Seismic mode “drumbeats”, caused by the movement of a viscous lava flow during the Kizimen volcano eruption in may–october 2011

© 2019 A.A. Shakirova, P.P. Firstov

KB GS RAS, Petropavlovsk-Kamchatsky, Russia

Abstract The “drumbeats” mode is a sequence of volcanic earthquakes with similar waveforms (multiplets) that are recorded from tens of minutes to months. As a rule, the “drumbeats” mode accompanies the squeezing of lava blocks on extrusive domes of andesite-dacite volcanoes. Squeezing and movement of a viscous lava flow during an eruption Kizimen volcano in 2010-2013 was accompanied by multiplets with energy classes $K<6$ (magnitudes < 2.5), which were recorded from tens of minutes to months. Two series of the strongest multiplets were recorded during the four months from May to mid-October 2011. The volcanic earthquakes of multiplets can be attributed to hybrid and long-period. The coordinates of the foci were identified for the most powerful 35 events of two multiplets of “drumbeats” mode and were localized in the frontal part of the lava flow. The location of the volcanic earthquakes hypocenters suggests that they are generated during the motion of a viscous lava flow the volcano slope. The emergence of multiplets, apparently, can be considered as a process of self-oscillations of the relaxation type.

Keywords Kamchatka, seismicity, volcano, earthquake, multiplet, drumbeats, high frequency, long-period, lava flow.

For citation Shakirova, A.A., & Firstov, P.P. (2019). [Seismic mode “drumbeats”, caused by the movement of a viscous lava flow during the Kizimen volcano eruption in may-october 2011]. R*ossiiskii seismologicheskii zhurnal* [Russian Journal of Seismology], *1*(1), 67-74. (In Russ.). doi: *https://doi.org/10.35540/2686-7907.2019.1.06*

References

Carlisle, C.J. (2013). *Pattern recognition in earthquake from the 2009 volcanic eruption of the redoubt, Alaska*. A thesis submitted in partial fulfillment of the degree of Master of Science in Geophysics Boise State University, 82 p.

Droznin, D.V., & Droznina, S.Ya. (2010). [Interactive program for processing seismic signals DIMAS]. *Seismicheskie pribori* [Seismic devices], *46*(3), 22-34. (In Russ.).

Dvigalo, V.N., Melekestsev, I.V., Shevchenko, A.V., & Svirid, I.Yu. (2013). [The eruption of Kizimen Volcano 2010-2012 - the most productive (according to remote sensing data) on Kamchatka at the beginning of the XXI century. Part I]. *Vulkanologiia i seismologiia* [Journal of Volcanology and Seismology], *6*, 3-21. (In Russ.).

Firstov, P.P., & Shakirova, A.A. (2014). [Features of seismicity during the preparation and in the process of the eruption of the volcano Kizimen (Kamchatka) in 2009-2013]. *Vulkanologiia i seismologiia* [Journal of Volcanology and Seismology], *4*, 3-20. (In Russ.).

Garcia, A.A., Kumagai, H., Samaniego, P., Mothes, P., Yepes, H., & Monzier, M. (2007). Seismic, petrologic, and geodetic analyzes of the 1999 dome-forming eruption of the Guagua Pichincha volcano, Ecuador. *Journal of Volcanology and Geothermal Research*, *161*, 333-351.

Gordeev, E.I., & Senyukov, S.L. (1998). [Seismic activation of the Koryaksky volcano in 1994: hybrid seismic events and their use for the assessment of volcanic danger]. *Vulkanologiia i seismologiia* [Journal of Volcanology and Seismology], *4-5*, 112-126. (In Russ.).

Harrington, R.M., & Brodsky, E.E. (2007). Volcanic hybrid earthquakes that are brittle-failure events. *Geophysical Research Letters*, 34(L06308). doi: *10.1029/2006GL028714*

Ivanov, B.V. (2008). *Andezity Kamchatk*i [Andesites of Kamchatka]. Moscow: Nauka Publ., 467 p. (In Russ.).

Kuzin, I.P. (1974). *Fokal’naia zona i stroenie verkhnei mantii v raione Vostochnoi Kamchatki* [The focal zone and structure of the upper mantle in the region of Eastern Kamchatka]. Moscow, Russia: Nauka Publ., 145 p. (In Russ.).

Matoza, R.S., & Chouet, A.B. (2010). Implications for hydrothermal dynamics during the 2004-2008 eruption of Mount St. Helens. *Journal of Geophysical Researc*h, *115*, 1-26.

Ovsyannikov, A.A., & Malik, N.A. (2011). [Tephra of the Kizimen volcano eruption in December 2010 - February 2011]. In *Vulcanism i svyazannie s nim processi. Materiali regionalnoi konferencii 30 mart - 1 aprel*, *2011*. [Volcanism and related processes. Mater Regional Conference March 30 - April 1. 2011] (pp. 57-61). Petropavlovsk-Kamchatsky, Russia: IVIS FEB RAS Publ. (In Russ.).

Power, J.A., Lahr, J.C., Page, R.A., Chouet, B.A., Stephens, C.D., Harlow, D.H., ... & Davies, J.N. (1994). Seismic evolution of the 1989–1990 eruption sequence of the Redoubt Volcano, Alaska. *Journal of Volcanology and Geothermal Research*, *62*, 69-94.

Rowe, C.A., Thurber, C.H., & White, R.A. (2004). Dome growth behavior at Soufriere Hills Volcano, Montserrat, revealed by relocation of volcanic event swarms, 1995-1996. *Journal of Volcanology and Geothermal Research*, *134*, 199-221.

Seismologicheskie i geofizicheskie issledovaniia na Kamchatke. K 50-letiiu detal'nykh seismologicheskikh nabliudenii (*red. E.I. Gordeev*, *V.N. Chebrov*) [Seismological and geophysical studies in Kamchatka. To the 50th anniversary of detailed seismological observations (Ed. E.I. Gordeev, V.N. Chebrov)] (2012). (pp. 49-50). Petropavlovsk-Kamchatsky, Russia: Hold. Comp. "New book" Publ. (In Russ.).

Senyukov, S.L., Nuzhdina, I.N., Droznina, S.Ya., et al. (2011). [Seismicity of Kizimen volcano]. In *Problemi kompleksnogo geophisicheskogo monitoringa Dalnego Vostoka* (*Red. V.N. Chebrov*) [Problems of complex geophysical monitoring of the Far East of Russia. Proceedings of the third scientific and technical conference (Ed. V.N. Chebrov)] (pp. 144-148). Obninsk, Russia: GS RAS Publ. (In Russ.).

Shantser, A.E., Kutyev, F.Sh., Petrov, V.S., et al. (1991). [Kizimen volcano]. In *Aktivnye volcani Kamchatk*i [Active volcanoes of Kamchatka] (pp. 18-23). Moscow, Russia: Nauka Publ. (In Russ.).

Sobolev, G.A. (1993). *Osnovy prognoza zemletriasenii* [Basics of earthquake prediction]. Moscow, Russia: Nauka Publ., 313 p. (In Russ.).

WinPOS paket obrabotki signalov. Rukovodstvo programmista. (2010). [WinPOS signal processing package. Programmer's Guide]. Mytischi, Russia: NPP "Measure" Publ., 80 p. (In Russ.).

Information about authors

Shakirova Aleksandra Al'bertovna, Junior Researcher of the Kamchatka Branch of Geophysical Survey of Russian Academy of Sciences (KB GS RAS), Petropavlovsk-Kamchatsky, Russia. E-mail: shaki@emsd.ru

Firstov Pavel Pavlovich, Dr., Head of Laboratory of the KB GS RAS, Petropavlovsk-Kamchatsky, Russia. E-mail: firstov@emsd.ru