EXPERIMENTAL INVESTIGATION OF THE LAMPROITE FORMATION

V.N. Zyryanov

Institute of Experimental Mineralogy, USSR Acad.Sci.

Constant scientific and practical interest in lamproites has made us initiate an experimental study of their formation. In our view, lamproites are a product of the fluid-magmatic interaction between mantle material and high potassium deep-seated fluids. To test this assumption we carried out model experiments on the interaction between mantle material and potash fluids in the superheated liquidus region. The liquidus of lamproite was earlier determined as 1125°C at $P(H_2O)$=1kb by Carmichael (1967) and as 1075°C at $P(H_2O)$=10kb by Arima & Edgar (1983). Based on these data, experimental conditions were accurately chosen to model the evolution of lamproite melt under decompression. Runs were performed in gas bombs with internal heating. The accuracy of the temperature and pressure control and measurements was 5°C, 50bar, respectively. The starting materials were mixtures of garnet hartzburgite(TYB 237) from Yakutia and alkali basalt (TF-38) from Galapagos in different proportions and the chemical KOH, K_2CO_3, KCl, KFHF·$2H_2O$ of analytical grade. Platinum capsules, 3mm in diameter, were charged with 25mg silicate material and 10mg potash chemical. In runs with K_2CO_3,KCl water was introduced into their composition in amounts of 20wt% of the rock weight. The charged capsules were sealed and loaded in fives into the thick-walled air-tight capsules filled with water. Since water dissociates at high temperature, the presence of water in the outer capsule after the run helped to maintain the water in the fluid at the original level. The capsules in the bombs were held at T=1100°C and P=5kb for 5 hours; after that the pressure was decreased to 2.5kb and one hour later the charges were quenched. The run products consisted of minerals and glass appeared as uncemented tuff. The minerals and glass were analyzed on the Camebax microprobe. The mineral-parageneses observed in the run products are given in Table 1.

Mineral-parageneses of the interaction between mafic-intramafic mixtures and K-fluids — Table 1

TYB 237: TF-38 wt%	KOH	K_2CO_3	KCl	KFHF·$2H_2O$
90:10	Ol+Phl+Mtch+Ks	Ol+Phl+Phl_1+Phl_2 (wolgidite)	Ol+Opx+Cpx+Gl (cedrecite)	Ol+Phl
80:20	Ol+CaOl+Phl+ Mtch+Gl (wolgidite)	Ol+Phl+Phl_1+Phl_2 (wolgidite)	Ol+Cpx+Gl (madupite)	CaOl+Phl+ Phl_1+Lar
50:50	Ol+Phl+Ks (fitzroite)	Ol+Phl+Phl_1+Gl (fitzroite)	Ol+Opx+Cpx+Phl+ Phl_1+KAmf+Gl (wayomingite)	Phl_1+Phl_2

After the minerals and glass were analyzed, the run products were converted into homogeneous glasses by fusing with the three-fold amount of lithium metaborate in carbide glass crucibles over gas burner. The resulting glasses were also analyzed on the microprobe. Their compositions, as normalized to 100%, are given in Table 2. Since the analyses cannot be claimed to correspond fully to the actual compositions because of very high dilution, only the Al_2O_3FeO and K_2O were used to derive the triangle diagram. The analyses showed that K_2CO_3, KCl and KOH fluids are most favorable for the generation of lamproite melts. With increasing basalt content in the mixture or decreasing partial melting, the points for the run products approached those for high-potash rocks from the Leucite Hills and Western Australia. The obtained products differed markedly from natural melts in that they had high magnesium and,consequently, low silicon.

Run products of the interaction between mafic-ultramafic mixtures and potassium fluids. Table 2

	KOH			K_2CO_3		
TYB237: TF-38 wt%	90:10	80:20	50:50	90:10	80:20	50:50
SiO_2	41.50	42.03	40.50	42.26	42.48	46.20
TiO_2	0.15	0.24	0.51	0.16	0.17	0.58
Al_2O_3	2.10	3.12	6.84	2.24	3.46	6.10
FeO	5.61	5.39	5.49	6.15	5.84	5.75
MnO	0.09	0.20	0.09	-	0.05	-
MgO	45.59	42.89	33.96	43.95	41.33	27.83
CaO	1.56	2.03	4.52	0.53	1.56	4.27
Na_2O	0.07	0.30	0.15	0.10	0.05	-
K_2O	3.31	4.76	7.86	4.59	5.52	8.95
	KCl			$KFHF \cdot 2H_2O$		
	90:10	80:20	50:50	90:10	80:20	50:50
SiO_2	44.21	49.00	48.43	31.89	38.51	41.92
TiO_2	0.14	0.20	0.95	0.04	0.57	0.13
Al_2O_3	2.12	2.56	5.06	2.17	6.71	4.47
FeO	5.55	5.84	5.14	3.95	4.78	5.07
MnO	0.06	-	-	0.02	0.05	0.01
MgO	44.12	39.03	30.10	37.36	28.69	38.23
CaO	1.74	2.44	6.27	1.63	6.86	1.17
Na_2O	0.09	-	-	0.12	0.25	0.11
K_2O	1.93	2.64	5.23	22.78	13.53	8.85

The material from the runs with $KF \cdot HF \cdot 2H_2O$ was the most different from natural lamproites. Despite some discrepancy between bulk compositions of natural lamproites and run products, the mineral-parageneses in the latter were used as the bases for classification. On the whole, all fluids used in the experimentations yielded compositions of enhanced magnesiality (100 Mg/Mg+Fe) which varied within narrow limits ($Ol_{91.5-92.2}$ $Opx_{92.4-95.5}$; $Cpx_{93.6-96.1}$; $Phl_{89.4-90.1}$; $KAmf_{90.1-92.7}$). By analogy with mineral composition from natural lamproites it can be concluded that run products contained no quench phases. It appears that all the minerals crystallized as a result of decreasing pressure from 5 to 2.5kb. Unlike natural lamproites, the run products contained no leucite Ti and Zr-bearing minerals. Leucite could be formed from the high-potash glass which however failed to crystallize because of high (20%) water content. Since the charge did not contain Ti and Zr, no priderite or wadite were formed. Their occurrence in natural lamproites indicates that Ti and Zr have redistributed from the substrate into the potash melts.

The present experiments have supported the view that lamproite melt can be formed as a result of the fluid-magmatic interaction between the mantle substance and high-potash fluids, Crystallization of fluid-magmatic mixture resulting in tuff or tuff-breccia structures takes place as the mixture erupts through the overlying rocks, under the continuing interaction with the fluid under decreasing pressure to precede a decrease in temperature.