

Table S1 Used reference materials and analytical lines

Element	Analytical line	Spectrometer	Reference material	σ	Detection limit* [wt%]
W	M α	TAP	CaWO ₄	0.02-0.09	0.04-0.17
W	M β **	TAP	CaWO ₄		
U	M β	PET	Vorlanite	0.21-0.34	0.06-0.20
U	M β	PET	UO ₂ -synt		
P	K α	PET	Apatite	0.01-0.02	0.01-0.10
Nb	L α	PET	Nb	0.11-0.21	0.04-0.13
Ta	M α	TAP	Ta	0.03-0.08	0.03-0.08
Si	K α	TAP	Diopside	0.01-0.20	0.01-0.20
Ti	K α	PET	Rutile	0.01-0.04	0.01-0.04
Zr	L α	PET	Zircon	0.05-0.11	0.05-0.11
Sn	L α	PET	Cassiterite	0.03-0.09	0.03-0.09
Th	M α	PET	ThO ₂ -synt	0.06-0.22	0.06-0.22
Al	K α	TAP	Orthoclase	0.01-0.16	0.004-0.19
Sc	K α	PET	Sc	0.01	0.01
Fe	K α	LIF	Fe ₂ O ₃	0.03-0.09	0.03-0.09
Y	L α	TAP	Y ₃ Al ₅ O ₁₂	0.01-0.58	0.01-0.58
La	L α	PET	LaB ₆	0.04-0.11	0.04-0.11
Ce	L α	PET	CeP ₅ O ₁₄	0.04-0.12	0.04-0.12
Pr	L β	LIF	PrP ₅ O ₁₄	0.01-0.28	0.09-0.28
Nd	L β	LIF	NdP ₅ O ₁₄	0.10-0.31	0.10-0.31
Sm	L α	LIF	REE3***	0.07-0.23	0.07-0.23
Eu	L β	LIF	REE2***	0.22-0.72	0.22-0.72
Gd	L α	LIF	GdP ₅ O ₁₄	0.06-0.25	0.06-0.25
Tb	L α	LIF	REE4***	0.16-0.54	0.16-0.54
Dy	L β	LIF	REE1***	0.05-0.80	0.05-0.92
Ho	L β	LIF	REE2***	0.27-0.44	0.27-0.40
Er	L α	LIF	REE1***	0.12-0.39	0.13-0.38
Tm	L α	LIF	REE2***	0.18-0.61	0.18-0.60
Yb	L α	LIF	REE3***	0.10-0.44	0.10-0.44
Lu	L α	LIF	REE4***	0.23-0.71	0.22-0.71
Bi	M α	PET	Bi ₂ Te ₃	0.01-0.11	0.10-0.11
Mg	K α	TAP	Diopside	0.01-0.02	0.01-0.02
Ca	K α	PET	Diopside	0.01-0.03	0.01-0.03
Mn	K α	LIF	Rhodonite	0.03-0.09	0.03-0.09
Sr	L α	TAP	SrTiO ₃	0.027	0.03
Pb	M α	PET	PbS	0.07-0.26	0.08-0.26
Na	K α	TAP	Albite	>0.01	>0.01
F	K α	TAP	Phlogopite	0.04-0.074	0.04-0.07

*Calculated by the electron probe micro-analyser software for the low and high beam current used in analysis

**W M β line was used in analyses pyrochlores containing significant amount of Ta due to coincidence W M α with Ta M β line.

***REE1-REE4 are synthetic reference glasses containing appropriate lanthanides (Drake and Weill 1972)

Table S2 Published chemical compositions of U-rich pyrochlore-group minerals and liandratite

A										B				
Constituents	Timofeev & Williams-Jones (2015)	Chakmourandian and Mitchel (2002)		Caprilli et al. (2006)	Caprilli et al.(2006)	Monchoux et al. (2006)	Uher et al. (1998)	Zurevinski and Mitchel (2004)	Hogarth (1989)	Mücke and Strunz (1978)	Lumpkin and Ewing (1996)	Abd El-Naby 2009		
	Uranopyrochlore	Khibina 9	Lovoziero 5	SFA1	SFP1	PE33	B14.2	J	1	II	205, 6	1	3	6
WO ₃					2.47									
UO ₃										48.73	54.87*	60.39	53.24	55.20
Nb ₂ O ₅	43.50	25.11	46.00	32.06	23.17	45.49	14.52	37.62	32.30	36.22	25.2	10.17	6.82	8.11
Ta ₂ O ₅	0.68	0.93	1.57	0.44	0.70	1.60	28.05		15.76	15.05	2.37	b.d.	0.39	0.15
SiO ₂	2.43	6.10		0.00	0.07			2.34				3.34	3.41	4.85
TiO ₂	2.67	4.76	9.45	14.53	19.73	8.00	12.60	11.84	9.27		6.48	9.45	9.28	8.03
ZrO ₂				1.56	0.00				0.28		0.10	1.89	4.11	7.16
HfO ₂												b.d.	0.05	b.d.
SnO ₂				0.09	0.58		0.77							
ThO ₂	0.09			0.44	0.51	1.59			0.07		1.19	0.01	b.d.	b.d.
UO ₂	26.80	46.2	26.35	27.33	30.43	28.32	26.64	27.98	26.44					
Al ₂ O ₃		1.82									0.79	0.12	0.20	0.37
V ₂ O ₃												1.37	1.07	0.86
Fe ₂ O ₃ **		0.41	0.07	0.98	0.34	0.80		2.23	0.64			1.23	0.89	1.04
Sb ₂ O ₃				0.19	0.15		0.00							
Y ₂ O ₃	1.44			0.01	0.22	0.13			0.17		0.18	b.d.	0.10	0.28
La ₂ O ₃	0.24	0.31	2.04	0.13	0.17	0.20			0.12					
Ce ₂ O ₃	1.04	1.97	3.52	0.45	0.82	1.43		2.08	0.21					
Pr ₂ O ₃	0.15					0.06					0.87			
Nd ₂ O ₃	0.88		0.47			0.73			0					
Sm ₂ O ₃						0.58								
CaO	4.79	3.94	2.69	14.52	10.78	8.9	9.91	15.74	8.69		0.26	3.44	4.04	3.79
MgO											0.02			
MnO	0.14	0.81		0.16	0.60		0.26				0.14			
FeO**	4.97						0.32				1.40			
SrO		0.59	1.91	0.00	0.00		0.06		0.16					
BaO											0.89			
PbO	0.72			0.00	0.00	0.46	0.19				2.10	2.00	1.34	1.26
Na ₂ O	0.27		1.01	2.42	3.19		2.97	0.79	5.29					
K ₂ O	0.09			0.06	0.17		0.09				0.70			
F				0.29	0.12		0.43		0.19		0.27			
O=F ₂				-0.12	-0.05	0.00	-0.18		-0.08		-0.11			
Total	90.90	92.95	95.08	95.54	94.017	98.29	96.63	100.62	99.51	100.00	97.72	94.62	85.99	92.87

Table S2 (continued)

All values are quoted in wt%

A – U-rich pyrochlore-group minerals

B – liandratite

*Recalculated as UO₃;

**Total Fe assumed to be FeO or Fe₂O₃ dependent on originally published

b.d. – below detection limit

References

Drake MJ, and Weill DF (1972) New rare earth element standards for electron microprobe analysis. Chem Geol 10:179–181