ISSN 1028-334X, Doklady Earth Sciences, 2013, Vol. 452, Part 1, pp. 953–957. © Pleiades Publishing, Ltd., 2013.
Original Russian Text © A.O. Volynets, D.V. Melnikov, A.I. Yakushev, 2013, published in Doklady Akademii Nauk, 2013, Vol. 452, No. 3, pp. 303–308.

GEOCHEMISTRY

First Data on Composition of the Volcanic Rocks of the IVS 50th Anniversary Fissure Tolbachik Eruption (Kamchatka)[1]

A. O. Volynets[a], D. V. Melnikov[a], and A. I. Yakushev[b]

Presented by Academiciam E. I. Gordeev April 15, 2013

Received May 15, 2013

Abstract—First data on major, minor and trace element (XRF. 1CP-MS) concentrations in the volcanic rocks of the IVS 50th anniversary Fissure Tolbachik eruption are reported for the period from 27.11.2012 to 25.01.2013; scheme of lava flows distribution by March 2013 is made. The volcanic rocks of the new eruption are substantially different from the other studied volcanic rocks of Tolbachinsky Dol by their higher alkalis and incompatible elements content. The rocks of the first three days of eruption (Menyailov Vent) have higher silica and alkalis content than all previously reported volcanic rocks of Tolbachinsky Dol. Volcanic rocks of the Naboko Vent, at silica content similar to high-Al basalts of Tolbachinsky Dol, have different concentrations of trace elements and some major elements (K_2O, CaO, TiO_2, P_2O_5). REE and other incompatible element concentrations in the rocks of the Menyailov Vent are higher than in the rocks of the Naboko Vent at the same element ratios. The differences of the volcanic rocks of the two vents of the new eruption may be caused by the fact that the erupted lavas came from the different levels of the same magma chamber.

Keywords: Fissure Tolbachik eruption; Tolbachinsky Dol, basaltic trachyandesites, major and trace elements, REE, magma, Kamchatka

DOI: 10.1134/S1028334X13090201

Tolbachinsky Dol, the southern part of one of the largest in Kamchatka zones of monogenetic volcanism, is superimposed to the Kluchevskaya group of volcanoes and was formed in Holocene [1, 2]. The last activity episode here took place in 1975–1976 years. This eruption is known as Great Fissure Tolbachik Eruption (GFTE) and is well studied [1, 2]. After 37 years of silence, the new fissure eruption began here on November 27th, 2012 and was named the IVS 50th anniversary Fissure Tolbachik Eruption (FTE-50). The general information about this eruption is submitted to Doklady Earth Sciences. Here we report the first data on composition and evolution of volcanic rocks of the new eruption during the first two months.

The eruption started from the fissure opening, fountain and effusion of lava at Igor Menyailov Vent (M Vent) (N 55°47′9″, E 160°19′39″, alt. 1900 m) (Fig. 1). A little bit later Sofia Naboko Vent was formed downslope (N Vent) (N 55°46′6″, E 160°18′59″, alt. 1650 m).

The volcanic rocks of the M Vent are sub-aphiric, black basaltic trachyandesites (Table 1, Fig. 2), with rare sub- and phenocrysts of Pl, Ol, Cpx and their glomerporphyric joints. The microlites of the groundmass, which has pylotaxitic and hyalopylitic structure, are represented by Pl, frequently dove-shaped, and, to a lesser extent, Ol, Px; TiMt is abundant. All together, the microstructures and textures of the lava produced at the beginning of the eruption show evidence of the very rapid supply of magma to the surface. The volcanic rocks of the N Vent are also basaltic trachyandesites, but have more mafic composition (Table 1, Fig. 2). The amount of phenocrysts increased; also, bigger Pl (up to 1–1.5 cm in diameter) and Ol (up to 3 mm in diameter) phenocrysts appear. Nonetheless, the overall structure remains aphyric.

The chemical composition of the eruption products is given in the Table 1 and Figs. 2–3. The volcanic rocks of the M Vent are the most SiO_2-rich. From December, when the activity was concentrated in the N Vent, the composition of rocks changed rather sharply: silica content dropped up to 2 wt % and remained at this level until the end of January; MgO, TiO_2 concentrations and Mg# increased; K_2O, Na_2O

[a] *Institute of Volcanology and Seismology FEB RAS, Petropavlovsk-Kamchatsky*
[b] *Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry RAS, Moscow, Russia*
e-mail a.volynets@gmail.com

[1] The article was translated by the author.

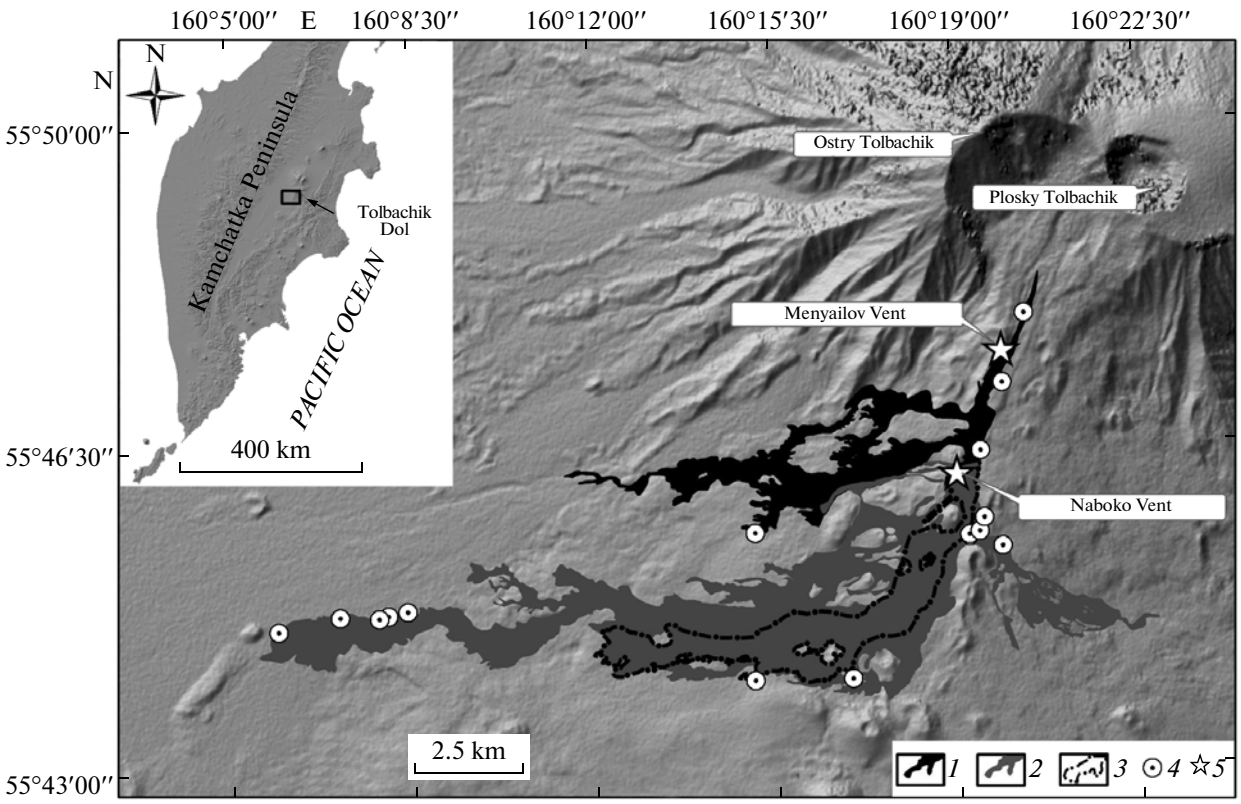


Fig. 1. Scheme of FTE-50 lava flows distribution by the end of March. Legend: *1*—Menyailov Vent lava flows; *2*—Naboko Vent lava flows; *3*—Menyailov Vent lava flows, later in most parts covered by Naboko Vent lavas; *4*—sampling sites; *5*—centers of the current eruption. This scheme is based on satellite images TERRA ASTER (NASA, JPL), EO-1 ALI (NASA) interpretation and field work observations. Topographic base - DEM SRTM X-band (DLR).

concentrations and K_2O/MgO ratio decreased. The first portions of the N Vent lavas, erupted during the period of December 2nd–7th, can be considered as interim between the M Vent lavas and the more recent lavas of the N Vent. The composition of the N Vent lavas remains practically constant during the December and January; the only exception is represented by the cinder from December 31st, which has lowered SiO_2, CaO, K_2O concentrations, and increased FeO.

The microelements concentrations show regular relations with major elements: Rb, Ba, Zr, Y show positive correlations with silica content, while Cr, Ni, Co—negative. The volcanic rocks of the M Vent have a bit higher concentrations of the REE and other incompatible elements than the rocks of the N Vent, but the elemental ratios remain constant (Fig. 3). These characteristics may be interpreted as a result of the fractionation of the single parent melt. The prominent Eu anomaly at REE distribution patterns (not shown here) indicates that Pl fractionation substantially influenced the composition of magma of the new eruption.

It is evident from the Harker diagrams (Fig. 2) that FTE-50 volcanic rocks, erupted during the period of November 2012–January 2013, noticeably differ from the previously studied volcanic rocks of Tolbachinsky Dol. All products of FTE-50 are richer in alkalis and TiO_2. Lavas of the M Vent are more acid than any of the erupted rocks of the monogenetic zone. The lavas of the N Vent, at silica content similar to the Southern Vent of GFTE and other alumina-rich basaltic andesites of the Dol, have lowered concentrations of Al_2O_3, CaO, MgO. These, rather special, characteristics of the products of the new eruption forced us to look for the matching types of rocks within the whole Kluchevskaya group of volcanoes, which is actually overlaid by the Tolbachik regional monogenetic zone. It turned out that FTE-50 products are similar to the high-K rocks of Plosky Sopki massif and fit their evolution trends, but are also different from them by several elements, most prominently by Ti content (Fig. 2). The basaltic trachyandesites of FTE-50 have higher REE, Y, Nb, Hf, Zr, Ta, Ti than previously studied GFTE rocks; Nb, Ta, Ti in them are also higher than in high-K volcanic rocks of Plosky Sopki massif (Fig. 3).

Summarizing the described above features of the FTE-50 volcanic rocks, we argue, that they are geochemically unique for Tolbachinsky Dol. At the same time, their geochemical characteristics allow us to suppose that they are genetically connected to the

Representative analyses of the FTE-50 volcanic rocks erupted from 27.11.2012 to 25.01.2013

Component	Number of sample							
	1	2	3	4	5	6	7	8
SiO_2	53.76	54.68	52.41	52.06	51.74	50.45	51.75	51.76
TiO_2	1.82	1.70	2.00	2.00	1.92	1.87	1.96	1.93
Al_2O_3	16.32	16.5	15.76	15.74	16.07	15.63	16.2	16.19
FeO*	9.20	8.65	10.32	10.51	10.56	12.57	10.49	10.55
MnO	0.17	0.17	0.17	0.17	0.17	0.18	0.17	0.17
MgO	3.37	2.98	3.81	4.02	4.1	4.18	4.13	4.15
CaO	7.26	6.67	7.56	7.48	7.37	7.02	7.32	7.31
Na_2O	3.81	4.04	3.52	3.56	3.58	3.48	3.61	3.58
K_2O	2.45	2.64	2.48	2.41	2.37	2.31	2.38	2.36
P_2O_5	0.69	0.77	0.6	0.66	0.7	0.68	0.7	0.7
Sum	98.84	98.79	98.63	98.61	98.59	98.37	98.71	98.70
Li	21.7	20.9	18.5	17.9	18.2	19.6	18.4	18.9
Be	2.0	2.1	1.9	1.8	1.9	1.9	1.9	2.0
Sc	27.3	25.8	30.3	29.3	28.3	27.5	26.9	27.4
V	264	214	260	306	302	286	286	299
Cr	15	8	20	20	30	79	33	42
Co	26	24	20	27	31	41	33	40
Ni	11	11	30	40	36	71	32	38
Ga	19.83	21.3	21.07	21.1	20.9	21.1	20.5	20.5
Rb	64	65	62	64	60	56	62	60
Sr	312	322	312	307	311	274	304	310
Y	52	50	39	43	48	44	50	46
Zr	257	262	227	245	252	226	252	257
Nb	9	9	8	8	8	8	8	8
Cs	2.3	2.7	2.4	2.3	2.3	2.3	2.2	2.2
Ba	571	604	557	553	566	504	554	574
La	22.3	23.7	21.7	21.5	21.2	21.2	20.6	21.4
Ce	56.5	63.6	57.7	55.0	55.2	54.3	54.2	55.7
Pr	7.8	8.2	7.6	7.6	7.4	7.5	7.3	7.5
Nd	35.7	37.7	34.4	34.8	34.5	33.7	33.8	34.8
Sm	8.4	9.0	8.3	8.4	8.2	8.1	8.2	8.2
Eu	2.2	2.4	2.1	2.2	2.2	2.1	2.1	2.2
Gd	8.6	9.0	8.1	8.3	8.2	8.1	8.2	8.2
Tb	1.3	1.4	1.3	1.3	1.2	1.2	1.2	1.2
Dy	7.8	7.9	7.3	7.4	7.3	7.2	7.2	7.4
Ho	1.6	1.7	1.5	1.5	1.5	1.5	1.5	1.5
Er	4.6	4.8	4.5	4.5	4.5	4.4	4.4	4.4
Tm	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Yb	4.4	4.5	4.1	4.1	4.1	4.0	4.0	4.1
Lu	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Hf	7.3	7.3	6.7	6.7	6.7	6.4	6.5	6.6
Ta	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Tl	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
Pb	8.4	9.7	8.4	8.4	8.2	8.2	7.9	8.0
Th	3.7	3.2	2.7	2.8	2.7	2.9	2.7	2.8
U	1.8	2.3	2.0	2.0	1.9	2.0	1.9	2.0

Note: Concentrations of major elements in wt %, microelements in ppm. Samples 1 and 2—Menyailov Vent, other—Naboko Vent: 1—TOLB-1201 (lava, 27.11.2012), 2—TM-08 (lava, 27.11.2012), 3—TM-1 (lava, 02.12.2012), 4—TM-6 (lava, 10.12.2012), 5—TM-10 (lava, 22.12.2012), 6—TOLB-1204 (cinder, 31.12.2012), 7—Tm-14 (lava, 21.01.2013), 8—TOLB-1307 (bomb, January 2013). Major elements, V, Cr, Co, Ni, Cu, Zn, Rb, Sr, Y, Zr, Nb, Ba, Pb were analyzed by XRF method in IGEM RAS; other elements were analyzed by ICP-MS in IMT RAS. All Fe is reported as FeO.

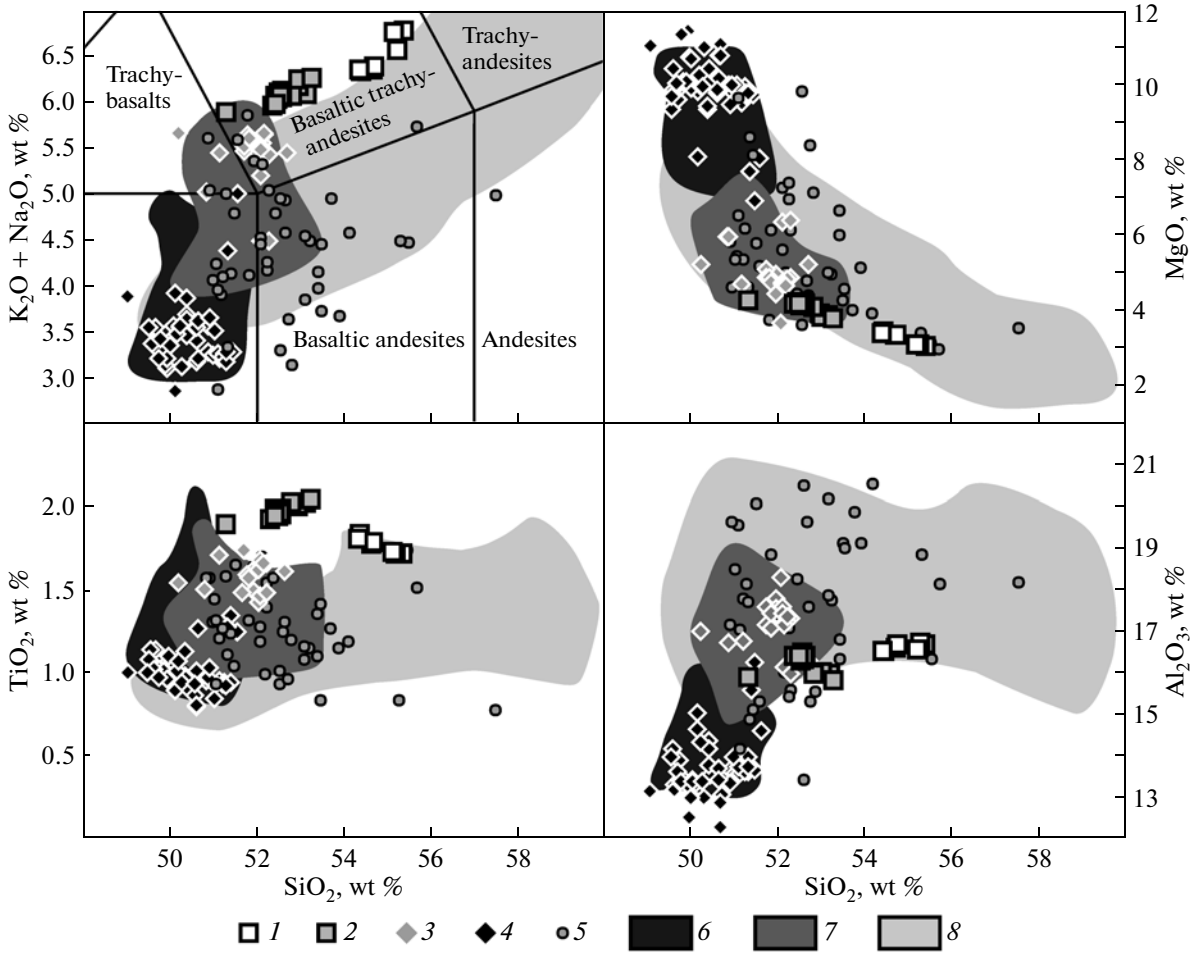
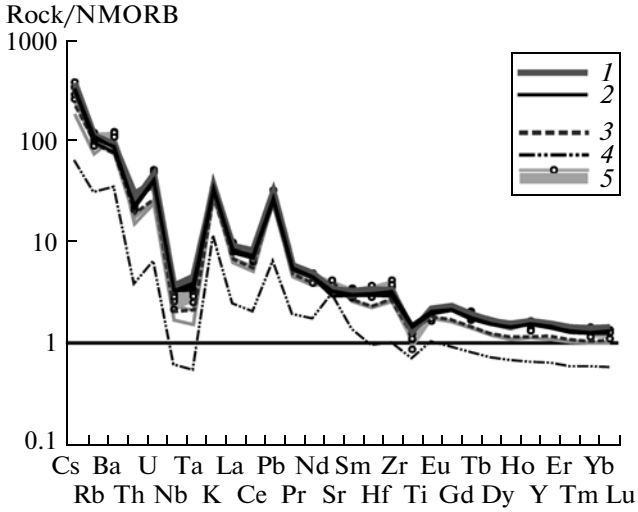


Fig. 2. Harker diagrams for FTE-50 volcanic rocks. Trachy andesite-basalts
(*1–2*) FTE-50: *1*—M Vent, *2*—N Vent; (*3–4*) GFTE: *3*—Southern Vent, *4*—Northern Vent; (*5*) Plosky and Ostry Tolbachik stratovolcanoes; (*6–7*) Tolbachinsky Dol: *6*—high-Mg, *7*—high-Al volcanic rocks; (*8*) Plosky Sopki volcanic rocks. Composition of rocks from Tolbachinsky Dol after [1, 3, 4, 5], Ostry and Plosky Tolbachik volcanoes—after [5, 6], Plosky Sopki—after [7, 8]. Discrimination lines on $K_2O + Na_2O - SiO_2$ diagram—after [9].



sources of the Southern Vent of GFTE and other high-Al basalts. The differences between the volcanic rocks of the upper Vent (M) and lower Vent (N) of the new fissure eruption may be due to the fact that the erupted lavas came from different levels of the single magma chamber. The top part of the magma chamber, substantially differentiated and probably to some extent assimilated the host rocks, erupted from the M Vent. From the N Vent, which is located down slope, less fractionated parts of the magma chamber started to drain.

Fig. 3. Distribution of REE and other incompatible microelements in FTE-50 volcanic rocks.
(*1–2*) FTE-50: *1*—M Vent, *2*—N Vent; (*3–4*) GFTE: *3*—Southern Vent, *4*—Northern Vent; (*5*) high-K volcanic rocks of the Plosky Sopki volcanic massif. Concentrations of elements in N-MORB after [10].

Thanks to N.V. Gorbach, N.A. Malik, B. Edwards, and A.B. Beloussov for providing the samples. Special thanks to A.D. Babansky for the help in analytical work, M.M. Pevzner and A.D. Babansky for critical reviews of this manuscript and V.S. Rodin for the sample preparation. The work is supported by IVS FED RAS, Program 9 of fundamental research by ESD RAS; FED RAS grant no. 12-III-A-08-165 (to A.V.) and NSF RAPID 1321648 to Ben Edwards.

REFERENCES

1. *The Great Fissure Tolbachik Eruption (1975–1976 years, Kamchatka)*, Ed. by S. A. Fedotov, G. B. Flerov, and A. M. Chirkov (Nauka, Moscow, 1984) [in Russian].
2. S. A. Fedotov, S. T. Balesta, V. N. Dvigalo, et al., *Active Volcanoes of Kamchatka. In 2 vol.* (Nauka, Moscow, 1991), Vol. 1, pp. 214–274 [in Russian].
3. O. N. Volynets, G. B. Flerov, E. I. Popolitov, V. A. Abramov, L. L. Petrov, and S. A. Shcheka, DAN USSR **238** (4), 940–943 (1978).
4. T. Churikova, F. Dorendorf, and G. Woerner, J. Petrol. **42**, 1567–1593 (2001).
5. M. Portnyagin, I. Bindeman, K. Hoernle, and F. Hauff, *Volcanism and Subduction: The Kamchatka Region* (AGU, Washington D.C., 2007), Vol. 172, pp. 203–244.
6. V. A. Ermakov and A. A. Vazheevskaya, Bul. Volcanol. Stations AN USSR, No. 49, 36–43 (1973) [in Russian].
7. T. G. Churikova and S. U. Sokolov, Geochemistry, No. 10, 1439–1448 (1993).
8. T. G. Churikova, *Geochemistry and Modeling of the Magmatic Process of Kluchevskoy Group of Volcanoes. PhD Thesis* (MSU, Moscow, 1993).
9. *A Classification of the Igneous Rocks and Glossary of Terms. Recommendations of the International Union of Geological Sciences on the systematics of igneous rocks*, Ed. by R. W. Le Maitre (Blackwell Scientific Publications, Oxford, 1989).
10. S. S. Sun and W. F. McDonough, Geol. Soc. London Spec. Publ. **42**, 313–345 (1989).