**Supplement 1 for “Short-term forecasting and detection of explosions during the 2016–2017 eruption of Bogoslof volcano, Alaska”**

 **ALASKA VOLCANO OBSERVATORY INFORMATION STATEMENT**
**U.S. Geological Survey**
**Tuesday, January 31, 2017, 1:47 PM AKST (Tuesday, January 31, 2017, 22:47 UTC)**

**BOGOSLOF VOLCANO** (VNUM #311300)
53°55'38" N 168°2'4" W, Summit Elevation 492 ft (150 m)
Current Volcano Alert Level: WARNING
Current Aviation Color Code: RED

**Summary of current activity**

Bogoslof volcano is in an active eruption sequence that began on December 12, 2016. Until recently, eruptive activity detected by remote monitoring instruments, in satellite data, and from pilot reports had been dominated by a series of short-duration (minutes to tens of minutes) explosive events. There were about 27 such events, occurring every 1 to 4 days. The resulting volcanic clouds rose to altitudes of 20,000 to 35,000 ft above sea level, and were typically discernible in satellite images for hours afterwards. Most of the clouds were ice-rich, due to the influx of seawater into the eruption column, but likely contained volcanic ash as well. Sulfur dioxide (SO2) gas clouds from some of these events were detected in satellite data, and the cloud from the December 21 event was tracked by satellite for five days to a location over the central United States (Nebraska).

Most recently, explosive ash emissions through the night of January 30-31 were more continuous in nature and produced an ash cloud to about 25,000 ft asl. The ash cloud was transported to the southeast over Unalaska Island and resulted in a trace amount of ash fallout in Unalaska/Dutch Harbor. This was the first such ashfall reported during the eruptive sequence.

Satellite images from today, January 31, show significant changes at Bogoslof Island. Whereas previous explosive events in this sequence had issued from a vent in shallow seawater, freshly erupted volcanic rock and ash have formed a barrier that separates the vent from the sea for the first time since the eruptive sequence began. As a result, we infer that this change has resulted in the more ash-rich emissions that occurred during the evening of January 30 to 31 (AKST).

A previous satellite image, from January 24, shows that the explosive eruptions to that time had significantly changed the shape and coastline of the island. On that date, the eruptive vent remained below sea level, most likely in the northern portion of a figure-eight-shaped bay, where upwelling volcanic gases were observed.

Only the strongest eruptive events are being detected by our monitoring network. It is likely that lower level, but still hazardous phenomena are occurring at the volcano during times when the volcano appears quiet on distant instruments

**Monitoring Status**

Bogoslof is not monitored by a local, on-island geophysical network, which limits our ability to detect unrest and forecast activity at this volcano. AVO is using seismic sensors from Okmok (32 mi, or 50 km) and Makushin (45 mi, or 72 km) volcanoes on neighboring Umnak and Unalaska Islands to monitor activity. Since the eruption began, patterns in seismicity prior to some significant explosive events have allowed AVO to provide some forecasts, whereas other explosions have occurred with no detectable precursors. Storms are common in the Aleutians during this time of year, and seismic signals are often masked by wind-generated noise.

In addition to seismicity, explosive volcanic activity also produces infrasound signals (pressure waves) that we can detect on sensors at Okmok volcano on neighboring Umnak Island, as well as more distant infrasound sensors in Dillingham and Sand Point. Since the pressure waves move at the speed of sound, there is a delay of tens of minutes between eruption onset and detection at distant infrasound sensors. As with seismic signals, storm noise can also mask explosions in infrasound data.

Data from the World Wide Lightning Location Network (<http://wwlln.net/>) provide near-real-time (within minutes) automated alerts of lightning strokes near Bogoslof that have been shown to be indicative of explosive activity at the volcano. Thus far, 18 of 28 explosive events have had associated lightning strokes.

AVO uses near-real-time satellite data to detect explosive eruptions, to estimate volcanic cloud height and to track the dispersion of the resulting volcanic clouds. Although we can detect energetic explosive activity in real-time, there is typically a lag of tens of minutes until we can characterize the magnitude of the event and the altitude of the volcanic cloud. These data can also detect highly elevated surface temperatures from lava effusion, the presence of a lava dome, or hot ash deposits. Heavy weather-cloud cover can obscure observations of volcanic activity in satellite data.

AVO will continue to provide timely warnings of activity given the constraints of the current monitoring data sources and will issue Volcanic Activity Notices (VANs) and Volcanic Observatory Notices for Aviation (VONAs) as needed.

**Prognosis**

On the basis of previous historical eruptions of Bogoslof, we can expect that episodic explosions, emitting ash-bearing volcanic clouds that reach 20,000 ft asl or higher, could continue for weeks or more. It is likely, but not certain, that the current eruption will continue to follow the pattern of other historical eruptions. Eventually a lava dome may be extruded at the surface. There is no indication at this time that current activity is building to a significantly larger eruption.

The shift in activity that occurred overnight January 30-31 was coincident with the growth of the new subaerial (above sea level) cone. This shift could result in some changes in the character of the eruption, as the extent of magma interaction with seawater will be reduced. Future explosive eruptions may become more ash-rich without the scrubbing effects of seawater. The probability of ashfall on neighboring communities (Nikolski, Unalaska, Akutan) may increase, depending on wind direction.

Continued volcanic activity, combined with erosion from wave action, likely will modify the island further. In this dynamic environment, the vent may sometimes be above, and sometimes below, sea level. The nature of future volcanic activity may shift accordingly, perhaps switching between short events with ice-rich clouds to longer, more ash-rich events.

**Hazards**

The main hazards associated with the current eruption are from volcanic clouds. Airborne ash is a significant hazard to aircraft. During specific explosive events, official forecasts of ash-cloud movement can be found at the Alaska Aviation Weather Unit (<http://aawu.arh.noaa.gov/>). Additionally, the Federal Aviation Administration (FAA) currently has issued a Temporary Flight Restriction (TFR) around Bogoslof (<http://tfr.faa.gov/tfr2/list.html>) that will remain in effect while the volcano is in eruption.

The potential for ashfall on local communities depends upon wind direction, eruption intensity and the mass of ash that is produced during each explosive episode. Ashfall was reported on Unalaska Island during eruptions in 1883-85, 1890, and 1906-07. The explosive eruptions of January 30-31 were the first events in the current sequence to produce trace ashfall on Unalaska/Dutch Harbor. AVO provides model outputs that predict ash fall and ash cloud information based on either hypothetical or actual eruption information on our website (<https://www.avo.alaska.edu/activity/Bogoslof.php>). Official forecasts of ashfall can be found at the National Weather Service Forecast Office website (<http://www.weather.gov/afc/>).

In addition to the hazards mentioned above, local hazards in the vicinity of Bogoslof can be severe during individual explosive events and may be present at other times though not detectable by our monitoring techniques. These include base surges, which are ring-shaped clouds of gas and suspended solid debris that move radially and rapidly outward from the vent area, hugging the ocean surface. Although we have not observed base surges directly, the landforms produced during this sequence suggest that surges have occurred. Based on studies at other volcanoes, it is possible for these flows to travel 4 miles (6 km) or more from the eruption site. Thus a reasonable hazard zone for base surges is 6 miles (10 km) beyond the volcano in all directions. The Coast Guard is issuing a Local Notice to Mariners in District 17 regarding the proximal hazards around Bogoslof Island (<https://www.navcen.uscg.gov/?pageName=lnmMain).>

Explosive disturbance of the ocean around the eruption site is likely displacing seawater and may be generating small waves. So far, such waves do not appear to be large or far-traveling and do not pose a significant hazard.

**Background**

Bogoslof Island is the largest of a cluster of small, low-lying islands making up the summit of a large submarine stratovolcano. The highest point above sea level prior to this eruption was about 100 m (300 ft); however, the volcano is frequently altered by both eruptions and wave erosion and has undergone dramatic changes in historical time. The two main islands currently above sea level are Fire Island and Bogoslof Island, both located about 98 km (61 mi) northwest of Unalaska/Dutch Harbor, 123 km (76 mi) northeast of Nikolski, and 149 km (93 mi) northeast of Akutan. The volcano is situated slightly north (behind) the main Aleutian volcanic front. Bogoslof volcano is within the U.S. Fish and Wildlife Service Alaska Maritime National Wildlife Refuge and is habitat for marine mammals and seabirds (<https://www.fws.gov/refuge/alaska_maritime/>).

At least 8 historical eruptions have been documented at Bogoslof. The most recent occurred from July 6 to 24, 1992, and produced episodic steam and ash emissions including an ash cloud up to 8 km (26,000 ft) above sea level and an extrusion of a 150 m (500 ft) by 275 m (900 ft) lava dome on the north end of the island. Previous eruptions of the volcano have lasted weeks to months, and have on occasion produced ash fall on the community of Unalaska. Eruptions of the volcano are often characterized by multiple explosive, ash-producing events such as we have seen in 2016 and 2017, as well as the growth of lava domes.

**OTHER ALASKA VOLCANOES**

Information on all Alaska volcanoes is available at : [http://www.avo.alaska.edu.](http://www.avo.alaska.edu./) Takawangha Volcano, Cleveland Volcano, and Pavlof Volcano are at Aviation Color Code YELLOW and Volcano Alert Level ADVISORY. All other Alaska volcanoes show no signs of significant unrest.

AVO scientists conduct daily checks of earthquake activity at all seismically-monitored volcanoes, examine web camera and satellite images for evidence of airborne ash and elevated surface temperatures, and consult other monitoring data as needed.

For definitions of Aviation Color Codes and Volcano Alert Levels, see: <http://www.avo.alaska.edu/color_codes.php>

SUBSCRIBE TO VOLCANO ALERT MESSAGES by email: <http://volcanoes.usgs.gov/vns/>

FOLLOW AVO ON FACEBOOK: <https://facebook.com/alaska.avo>

FOLLOW AVO ON TWITTER: <https://twitter.com/alaska.avo>

**CONTACT INFORMATION:**

Michelle Coombs, Scientist-in-Charge, USGS
mcoombs@usgs.gov (907) 786-7497

Jeff Freymueller, Coordinating Scientist, UAFGI
jfreymueller@alaska.edu (907) 322-4085

The Alaska Volcano Observatory is a cooperative program of the U.S. Geological Survey, the University of Alaska Fairbanks Geophysical Institute, and the Alaska Division of Geological and Geophysical Surveys.