Another "Great Tolbachik" Eruption?

PAGES 189–191

On 27 November 2012 at 1715 local time, a focused swarm of earthquakes was interpreted as the start of a new ongoing eruption on the south flank (Tolbachinsky Dol) of Plosky Tolbachik volcano in east central Kamchatka, Russia (Figure 1a) [*Samoylenko et al.*, 2012]. Visual observations on 29 November showed ash shooting from two fractures as well as long, rapidly moving lava flows. Although the initial ash clouds reached 6 kilometers in height, subsequent ashfall has been limited to the area around the main vents, and no permanent settlements are in danger from advancing lava flows (the closest settlements are about 40 kilometers from the volcano). Including this eruption, six different volcanoes are presently active in Kamchatka.

The previous eruption at this site, the "Great Tolbachik" eruption of 1975–1976, lasted 18 months, produced more than 2 cubic kilometers of lava and tephra, and is the largest documented effusive eruption in the Kuril-Kamchatka arc during the past 200 years [*Fedotov and Markhinin*, 1983]. Preliminary findings show that the new activity differs from the 1975–1976 eruption in several ways: It is being fed from a relatively shallow (<10 kilometer deep) crustal storage area, its initial lava compositions are more evolved, it has produced less ash, and its lava discharge rates are almost 4 times larger than those estimated for the previous eruption. Observations made by personnel of the Institute of Volcanology and Seismology (IVS) and jointly funded IVS–National Science Foundation (NSF) expeditions in late January 2013 cover the first few months of the eruption.

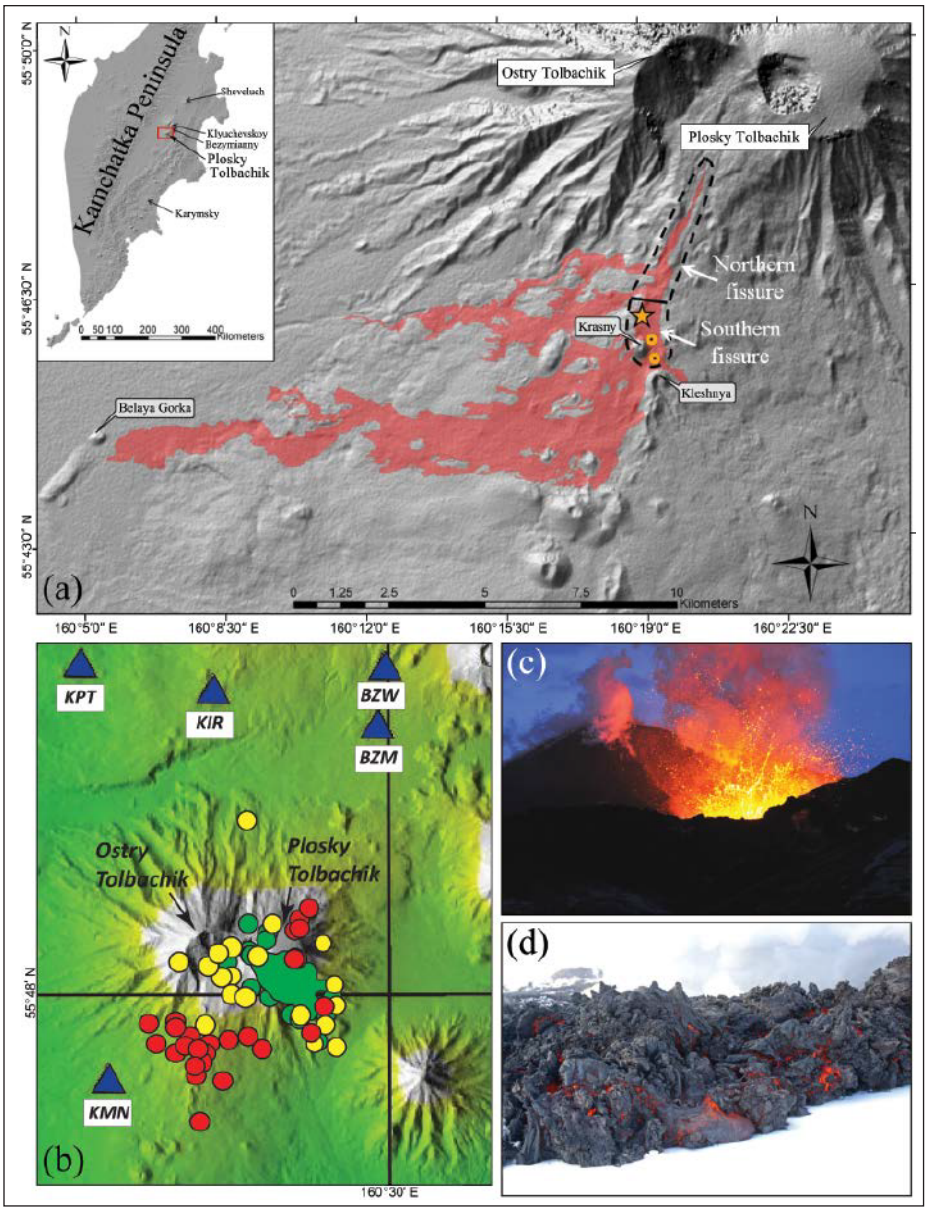

Fig. 1. (a) Map of lava fields and main vent (star) as of 15 February 2013 shown on a hillshade derived from a Shuttle Radar Topography Mission X-band digital elevation model. Three older, preexisting cinder cones are shown as geographic reference points (Belaya Gorka, Kleshnya, and Krasny). Two areas where lava tubes are feeding surface flows are also indicated (orange circles with black centers). (b) Map showing the progression of earthquakes on 27 November from immediately before the eruption (green) to the first explosive phase (yellow) to the start of the lava flow activity (red). (c) Explosive activity from the main cone, shooting glowing lava bombs more than 100 meters above the crater floor (25 January). (d) Slabby pahoehoe lava flow approximately 1 meter thick moving on top of snow (mid-February).

Overview of Eruption Activity

Unlike the 1975 eruption, which was predicted 1 week in advance based on strong precursory seismicity at five seismic stations, the eruption that began in November 2012 was preceded by much weaker seismicity, so scientists were not able to predict this eruption. Earthquake hypocenters registered from more than 10 local seismometers were generally at depths of less than 10 kilometers and were mostly located below Plosky Tolbachik before earthquake activity migrated south to the eruption site (Figure 1b).

Initial activity produced two primary fissures: a northern one, with four different active vents, and a southern fissure (Figure 1a). By the second day of the eruption, lava flows extended 9 kilometers from vent areas down into surrounding forests [*Samoylenko et al.*, 2012]. As of February 2013, weak explosive and effusive activity was ongoing at the main cone, and lava flows were active throughout the lava flow field from the southern fissure to Belaya Gorka, an older cinder cone 12 kilometers from the main vent (Figure 1a).

Effusive and explosive activities have continued since the start of the eruption (Figures 1c and 1d). Ash from the initial explosive activity was deposited up to 60 kilometers west of the main vent area, and initial sulfur dioxide (SO_2) gas emissions are estimated to have been approximately 60 metric tons. By late January, ash production was minor and the continuous explosions from the main cone had weakened. The highest lava flow rates at the surface (approximately 1 meter per second) were near lava tube openings in the upper part of the lava field (Figure 1a). The eruption is now dominantly producing pahoehoe (smooth), slabby pahoehoe, and `a`a (rough) lava flows.

Minor phreatomagmatic explosions were seen at the leading edges of lava flows advancing over snow during the first week of the eruption [*Samoylenko et al.*, 2012]. During January and February, active `a`a flows were observed moving over snow in the lower part of the flow field, and reports documented

heated meltwater discharge and active downslope flows. Lava-snow interaction continued as snow accumulated through the winter (Figure 1d).

Preliminary Petrology

Lava and tephra from the start of the eruption have isolated large crystals of plagioclase with smaller crystals of olivine and clinopyroxene. Preliminary geochemistry shows that samples are basaltic trachyandesite, with higher concentrations of silicon dioxide (52–54 weight percent) than in the basalts that erupted in 1975–1976 (48–50 weight percent). Field measurements using thermocouples and infrared radiometers show that the surface temperatures of active lava streams seen in Figure 1d are more than 1000°C.

Comparison to the "Great Tolbachik" Eruption of 1975–1976

The new eruption shows striking differences compared to the 1975–1976 event. The seismicity at eruption onset was of lower magnitude and was confined to the crust (<10 kilometer depth), while the 1975–1976 eruption produced stronger earthquakes and showed clear seismic evidence of transport from mantle depths (>25 kilometers). In its first 2 months, the present eruption has already produced more than 20% of the bulk volume of the 1975–1976 eruption, which lasted 18 months. Estimated lava discharge rates during early parts of the ongoing eruption were up to 400 cubic meters per second, which is significantly higher than the maximum estimated lava discharge rates for the 1975–1976 eruption (100 cubic meters per second) [*Samoylenko et al.*, 2012]. In addition, subsidence within the summit caldera on top of the adjacent Plosky Tolbachik volcano was significant during the 1975–1976 eruption but has not yet been observed during the present eruption, although the summit caldera appears to have new fumaroles.

As the eruption continues, a wide range of projects is under way to characterize the eruption. Geophysical studies by IVS/Kamchatka Branch of Geophysical Survey are under way. Staff from IVS and the University of Alaska Fairbanks are studying lava mineralogy and compositions as well as collaborating in field- and satellite-based mapping of lava flows and lava/tephra-snow interactions with staff from Dickinson College.

A short video highlighting aspects of the eruption can be seen at http://www.volkstat.ru/news.php?postid=200#top.

Acknowledgments

We appreciate logistical and photographic support in the field by A. Bichenko and S. Michaelov. Fieldwork was funded in part through a collaborative NSF RAPID grant to B. E. (EAR 1321648) and P. I. (EAR 1321636). Reviews by two anonymous referees improved manuscript and figure clarity. Funding for ongoing monitoring is being provided by the Russian Academy of Sciences.

References

Fedotov, S. A., and Y. K. Markhinin (1983), *The Great Tolbachik Fissure Eruption: Geological and Geophysical Data 1975–1976*, 341 pp., Cambridge Univ. Press, Cambridge, U. K.

Samoylenko, S., D. Melnikov, M. Magus'kin, and A. Ovsyannikov (2012), The beginning of new fissure Tolbachik eruption in 2012 [in Russian], *Vestnik Kraunz, 2,* 20–22.

—Ben Edwards, Department of Earth Sciences, Dickinson College, Carlisle, Pa.; E-mail: edwardsb@dickinson.edu; Alexander Belousov, Marina Belousova, Anna Volynets, Dmitry Melnikov, and Sergey Chirkov, Institute of Volcanology and Seismology, Petropavlovsk-Kamchatsky, Russia; Sergey Senyukov, Kamchatka Branch of Geophysical Survey, Petropavlovsk-Kamchatsky, Russia; Evgenii Gordeev and Yaroslav Muraviev, Institute of Volcanology and Seismology, Petropavlovsk-Kamchatsky, Russia; Pavel Izbekov, Geophysical Institute, University of Alaska-Fairbanks; and Yury Demianchuk, Institute of Volcanology and Seismology, Petropavlovsk-Kamchatsky, Russia