AKAD. NAUK SSSR
Doklady Earth. Sci. Sec. 1984, v. 274, p. 189-192

TWO LAVA SERIES WITH A RELATIVELY HIGH ALKALI CONTENT IN THE LATE CENOZOIC VOLCANIC BELT OF THE CENTRAL RANGE, KAMCHATKA[1]

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(Presented by Academician L.V. Tauson, June 9, 1983)

Information on lavas relatively high in alkalies and exposed along late Pliocene-Quaternary volcanics in the Central Range, Kamchatka, is given in various publications [1-4], although their petrologic and chemical classification has not yet been reliably proved. Our recent detailed study of the composition of these lavas has revealed among them two rock series, differing in chemical and mineral composition: the absarokite-shoshonite-latite-trachyte (ABSLT) and the alkalic olivine basalt-trachyte – trachyrhyolite - comendite (ALBTC).

Lavas of the ABSLT series differ from those of the ALBTC in their higher concentrations of K, Rb, F, V and, in intermediate and silicic varieties, of Ba and Sr, too, as well as in their relatively high F/B and K/Na ratios (Tables 1 and 2). Lavas of the ALBTC series, though, are persistently higher in Na, Zr, Nb, B, Ni, Cr and light REE and have relatively high K/Rb, Zr/Hf and La/Yb ratios. In rocks of the ABSLT series, equalization of Na and K concentrations is discernible already in andesite-basalt, whereas in those of the ALBTC it happens only at the level of silicic rocks containing 65 to 66 percent SiO_2. Basalt and andesite-basalts of the ALBTC also are relatively high in titanium.

Relatively high titanium concentrations are characteristic of melanocratic mineral phenocrysts in rocks of the ALBTC. Thus, clinopyroxenes in basalt of this series are present as titanaugite, and the amphiboles in andesite-basalt and andesite as kaersutite, whereas in rocks of the ABSLT series they occur as augite and common hornblende, respectively. Mica phenocrysts in lavas of the ABLTC series also are relatively high in titanium. Biotites in intermediate and silicic rocks of the ABSLT series contain very high fluorine concentrations that reach 4 to 4.5 percent as compared with only 1 to 1.5 percent in rocks of the ALBTC series.

Alkalic feldspar phenocrysts in lavas of the ABSLT series generally are richer in the orthoclase minal (sanidine) than those in lavas of the ALBTC series (sodic

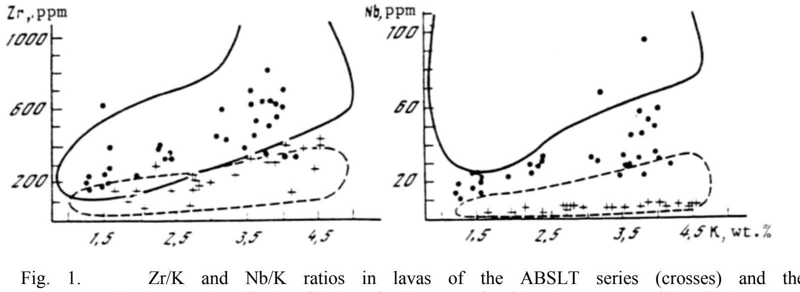

Fig. 1. Zr/K and Nb/K ratios in lavas of the ABSLT series (crosses) and the ALBTC (dots). Dash line) field of lavas of island arcs; solid line) same, continental rift zones, published data.

[1]Translated from: Dve serii lav povyshennoy shchelochnosti v pozdnekaynoyskoy vulkanicheskoy zone Sredinnogo khrebta Kamchatki. Doklady Akademii Nauk SSSR, 1984, Vol. 274, No. 5, pp. 1185-1188.

Table 1

Chemical composition of subalkalic and alkalic lavas

Oxide	1	2	3	4	5	6
SiO_2	50,37	50,16	55,59	54,86	58,74	59,70
TiO_2	0,93	1,61	1,14	1,40	0,99	1,12
Al_2O_3	18,03	17,44	16,50	18,06	16.88	17,80
Fe_2O_3	3,93	3,79	3,14	4,19	3,21	2,57
FeO	5,87	6,19	5,94	3,90	3,51	3,24
MnO	0,15	0,15	0,08	0,13	0,14	0,14
MgO	5,31	5,86	3,14	2,91	2,32	1,58
CaO	9,41	8,27	6,42	6,07	5,05	3,54
Na_2O	2,91	3,79	3,89	4,64	4,04	5,27
K_2O	1,95	1,77	3,80	2,52	3,82	3,52
P_2O_5	0,34	0,50	0,34	0,48	0,41	0,45
Ign. loss	0,87	0,56	0,54	1,13	0,93	1,13
Σ	100,07	100,04	99,71	100,29	100,04	100,06
n	30(33)	30(35)	7	7(8)	11	8(12)

Table 1 (cont.)

Oxide	7	8	9	10	11	12
SiO_2	62,04	62,14	67,67	65,65	72,19	72,12
TiO_2	0,94	0,91	0,61	0,70	0,18	0,07
Al_2O_3	16,61	17,34	15,48	16,97	14,36	13,09
Fe_2O_3	2,82	2,67	1,51	2,48	1,30	1,49
FeO	2,23	2,06	1,55	1,46	0,82	1,00
MnO	0,11	0,14	0,10	0,14	0,09	0,05
MgO	1,58	1,18	0,64	0,85	0,42	0,30
CaO	3,64	2,43	1,87	1,75	0,85	0,95
Na_2O	4,36	5,35	4,70	5,38	4,57	5,11
K_2O	4,69	4,09	5,15	4,83	4,59	4,57
P_2O_5	0,32	0,22	0,12	0,16	0,03	0,04
Ign. loss	0,96	0,87	0,79	0,64	0,53	0,77
Σ	100,30	99,40	100,19	101,01	99,95	99,56
n	13	14(20)	15	29(40)	11(22)	3

Note. 1, 3, 5, 7, 9) rocks of shoshonite-latite series; 2, 4, 6, 8, 10 to 12) rocks of alkalic olivine basalt-comendite series [11) trachyrhyolite, 12) comendite]; *n)* number of analyses used to calculate mean values and, in parentheses, SiO_2, Na_2O and K_2O.

sanidine and anorthoclase). In basalt of the ALBTC series, there are high-alumina augite megacrysts, similar in composition to clinopyroxene megacrysts in continental alkalic basalt lavas, as well as olivine clinopyroxenite inclusions with high-alumina spinel. Finally, in the matrix of comendite, the most silicic representative of this series, there are clinopyroxenes like sodium ferrohedenbergite and aegirine-augite, as well as alkalic amphiboles of the arfvedsonite-riebeckite and the richterite-calcium richterite series. Lavas of the ABSLT series lack melanocratic alkalic minerals.

In terms of concentration of Nb, Zr and, in basalt, of Ti, too, rocks of the ABSLT series are typical representatives of island-arc volcanics, whereas those of the ALBTC in this respect are closer to lavas of continental rift zones (Fig. 1). Typical lavas of the ABSLT series have been described on many island arcs with a continental crust [5-8], as well as along active continental margins [8-10]. Lavas of the other series, though very characteristic of intraplate rift zones and ocean islands, are found, too, along active continental margins [11], whereas only isolated examples of them are known on island arcs [12, 13]. Compositional differences between rocks of the ABSLT and the ALBTC series presumably reflect the different modes of generation of their parental magmas, which in the first instance are emplaced in an environment

Table 2

Concentrations of alkalies (in percent) and trace elements (in ppm) in subalkalic and alkalic lavas

Element	1	2	3	4	5	6	7	8	9	10	11	12
Na	2,22(52)	2,80(57)	2,79(17)	3,22(14)	2,89(22)	3,82(19)	3,11(18)	4,10(41)	3,40(25)	3,97(58)	3,47(37)	3,87(7)
K	1,71(52)	1,45(58)	2,79(17)	2,03(14)	3,02(22)	2,74(19)	3,80(18)	3,59(41)	4,27(25)	3,97(57)	3,82(37)	3,89(7)
Rb	39(28)	20,4(35)	51(9)	31,5(9)	61(11)	45,4(10)	72(6)	55,3(25)	92,2(10)	59,6(18)	110(17)	116(6)
Li	7,3(27)	8,1(35)	8(6)	10,7(8)	13(11)	16(10)	17(6)	14,3(25)	20,1(8)	16,1(18)	34(16)	16(5)
F	479(9)	626(16)	1032(4)	220(1)	635(4)	646(4)	850(3)	567(17)	791(7)	406(12)	235(12)	250(2)
B	12(9)	15(15)	13(4)	16,5(1)	15(4)	23(4)	81(3)	36(17)	22,4(8)	37(12)	78(12)	112(2)
Be	2,1(9)	1,7(16)	2,8(4)	2,5(1)	3,0(4)	2,8(4)	6,0(3)	2,5(16)	3,3(8)	3,5(6)	5,6(13)	5,6(2)
Ba	553(28)	486(31)	1092(9)	710(3)	1227(11)	887(5)	1450(6)	1279(10)	1410(10)	956(5)	156(7)	112(4)
Sr	665(28)	672(31)	740(9)	743(3)	703(11)	550(5)	592(6)	270(10)	314(10)	150(5)	<50(7)	41(3)
Ni	30(27)	74(34)	13,6(5)	34(5)	<8(11)	16(7)	<8(7)	5,8(10)	<8(9)	13,5(4)	2,8(5)	5,7(2)
Co	29(27)	32(34)	17(9)	23(5)	14(11)	14(8)	5,9(7)	2,9(12)	3,3(9)	2,8(4)	1,2(7)	1(2)
Cr	65(27)	104 (34)	23,4(9)	39(3)	21,4(11)	36(6)	12,7(7)	48(13)	8,9(9)	36(3)	9(9)	15(3)
V	259(27)	204(31)	156(9)	92(3)	135(11)	97(4)	48(7)	27,5(10)	22(5)	14(1)	5,5(7)	5,6(2)
Cu	85(27)	75(33)	67(9)	68(3)	50(11)	36(8)	15(7)	23(9)	8,7(9)	31(2)	12(3)	8(4)
Zn	94(27)	89(32)	87(9)	93(3)	85(11)	104(7)	81(7)	86(9)	56	78(2)	93(3)	65(4)
Nb	4,0(4)	18,5(10)	6,5(3)	31,4(2)	5,4(4)	26,6(3)	6,7(4)	38,4(10)	7,1(6)	31,4(4)	46,2(4)	108(4)
Ta	0,3(1)	0,7(5)	—	—	—	1,6(3)	0,5(2)	1,6(10)	0,35(4)	1,7(4)	2,6(4)	5,0(1)
Zr	158(4)	279(10)	182(3)	355 (2)	221(4)	380(3)	330(4)	637(10)	342(6)	596(4)	378(4)	560(4)
Hf	4,7(3)	7,5(10)	10,1(3)	6,9(2)	5,6(4)	7,6(3)	6,6(4)	9,4(10)	7,3(6)	18,7(4)	8,4(4)	9,0(1)
La	17(2)	23,5(7)	10(1)	25(2)	19(2)	37,2(6)	23(3)	48(13)	26(4)	48(5)	76(9)	76(2)
Ce	45(2)	52(7)	55(1)	41(2)	45(2)	65,5(6)	53,5(3)	74(13)	61(4)	91(5)	95(7)	110(2)
Nd	32,5(2)	34(5)	17(1)	41(2)	30,5(2)	38,5(4)	33,5(3)	50(11)	38(4)	40(5)	47(7)	62(2)
Y	41(2)	25,8(7)	40(1)	22,5(2)	47(2)	30,1(6)	43,5(3)	33(13)	45(4)	32,6(5)	41(7)	40(2)
Yb	4,15(2)	2,6(7)	4,0(1)	2,4(2)	4,5(2)	3,1(6)	4,3(3)	3,4(13)	4,45(4)	3,1 (5)	5,5(7)	4,6(2)

Note. Same column numbers as in Table 1. Number of analyses used to calculate mean values are given in parentheses.

of general compression characteristic of island arcs and, in the second, under conditions of local extension in rear arc zones [5, 8, 14].

The presence of rocks of the ALBTC series uncharacteristic of island arcs in the rear zone of the Central Range volcanic belt, Kamchatka, could be due to rearrangement of the regional structure that began in the Pliocene. At that time in eastern Kamchatka, a new volcanic belt (the East Kamchatka) was formed, the plate-subduction zone receded spasmodically toward the east [15], and the Central Range volcanic belt was converted to a rear arc zone with a tectonically stable regime. It could have been precisely under such conditions that tensile stress developed and created the volcanotectonic basins to which rocks of the ALBTC series are confined. The local coincidence of lavas of both series within the same structures (e.g., the Kekuknay volcano), where lavas of the ABSLT series were erupted before those of the ALBTC, suggests a change there from compression to extension.

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