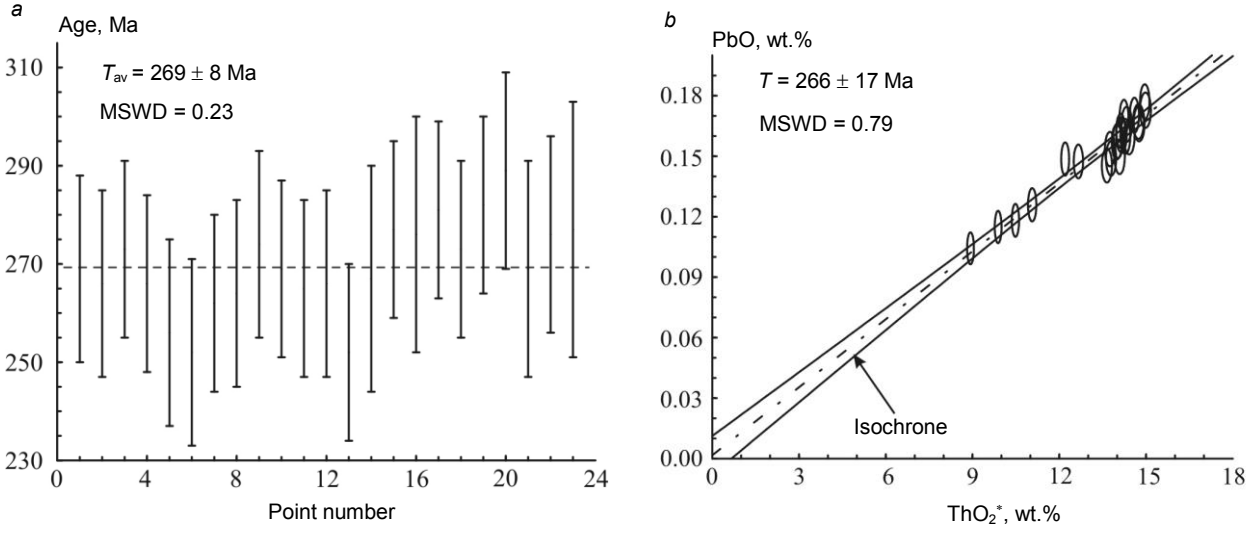

Figure 4. Weighted average age (*a*) and isochrone (*b*) for relict monazite

Рисунок 4. Средневзвешенный возраст (*а*) и изохрона (*б*) по реликтовому монациту

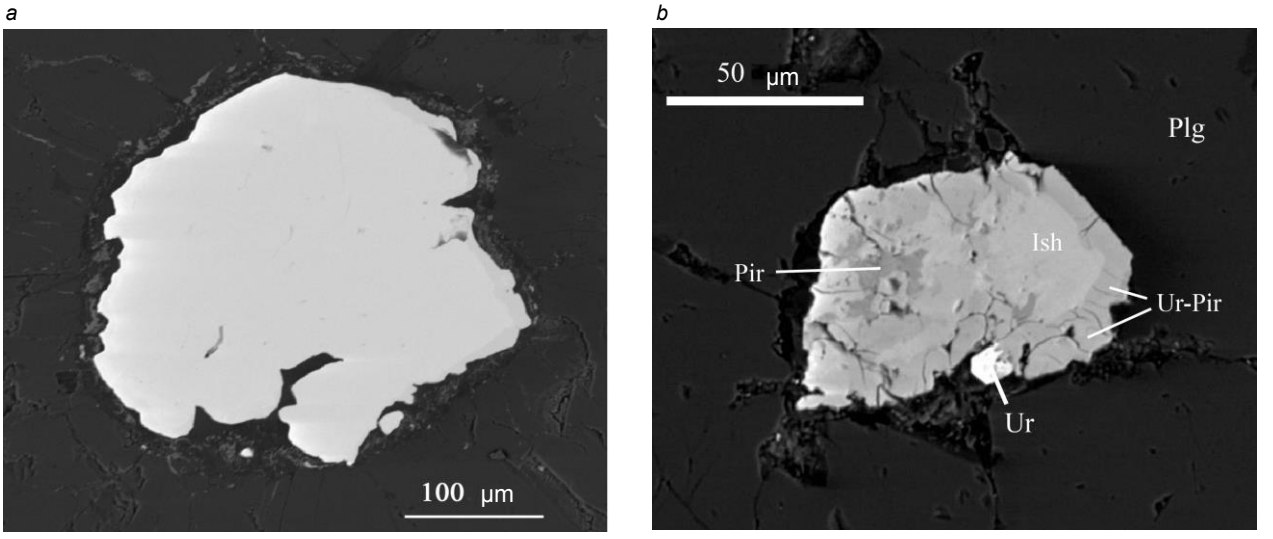

Figure 5. Uraninite grains from various plagioclasites: *a* – from an ordinary vein (sample no. 9-3l/13); *b* – from a boudinated vein (sample no. 15l/10); Ish – ishikawaite, Ur – uraninite, Pir – pyrochlore, Ur-Pir – uranium pyrochlore, Plg – anorthite. BSE-photo, CAMECA SX 100 microanalyzer, analyst V. V. Khiller

Рисунок 5. Зерна уранинита из разных плагиоклазитов: *а* – из обычной жилы (обр. № 9-3л/13); *б* – из будинированной жилы (обр. № 15л/10); Ish – ишикаваит, Ur – уранинит, Pir – пирохлор, Ur-Pir – уранпирохлор, Plg – анортит. BSE-фото, микроанализатор CAMECA SX 100, аналитик В. В. Хиллер

Table 2. Chemical composition of uraninite in undeformed plagioclasites, wt. %
Таблица 2. Химический состав уранинита в недеформированных плагиоклазитах, мас. %

Analysis number	Oxides								Total
	ThO_2	UO_2	Ce_2O_3	Pr_2O_3	Nd_2O_3	Y_2O_3	PbO	CaO	
1	11,09	79,61	0,22	–	0,16	0,14	2,88	0,90	94,98
2	11,55	80,90	0,22	0,01	0,22	0,17	2,91	0,91	96,89
3	12,11	79,39	0,31	0,08	0,12	0,35	2,88	0,81	96,05
4	10,88	80,74	0,15	0,02	0,14	0,22	2,94	1,10	96,20
5	11,53	80,67	0,15	0,14	0,10	0,13	2,92	0,87	96,50
6	11,04	81,24	0,23	–	0,16	0,21	2,96	0,87	96,70
7	10,47	81,29	0,23	0,05	0,14	0,17	2,91	0,90	96,15
8	11,89	79,67	0,25	0,12	0,27	0,39	2,88	0,73	96,21
9	11,29	81,70	0,28	0,00	0,19	0,12	2,95	1,01	97,53
10	12,28	81,51	0,22	0,10	0,20	0,10	2,96	0,89	98,26
11	12,32	81,39	0,21	0,03	0,18	0,39	2,93	0,74	98,19
12	10,55	82,85	0,22	0,14	0,28	0,21	3,02	0,88	98,15
13	12,07	81,56	0,19	0,03	0,19	0,35	2,94	0,77	98,11
14	10,89	82,64	0,25	–	0,25	0,21	2,99	0,87	98,09
15	11,16	82,65	0,33	0,03	0,25	0,18	2,96	0,88	98,44
16	9,72	82,49	0,23	–	0,17	0,28	2,98	0,89	96,76
17	10,87	82,71	0,23	0,11	0,18	0,19	3,01	0,92	98,21
18	11,23	82,46	0,21	–	0,13	0,17	3,00	0,84	98,03

Table 3. Chemical composition of uraninite in deformed plagioclasites, wt. %
Таблица 3. Химический состав уранинита в деформированных плагиоклазитах, мас. %

Analysis number	Oxides									Total
	WO_3	Nb_2O_5	Ta_2O_5	ThO_2	UO_2	Ce_2O_3	Y_2O_3	PbO	CaO	
1	0,37	0,80	0,11	42,32	46,76	0,24	0,52	2,03	0,52	93,67
2	0,41	0,70	0,14	38,54	52,45	0,26	0,56	2,13	0,38	95,56
3	0,56	0,75	–	38,42	52,74	0,01	0,58	2,22	0,39	95,66
4	0,39	0,86	0,08	38,46	52,60	–	0,60	2,33	0,44	95,76
5	0,43	0,90	0,02	37,76	52,79	0,04	0,60	2,25	0,46	95,23
6	0,64	0,85	–	37,54	52,91	0,15	0,54	2,12	0,54	95,28
7	0,54	0,39	0,31	26,34	60,89	0,07	0,05	2,27	0,36	91,22
8	0,65	0,35	0,05	25,86	61,27	–	–	2,33	0,32	90,82
9	0,58	0,32	0,13	26,74	61,75	0,04	0,37	2,35	0,41	92,62
10	0,62	0,36	0,07	27,55	59,62	0,02	–	2,29	0,42	90,95
11	0,61	0,43	–	29,15	57,71	0,01	0,26	2,19	0,72	91,08
12	0,40	0,81	–	44,75	47,71	0,06	0,10	2,04	0,39	96,25
13	0,38	0,91	–	43,15	48,79	0,08	0,41	2,03	0,36	96,11
14	0,52	0,37	–	28,65	58,49	–	0,25	2,18	0,45	90,91

probability = 0.95 (fig. 4, *b*). This dating is very similar to the age we obtained for monazite from intragranitic pegmatites – 266.4 ± 2.6 Ma [11]. It is likely that this accessory monazite is a relict, preserved during the desilication of granite pegmatite. This hypothesis is supported by the fact that monazite is xenomorphic and rarely occurs in plagioclasite veins; it forms clusters of grains only in some parts of the veins.

Uraninite, in contrast to monazite, is often found in desilicated veins and even forms clusters visible to the naked eye. At the same time, accessory uraninites from different plagioclasites (normal and tectonized) differ in chemical composition and dating.

In normal undeformed plagioclasite veins, uraninite forms scattered dissemination in anorthite and composes rounded grains up to 0.5 mm in size (fig. 5, *a*). Visually, they are pitch black and have red-brown pleochroic courtyards. At the edges of the grains there is a secondary rim of more aqueous uraninite (i. e. pitchblende). Because of this, the plagioclasite matrix around the uranium mineral is broken by radial cracks (with the development of pitchblende, an increase in the volume of the substance occurs). The mineral (table 2) contains significant impurities of thorium (ThO_2 up to 11,6 wt. %) and lead (PbO up to 3.0 wt. %).

In 1959 V. A. Leonova established the relationship between the unit cell parameters and impurities in the composition of uraninite [13]. When the content of thorium in this uraninite is 3.4–4.2 at. % Th, the unit cell parameter obtained is a_o = 5,480-5,483 Å. For synthetic (reference) uraninite, this parameter is

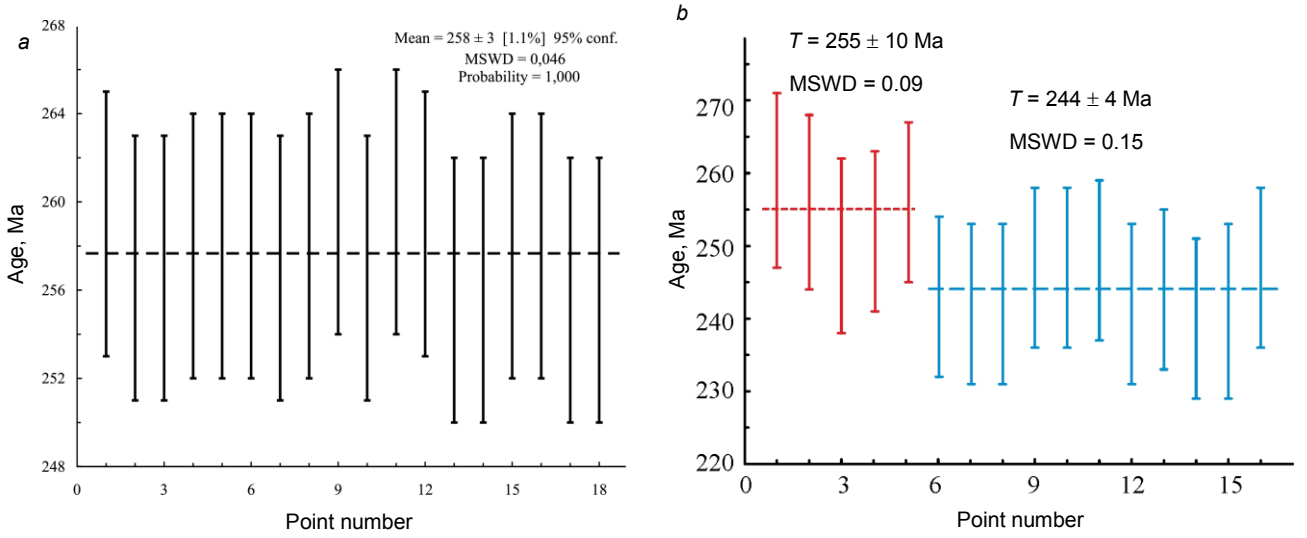

Figure 6. Weighted average ages for uraninite: *a* – sample no. 9-3l/13; *b* – sample no. 15l/10
Рисунок 6. Средневзвешенные возрасты по уранониту: *а* – обр. № 9-3л/13; *б* – обр. № 15л/10

defined as 5,4682 Å, and for natural uraninites it varies greatly from 5.33 to 5.49 Å. In this case, it is known that the unit cell parameter decreases with an increase in the degree of uranium oxidation [14]. That is, Lipovskoye uraninite is quite close to the synthetic standard in terms of unit cell parameters and is not metamict, and also contains a small amount of more oxidized uranium (UO_3 and U_3O_8).

The high content of lead obtained by microprobe analysis and the good crystallinity of the substance make it possible to use this accessory uraninite as a geochronometer mineral. The calculated age of uraninite falls within a relatively narrow range of 260–253 Ma, with a weighted average of 257.8 ± 3 Ma (fig. 6, *a*). Interestingly, in pitchblende rim, the age of the mineral sharply "drops" to 240 Ma [15].

In tectonized (deformed) plagioclasite veins, uraninite forms scattered dissemination in plagioclases and intergrowths with minerals of the pyrochlore group, composes isometric inclusions up to 50 μm in size. The mineral is confined to places of secondary alteration of niobotantalates and, apparently, is a product of the destruction of the primary matrix of pyrochlores, which is characterized by increased contents of UO_2 (up to 22 wt. %) and ThO_2 (up to 8 wt. %). The composition of uraninite (table 3) is characterized by impurities of ThO_2 (from 26 to 45 wt. %), PbO (up to 2.4 wt. %), Nb_2O_5 (up to 0.9 wt. %) and Y_2O_3 (up to 0.65 wt. %). According to the data obtained by the CHIME method (chemical Th–U–Pb_{total} dating), two ages are calculated in these uraninites. In the central part of some grains, 255 ± 10 Ma is obtained; dates close to uraninites from undeformed plagioclasite veins. In the marginal parts of the grains and in some separate individuals, a younger age of 244 ± 4 Ma is calculated (fig. 6, *b*).

Thus, plagioclasites, according to the CHIME method, show three ages: 269 ± 8 Ma (monazite), 258 ± 3, and 244 ± 4 Ma (both uraninite). It seems to us that the plagioclasite bodies of the Lipovskoye vein field were formed after classical quartz-K-feldspar (topaz-beryl) granitic pegmatites, which formed in the Middle Permian, approximately 266 million years ago. It follows from this that desilication of granitic pegmatites occurred immediately, as soon as they intruded and cut through the body of ultramafic rocks.

Somewhat later, during the formation of lithium-bearing (lepidolite-albite) pegmatites (approximately 258–255 Ma ago), under the influence of their heat flow and the fluid component of the surrounding serpentinites, plagioclasites experienced recrystallization. It is likely that complex metasomatic carracks formed around the veins at this very moment. Still later (approximately 244 Ma ago), as a result of Triassic tectonic-magmatic activation, some desilicated veins underwent tectonic deformations, which led to recrystallization of accessory uraninite and, accordingly, rejuvenation of its age.

Conclusions

Thus, we have studied in detail the accessory radioactive minerals (monazite and uraninite) from plagioclasite veins of the Lipovskoye pegmatite field. Microprobe data on the composition of these minerals have been obtained, and the complex geochronology of these rocks has been established by chemical dating. These plagioclasite bodies were formed after the Middle Permian quartz-potassium feldspar (topaz–beryl) granitic pegmatites, widely developed within the Lipovskoye vein field, and later were subjected to superimposed changes twice in the Upper Permian and Triassic times.

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Геохронология плагиоклазитовых жил из Липовского пегматитового поля (Средний Урал)

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Аннотация

Актуальность работы обусловлена необходимостью совершенствования метода химического датирования в применении к высокоториевым и высокоурановым акцессорным минералам, которые сложно датировать изотопными методами исследования.

***Цель работы*:** исследование химического состава монацита и уранинита из плагиоклазитовых жил Липовского пегматитового поля и определение их возраста.

***Методология исследования*:** количественный анализ химического состава монацита и уранинита выполнен на рентгеноспектральном электронно-зондовом микроанализаторе CAMECA SX 100. Условия измерения: ускоряющее напряжение 15 кВ, сила тока 250 нА, диаметр пучка электронов 2 мкм. Давление в камере образцов 2×10^{-4} Па. Спектры получены на наклонных волновых спектрометрах, измерение интенсивности проводилось по аналитическим линиям: Th *Ma*, U *Mb*, Pb *Ma*, Y *La*, Si *Ka*, Ca *Ka*, P *Ka*, Ce *La*, La *La*, Pr *Lb*, Nd *La*, Sm *Lb*, Dy *La*, Gd *Lb*. Расчет возраста проводился по известным методикам зарубежных авторов в дополнение к собственным наработкам.

Результаты. По химическому составу монацит относится к цериевой разновидности и характеризуется высокими содержаниями ThO_2 до 13,4 мас. %, UO_2 до 0,8 мас. % и PbO до 0,18 мас. %. По данным химического датирования монацит-(Ce) дает возраст 266 ± 17 млн лет. В недеформированных плагиоклазитах уранинит содержит примеси ThO_2 до 11,6 мас. % и PbO до 3,0 мас. %, его рассчитанный возраст – 258 ± 3 млн лет. В тектонизированных плагиоклазитах уранинит отличается примесями ThO_2 от 26 до 45 мас. % и PbO до 2,4 мас. %. По данным химического датирования, в этих уранинитах рассчитываются два возраста, в центральной части зерен получается 255 ± 10 млн лет, а в краевых частях зерен – 244 ± 4 млн лет.

Выводы. Получены микрозондовые данные по составу этих минералов и методом химического датирования установлена сложная геохронология данных пород. Данные плагиоклазитовые тела образовались по среднепермским кварц-калишпатовым (топаз-берилловым) гранитным пегматитам, широко развитым в пределах Липовского поля, а позже дважды подвергались наложенным изменениям в верхнепермское и триасовое время.

***Ключевые слова*:** монацит, уранинит, плагиоклазиты, геохронология, Липовское жильное поле, Средний Урал.

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