PETROLOGY OF THE 2016 ERUPTION OF PAVLOF VOLCANO, ALASKA: INSIGHTS ON THE MAGMA PLUMBING SYSTEM

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Background

Pavlof Volcano (55.4173° N, 161.8937° W, 2518 m asl) is a conically-shaped stratovolcano (fig. 1) located on the southwestern part of the Alaska Peninsular. With 25 confirmed eruptions in the 20th century and 5 eruptions since 2000 AD, Pavlof Volcano is considered to be one of the most active volcanos in Alaska. The eruptive activity typically includes Strombolian lava fountaining, episodes of sub-Plinian ash emissions, effusive activity, as well as the formation of pyroclastic density currents, which, depending on snow conditions, may trigger the formation of lahars and mud flows (Waythomas et al., 2014).

The most recent episode of volcanic activity at Pavlof started abruptly on March 27, 2016 with no warning and no precursory seismic activity (Fee et al., 2017). The first 20 hours of the eruption were characterized by a continuous, vigorous ash emission to an altitude of ca. 8.5 km, which produced an ash cloud drifting for more than 600 km across the Bering Sea and the interior Alaska. Lava fountaining occurred simultaneously forming spatter deposits, which collapse formed several pyroclastic density currents. The latter were hot enough to melt underlying snow and ice, and to produce extensive lahars. After ca. 20 hours of activity the ash emission became intermittent, the lava fountaining gradually declined, and the eruptive activity waned on March 29, 2016.

Petrological Observations

In this study we used a sample of ash collected on March 28, 2016 by Allan Brandell of Nelson Lagoon, ca. 75 km to the North East from Pavlof Volcano. In addition, we used three tephra samples collected by Max Kaufman, AVO at the saddle between Pavlof Volcano and Pavlof Sister Volcano during maintenance of AVO's seismic stations, a few months after the end of eruptive activity. Both samples appear to represent tephra fall deposits of March 27-29, 2016 eruption of Pavlof Volcano, uncontaminated, and well preserved. Whole-rock composition of the tephra samples was analyzed at GeoAnalytical Lab of the Washington State University (Johnson et al., 1999). Compositions of minerals and glasses, as well as ash particles morphology, were studied using JEOL 8350f at the Advanced Instrumentation Laboratory, University of Alaska Fairbanks.

The primary juvenile product of the 2016 eruption of Pavlof Volcano is a low-silica basaltic andesite (LSBA) with 53.00-53.11 wt.% of SiO_2 and 0.57-0.61 wt.% K_2O (fig. 2). The LSBA is comprised of 17 vol.% of plagioclase phenocrysts, 4 vol.% of olivine phenoscrysts, as well as a matrix glass. The glass is clear, dark-brown and contains euhedral microlites of plagioclase, olivine, and Ti-magnetite. Composition of plagioclases in LSBA is strongly bi-modal. Composition of phenocryst cores of plagioclases varies from 68 to 78 An mol.%, whereas composition of phenocryst rims of plagioclases, as well as composition of plagioclase microlites varies from 50 to 60 An mol.%. The boundary between An_{68-78} cores and the An_{50-60} outermost rims of plagioclase phenocrysts is step-wise; width of rims does not exceed 5 microns (fig. 3).

Figure 1: Pavlof Sister (left) and Pavlof (center) Volcanoes, July 2017

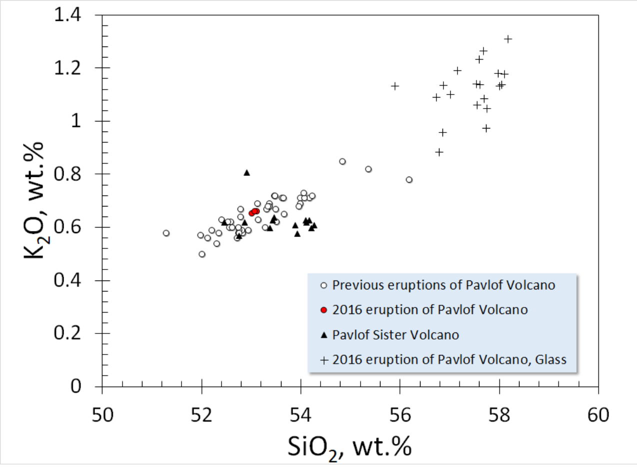

Figure 2: Whole rock and glass composition of tephra produced by the 2016 eruption of Pavlof Volcano. Whole rock composition of prior eruptions of Pavlof and Pavlof Sister Volcanoes from Mangan et al.(2009) is shown for comparison.

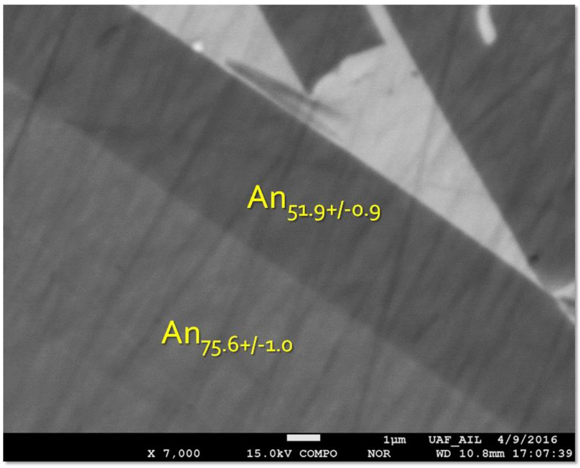

Figure 3: BSE image of plagioclase crystal showing a step-wise boundary between its calcic core and the 5-micron-wide sodic rim.

Composition of olivines in LSBA is homogeneous and varies in a vary in a very narrow range within individual crystals, as well as between crystals from 69.1 to 71.9 Fo mol.%. Occasionally, the outermost rim of olivine crystals is characterized by a gradual decrease of Fo component to 67.3 mol.% on a scale of 5-10 micrones. Matrix glass of LSBA is very homogeneous with 55.9-58.2 wt.% of SiO_2 and 0.89-1.31 wt.% K_2O (fig. 2).

In addition to LSBA the products of 2016 eruption of Pavlof contain conspicuous amount of the crystal-rich, roundly-shaped clots (fig. 4). These clots differ from the host LSBA by a significantly higher, up to 100 vol.% microlite content in the matrix. The outermost zones of olivine crystals in the crystal-rich clots are replaced by Ti-magnetite and orthopyroxene. Composition of the altered olivine cores is 98-99 Fo mol.%. Composition of plagioclase crystals in the crystal-rich clots is the same as in the LSBA.

Volcanic ash particles of the March 27-28 period of eruption are represented by three main morphological groups: (1) fine (< 20 micron), angular glass shards, (2) platy crystals, (3) large (100-250 micron) composite particles, often with smooth surfaces (fig. 5).

Preliminary Interpretation

Plagioclase-olivine low silica basaltic andesite is a primary product of the 2016 eruption of Pavlof Volcano. Low crystallinity, low silica content in the melt, as well as smooth surfaces of ash particles (fig. 5) suggest a very low viscosity of the magma. The 2016 eruption of Pavlof also produced a subordinate amount

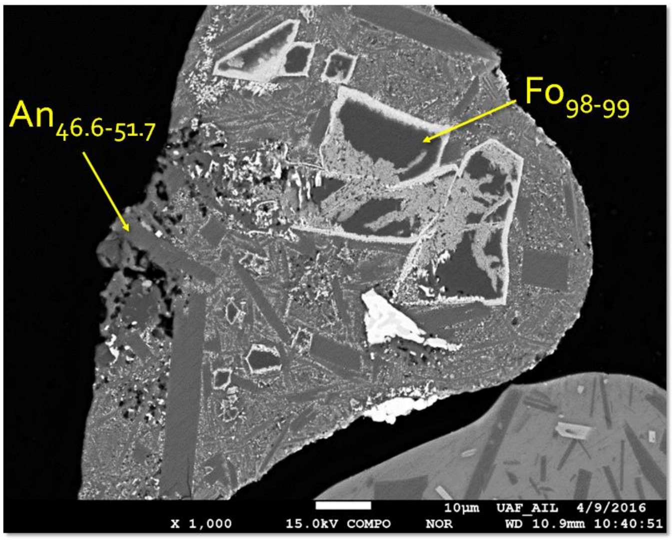

Figure 4: BSE image of rounded, crystal-rich clot with altered olivine.

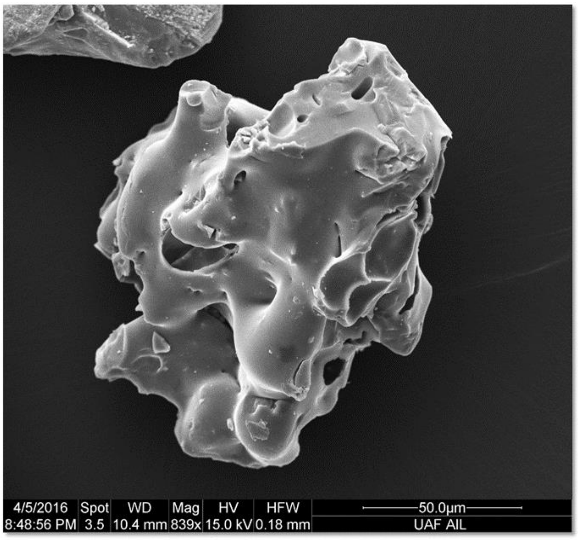

Figure 5: Large composite ash particle with smooth surface.

of material characterized by a higher crystallinity and the presence of Fo_{98-99} olivines with altered outermost zones (fig. 4). Round shapes of crystal-rich particles suggest to us that this material was molten at the time of eruption and therefore represents a subordinate magmatic, juvenile component. Its high crystallinity, presence of altered Fo_{98-99} olivines, together with the presence of sodic plagioclases are indicative of a prolong residence time at magmatic temperatures. Therefore, these crystal-rich clots (fig. 4) may represent a recycled magma, which remained in a molten state in the Pavlov's plumbing system since the previous eruption or recharge.

What are the main ingredients for an aseismic start of eruption? Our observations suggest that a low magma viscosity, as well as the open conduit filled with molten magma may have played a significant role in the aseismic start of the eruption of Pavlof Volcano in 2016. However, the question is what keeps the conduit open? Is the flux of volcanic gases at Pavlof is high enough to maintain magmatic temperatures of its conduit? We intend to answer this question by means of numerical modeling.

References

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