Supplementary Materials: Neoproterozoic Lysan Alkaline-Ultramafic Complex in the Eastern Sayan, Southern Siberia, Russia: Mineralogical constraints of Carbonate Rocks and Albitite for petrogenesis

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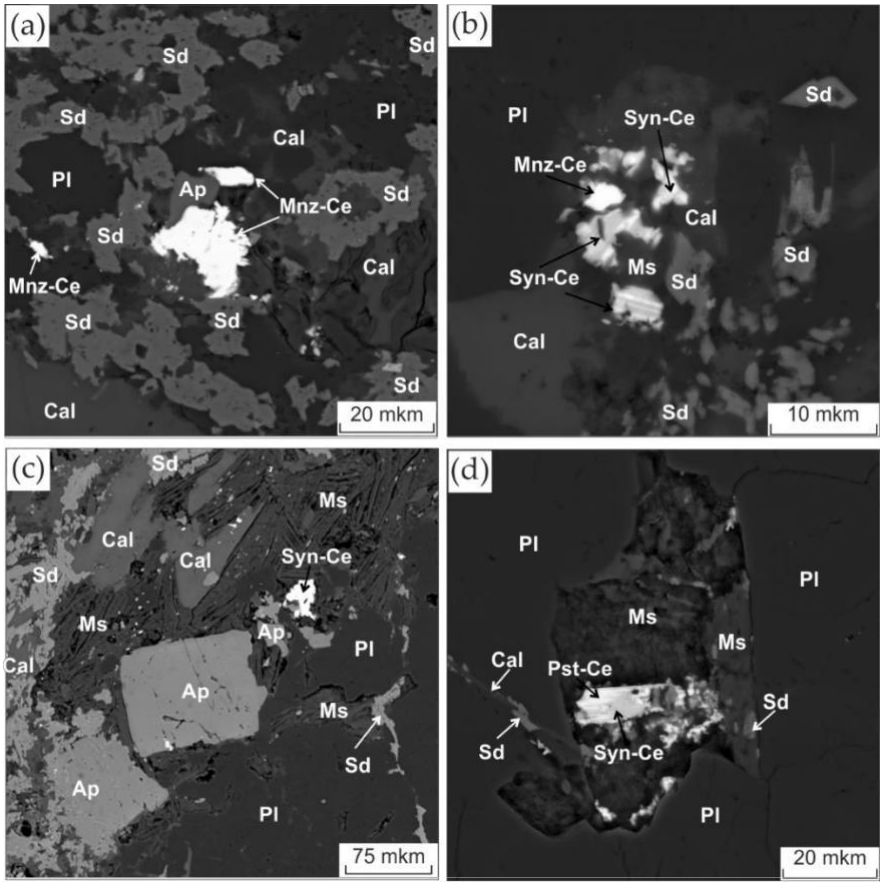

Figure S1. Relationships between rock-forming and accessory minerals in a calcite-siderite matrix. Cal – calcite, Sd – siderite, Ms – white mica, Pl – plagioclase, Ap – apatite, Syn-Ce - synchysite-(Ce), Pst-Ce - parisite-(Ce), Mnz-Ce – monazite-(Ce). BSE image.

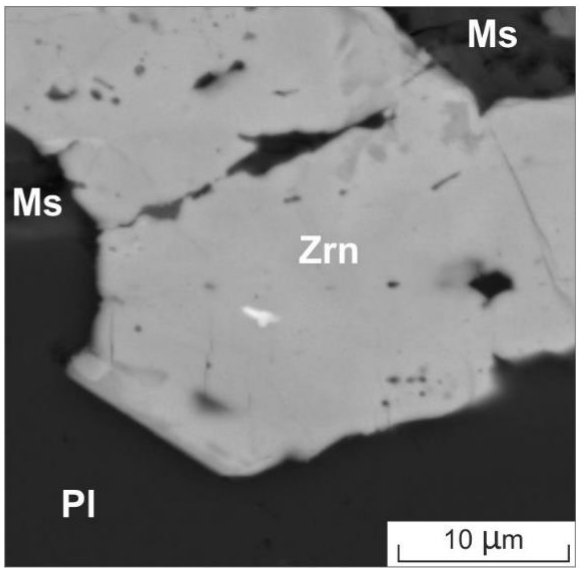

Figure S2. Baddeleyite (white) within zircon. Ms – white mica, Pl – plagioclase, Zrn – zircon. BSE image.

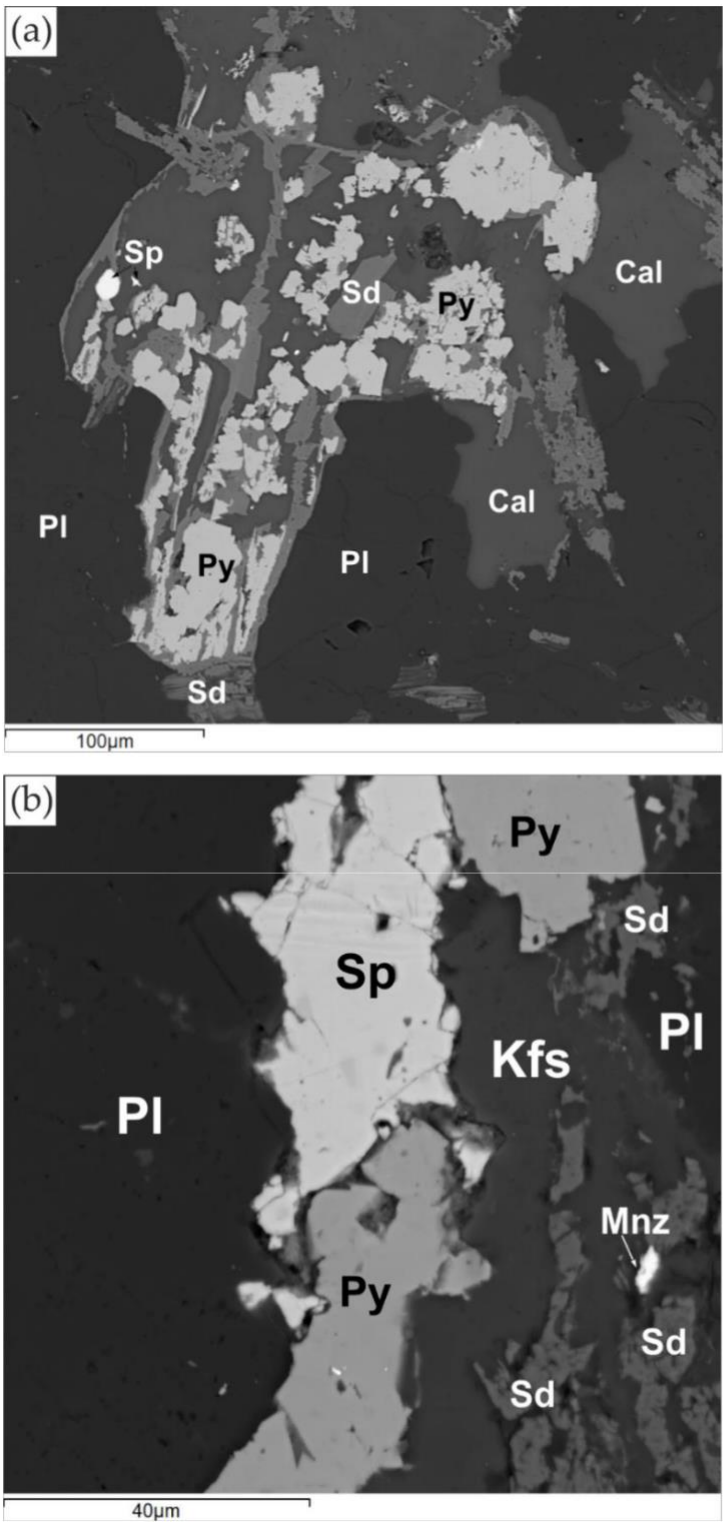

Figure S3. Sulphide. Cal – calcite, Sd – siderite, Mnz – monazite, Pl – plagioclase, Py – pyrite, Sp - sphalerite. BSE image.

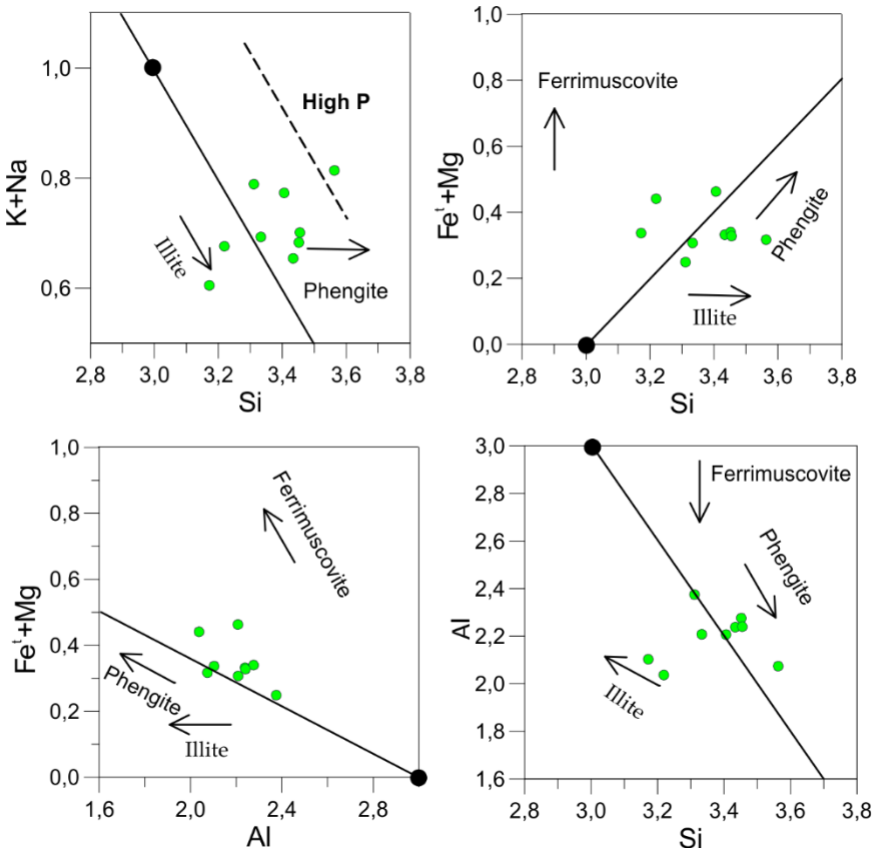

Figure S4. Diagrams of the chemical composition of white micas. Black points and solid lines respectively indicate the theoretical muscovite position and corresponding exchange vectors.

Table S1. Representative EPMA of white mica, wt. %

Sample	SiO_2	TiO_2	Al_2O_3	FeO_t	MgO	K_2O	Total
7821-1	54.52	0.38	26.93	3.26	1.43	8.97	95.49
7821-1	50.21	1.73	30.55	2.48	1.14	9.38	95.49
7821-1	52.86	0.53	29.07	2.91	1.73	8.4	95.50
7821-1	50.7	3.74	28.5	2.67	1.63	8.26	95.50
7821-3	47.87	8.35	26.93	3.12	1.66	7.16	95.09
7821-3	52.7	b.l.d.	29.14	3.03	1.72	7.87	94.46
7821-3	47.92	6.9	25.74	5.08	1.54	7.89	95.07
7821-3	51.12	0.28	28.1	5.1	1.8	9.09	95.49
7821-3	52.85	b.l.d.	29.57	3.17	1.72	8.19	95.50

Note. b.d.l. - below detection limit

Table S2. Representative EPMA of apatite, wt. %

Oxide wt.%	7821-1	7821-3	7821-3	7821	7821	7821	7821
CaO	53,80	54,09	52,99	53,31	53,55	53,77	53,51
FeO	0,66	0,70	0,79	0,59	0,51	0,51	0,50
Ce_2O_3	0,28	b.l.d.	0,92	b.l.d.	b.l.d.	b.l.d.	b.l.d.
P_2O_5	40,35	40,78	39,08	40,56	40,27	40,50	40,30
SiO_2	0,53	0,00	1,32	0,16	0,53	0,68	0,64
F	4,18	4,20	3,90	4,49	4,23	4,45	4,58
Total	99,79	99,77	99,00	99,10	99,09	99,91	99,54

Note. b.d.l. - below detection limit

Table S3. Representative EPMA of monazite.

Oxide wt.%	7821-1	7821-1	7821-1	7821-1	7821-1	7821-3	7821-3	7821-3	7821-3	7821-3	7821-3
SiO_2	0.79	0.39	0.26	5.44	5.88	0.27	0.36	b.d.l.	b.d.l.	0.67	3.05
FeO	1.08	1.37	1.69	1.15	1.84	1.00	0.91	0.92	1.00	1.37	0.00
CaO	0.39	0.60	0.76	0.21	0.77	0.74	0.55	0.48	0.98	0.71	1.33
P_2O_5	29.61	29.00	29.22	30.70	28.61	29.52	29.61	29.33	29.13	28.55	30.83
Ce_2O_3	31.14	32.22	29.82	30.05	29.15	33.07	33.69	33.01	32.39	33.18	28.35
La_2O_3	14.99	12.72	12.32	13.94	11.13	14.64	15.11	16.04	15.99	15.40	18.45
Pr_2O_3	3.27	3.53	3.70	2.98	3.12	3.48	3.44	3.12	3.05	3.43	1.87
Nd_2O_3	13.60	14.11	15.60	12.25	11.96	12.51	12.78	13.43	12.67	12.64	10.48
Sm_2O_3	2.09	2.04	3.20	1.65	1.97	2.07	2.04	2.19	2.14	2.13	1.85
Gd_2O_3	1.24	1.45	2.22	0.76	1.09	0.93	1.08	1.14	1.04	1.07	1.68
ThO_2	b.d.l.	b.d.l.	b.d.l.	0.70	1.21	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	1.19
Total	98.20	97.45	98.80	99.81	98.98	98.23	99.57	99.67	98.40	99.14	99.06
Structural formulae on basis of 4 oxygens											
Si	0.031	0.016	0.010	0.206	0.075	0.011	0.014	0.000	0.000	0.027	0.117
Fe	0.036	0.046	0.056	0.036	0.118	0.033	0.030	0.031	0.033	0.046	0.000
Ca	0.017	0.026	0.032	0.009	0.033	0.031	0.023	0.021	0.042	0.030	0.055
Ce	0.452	0.474	0.434	0.418	0.435	0.480	0.486	0.479	0.473	0.486	0.398
La	0.219	0.189	0.181	0.195	0.167	0.214	0.219	0.234	0.235	0.227	0.261
Pr	0.047	0.052	0.054	0.041	0.046	0.050	0.049	0.045	0.044	0.050	0.026
Nd	0.192	0.202	0.221	0.166	0.174	0.177	0.180	0.190	0.181	0.181	0.144
Sm	0.029	0.028	0.044	0.022	0.028	0.028	0.028	0.030	0.029	0.029	0.024
Gd	0.016	0.019	0.029	0.010	0.015	0.012	0.014	0.015	0.014	0.014	0.021
Th	0.000	0.000	0.000	0.006	0.011	0.000	0.000	0.000	0.000	0.000	0.010
Total	1.039	1.052	1.061	1.109	1.102	1.038	1.043	1.044	1.052	1.090	1.057
P	0.993	0.986	0.983	0.986	0.986	0.992	0.987	0.984	0.984	0.967	1.002

Note. b.d.l. - below detection limit; are based on 4 oxygens

Table S4. Representative EPMA of REE fluorcarbonate, wt. %.

Oxide wt.%	**7821-3**	**7821-2**	**7821-2**	**7821-3**	**7821-3**	**7821-3**	**7821-3**	**7821-3**	**7821-3**	**7821-3**
	1	2	3	4	5	6	7	8	9	10
CaO	3.38	10.45	11.76	17.02	17.53	18.00	13.55	18.84	17.92	18.71
Ce_2O_3	32.45	25.65	25.48	24.41	20.17	19.62	23.13	19.91	19.29	20.02
La_2O_3	14.68	14.31	14.19	15.15	9.32	8.93	12.44	9.99	9.47	10.67
Pr_2O_3	3.20	2.43	2.60	1.63	2.15	2.36	2.41	2.00	1.95	2.14
Nd_2O_3	13.81	9.89	10.48	6.62	9.86	9.47	10.26	9.64	9.49	9.59
Sm_2O_3	2.08	1.50	1.54	0.00	2.07	2.15	1.87	1.59	1.27	1.87
Eu_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Gd_2O_3	1.15	0.87	0.00	0.00	1.51	1.70	1.23	1.35	1.33	1.41
Y_2O_3	2.15	0.81	1.95	1.31	3.72	4.53	2.09	2.41	3.45	2.02
ThO_2	b.d.l.	2.78	b.d.l.	0.93	b.d.l.	b.d.l.	b.d.l.	0.63	1.53	b.d.l.
F	6.82	5.86	5.93	4.15	4.09	4.74	3.56	5.59	5.73	3.70
Total	79.73	74.56	73.93	71.22	70.41	71.51	70.54	71.94	71.43	70.98
Structural formulae										
Ca	0.124	0.995	1.063	0.980	0.968	0.963	0.811	1.062	1.003	1.047
Ce	0.406	0.834	0.787	0.480	0.381	0.359	0.473	0.383	0.369	0.383
La	0.185	0.469	0.441	0.300	0.177	0.165	0.256	0.194	0.182	0.206
Pr	0.040	0.079	0.080	0.032	0.040	0.043	0.049	0.038	0.037	0.041
Nd	0.168	0.314	0.316	0.127	0.181	0.169	0.205	0.181	0.177	0.179
Sm	0.025	0.046	0.045	0.000	0.037	0.037	0.036	0.029	0.023	0.034
Eu	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
Gd	0.013	0.026	0.000	0.000	0.026	0.028	0.023	0.023	0.023	0.024
Y	0.039	0.039	0.088	0.037	0.102	0.121	0.062	0.067	0.096	0.056
Th	0.000	0.056	0.000	0.011	0.000	0.000	0.000	0.008	0.018	0.000
Total	0.999	2.857	2.818	1.968	1.911	1.884	1.915	1.986	1.928	1.984
F	0.736	1.647	1.582	0.705	0.666	0.749	0.629	0.929	0.947	0.611
OH*	0.264	0.353	0.611	0.295	0.334	0.251	0.371	0.071	0.053	0.389

Note. 1 - bastnäsite-(Ce), 2,3 - parisite-(Ce), 4-10 - synchysite-(Ce); * - by stoichiometry. b.d.l. - below detection limit. Structural formulae on basis of 4 anions (1), 11 anions (2,3), 7 anions (4-10).

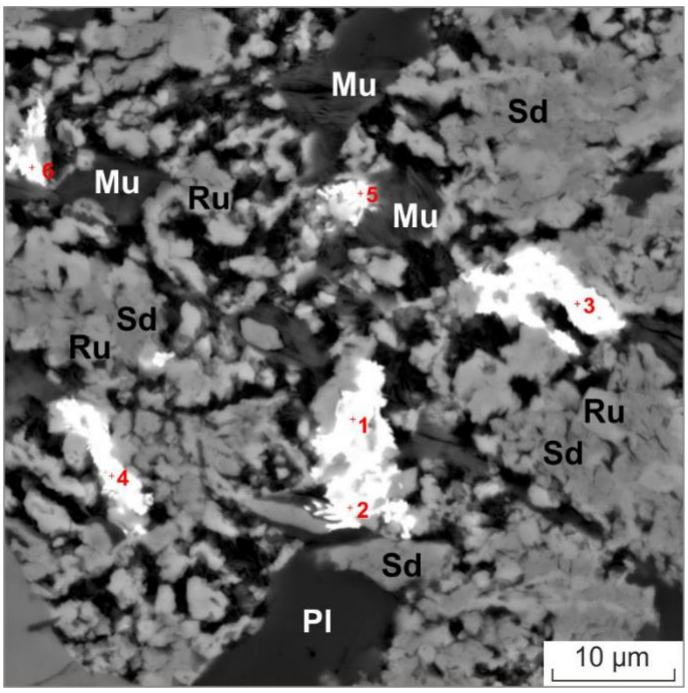

Figure S5. Unidentified REE phases (white) in rutile (Rt) – siderite (Sd) – muscovite (Ms) aggregate. BSE image. The analysis point is indicated by the red cross and Arabic numeral.

Table S5. EPMA of unidentified REE phases, wt. %

Sample	7821-3	7821-3	7821-3	7821-3	7821-3	7821-3
Point	1	2	3	4	5	6
SiO_2	1.26	2.14	5.9	6.5	7.44	5.99
TiO_2	21.22	8.79	18.00	6.46	25.85	18.47
Al_2O_3	0.72	1.34	3.74	4.01	4.69	3.87
FeO	0.49	0.78	1.34	1.36	1.13	1.35
CaO	12.4	13.19	8.93	7.78	6.87	7.88
K_2O	0.29	0.35	0.88	0.72	0.76	0.84
Ce_2O_3	14.24	17.71	15.23	20.51	13.93	15.88
La_2O_3	7.24	8.07	7.41	10.51	7.11	7.92
Pr_2O_3	b.d.l	1.85	1.26	1.9	1.3	1.56
Nd_2O_3	7.08	8.56	6.56	8.57	6.31	6.78
Sm_2O_3	b.d.l	1.33	0.94	1.04	0.97	1.00
Gd_2O_3	b.d.l	1.04	0.78	b.d.l	0.78	0.74
Y_2O_3	2.73	2.87	1.24	1.3	1.26	0.95
ThO_2	b.d.l	b.d.l	0.81	0.88	0.8	1.09
F	4.42	4.22	3.25	5.62	6.99	4.75
Total	72.09	72.24	76.27	77.16	86.19	79.07

Note. b.d.l. - below detection limit