Periodic lava fountaining on basaltic volcanoes: dynamic behavior and experimental model

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Since 1983 we have been conducting volcanological and geophysical studying of lava fountains at the Klyuchevskoy volcano. Analysis of continuously registered volcanic tremor, processed by means of statistical analysis, allowed us for the first time to identify steady periodicities in the dynamics of fountaining which are manifested in a wide time range: from tens of minutes – to tens of hours. When studying the eruptions of 1984, 1993 and 2007 it has been established that at steady increase of magma discharge in crater three regimes of fountaining are sequentially manifested: steady low-intensity, periodic and steady high-intensity. Two intervals of change of the regime (ICR) – ICR-1 of "entry" to the periodic regime and ICR-2 of "exit" from it have been identified. The obtained results laid the basis for laboratory experiments.

Analysis of descriptions of eruptions and seismograms at other basalt volcanoes has allowed to establish periodic fountaining at Etna, Karkar, Kilauea, Manam, Niragongo, Tolbachik and at an underwater volcano NW Rota-1.

Processes determining periodic lava fountaining were studied through the use of constructed by us in 2003-07 Complex Apparatus for Modeling Basaltic Eruptions – CAMBE. It is 18 m high and consists of modeling and recording systems. When creating the Complex, the geometric parameters of the actual feeding system of the Klyuchevskoy volcano have been considered; the ratio of CAMBE's channel diameter to its height is $\sim$ 1:1000. There is no analogue to CAMBE in the world.

Our goal was to reveal the causes of periodicities in the dynamics of lava fountaining at basalt volcanoes. Experimental studies included studying of behavior of gas bubbles during their barbotage in vertical pipes through model liquids of various densities with subsequent comparison of the obtained data to real volcanic events. The majority of experiments have been conducted with the bubbles of one size that relates to the internal diameter of the hose as $\sim$ 1:20 which excludes a possibility of locking the internal section of the hose by a large bubble.

In the course of experiments, a new earlier unknown morphologically steady gas-hydrodynamic structure – an open bubbly cluster has been identified. It represents a volume of liquid with high concentration of bubbles, separated with a liquid containing no free gas phase from above and from below. A set of open bubbly clusters (following one another at a fixed distance), divided by liquid without bubbles, represents a periodic regime of open clusters.

Comparison of CAMBE acoustic records with diagrams of Klyuchevskoy volcanic tremor showed good correlation between the modeled and natural data. The results obtained allowed us to suggest a new pattern for gas-hydrodynamic migration of magmatic melt in the feeding channel, where the regime of open gas clusters accounts for periodic lava fountaining during basaltic volcanic eruptions.