OVERVIEW OF THE 2016-2018 ERUPTION ACTIVITY OF EBEKO VOLCANO (KURILE ISLANDS)

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Ebeko volcano is situated in the northern Vernadskii Range on Paramushir I., Kurile Islands, 6 km of the town of Severo-Kuril'sk. It is characterized by strong fumarolic and hydrothermal activity and phreatic and phreatic--magmatic eruptions. Current eruptive activity of Ebeko volcano began on October 2016 and continues to the present (May 2018). Here we divide the eruption into five phases: pre-eruption activity (2015-2016) and the 4 phases of eruption activity. Phases of activity were identified by the power of eruption and dislocation of eruptive vents.

Pre-eruption activity (2015-2016). Since the eruption of Ebeko volcano (Kuril Islands) during 2009 (Kotenko et al., 2010) all fumaroles have been stable active (Kalacheva et al., 2016). The main unloading (60-90%) occurred from the vents in the Active Funnel. For subsequent events, it is important that a short-term phreatic eruption was observed from the Middle crater in 2011 and formed two maars on the bottom (Kotenko et al., 2012). During the period 2015-September 2016 fumaroles discharging inside the crater and from eastern flankes were collected for chemical analyses. Retrospective analysis of the chemical composition of fumarole gases and isotopic composition of their condensates showed the presence of pre-eruption precursors (Fig. 1). Before the eruption occurred an increase in the concentration of some gases (SO_2, CO_2, H_2), changes in their relative concentrations, in the deep temperatures and in the isotopic compositions of fumarolic condensates (ŭ^{18}O and ŭD). The experimental geothermometer of Taran for natural steam jets (1988), based of the H_2 concentration, show an increase of deep temperatures for fumarolic gas.

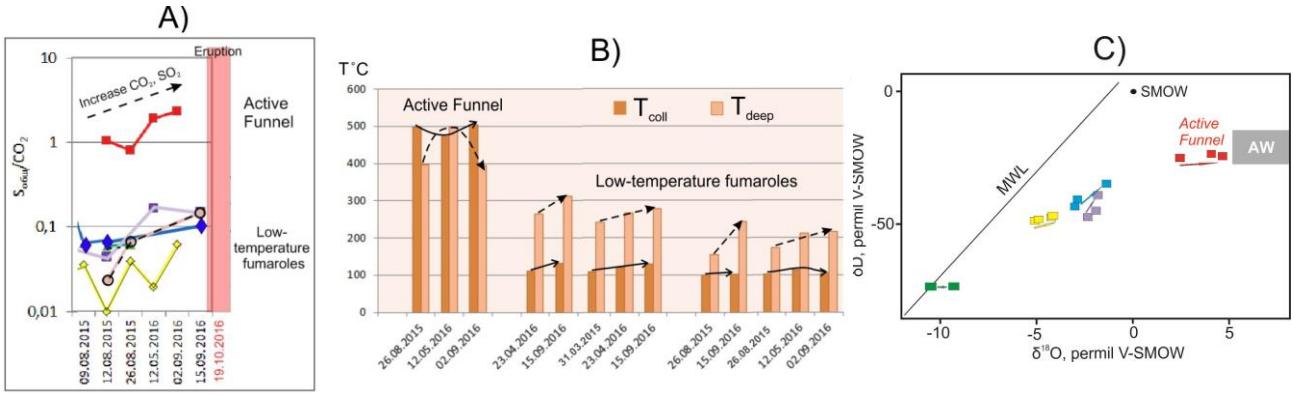

Fig.1. A) Time evolution of $S_{tot}/C0_2$ molar ratios in Ebeko fumarolic gas. Timing of 2016 eruption is also shown. B) Time evolution of deep and collected temperatures. C) Time evolution of isotopic compositions of the volcanic gas condensate (δD vs $\delta^{18}O$ plot) MWL – Meteoric Water Line; AW – "Andesitic" (Arc) Water (Taran et al., 1989)

Phase 1 (19-20 October, 2016). On October 19-20, 2016 the first eruption of Ebeko volcano took place (Kotenko et al., 2018). Periodic explosions of volcanic ash observed to a height of 2 km ASL. The ash plume spread over 6-12 km to the East and North-East.

Phase 2 (Nov 8, 2016-Apr, 2017). The second eruption of Ebeko volcano began on November 8, 2016 and continues to the present. Phase 2 was characterized by strong and frequent periodic explosions of volcanic ash up to 2.8 km above the crater (~30 explosions per day). Volcanic ash and gas came from three active vents. Two vents were located at the bottom of the Middle Crater (Maar eruption in 2011) and one in the Active Funnel (eruption vents in 2009).

Phase 3 (May 2017 - March 2018). For 3 phase, there was only one vent in the Active Funnel and reduced the number of explosions to 16-20 per day. The height of the volcanic ash was up to 2.8 km above the crater.

Phase 4 (April-May 2018). The second vent in the Active crater on the west side of the crater was formed in April 2018. In August 2017 on the future site of the crater arose a moat of many phreatic craters with a length of 40 m and a depth of 12 m (Kotenko et al., 2018). Both vents emit periodically volcanic ash. Also was formed fumarole field in the central part of the bottom of the Middle Crater. The height of the explosions, which were observed, reached 1.7 km above the crater, which is less than phase 3.

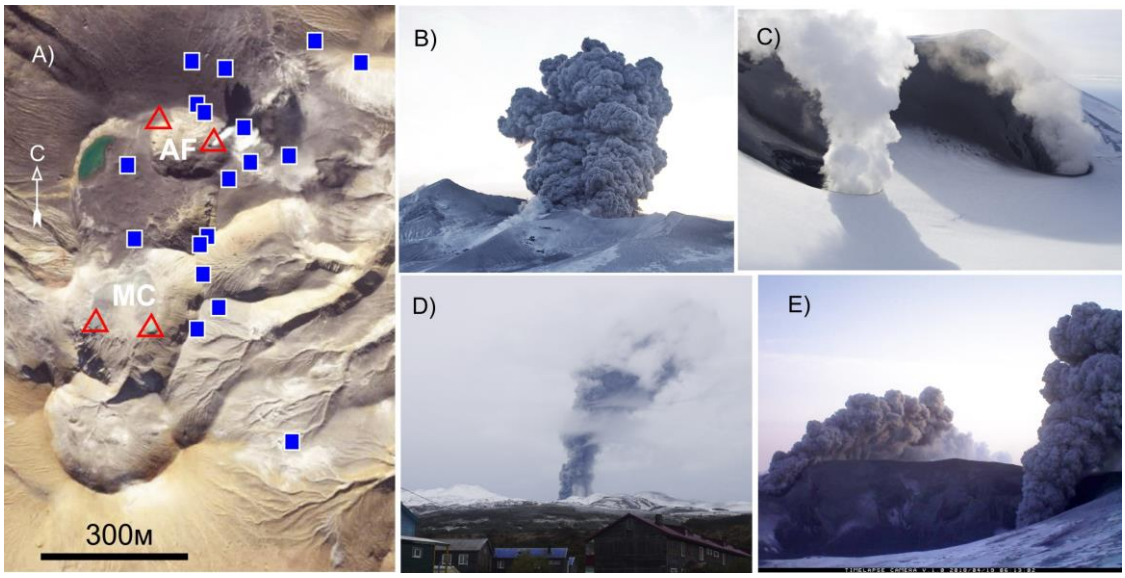

Fig.2. A) Map of Ebeko volcano and ash sampling locations (blue squares) and the active vents (red triangles). AF - Active Funnel. MC - Middle Crater. B) A typical explosion from Middle Crater. C) Two vents at the bottom of the Middle Crater. D) A typical vulcanian explosion from Active Funnel. Photo was taken from Severo-Kuril'sk. The plume is ~1.7km above the vent. E) Two vents at the Active Funnel. Photo by T. Kotenko

The graph (Fig.3 A) shows the maximum height of ash explosions (above the crater) in the month, the wind speed at the highest point of the column and the maximum number of explosions per day. We note a gradual decrease in explosive activity from Phase 2 to Phase 4. Only some ash plumes have been detected from satellites, as reported by Tokyo VAAC and KVERT.

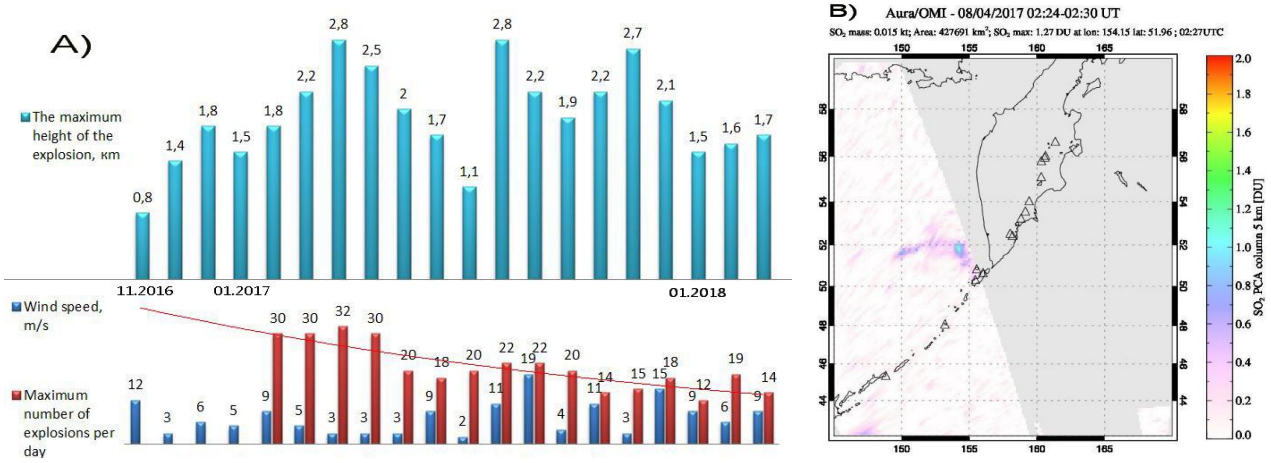

Fig.3. A) Time evolution of volcanic explosions. B) OMI images of the explosive SO_2 from Ebeko volcano on 4 August 2017.

According to our data, the sulfur-dioxide flux was 10-26 tons per a single explosion (the average duration of the explosions was about 10 minutes) (Kotenko et al., 2018). Only some SO_2 fluxes were repeatedly changed by the Ozone Monitoring Instrument of the satellite AURA (https://so2.gsfc.nasa.gov/pix/daily), the plumes had an area of 100-428,000 km^2 and SO_2 masses from 10 to 167 t.

The authors analyzed the chemical, mineral, and granulometric compositions of tephra. Tephra erupted by Ebeko volcano ranging in size from ash (the overwhelming number) to rock blocks. The studied tephra does not contain magmatic components. The authors classify the eruptions as phreatic. The tephra is mainly andesitic composition, K-middle (Fig.4). The gross total volume of the erupted material (for August 2017) was estimated to exceed 1.5 million tons.

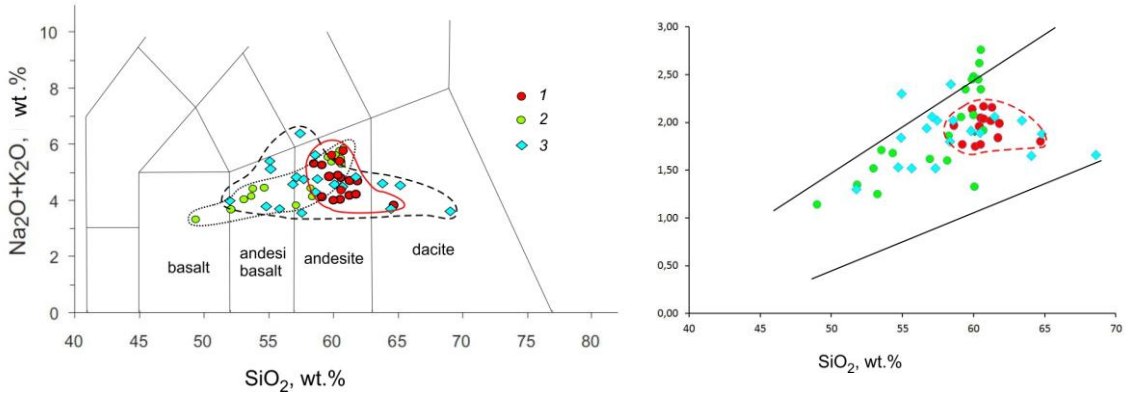

Fig.4. Classificatory diagrams (Na_2O+K_2O vs SiO_2 plot) and (K_2O vs SiO_2 plot) for 2016-2017 tephra (red circles). The compositions of lavas (green circles) (Melekestsev et al., 1993[1]) and ashes of previous eruptions (rhombuses) (Kotenko et. al., 2012, Melekestsev et al., 1993[2]) are also shown

Each eruption is a unique combination of volcanic hazards. In the proximal hazard zone, (within a radius of 150-300 m around the craters) there is a fall of blocks, lapilli, and there is a strong air pollution with volcanic gases. In the distal hazard zone, (within a radius of 10-12 km from the volcano) ash is falling out and there is also air pollution from toxic volcanic gases. In this area is the town of Severo-Kuril'sk. A small amount of the ash but for a long time more than 1.5 years creates problems for people. Ash falls and air pollution with volcanic gases seriously worsen air quality and create problems for people with health and with the operation of technical ones.

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