Deposited Material

Clay mineralogy and chemistry of the halloysite and alunite deposits in the Turplu area, Balikesir, Turkey

Ö. Işık Ece[1,2,*] and Paul A. Schroeder[1]

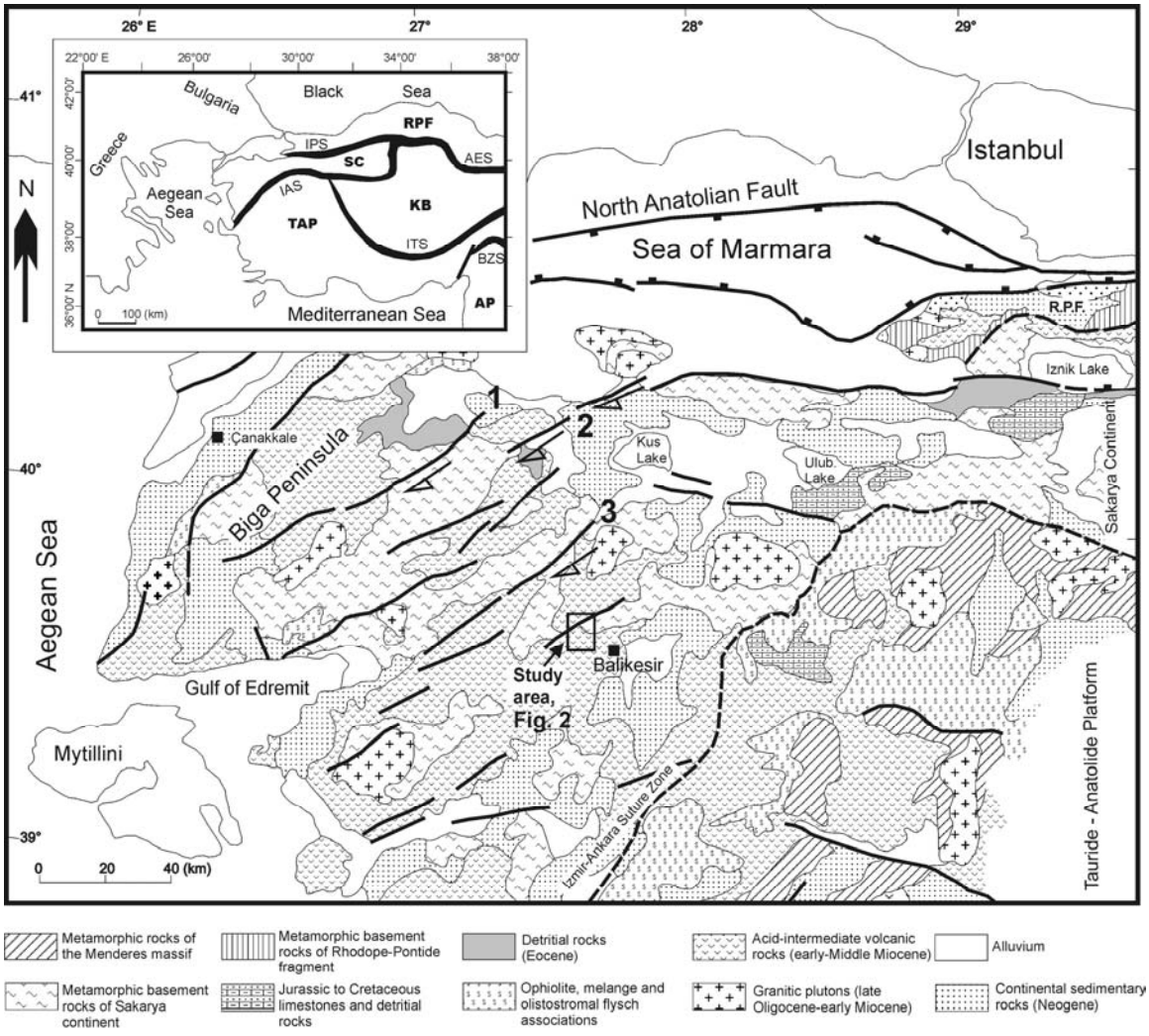

Figure A1. Index map of the Biga Peninsula (after Genç, 1998), indicating area of study. En-echelon faults are regional trends represented by (1) Manyas-Danışment fault in the southeast, (2) the Yenice-Gönen fault in the middle and (3) the Sarıköy-Inova fault in the northwest.

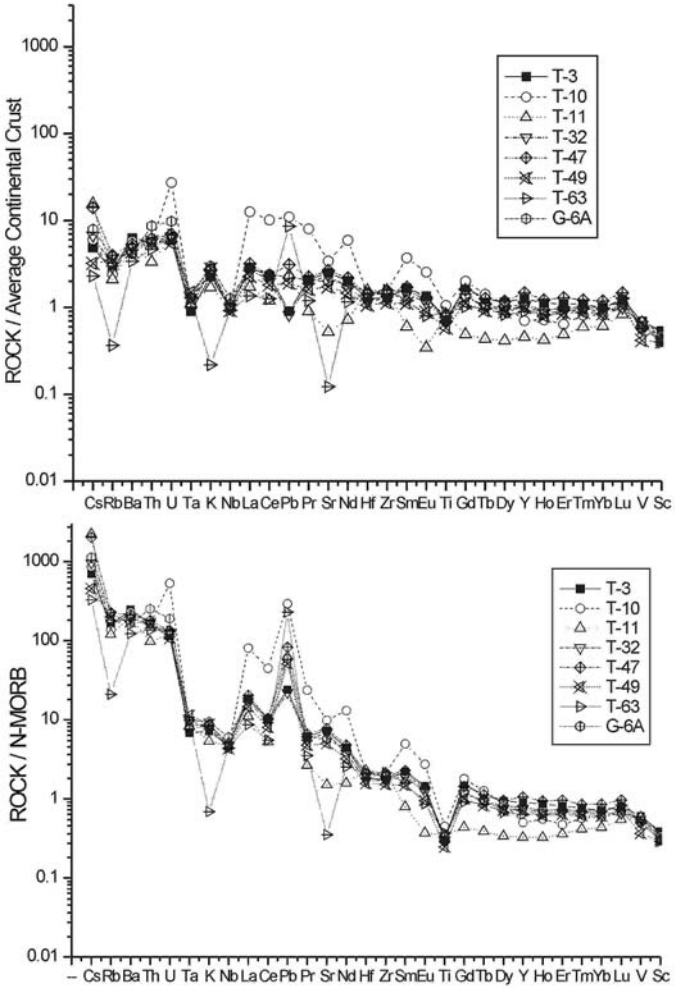

Figure A2. N-MORB (Normalized Mid Ocean Ridge Basalts) and average bulk continental crust normalized elemental abundance patterns for the volcanic rocks in the study area. N-MORB values determined from Sun and McDonough (1989) and average bulk continental crust values from Taylor and McLennan (1985).

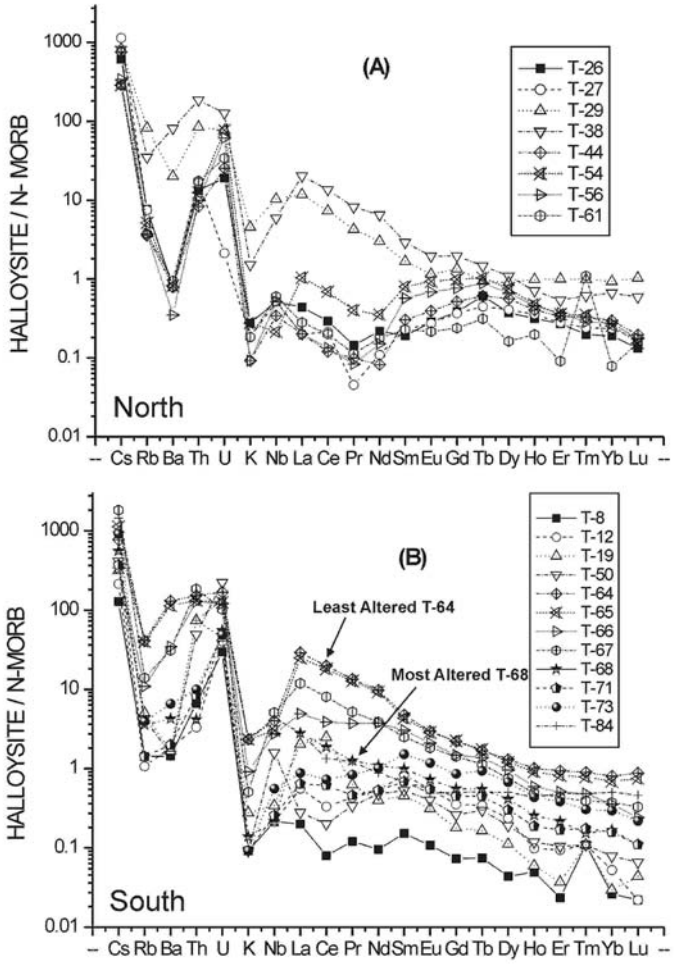

Figure A3. N-MORB normalized elemental abundance patterns for the (A) north mine and (B) south mine halloysite samples. Also included are data from the core stone reactions from (Figure 3) from the core of andesitic tuff (T-64) to the most altered (T-68).

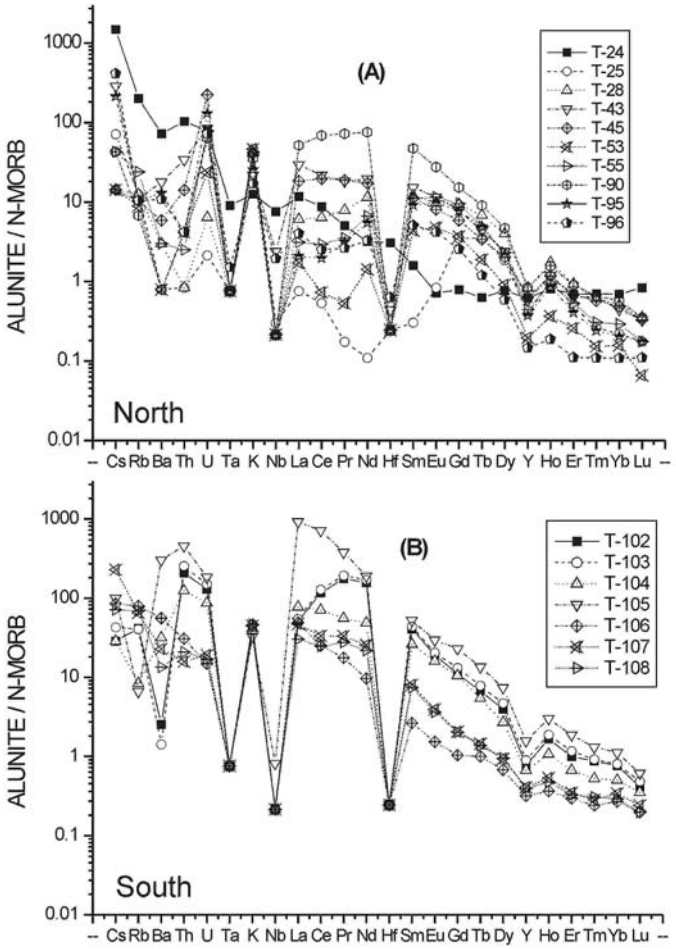

Figure A4. N-MORB-normalized elemental abundance patterns for the (A) north mine and (B) south mine alunite samples.

Table A1. Geochemical analyses of the andesitic rocks of the Turplu area.

Sample No.	T-3	T-10	T-11	T-32	T-47	T-49	T-63	G-6A	N-MORB*	Bulk Cont. Crust^
SiO_2	61.07	62.53	63.69	60.09	58.74	64.37	64.23	57.81	50.40	57.30
Al_2O_3	16.70	19.30	16.92	16.41	16.25	14.73	16.98	15.40	15.20	15.90
Fe_2O_3	5.18	2.43	5.31	5.54	6.04	5.12	6.05	5.53	9.44	20.02
MgO	1.89	0.07	0.56	2.16	2.51	1.99	0.15	3.60	8.96	5.30
CaO	4.68	0.10	0.05	5.27	5.44	4.30	0.06	3.89	11.40	7.40
Na_2O	3.15	0.15	0.20	3.23	3.22	2.94	0.04	2.30	2.30	3.10
K_2O	2.49	3.08	1.87	2.65	2.98	3.03	0.24	3.27	0.14	1.10
TiO_2	0.65	0.95	0.74	0.65	0.63	0.52	0.78	0.72	1.27	0.90
P_2O_5	0.25	0.43	0.01	0.18	0.20	0.13	0.12	0.22	0.14	
MnO	0.09	0.01	0.01	0.04	0.08	0.09	0.00	0.10	0.18	0.18
Cr_2O_3	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01		0.05
LOI	3.50	10.30	10.40	3.00	3.60	2.00	10.90	6.90		
Ba	1564.0	1443.0	1240.0	1213.0	1338.0	1088.0	849.3	1045.0	6.3	250.0
Sc	16.0	14.0	12.0	16.0	13.0	12.0	12.0	14.0	41.4	30.0
Mo	0.3	1.1	1.0	0.8	0.2	0.3	2.9	1.0	0.3	1.0
Cu	20.9	3.9	24.0	14.8	5.5	4.7	19.2	20.8	74.4	75.0
Pb	7.2	88.1	18.8	6.6	24.8	15.2	68.7	17.7	0.3	8.0
Zn	41.0	4.0	7.0	48.0	65.0	33.0	65.0	46.0		80.0
Ni	7.8	2.0	1.6	6.5	6.6	3.2	8.9	8.4	177.0	105.0
As	3.6	89.9	10.6	7.8	39.6	12.7	83.9	3.9		1.0
Cd	0.1	0.5	0.1	0.4	0.3	0.2	7.2	0.1		98.0
Sb	0.8	0.4	0.4	0.6	10.1	0.7	2.0	0.2	0.0	0.2
Bi	0.1	3.5	1.2	<0.1	0.3	<0.1	5.8	<0,1		60.0
Tl	0.1	0.4	0.1	0.1	0.1	0.1	0.2	0.1	0.0	360.0

Co	43.4	5.9	22.2	42.3	29.4	33.8	28.1	24.3	50.0	29.0
Cs	4.9	6.0	15.7	6.7	14.1	3.2	2.3	7.9	0.0	1.0
Ga	18.2	21.7	19.4	17.2	20.0	14.8	16.9	17.6		18.0
Hf	3.8	4.3	4.7	3.5	4.2	3.2	4.4	4.4	2.1	3.0
Nb	10.9	11.2	10.9	11.1	11.8	10.1	10.2	14.0	2.3	11.0
Rb	85.7	76.6	67.2	95.0	127.0	111.9	11.7	122.5	0.6	32.0
Sr	651.5	887.4	136.1	608.9	692.4	448.2	31.7	509.8	90.0	260.0
Ta	0.9	1.1	1.1	1.3	1.0	1.5	1.3	1.3	0.1	1.0
Th	19.9	19.4	11.7	19.8	21.6	19.9	16.3	30.3	0.1	3.5
U	5.4	24.9	5.7	6.0	6.3	5.0	6.2	8.9	0.0	0.9
V	158.0	152.0	154.0	145.0	130.0	96.0	134.0	136.0	262.0	230.0
W	161.1	133.6	31.7	850.6	96.1	1222.7	721.0	51.0	0.0	1.0
Zr	128.1	156.1	156.5	127.6	144.8	113.0	157.1	146.0	74.0	100.0
Y	25.4	14.1	9.1	20.7	29.6	20.1	17.9	21.8	28.0	20.0
La	46.3	201.4	27.6	42.5	50.9	36.5	21.7	45.1	2.5	16.0
Ce	75.8	335.8	39.6	69.9	76.9	59.9	41.5	79.3	7.5	33.0
Pr	8.2	31.3	3.5	7.5	8.7	6.3	4.7	8.1	1.3	3.9
Nd	32.4	95.1	11.5	27.4	34.9	23.5	18.5	31.3	7.3	16.0
Sm	5.8	13.0	2.1	5.0	6.0	3.9	4.2	5.5	2.6	3.5
Eu	1.5	2.8	0.4	1.3	1.4	1.0	0.9	1.4	1.0	1.1
Gd	5.6	6.6	1.6	4.3	5.3	3.7	3.4	4.5	3.7	3.3
Tb	0.8	0.9	0.3	0.6	0.8	0.6	0.6	0.6	0.7	0.6
Dy	4.2	4.0	1.5	3.4	4.4	3.3	3.1	3.7	4.6	3.7
Ho	0.9	0.6	0.3	0.7	1.0	0.6	0.6	0.7	1.0	0.8
Er	2.4	1.4	1.1	2.0	2.9	1.9	2.0	2.2	3.0	2.2
Tm	0.4	0.3	0.2	0.3	0.4	0.3	0.3	0.3	0.5	0.3
Yb	2.2	1.8	1.3	2.0	2.6	1.9	2.1	2.3	3.1	2.2
Lu	0.4	0.3	0.3	0.3	0.4	0.3	0.4	0.3	0.5	0.3

Table A2. Geochemical analyses of the alunite and halloysite samples from south mine of Turplu.

Sample No	T-102	T-103	T-104	T-105	T-106	T-107	T-108	T-8	T-12	T-19	T-50	T-64	T-65	T-66	T-67	T-68	T-71	T-73	T-84
	Alunite							Halloysite											
SiO_2	0.08	0.06	1.12	4.71	0.59	1.13	0.25	42.69	42.16	39.66	40.79	57.08	55.63	37.07	57.07	41.89	41.61	41.34	42.49
Al_2O_3	38.59	38.39	39.64	36.07	40.15	39.59	40.15	34.43	34.36	33.82	33.05	22.43	23.23	25.21	24.44	34.23	33.67	34.27	30.09
Fe_2O_3	1.96	1.86	0.1	0.43	0.14	0.14	0.14	0.21	0.53	0.14	0.43	5.6	4.26	2.05	1.27	0.18	0.23	0.16	7.36
MgO	<0.01	0.01	0.01	0.03	0.1	0.1	0.1	0.04	0.01	0.01	0.02	0.25	0.22	0.05	0.08	0.02	0.01	0.02	0.08
CaO	1.36	1.45	1.67	0.98	0.3	0.67	0.51	0.04	0.02	0.03	0.04	0.27	0.28	0.07	0.28	0.01	0.01	0.01	0.07
Na_2O	1.48	1.42	0.41	0.3	1.04	0.96	1.07	0.01	0.01	0.04	0.02	0.03	0.05	0.01	0.02	0.02	0.01	0.01	0.03
K_2O	8.52	8.48	9.06	7.12	10.04	9.7	9.99	0.02	0.02	0.06	0.02	0.51	0.51	0.2	0.11	0.03	<0.02	0.02	0.51
TiO_2	<0.01	<0.01	<0.01	0.09	0.02	0.02	0.01	0.02	0.02	0.04	0.18	0.72	0.57	0.25	0.53	0.04	0.03	0.08	0.56
P_2O_5	3.78	4.05	4.98	5.59	1.08	1.79	1.53	0.26	0.24	0.92	0.13	0.8	0.79	2.51	1.09	0.26	0.18	0.2	0.08
MnO	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07	<0.01	<0.01	<0.01	0.01
Cr_2O_3	0.002	<0.001	0.003	<0.01	0.002	0.001	0.001	0.003	0.004	0.002	0.004	0.003	0.004	0.004	0.006	0.002	0.002	0.002	0.007
Na/K	0.15	0.15	0.04	0.04	0.09	0.09	0.09												
Ba	16	9	199	1912	354	144	85	9	14	11	13	767	679	196	184	31	11	38	122
Sc	37	37	29	107	41	66	54	37	28	114	25	18	17	82	66	14	18	19	8
LOI	44.5	44.4	42.4	41.7	45.7	45.2	45.7	22.2	22.5	25	25	11.9	14.1	32.2	14.6	23.2	24.1	23.6	18.6
Mo	0.5	0.5	0.2	1.3	0.1	0.1	0.1	<0.1	<0.1	<0.1	0.3	2.7	1.9	0.5	1.6	<0.1	0.1	0.1	1.3
Cu	10.6	10.4	2.2	6.8	0.6	0.8	0.8	72.3	32.2	202.6	11.3	34.4	14	5.9	8.8	10.9	7.6	12.5	157.7
Pb	0.2	<0.1	3	3.5	0.2	0.2	0.2	0.9	0.5	1.2	5.4	200.1	90.5	55.5	27.9	3.6	2.4	14.5	48.2
Zn	22	24	15	46	90	90	95	10	3	44	425	16	11	13	20	11	8	53	28
Ni	9.7	4.1	3.4	34.9	3.6	13	5.5	235.2	27.2	671.4	404.2	5.3	11.6	33.9	35.2	23.6	10.9	39.3	62.3
As	8.8	11.9	6	21.6	1.5	5.8	3.6	50.1	9.6	96	45.7	62.6	69.2	90	261.4	23.6	21	18.8	224.9
Cd	2.3	3.1	0.2	4.6	5.3	1.2	3.9	0.6	0.1	0.4	2212.7	0.3	0.3	0.4	0.8	0.2	0.2	0.6	0.3
Sb	0.2	0.3	4.4	1.3	0.1	0.6	0.7	0.3	0.1	0.3	1.1	2.1	2	0.9	3.7	0.4	0.3	0.7	9.3
Bi	0.1	<0.1	0.1	1	0.1	0.1	0.1	0.3	0.2	0.2	1.9	5.2	4.7	1.3	1.3	0.1	<0.1	0.1	15
Ag	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Au(ppb)	0.5	3.1	9.4	22.9	1.1	0.5	0.6	2	1.4	1.9	3.4	5.5	14.5	4.1	1.8	<0.5	<0.5	2.6	11.1
Hg	0.13	0.1	2.55	7.99	0.01	0.01	0.01	0.11	0.21	0.07	0.62	4.43	6.69	0.4	0.31	0.12	0.09	0.15	1.94
Tl	0.5	0.5	0.4	1.5	0.1	0.2	0.3	0.7	<0.1	1.8	1.7	0.1	0.2	1.9	1.7	0.1	<0.1	0.1	0.7
Co	2.5	2.3	1.5	2.6	12.9	17.2	15.2	18.8	9	20.4	68.1	37	19.5	61.1	70	8.9	33.1	26.1	131.5
Cs	0.2	0.3	0.2	0.7	0.6	1.6	0.5	0.9	1.5	2.2	2.9	5.4	7.9	2.4	12.8	3.9	2.6	6.4	10.1
Ga	6.9	9	7.2	23.2	3.5	3.5	3.5	1.4	0.6	1.2	3.5	18	13.9	7.9	18.6	1.5	1.5	3	24.8
Hf	<0.5	<0.5	<0.5	<0.5	0.5	0.5	0.5	<0.5	<0.5	<0.5	0.7	3.4	3.1	2	3.4	<0.5	<0.5	<0.5	4.2
Nb	<0.5	<0.5	<0.5	1.9	0.5	0.5	0.5	<0.5	<0.5	0.8	3.7	9.4	7	6.4	11.9	0.5	0.6	1.3	10.1

Rb	23.5	22.8	4.7	3.7	44.7	36.5	38.7	0.8	0.6	2.8	2.4	22.9	22.4	6.1	7.8	2	0.8	2.2	23.2
Sn	<1	<1	<1	<1	16	2	5	<1	<1	<1	<1	2	1	<1	2	<1	<1	<1	<1
Sr	1124.6	1274.7	5635.2	14707	2926.6	2062.6	1677.6	6.9	2.1	42.2	2.6	1005.3	1015.4	116.3	495.8	38.6	8.8	6.8	161
Ta	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	0.3	0.9	0.7	0.6	1.4	<0.1	<0.1	0.1	0.8
Th	25.1	30.5	14.9	54.9	3.7	1.9	2.5	0.8	0.4	8.9	5.9	18.3	15.9	15.4	22.1	0.5	1	1.2	8.9
U	6.1	7.1	4.1	8.7	0.7	0.9	0.8	1.4	1.9	2.1	10.5	7.9	5.9	5.7	4.8	2.6	2.3	2.3	6.4
V	465	441	404	499	461	515	488	19	52	21	40	136	108	42	81	32	42	72	126
W	0.3	0.2	0.4	4.1	0.1	0.1	0.1	10.1	3.4	19.5	18	106.7	71.1	52.3	81.7	6.5	13.2	17.7	100.4
Zr	0.6	0.6	4.4	17.9	6.9	4.5	2.2	4.3	2.3	8	27.8	127.5	111.3	67	98.2	7.3	5.9	12.3	120.2
Y	21.8	25.1	18.8	44.1	8.9	11.4	11.1	0.6	1.2	0.7	1.6	26.3	23.6	7.9	8.4	3	2.3	5.1	9
La	127.5	136.1	193.1	2311	122.7	118.3	75.7	<0,5	1.4	5.1	0.7	72.6	62.1	12.3	29.7	7	1.6	2.2	7.1
Ce	871.5	959.1	533	5361	190	250	185.4	0.6	2.5	18.7	1.5	149.2	135.5	29.2	60.7	14	4.6	5.5	10.1
Pr	233.42	255.11	73.39	504.48	23.33	43.73	36.41	0.16	0.57	0.83	0.45	17.82	16.81	4.92	6.88	1.66	0.61	1.11	1.61
Nd	1146.5	1248.3	356.9	1387.7	70.9	186.6	159.9	0.7	3.9	2.9	3.5	71.2	67.5	27.6	28.4	8	3.9	7.4	6.4
Sm	107.6	115.3	69.1	137.6	7	21.1	19.6	0.4	2.2	1.2	1.4	12.5	11.4	8	6.6	2.6	1.8	4	1.8
Eu	19.54	20.87	16.34	30.36	1.57	4.02	3.71	0.11	0.56	0.32	0.41	3.02	2.92	2.14	1.86	0.74	0.56	1.2	0.5
Gd	40.6	48.34	38.54	84.24	3.83	7.56	7.48	0.27	1.31	0.66	0.96	8.13	8.25	5.5	5.25	2.05	1.65	3.17	1.85
Tb	4.52	5.27	3.65	9.1	0.67	0.97	0.92	0.05	0.23	0.11	0.2	1.13	1.17	0.92	0.76	0.37	0.3	0.63	0.34
Dy	18.07	21.4	12.25	33.61	3.09	4.27	4.33	0.2	1.08	0.51	0.87	5.92	5.5	4.37	3.43	1.88	1.38	3.08	2.29
Ho	1.68	1.9	1.08	3.04	0.37	0.54	0.48	<0.05	0.1	0.06	0.12	1.02	0.92	0.6	0.5	0.26	0.19	0.44	0.44
Er	2.95	3.48	1.99	5.54	0.88	1.03	0.97	0.07	0.28	0.11	0.31	2.79	2.42	1.51	1.28	0.64	0.5	1.14	1.44
Tm	0.4	0.42	0.24	0.6	0.11	0.13	0.14	<0.05	<0.05	<0.05	0.05	0.41	0.36	0.22	0.18	0.07	0.08	0.14	0.22
Yb	2.33	2.45	1.54	3.42	0.82	1.04	0.89	0.08	0.16	0.09	0.24	2.45	2.11	1.08	1.14	0.51	0.48	0.9	1.54
Lu	0.19	0.22	0.16	0.28	0.09	0.11	0.09	<0.01	0.01	0.02	0.03	0.4	0.34	0.11	0.15	0.05	0.05	0.1	0.21

Table A3. Geochemical analyses of the alunite and halloysite samples from north mine of Turplu.

Sample No	T-24	T-25	T-28	T-43	T-45	T-53	T-55	T-90	T-95	T-96	T-26	T-27	T-29	T-38	T-44	T-54	T-56	T-61	T-74 Conc.
	Alunite										Halloysite								
SiO_2	68.29	3.09	0.14	16.35	0.35	0.34	0.42	6.85	17.07	24.47	35.73	38.43	66.45	60.84	36.23	39.81	40.18	39	6.47
Al_2O_3	15.18	39.77	34.04	35.01	32.11	34.58	39.39	37.24	36.74	36.99	35.96	34.34	19.48	15.86	37.12	33.24	34.28	31.41	10.86
Fe_2O_3	4.14	0.16	0.1	1.06	0.13	0.09	0.13	0.17	0.25	0.24	0.22	0.21	1	6.3	0.3	0.37	0.35	1.03	62.13
MgO	0.97	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.07	0.02	0.01	0.03	0.62	0.14	0.03	0.01	0.01	0.02	0.22
CaO	0.07	0.22	1.01	0.83	9.87	0.23	2.59	0.79	0.89	0.57	0.02	0.02	0.05	0.13	0.05	0.03	0.04	0.02	0.05
Na_2O	0.09	0.82	0.8	0.33	0.79	0.67	1.13	0.53	0.42	0.3	0.02	0.02	0.06	0.03	0.04	0.03	0.01	0.01	0.02
K_2O	2.73	10.05	8.96	4.71	9.06	10.04	9.22	7.67	5.55	3.69	0.06	0.04	0.99	0.33	0.02	0.06	0.02	0.04	0.02
TiO_2	0.82	0.03	<0,01	0.26	0.01	<0,01	0.01	<0.01	0.03	0.19	0.05	0.05	1.09	0.68	0.05	0.01	0.07	0.07	0.18
P_2O_5	0.07	0.57	2.96	2.27	8.71	0.62	3.22	3.13	1.67	1.09	0.51	0.35	0.08	0.06	0.71	0.77	0.69	0.03	0.1
MnO	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	4.38
Cr_2O_3	0.014	0.004	0.001	0.003	0.002	0.001	0.001	0.001	0.001	0.001	<0.001	0.003	0.009	0.013	0.001	0.001	0.003	0.002	0.003
Na/K	0.03	0.07	0.08	0.06	0.08	0.06	0.11	0.06	0.7	0.07									
Ba	458	<5	19	113	37	1.8	19	<5	82	68	<5	<5	127	514	<5	5.2	2.2	6	2.9
Sc	12	6	4	17	4	5	10	11	15	14	1	1	16	10	2	2	2	4	6
S		5.32	4.56	4.57	6.16	5.84	5.94												
LOI	7.5	45.1	44.9	38.5	38.6	44.9	43.7	42.3	37.1	32.2	27.4	26.5	10.1	14.8	25.2	25.5	24.1	28	13.9
Mo	0.5	0.1	<0.1	0.1	0.5	<0.1	0.3	0.1	0.1	0.1	0.2	0.1	2.6	20.6	<0.1	0.1	<0.1	0.6	0.8
Cu	33.4	1.1	0.7	49.6	36.1	1.1	9.3	1.7	10.7	31.7	16.6	20.3	3	10307.1	15.5	55.2	30	28.8	78.4
Pb	72.5	2	0.2	12.8	14.1	0.2	0.4	0.2	0.7	1.2	4.2	0.7	85.7	79	4.4	3.7	2.8	4	2.6
Zn	3	10	16	104	27	19	20	8	1	1	16	17	3	55	29	3	12	87	5329
Ni	1.7	2.4	1	37.2	2.7	0.9	0.1	1.5	4.7	36.4	206.5	213.3	0.9	88.5	214.6	208.4	154.7	204.9	220.6
As	8.2	9.6	3.8	55.7	4.4	2.8	4.2	4.5	15.1	30.6	70.6	64.3	6.8	47	80.5	117.5	85.9	40.9	33.5
Cd	<0.1	<0.1	0.1	8.3	0.7	0.3	0.7	0.4	0.1	0.1	<0.1	<0.1	<0.1	4.6	0.1	0.2	0.1	0.2	7.2
Sb	0.3	0.8	0.2	0.9	2.4	0.8	1	0.2	0.4	0.3	0.7	1.5	0.7	1.6	0.8	1.2	1.1	1	0.7
Bi	3	0.1	<0.1	0.6	<0,1	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.1	1	7.8	0.2	1	0.9	0.6	1
Ag	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Au (ppb)	15.5	19.4	2.3	8.5	43.1	1.7	19.5	5.4	9.7	6.4	5.4	3.6	66.6	11.4	2.4	2.3	16	3.7	1.2
Hg	0.01	0.14	0.01	0.34	0.02	<0.01	0.03	0.01	0.02	0.03	0.01	0.01	0.02	0.37	<0.01	0.03	0.01	0.2	0.11
Tl	0.2	0.1	0.1	0.3	0.1	<0,1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.1	0.1	0.1	0.1	5
Co	1.1	2.7	6.2	7.5	1.8	25.2	1.3	1.5	2.5	3.2	4	6.7	1.2	343.9	8.3	6.3	6.4	7.8	981.2
Cs	10.4	0.5	<0.1	2	0.1	<0,1	0.3	0.3	1.5	2.9	4.3	8	5.8	5.7	5.3	2	2.4	2	1.5
Ga	21	1.2	<0.5	7.2	<0.5	<0.5	<0.5	4	1.8	5.2	1.4	2.6	25.4	22.2	1	<0.5	1.3	2.7	10
Hf	6.3	<0.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	0.5	1.3	<0.5	<0.5	5.4	4.4	<0.5	<0.5	<0.5	0.5	0.6

Nb	17.8	0.7	<0,5	5.6	<0.5	<0.5	<0.5	<0.5	0.5	4.5	1.2	1.2	24.2	13.8	0.8	<0.5	1.2	1.4	3.6
Rb	112.6	7	7	6.1	5.8	5	13.4	3.8	5.9	5.9	4.3	4.2	46.2	19.6	2	2.9	2.1	2.1	2.4
Sn	4	<1	<1	1	2	<1	<1	<1	16	5	1	3	6	3	<1	<1	<1	<1	<1
Sr	59.7	275.8	2039.3	3573.1	1547.7	440.8	789.8	10634.3	959.4	1060.1	8.8	1.9	110	45.2	3.1	65.6	12.5	6.8	53.4
Ta	1.2	<0.1	<0.1	0.4	0.1	<0.1	<0.1	<0.1	0.1	0.2	0.1	0.1	1.6	1	<0.1	<0.1	0.1	<0.1	0.3
Th	12.4	0.1	<0,1	4.1	1.7	0.5	0.3	0.5	0.5	2.4	1.6	2	10.2	22.4	1	1.5	1.2	2.1	2.5
U	3.7	0.1	0.3	4	10.5	1.1	3.7	3	6.1	3.4	0.9	0.1	3.6	6	1.2	3.6	2.9	1.6	2.9
V	135	480	428	292	456	338	431	422	218	214	50	20	62	116	63	19	39	31	41
W	2.4	0.1	12.7	1.2	2	49.6	0.8	0.3	0.2	0.6	0.1	0.2	5.4	10	2.9	3.8	11.5	3	27.9
Zr	158.4	3.9	0.5	42.5	0.5	1.6	0.5	0.5	4.5	56	5.9	10.8	194.2	135.6	8.2	3.3	12.3	12.4	27.6
Y	17.3	11.1	23.2	16.2	17.9	5.5	12.5	23.8	10.5	4.1	3.4	4.8	24.4	16.9	4.8	5.1	4.9	3.1	392.7
La	29.4	1.9	15.2	73.7	46.1	4.3	7.8	129.7	5.2	10.1	1.1	<0.5	29.6	50.9	0.5	2.6	<0.5	0.7	61.9
Ce	65.8	4	47.9	163.4	148.3	5.5	22.3	515	14.7	18.9	2.2	1.6	55.2	101.5	0.9	5.2	1	1.5	173.1
Pr	6.68	0.23	10.39	24.23	24.81	0.7	4.67	95.61	4.18	3.47	0.19	0.06	5.63	10.78	0.13	0.53	0.11	0.15	16.77
Nd	23.2	0.8	83.9	142.7	125.7	10.4	48.6	554.2	39.9	23.9	1.6	0.8	21.9	47.7	0.6	2.6	1.1	1.3	100.7
Sm	4.2	0.8	31.7	40.2	29.4	11.6	29.1	124.5	24.1	13.4	0.5	0.6	4.4	7.7	0.8	2.1	1.5	0.6	40.5
Eu	0.73	0.85	9.86	11.77	8.23	4.86	11.76	28.15	10.05	4.29	0.29	0.28	1.18	1.99	0.4	0.95	0.7	0.22	15.28
Gd	2.91	12.9	34.49	29.37	21.73	13.59	35.26	56.13	28.36	9.42	1.42	1.36	4.94	7.22	1.91	3.66	2.81	0.88	78.89
Tb	0.42	2.39	4.61	2.91	2.28	1.26	3.3	6.07	3.29	0.8	0.41	0.3	0.63	0.98	0.41	0.69	0.59	0.21	12.38
Dy	3.48	8.41	18.24	10.94	9.2	4.15	10.5	21.36	9.97	2.67	1.7	1.85	4.08	4.94	2.56	3.47	3.05	0.74	73.62
Ho	0.82	1.04	1.76	1.21	1.19	0.37	0.95	1.58	0.86	0.19	0.32	0.36	1	0.72	0.41	0.48	0.46	0.2	14.9
Er	2.07	1.46	2.78	1.9	2.04	0.77	1.58	2.69	1.21	0.33	0.81	0.83	2.98	1.6	1	1.06	1.09	0.27	42.4
Tm	0.32	0.12	0.28	0.29	0.26	0.07	0.14	0.3	0.11	0.05	0.09	0.11	0.45	0.28	0.15	0.16	0.13	<0.5	5.49
Yb	2.12	0.67	1.54	1.36	1.48	0.48	0.89	1.74	0.62	0.33	0.58	0.72	2.85	2.03	0.91	0.78	0.84	0.24	32.5
Lu	0.38	0.08	0.16	0.15	0.15	0.03	0.08	0.16	0.08	0.05	0.06	0.08	0.47	0.27	0.09	0.07	0.08	0.07	4.86

Table A4. Alteration index relations between fresh andesite and, alunite and halloysite samples from north and south mines. Method of Altaner *et al*. (2003). Values of –100% indicate complete removal relative to parent rock. Positive values indicate a net gain though volume compaction and/or importing through precipitiation.

Sample No	T-8	T-12	T-19	T-50	T-64	T-65	T-66	T-67	T-68	T-71	T-73	T-84
					Halloysite		South Mine					
ΔSiO_2	–66.14	–66.49	–67.98	–66.29	–30.5	–34.6	–59.84	–36.23	–66.58	–66.25	–67.06	–61.44
ΔFe_2O_3	–98.19	–95.43	–98.77	–96.15	–26.05	–45.68	–75.91	–84.61	–98.44	–97.98	–98.62	–27.55
ΔMgO	–99.12	–99.78	–99.77	–99.54	–91.53	–92.8	–98.49	–97.51	–99.56	–99.77	–99.56	–97.98
ΔCaO	–99.64	–99.82	–99.72	–99.62	–96.25	–96.25	–99.14	–96.43	–99.91	–99.91	–99.91	–99.28
ΔNa_2O	–99.85	–99.85	–99.39	–99.69	–99.32	–98.91	–99.79	–99.58	–99.7	–99.85	–99.85	–99.49
ΔK_2O	–99.64	–99.64	–98.9	–99.63	–85.92	–86.41	–95.09	–97.21	–99.46	–99.63	–99.64	–89.51
ΔTiO_2	–98.53	–98.53	–97.01	–86.25	–18.96	–38.05	–74.96	–45.25	–97.05	–97.75	–94.12	–53.01
ΔP_2O_5	–31.16	–36.32	147.99	–64.14	225.16	210.04	807.69	306.59	–30.75	–51.26	–46.79	–75.76
ΔMnO	–88.09	–88.06	–87.87	–87.59	–81.71	–82.34	–83.73	17.5	–88.02	–87.82	–88.03	–86.37

Sample No	T-25	T-28	T-43	T-45	T-53	T-55	T-26	T-27	T-44	T-54	T-56	T-61
		Alunite		North Mine					Halloysite			
ΔSiO_2	–97.88	–99.89	–87.25	–99.7	–99.73	–99.71	–72.87	–69.44	–73.35	–67.29	–67.99	–66.09
ΔFe_2O_3	–98.81	–99.13	–91.03	–98.8	–99.23	–99.02	–98.19	–98.19	–97.61	–96.73	–96.98	–90.29
ΔMgO	–99.81	–99.78	–99.78	–99.53	–99.78	–99.81	–99.79	–99.34	–99.39	–99.77	–99.78	–99.52
ΔCaO	–98.28	–90.76	–92.62	–4.29	–97.93	–79.53	–99.83	–99.89	–99.58	–99.72	–99.67	–99.82
ΔNa_2O	–89.53	–88.06	–95.21	–87.5	–90.16	–85.43	–99.72	–99.71	–99.45	–99.54	–99.85	–99.88
ΔK_2O	56.48	62.99	–16.69	74.72	79.79	44.95	–98.97	–99.29	–99.67	–98.88	–99.69	–99.21
ΔTiO_2	–98.09	–99.26	–81.25	–99.21	–99.27	–99.36	–96.49	–96.34	–96.59	–99.24	–94.85	–94.37
ΔP_2O_5	30.67	692.75	491.12	2372.9	63.46	645.26	29.29	–7.09	74.38	111.19	83.53	–91.29
ΔMnO	–89.69	–87.95	–88.28	–87.24	–88.14	–89.59	–88.59	–88.05	–88.95	–87.66	–88.03	–86.94

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