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12 Element contents determined by ICP-AES and ICP-MS at Grenoble on nine obsidian artifacts from Tell Kosak Shamali: Results and inferences on provenance

Ludovic Bellot-Gurlet, Gérard Poupeau and Céline Bressy

12.1 Introduction

Results for trace elements including REE obtained by ICP-MS are presented in Table 12.1, and for major elements measured by ICP-AES in Table 12.2. They were obtained using the protocols described in Bellot-Gurlet (1998) and Bellot-Gurlet and others (1999). For provenance determination we compared the data on artifacts with those previously obtained in our laboratory on obsidian samples from various sources.

12.2 Comments on trace element contents

The data are conventionally presented in diagrams of normalized element abundances (e.g. Poidevin 1998; Chataigner *et al.* 1998). The norm selected is the composition of the primitive earth mantle as given by Sun and McDonough (1989).

In Fig. 12.1, the compositions of the nine artifacts are presented. It is clear that three compositional groups are present with respectively six, two and one samples.

In Fig. 12.2, the compositions of the six artifacts defining the most important group: BE7-11, AE4-16, AF5-8, AD5-39, AD4-28-28 and BD7-51 are reported. These artifacts present a peralcaline affinity of the "Bingöl-A"-type compositional group of Cauvin and others (1986, 1991).

This source compositional group includes geological obsidians from the Bingöl region (Orta Duz and Çavuşlar source areas; Cauvin *et al.* 1986, 1991) and from the Nemrut Dağ volcano, the only known prealcaline sources in Eastern

Anatolia, which cannot be discriminated on the basis of their trace element contents (Poidevin 1998). This appears in Fig. 12.2 where we plotted our data on two peralcaline Bingöl samples (one from Orta Duz and one from Çavuşlar) and five Nemrut Dağ samples (three from the inside of the caldera, two from the south flank).

It also appears that the artifacts in this peralcaline group cannot be distinguished from the source samples presented. Thus, trace element data allows one to claim that these "archaeological" obsidians must come either from the Bingöl region or the Nemrut Dağ volcano.

In Fig. 12.3, the composition of artifacts AE4-10 and AD 5-59 is compared to that of two geological samples from the Bingöl region (respectively: Çatak and Ala Tepe source areas) belonging to the "Bingöl-B"-type compositional group of Cauvin and others (1986, 1991) with a calco-alkaline affinity. The artifacts clearly belong to this group and therefore these obsidians come from one of the three source areas of the Bingöl region which provide calco-alkaline obsidians: Ala Tepe, Çatak, or Çavuşlar.

In Fig. 12.4 are reported the compositions of artifact AF5-19 and of source samples from the Göllü Dağ massif. The nine Göllü Dağ samples, which come respectively from Kayirli East (six samples) and Kömürcü (three samples), belong to the "Göllü Dağ East" geochemical group (Poidevin 1998). As shown in this figure, artifact AF5-19 pertains to this geochemical group and therefore comes from the Kömürcü or Kayirli East sources, known for the good knapping quality of their obsidians.

Table 12.1 Trace element content for the nine artifacts with their compositional source group attribution.

Compositional group	Bingöl-B		Göllü Dağ East	Bingöl-A					
	AE4-10	AD5-59	AF5-19	AE4-16	AD5-39	AD4-28-28	BD7-51	BE7-11	AF5-8
Sample									
Elements (ppm)									
Co	1.103	1.094	0.105	0.035	0.058	0.025	0.022	0.017	0.015
Rb	219.65	221.16	189.95	213.53	219.98	203.43	203.48	209.01	208.2
Sr	43.982	41.957	12.109	0.732	1.031	0.907	0.291	0.375	0.382
Y	31.245	30.753	22.129	132.02	149.87	134.19	132.08	135.21	135.55
Zr	352.17	344.03	80.042	1201.0	1337.1	1303.1	1273.9	1316.5	1315.7
Nb	18.941	19.361	25.585	54.024	61.462	64.734	69.245	66.799	67.163
Cs	10.616	10.856	7.804	12.402	14.093	7.325	6.859	7.300	7.277
Ba	374.53	375.5	165.47	5.315	4.49	1.666	4.171	3.931	3.786
La	36.546	36.737	22.629	82.01	87.483	84.172	85.172	84.996	87.371
Ce	69.502	71.411	44.299	176.32	189.57	182.64	184.55	183.99	188.8
Pr	7.173	7.309	4.334	21.111	22.527	21.698	21.835	21.766	22.195
Nd	23.431	23.759	13.182	80.511	85.897	81.42	81.788	81.95	83.639
Sm	4.324	4.354	2.628	17.569	19.033	17.829	17.723	17.892	18.159
Eu	0.462	0.451	0.155	0.441	0.559	0.364	0.355	0.370	0.363
Gd	4.443	4.433	2.796	17.853	19.48	17.825	17.988	17.797	18.301
Tb	0.761	0.751	0.501	3.424	3.816	3.435	3.351	3.491	3.464
Dy	4.385	4.388	2.976	20.284	23.124	20.586	20.201	20.694	20.555
Ho	0.952	0.962	0.649	4.387	5.004	4.454	4.388	4.479	4.471
Er	2.920	2.904	1.955	12.586	14.412	12.888	12.631	12.895	12.851
Yb	3.247	3.303	2.249	12.476	14.012	12.828	12.555	12.782	12.958
Lu	0.525	0.512	0.343	1.91	2.09	1.949	1.922	1.949	1.944
Hf	8.522	8.500	3.173	27.000	30.639	28.88	27.812	29.065	28.696
Ta	1.81	1.946	2.446	3.904	4.818	4.323	4.619	4.395	4.402
W	3.728	3.935	3.157	4.585	5.463	3.635	3.724	3.732	3.789
Pb	26.98	27.535	21.807	32.469	35.33	26.566	26.054	26.956	27.221
Th	25.299	26.218	20.837	26.375	28.888	23.671	23.388	23.84	23.724
U	8.664	8.885	8.015	9.786	10.943	7.665	7.708	7.723	7.678

Table 12.2 Major element content for the nine artifacts with their compositional source group attribution.

Compositional group	Bingöl-B		Göllü Dağ East	Bingöl-A					
	AE4-10	AD5-59	AF5-19	AE4-16	AD5-39	AD4-28-28	BD7-51	BE7-11	AF5-8
Sample									
Oxydes(%)									
Al ₂ O ₃	14.78	14.20	12.55	10.99	10.71	10.92	11.18	11.39	11.73
Fe ₂ O ₃	2.02	1.92	0.85	4.27	4.37	3.04	3.09	3.10	3.13
MnO	0.042	0.039	0.063	0.079	0.076	0.055	0.092	0.061	0.062
MgO	0.154	0.160	0.040	0.004	0.006	0.001	0.001	0.001	0.001
CaO	0.734	0.701	0.429	0.199	0.182	0.080	0.185	0.171	0.182
Na ₂ O	4.91	4.82	4.02	5.25	5.56	4.95	5.20	5.00	5.07
K ₂ O	5.05	4.99	4.37	4.63	4.40	4.84	4.53	4.70	4.46
TiO ₂	0.211	0.193	0.061	0.207	0.202	0.150	0.156	0.156	0.162

Table 12.3 Summary of provenances for the nine Tell Kosak Shamali artifacts.

Samples	Provenances
AE4-10 AD5-59	Bingöl calco-alkaline sources: Ala Tepe, Çatak, and/or Çavuşlar
AF5-19	Göllü Dağ East obsidians: Kömürcü or Kayirli East sources
AE4-16 AD5-39	Bingöl peralkaline sources (Orta Duz and/or Çavuşlar) and/or obsidians from the caldera of Nemrut Dağ volcano
AD4-28-28 BD7-51 BE7-11 AF5-8	Bingöl peralkaline sources (Orta Duz and/or Çavuşlar) and/or obsidians from the South flank of Nemrut Dağ volcano

12.3 Comments on major element contents

As proposed by Poidevin (1998) it may be possible to discriminate Nemrut Dağ obsidians from Bingöl peralcaline artifacts on the basis of CNK/A vs. NK/A diagrams (Fig. 12.5), which illustrate the degree of peralcalinity of samples. Among our seven Nemrut Dağ and Bingöl peralcalines geological samples analyzed, Nemrut Dağ caldera lake obsidians are in the upper part of the diagram, South Nemrut Dağ ones in the lower part, and Bingöl obsidians are in between, with one Nemrut Dağ “undetermined” caldera sample (sample AG36 of Innocenti *et al.* 1976). The same kind of discrimination can be also illustrated by the Al vs. Fe binary diagram of Fig. 12.6 where again lake and South Nemrut Dağ geological samples are reported in two areas distinct from the Bingöl and the Nemrut Dağ “undetermined” caldera obsidian.

Our six peralcalines artifacts illustrate the limits of these discriminations between these obsidians with very similar compositions. Indeed artifacts AE4-16 and AD5-39 seem clearly to belong to the “Bingöl domain” (Figs. 12.5 and 12.6), but the other artifacts slip towards South Nemrut Dağ characteristics. Thus with the available analyses it is not possible to fix the precise limits of each group and therefore insure a provenance for all peralcaline obsidians. Thus for artifacts AD4-28-28, BD7-51, BE7-11 and AF5-8, we can only propose an attribution to peralcaline obsidians from either Bingöl or South Nemrut Dağ.

For compositions close to Bingöl peralcaline obsidians, because a caldera-lake composition has never been observed to date for Near Eastern artifacts (see compilation by Chataigner 1998) and because of the difficult access to the inside of the Nemrut Dağ caldera, one may guess for these samples a more probable Bingöl area origin.

12.4 Conclusions on provenance

From ICP data, the source material of the analyzed artifacts might come respectively

from (see Table 12.3):

- the South flank of the Nemrut Dağ volcano and/or the peralcaline obsidians of the Bingöl area (Orta Duz and/or Çavuşlar) for four artifacts: BE7-11, AF5-8, BD7-51, and AD4-28-28,
- the Nemrut Dağ volcano or rather (see above) the Bingöl sources of peralcaline obsidians (Orta Duz and/or Çavuşlar) for two artifacts: AE4-16 and AD5-39,
- the Bingöl sources of calco-alkaline obsidians (Ala Tepe and/or Çatak and/or Çavuşlar) for two artifacts: AE4-10 and AD5-59,
- the Kömürcü or Kayirli East sources in the Göllü Dağ massif for the last one: AF5-19.

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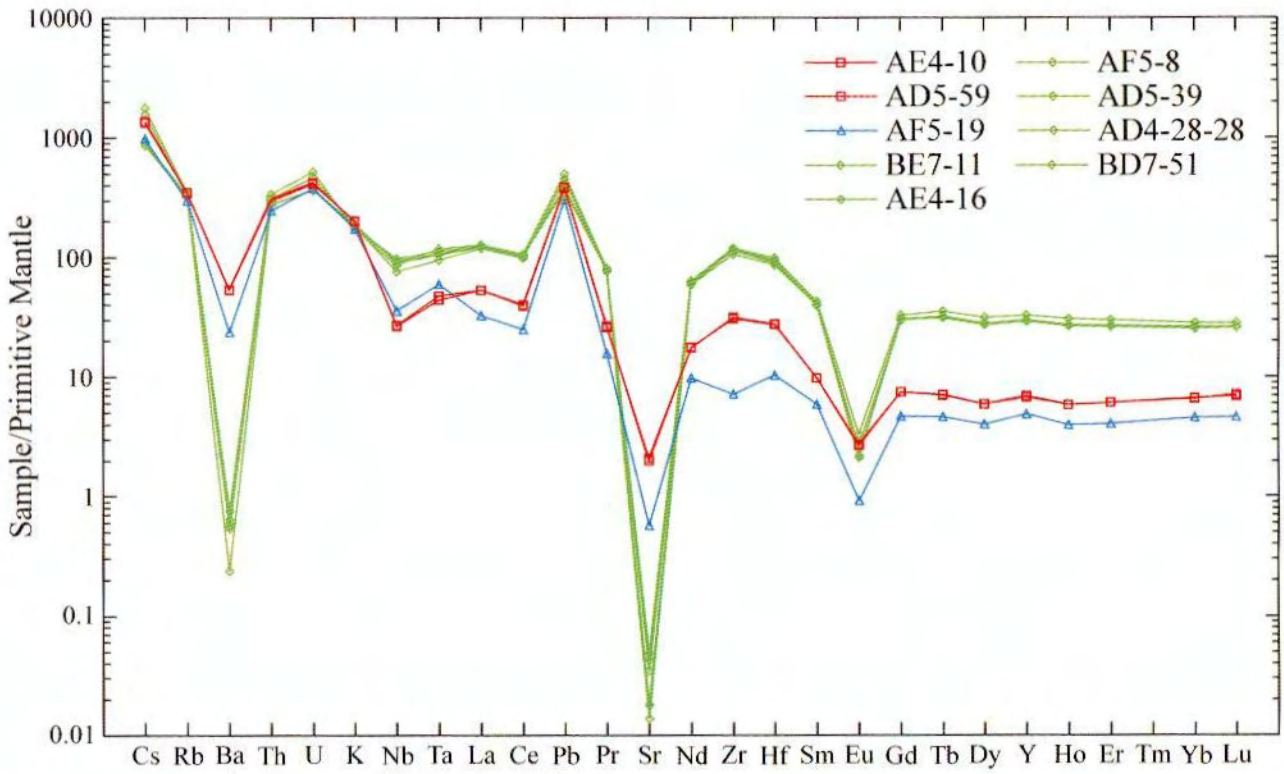


Fig. 12.1 Primitive mantle normalized diagram for the nine artifacts.

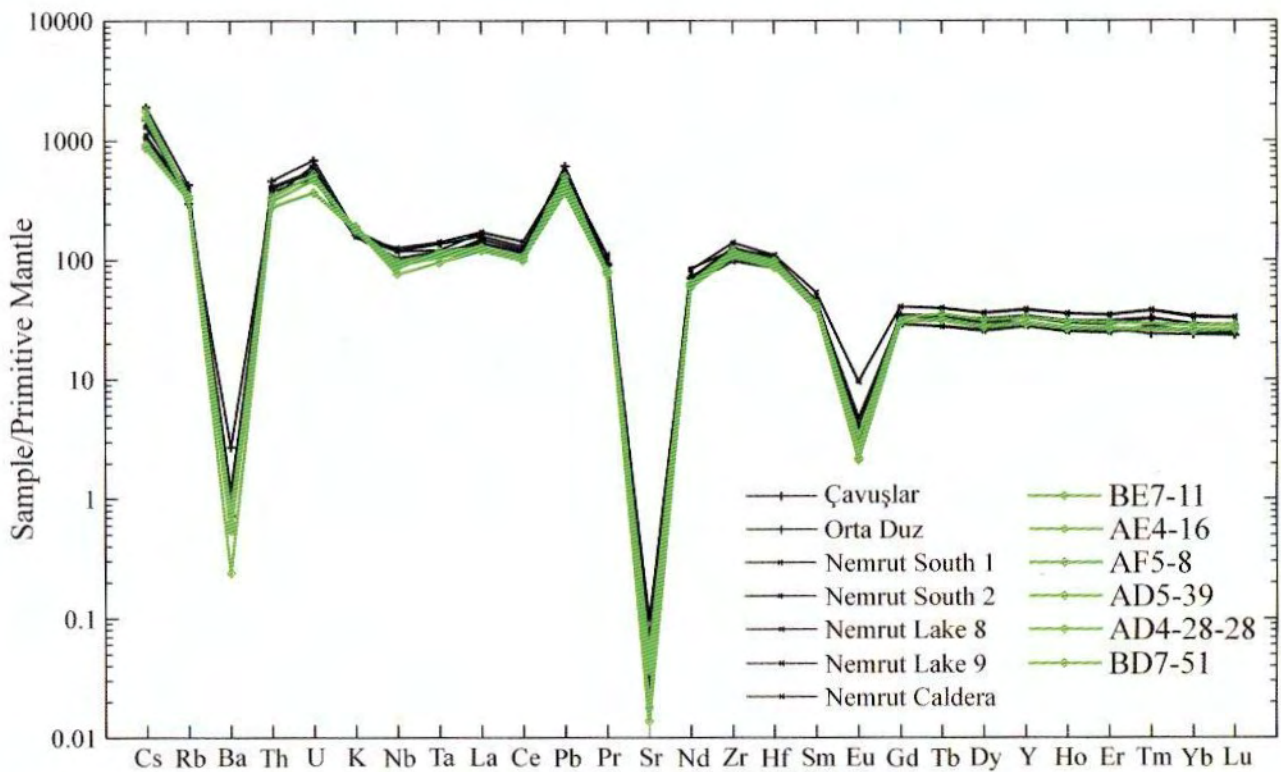


Fig. 12.2 Primitive mantle normalized diagram for the six artifacts which present a Bingöl-A composition.

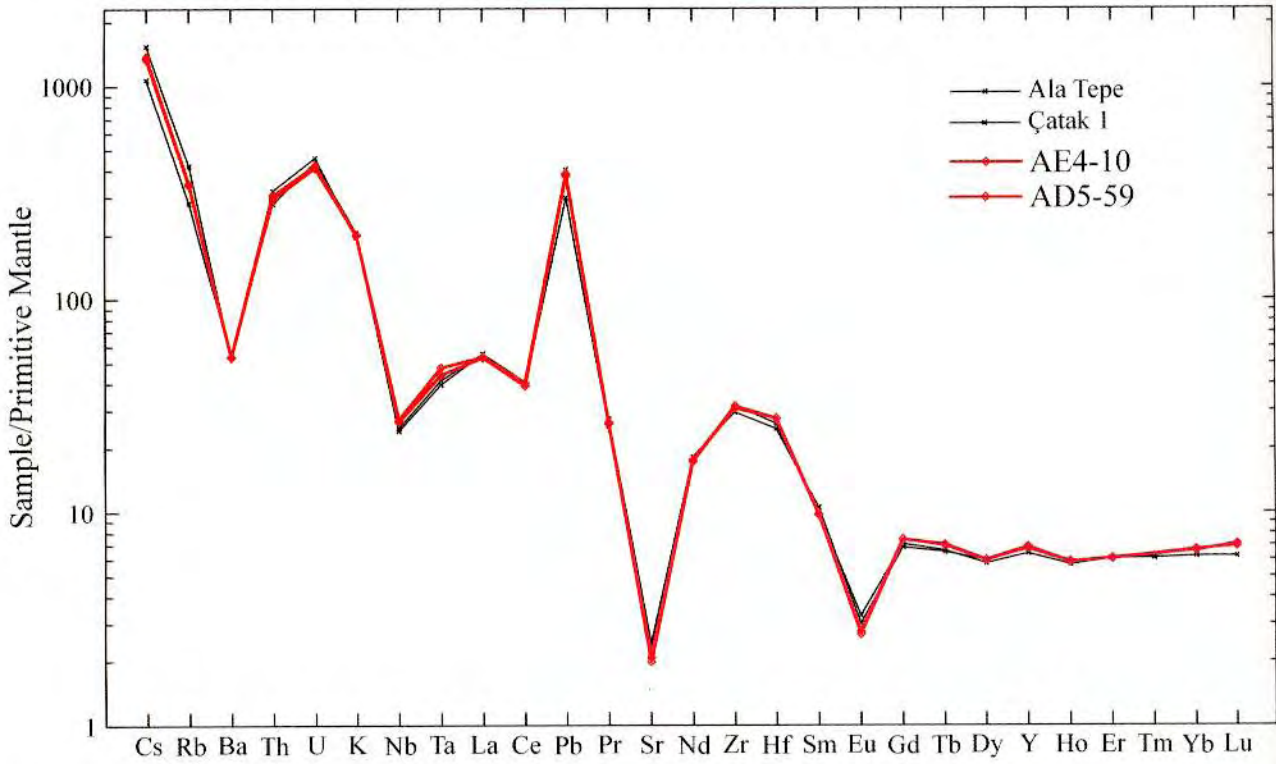


Fig. 12.3 Primitive mantle normalized diagram for the two artifacts which present a Bingöl-B composition.

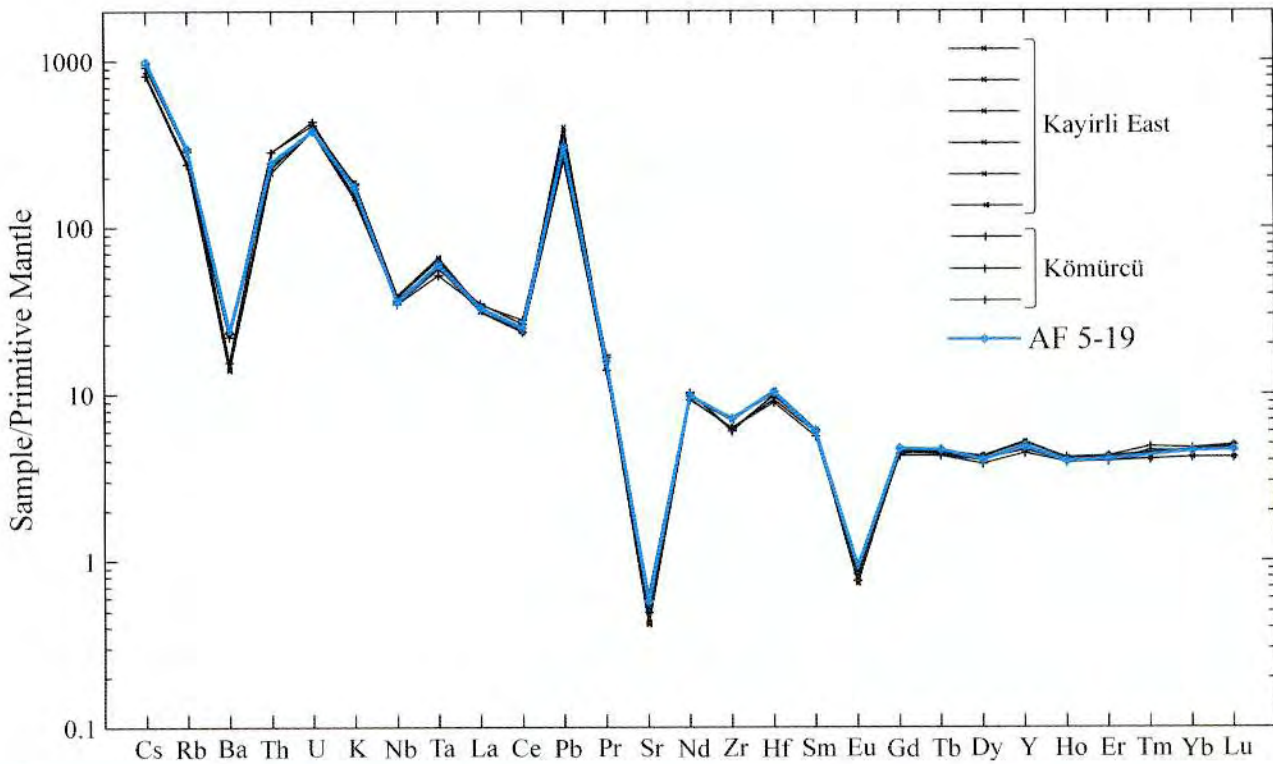


Fig. 12.4 Primitive mantle normalized diagram for the artifacts which present a Göllü Dağ East composition.

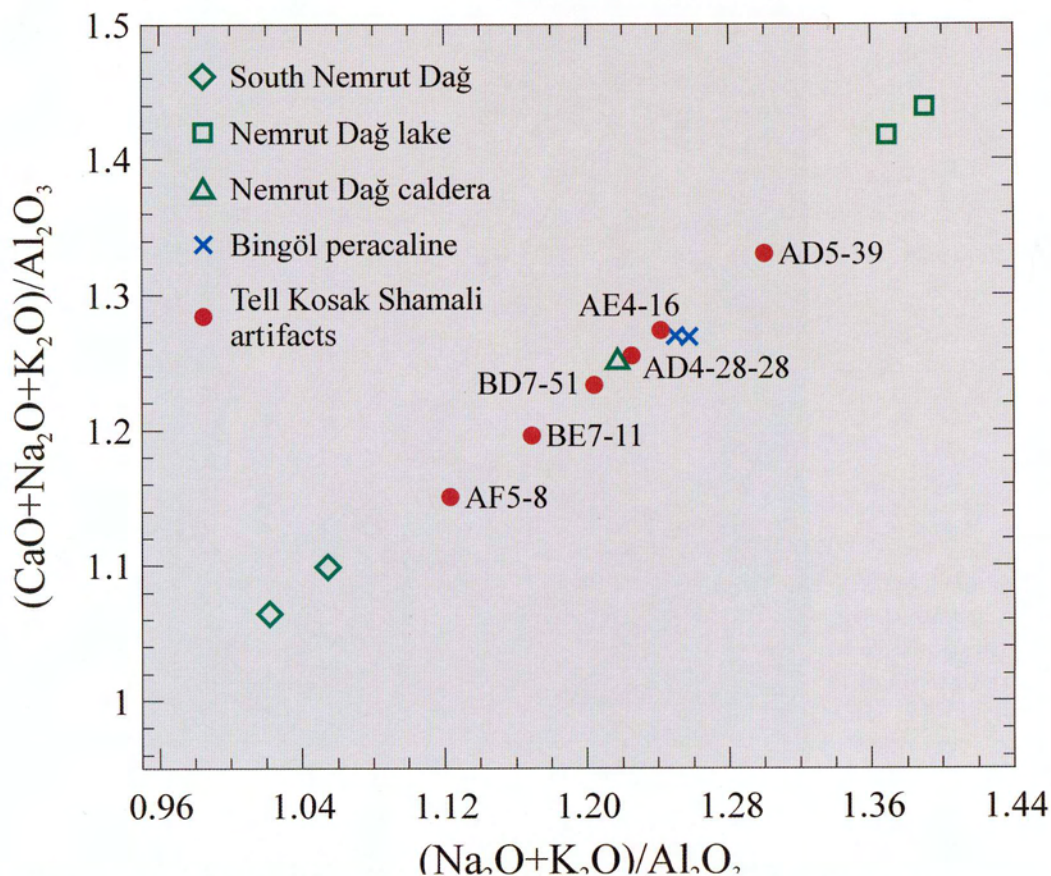


Fig. 12.5 $(CaO+Na_2O+K_2O)/Al_2O_3$ vs $(Na_2O+K_2O)/Al_2O_3$ diagram (CNK vs NK) for the six peralcaline artifacts and our peralcaline source samples from Bingöl and Nemrut Dağ.

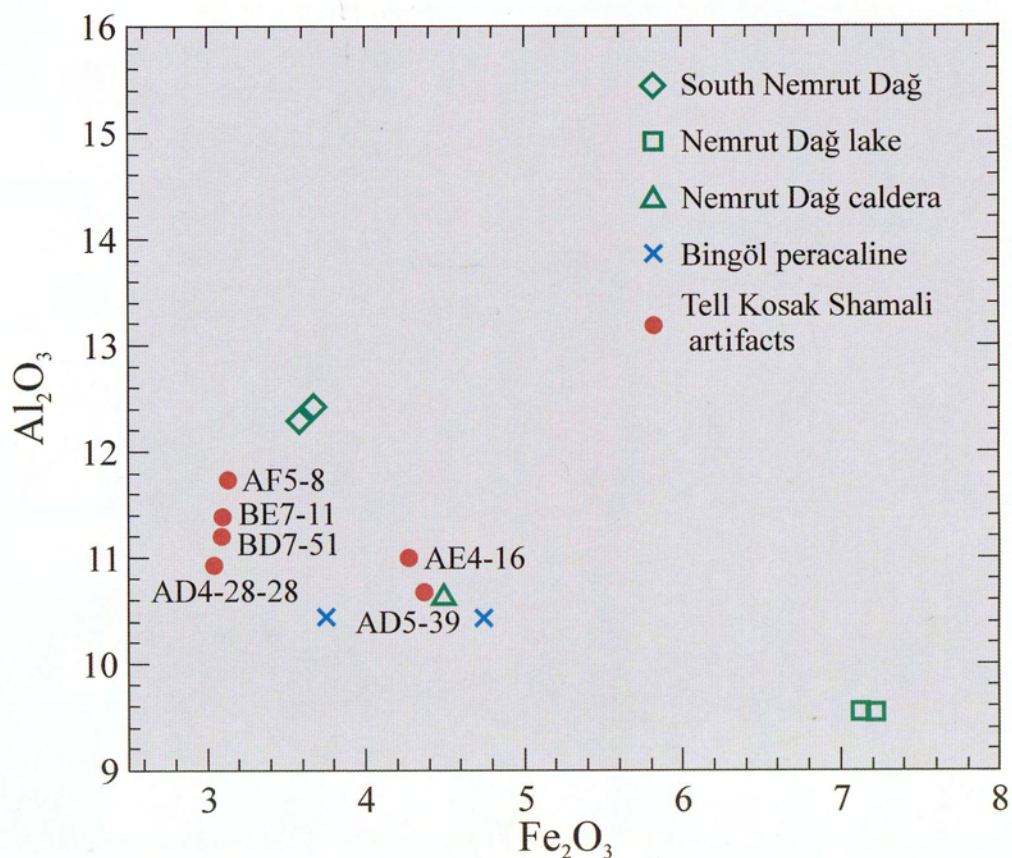


Fig. 12.6 Al_2O_3 vs Fe_2O_3 diagram for the six peralcaline artifacts and our peralcaline source samples from Bingöl and Nemrut Dağ.

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