ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
«САНКТ-ПЕТЕРБУРГСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ»

Институт наук о Земле
Кафедра геохимии

Геохимия акцессорной минерализации литий-фтористых гранитов Тургинского массива в Восточном Забайкалье и ее генетическое значение

Борисова Евгения Борисовна

Выпускная квалификационная работа
по направлению 05.03.01 "Геология"
по геофизико-геохимической группе профилей

Научный руководитель:
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(подпись руководителя)
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Д-г.м.н., проф. **Чарыкова М.В.**
____
(подпись заведующего)

САНКТ-ПЕТЕРБУРГ
2019

[illegible]

Li-F

Hitachi TM-3000

Hitachi S-3400N

[illegible] 1. [illegible]

1.1. [illegible].

[illegible] 250 [illegible] (1).

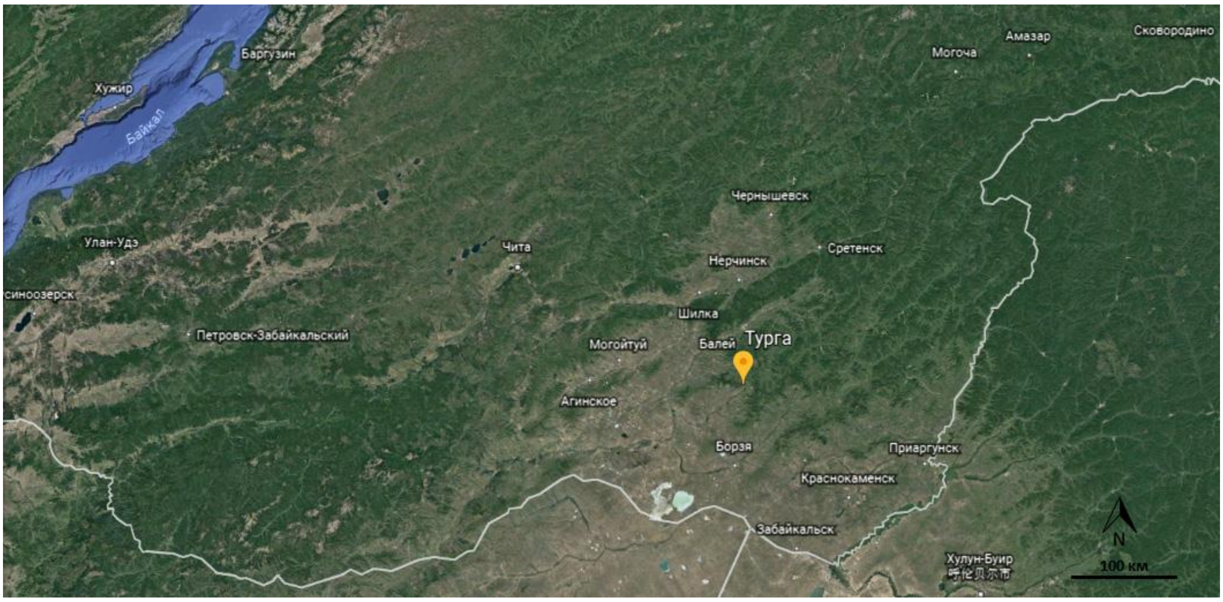
[illegible] (10 [illegible]), [illegible] (50 [illegible]), [illegible].

[illegible] ([illegible]), [illegible].

[illegible] 650 [illegible] 750 [illegible] (2). [illegible] -20 °[illegible], [illegible] - +21 °[illegible]. [illegible] 300 [illegible] 400 [illegible]. [illegible] ([illegible] 8 [illegible], [illegible] 167 [illegible]), [illegible] ([illegible] 96 [illegible], [illegible] 1032 [illegible]). [illegible]

[illegible]-[illegible]-[illegible]-[illegible]-[illegible].

[illegible] (…, 2012). [illegible]: [illegible], [illegible], [illegible] ([illegible]).



[illegible] 1. [illegible] Google Earth.

[illegible] 2. [illegible] Google Earth.

1.2. [illegible]

[illegible]

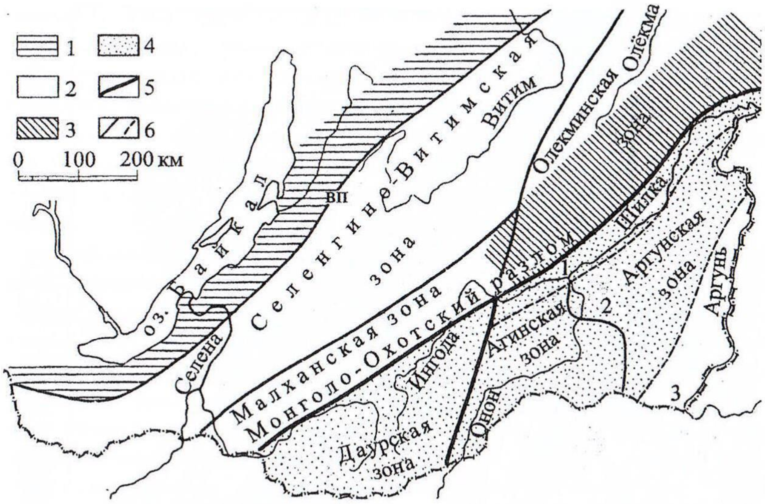
[illegible]

[illegible]

[illegible] 1972).

[illegible] (fig.3). [illegible]

[illegible] (2002).



1 — область протерозойской складчатости; 2 — область каледонской складчатости Западного и Северо-Западного Забайкалья; 3 — молибденово-золотой пояс в области каледонской складчатости; 4 — область герцинской складчатости (оловянно-вольфрамовый пояс Центрального и Восточного Забайкалья); 5 — глубинные разломы; 6 — границы структурно-формационных зон; цифры на схеме — структурно-формационные подзоны Аргунской зоны: 1 — Пришилкинская; 2 — Газимурская; 3 — Урулюнгуевская.

[illegible] 3. [illegible] 1977).

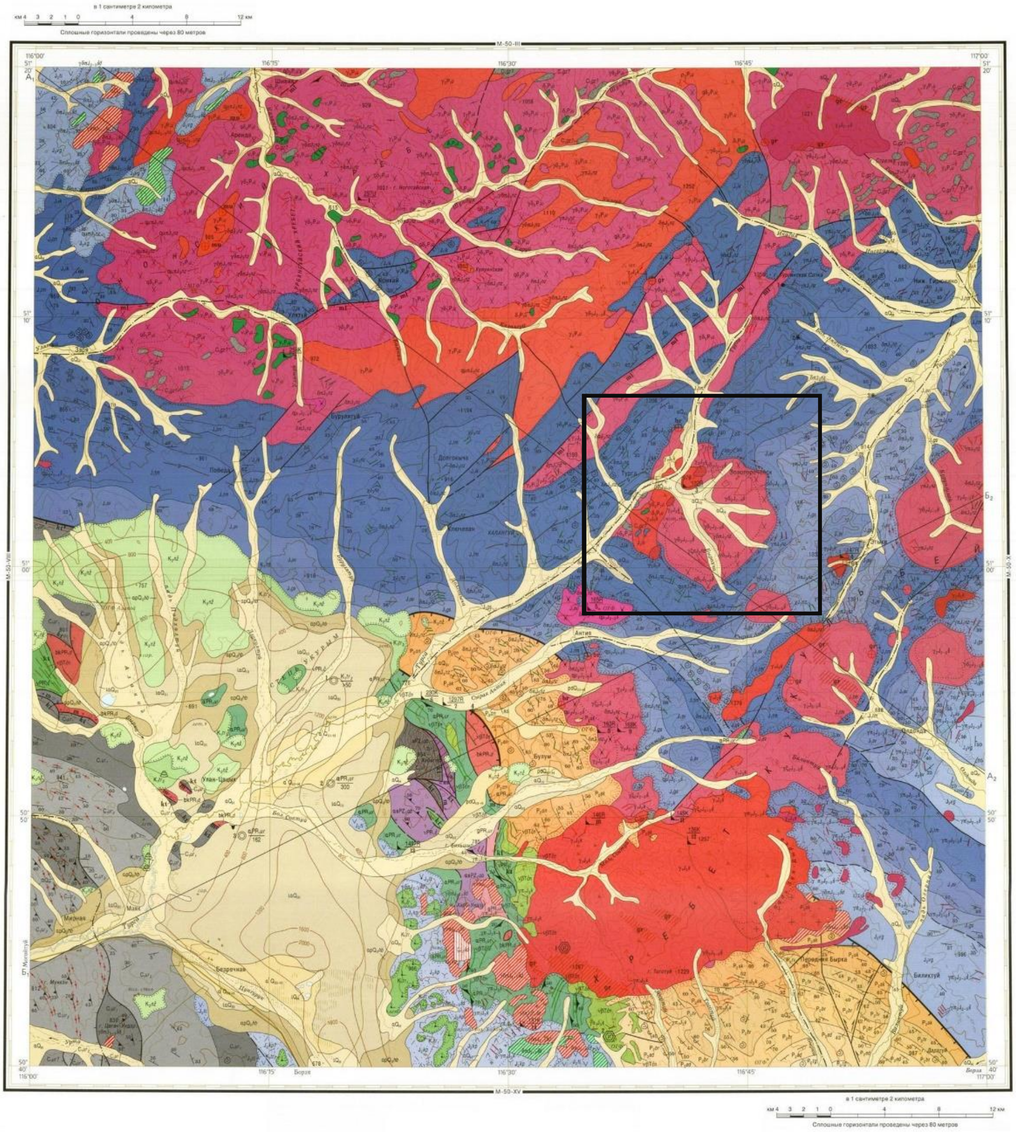
[illegible] 2001) [illegible] (M-50-IX) [illegible]

[illegible] 1980-[illegible]

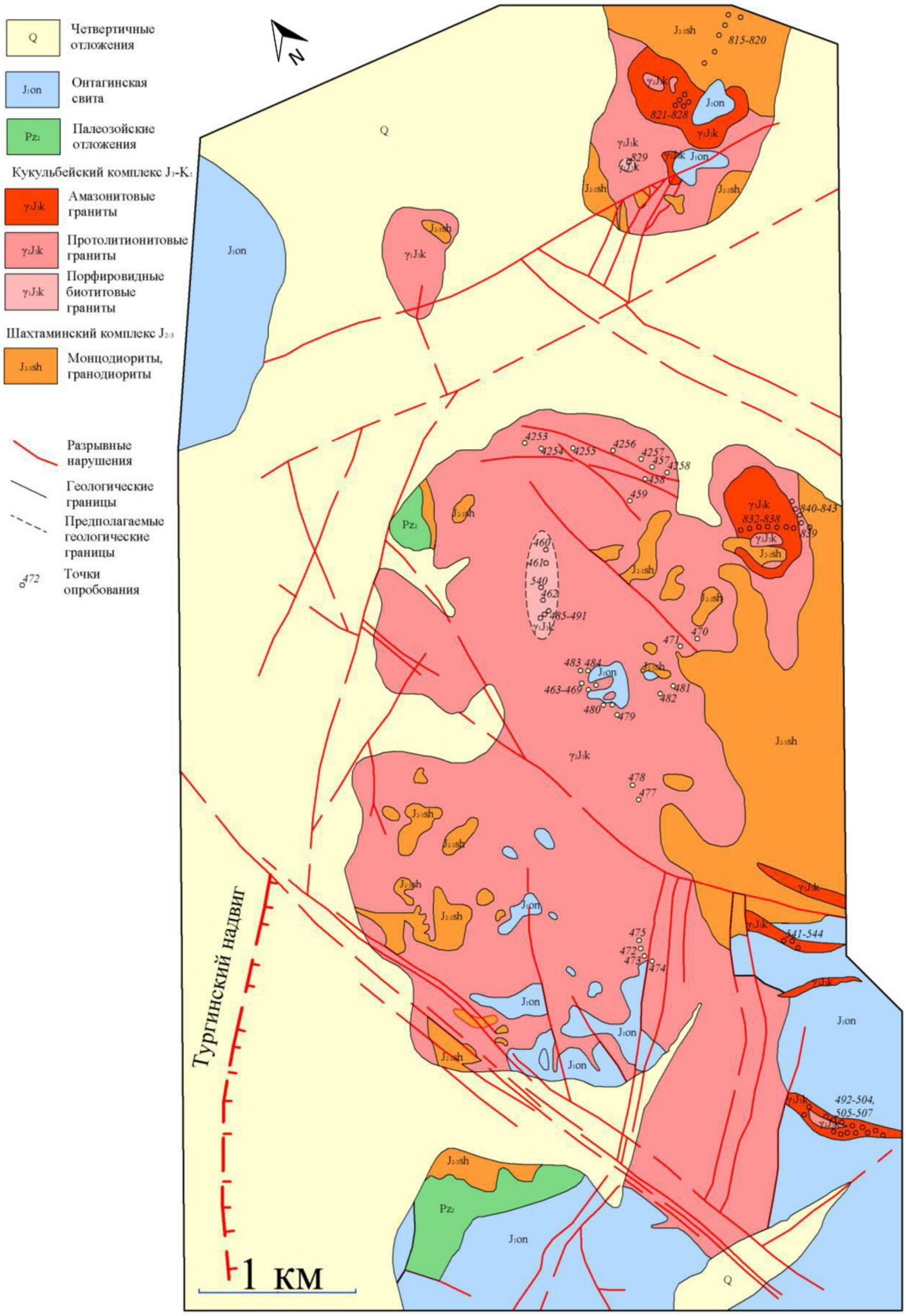
1.3. [illegible]

[illegible] 80 [illegible] (1983).

[illegible] (158 [illegible]) [illegible] (139±2 [illegible]). [illegible] (1983). [illegible] 5.



[illegible] 4. [illegible] 1: 200 000 ([illegible] M-50-IX) «[illegible]» ([illegible]).



[illegible] 5. [illegible] ., [illegible] ., 1983; [illegible] ., 1988, 2009.

[illegible] 2. [illegible]

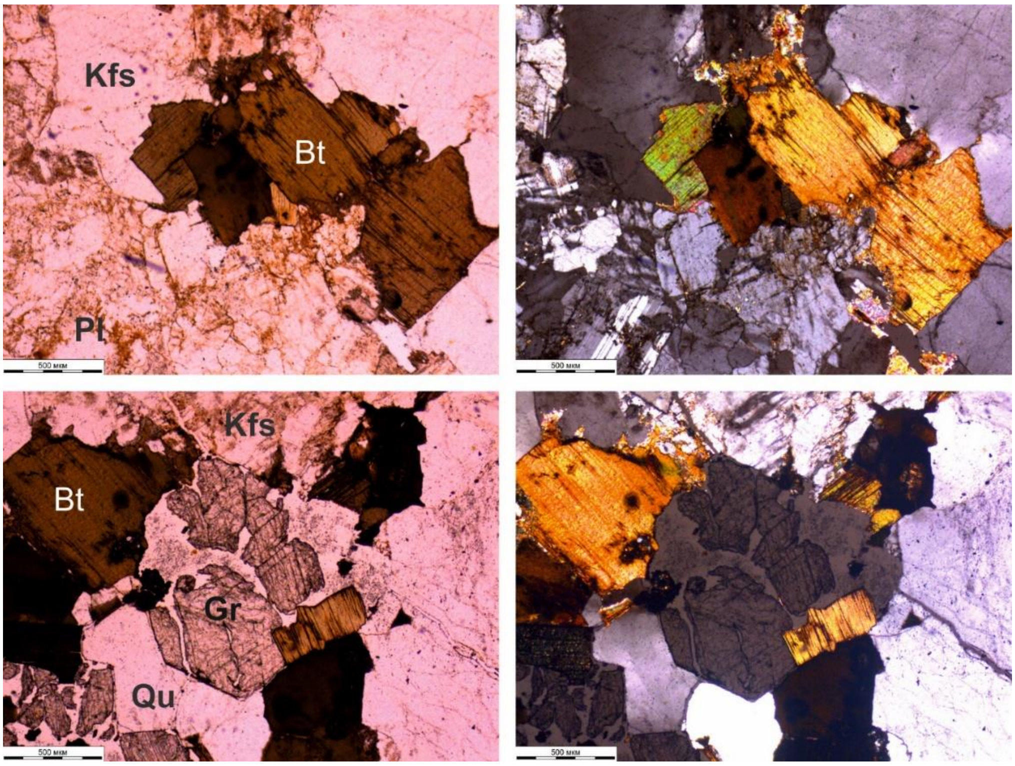
[illegible] (ИГ-829, ИГ-436, ИГ-438), [illegible] (ИГ-841, ИГ-842, ИГ-844) [illegible] (ИГ-826, ИГ-834, ИГ-492, ИГ-494, ИГ-495). [illegible]

2.1. [illegible]

[illegible] (Рис. 6). [illegible] (Qu ≈ 30%), [illegible] (Kfs = 20-30%), [illegible] (Pl = 25-35%), [illegible] (Bt ≈ 5%). [illegible]: Fe-Mn-[illegible], [illegible] 1 [illegible]

[illegible] 6. [illegible] ИГ-829. [illegible]

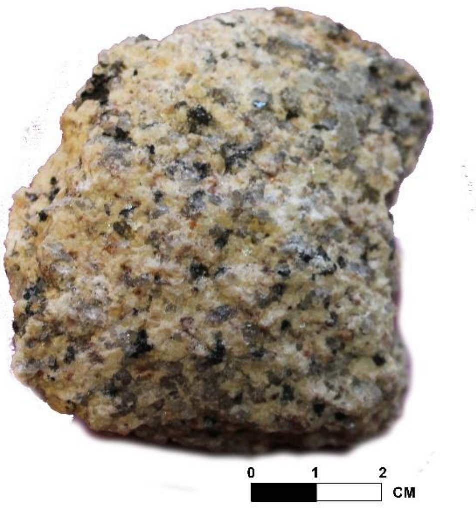
[illegible] An10 [illegible] An18. [illegible] (Рис. 7).



[illegible] 7. [illegible]

2.2. [illegible]

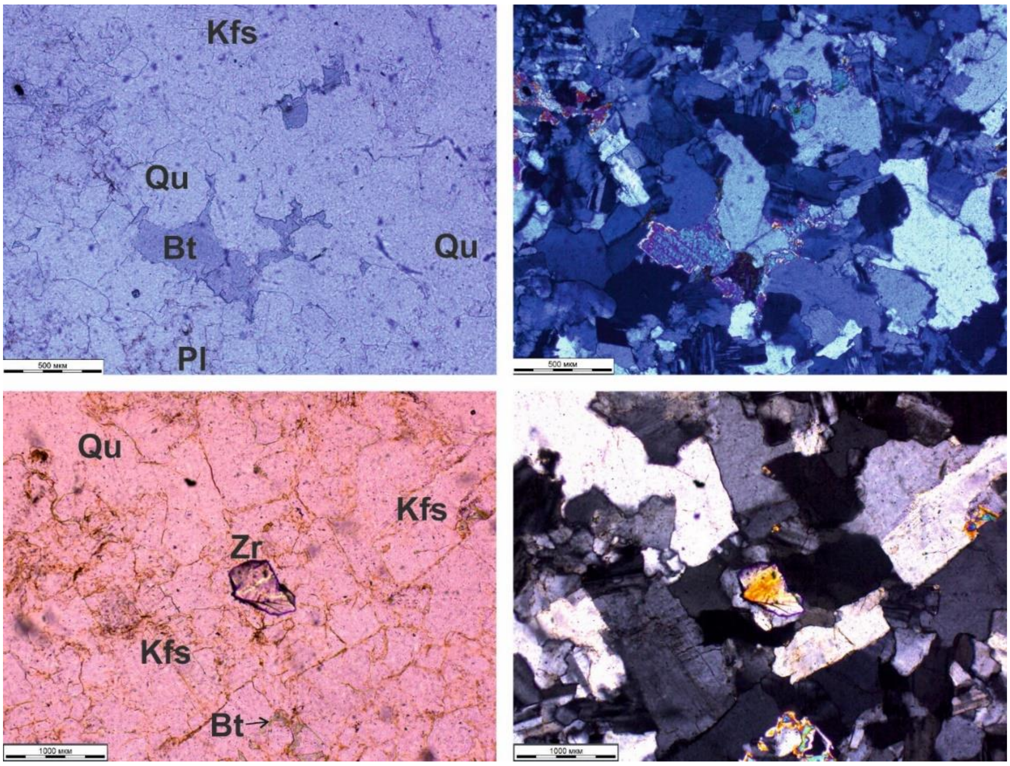
[illegible] 3-5 [illegible]), [illegible] 1 [illegible]) ([illegible] 8).



[illegible] 8. [illegible]-842. [illegible]

[illegible] (Qu = 25-30%), [illegible] (Pl = 35-40%), [illegible] (Kfs = 20-30%), [illegible] (≤5%). [illegible]

[illegible] 1-2 [illegible] An15 [illegible] An5. [illegible] (9).



[illegible] 9. [illegible]

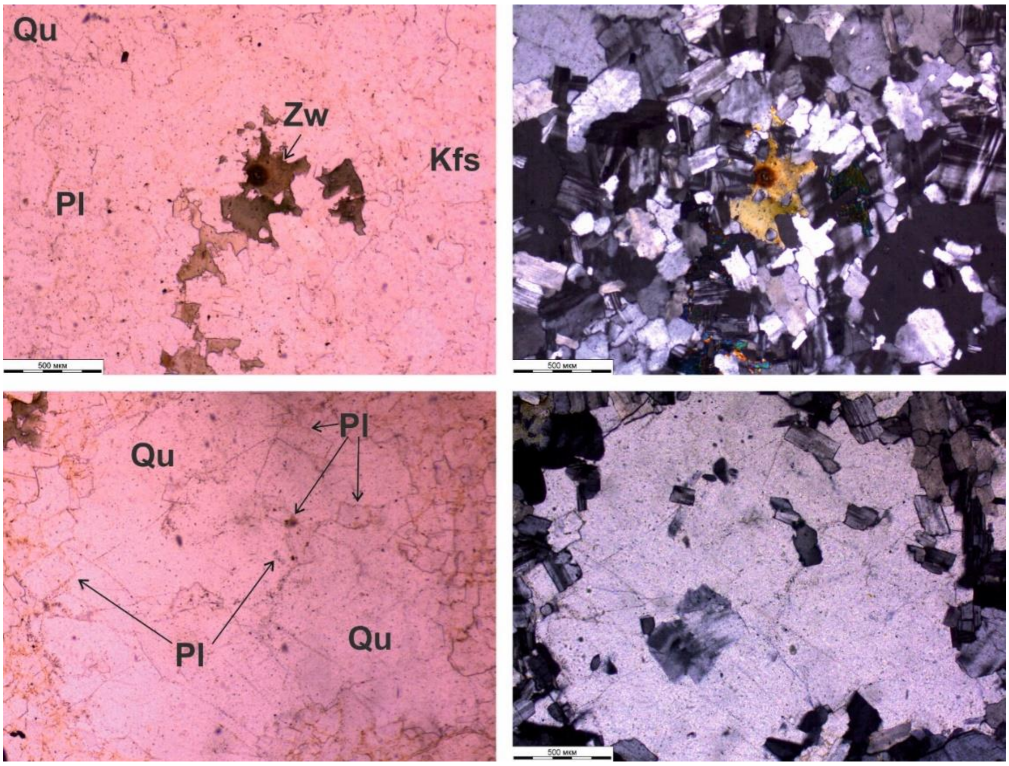
2.3. [illegible]

[illegible] (10 [illegible]), [illegible] (Qu = 35-45%), [illegible] (Ab = 30-40%), [illegible] (Kfs = 20-30%), [illegible] (Zw [illegible] 10%). [illegible] 3 [illegible] ([illegible]-826, [illegible]-834, [illegible]-492), [illegible] 1 [illegible] ([illegible]-495). [illegible]

[illegible] 3 [illegible] 1 [illegible]

[illegible] 10. [illegible]-494. [illegible]

[illegible] «snowball» [illegible] An10 [illegible] An0. [illegible] ([illegible] 11).



[illegible] 11. [illegible]

[illegible] 3. [illegible]

[illegible] (2004). [illegible]

[illegible] Hitachi TM-3000 [illegible] Hitachi S-3400N [illegible]

[illegible] (Fe-Mn)-[illegible] Fe-[illegible] Fe-[illegible] (Y), [illegible] Fe-[illegible]

[illegible] LREE: [illegible] (La,Ce)F_3, [illegible] LREE [illegible] (Ca, Ce, La)$_2$(Al, Fe)$_3$(SiO_4)$_3$(OH), [illegible] - [illegible]-(Ce) Ca(Ce, La)$_2$(CO_3)$_3$$F_2$ [illegible] (Ce,La,Y)CO_3F.

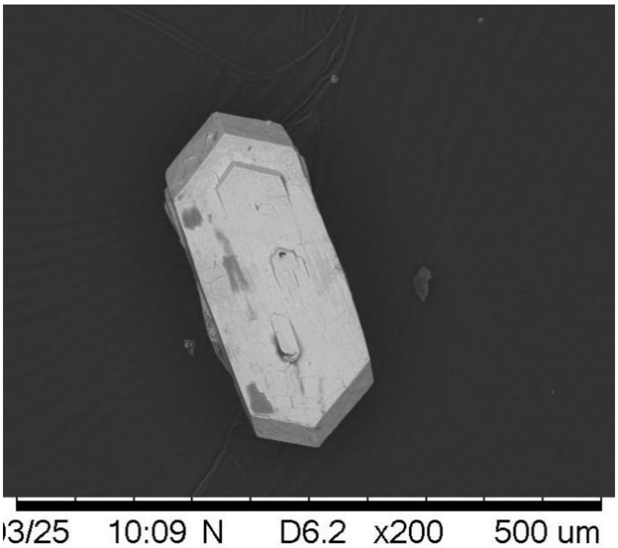
[illegible]

3.1. [illegible]

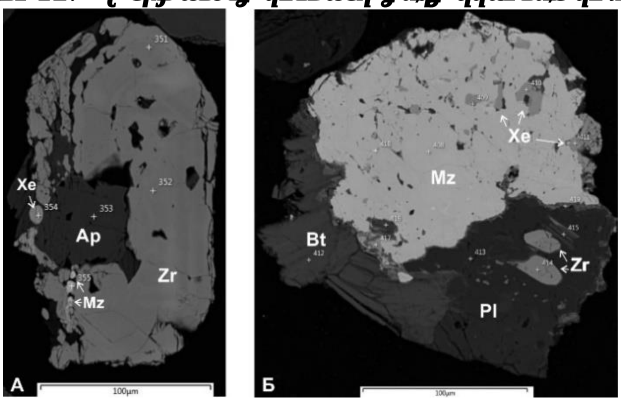
[illegible]

[illegible] (2013). [illegible] BSE-[illegible]

[illegible] (12, 13). [illegible] HfO2 [illegible] 1,2 [illegible] 2,5 [illegible]%, [illegible].



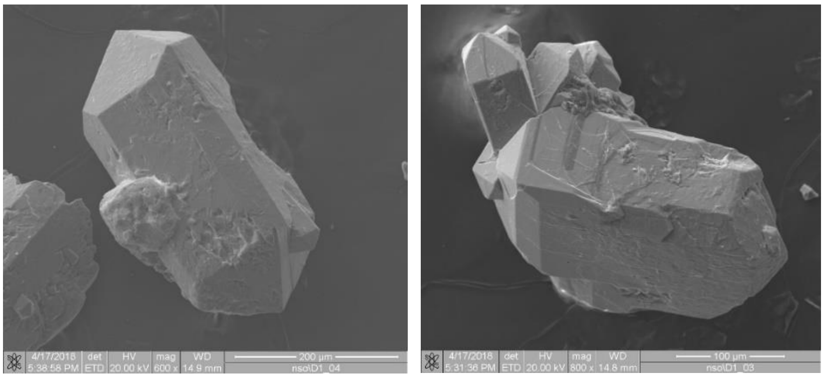
[illegible] 12. [illegible]



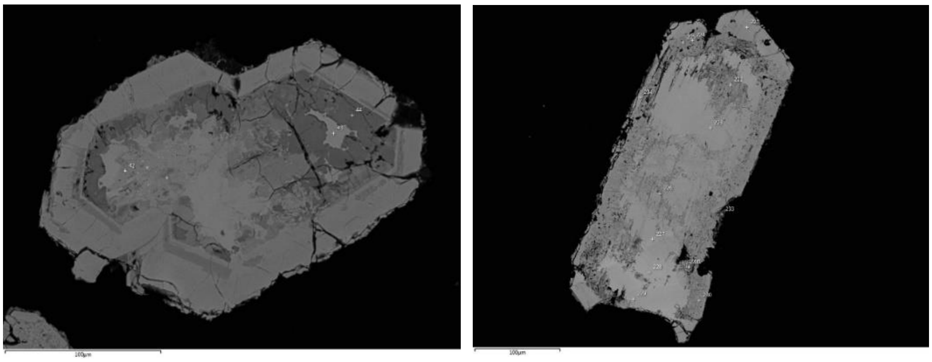
[illegible] 13. [illegible]; [illegible]

[illegible] (14, 15). [illegible] (2015). [illegible] BSE-

[illegible] ([illegible] 13). [illegible] U, Th [illegible] REE, [illegible] Hf [illegible] 2-5 [illegible] % HfO_2, [illegible] 7 [illegible] % [illegible]. [illegible] ThO_2 [illegible] 1-3%, UO_2 [illegible] 2-6%, [illegible] 18%, [illegible]

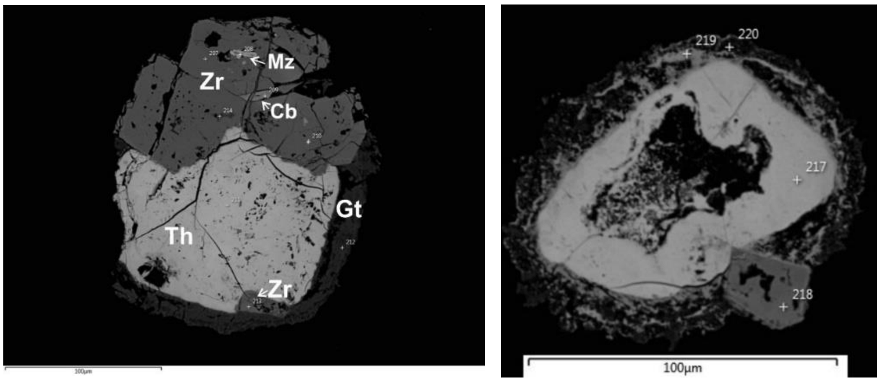


[illegible] 14. [illegible]

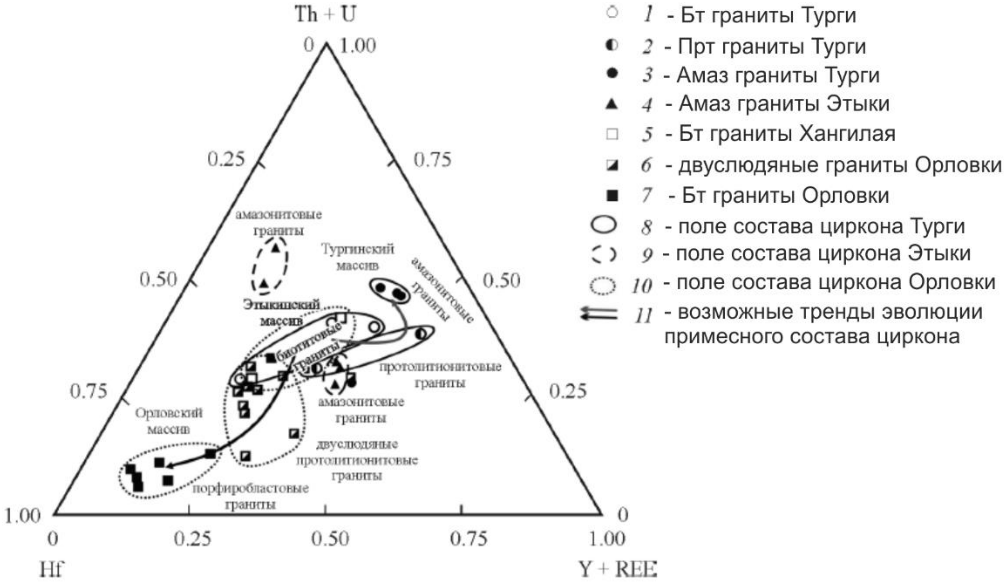


[illegible] 15. [illegible] BSE-[illegible].

[illegible] U, Th [illegible] REE. [illegible] HfO_2 [illegible] 2-5 [illegible] %, [illegible] 7 [illegible] % [illegible]. [illegible] ThO_2 [illegible] 1-3%, UO_2 [illegible] 2-6%, [illegible] 18%, [illegible] ([illegible] 16). [illegible]



[illegible] 16. [illegible] BSE-[illegible].

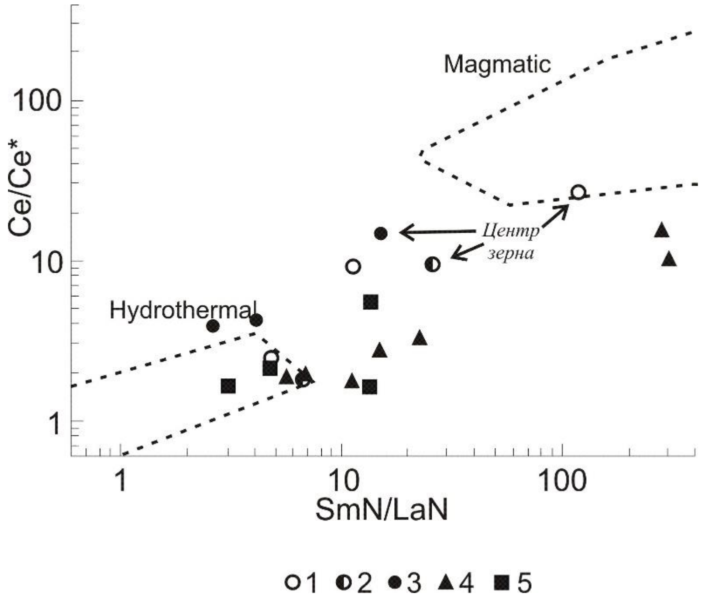


[illegible] 17. [illegible] Th+U, Hf, Y+REE ([illegible], 2013).

[illegible] Hf – Th+U – Y+REE ([illegible] 17). [illegible] U+Th (~ [illegible] 35%). [illegible] Y+REE [illegible] 40 [illegible]%, [illegible] Th+U ([illegible] 45 [illegible]%) [illegible] Y+REE. [illegible]

[illegible] (2011) [illegible] (2018). [illegible] Eu- [illegible] Ce- [illegible]

[illegible] 2011).

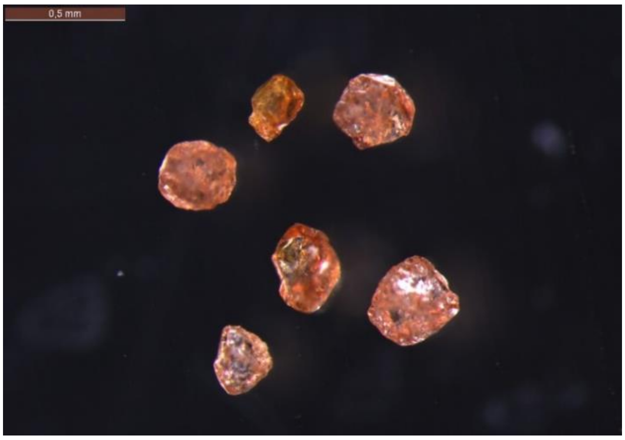


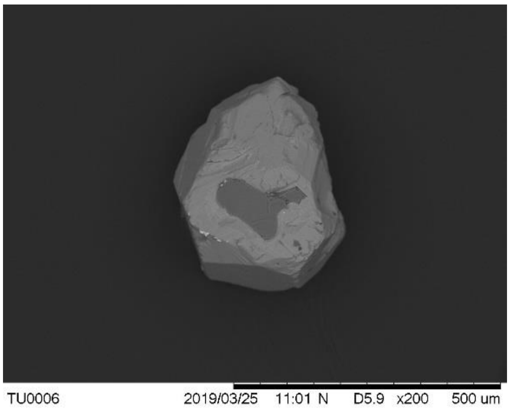
[illegible] 18. [illegible] SmN/Lan [illegible] Ce/Ce, [illegible] (Pelleter et al.,2007). [illegible]-1 [illegible], [illegible]-2 [illegible], [illegible]-3 [illegible]; [illegible]-522, [illegible]-2250 [illegible].*

[illegible] (18), [illegible] Ce/Ce* - $(Sm/La)_N$ [illegible] 2018).

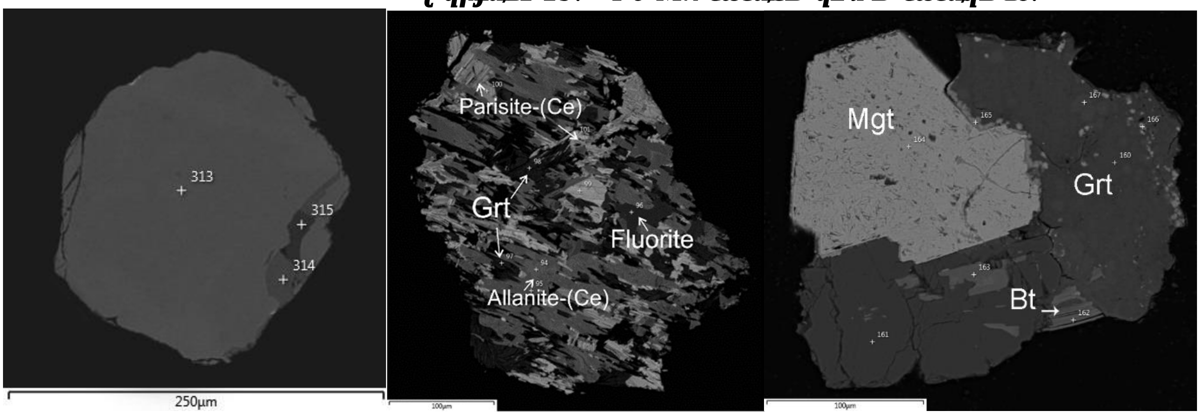
3.2. [illegible]

[illegible] **$(Fe,Mn)_3(Al,Fe)_2[SiO_4]_3$** [illegible] 0,2 [illegible] 0,5 [illegible] (19, 20). [illegible] (20). [illegible] (20).





[illegible] 19. Fe-Mn [illegible].



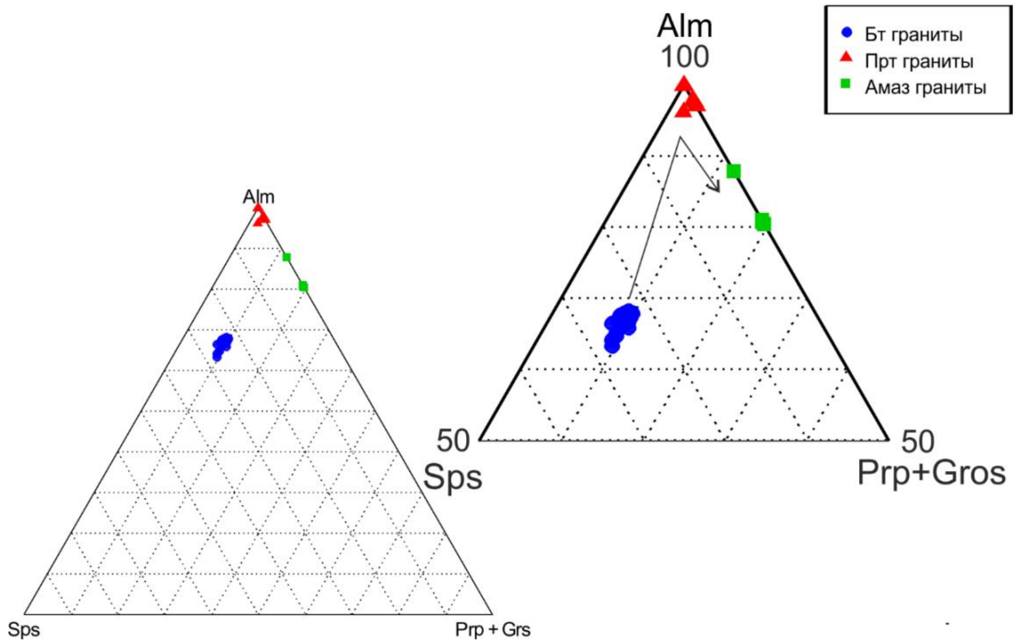
[illegible] 20. [illegible] (BSE-[illegible]).

[illegible] [illegible] (II) [illegible] 63 [illegible] 68%, [illegible] 22,2 [illegible] 27%, [illegible] 2,2 [illegible] 4% [illegible] 4,7 [illegible] 6,6%.

[illegible] 77 [illegible] 96%, [illegible] 0 [illegible] 2%, [illegible]

[illegible] 80-87%, [illegible] 13-20%.

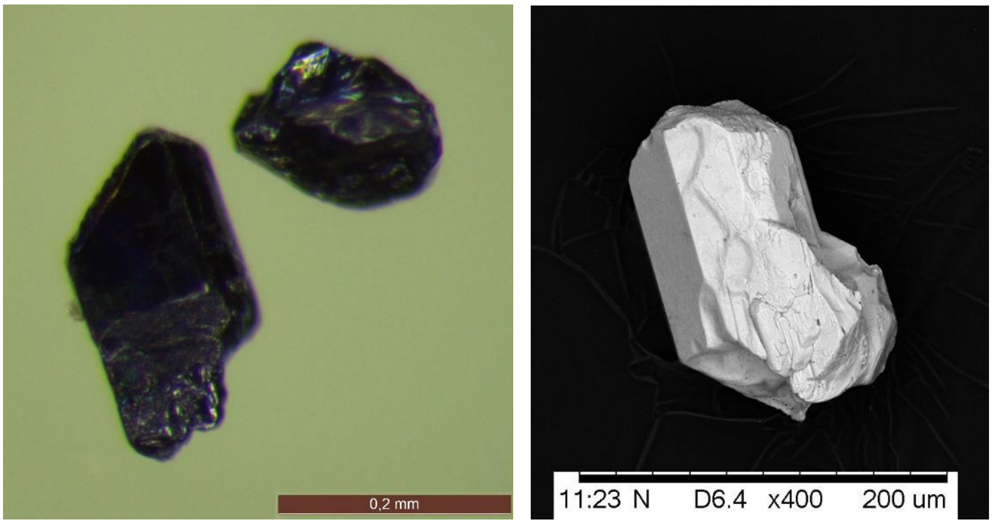
[illegible] 21).



[illegible] 21. [illegible] Alm [illegible] Sps [illegible] Prp+Grs [illegible]

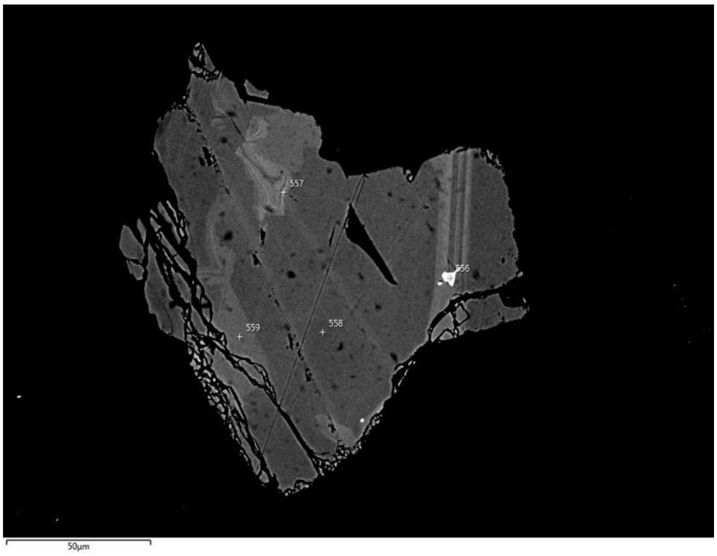
3.3. [illegible]

[illegible] Ta [illegible] Nb [illegible] Li-F [illegible] (1 [illegible]) [illegible] (22) $Fe^{2+}Nb_2O_6$ [illegible] Mn [illegible] Ta. [illegible]

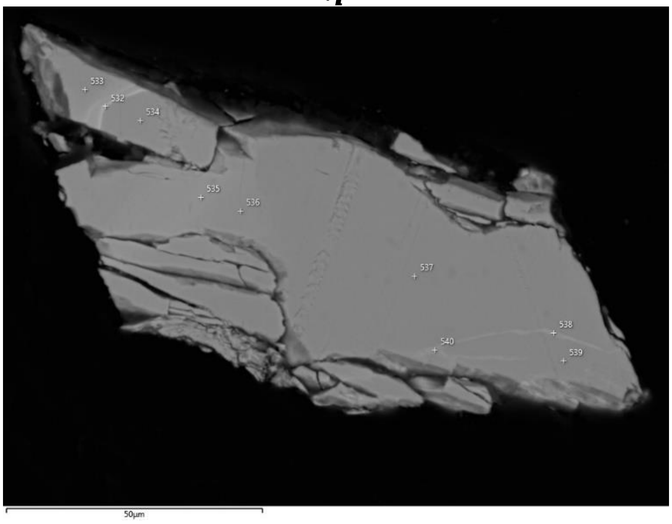


[illegible] 22. [illegible]

[illegible] (23), [illegible] (24). [illegible] Ta [illegible] W, [illegible]



[illegible] 23. [illegible] (556) [illegible].

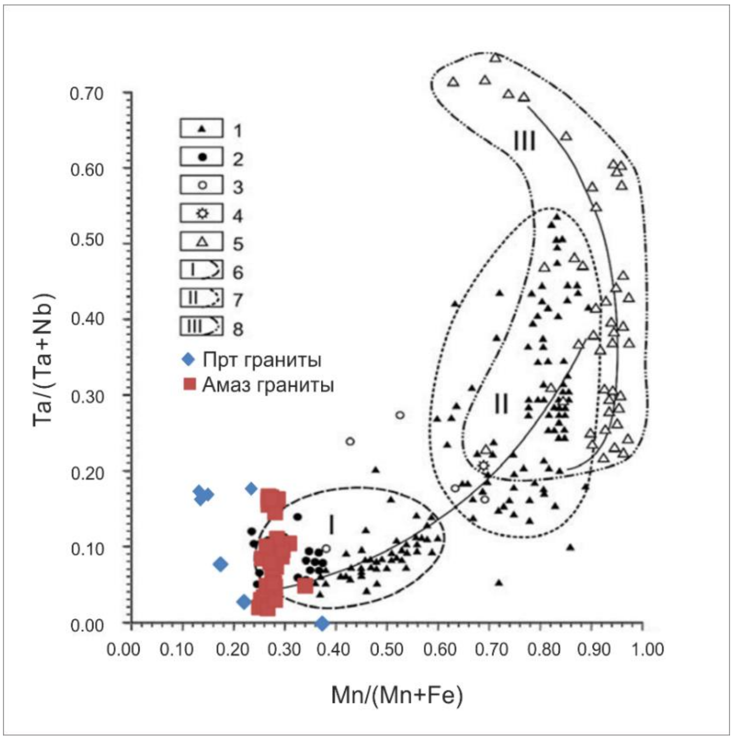


[illegible] 24. [illegible] (?)(Nb,W,Ta,Fe,Mn)2O4 [illegible].

[illegible] (%): Ta_2O_5 0,65–15,06; Nb_2O_5 60,32-73.68; FeO 13.51–17.55; MnO 3.71–8.0; Ta/(Ta+Nb)=0.05–0.17 ([illegible] 0.08), Mn/(Mn+Fe)=0.17–0.37 ([illegible] 0.28). [illegible] 2.86 TiO_2 ([illegible] 1.2) [illegible] 5.41 WO_3 ([illegible] 2.7). [illegible] (1), [illegible] 0.26 [illegible] 0.28 [illegible] 0.04 [illegible] 0.09. [illegible] 1.6 [illegible] 1.1 [illegible]% TiO_2.

[illegible] Ta/(Ta+Nb)=0.04–0.53 ([illegible] 0.2), Mn/(Mn+Fe)=0.29–0.9 ([illegible] 0.66). [illegible] Ta/(Ta+Nb)=0.11, Mn/(Mn+Fe)=0.44 [illegible] (%) [illegible] (0.03 SnO_2), [illegible] (0.42 Sc_2O_3), [illegible] (0.48 WO_3) [illegible] (0.48 TiO_2). [illegible] (Ta/(Ta+Nb)=0.3) [illegible] (Mn/(Mn+Fe) = 0.78), [illegible] (%) [illegible] (0.2 SnO_2), [illegible] (0.75 Sc_2O_3), [illegible] (1.52 WO_3) [illegible] (2.11 TiO_2) ([illegible], 2008).

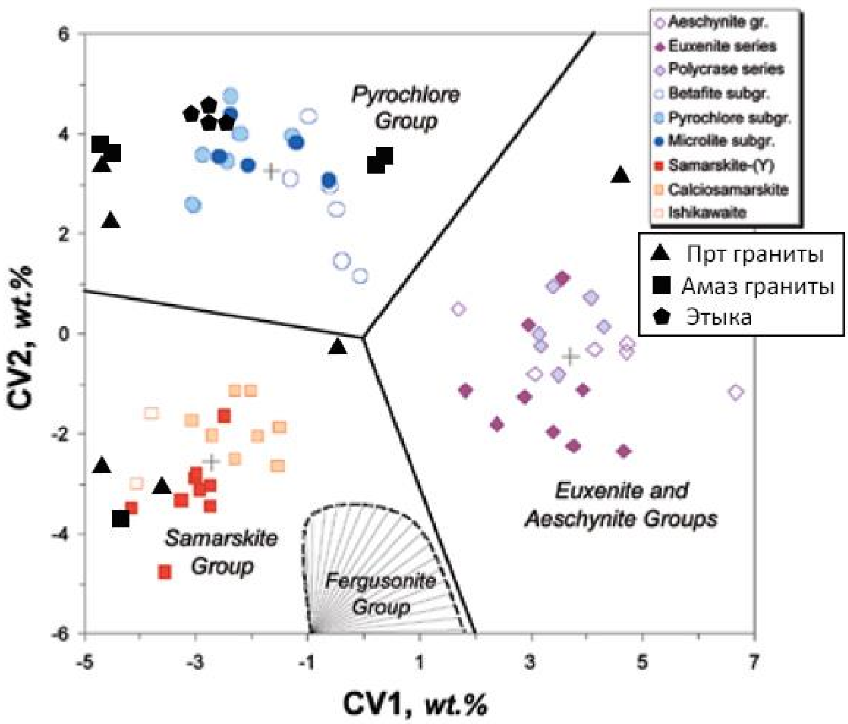
[illegible] ([illegible], 2008). [illegible] ([illegible], 2008). [illegible]



[illegible] 25. [illegible] Ta/(Ta+Nb) – Mn/(Mn+Fe). [illegible]: 1 – [illegible], 2 – [illegible]; 3 – [illegible]: 4 – [illegible], 5 – [illegible]; [illegible]: 6 – [illegible], 7 – [illegible].

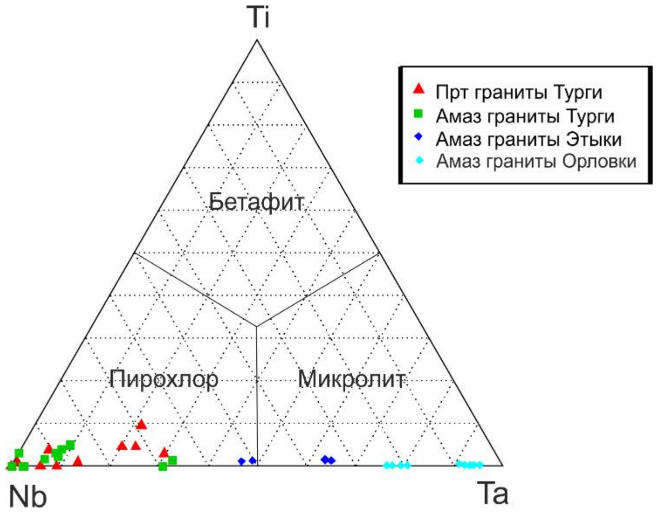
[illegible] U, Nb-[illegible]. [illegible] (Y,REE,U,Th)-(Nb,Ta,Ti) [illegible] A- [illegible] I-[illegible] (Ercit 2006). [illegible]

[illegible] (Ercit, 2006) ([illegible] 26). [illegible] CV1 = 0.245 Na + 0.106 Ca – 0.077 (Fe+Mn) + 0.425 Pb + 0.220 Y + 0.280 LREE+ 0.137 HREE + 0.100 (U+Th) + 0.304 Ti + 0.097 Nb+ 0.109 (Ta+W) – 12.81 ([illegible]% [illegible]), CV2 = 0.102 Na – 0.113 Ca – 0.371 (Fe+Mn) – 0.167 Pb – 0.395 Y – 0.280 LREE – 0.265 HREE – 0.182 (U+Th) – 0.085 Ti – 0.166 Nb – 0.146 (Ta+W) + 17.29 ([illegible]% [illegible]).



[illegible] 26. [illegible] (Y, REE, U, Th)-(Nb, Ta, Ti) [illegible]. [illegible] CV1, CV2 [illegible] 1 [illegible] 2 [illegible].

[illegible] ([illegible] 27).



[illegible] 27. [illegible] (Nb, Ta, Ti) [illegible] (Hogarth,1961).

[illegible] Na [illegible] Si [illegible] Ta ([illegible], 1970). [illegible] Nb, [illegible] Na [illegible].

3.4. [illegible]

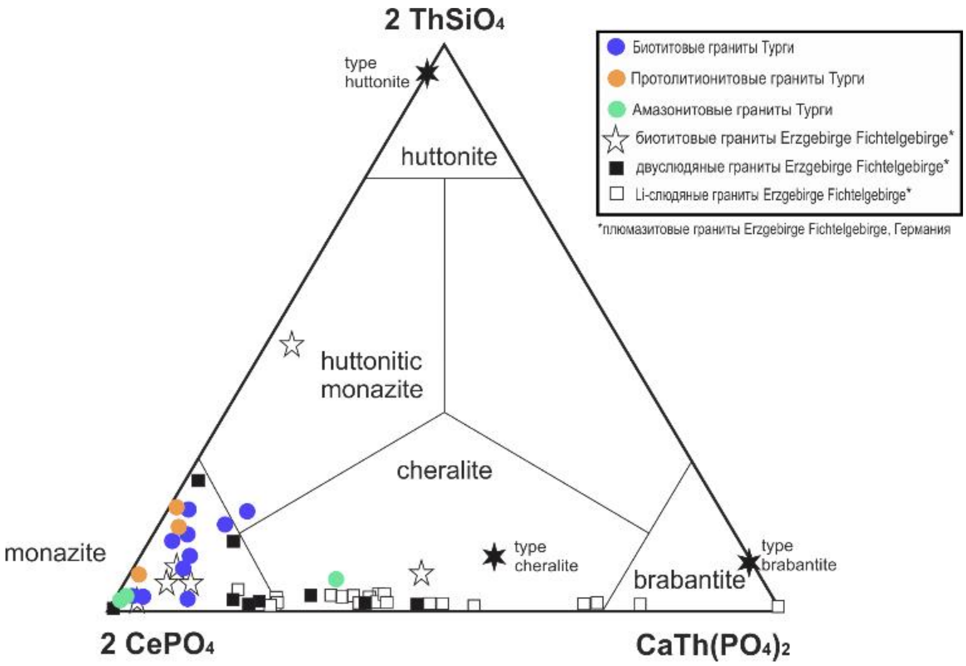
[illegible] LREE [illegible] LREE [illegible] Th [illegible] (22,82 [illegible]%). [illegible] LREE, [illegible] Y. [illegible] (Förster, 1998).

[illegible] ABO_4, [illegible] A = REE, Y, Th, U, Ca, Pb [illegible] B = P, Si. [illegible] 3 [illegible]-Ce ($CePO_4$), [illegible] ($CaTh(PO_4)_2$), [illegible] ($ThSiO_4$), [illegible].

[illegible]

1. [illegible] $[Th^{4+}, U^{4+}, Ca^{2+}]$ [illegible] $2 REE^{3+}$
2. [illegible] $[Th^{4+}, U^{4+}, (SiO_4)^{4-}]$ [illegible] $[REE^{3+}, (PO_4)^{3-}]$.

[illegible] (%) [illegible] 2 $CePO_4$ - $CaTh(PO_4)_2$ – 2 $ThSiO_4$ [illegible] 28). [illegible] Erzgebirge Fichtelgebirge [illegible] Förster, 1998. [illegible] Ce [illegible]

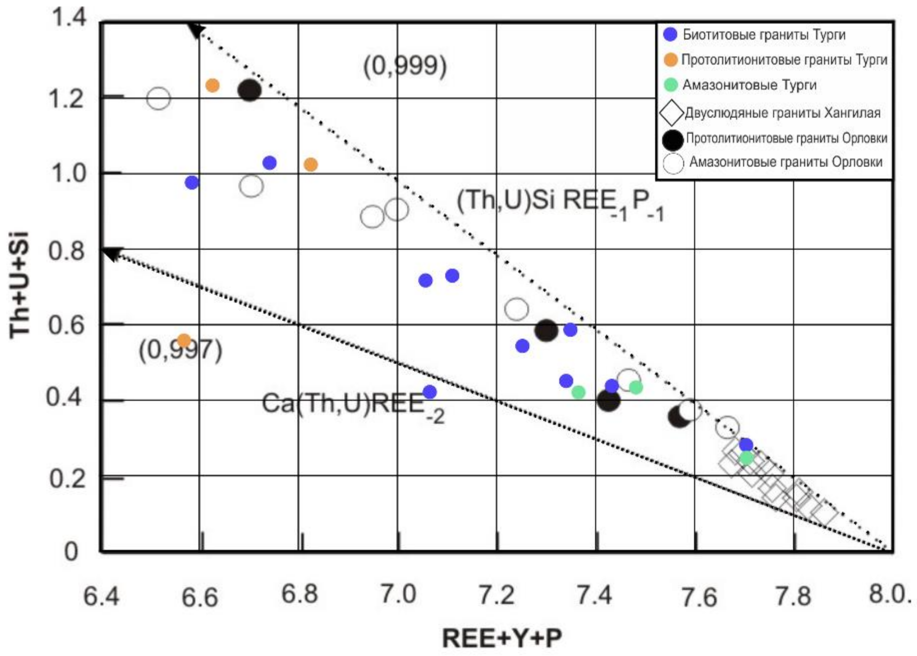


[illegible] 28. [illegible] Erzgebirge Fichtelgebirge ([illegible]).

[illegible] LREE (light rare earth elements) ([illegible] Eu) [illegible] HREE (heavy rare earth elements). [illegible] SiO_2, CaO [illegible] P_2O_5, [illegible] LREE [illegible] Th, [illegible] (Förster,1998).

[illegible] Li-F [illegible] REE [illegible] U [illegible] Th ([illegible] 29). [illegible]

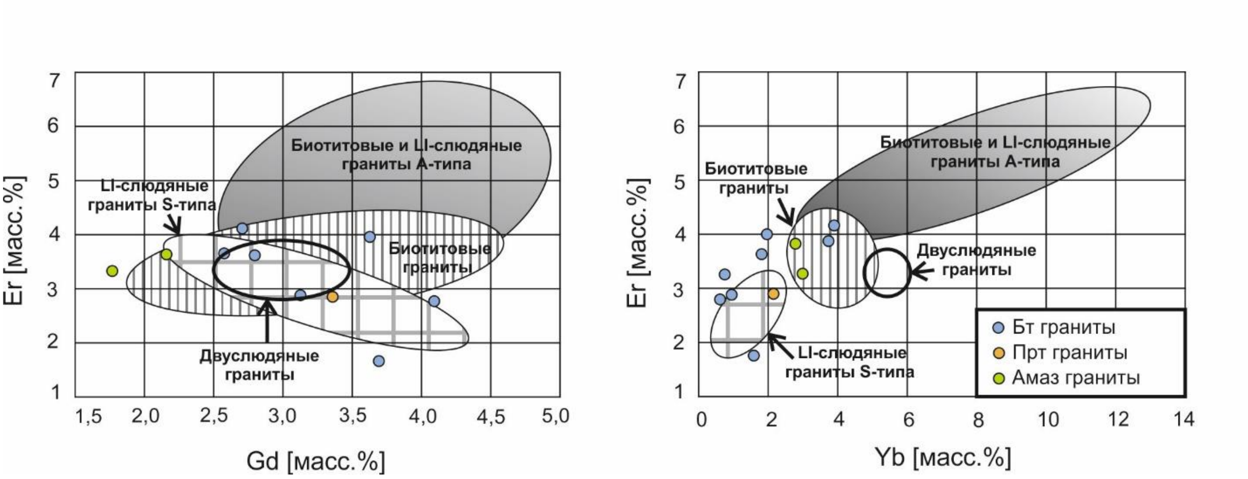
[illegible] (HREE-PO4 ... YPO4 > 90 ...%) [illegible]



[illegible] 29. [illegible] (REE+Y+P) [illegible] (Th+U+Si) [illegible] 16 [illegible]. [illegible] (Th, U) Si $REE_{-1}P_{-1}$ [illegible] Ca(Th, U)REE_{-2} [illegible] (Förster,1998).

[illegible] HREE-PO_4, [illegible] YPO_4 > 90 [illegible]%. [illegible] 70-80 [illegible]% YPO_4 [illegible] 16-25 [illegible]% HREE-PO_4. [illegible]

[illegible] HREE [illegible] Li- [illegible] A- [illegible] (Förster,1998) [illegible] HREE [illegible] (30), [illegible] Er, Gd, Dy [illegible] Er [illegible] Gd [illegible] Er [illegible] Yb [illegible] Li- [illegible] S- [illegible] Li- [illegible] S- [illegible] Li- [illegible].



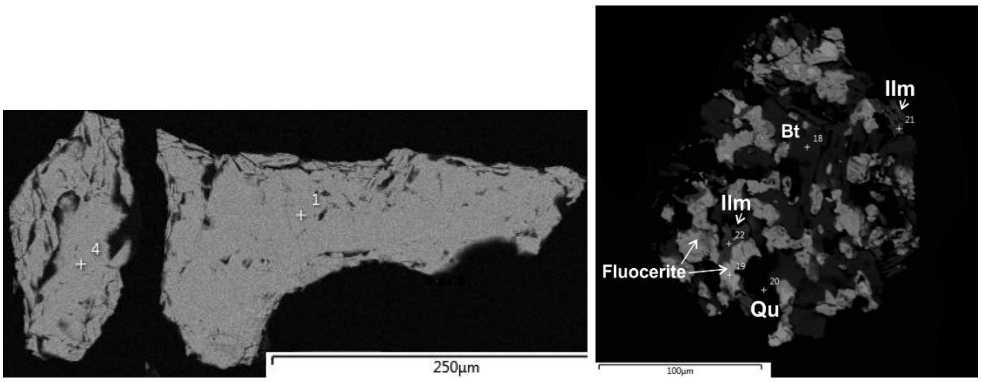
[illegible] 30. [illegible] Er/Gd [illegible] Er/Dy [illegible].

3.5. [illegible]

[illegible] (до 5 [illegible] % Y_2O_3).

[illegible] $(La,Ce)F_3$, [illegible] LREE [illegible] $(Ca, Ce, La)_2(Al, Fe)_3(SiO4)_3(OH)$, [illegible] $(Ce,La,Y)CO_3F$ [illegible] $Ca(Ce, La)_2(CO3)_3F_2$.

[illegible] (рис. 31).

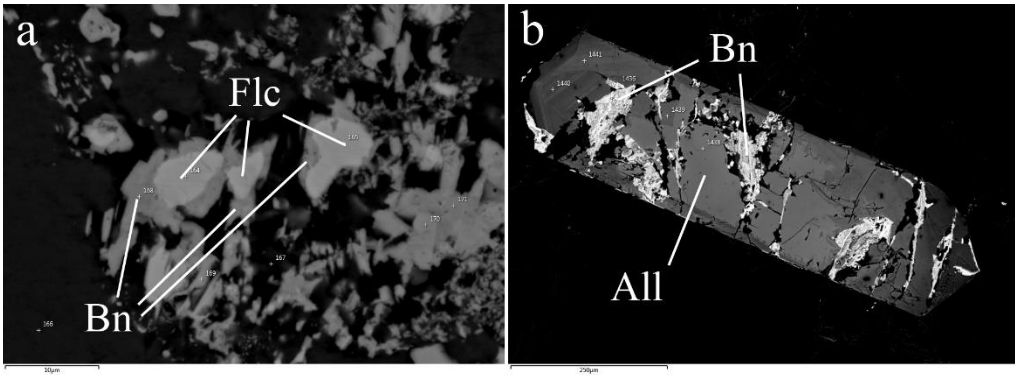


[illegible] 31. [illegible].

[illegible] (31.22-45.63 [illegible] % Ce_2O_3, 9.06-27.44 [illegible] % La_2O_3, 8.16-18.58 [illegible] % Nd_2O_3, 2.57-4.79 [illegible] % Pr_2O_3). [illegible]

[illegible] Th [illegible] 8.23 [illegible] %, Ca [illegible] 2.1 [illegible] %, Si [illegible] 4.26 [illegible] % [illegible] 8 [illegible] %. [illegible] ([illegible], 1973), [illegible] «[illegible]».

[illegible] ([illegible], 1973), [illegible] ([illegible] 32).



[illegible] 32. a – [illegible]; b – [illegible]. Flc – fluocerite, Bn – bastnaesite, All – allanite

[illegible] + [illegible] + [illegible] ([illegible], 1973). [illegible] Ca [illegible] (La,Ce)(CO3)F [illegible] ([illegible], REE-[illegible]) [illegible] REE ([illegible], 1973).

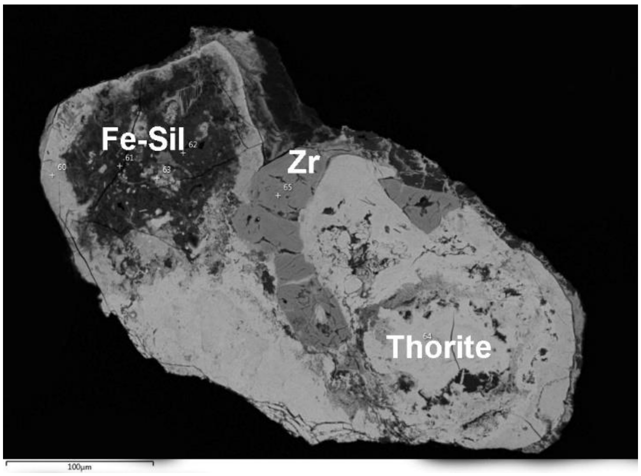
3.6. REE-Y-Th-U-Zr-[illegible]

[illegible] REE-Y-Th-U-Zr-[illegible]: [illegible] $ThSiO_4$, [illegible] $ZrSiO_4$, [illegible] $XePO_4$, [illegible] $U(SiO_4)_{1-x}(OH)_{4x}$, [illegible] $ThSiO_4$ [illegible].

[illegible] (Erzgebirge) [illegible] P, [illegible] I- [illegible] A-[illegible] (Förster, 2006).

[illegible] 40 [illegible] (Förster, 2006).

[illegible] (33), [illegible] 30 [illegible] (34)



[illegible] 33. [illegible]

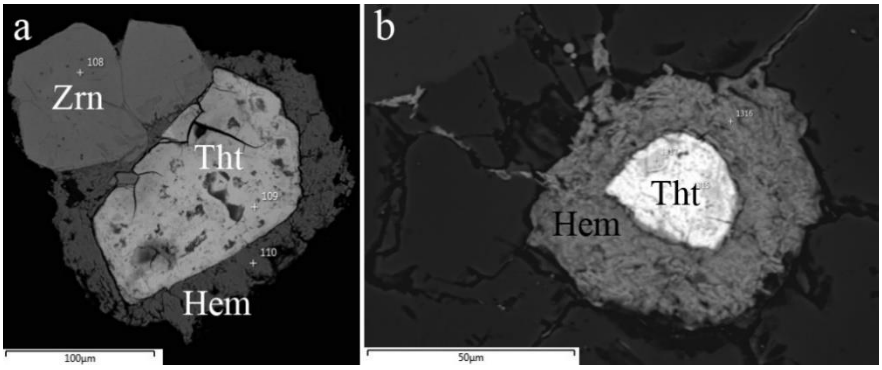


Рисунок 34. [illegible]: a – [illegible]; b – [illegible]; Tht – [illegible], Zrn – [illegible], Hem – [illegible].

[illegible] Th [illegible] LREE ([illegible] 60-90%) [illegible] (Förster, 2006), [illegible] Zr, Th, U, [illegible], Y [illegible] REE-Y-Th-U-Zr-[illegible] (Förster, 2006).

[illegible] Th – Y – Zr – U, [illegible] F, [illegible] Th, Y (HREE), Zr [illegible] U, [illegible] (Förster, 2006).

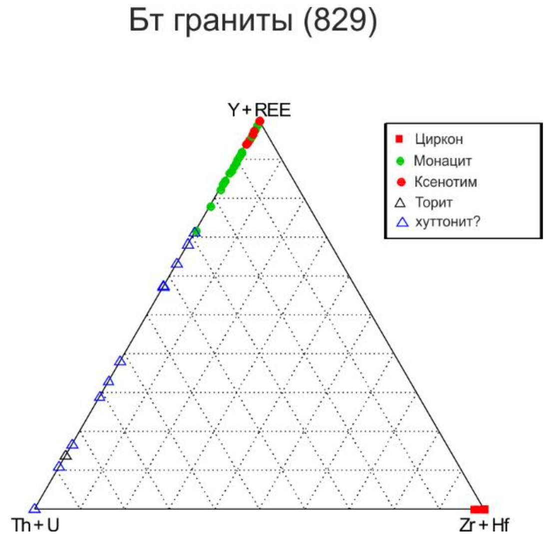


Рисунок 35. [illegible] Th+U – Y+REE – Zr+Hf ([illegible] Förster, 2006).

[illegible] (Ce, LREE)Th[PO_4]SiO_4. [illegible] (рис. 35) [illegible] Th+U [illegible] Y+REE, [illegible]

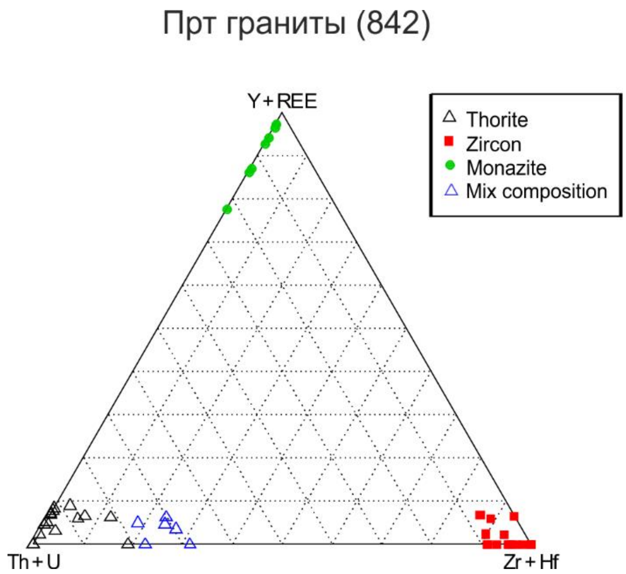


Рисунок 36. [illegible] Th+U – Y+REE – Zr+Hf ([illegible] Förster, 2006).

[illegible] U, Y [illegible] W. [illegible] ~30 [illegible] Fe [illegible] 18 [illegible]% ThO_2, [illegible] (Y, REE, Th, U), [illegible] (рис. 36)

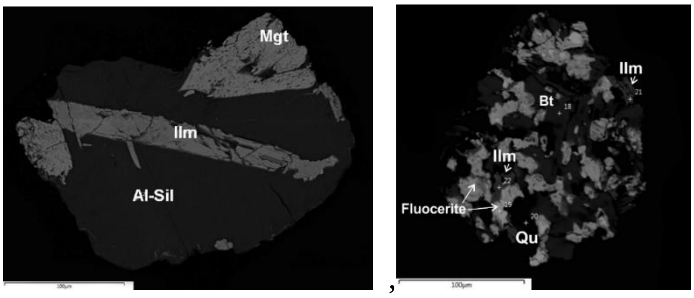
Рисунок 37. [illegible] Th+U – Y+REE – Zr+Hf ([illegible] Förster, 2006).

[illegible] HREE, [illegible]. [illegible] REE, [illegible] ([illegible] 37).

3.7. [illegible]

[illegible] Bt, Qu, Fsp. [illegible] MnO 4-7 [illegible]%. [illegible] 3 [illegible]% ZnO, [illegible] 1-5% [illegible] 15% MnO, [illegible] Nb_2O_5 [illegible] 9 [illegible]%,

[illegible] Zn-[illegible] (2016, Procházka 2010).



[illegible] 38. [illegible].

[illegible] 4. [illegible]

[illegible] PT-[illegible] [illegible] Li-F [illegible] F [illegible] Li [illegible] Zr, Nb, Ta [illegible]

[illegible] :

1. [illegible] Ti [illegible] «Ti-in-Zircon» (Ferry, 2006)
2. [illegible] Zr (Watson, Harrison, 1983)
3. [illegible], 1965);
4. [illegible] Gd [illegible] (Gratz R., Henrich W., 1998).

[illegible] 1. [illegible] Li-F [illegible]

[illegible] 750 °C [illegible] 2 [illegible]

[illegible] Ti [illegible].

[illegible] «Ti [illegible]» (Watson et al., 2006) [illegible] Ti), [illegible] 30 ppm Ti, [illegible] Ti [illegible] 30 ppm. [illegible]:

$$log(Tizrn) = \frac{(6.01 \pm 0,03) - (5080 \pm 30)}{T(K)}$$

[illegible]

[illegible] 1. [illegible] «Ti [illegible]».

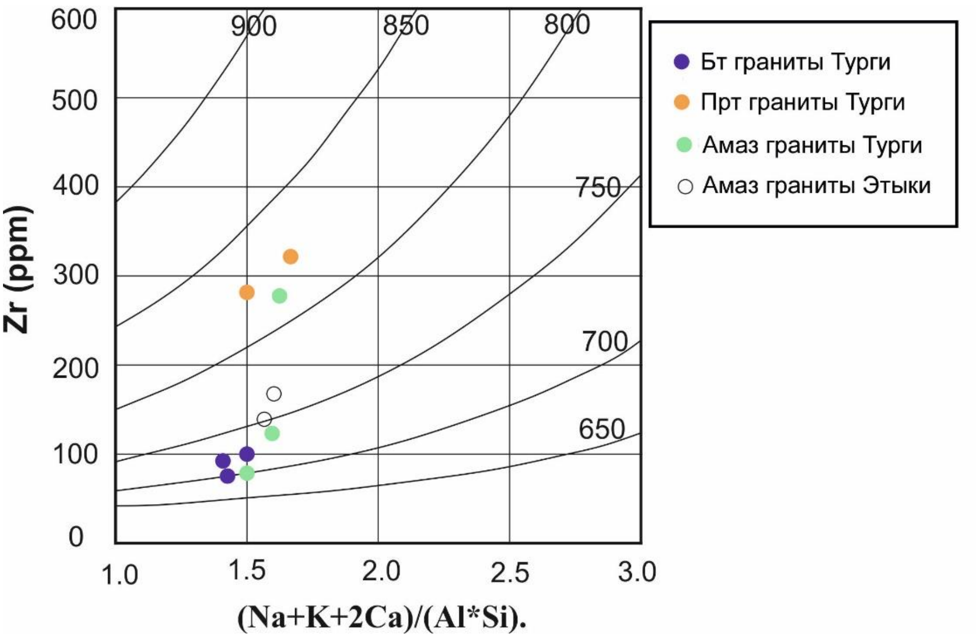
	Ту-835	Э-522		
Ti, ppm	22,04	4, 43	9,18	1,86
T, K	1088	947	1006	885
T, ^{O}C	**815**	**675**	**730**	**610**
		Средняя T^{O}C 671±50		

[illegible]

[illegible] ICP-MS ([illegible]). [illegible] 3, [illegible] Zr - (Na+K+2Ca)/(Al*Si) [illegible] ([illegible]22). [illegible] (≈830 C), [illegible] (700-740 C), [illegible] (700-820 C [illegible], 750-870 C [illegible]).

[illegible] 2. [illegible] (Na+K+2Ca)/(Al*Si) [illegible].

	Бт граниты			Прт граниты		Амаз граниты			Амаз граниты Этыки		
Компонент	**Ту-829**	**Ту-483**	**Ту-470**	**Ту-466**	**Ту-474**	**Ту-494**	**Ту-543**	**Ту- 437**	**Э-493**	**Э-1683**	**Э-1684**
SiO2	75,3	75	75,3	76,1	75,2	75,9	77,6	71	71,3	76	65,3
Al2O3	13,4	13,9	13,6	12,8	12,6	12,8	12,7	16,1	16,6	13,3	15,4
CaO	1,05	0,98	1,01	0,93	1,09	0,92	0,9	0,91	0,94	0,94	1,63
Na2O	3,97	3,71	3,85	3,46	3,99	4,56	5,99	5,85	6,18	3,48	4,17
K2O	4,65	4,99	4,83	5,24	4,91	4,22	1,29	4,57	4,1	4,79	4,69
Na2O+K2O	8,62	8,7	8,68	8,7	8,9	8,78	7,28	10,42	10,28	8,27	8,86
K/Na	0,77	0,89	0,83	1,00	0,81	0,61	0,14	0,51	0,44	0,91	0,74
A/CNK	0,99	1,05	1,02	0,98	0,91	0,93	0,99	0,99	1,02	1,05	1,03
K/(K+Na)	0,44	0,47	0,45	0,50	0,45	0,38	0,12	0,34	0,30	0,48	0,43
(Na+K)/Al	0,86	0,83	0,85	0,89	0,94	0,94	0,89	0,90	0,88	0,82	0,77
(Na+K+2Ca)/(Al*Si)	**1,49**	**1,43**	**1,46**	**1,51**	**1,63**	**1,60**	**1,47**	**1,62**	**1,57**	**1,40**	**1,60**
Zr, ppm	**100**	**71,9**	**92,9**	**279**	**332**	**129**	**74,3**	**278**	**143**	**424**	**167**



[illegible] 39. [illegible] Zr-(Na+K+2Ca)/(Al*Si) [illegible] (Watson, Harrison, 1983).

[illegible]

[illegible] N1 [illegible] N2, [illegible] Na [illegible] Hitachi S-3400N [illegible] Na [illegible] 400°C, [illegible]

[illegible]

[illegible] Gd, [illegible] (Gratz R., Henrich W., 1998):

$$D_{Gd}(T) = -0{,}5886 + 1{,}591 * 10^{-3} * T\ (^{o}C,$$

[illegible] $D_{Gd} = \frac{X_{Gd}monazite}{X_{Gd}xenotime}$, [illegible] $$T\,(^{o}C) = \frac{D_{Gd} + 0{,}5886}{1{,}59 * 10^{-3}}$$

[illegible]

	Бт граниты Турги						Прт граниты
D_{Gd}	1,1383	0,7101	0,5399	0,4816	0,5312	0,7313	1,8632
T °C	**1085**	**815**	**710**	**675**	**700**	**830**	**1540**

[illegible] **800±140.**

[illegible]

[illegible] *3.* [illegible] C°.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
«Ti [illegible]» (Ferry, 2006)	–	–	810	670±50
[illegible] (Watson, Harrison, 1983)	720±20	820±20	750±50	–
[illegible] (Gratz, Heinrich, 1998)	800±140	1540 (?)	–	–
[illegible] ([illegible])	400-450	400-410	400-430	400-410

[illegible] ([illegible], 1979; [illegible], 2002) [illegible] Li-F [illegible] 600-650°C. [illegible]

[illegible]

[illegible] 17 [illegible] LREE, U, F-[illegible] [illegible]-(Ce), [illegible]-(Ce), [illegible] Li-F [illegible].

[illegible] LREE, U, Th [illegible] F. [illegible] U, Nb, Fe, Y, [illegible].

[illegible] Mn [illegible] Ta. [illegible] Li-F [illegible] (1998).

[illegible] (800-1500 C) [illegible] (720-800 C) [illegible] (750-815 C), [illegible] (?) [illegible].

[illegible] Li-F [illegible].

[illegible]

[illegible]

[illegible]:

1. [illegible] 2013, CXLII, [illegible] 3, [illegible] 1-27.
2. [illegible] 1972, 272 [illegible]
3. [illegible] 2009, [illegible] 17, [illegible] 1, [illegible] 28-50.
4. [illegible] CXLVII, [illegible] 6, [illegible] 1-21.
5. [illegible] 3PMO. 2004, [illegible] 6, [illegible] 1-7.
6. [illegible] 1:1000000 [illegible] -49 [illegible] 2012, [illegible] 3-4;
7. [illegible] 2008. [illegible] 43. [illegible] 37-44.
8. [illegible] 1965, [illegible] 49- 60.
9. [illegible] 2002. 357 [illegible]
10. [illegible] 1983, 182 [illegible]
11. [illegible] 1973. [illegible] 22, [illegible] 143-157.
12. [illegible] ZnTiO3 [illegible] XXXIII [illegible] 2016. [illegible] 153-155.

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[illegible]:

1. [illegible], 2011 [illegible]
2. [illegible], 2015, 149 [illegible]

[illegible]:

1. ʌ teʘɢdʒj dʤs dʑʃfɱʆʘɢtsfɱʑʜʘteʃɱʆɘj dʑdʑtsʡ ɢj tsdʑtsɢʗʃɥj fɱʃtsʡ ʢʘtedsʳ M-50-IX // geolkarta.ru
2. ʅ ʙʲ ʷfɱʤʑʃlsj dʑ dʑʘʷ ʟʘʄ ʗfɱʃʘʢ ɢtsfɱʑʜʘteʃɱʆɘj dʑdʑtsʡ ɢj tsdʑtsɢʗʃɥj fɱʃtsʡ ʢʘtedsj, dʑʃfɱʆ M-50-IX (ʂ ʘdʑʘdʑɢdʑʡ). ʉ ɫ ʙ: ʀ ʟʜ-ɘts ʉ ɫ ʙ ʢʘtedstsɢteʘʷ ʗɥ. ʬ-ʢʗ ʅ ʉ ʈ ʇ ʈ ʀ, 2001, 159 fɱ // geokniga.ru

ʉ tʃʗfɱʆʢ lsʘʙdʑʃɥ:

ʊʘʙdʑʃɥʘ1. ʈ ʝ ʟdʑdʑ lsʘdsʳ teʘfɱɥj lsʘlsj dʑʃʝ teʘlsdʑteʄts ɢj tslsj tedʑtsdʑj lstedʑ «Ti ɘ ɥʗteʢtsdʑ».

ʊʘʙdʑʃɥʘ2. ʈ ʘfɱɥʸ ls tslsdʑtsʰ ʝ dʑʃʷ (Na+K+2Ca)/(Al*Si) ɘ teʘʟdʑ ʭ lsʗʄʘʡ ɢteʘdʑʃlstsɘ.

ʊʘʙdʑʃɥʘ3. ʉ ɘtsʜdʑʘʸ lsʘʙdʑʃɥʘʄts teʘfɱɥʗlsʘdʑdʑ dʒlsj dʑʃʝ teʘlsdʑteʘdʒʢ teʗfɱʆʘdʑdʑʃʟʘɥʗʗ ɘ C°.

[illegible]

[illegible] 1. [illegible] Google Earth.

[illegible] 2. [illegible] Google Earth.

[illegible] 3. [illegible] ([illegible], 1977).

[illegible] 4. [illegible] 1: 200 000 ([illegible] M-50-IX) «[illegible]» ([illegible]).

[illegible] 5. [illegible], 1983; [illegible], 1988, 2009.

[illegible] 6. [illegible]-829. [illegible]

[illegible] 7. [illegible]

[illegible] 8. [illegible]-842. [illegible]

[illegible] 9. [illegible]

[illegible] 10. [illegible]-494. [illegible]

[illegible] 11. [illegible]

[illegible] 12. [illegible]

[illegible] 13. [illegible]

[illegible] 14. [illegible]

[illegible] 15. [illegible] BSE-[illegible]

[illegible] 16. [illegible] BSE-[illegible]

[illegible] 17. [illegible] Th+U, Hf, Y+REE ([illegible], 2013).

[illegible] 18. [illegible] SmN/Lan [illegible] Ce/Ce*, [illegible] (Pelleter et al.,2007). [illegible]-1 [illegible], [illegible]-2 [illegible], [illegible]-3 [illegible]; [illegible] -522, [illegible] -2250 [illegible]

[illegible] 19. Fe-Mn [illegible]

[illegible] 20. [illegible] (BSE-[illegible]).

[illegible] 21. [illegible] Alm [illegible], Sps [illegible], Prp+Grs [illegible]

[illegible] 22. [illegible] ([illegible]).

[illegible] 23. [illegible] (Ю556) [illegible].

[illegible] 24. [illegible] (?)(Nb,W,Ta,Fe,Mn)2O4 [illegible].

[illegible] 25. [illegible] Ta/(Ta+Nb) ї Mn/(Mn+Fe). [illegible]: 1 ї [illegible], 2 ї [illegible]; 3 ї [illegible]: 4 ї [illegible], 5 ї [illegible]; [illegible]: 6 ї [illegible], 7 ї [illegible].

[illegible] 26. [illegible] (Y, REE, U, Th)-(Nb, Ta, Ti) [illegible]. [illegible] CV1, CV2 [illegible] 1 [illegible] 2 [illegible].

[illegible] 27. [illegible] (Nb, Ta, Ti) [illegible] (Hogarth,1961).

[illegible] 28. [illegible] Erzgebirge Fichtelgebirge ([illegible]).

[illegible] 29. [illegible] (REE+Y+P) [illegible] (Th+U+Si) [illegible] 16 [illegible] (Th, U) Si $REE_{-1}P_{-1}$ [illegible] Ca(Th, U)REE_{-2} [illegible] (Förster,1998).

[illegible] 30. [illegible] Er/Gd [illegible] Er/Dy [illegible].

[illegible] 31. [illegible].

[illegible] 32. a ї [illegible] b ї [illegible] Flc ї fluocerite, Bn ї bastnaesite, All ї allanite

[illegible] 33. [illegible].

[illegible] 34. [illegible]: a ї [illegible] b ї [illegible]; Tht ї [illegible], Zrn ї [illegible], Hem ї [illegible].

[illegible] 35. [illegible] Th+U ї Y+REE ї Zr+Hf ([illegible] Förster, 2006).

[illegible] 36. [illegible] Th+U ї Y+REE ї Zr+Hf ([illegible] Förster, 2006).

[illegible] 37. [illegible] Th+U ї Y+REE ї Zr+Hf ([illegible] Förster, 2006).

[illegible] 38. [illegible].

[illegible] 39. [illegible] Zr-(Na+K+2Ca)/(Al*Si) [illegible] (Watson, Harrison, 1983).

[illegible]

Ab – [illegible]

An – [illegible]

BSE – [illegible]

Bt - [illegible]

CL – [illegible]

Pl – [illegible]

Qu – [illegible]

Zw - [illegible]

[illegible] – [illegible]

[illegible] – [illegible]

[illegible] – [illegible]

[illegible] – [illegible]

[illegible] - [illegible]

[illegible] – [illegible]

[illegible], REE – [illegible]

[illegible] – [illegible]