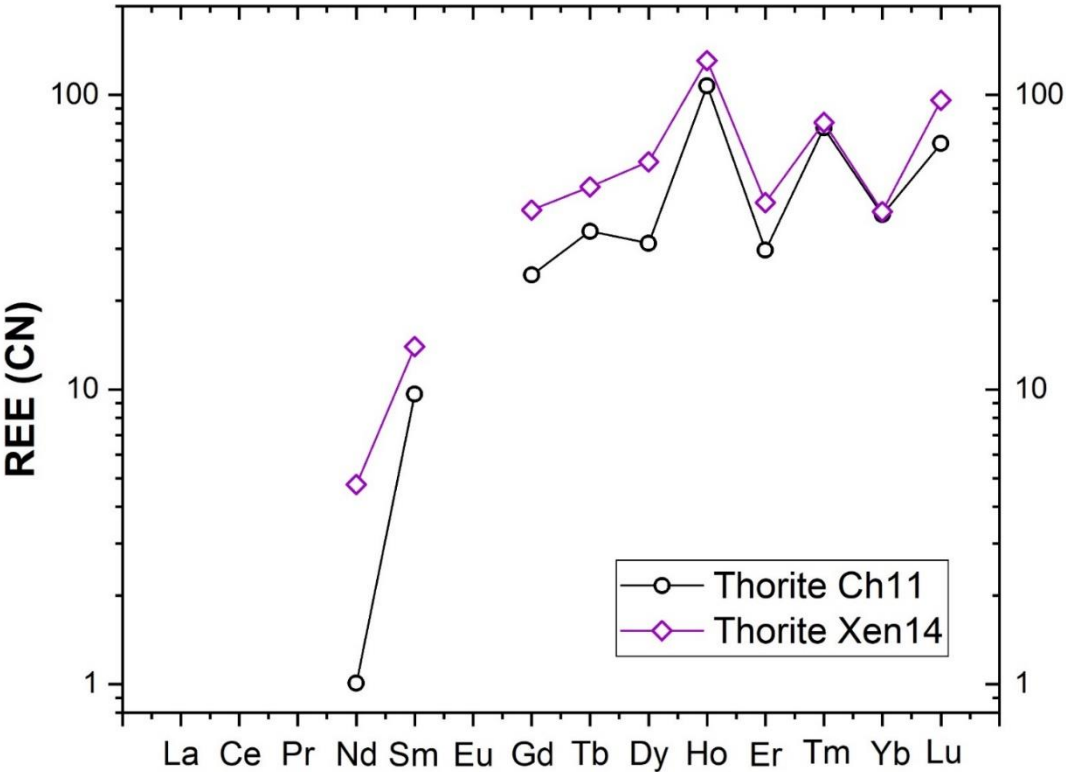


**Fig. S1.** Average concentration of REE (normalized to the CN-1 chondrite, after Wasson and Kallemeyn (1988)), for the ThSiO<sub>4</sub> grains included into Ch11 and Xen14 samples.



6 **Table S1.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
7 EPMA-WDS data points of the Mon1 sample.

	Mon1-1	Mon1-2	Mon1-3	Mon1-4	Mon1-5	Mon1-6	Mon1-7	Mon1-8	Mon1-9	Mon1-10
As <sub>2</sub> O <sub>5</sub>	0.20	0.22	0.12	0.12	0.1	0.18	0.13	0.1	0.23	0.11
P <sub>2</sub> O <sub>5</sub>	29.00	28.33	28.39	28.94	28.81	28.55	28.47	28.69	28.40	28.83
SiO <sub>2</sub>	0.15	0.09	0.05	0.09	0.11	0.37	0.35	0.34	0.31	0.26
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
CaO	1.16	1.65	1.59	1.61	1.23	1.52	1.55	1.38	1.44	0.88
Y <sub>2</sub> O <sub>3</sub>	1.00	0.76	0.75	0.65	0.70	1.08	1.00	1.12	0.99	0.96
La <sub>2</sub> O <sub>3</sub>	12.35	13.98	14.59	14.19	14.76	12.12	12.44	12.40	12.77	12.77
Ce <sub>2</sub> O <sub>3</sub>	29.82	30.88	30.00	30.37	31.23	28.97	29.07	29.22	28.77	30.52
Pr <sub>2</sub> O <sub>3</sub>	3.26	2.79	3.44	3.28	3.45	3.39	3.35	3.31	3.11	3.36
Nd <sub>2</sub> O <sub>3</sub>	14.36	12.79	12.31	12.15	12.46	13.06	12.55	13.23	12.98	13.39
Sm <sub>2</sub> O <sub>3</sub>	3.21	2.18	2.07	2.15	2.16	2.56	2.67	2.70	2.68	2.63
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	2.33	1.69	1.33	1.74	1.51	2.24	1.89	2.18	1.97	1.86
Tb <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Dy <sub>2</sub> O <sub>3</sub>	0.19	0.26	0.28	0.18	0.19	0.47	0.66	0.41	0.70	0.54
Ho <sub>2</sub> O <sub>3</sub>	0.75	0.26	0.40	0.36	0.21	0.63	0.41	0.49	0.49	0.54
Er <sub>2</sub> O <sub>3</sub>	b.d.l.	0.03	b.d.l.	0.06	0.10	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Tm <sub>2</sub> O <sub>3</sub>	b.d.l.	0.03	b.d.l.	0.17	0.05	0.13	0.10	0.06	b.d.l.	0.30
Yb <sub>2</sub> O <sub>3</sub>	0.02	b.d.l.	b.d.l.	0.01	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.08
Lu <sub>2</sub> O <sub>3</sub>	0.14	0.12	0.05	0.46	0.13	0.02	0.18	0.19	0.14	0.03
PbO	0.03	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.12	0.10	b.d.l.	0.01	b.d.l.
ThO <sub>2</sub>	1.47	2.51	2.76	2.57	2.11	4.45	4.52	4.26	4.03	2.31
UO <sub>2</sub>	0.20	b.d.l.	0.07	0.07	b.d.l.	0.04	b.d.l.	b.d.l.	0.01	0.18
Tot.	99.74	98.67	98.29	99.27	99.41	99.99	99.54	100.17	99.13	99.64
	Mon1-1	Mon1-2	Mon1-3	Mon1-4	Mon1-5	Mon1-6	Mon1-7	Mon1-8	Mon1-9	Mon1-10
As	0.004	0.004	0.002	0.002	0.002	0.003	0.002	0.002	0.004	0.002
P	0.974	0.965	0.970	0.975	0.972	0.961	0.963	0.964	0.963	0.972
Si	0.006	0.003	0.002	0.003	0.004	0.014	0.014	0.013	0.012	0.010

V	/	/	/	/	/	/	/	/	/	/
Ca	0.049	0.071	0.069	0.069	0.052	0.065	0.066	0.058	0.062	0.037
Y	0.021	0.016	0.016	0.013	0.014	0.022	0.021	0.023	0.021	0.020
La	0.180	0.207	0.217	0.208	0.217	0.177	0.183	0.181	0.188	0.187
Ce	0.433	0.455	0.443	0.442	0.455	0.421	0.425	0.424	0.422	0.445
Pr	0.047	0.041	0.050	0.047	0.050	0.049	0.048	0.048	0.045	0.048
Nd	0.203	0.183	0.177	0.172	0.177	0.185	0.179	0.187	0.185	0.190
Sm	0.044	0.030	0.028	0.029	0.029	0.035	0.036	0.037	0.037	0.036
Eu	/	/	/	/	/	/	/	/	/	/
Gd	0.030	0.022	0.017	0.023	0.020	0.029	0.025	0.028	0.026	0.024
Tb	/	/	/	/	/	/	/	/	/	/
Dy	0.002	0.003	0.003	0.002	0.002	0.006	0.008	0.005	0.009	0.007
Ho	0.009	0.003	0.005	0.004	0.002	0.008	0.005	0.006	0.006	0.006
Er	/	/	/	/	0.001	/	/	/	/	/
Tm	/	/	/	0.002	/	0.001	0.001	/	/	0.003
Yb	/	/	/	/	/	/	/	/	/	/
Lu	0.001	0.001	/	0.005	0.001	/	0.002	0.002	0.001	/
Pb	/	/	/	/	/	0.001	0.001	/	/	/
Th	0.013	0.023	0.025	0.023	0.019	0.040	0.041	0.038	0.036	0.021
U	0.001	/	/	/	/	/	/	/	/	0.001

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10 **Table S2.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
 11 EPMA-WDS data points of the Mon2 sample.

	Mon2-1	Mon2-2	Mon2-3	Mon2-4	Mon2-5	Mon2-6	Mon2-7	Mon2-8
As <sub>2</sub> O <sub>5</sub>	2.04	2.17	3.12	3.15	1.63	2.18	1.40	2.44
P <sub>2</sub> O <sub>5</sub>	28.33	28.50	26.85	26.69	28.30	27.30	28.62	27.55
SiO <sub>2</sub>	0.09	0.13	0.39	0.59	0.12	0.22	0.14	0.20
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
CaO	0.36	0.20	0.85	1.19	0.68	1.22	0.26	0.71
Y <sub>2</sub> O <sub>3</sub>	0.50	0.43	0.49	0.54	0.56	0.67	0.52	0.49
La <sub>2</sub> O <sub>3</sub>	13.55	12.86	12.40	12.39	14.53	13.11	12.40	13.44
Ce <sub>2</sub> O <sub>3</sub>	32.61	32.10	30.64	29.13	31.78	30.80	31.55	31.91
Pr <sub>2</sub> O <sub>3</sub>	3.90	3.74	3.10	3.33	3.86	3.69	4.03	3.93
Nd <sub>2</sub> O <sub>3</sub>	13.96	14.99	13.44	12.72	13.42	12.86	15.03	13.21
Sm <sub>2</sub> O <sub>3</sub>	2.73	2.64	2.50	2.38	2.42	2.28	2.81	2.30
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	1.36	1.35	1.21	1.63	1.93	1.59	1.62	1.17
Tb <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Dy <sub>2</sub> O <sub>3</sub>	0.12	0.11	0.46	0.49	0.37	0.26	0.15	0.43
Ho <sub>2</sub> O <sub>3</sub>	0.01	0.23	0.41	0.45	0.22	0.54	0.29	0.41
Er <sub>2</sub> O <sub>3</sub>	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Tm <sub>2</sub> O <sub>3</sub>	0.01	0.01	b.d.l.	b.d.l.	b.d.l.	0.32	b.d.l.	b.d.l.
Yb <sub>2</sub> O <sub>3</sub>	b.d.l.	0.06	b.d.l.	b.d.l.	0.06	b.d.l.	b.d.l.	0.01
Lu <sub>2</sub> O <sub>3</sub>	b.d.l.	0.11	0.14	0.03	b.d.l.	0.23	b.d.l.	0.34
PbO	b.d.l.	0.05	b.d.l.	b.d.l.	0.03	b.d.l.	b.d.l.	b.d.l.
ThO <sub>2</sub>	0.90	1.36	4.35	5.30	0.94	2.41	1.28	2.01
UO <sub>2</sub>	0.18	b.d.l.	0.23	0.11	0.23	0.13	0.13	0.06
Tot.	100.74	101.12	100.65	100.19	101.16	99.88	100.30	100.69
	Mon2-1	Mon2-2	Mon2-3	Mon2-4	Mon2-5	Mon2-6	Mon2-7	Mon2-8
As	0.042	0.044	0.065	0.065	0.033	0.045	0.029	0.050
P	0.947	0.948	0.908	0.903	0.945	0.926	0.959	0.927
Si	0.003	0.005	0.015	0.023	0.004	0.009	0.005	0.008

V	/	/	/	/	/	/	/	/
Ca	0.015	0.008	0.036	0.051	0.028	0.052	0.011	0.030
Y	0.010	0.009	0.010	0.011	0.011	0.014	0.011	0.010
La	0.197	0.186	0.182	0.182	0.211	0.193	0.181	0.197
Ce	0.471	0.461	0.448	0.426	0.459	0.451	0.457	0.464
Pr	0.056	0.053	0.045	0.048	0.055	0.054	0.058	0.057
Nd	0.196	0.210	0.191	0.181	0.189	0.184	0.212	0.187
Sm	0.037	0.035	0.034	0.032	0.032	0.031	0.038	0.031
Eu	/	/	/	/	/	/	/	/
Gd	0.017	0.017	0.016	0.021	0.025	0.021	0.021	0.015
Tb	/	/	/	/	/	/	/	/
Dy	0.001	0.001	0.005	0.006	0.004	0.003	0.001	0.005
Ho	/	0.002	0.005	0.005	0.002	0.006	0.003	0.005
Er	/	/	/	/	/	/	9.562	/
Tm	/	/	/	/	/	0.004	/	/
Yb	/	/	/	/	/	/	/	/
Lu	/	0.001	0.001	/	/	0.002	/	0.004
Pb	/	/	/	/	/	/	/	/
Th	0.008	0.012	0.039	0.048	0.008	0.022	0.011	0.018
U	0.001	/	0.002	0.001	0.002	0.001	0.001	/

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18 **Table S3.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
19 EPMA-WDS data points of the Gasp3 sample.

	Gasp3-1	Gasp3-2	Gasp3-3	Gasp3-4	Gasp3-5	Gasp3-6	Gasp3-7	Gasp3-8
As <sub>2</sub> O <sub>5</sub>	40.59	39.90	38.79	39.13	36.38	38.81	38.67	36.60
P <sub>2</sub> O <sub>5</sub>	0.36	0.25	0.82	0.27	3.01	0.55	0.48	0.87
SiO <sub>2</sub>	1.43	1.64	1.36	2.39	1.21	1.90	2.29	1.56
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
CaO	1.22	1.34	1.79	1.44	1.56	1.41	1.44	1.50
Y <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
La <sub>2</sub> O <sub>3</sub>	12.16	11.30	10.89	11.18	11.79	11.92	10.74	11.07
Ce <sub>2</sub> O <sub>3</sub>	29.09	27.38	28.96	27.08	31.19	27.40	27.47	27.84
Pr <sub>2</sub> O <sub>3</sub>	3.38	3.08	3.03	2.98	2.95	2.94	2.68	2.83
Nd <sub>2</sub> O <sub>3</sub>	11.54	12.75	10.86	12.27	10.26	11.72	12.15	11.48
Sm <sub>2</sub> O <sub>3</sub>	1.26	1.66	1.33	1.73	0.90	1.58	1.84	1.16
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	0.20	0.56	0.53	0.58	0.19	0.62	0.30	0.04
Tb <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Dy <sub>2</sub> O <sub>3</sub>	0.05	b.d.l.	0.13	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.06
Ho <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.06
Er <sub>2</sub> O <sub>3</sub>	0.03	0.05	0.01	0.13	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Tm <sub>2</sub> O <sub>3</sub>	b.d.l.	0.07	b.d.l.	0.15	b.d.l.	b.d.l.	0.02	b.d.l.
Yb <sub>2</sub> O <sub>3</sub>	0.16	b.d.l.	0.11	b.d.l.	b.d.l.	0.06	b.d.l.	0.04
Lu <sub>2</sub> O <sub>3</sub>	b.d.l.	0.09	b.d.l.	b.d.l.	0.08	b.d.l.	0.14	b.d.l.
PbO	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.09	b.d.l.	0.07	b.d.l.
ThO <sub>2</sub>	0.32	0.14	0.65	1.74	0.95	1.03	2.23	0.13
UO <sub>2</sub>	0.01	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Tot.	101.88	100.27	99.33	101.12	100.63	100.05	100.57	95.38
	Gasp3-1	Gasp3-2	Gasp3-3	Gasp3-4	Gasp3-5	Gasp3-6	Gasp3-7	Gasp3-8
As	0.945	0.942	0.922	0.914	0.846	0.917	0.909	0.907
P	0.013	0.009	0.031	0.010	0.113	0.021	0.018	0.035
Si	0.063	0.074	0.062	0.107	0.054	0.086	0.103	0.074

V	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Ca	0.058	0.064	0.087	0.069	0.074	0.068	0.069	0.076
Y	/	/	/	/	/	0.001	/	0.001
La	0.199	0.188	0.182	0.184	0.193	0.198	0.178	0.193
Ce	0.474	0.452	0.482	0.443	0.508	0.453	0.452	0.483
Pr	0.054	0.050	0.050	0.048	0.047	0.048	0.044	0.049
Nd	0.183	0.205	0.176	0.195	0.163	0.189	0.195	0.194
Sm	0.019	0.025	0.020	0.026	0.013	0.024	0.028	0.019
Eu	/	/	/	/	/	/	/	/
Gd	0.003	0.008	0.008	0.008	0.002	0.009	0.004	/
Tb	/	/	/	/	/	/	/	/
Dy	/	/	0.001	/	/	/	/	0.001
Ho	/	/	/	/	/	/	/	/
Er	/	/	/	0.001	/	/	/	/
Tm	/	0.001	/	0.002	/	/	/	/
Yb	0.002	/	0.001	/	/	/	/	/
Lu	/	0.001	/	/	0.001	/	0.001	/
Pb	/	/	/	/	0.001	/	/	/
Th	0.003	0.001	0.006	0.017	0.009	0.010	0.022	0.001
U	/	/	/	/	/	/	/	/

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26    **Table S4.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
27    EPMA-WDS data points of the Gasp4 sample.



	Gasp4-1	Gasp4-2	Gasp4-3	Gasp4-4	Gasp4-5	Gasp4-6	Gasp4-7	Gasp4-8	Gasp4-9	Gasp4-10	Gasp4-11	Gasp4-12	Gasp4-13	Gasp4-14	Gasp4-15	Gasp4-16	Gasp4-17	Gasp4-18	Gasp4-19	Gasp4-20
As <sub>2</sub> O <sub>5</sub>	40.22	38.45	39.92	40.15	40.99	42.06	41.43	42.63	42.52	42.97	42.52	42.69	40.90	41.23	41.09	41.33	40.96	42.16	41.07	42.45
P <sub>2</sub> O <sub>5</sub>	0.35	0.06	0.04	0.61	0.11	b.d.l.	0.05	0.02	0.24	0.26	0.04	0.23	0.02	0.13	0.07	0.16	0.12	0.03	0.06	0.04
SiO <sub>2</sub>	2.03	3.11	1.97	1.70	1.99	1.28	0.60	1.17	0.58	0.67	1.01	0.70	1.61	1.58	1.42	1.68	1.77	1.66	1.60	1.47
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
CaO	1.80	1.69	1.71	1.88	2.03	1.90	2.15	2.05	1.73	1.86	1.64	1.74	2.25	2.00	1.64	1.98	2.26	2.14	2.08	1.96
Y <sub>2</sub> O <sub>3</sub>	0.13	0.04	0.04	0.05	0.11	0.03	b.d.l.	0.02	b.d.l.	b.d.l.	0.01	b.d.l.	0.01	0.09	0.05	0.09	0.11	b.d.l.	0.19	b.d.l.
La <sub>2</sub> O <sub>3</sub>	12.14	10.89	11.97	13.24	12.01	13.42	14.43	13.43	13.30	13.39	13.94	13.84	12.51	12.50	12.84	12.97	12.00	12.38	12.77	13.22
Ce <sub>2</sub> O <sub>3</sub>	27.11	24.56	25.29	25.97	26.25	27.24	26.01	26.96	27.15	27.76	26.99	27.59	26.84	27.41	27.95	27.11	27.32	27.53	27.09	27.10
Pr <sub>2</sub> O <sub>3</sub>	2.76	2.52	2.69	1.92	2.72	2.67	2.60	2.64	2.62	2.27	2.43	2.82	2.47	2.60	2.53	2.58	2.58	2.73	2.56	2.46
Nd <sub>2</sub> O <sub>3</sub>	9.58	8.23	8.03	8.04	9.40	9.43	9.22	9.46	9.46	8.90	9.01	9.24	10.20	9.89	10.11	10.06	10.03	10.01	9.602	10.13
Sm <sub>2</sub> O <sub>3</sub>	1.32	1.33	1.06	0.91	1.35	1.18	1.04	1.05	1.10	0.96	1.08	1.29	1.48	1.24	1.47	1.37	1.33	1.24	1.33	1.29
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	0.72	0.80	0.56	0.56	0.55	0.50	0.41	0.72	0.47	0.31	0.49	0.50	0.81	0.55	0.97	0.71	0.81	0.60	0.74	0.72
Tb <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Dy <sub>2</sub> O <sub>3</sub>	b.d.l.	0.12	0.04	0.17	0.04	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	0.19	b.d.l.	b.d.l.	0.22	b.d.l.	b.d.l.	0.03	b.d.l.
Ho <sub>2</sub> O <sub>3</sub>	0.13	b.d.l.	b.d.l.	b.d.l.	0.16	0.05	b.d.l.	0.14	b.d.l.	0.12	b.d.l.	0.01	0.05	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Er <sub>2</sub> O <sub>3</sub>	0.13	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.06	0.23	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.22	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.
Tm <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	0.03	0.09	b.d.l.	0.06	b.d.l.	0.01	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.13	b.d.l.	b.d.l.	b.d.l.
Yb <sub>2</sub> O <sub>3</sub>	b.d.l.	0.12	0.17	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.12	b.d.l.	0.08	b.d.l.	b.d.l.	0.06	0.22	b.d.l.	0.01	0.04	b.d.l.	b.d.l.	0.12
Lu <sub>2</sub> O <sub>3</sub>	b.d.l.	0.11	0.16	0.08	0.06	b.d.l.	0.09	0.05	0.12	b.d.l.	0.15	b.d.l.	b.d.l.	0.02	0.07	0.02	0.07	0.07	b.d.l.	b.d.l.
PbO	0.21	b.d.l.	0.02	0.14	0.06	b.d.l.	0.12	0.04	0.07	0.04	b.d.l.	0.12	0.01	b.d.l.	0.06	b.d.l.	0.10	0.02	0.07	b.d.l.
ThO <sub>2</sub>	3.93	9.13	6.52	5.05	3.14	0.96	0.46	0.83	1.08	1.20	0.63	0.90	0.53	1.06	0.49	0.93	0.92	0.05	1.46	b.d.l.
UO <sub>2</sub>	0.15	0.26	0.19	0.12	0.08	b.d.l.	0.17	b.d.l.	0.05	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.06	b.d.l.	0.06	0.04
Tot.	102.77	101.49	100.46	100.69	101.22	100.87	99.15	101.40	100.57	100.87	99.99	101.96	100.02	100.58	100.83	101.29	100.69	100.69	100.80	101.06
UO <sub>2</sub>																				
	Gasp4-1	Gasp4-2	Gasp4-3	Gasp4-4	Gasp4-5	Gasp4-6	Gasp4-7	Gasp4-8	Gasp4-9	Gasp4-10	Gasp4-11	Gasp4-12	Gasp4-13	Gasp4-14	Gasp4-15	Gasp4-16	Gasp4-17	Gasp4-18	Gasp4-19	Gasp4-20
As	0.926	0.900	0.943	0.938	0.949	0.978	0.988	0.984	0.995	0.997	0.995	0.987	0.958	0.960	0.962	0.955	0.951	0.972	0.957	0.978
P	0.013	0.002	0.001	0.023	0.004	/	0.002	/	0.009	0.009	0.001	0.008	0	0.005	0.002	0.006	0.004	0.001	0.002	0.001
Si	0.089	0.139	0.089	0.076	0.088	0.057	0.027	0.051	0.026	0.029	0.045	0.031	0.072	0.070	0.063	0.074	0.078	0.073	0.071	0.064
V	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Ca	0.085	0.081	0.083	0.090	0.096	0.090	0.105	0.097	0.083	0.088	0.078	0.082	0.108	0.095	0.078	0.093	0.107	0.101	0.099	0.092
Y	0.003	/	0.001	0.001	0.002	/	/	/	/	/	/	/	/	0.002	0.001	0.002	0.002	/	0.004	/
La	0.197	0.179	0.199	0.218	0.196	0.220	0.242	0.218	0.219	0.219	0.230	0.225	0.206	0.205	0.212	0.211	0.196	0.201	0.209	0.215
Ce	0.437	0.402	0.418	0.424	0.425	0.443	0.434	0.436	0.445	0.451	0.442	0.446	0.440	0.447	0.458	0.439	0.444	0.444	0.442	0.437
Pr	0.044	0.041	0.044	0.031	0.044	0.043	0.043	0.042	0.042	0.036	0.039	0.045	0.040	0.042	0.041	0.041	0.041	0.043	0.041	0.039
Nd	0.150	0.131	0.129	0.128	0.148	0.149	0.150	0.149	0.151	0.141	0.144	0.146	0.163	0.157	0.161	0.158	0.159	0.157	0.152	0.159
Sm	0.020	0.020	0.016	0.014	0.020	0.018	0.016	0.016	0.016	0.014	0.016	0.019	0.022	0.019	0.022	0.020	0.020	0.018	0.020	0.019
Eu	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Gd	0.010	0.011	0.008	0.008	0.008	0.007	0.006	0.010	0.007	0.004	0.007	0.007	0.012	0.008	0.014	0.010	0.011	0.008	0.010	0.010

Tb	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Dy	/	0.001	/	0.002	/	/	/	/	/	/	/	0.002	/	/	0.003	/	/	/	/
Ho	0.001	/	/	/	0.002	/	/	0.002	/	0.001	/	/	/	/	/	/	/	/	/
Er	0.001	/	/	/	/	/	0.003	/	/	/	/	0.003	/	/	/	/	/	/	/
Tm	/	/	/	/	0.001	/	/	/	/	/	/	/	/	/	/	0.001	/	/	/
Yb	/	0.001	0.002	/	/	/	/	0.001	/	0.001	/	/	/	0.003	/	/	/	/	0.001
Lu	/	0.001	0.002	0.001	/	/	0.001	/	0.001	/	0.002	/	/	/	/	/	0.001	/	2.381
Pb	0.002	/	/	0.001	/	/	0.001	/	/	/	/	0.001	/	/	/	0.001	/	/	/
Th	0.039	0.093	0.067	0.051	0.031	0.009	0.004	0.008	0.011	0.012	0.006	0.009	0.005	0.010	0.005	0.009	0.009	/	0.014
U	0.001	0.002	0.001	0.001	/	/	0.001	/	/	/	/	/	/	/	/	/	/	/	/

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37 **Table S5.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
38 EPMA-WDS data points of the Ch6 sample.

	Ch6-1	Ch6-2	Ch6-3	Ch6-4	Ch6-5	Ch6-6	Ch6-7	Ch6-8	Ch6-9	Ch6-10	Ch6-11	Ch6-12	Ch6-13	Ch6-14	Ch6-15	Ch6-16
As <sub>2</sub> O <sub>5</sub>	34.40	34.77	35.57	35.07	30.14	34.46	32.16	30.56	34.40	32.17	34.44	35.07	31.92	35.61	33.06	33.01
P <sub>2</sub> O <sub>5</sub>	7.38	7.01	6.48	6.41	10.1	6.87	8.82	10.0	6.66	8.29	7.12	6.62	9.36	2.17	7.99	8.02
SiO <sub>2</sub>	0.57	0.59	0.62	0.66	0.49	0.75	0.39	0.50	1.02	0.77	0.62	0.67	0.61	3.17	0.72	0.71
V <sub>2</sub> O <sub>5</sub>	b.d.l.	0.07	b.d.l.	b.d.l.	0.04	0.01	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.01
CaO	b.d.l.	0.03	0.03	0.01	b.d.l.	0.03	0.06	0.04	0.01	0.02	0.03	0.04	0.02	0.01	b.d.l.	b.d.l.
Y <sub>2</sub> O <sub>3</sub>	34.57	34.01	33.80	33.47	35.05	33.35	34.47	34.89	33.01	33.36	33.61	34.21	34.35	25.38	33.81	33.65
La <sub>2</sub> O <sub>3</sub>	b.d.l.	0.03	b.d.l.	b.d.l.	b.d.l.	0.01	0.22	0.13	b.d.l.	0.13	0.02	b.d.l.	b.d.l.	0.01	b.d.l.	0.05
Ce <sub>2</sub> O <sub>3</sub>	0.36	0.04	0.16	0.19	0.15	0.18	0.33	0.13	0.04	0.01	0.08	0.01	0.11	0.37	0.10	0.06
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.10	0.09	0.11	0.17	0.04	0.09	0.07
Nd <sub>2</sub> O <sub>3</sub>	0.64	0.61	0.56	0.59	0.38	0.58	0.57	0.40	0.65	0.52	0.45	0.58	0.71	2.20	0.85	0.62
Sm <sub>2</sub> O <sub>3</sub>	0.99	0.92	0.92	0.87	0.73	0.87	0.95	1.02	0.97	1.00	0.85	1.11	0.96	2.36	1.30	0.91
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	0.10	0.02	0.10	b.d.l.	0.05	0.07	b.d.l.	0.04	0.03	b.d.l.	0.09	0.25	0.02	0.20	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	2.46	2.50	2.40	2.60	2.10	2.49	2.71	2.61	2.90	2.81	2.35	2.40	2.69	4.52	3.18	2.58
Tb <sub>2</sub> O <sub>3</sub>	0.57	0.77	0.71	0.31	0.67	0.68	0.59	0.55	0.61	0.37	0.63	0.62	0.57	0.76	0.60	0.58
Dy <sub>2</sub> O <sub>3</sub>	4.89	4.89	5.36	5.11	5.07	4.58	5.21	4.45	4.70	4.70	4.72	4.98	4.72	4.58	4.67	4.90
Ho <sub>2</sub> O <sub>3</sub>	2.24	2.38	2.24	2.40	2.15	2.46	2.27	2.57	2.54	2.39	2.40	2.59	2.43	3.05	2.66	2.11
Er <sub>2</sub> O <sub>3</sub>	3.29	3.53	3.39	3.39	3.85	3.47	3.37	3.12	3.51	2.95	3.32	3.45	3.26	2.23	3.19	3.56
Tm <sub>2</sub> O <sub>3</sub>	0.48	0.61	0.33	0.47	0.49	0.62	0.38	0.29	0.37	0.30	0.35	0.52	0.51	0.52	0.47	0.11
Yb <sub>2</sub> O <sub>3</sub>	3.20	2.90	3.04	2.65	2.92	3.14	3.10	2.77	2.97	2.96	2.92	2.81	2.85	1.73	2.46	3.01
Lu <sub>2</sub> O <sub>3</sub>	1.15	1.19	1.10	1.27	1.26	1.32	0.82	1.18	1.16	1.54	1.28	1.35	1.35	1.13	1.20	0.99
PbO	0.08	0.12	0.32	0.29	0.19	0.18	0.20	0.26	0.06	0.29	0.15	0	0.37	0.31	0.13	0.21
ThO <sub>2</sub>	2.06	2.55	2.31	2.66	1.72	2.81	1.87	2.10	4.27	2.68	2.38	2.41	2.17	10.8	2.87	2.79
UO <sub>2</sub>	0.82	1.17	1.02	1.12	0.71	1.11	0.70	0.62	1.17	0.82	1.33	1.04	0.65	1.96	0.60	0.81
Tot.	100.22	100.89	100.49	99.75	98.31	100.13	99.38	98.32	101.17	98.32	99.25	100.79	100.13	103.07	100.27	98.85
	Ch6-1	Ch6-2	Ch6-3	Ch6-4	Ch6-5	Ch6-6	Ch6-7	Ch6-8	Ch6-9	Ch6-10	Ch6-11	Ch6-12	Ch6-13	Ch6-14	Ch6-15	Ch6-16
As	0.716	0.724	0.745	0.741	0.627	0.724	0.670	0.635	0.720	0.679	0.725	0.732	0.657	0.782	0.689	0.693
P	0.248	0.236	0.220	0.219	0.340	0.234	0.297	0.337	0.226	0.283	0.242	0.224	0.312	0.077	0.269	0.273
Si	0.022	0.023	0.025	0.026	0.019	0.030	0.015	0.019	0.041	0.031	0.025	0.027	0.024	0.133	0.028	0.028

V	0	0.002	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0
Ca	0	0.001	0.001	0	0	0.001	0.002	0.002	0	0	0.001	0.001	0	0	0	0
Y	0.732	0.721	0.720	0.720	0.742	0.713	0.731	0.737	0.703	0.717	0.720	0.727	0.720	0.567	0.717	0.719
La	0	0	0	0	0	0	0.003	0.001	0	0.002	0	0	0	0	0	0
Ce	0.005	0	0.002	0.002	0.002	0.002	0.004	0.001	0	0	0.001	0	0.001	0.005	0.001	0.001
Pr	0	0	0	0	0	0	0	0	0	0.001	0.001	0.001	0.002	0	0.001	0.001
Nd	0.009	0.008	0.008	0.008	0.005	0.008	0.008	0.005	0.009	0.007	0.006	0.008	0.010	0.033	0.012	0.008
Sm	0.013	0.012	0.012	0.012	0.010	0.012	0.013	0.014	0.013	0.014	0.011	0.015	0.013	0.034	0.017	0.012
Eu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gd	0.032	0.033	0.031	0.034	0.027	0.033	0.035	0.034	0.038	0.037	0.031	0.031	0.035	0.063	0.042	0.034
Tb	0.007	0.010	0.009	0.004	0.008	0.009	0.007	0.007	0.008	0.005	0.008	0.008	0.007	0.010	0.007	0.007
Dy	0.062	0.062	0.069	0.066	0.065	0.059	0.067	0.056	0.060	0.061	0.061	0.064	0.059	0.061	0.060	0.063
Ho	0.028	0.030	0.028	0.030	0.027	0.031	0.028	0.032	0.032	0.030	0.030	0.032	0.030	0.040	0.033	0.026
Er	0.041	0.044	0.042	0.043	0.048	0.043	0.042	0.039	0.044	0.037	0.042	0.043	0.040	0.029	0.039	0.045
Tm	0.005	0.007	0.004	0.006	0.006	0.007	0.004	0.003	0.004	0.003	0.004	0.006	0.006	0.006	0.005	0.001
Yb	0.038	0.035	0.037	0.032	0.035	0.038	0.037	0.033	0.036	0.036	0.035	0.034	0.034	0.022	0.029	0.036
Lu	0.013	0.014	0.013	0.015	0.015	0.016	0.009	0.014	0.014	0.018	0.015	0.016	0.016	0.014	0.014	0.012
Pb	0	0.001	0.003	0.003	0.002	0.002	0.002	0.002	0	0.003	0.001	0	0.003	0.003	0.001	0.002
Th	0.018	0.023	0.021	0.024	0.015	0.025	0.017	0.018	0.038	0.024	0.021	0.021	0.019	0.103	0.026	0.025
U	0.007	0.010	0.009	0.010	0.006	0.009	0.006	0.005	0.010	0.007	0.011	0.009	0.005	0.018	0.005	0.007

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45 **Table S6.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
 46 EPMA-WDS data points of the Ch7 sample.

	Ch7-1	Ch7-2	Ch7-3	Ch7-4	Ch7-5	Ch7-6	Ch7-7	Ch7-8	Ch7-9	Ch7-10
As <sub>2</sub> O <sub>5</sub>	39.44	36.83	37.77	37.76	32.82	37.23	35.65	35.75	35.25	38.26
P <sub>2</sub> O <sub>5</sub>	4.01	4.84	4.63	4.77	8.87	6.12	6.13	6.37	6.53	4.24
SiO <sub>2</sub>	0.82	1.08	0.95	0.83	0.29	0.34	0.80	0.65	0.65	0.71
V <sub>2</sub> O <sub>5</sub>	0.03	b.d.l.	b.d.l.	0.10	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	0.01
CaO	b.d.l.	0.03	0.03	b.d.l.	b.d.l.	0.03	b.d.l.	0.03	0.01	b.d.l.
Y <sub>2</sub> O <sub>3</sub>	35.50	35.11	35.30	35.46	37.17	36.21	36.01	36.51	36.67	36.03
La <sub>2</sub> O <sub>3</sub>	0.07	0.02	0.04	0.08	0.02	0.16	b.d.l.	0.08	b.d.l.	b.d.l.
Ce <sub>2</sub> O <sub>3</sub>	0.18	0.20	0.05	0.08	0.01	0.19	0.16	0.19	0.02	b.d.l.
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.05
Nd <sub>2</sub> O <sub>3</sub>	0.25	0.21	0.23	0.22	0.07	0.32	0.35	0.24	0.18	0.21
Sm <sub>2</sub> O <sub>3</sub>	0.34	0.61	0.60	0.22	0.30	0.53	0.34	0.37	0.37	0.45
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.09	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	1.85	1.51	1.77	1.38	1.39	1.72	1.43	1.44	1.59	1.53
Tb <sub>2</sub> O <sub>3</sub>	0.52	0.29	0.33	0.50	0.47	0.62	0.47	0.43	0.57	0.37
Dy <sub>2</sub> O <sub>3</sub>	4.30	4.07	4.41	4.06	4.14	4.38	3.84	3.98	3.68	3.93
Ho <sub>2</sub> O <sub>3</sub>	2.28	1.77	1.94	1.73	1.70	2.02	1.81	1.84	1.57	1.84
Er <sub>2</sub> O <sub>3</sub>	3.26	3.24	3.26	3.58	3.72	3.20	3.27	3.50	3.47	3.42
Tm <sub>2</sub> O <sub>3</sub>	0.53	0.35	0.31	0.33	0.39	0.38	0.32	0.18	0.48	0.38
Yb <sub>2</sub> O <sub>3</sub>	2.56	2.85	2.77	3.12	2.98	3.14	3.25	3.19	2.97	2.59
Lu <sub>2</sub> O <sub>3</sub>	0.89	1.05	1.15	0.74	1.33	1.08	0.98	1.15	0.96	0.94
PbO	0.27	0.13	0.29	0.24	0.20	0.31	0.40	0.33	0.26	0.39
ThO <sub>2</sub>	0.90	0.95	0.89	0.99	0.33	0.52	0.71	0.55	0.67	0.84
UO <sub>2</sub>	3.85	4.01	4.04	3.68	2.08	2.15	3.78	2.83	3.24	2.97
Tot.	101.95	99.26	100.85	99.94	98.37	100.73	99.79	99.72	99.32	99.29
	Ch7-1	Ch7-2	Ch7-3	Ch7-4	Ch7-5	Ch7-6	Ch7-7	Ch7-8	Ch7-9	Ch7-10
As	0.821	0.780	0.792	0.794	0.679	0.770	0.746	0.745	0.737	0.811
P	0.135	0.166	0.157	0.162	0.297	0.205	0.207	0.215	0.221	0.145
Si	0.032	0.043	0.038	0.033	0.011	0.013	0.032	0.026	0.026	0.029

V	0.001	0	0	0.003	0	0	0	0	0	0
Ca	0	0.001	0.001	0	0	0.001	0	0.001	0	0
Y	0.752	0.757	0.753	0.759	0.783	0.762	0.767	0.775	0.781	0.778
La	0.001	0	0	0.001	0	0.002	0	0.001	0	0
Ce	0.002	0.003	0	0.001	0	0.002	0.002	0.002	0	0
Pr	0	0	0	0	0	0	0	0	0	0
Nd	0.003	0.003	0.003	0.003	0.001	0.004	0.005	0.003	0.002	0.003
Sm	0.004	0.008	0.008	0.003	0.004	0.007	0.004	0.005	0.005	0.006
Eu	0	0	0	0	0	0	0	0	0	0
Gd	0.024	0.020	0.023	0.018	0.018	0.022	0.019	0.019	0.021	0.020
Tb	0.006	0.003	0.004	0.006	0.006	0.008	0.006	0.005	0.007	0.005
Dy	0.055	0.053	0.057	0.052	0.052	0.055	0.049	0.051	0.047	0.051
Ho	0.028	0.022	0.024	0.022	0.021	0.025	0.023	0.023	0.019	0.023
Er	0.040	0.041	0.041	0.045	0.046	0.039	0.041	0.043	0.043	0.043
Tm	0.006	0.004	0.003	0.004	0.004	0.004	0.004	0.002	0.005	0.004
Yb	0.031	0.035	0.033	0.038	0.036	0.037	0.039	0.038	0.036	0.032
Lu	0.010	0.012	0.013	0.009	0.015	0.012	0.011	0.013	0.011	0.011
Pb	0.002	0.001	0.003	0.002	0.002	0.003	0.004	0.003	0.002	0.004
Th	0.008	0.008	0.008	0.009	0.002	0.004	0.006	0.005	0.006	0.007
U	0.034	0.036	0.036	0.032	0.018	0.018	0.033	0.025	0.028	0.026

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53 **Table S7.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
54 EPMA-WDS data points of the Ch8 sample.

	Ch8-1	Ch8-2	Ch8-3	Ch8-4	Ch8-5	Ch8-6	Ch8-7	Ch8-8
As <sub>2</sub> O <sub>5</sub>	37.14	35.64	35.73	34.22	36.45	34.72	36.70	36.97
P <sub>2</sub> O <sub>5</sub>	5.25	6.21	5.23	6.47	4.73	7.14	5.36	4.63
SiO <sub>2</sub>	0.61	0.62	0.69	0.76	0.60	0.43	0.67	0.76
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	0.01	0.04	0.01	b.d.l.	b.d.l.	b.d.l.
CaO	0.01	0.01	b.d.l.	b.d.l.	b.d.l.	0.04	b.d.l.	0.02
Y <sub>2</sub> O <sub>3</sub>	33.67	34.71	34.38	35.04	34.39	35.22	34.17	33.78
La <sub>2</sub> O <sub>3</sub>	0.04	0.01	0.07	b.d.l.	b.d.l.	0.09	0.10	b.d.l.
Ce <sub>2</sub> O <sub>3</sub>	0.10	0.18	b.d.l.	b.d.l.	0.19	0.10	0.16	0.03
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	0.12	b.d.l.	b.d.l.	0.03	0.03	0.03	b.d.l.
Nd <sub>2</sub> O <sub>3</sub>	0.41	0.22	0.49	0.09	0.42	0.32	0.54	0.40
Sm <sub>2</sub> O <sub>3</sub>	0.89	0.92	0.86	0.65	0.97	0.78	0.82	0.92
Eu <sub>2</sub> O <sub>3</sub>	b d.l	b d.l	b d.l	b d.l	b d.l	b d.l	b d.l	b d.l
Gd <sub>2</sub> O <sub>3</sub>	2.84	2.66	3.13	2.64	3.35	3.02	3.20	3.08
Tb <sub>2</sub> O <sub>3</sub>	0.49	0.52	0.56	0.68	0.67	0.65	0.50	0.64
Dy <sub>2</sub> O <sub>3</sub>	4.79	5.34	5.12	5.25	5.59	5.58	5.58	5.21
Ho <sub>2</sub> O <sub>3</sub>	2.76	2.55	2.60	2.58	2.70	2.60	2.69	2.91
Er <sub>2</sub> O <sub>3</sub>	3.06	3.19	3.03	3.02	3.01	2.72	2.88	3.11
Tm <sub>2</sub> O <sub>3</sub>	0.40	0.65	0.40	0.46	0.24	0.48	0.72	0.35
Yb <sub>2</sub> O <sub>3</sub>	2.84	3.22	2.52	2.08	1.69	2.00	1.88	2.34
Lu <sub>2</sub> O <sub>3</sub>	1.33	1.27	1.21	1.50	1.33	1.22	1.11	1.05
PbO	0.26	0.31	0.20	0.21	0.18	0.25	0.25	0.24
ThO <sub>2</sub>	3.08	3.04	3.31	3.39	3.05	2.07	2.91	3.09
UO <sub>2</sub>	0.34	0.36	0.28	0.58	0.32	0.49	0.43	0.30
Tot.	100.41	102.04	99.92	99.81	100.00	100.16	100.80	99.90
	Ch8-1	Ch8-2	Ch8-3	Ch8-4	Ch8-5	Ch8-6	Ch8-7	Ch8-8
As	0.784	0.741	0.762	0.723	0.780	0.724	0.772	0.789
P	0.179	0.209	0.180	0.221	0.164	0.241	0.182	0.160
Si	0.025	0.024	0.028	0.030	0.024	0.017	0.027	0.031

V	0	0	0	0.001	0	0	0	0
Ca	0	0	0	0	0	0.001	0	0.001
Y	0.723	0.735	0.747	0.753	0.749	0.747	0.732	0.734
La	0	0	0.001	0	0	0.001	0.001	0
Ce	0.001	0.002	0	0	0.002	0.001	0.002	0
Pr	0	0.001	0	0	0	0	0	0
Nd	0.005	0.003	0.007	0.001	0.006	0.004	0.007	0.005
Sm	0.012	0.012	0.012	0.009	0.013	0.010	0.011	0.013
Eu	0	0	0	0	0	0	0	0
Gd	0.038	0.035	0.042	0.035	0.045	0.040	0.042	0.041
Tb	0.006	0.006	0.007	0.009	0.009	0.008	0.006	0.008
Dy	0.062	0.068	0.067	0.068	0.073	0.071	0.072	0.068
Ho	0.035	0.032	0.033	0.033	0.035	0.033	0.034	0.037
Er	0.038	0.039	0.038	0.038	0.038	0.034	0.036	0.039
Tm	0.005	0.008	0.005	0.005	0.003	0.006	0.009	0.004
Yb	0.035	0.039	0.031	0.025	0.021	0.024	0.023	0.029
Lu	0.016	0.015	0.014	0.018	0.016	0.014	0.013	0.012
Pb	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002
Th	0.028	0.027	0.030	0.031	0.028	0.018	0.026	0.028
U	0.003	0.003	0.002	0.005	0.002	0.004	0.003	0.002

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60 **Table S8.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
61 EPMA-WDS data points of the Ch9 sample.

	Ch9-1	Ch9-2	Ch9-3	Ch9-4	Ch9-5	Ch9-6	Ch9-7	Ch9-8	Ch9-9	Ch9-10
As <sub>2</sub> O <sub>5</sub>	38.83	37.71	35.99	34.75	36.14	34.80	36.16	34.38	36.80	37.09
P <sub>2</sub> O <sub>5</sub>	3.94	4.44	5.57	7.27	5.81	6.69	5.89	6.53	5.24	5.06
SiO <sub>2</sub>	0.81	0.65	0.81	0.16	0.59	0.57	0.68	0.59	0.85	0.52
V <sub>2</sub> O <sub>5</sub>	0.03	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.04	b.d.l.
CaO	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	0.02	b.d.l.	0.05	0.01	0.03
Y <sub>2</sub> O <sub>3</sub>	34.95	34.09	34.37	35.01	33.70	34.58	34.06	33.94	34.45	33.91
La <sub>2</sub> O <sub>3</sub>	0.07	0.04	0.07	b.d.l.	0.14	0.04	0.07	0.07	0.07	0.02
Ce <sub>2</sub> O <sub>3</sub>	0.17	0.14	0.17	0.12	0.19	b.d.l.	0.28	0.16	0.10	0.04
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	0.04	0.08	0.14	0.11	0.08	b.d.l.	0.05
Nd <sub>2</sub> O <sub>3</sub>	0.25	0.40	0.25	0.19	0.53	0.47	0.48	0.32	0.39	0.47
Sm <sub>2</sub> O <sub>3</sub>	0.34	0.83	0.55	0.62	0.80	0.75	0.93	0.71	0.94	0.69
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	1.82	3.25	2.62	2.66	3.35	3.45	3.27	3.15	2.85	2.79
Tb <sub>2</sub> O <sub>3</sub>	0.52	0.71	0.52	0.60	0.68	0.64	0.76	0.85	0.52	0.81
Dy <sub>2</sub> O <sub>3</sub>	4.23	5.13	4.65	4.77	5.27	5.18	5.25	5.10	4.96	5.05
Ho <sub>2</sub> O <sub>3</sub>	2.24	2.66	2.66	2.45	2.77	2.77	2.77	2.61	2.74	2.75
Er <sub>2</sub> O <sub>3</sub>	3.21	3.15	3.31	3.42	3.01	3.04	2.92	2.89	2.77	3.39
Tm <sub>2</sub> O <sub>3</sub>	0.52	0.50	0.49	0.48	0.61	0.45	0.39	0.38	0.32	0.29
Yb <sub>2</sub> O <sub>3</sub>	2.52	2.31	2.38	3.31	1.76	1.86	1.96	2.31	2.22	3.33
Lu <sub>2</sub> O <sub>3</sub>	0.87	1.08	0.88	1.01	1.39	1.22	0.98	1.17	1.47	1.37
PbO	0.26	0.20	0.20	0.47	0.19	0.06	0.22	0.38	0	0.21
ThO <sub>2</sub>	0.89	3.60	4.23	1.50	2.31	2.48	3.09	2.36	3.77	2.94
UO <sub>2</sub>	3.79	0.21	0.51	0.11	0.44	0.71	0.76	0.64	0.32	0.15
Tot.	100.38	101.35	100.35	99.07	99.87	100.06	101.11	98.78	100.91	101.11
	Ch9-1	Ch9-2	Ch9-3	Ch9-4	Ch9-5	Ch9-6	Ch9-7	Ch9-8	Ch9-9	Ch9-10
As	0.821	0.797	0.759	0.730	0.764	0.730	0.757	0.732	0.772	0.783
P	0.135	0.152	0.190	0.247	0.199	0.227	0.199	0.225	0.178	0.173
Si	0.032	0.026	0.032	0.006	0.024	0.023	0.027	0.024	0.034	0.021

V	0.001	0	0	0	0	0	0	0	0.001	0
Ca	0	0	0	0	0	0.001	0	0.002	0	0.001
Y	0.752	0.733	0.738	0.749	0.725	0.739	0.726	0.736	0.735	0.729
La	0.001	0	0.001	0	0.002	0	0.001	0.001	0.001	0
Ce	0.002	0.002	0.002	0.001	0.002	0	0.004	0.002	0.001	0
Pr	0	0	0	0	0.001	0.002	0.001	0.001	0	0
Nd	0.003	0.005	0.003	0.002	0.007	0.006	0.006	0.004	0.005	0.006
Sm	0.004	0.011	0.007	0.008	0.011	0.010	0.012	0.010	0.013	0.009
Eu	0	0	0	0	0	0	0	0	0	0
Gd	0.024	0.043	0.035	0.035	0.045	0.045	0.043	0.042	0.037	0.037
Tb	0.006	0.009	0.006	0.008	0.009	0.008	0.010	0.011	0.006	0.010
Dy	0.055	0.066	0.060	0.061	0.068	0.067	0.067	0.066	0.064	0.065
Ho	0.028	0.034	0.034	0.031	0.035	0.035	0.035	0.033	0.035	0.035
Er	0.040	0.040	0.041	0.043	0.038	0.038	0.036	0.037	0.034	0.043
Tm	0.006	0.006	0.006	0.006	0.007	0.005	0.004	0.004	0.004	0.003
Yb	0.031	0.028	0.029	0.040	0.021	0.022	0.024	0.028	0.027	0.041
Lu	0.010	0.013	0.010	0.012	0.016	0.014	0.011	0.014	0.017	0.016
Pb	0.002	0.002	0.002	0.005	0.002	0	0.002	0.004	0	0.002
Th	0.008	0.033	0.038	0.013	0.021	0.022	0.028	0.021	0.034	0.027
U	0.034	0.001	0.004	0.001	0.003	0.006	0.006	0.005	0.002	0.001

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67 **Table S9.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
68 EPMA-WDS data points of the Ch10 sample.

	Ch10-1	Ch10-2	Ch10-3	Ch10-4	Ch10-5	Ch10-6	Ch10-7	Ch10-8	Ch10-9	Ch10-10	Ch10-11	Ch10-12	Ch10-13
As <sub>2</sub> O <sub>5</sub>	36.94	36.87	38.02	34.77	36.91	35.12	35.20	36.53	36.00	35.66	35.95	35.50	36.00
P <sub>2</sub> O <sub>5</sub>	5.35	5.23	4.81	6.72	5.32	5.78	6.86	3.93	4.47	5.59	5.39	5.50	5.32
SiO <sub>2</sub>	0.69	0.67	0.62	0.55	0.67	0.78	0.45	1.49	1.59	0.70	0.82	0.84	0.78
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	0.05	b.d.l.	b.d.l.	0.02	0.01	0.05	b.d.l.	b.d.l.	b.d.l.	0.05	0.02
CaO	b.d.l.	0.02	0.03	b.d.l.	0.02	b.d.l.	0.01	b.d.l.	0.03	b.d.l.	0.01	0.03	b.d.l.
Y <sub>2</sub> O <sub>3</sub>	34.80	35.19	34.44	35.38	34.30	34.78	35.06	29.91	30.06	31.93	30.84	31.77	31.83
La <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	0.03	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.05	b.d.l.	b.d.l.	0.01	0.03	b.d.l.
Ce <sub>2</sub> O <sub>3</sub>	0.12	0.23	0.10	0.01	0.14	0.03	0.20	0.02	0.01	0.25	0.18	0.20	0.14
Pr <sub>2</sub> O <sub>3</sub>	0.25	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.01	b.d.l.	b.d.l.	0.09	0.03	0.05	0.06	b.d.l.
Nd <sub>2</sub> O <sub>3</sub>	0.48	0.40	0.48	0.03	0.65	0.16	0.42	0.23	0.39	0.50	0.53	0.21	0.34
Sm <sub>2</sub> O <sub>3</sub>	0.67	0.70	0.93	0.55	1.06	0.75	0.56	0.70	0.64	0.73	0.76	0.48	0.99
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	2.64	2.81	3.00	2.09	3.07	2.50	2.28	2.21	2.08	1.99	1.73	1.65	1.90
Tb <sub>2</sub> O <sub>3</sub>	0.70	0.65	0.74	0.48	0.55	0.52	0.59	0.46	0.39	0.58	0.60	0.36	0.50
Dy <sub>2</sub> O <sub>3</sub>	5.36	5.33	5.43	5.41	5.58	5.26	5.38	4.96	4.85	4.82	4.39	4.75	4.73
Ho <sub>2</sub> O <sub>3</sub>	2.47	2.72	2.69	2.33	2.78	2.57	2.46	2.45	2.09	2.25	2.17	2.07	2.03
Er <sub>2</sub> O <sub>3</sub>	2.80	3.07	2.90	3.05	2.98	3.16	3.13	3.73	4.13	4.24	4.13	4.20	4.12
Tm <sub>2</sub> O <sub>3</sub>	0.49	0.18	0.33	0.32	0.35	0.27	0.36	0.60	0.64	0.69	0.83	0.63	0.53
Yb <sub>2</sub> O <sub>3</sub>	2.21	1.91	2.05	2.14	2.05	1.87	1.99	4.49	4.71	4.84	5.07	5.15	5.47
Lu <sub>2</sub> O <sub>3</sub>	1.03	1.24	1.02	1.06	1.25	1.21	1.01	1.73	1.52	1.45	1.36	1.59	1.32
PbO	0.24	0.27	0.45	0.27	0.25	0.23	0.25	0.29	0.31	0.20	0.19	0.33	0.13
ThO <sub>2</sub>	2.52	2.22	1.95	1.16	1.72	1.72	0.78	4.41	4.94	2.24	2.29	2.50	2.74
UO <sub>2</sub>	1.73	1.72	1.90	2.06	2.13	2.31	2.32	2.14	2.14	1.41	1.26	2.00	1.58
Tot.	101.69	101.52	102.05	98.49	101.88	99.17	99.41	100.48	101.17	100.26	98.67	100.04	100.59
	Ch10-1	Ch10-2	Ch10-3	Ch10-4	Ch10-5	Ch10-6	Ch10-7	Ch10-8	Ch10-9	Ch10-10	Ch10-11	Ch10-12	Ch10-13
As	0.771	0.771	0.794	0.734	0.772	0.747	0.737	0.792	0.773	0.762	0.776	0.761	0.769
P	0.181	0.177	0.162	0.230	0.180	0.199	0.232	0.138	0.155	0.193	0.188	0.190	0.184
Si	0.027	0.026	0.024	0.022	0.027	0.032	0.018	0.061	0.065	0.028	0.034	0.034	0.031
V	0	0	0.001	0	0	0	0	0.001	0	0	0	0.001	0

Ca	0	0.001	0.001	0	0	0	0	0	0.001	0	0	0.001	0
Y	0.739	0.749	0.732	0.761	0.730	0.753	0.747	0.660	0.657	0.694	0.678	0.693	0.692
La	0	0	0	0	0	0	0	0	0	0	0	0	0
Ce	0.001	0.003	0.001	0	0.002	0	0.003	0	0	0.003	0.002	0.003	0.002
Pr	0.003	0	0	0	0	0	0	0	0.001	0	0	0.001	0
Nd	0.006	0.005	0.006	0	0.009	0.002	0.006	0.003	0.005	0.007	0.007	0.003	0.005
Sm	0.009	0.009	0.012	0.007	0.014	0.010	0.007	0.010	0.009	0.010	0.010	0.006	0.014
Eu	0	0	0	0	0	0	0	0	0	0	0	0	0
Gd	0.034	0.037	0.039	0.028	0.040	0.033	0.030	0.030	0.028	0.027	0.023	0.022	0.025
Tb	0.009	0.008	0.009	0.006	0.007	0.007	0.007	0.006	0.005	0.007	0.008	0.004	0.006
Dy	0.069	0.068	0.069	0.070	0.072	0.069	0.069	0.066	0.064	0.063	0.058	0.062	0.062
Ho	0.031	0.034	0.034	0.030	0.035	0.033	0.031	0.032	0.027	0.029	0.028	0.027	0.026
Er	0.035	0.038	0.036	0.038	0.037	0.040	0.039	0.048	0.053	0.054	0.053	0.054	0.053
Tm	0.006	0.002	0.004	0.004	0.004	0.003	0.004	0.007	0.008	0.008	0.010	0.008	0.006
Yb	0.026	0.023	0.025	0.026	0.025	0.023	0.024	0.056	0.059	0.060	0.064	0.064	0.068
Lu	0.012	0.015	0.012	0.012	0.015	0.014	0.012	0.021	0.018	0.018	0.017	0.019	0.016
Pb	0.002	0.003	0.004	0.002	0.002	0.002	0.002	0.003	0.003	0.002	0.002	0.003	0.001
Th	0.022	0.020	0.017	0.010	0.015	0.015	0.007	0.041	0.046	0.020	0.021	0.023	0.025
U	0.015	0.015	0.016	0.018	0.019	0.020	0.020	0.019	0.019	0.012	0.011	0.018	0.014

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75 **Table S10.** chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
76 EPMA-WDS data points of the Ch11 sample (\*: data point referring to ThSiO<sub>4</sub> inclusions)

	Ch11-1	Ch11-2	Ch11-3	Ch11-4	Ch11-5	Ch11-6*	Ch11-7	Ch11-8	Ch11-9	Ch11-10
As <sub>2</sub> O <sub>5</sub>	22.21	19.55	23.39	41.63	45.10	4.429	43.35	36.51	21.75	38.14
P <sub>2</sub> O <sub>5</sub>	17.24	19.10	14.62	1.17	0.27	1.51	0.25	4.45	16.05	2.74
SiO <sub>2</sub>	0.04	0.17	0.86	0.43	0.04	14.52	0.02	1.10	0.83	1.50
V <sub>2</sub> O <sub>5</sub>	0.04	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.
CaO	b.d.l.	0.04	b.d.l.	0.12	0.11	b.d.l.	0.10	0.02	0.02	0.04
Y <sub>2</sub> O <sub>3</sub>	38.10	38.03	35.59	26.55	22.82	5.083	20.04	31.37	36.07	27.97
La <sub>2</sub> O <sub>3</sub>	0.02	b.d.l.	b.d.l.	0.24	0.51	b.d.l.	0.73	0.07	b.d.l.	0.04
Ce <sub>2</sub> O <sub>3</sub>	b.d.l.	0.07	0.10	2.34	3.47	0.02	3.87	0.75	0.10	0.64
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	0.06	b.d.l.	0.63	0.84	b.d.l.	1.23	b.d.l.	0.06	0.20
Nd <sub>2</sub> O <sub>3</sub>	0.39	0.30	0.42	4.13	8.99	0.05	10.8	1.38	0.35	2.73
Sm <sub>2</sub> O <sub>3</sub>	0.68	0.75	0.68	2.14	4.84	0.16	5.18	1.37	0.41	1.86
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	1.99	2.11	1.89	3.57	5.09	0.56	5.63	2.82	1.94	3.33
Tb <sub>2</sub> O <sub>3</sub>	0.62	0.35	0.52	0.51	0.56	0.14	0.59	0.60	0.38	0.47
Dy <sub>2</sub> O <sub>3</sub>	5.13	4.92	5.11	4.19	3.13	0.88	2.96	4.85	5.19	4.35
Ho <sub>2</sub> O <sub>3</sub>	2.43	2.09	2.19	2.63	2.70	0.67	2.80	2.61	2.29	2.55
Er <sub>2</sub> O <sub>3</sub>	4.01	4.18	3.69	2.71	1.11	0.54	0.81	3.40	3.75	2.63
Tm <sub>2</sub> O <sub>3</sub>	0.78	0.52	0.30	0.57	0.43	0.21	0.50	0.50	0.34	0.42
Yb <sub>2</sub> O <sub>3</sub>	4.16	4.26	3.87	2.62	0.82	0.71	0.90	3.20	3.48	2.34
Lu <sub>2</sub> O <sub>3</sub>	1.36	1.38	1.28	0.78	0.52	0.19	0.48	1.18	1.49	0.93
PbO	0.25	0.28	0.24	0.22	b.d.l.	0.01	b.d.l.	0.18	0.29	0.23
ThO <sub>2</sub>	0.53	0.79	2.85	1.10	b.d.l.	59.41	0.06	3.01	2.58	4.23
UO <sub>2</sub>	b.d.l.	0.04	1.45	1.04	0.07	5.41	b.d.l.	1.56	0.95	2.07
Tot.	100.07	99.09	99.17	99.42	101.52	94.59	100.41	101.06	98.45	99.53
	Ch11-1	Ch11-2	Ch11-3	Ch11-4	Ch11-5	Ch11-6	Ch11-7	Ch11-8	Ch11-9	Ch11-10
As	0.435	0.381	0.473	0.929	0.993	0.125	0.983	0.782	0.436	0.839
P	0.547	0.603	0.479	0.042	0.009	0.069	0.009	0.154	0.522	0.097
Si	0.001	0.006	0.033	0.018	0.002	0.789	0	0.045	0.032	0.063
V	0.001	0	0	0	0	0.001	0	0	0	0

Ca	0	0.001	0	0.005	0.005	0	0.004	0.001	0.001	0.001
Y	0.760	0.755	0.733	0.603	0.511	0.147	0.462	0.684	0.737	0.626
La	0	0	0	0.003	0.008	0	0.011	0.001	0	0
Ce	0	0.001	0.001	0.036	0.053	0	0.061	0.011	0.001	0.009
Pr	0	0	0	0.009	0.012	0	0.019	0	0	0.003
Nd	0.005	0.004	0.005	0.063	0.135	0.001	0.167	0.020	0.004	0.041
Sm	0.008	0.009	0.009	0.031	0.070	0.003	0.077	0.019	0.005	0.027
Eu	0	0	0	0	0	0	0	0	0	0
Gd	0.024	0.026	0.024	0.050	0.071	0.010	0.081	0.038	0.024	0.046
Tb	0.007	0.004	0.006	0.007	0.007	0.002	0.008	0.008	0.004	0.006
Dy	0.062	0.059	0.063	0.057	0.042	0.015	0.041	0.064	0.064	0.059
Ho	0.029	0.024	0.027	0.035	0.036	0.011	0.038	0.034	0.028	0.034
Er	0.047	0.049	0.044	0.036	0.014	0.009	0.011	0.043	0.045	0.034
Tm	0.009	0.006	0.003	0.007	0.005	0.003	0.006	0.006	0.004	0.005
Yb	0.047	0.048	0.045	0.034	0.010	0.011	0.012	0.040	0.040	0.030
Lu	0.015	0.015	0.015	0.010	0.006	0.003	0.006	0.014	0.017	0.011
Pb	0.002	0.002	0.002	0.002	0	0	0	0.002	0.003	0.002
Th	0.004	0.006	0.025	0.010	0	0.734	0	0.028	0.022	0.040
U	0	0	0.012	0.009	0	0.065	0	0.014	0.008	0.019

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83 **Table S11.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
84 EPMA-WDS data points of the Ch12 sample.

	Ch12-1	Ch12-2	Ch12-3	Ch12-4	Ch12-5
As <sub>2</sub> O <sub>5</sub>	39.13	38.08	38.16	40.50	37.68
P <sub>2</sub> O <sub>5</sub>	4.32	5.25	5.02	3.55	5.49
SiO <sub>2</sub>	0.10	0.15	0.16	0.14	0.02
V <sub>2</sub> O <sub>5</sub>	b.d.l.	0.06	b.d.l.	b.d.l.	0.05
CaO	b.d.l.	0.01	0.04	b.d.l.	0.03
Y <sub>2</sub> O <sub>3</sub>	34.23	35.51	34.25	34.73	35.47
La <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	0.13	0.13
Ce <sub>2</sub> O <sub>3</sub>	0.21	0.11	0.16	0.08	0.01
Pr <sub>2</sub> O <sub>3</sub>	0.09	b.d.l.	0.03	b.d.l.	b.d.l.
Nd <sub>2</sub> O <sub>3</sub>	0.68	0.26	0.78	0.42	0.42
Sm <sub>2</sub> O <sub>3</sub>	0.94	0.57	1.23	0.69	0.52
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	2.76	2.98	3.31	3.02	2.52
Tb <sub>2</sub> O <sub>3</sub>	0.73	0.65	0.97	0.89	0.68
Dy <sub>2</sub> O <sub>3</sub>	5.10	5.60	5.62	6.18	5.62
Ho <sub>2</sub> O <sub>3</sub>	2.73	2.69	2.88	2.95	2.25
Er <sub>2</sub> O <sub>3</sub>	2.59	3.38	2.58	3.06	3.23
Tm <sub>2</sub> O <sub>3</sub>	0.54	0.30	0.30	0.31	0.27
Yb <sub>2</sub> O <sub>3</sub>	2.03	2.09	1.74	2.25	2.43
Lu <sub>2</sub> O <sub>3</sub>	1.01	1.31	1.54	0.99	1.31
PbO	0.21	0.18	0.26	0.29	0.23
ThO <sub>2</sub>	0.66	0.39	0.36	0.27	0.21
UO <sub>2</sub>	0.77	0.99	0.60	0.78	0.78
Tot.	98.93	100.63	100.08	101.32	99.43

	Ch12-1	Ch12-2	Ch12-3	Ch12-4	Ch12-5
As	0.835	0.797	0.806	0.854	0.794
P	0.149	0.178	0.171	0.121	0.187
Si	0.004	0.006	0.006	0.005	0
V	0	0.002	0	0	0.001

Ca	0	0	0.001	0	0.001
Y	0.743	0.756	0.736	0.745	0.761
La	0	0	0	0.002	0.001
Ce	0.003	0.001	0.002	0.001	0
Pr	0.001	0	0	0	0
Nd	0.009	0.003	0.011	0.006	0.006
Sm	0.013	0.007	0.017	0.009	0.007
Eu	0	0	0	0	0
Gd	0.037	0.039	0.044	0.040	0.033
Tb	0.009	0.008	0.012	0.011	0.009
Dy	0.067	0.072	0.073	0.080	0.073
Ho	0.035	0.034	0.037	0.037	0.028
Er	0.033	0.042	0.032	0.038	0.041
Tm	0.006	0.003	0.003	0.004	0.003
Yb	0.025	0.025	0.021	0.027	0.029
Lu	0.012	0.015	0.018	0.012	0.015
Pb	0.002	0.002	0.002	0.003	0.002
Th	0.006	0.003	0.003	0.002	0.001
U	0.007	0.008	0.005	0.007	0.007

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91 **Table S12.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
 92 EPMA-WDS data points of the Ch13 sample.

	Ch13-1	Ch13-2	Ch13-3	Ch13-4	Ch13-5	Ch13-6	Ch13-7	Ch13-8	Ch13-9
As <sub>2</sub> O <sub>5</sub>	30.95	32.11	38.24	42.80	35.82	34.31	40.42	35.84	36.79
P <sub>2</sub> O <sub>5</sub>	4.52	3.37	1.51	1.51	2.49	2.36	1.46	1.38	2.06
SiO <sub>2</sub>	3.61	2.93	2.93	1.30	2.20	2.54	1.10	2.92	2.07
V <sub>2</sub> O <sub>5</sub>	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
CaO	1.15	1.26	0.09	0.03	0.88	0.63	0.03	0.06	0.55
Y <sub>2</sub> O <sub>3</sub>	30.00	26.30	27.19	31.94	32.00	28.53	30.60	25.94	30.26
La <sub>2</sub> O <sub>3</sub>	b.d.l.	0.20	b.d.l.	b.d.l.	0.08	b.d.l.	0.10	0.03	0.02
Ce <sub>2</sub> O <sub>3</sub>	0.21	0.14	0.13	0.10	0.24	0.07	0.20	0.26	0.08
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	0.01	0.11	0.13	b.d.l.	0.03	0.03	0.10	b.d.l.
Nd <sub>2</sub> O <sub>3</sub>	0.07	0.57	0.94	0.77	0.28	0.50	0.77	0.89	0.34
Sm <sub>2</sub> O <sub>3</sub>	0.27	1.05	1.60	0.73	0.26	0.93	0.84	1.40	0.51
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	1.83	4.19	5.44	1.72	1.72	3.67	1.70	4.33	2.54
Tb <sub>2</sub> O <sub>3</sub>	0.53	0.86	0.84	0.47	0.48	0.76	0.40	0.68	0.63
Dy <sub>2</sub> O <sub>3</sub>	4.16	4.85	5.05	3.81	4.12	4.77	3.95	5.12	4.80
Ho <sub>2</sub> O <sub>3</sub>	1.90	2.94	3.44	1.87	1.88	2.68	2.00	2.94	1.99
Er <sub>2</sub> O <sub>3</sub>	2.34	2.06	1.76	3.73	2.52	2.26	3.76	2.49	2.33
Tm <sub>2</sub> O <sub>3</sub>	b.d.l.	0.21	0.48	0.68	0.40	0.45	0.71	0.41	b.d.l.
Yb <sub>2</sub> O <sub>3</sub>	1.85	1.39	1.24	4.58	1.93	1.99	4.55	1.42	1.64
Lu <sub>2</sub> O <sub>3</sub>	1.00	1.14	1.04	0.94	1.09	0.95	1.49	0.92	1.01
PbO	0.10	b.d.l.	0.18	0.07	0.14	0.39	0.01	0.23	0.30
ThO <sub>2</sub>	10.1	12.7	8.75	1.70	7.14	8.99	1.40	8.47	6.64
UO <sub>2</sub>	4.37	3.25	3.29	4.60	4.97	4.14	3.72	3.24	3.78
Tot.	99.15	101.67	104.35	103.59	100.74	101.05	99.36	99.18	98.43
	Ch13-1	Ch13-3	Ch13-4	Ch13-5	Ch13-6	Ch13-7	Ch13-8	Ch13-9	Ch13-
As	0.674	0.713	0.822	0.899	0.782	0.765	0.892	0.814	0.820
P	0.159	0.121	0.052	0.051	0.088	0.085	0.052	0.050	0.074
Si	0.150	0.124	0.120	0.052	0.092	0.108	0.046	0.126	0.088
V	0	0	0	0	0	0	0	0	0

Ca	0.051	0.057	0.004	0.001	0.039	0.029	0.001	0.003	0.025
Y	0.665	0.594	0.595	0.683	0.711	0.648	0.687	0.599	0.686
La	0	0.003	0	0	0.001	0	0.001	0	0
Ce	0.003	0.002	0.002	0.001	0.003	0.001	0.003	0.004	0.001
Pr	0	0	0.001	0.001	0	0	0	0.001	0
Nd	0.001	0.008	0.013	0.011	0.004	0.007	0.011	0.013	0.005
Sm	0.003	0.015	0.022	0.010	0.003	0.013	0.012	0.021	0.007
Eu	0	0	0	0	0	0	0	0	0
Gd	0.025	0.059	0.074	0.022	0.023	0.052	0.023	0.062	0.035
Tb	0.007	0.012	0.011	0.006	0.006	0.010	0.005	0.009	0.008
Dy	0.055	0.066	0.066	0.049	0.055	0.065	0.053	0.071	0.066
Ho	0.025	0.039	0.045	0.023	0.025	0.036	0.026	0.040	0.027
Er	0.030	0.027	0.022	0.047	0.033	0.030	0.049	0.034	0.031
Tm	0	0.002	0.006	0.008	0.005	0.006	0.009	0.005	0
Yb	0.023	0.018	0.015	0.056	0.024	0.025	0.058	0.018	0.021
Lu	0.012	0.014	0.012	0.011	0.013	0.012	0.019	0.012	0.013
Pb	0.001	0	0.002	0	0.001	0.004	0	0.002	0.003
Th	0.096	0.123	0.081	0.015	0.067	0.087	0.013	0.083	0.064
U	0.040	0.030	0.030	0.041	0.046	0.039	0.035	0.031	0.035

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99 **Table S13.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
100 EPMA-WDS data points of the Xen14 sample (\*: data point referring to ThSiO<sub>4</sub> inclusions).

	Xen14-1	Xen14-2	Xen14-3	Xen14-4	Xen14-5	Xen14-6	Xen14-7	Xen14-8	Xen14-9	Xen14-10	Xen14-11	Xen14-12	Xen14-13	Xen14-14	Xen14-15	Xen14-16	Xen14-17
As <sub>2</sub> O <sub>5</sub>	6.37	5.63	4.25	3.75	5.52	5.57	5.92	3.45	3.92	5.18	6.81	6.01	5.88	6.20	5.94	5.81	6.33
P <sub>2</sub> O <sub>5</sub>	27.56	27.83	30.33	30.38	28.59	28.33	28.77	31.00	29.94	28.53	28.23	28.98	27.77	28.55	27.93	25.99	28.57
SiO <sub>2</sub>	0.75	0.72	0.06	b.d.l.	0.39	0.59	0.27	0.03	0.06	0.32	0.18	0.19	0.81	0.16	0.66	0.74	0.28
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.	b.d.l.	0.08	0.03	b.d.l.	b.d.l.	0.01	0.02	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.
CaO	b.d.l.	b.d.l.	0.01	0.01	0.04	0.02	b.d.l.	0.01	0.01	0.03	b.d.l.	b.d.l.	0.07	b.d.l.	b.d.l.	0.07	0.05
Y <sub>2</sub> O <sub>3</sub>	38.76	38.86	40.71	40.61	39.23	38.91	38.82	40.35	40.39	39.14	40.26	39.32	38.75	39.81	38.81	37.11	39.21
La <sub>2</sub> O <sub>3</sub>	0.04	0.02	b.d.l.	0.06	0.04	0.12	0.03	b.d.l.	0.05	0.01	0.03	b.d.l.	b.d.l.	b.d.l.	0.10	b.d.l.	b.d.l.
Ce <sub>2</sub> O <sub>3</sub>	0.03	0.04	0.07	0.04	0.02	0.02	0.11	0.05	b.d.l.	0.17	b.d.l.	b.d.l.	b.d.l.	0.05	0.17	b.d.l.	0.13
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	0.08	b.d.l.	b.d.l.	0.10	b.d.l.	0.09	0.00	b.d.l.	0.03	0.18	0.15	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Nd <sub>2</sub> O <sub>3</sub>	0.32	0.20	0.11	0.19	0.28	0.24	0.32	0.27	0.29	0.23	0.25	0.23	0.39	0.08	0.24	0.33	0.18
Sm <sub>2</sub> O <sub>3</sub>	0.74	0.43	0.62	0.55	0.72	0.69	1.03	0.81	0.78	0.72	0.43	0.78	0.69	0.55	0.86	0.60	0.86
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	3.63	3.33	3.86	3.66	4.01	3.02	4.95	4.15	4.39	3.81	3.27	4.39	2.95	3.63	3.10	3.05	4.64
Tb <sub>2</sub> O <sub>3</sub>	0.86	0.89	0.76	0.78	1.01	0.81	0.97	0.90	0.85	0.96	0.73	1.05	0.77	0.89	0.84	0.71	1.07
Dy <sub>2</sub> O <sub>3</sub>	6.27	5.93	6.53	6.22	6.69	5.98	6.40	6.31	6.13	6.27	5.79	6.48	5.84	6.34	6.33	5.36	6.22
Ho <sub>2</sub> O <sub>3</sub>	3.05	2.83	3.58	3.43	3.32	2.82	3.86	3.57	3.44	3.28	2.81	3.41	2.65	3.29	3.05	2.70	3.64
Er <sub>2</sub> O <sub>3</sub>	3.68	3.13	3.92	3.60	3.38	3.68	3.20	3.75	3.57	3.37	4.13	3.73	3.34	3.82	3.50	3.23	3.24
Tm <sub>2</sub> O <sub>3</sub>	0.59	0.53	0.41	b.d.l.	0.28	0.61	0.53	0.51	0.45	0.30	0.55	0.55	0.42	0.37	0.47	0.42	0.60
Yb <sub>2</sub> O <sub>3</sub>	3.38	3.30	3.42	3.49	2.72	3.24	2.51	3.71	3.10	2.34	3.31	2.99	3.58	3.42	3.05	3.17	2.74
Lu <sub>2</sub> O <sub>3</sub>	1.55	1.61	1.48	1.41	1.55	1.95	1.88	1.07	1.34	1.50	1.45	1.39	1.55	1.51	1.71	1.51	1.47
PbO	0.26	0.31	0.13	0.21	0.05	0.26	0.36	0.10	0.39	0.12	0.35	0.29	0.28	0.34	0.23	0.47	0.26
ThO <sub>2</sub>	3.67	3.31	0.86	0.59	2.39	3.10	1.55	0.59	0.75	1.65	1.50	1.37	3.87	1.18	2.98	3.49	1.34
UO <sub>2</sub>	0.24	0.63	0.39	0.19	0.62	0.74	0.42	0.35	0.27	0.70	0.18	0.56	0.49	0.44	0.46	0.31	0.37
Tot.	101.85	99.73	101.58	99.27	101.04	100.79	102.18	101.11	100.24	98.75	100.52	101.98	100.18	100.70	100.50	95.16	101.28

	Xen14-1	Xen14-2	Xen14-3	Xen14-4	Xen14-5	Xen14-6	Xen14-7	Xen14-8	Xen14-9	Xen14-10	Xen14-11	Xen14-12	Xen14-13	Xen14-14	Xen14-15	Xen14-16	Xen14-17
As	0.118	0.105	0.077	0.069	0.102	0.103	0.108	0.062	0.072	0.097	0.110	0.114	0.116	0.121	0.119	0.115	0.107
P	0.829	0.846	0.894	0.907	0.857	0.853	0.856	0.912	0.895	0.868	0.843	0.831	0.852	0.850	0.845	0.848	0.870
Si	0.026	0.026	0.002	0	0.013	0.021	0.009	0.001	0.002	0.011	0.023	0.028	0.010	0.005	0.005	0.013	0
V	0	0	0	0	0	0	0.002	0	0	0	0	0	0	0	0	0	0

Ca	0	0	0	0	0.001	0	0	0	0	0.001	0	0.002	0.001	0.001	0	0	0.001
Y	0.732	0.742	0.754	0.762	0.739	0.736	0.726	0.746	0.759	0.748	0.737	0.746	0.735	0.744	0.742	0.730	0.774
La	0	0	0	0	0	0.001	0	0	0	0	0.001	0	0	0	0.001	0.001	0
Ce	0	0	0	0	0	0	0.001	0	0	0.002	0.002	0	0.001	0.002	0.002	0	0
Pr	0	0.001	0	0	0.001	0	0.001	0	0	0	0	0	0	6.958	0	0	0.001
Nd	0.004	0.002	0.001	0.002	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.004	0.002	0.002	0.003	0.004	0.002
Sm	0.009	0.005	0.007	0.006	0.008	0.008	0.012	0.009	0.009	0.008	0.010	0.007	0.010	0.008	0.010	0.012	0.006
Eu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gd	0.042	0.039	0.044	0.042	0.047	0.035	0.057	0.047	0.051	0.045	0.036	0.038	0.054	0.050	0.050	0.050	0.036
Tb	0.010	0.010	0.008	0.009	0.011	0.009	0.011	0.010	0.009	0.011	0.009	0.008	0.012	0.010	0.010	0.010	0.009
Dy	0.071	0.068	0.073	0.070	0.076	0.068	0.072	0.070	0.069	0.072	0.072	0.065	0.070	0.069	0.070	0.075	0.071
Ho	0.034	0.032	0.039	0.038	0.037	0.032	0.043	0.039	0.038	0.037	0.034	0.032	0.040	0.039	0.039	0.036	0.034
Er	0.041	0.035	0.042	0.039	0.037	0.041	0.035	0.040	0.039	0.038	0.039	0.038	0.035	0.037	0.041	0.038	0.038
Tm	0.006	0.005	0.004	0	0.003	0.006	0.005	0.005	0.005	0.003	0.005	0.004	0.006	0.005	0.003	0.005	0.002
Yb	0.036	0.036	0.036	0.037	0.029	0.035	0.027	0.039	0.033	0.025	0.033	0.036	0.029	0.028	0.033	0.029	0.032
Lu	0.016	0.017	0.015	0.015	0.016	0.021	0.019	0.011	0.014	0.016	0.018	0.017	0.015	0.018	0.018	0.013	0.018
Pb	0.002	0.003	0.001	0.002	0	0.002	0.003	0	0.003	0.001	0.002	0.004	0.002	0.002	0.001	0.002	0.002
Th	0.029	0.027	0.006	0.004	0.019	0.025	0.012	0.004	0.006	0.013	0.024	0.030	0.010	0.010	0.010	0.015	0.002
U	0.001	0.005	0.003	0.001	0.004	0.005	0.003	0.002	0.002	0.005	0.003	0.002	0.002	0.001	0.004	0.004	0

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	Xen14-18	Xen14-19	Xen14-20	Xen14-21	Xen14-22	Xen14-23	Xen14-24	Xen14-25	Xen14-26*	Xen14-27*
As <sub>2</sub> O <sub>5</sub>	6.60	6.50	6.19	5.87	6.18	6.20	3.73	3.53	1.66	1.30
P <sub>2</sub> O <sub>5</sub>	28.54	28.33	28.06	29.35	27.49	27.60	30.25	30.52	6.76	1.92
SiO <sub>2</sub>	0.16	0.14	0.38	b.d.l.	0.73	0.70	0.22	0.06	13.89	17.23
V <sub>2</sub> O <sub>5</sub>	0.01	b.d.l.	0.02	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.011	0.09	0.13
CaO	0.03	0.02	0.01	0.05	b.d.l.	0.03	0.03	b.d.l.	0.02	b.d.l.
Y <sub>2</sub> O <sub>3</sub>	39.72	39.57	38.43	41.55	38.55	38.48	40.58	40.11	9.45	3.27
La <sub>2</sub> O <sub>3</sub>	b.d.l.	0.09	0.12	b.d.l.	0.05	b.d.l.	b.d.l.	0.04	b.d.l.	b.d.l.
Ce <sub>2</sub> O <sub>3</sub>	0.19	0.20	0.04	0.07	b.d.l.	0.09	0.17	0.13	b.d.l.	0.14
Pr <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	0.12	b.d.l.	b.d.l.	0.09	0.03	b.d.l.	0.02
Nd <sub>2</sub> O <sub>3</sub>	0.17	0.24	0.37	0.23	0.25	0.48	0.43	0.26	0.34	0.15
Sm <sub>2</sub> O <sub>3</sub>	0.74	0.84	1.01	0.50	0.81	0.61	1.04	0.86	0.21	0.26
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	4.35	4.27	4.23	3.15	3.39	3.44	4.19	5.03	1.16	0.70

Tb <sub>2</sub> O <sub>3</sub>	0.92	0.94	0.87	0.81	0.68	0.80	0.92	0.91	0.16	0.24
Dy <sub>2</sub> O <sub>3</sub>	6.15	6.21	6.56	6.31	6.23	6.21	6.17	6.70	2.18	1.16
Ho <sub>2</sub> O <sub>3</sub>	3.53	3.51	3.18	3.06	3.10	3.12	3.32	4.14	1.07	0.55
Er <sub>2</sub> O <sub>3</sub>	3.36	3.77	3.46	3.45	3.39	3.70	3.83	3.55	1.04	0.53
Tm <sub>2</sub> O <sub>3</sub>	0.47	0.32	0.53	0.26	0.68	0.48	0.57	0.53	0.44	0.01
Yb <sub>2</sub> O <sub>3</sub>	2.69	3.07	2.67	3.03	3.19	3.21	2.97	2.64	1.13	0.33
Lu <sub>2</sub> O <sub>3</sub>	1.69	1.74	1.26	1.73	1.83	1.63	1.57	1.62	0.44	0.08
PbO	0.26	0.17	0.28	0.31	0.19	0.04	0.45	0.30	0.08	b.d.l.
ThO <sub>2</sub>	1.26	1.32	1.87	0.31	3.41	3.19	1.06	0.64	51.62	65.50
UO <sub>2</sub>	0.22	0.56	0.56	0.01	0.48	0.41	0.17	0.32	3.63	5.12
Tot.	101.15	101.96	100.30	100.26	100.73	100.52	101.86	102.03	95.45	98.72

	Xen14-18	Xen14-19	Xen14-20	Xen14-21	Xen14-22	Xen14-23	Xen14-24	Xen14-25	Xen14-26	Xen14-27
As	0.115	0.126	0.110	0.110	0.114	0.116	0.068	0.064	0.042	0.035
P	0.833	0.845	0.860	0.841	0.855	0.835	0.893	0.900	0.282	0.084
Si	0.026	0.006	0.006	0.029	0.005	0.025	0.007	0.002	0.685	0.892
V	0	0	0	0	0	0	0	0	0.003	0.005
Ca	0	0	0	0.002	0	0	0.001	0	0.001	0
Y	0.735	0.758	0.733	0.737	0.749	0.732	0.753	0.743	0.248	0.090
La	0	0	0	0	0	0	0	0	0	0
Ce	0	0	0	0	0	0.001	0.002	0.001	0	0.002
Pr	0	0.002	0.002	0	0	0	0.001	0	0	0
Nd	0.003	0.003	0.002	0.005	0.001	0.006	0.005	0.003	0.006	0.002
Sm	0.010	0.005	0.009	0.008	0.006	0.007	0.012	0.010	0.003	0.004
Eu	0	0	0	0	0	0	0	0	0	0
Gd	0.040	0.038	0.051	0.035	0.042	0.040	0.048	0.058	0.019	0.012
Tb	0.008	0.008	0.012	0.009	0.010	0.009	0.010	0.010	0.002	0.004
Dy	0.071	0.066	0.073	0.067	0.072	0.071	0.069	0.075	0.034	0.019
Ho	0.035	0.031	0.038	0.030	0.037	0.035	0.036	0.045	0.016	0.009
Er	0.038	0.045	0.041	0.037	0.042	0.041	0.042	0.038	0.016	0.008
Tm	0.007	0.006	0.006	0.004	0.004	0.005	0.006	0.005	0.006	0
Yb	0.034	0.035	0.031	0.039	0.036	0.035	0.031	0.028	0.017	0.005
Lu	0.019	0.015	0.014	0.016	0.016	0.017	0.016	0.017	0.006	0.001
Pb	0.001	0.003	0.002	0.002	0.003	0	0.004	0.002	0.001	0
Th	0.027	0.012	0.010	0.031	0.009	0.025	0.008	0.005	0.579	0.771
U	0.003	0.001	0.004	0.003	0.003	0.003	0.001	0.002	0.039	0.059

102 **Table S14.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
103 EPMA-WDS data points of the Mon14 sample.

	Mon14-1	Mon14-2	Mon14-3	Mon14-4	Mon14-5	Mon14-6	Mon14-7	Mon14-8	Mon14-9	Mon14-10	Mon14-11	Mon14-12
As <sub>2</sub> O <sub>5</sub>	2.8	2.85	1.53	1.42	2.05	1.4	1.61	1.97	1.47	1.37	2.47	2.58
P <sub>2</sub> O <sub>5</sub>	27.11	26.60	28.21	28.10	28.32	28.55	28.09	27.64	27.93	28.24	26.93	26.76
SiO <sub>2</sub>	0.69	0.65	0.10	0.06	0.11	0.02	0.06	0.06	0.05	0.08	0.53	0.48
V <sub>2</sub> O <sub>5</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
CaO	1.11	1.09	1.33	1.43	0.55	0.54	1.47	1.16	1.40	1.43	1.59	1.17
Y <sub>2</sub> O <sub>3</sub>	0.58	0.62	0.53	0.59	0.60	0.43	0.39	0.49	0.60	0.47	0.62	0.60
La <sub>2</sub> O <sub>3</sub>	12.31	12.47	14.70	15.00	13.35	15.61	15.82	15.15	15.10	15.67	12.47	12.48
Ce <sub>2</sub> O <sub>3</sub>	29.74	28.82	31.87	31.22	31.40	32.95	32.07	32.12	30.10	31.15	28.41	30.19
Pr <sub>2</sub> O <sub>3</sub>	3.25	3.09	3.48	3.50	3.93	3.56	3.44	3.45	3.55	3.48	3.43	3.42
Nd <sub>2</sub> O <sub>3</sub>	13.02	13.52	12.43	12.47	14.46	12.70	12.21	12.99	12.78	12.49	12.75	12.70
Sm <sub>2</sub> O <sub>3</sub>	2.39	2.45	1.97	2.22	2.39	2.23	2.18	2.28	2.11	1.86	2.24	2.07
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	1.55	1.43	1.36	1.46	2.06	1.23	1.04	1.31	1.47	1.06	1.64	1.31
Tb <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Dy <sub>2</sub> O <sub>3</sub>	0.40	0.25	0.18	0.13	0.32	0.41	0.18	0.15	0.21	0.27	0.43	0.27
Ho <sub>2</sub> O <sub>3</sub>	0.13	0.42	0.13	0.36	0.44	0.24	0.20	0.26	0.15	0.36	0.25	0.10
Er <sub>2</sub> O <sub>3</sub>	0.22	0.02	b.d.l.	b.d.l.	0.03	b.d.l.	0.03	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.05
Tm <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.17	b.d.l.	b.d.l.	b.d.l.	0.15	0.14	0.17	0.21
Yb <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.09	0.39	b.d.l.	0.02
Lu <sub>2</sub> O <sub>3</sub>	0.14	0.24	b.d.l.	0.04	0.18	b.d.l.	0.07	b.d.l.	0.05	0.03	b.d.l.	0.18
PbO	b.d.l.	b.d.l.	b.d.l.	0.01	0.20	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.07	0.08	b.d.l.
ThO <sub>2</sub>	5.38	5.39	1.32	1.60	1.20	0.57	1.33	0.68	1.64	1.06	5.70	4.73
UO <sub>2</sub>	0.09	0.17	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	0.05	0.06	0.01	0.08	0.15
Tot.	100.98	100.14	99.20	99.70	101.84	100.52	100.26	99.83	98.97	99.70	99.86	99.56
	Mon14-1	Mon14-2	Mon14-3	Mon14-4	Mon14-5	Mon14-6	Mon14-7	Mon14-8	Mon14-9	Mon14-10	Mon14-11	Mon14-12
As	0.058	0.059	0.031	0.029	0.042	0.028	0.033	0.041	0.030	0.028	0.051	0.054
P	0.909	0.904	0.951	0.947	0.941	0.956	0.943	0.935	0.948	0.950	0.914	0.913
Si	0.027	0.026	0.004	0.002	0.004	0.001	0.002	0.002	0.002	0.003	0.021	0.019
V	0	0	0	0	0	0	0	0	0	0	0	0

Ca	0.047	0.047	0.057	0.061	0.023	0.023	0.062	0.050	0.060	0.061	0.068	0.050
Y	0.012	0.013	0.011	0.012	0.012	0.009	0.008	0.010	0.012	0.010	0.013	0.013
La	0.179	0.184	0.216	0.220	0.193	0.227	0.231	0.223	0.223	0.229	0.184	0.185
Ce	0.431	0.423	0.464	0.455	0.451	0.477	0.465	0.469	0.442	0.453	0.416	0.445
Pr	0.047	0.045	0.050	0.050	0.056	0.051	0.049	0.050	0.051	0.050	0.050	0.050
Nd	0.184	0.193	0.176	0.177	0.202	0.179	0.172	0.185	0.183	0.177	0.182	0.182
Sm	0.032	0.033	0.027	0.030	0.032	0.030	0.029	0.031	0.029	0.025	0.030	0.028
Eu	0	0	0	0	0	0	0	0	0	0	0	0
Gd	0.020	0.019	0.018	0.019	0.026	0.016	0.013	0.017	0.019	0.014	0.021	0.017
Tb	0	0	0	0	0	0	0	0	0	0	0	0
Dy	0.005	0.003	0.002	0.001	0.004	0.005	0.002	0.001	0.002	0.003	0.005	0.003
Ho	0.001	0.005	0.001	0.004	0.005	0.003	0.002	0.003	0.001	0.004	0.003	0.001
Er	0.002	0	0	0	0	0	0	0	0	0	0	0
Tm	0	0	0	0	0.002	0	0	0	0.001	0.001	0.002	0.002
Yb	0	0	0	0	0	0	0	0	0.001	0.004	0	
Lu	0.001	0.002	0	0	0.002	0	0	0	0	0	0	0.002
Pb	0	0	0	0	0.002	0	0	0	0	0	0	0
Th	0.048	0.049	0.012	0.014	0.010	0.005	0.012	0.006	0.015	0.009	0.051	0.043
U	0	0.001	0	0	0	0	0	0	0	0	0	0.001

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111 **Table S15.** Chemical composition (expressed in oxide wt % and in atoms per formula unit calculated on the basis of 4 oxygen atoms) of all the  
 112 EPMA-WDS data points of the Ch16 sample.

	Ch16-1	Ch16-2	Ch16-3	Ch16-4	Ch16-5	Ch16-6	Ch16-7	Ch16-8	Ch16-9	Ch16-10	Ch16-11	Ch16-12	Ch16-13
As <sub>2</sub> O <sub>5</sub>	31.99	39.91	39.61	37.71	23.63	38.16	38.91	18.40	24.11	36.45	38.88	38.85	36.31
P <sub>2</sub> O <sub>5</sub>	3.24	1.91	3.04	6.53	7.27	4.05	2.43	11.88	7.68	2.43	2.78	2.45	3.02
SiO <sub>2</sub>	2.73	1.98	1.68	0.32	2.83	1.31	2.16	2.64	3.03	2.66	2.16	2.58	2.20
V <sub>2</sub> O <sub>5</sub>	0.04	b.d.l.	b.d.l.	b.d.l.	0.02	b.d.l.	0.03	0.03	b.d.l.	0.05	b.d.l.	0.05	b.d.l.
CaO	0.83	b.d.l.	0.05	b.d.l.	1.71	0.11	b.d.l.	1.93	1.82	0.19	0.02	0.05	0.59
Y <sub>2</sub> O <sub>3</sub>	28.94	30.52	30.53	34.68	27.48	31.50	30.69	30.28	29.29	32.26	35.04	32.53	32.22
La <sub>2</sub> O <sub>3</sub>	0.07	0.06	b.d.l.	b.d.l.	b.d.l.	0.03	0.05	0.23	0.06	0.07	0.01	0.14	b.d.l.
Ce <sub>2</sub> O <sub>3</sub>	0.13	0.19	0.28	0.29	0.16	0.22	0.10	0.55	0.35	b.d.l.	b.d.l.	0.03	0.20
Pr <sub>2</sub> O <sub>3</sub>	0.05	b.d.l.	0.01	0.06	0.03	b.d.l.	b.d.l.	0.02	b.d.l.	0.12	0.04	b.d.l.	b.d.l.
Nd <sub>2</sub> O <sub>3</sub>	0.49	0.99	1.43	1.29	0.66	1.20	0.79	0.43	0.32	0.10	0.06	0.27	0.33
Sm <sub>2</sub> O <sub>3</sub>	0.78	0.98	1.56	1.22	0.73	1.41	0.71	0.33	0.22	0.67	0.10	0.65	0.33
Eu <sub>2</sub> O <sub>3</sub>	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.
Gd <sub>2</sub> O <sub>3</sub>	2.15	1.99	2.83	2.84	1.95	2.98	2.01	2.36	2.09	2.82	1.55	2.58	1.86
Tb <sub>2</sub> O <sub>3</sub>	0.55	0.40	0.68	0.72	0.45	0.59	0.52	0.49	0.41	0.61	0.65	0.79	0.66
Dy <sub>2</sub> O <sub>3</sub>	4.29	4.35	4.59	4.81	4.21	4.77	4.48	4.39	4.22	4.94	4.10	5.16	3.71
Ho <sub>2</sub> O <sub>3</sub>	1.82	1.83	2.40	1.97	1.85	2.19	1.89	1.76	1.94	2.39	1.72	2.48	1.96
Er <sub>2</sub> O <sub>3</sub>	3.07	3.27	2.86	3.69	2.53	3.18	3.30	2.27	2.11	2.49	2.80	2.50	2.76
Tm <sub>2</sub> O <sub>3</sub>	0.50	0.64	0.51	0.56	0.11	0.63	0.37	0.04	0.18	0.15	0.19	0.33	0.33
Yb <sub>2</sub> O <sub>3</sub>	3.26	3.51	3.31	3.62	2.64	2.93	3.66	1.62	1.47	1.42	1.86	1.47	1.68
Lu <sub>2</sub> O <sub>3</sub>	1.17	0.99	1.29	1.49	0.96	1.12	1.74	1.26	1.17	1.27	0.64	0.95	1.01
PbO	0.24	0.10	0.22	0.27	0.25	0.29	0.20	0.29	0.24	0.23	0.03	0.29	0.29
ThO <sub>2</sub>	5.82	3.42	4.24	0.44	11.52	2.97	3.17	11.81	10.96	7.26	4.21	6.75	6.76
UO <sub>2</sub>	5.82	5.86	3.19	1.20	4.37	3.02	6.06	3.18	4.48	4.14	4.17	4.33	3.43
Tot.	98.10	102.97	104.41	103.93	95.47	102.76	103.38	96.30	96.19	102.81	101.11	105.32	99.75
	Ch16-1	Ch16-2	Ch16-3	Ch16-4	Ch16-5	Ch16-6	Ch16-7	Ch16-8	Ch16-9	Ch16-10	Ch16-11	Ch16-12	Ch16-13
As	0.724	0.851	0.828	0.763	0.543	0.802	0.826	0.403	0.540	0.780	0.818	0.806	0.786
P	0.118	0.066	0.103	0.214	0.271	0.138	0.083	0.422	0.279	0.084	0.094	0.082	0.106
Si	0.118	0.080	0.067	0.012	0.124	0.052	0.087	0.110	0.130	0.109	0.087	0.102	0.091
V	0.001	0	0	0	0	0	0.001	0.001	0	0.001	0	0.001	0



Ca	0.038	0	0.002	0	0.080	0.005	0	0.086	0.083	0.008	0	0.002	0.026
Y	0.667	0.662	0.649	0.714	0.643	0.674	0.663	0.676	0.668	0.703	0.750	0.687	0.710
La	0.001	0	0	0	0	0	0	0.003	0	0.001	0	0.002	0
Ce	0.002	0.002	0.004	0.004	0.002	0.003	0.001	0.008	0.005	0	0	0	0.003
Pr	0	0	0	0	0	0	0	0	0	0.001	0	0	0
Nd	0.007	0.014	0.020	0.017	0.010	0.017	0.011	0.006	0.004	0.001	0	0.003	0.004
Sm	0.011	0.013	0.021	0.016	0.011	0.019	0.010	0.004	0.003	0.009	0.001	0.008	0.004
Eu	0	0	0	0	0	0	0	0	0	0	0	0	0
Gd	0.030	0.027	0.037	0.036	0.028	0.039	0.027	0.032	0.029	0.038	0.020	0.034	0.025
Tb	0.007	0.005	0.008	0.009	0.006	0.007	0.007	0.006	0.005	0.008	0.008	0.010	0.009
Dy	0.059	0.057	0.059	0.060	0.059	0.061	0.058	0.059	0.058	0.065	0.053	0.066	0.049
Ho	0.025	0.023	0.030	0.024	0.026	0.028	0.024	0.023	0.026	0.031	0.022	0.031	0.025
Er	0.041	0.041	0.035	0.045	0.034	0.040	0.042	0.029	0.028	0.032	0.035	0.031	0.036
Tm	0.006	0.008	0.006	0.006	0.001	0.007	0.004	0	0.002	0.001	0.002	0.004	0.004
Yb	0.043	0.043	0.040	0.042	0.035	0.035	0.045	0.020	0.019	0.017	0.022	0.017	0.021
Lu	0.015	0.012	0.015	0.017	0.012	0.013	0.021	0.016	0.015	0.015	0.007	0.011	0.012
Pb	0.002	0.001	0.002	0.002	0.003	0.003	0.002	0.003	0.002	0.002	0	0.003	0.003
Th	0.057	0.031	0.038	0.003	0.115	0.027	0.029	0.112	0.106	0.067	0.038	0.061	0.063
U	0.056	0.053	0.028	0.010	0.042	0.027	0.054	0.029	0.042	0.037	0.037	0.038	0.031

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120 **Table S16.** Selected statistical parameters pertaining to the single-crystal X-ray diffraction data collections and structure refinements of this study.

Sample	$R_{int}$	$R_1$ (obs)	$R_1$ (all)	$wR_1$ (obs)	Observed reflections $I > 3\sigma(I)$	Unique reflections	Refined param.	Isotropic Extinction refined	Exposure time per frame (s)	Crystal size ( $\mu\text{m} \cdot \mu\text{m} \cdot \mu\text{m}$ )
Mon1	0.0532	0.0276	0.0317	0.0344	1351	1515	55	no	0.5	200·100·100
Mon2	0.0353	0.0257	0.0299	0.0299	1314	1515	55	no	3	80·80·70
Gasp3	0.0544	0.0398	0.0726	0.0409	1032	1582	55	no	170	10·10·5
Gasp4	0.0939	0.0473	0.0750	0.0487	831	1088	56	yes	60	20·20·10
Ch6	0.0270	0.0161	0.0188	0.0205	190	219	12	yes	15	50·30·30
Ch7	0.0382	0.0361	0.0497	0.0829	159	219	11	no	20	50·50·30
Ch8	0.0531	0.0351	0.0426	0.0364	108	135	11	no	60	40·30·30
Ch9	0.0299	0.0229	0.0297	0.0270	119	151	11	no	10	20·20·15
Ch10	0.0546	0.0444	0.0511	0.0502	180	218	11	no	20	40·30·20
Ch11	0.0591	0.0371	0.0553	0.0454	151	214	11	no	10	20·20·15
Ch12	0.0109	0.0142	0.0153	0.0286	110	115	11	no	60	20·20·10
Ch13	0.0374	0.0330	0.0698	0.0373	132	223	11	no	60	20·20·10
Xen14	0.0282	0.0214	0.0260	0.0270	127	142	11	no	16	20·20·15
Mon14	0.0494	0.0194	0.0235	0.0228	917	1029	55	no	2	50·50·50
Ch16	0.0492	0.0439	0.0567	0.0530	88	107	11	no	30	30·30·20

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126 **Table S17.** Unit-cell, A-site polyhedron and T-site tetrahedron volumes of selected synthetic REETO<sub>4</sub> compounds.

Compound	Structure type	Unit-cell Volume (Å <sup>3</sup> )	A-site polyhedron (Å <sup>3</sup> )	T-site tetrahedron (Å <sup>3</sup> )	Reference
YPO <sub>4</sub>	zircon	286.53(5)	23.15(6)	1.86(1)	Ni <i>et al.</i> 1995
LaPO <sub>4</sub>	monazite	305.73(6)	33.31(8)	1.858(8)	Ni <i>et al.</i> 1995
CePO <sub>4</sub>	monazite	299.93(7)	32.56(8)	1.837(7)	Ni <i>et al.</i> 1995
NdPO <sub>4</sub>	monazite	291.31(7)	31.27(8)	1.851(7)	Ni <i>et al.</i> 1995
TbPO <sub>4</sub>	zircon	291.14(8)	23.73(7)	1.84(1)	Ni <i>et al.</i> 1995
HoPO <sub>4</sub>	zircon	287.92(7)	23.34(8)	1.85(1)	Ni <i>et al.</i> 1995
DyPO <sub>4</sub>	zircon	284.62(6)	23.08(7)	1.83(1)	Ni <i>et al.</i> 1995
YbPO <sub>4</sub>	zircon	287.92(7)	22.20(7)	1.83(1)	Ni <i>et al.</i> 1995
LuPO <sub>4</sub>	zircon	273.58(8)	21.84(7)	1.83(1)	Ni <i>et al.</i> 1995
YAsO <sub>4</sub>	zircon	312.27(4)	23.46(4)	2.377(9)	Ledderboge <i>et al.</i> 2018
LaAsO <sub>4</sub>	monazite	330.65(3)	33.84(5)	2.400(5)	Kang and Schleid, 2005
CeAsO <sub>4</sub>	monazite	327.29(11)	38.34(14)	2.43(2)	Brahim <i>et al.</i> 2002
NdAsO <sub>4</sub>	monazite	315.67(3)	31.75(8)	2.399(9)	Schmidt <i>et al.</i> 2005
TbAsO <sub>4</sub>	zircon	319.9(2)	24.14(13)	2.42(3)	Long and Stager, 1977
HoAsO <sub>4</sub>	zircon	314.5(3)	23.73(5)	2.377(9)	Schmidt <i>et al.</i> 2005
DyAsO <sub>4</sub>	zircon	312.8(2)	23.51(10)	2.39(2)	Long and Stager, 1977
YbAsO <sub>4</sub>	zircon	303.40(3)	22.52(4)	2.38(1)	Kang <i>et al.</i> 2005
LuAsO <sub>4</sub>	zircon	300.69(15)	22.28(6)	2.37(1)	Lohmüller <i>et al.</i> 1973

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