VOLCANIC ERUPTION RESPONSE: CLEVELAND, PAVLOF, AND VENIAMINOF VOLCANOES

Veniaminof volcano in eruption on August 21, 2013. Photo by Game McGimsey, USGS. Image URL: http://www.avo.alaska.edu/images/image.php?id=55161

Three volcanic eruptions occurred in Alaska during 2013: Cleveland volcano in the central Aleutians, and Pavlof and Veniaminof volcanoes on the Alaska Peninsula. During volcanic eruptions DGGS volcanology section staff spend a significant amount of time responding to the eruption. Responsibilities include responding to e-mails from the public, ensuring the public website contains the most up-to-date volcanic information releases and photographs, keeping the internal data flow manageable through the internal website and communications log, participating in daily seismic and remote sensing data monitoring checks, contributing to eruption scenario forecasts, and keeping a detailed record of ash fall, eruption chronology, and the eruption's impact on air traffic and infrastructure.

The current eruption of Cleveland volcano began on May 4, 2013, when multiple explosions were detected in infrasound arrays. Cleveland volcano is not seismically monitored and AVO relies on infrasound and satellite data to detect activity at the volcano. The volcano has remained at an elevated alert level since May; intermittent explosions are detected with infrasound and thermal anomalies are seen in satellite data. The volcano also erupted in 2011 and 2012, producing ash clouds as high as 12 kilometers (39,000 feet) above sea level, as well as lava flows and hot avalanches that reached the sea.

On May 13, 2013, seismic activity increased at Pavlof volcano and an intense summit thermal anomaly was detected in satellite imagery. On May 14, pilot reports confirmed the eruption was underway with a small lava flow near the summit. Elevated seismic activity, lava fountaining, and occasional steam, gas, and ash plumes to 22,000 feet (6,700 meters) continued until about May 24. The lava flow extended about 1.5 kilometers down the north flank of the volcano. During the eruption, regional air carriers canceled passenger and cargo flights to communities near Pavlof, including Sand Point. Flights were canceled on May 20 and June 4, 5, 6, and 25. Trace amounts of ash fell on the communities of Sand Point (May 19), Nelson Lagoon (May 20–22), Cold Bay (June 6–7), and King Cove (June 25).

Activity at Veniaminof volcano began on June 8, 2013, when AVO detected gradually increasing seismic tremor. On June 13, AVO increased the Aviation Color Code to Orange and the Volcano Alert Level to Advisory, noting that elevated surface temperatures observed in satellite data from that morning indicated an eruption with low-level effusive activity and small explosions was likely underway. From August 30 through September 2, increased seismicity, continuous tremor, lava fountaining, and ash emissions as high as 15,000–20,000 feet occurred, marking some of the strongest eruptive activity within the 2013 eruption. At the time of this writing, seismicity at Veniaminof remains elevated and the lava flows coming from the intracaldera cone, contained within the caldera walls, are approximately 300–1,000 meters in length and up to 50 meters in width.

For the complete record of these eruptions and others, visit the Alaska Volcano Observatory website at www.avo.alaska.edu.

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ALASKA TEPHRA DATABASE

Figure 1. DGGS geologist Janet Schaefer inspects layers of volcanic ash (tephra) erupted from Chiginagak volcano on the Alaska Peninsula.

In 2014 the DGGS Volcanology Section will begin developing a comprehensive database of Alaska volcanic ash, or tephra. This database will house all pertinent Alaska tephra information necessary for sample processing, archiving, and scientific research. Developing correlations of tephra records across Alaska and the northern hemisphere requires an understanding of the age, chemistry, and character of tephra deposits. Tephra studies are a key component in understanding the magnitude and frequency of volcanic eruptions and help improve volcanic ashfall hazard assessments. In addition, tephrostratigraphy is an integral part of linking marine, lacustrine, and terrestrial records to aid research in paleoclimate studies and archaeology. Chemical, stratigraphic, and age data for Alaska tephras are currently dispersed in hundreds of publications and unpublished lab results, making efficient querying of information for specific research purposes impossible. Creating, populating, and developing web portals to a comprehensive tephra database will alleviate this difficulty and open up Alaska tephra data to geoscientists.

Although the tephra database is in its infancy, we have completed the following preliminary work: Carried out an initial needs assessment, prioritized the data tables that should be created and populated first, and created a draft schema to store the tephra sample metadata and electron microprobe analyses.

The entire DGGS Volcanology Section will be involved in this project by combining their expertise in a concerted effort to create and maintain a scientifically relevant and user-friendly database of Alaska tephras: Janet Schaefer, tephrochronology; Cheryl Cameron, database development; and Seth Snedigar, programming. This is a multi-year effort and the group is working closely with USGS geologist Kristi Wallace and the USGS Alaska Tephra Lab housed at the Alaska Volcano Observatory office in Anchorage.

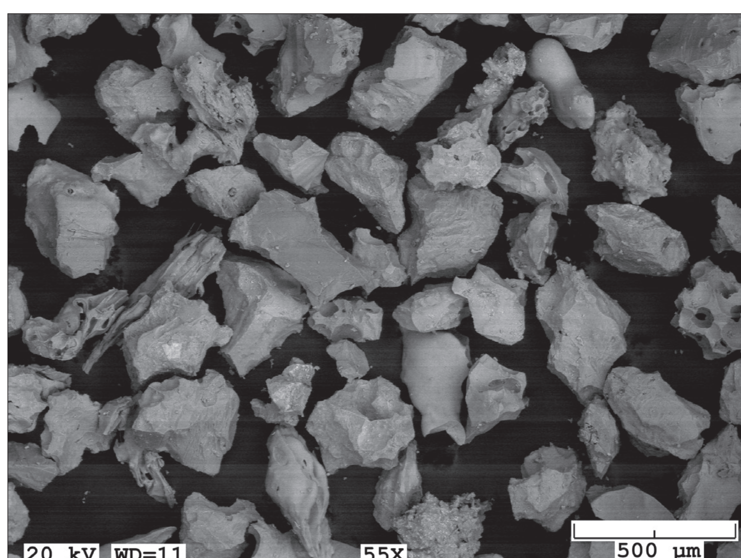

Figure 2. Backscattered electron image of ash erupted from Veniaminof volcano on August 18, 2013.

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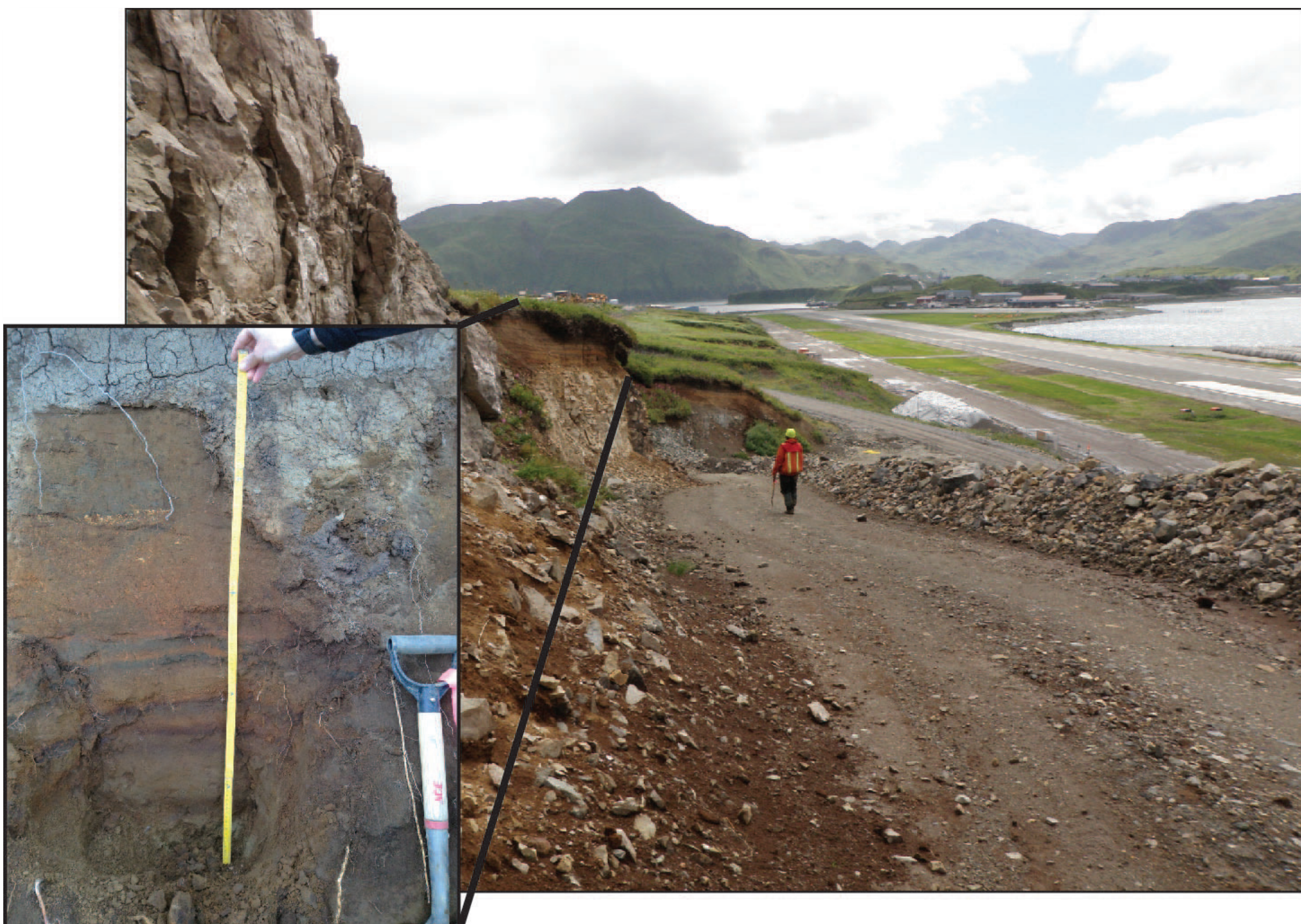
HOLOCENE ERUPTION HISTORY OF MAKUSHIN VOLCANO

Eruptions from Makushin volcano pose a hazard to facilities and residents of Dutch Harbor/Unalaska, the most productive fishing port in the nation. Given the potential impacts to Dutch Harbor, especially from volcanic ash fall, the Alaska Volcano Observatory has prioritized scientific investigations at Makushin to better understand the three voluminous early Holocene eruptions and numerous small ash fall events that have impacted the Dutch Harbor/Unalaska region.

DGGS geologist Janet Schaefer, along with colleagues Jessica Larsen and Jim Begét of the University of Alaska Fairbanks and Jim Vallance of the U.S. Geological Survey Cascades Volcano Observatory, are working to refine understanding of the recent volcanic history of Makushin volcano. Fieldwork over the last two years has focused on stratigraphic and geochemical studies of the caldera-forming eruptions and post-caldera ash fall. During the first of these explosive eruptions, ~8,700 years ago, voluminous basaltic andesite ignimbrites filled surrounding valleys to depths of 100 meters or more. Magma output was sufficient to cause collapse of the edifice to form a 2 x 3 kilometer-wide crater. During the next explosive eruption, ~8,000 years ago, pyroclastic density currents swept across the bay and deposited ash and pumice as much as 50 centimeters thick in the vicinity of Dutch Harbor (see figure). Yet another explosive eruption ~7,700 years ago produced a thick pumice and ash fall. Near the airport in Dutch Harbor this deposit contains pumice clasts as large as 1 centimeter diameter in a layer 1.7 centimeters thick. Dozens of smaller eruptions have occurred since then, depositing ash from a few millimeters to a few centimeters thick, with several deposits reaching Dutch Harbor/Unalaska.

Current work consists of detailed stratigraphic descriptions and tephra collection at multiple sites around the volcano to help refine the Holocene eruption history and to improve our understanding of the volumes, distribution, and recurrence interval of recent explosive eruptions.



DGGS geologist Janet Schaefer walks along a road cut above the Dutch Harbor airport, where multiple explosive eruptions from Makushin volcano over the last ~9,000 years have deposited layers of ash from a few millimeters to several centimeters thick.

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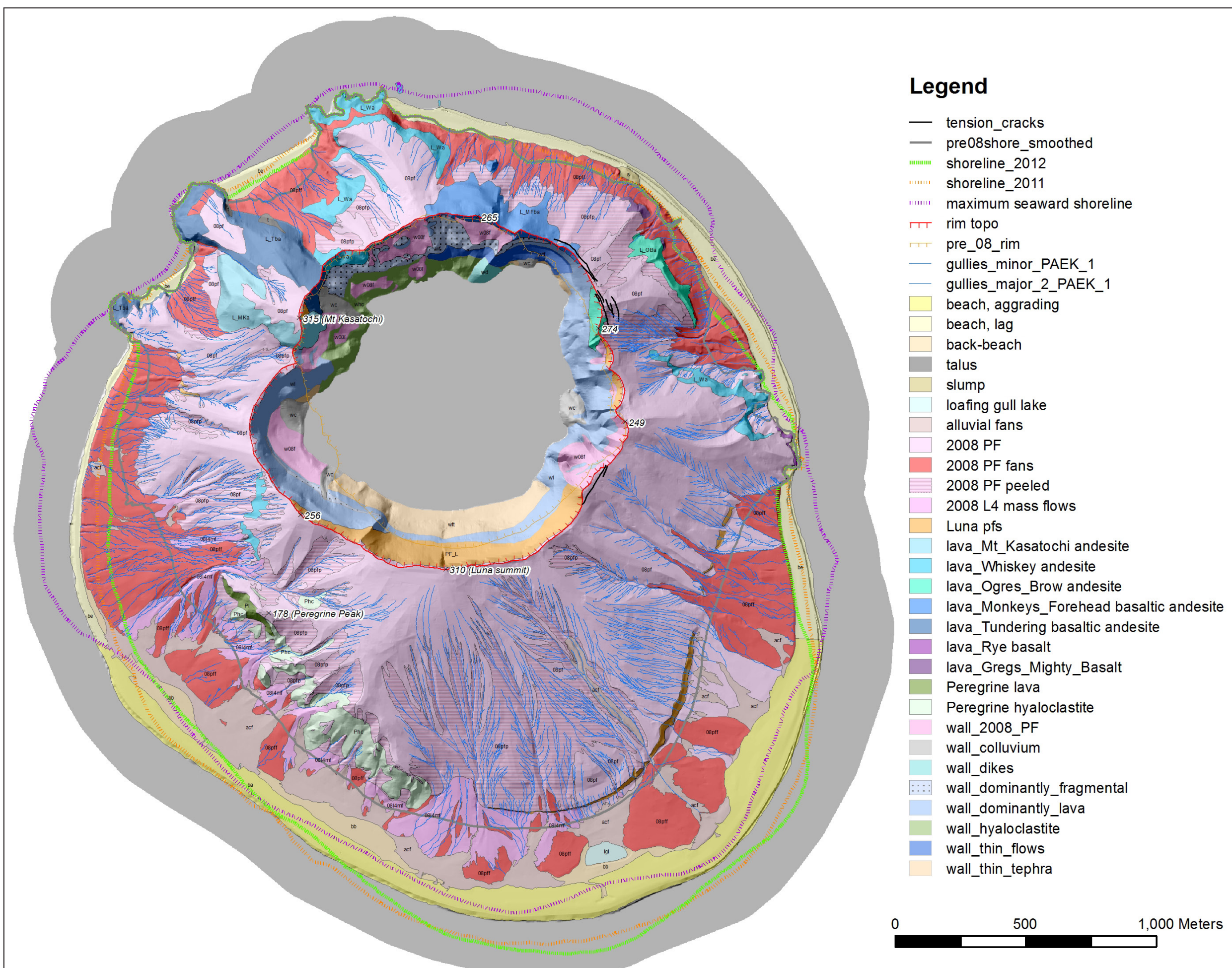
ALASKA DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
FY14 Project Description

KASATOCHI VOLCANO: GEOLOGIC MAPPING AND VOLCANOLOGICAL STUDIES

Kasatochi is a 7 square kilometer (2.7 square mile) island volcano midway between Atka and Adak, in the Aleutian Islands. It provides nesting territory for several hundred thousand seabirds, is one of the largest sea lion rookeries in the Aleutians, and has been closely studied by the U.S. Fish and Wildlife Service (USFWS) and other biologists in recent decades. In August 2008 Kasatochi erupted for the first time in written history. The eruption was about a thousand times more energetic than any other Alaska eruption in nearly a century. During the day-long eruption the area of the island increased by 40 percent, the area enclosed by the crater rim increased by 30 percent, the crater-lake grew by 70 percent, and pyroclastic deposits completely covered seabird nesting crevices. A multiagency and multidisciplinary group quickly assembled, attracted to the rare opportunity to study the regrowth of an ecosystem that had been nearly obliterated. The study has been funded by the North Pacific Research Board, U.S. Geological Survey, USFWS, and the Alaska Volcano Observatory (AVO). Prior to the eruption the geology was virtually unknown. As an AVO partner organization, the Division of Geological & Geophysical Surveys (DGGS) is leading the effort to produce the first-ever geologic map of Kasatochi as part of the ecosystem recovery project, and as a lead-in to volcanologic and petrologic studies. Fieldwork has been based off the USFWS refuge ship Tiglax on 2–3-day trips twice each summer starting in 2009, although winds and waves that precluded landing a skiff on the island have resulted in dramatically reduced on-island time on some of the trips. To date roughly 100 rock samples have been collected and analyzed chemically and petrographically. These data and field mapping have served to distinguish several major pre-eruption rock units. Additionally 3,500 mineral analyses have been collected from a stratigraphically and compositionally representative subset of samples. The mineral analyses provide important information about complex petrogenetic (rock-forming) processes. The 2008 eruption, probably because it was so energetic, brought to the surface many nodules of cumulate zero-age gabbroic "crystal mush." Such nodules are unusual, though not unique and, as the solid residue of petrogenesis, provide important additional constraints on processes governing the genesis of magmas. The geologic map is complete (see figure), and writing of unit descriptions and other explanatory information is underway.



Draft geologic map of Kasatochi volcano.

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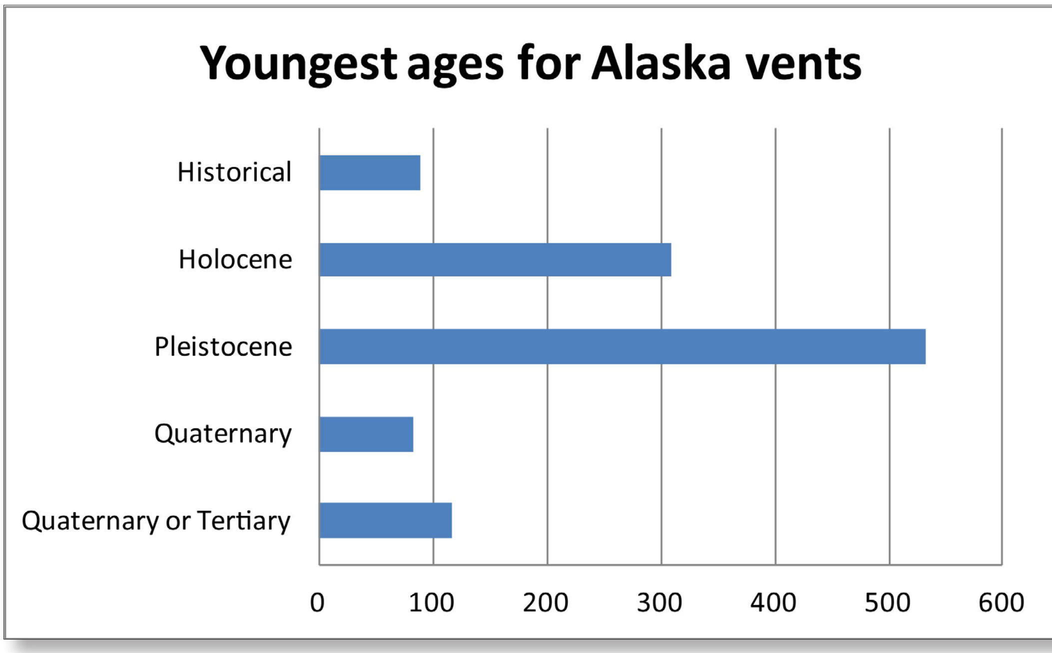
DATABASE OF QUATERNARY VOLCANIC VENTS IN ALASKA

The Alaska Volcano Observatory currently uses an informal set of names for about 140 "volcanoes" (www.avo.alaska.edu/volcanoes). Some names refer to large, complex volcanic centers, while others indicate only a specific cone. The database of Quaternary volcanic vents expands the list of 140 volcanoes to include all volcanic vents (where magma has reached the surface) over the past 1.8 million years. This list currently contains 1,126 subaerial entries. This database of all known (published, or unpublished with permission) Quaternary vents was developed to better describe the nature and character of Quaternary volcanism in Alaska, and specifically to aid in the discussion of spatial and temporal patterns of Alaska volcanism.



Graph of Alaska Quaternary vents by known or suspected ages. Vents are classified as simply "Quaternary" when we don't know whether they are Holocene or Pleistocene, and "Quaternary or Tertiary" for those vents for which Quaternary age is less certain.

For each vent, we have compiled the following information:

- its place within geographic and volcanic hierarchies
- a broad morphology designator (for example, cone, dome, stratovolcano, etc.)
- a location (latitude and longitude)
- a confidence ranking for the location
- a confidence ranking for whether or not the feature is a vent
- an age of youngest eruption (magma reaching the surface of the earth)
- a short text field describing the basis for the age designation
- for those vents with published information, links to selected publications

For the more common morphologies, this compilation effort has classified 114 features as stratovolcanoes, 30 shield volcanoes, 287 cones, 294 monogenetic cones, and 174 domes. Although we currently have only two submarine entries, we expect to add more than 100 newly discovered seafloor cones. This list is a starting point for cataloguing and describing Alaska's young vents, and we hope it is continually updated and improved by the addition of newly discovered vents. We invite the community of volcanologists who study Alaska volcanism to help us increase the value of this database by adding new vents as they are discovered, and by improving the geologic descriptions of known vents as new information becomes available.

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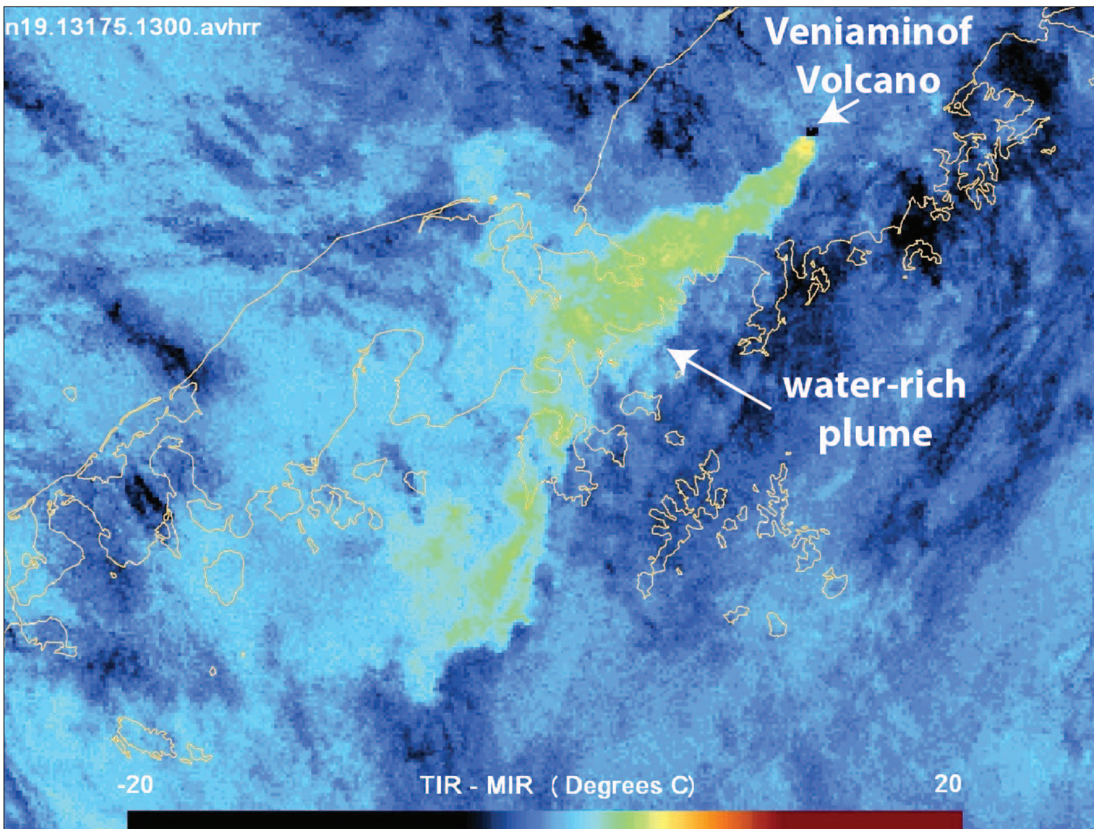
ALASKA VOLCANO OBSERVATORY (AVO) REMOTE SENSING OBSERVATION DATABASE

Although Alaska has more than 50 historically active volcanoes, only 29 are monitored seismically. The remaining volcanoes are monitored by satellite. At least once a day, AVO geologists examine satellite images for signs of volcanic unrest or eruption, such as ash plumes or elevated surface temperatures. To ensure that these observations and selected images are distributed, archived, and searchable, AVO/DGGS is creating a database and associated software to store the information internally. This application and database are designed to work with "VolcView", the U.S. Geological Survey satellite image viewing web application (http://volcview.wr.usgs.gov).

The software will allow users to upload image files to the observation database directly from their computer, or from a URL, and annotate the images with captions as appropriate. Users will have the capability to execute multiple cycles of adding text and images and previewing the results. Once the user is satisfied with the look of their report it is submitted to the database. At this stage the report is tagged with associated volcano names and keywords, and parsed into separate tables so it can be easily queried. Finally, the report is entered into the internal AVO communication log system and emailed to the AVO operations group.

This product is currently in the testing phase. We anticipate using it in daily operations in early 2014.



An extensive water-rich plume from Veniaminof volcano, June 24, 2013. This image was created by Dave Schneider, AVO/USGS, by enhancing the night-time thermal and mid-infrared satellite data. The new remote sensing observation database will allow this type of image and data analysis to be linked and available through an online query interface.

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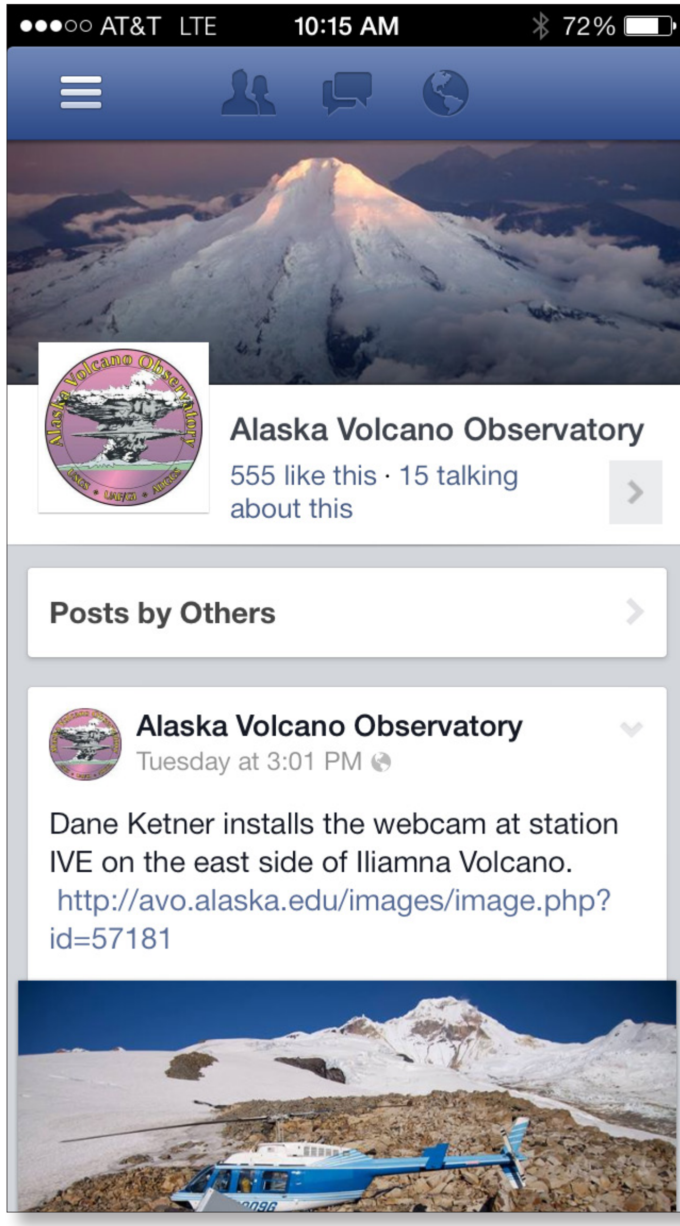
ALASKA VOLCANO OBSERVATORY (AVO) SOCIAL MEDIA

The Alaska Volcano Observatory has three primary objectives: (1) to conduct monitoring and other scientific investigations to assess the nature, timing, and likelihood of volcanic activity; (2) to assess volcanic hazards associated with anticipated activity, including kinds of events, their effects, and areas at risk; and (3) to provide timely and accurate information on volcanic hazards and warnings of impending dangerous activity to local, state, and federal officials and the public. As an AVO partner, and in support of the third primary objective, the Division of Geological & Geophysical Surveys' (DGGS) Volcanology Section is working to use social media such as Twitter and Facebook to reach a larger and more diverse audience than our current website, fax, and email protocols.

In 2013 DGGS created an AVO-specific Facebook account (http://facebook.com/alaska.avo) as part of the overall social media plan. This account is in addition to the Twitter presence AVO has maintained since 2009 (http://twitter.com/alaska_avo). To keep this account up to date with the latest official information, pictures, and news, several pieces of software used by other elements of AVO were updated to communicate with Facebook. The Hazard Notification System (HANS), which sends out Daily Status Reports, Weekly Updates, and other official notices, now also sends a short synopsis of each message to the Facebook account, as well as selected important updates to the Twitter account. We updated our internal image database so that AVO staff can upload images and captions directly to both Twitter and Facebook with the click of a button. DGGS–AVO staff also maintain a schedule to monitor the Facebook page, moderating comments and images as needed so the page contains appropriate information only.

We believe social media are excellent tools to provide rapid communication to our users, with some important qualifications: (1) information posted to social media must be the same information contained in our formal notices and our website; (2) social media posts must continue to provide links to full and complete information (rather than being an informational dead end); and (3) monitoring and maintaining social media accounts must not require unreasonable staff resources. Not only do social media help AVO reach an increasingly mobile-device-oriented public, it assists the public in communicating with AVO, especially for ashfall accounts, eruption photos, and information about eruption impacts.



AVO's newly created Facebook page, as viewed from a mobile device.

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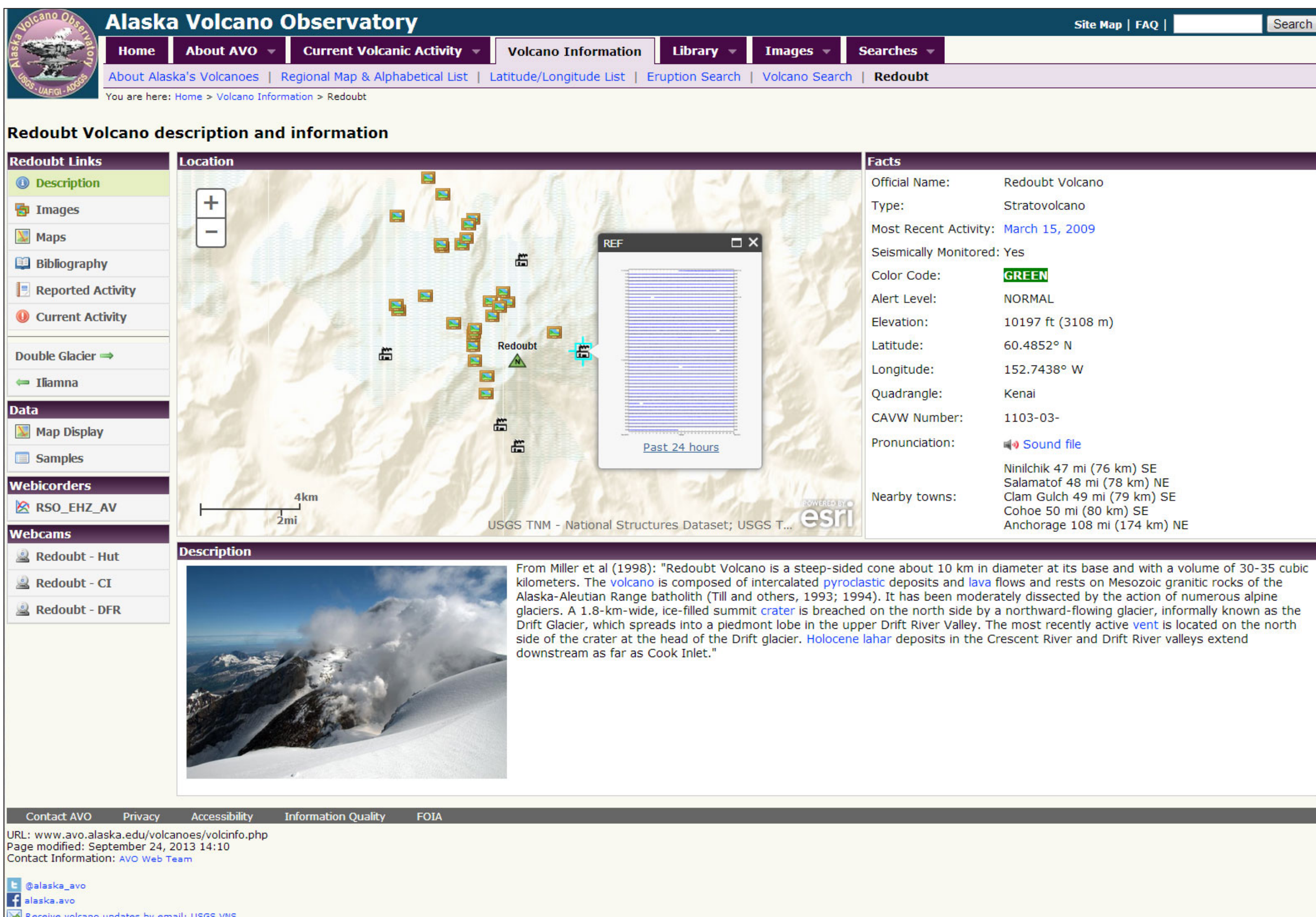
ALASKA VOLCANO OBSERVATORY (AVO) WEBSITE

The AVO public website (http://www.avo.alaska.edu) serves about 3,000,000 pages to well over 100,000 unique visitors per month, and is among the top ten most-visited USGS and USGS-affiliated websites in the country. It continues to be the most complete single resource on Quaternary volcanism in Alaska. The Division of Geological & Geophysical Surveys (DGGS) was the original creator of the AVO website in 1994, and continues to be the site designer, builder, and manager. The website is dynamically driven by the Geologic Database of Information on Volcanoes in Alaska (GeoDIVA).

The website and underlying content rely on several pieces of vendor-supplied software to operate efficiently. These external software products are continually updated, with new official versions being released on a regular basis. To keep the website performing at peak capability and running securely, the new software is tested locally and then installed on the production servers that run the website. This year DGGS upgraded the scripting language software (PHP) to the newest released versions.

Throughout the year DGGS adds many enhancements to the website software that improve the experience for both our public and internal users. A short list of 2013 improvements includes: Upgrades to the public e-mail system, allowing scientists to receive a text message when the website receives an e-mail regarding ash fall; a new interface for viewing webcam images, adding code that automatically generates videos from the previous 12- and 24-hour intervals; and continued updates to the web-mapping interface, with addition of dynamic, interactive location and information maps to more pages on the website (see figure).

DGGS/AVO is on the leading edge of web and database development for volcano observatories, and portions of DGGS-written database software have been installed at other U.S. volcano observatories. DGGS is following new and emerging technologies, such as sphinx text searches, that will allow us to further enhance AVO's web presence and data dissemination abilities. We continually refine and enhance the applications that AVO and other observatories use on a regular basis. We will maintain our focus on continual incremental improvements to the site, and serving new database modules as they become available.



Redoubt Volcano's information page, showing an updated webmap that includes geo-located photographs and seismic stations that link to actual data from the station.

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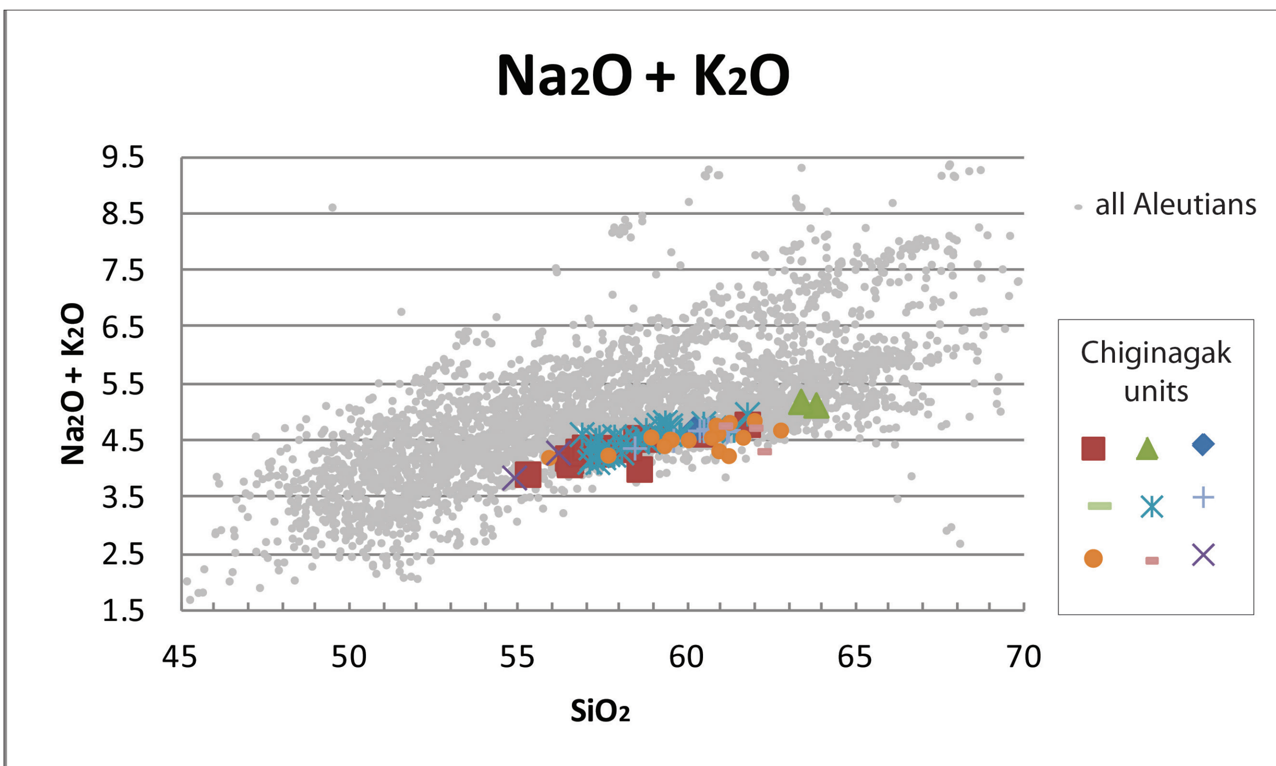
ALASKA VOLCANO OBSERVATORY (AVO) GEOCHEMICAL DATABASE

As part of DGGS's ongoing efforts with the Geological Database of Information on Volcanoes in Alaska (GeoDIVA), DGGS/AVO staff have created a database structure to hold geochemical data on Quaternary volcanic rocks in Alaska. Published data will be available to the public through AVO's website, and searchable by map, volcano, sample metadata information, or specific geochemical values or analysis types. Data are already available on the public website on a per-volcano basis. Unpublished data are available internally to AVO users if the data owner has granted explicit permission.

Currently, whole-rock major and trace element values, water cation and anion analyses, and analysis metadata are loaded in the database. The system is designed to accommodate other types of geochemical data as well, and is intended to be compatible with other major geochemical database efforts (e.g. EarthChem). We are making every effort to provide the best data possible for each sample and analysis, which often entails additional actions such as tracking down obscure references and untangling sample nomenclature through the decades. In addition, we have adjusted the results for hundreds of samples analyzed by inductively coupled plasma mass spectrometry (ICP-MS) at Washington State University prior to 2007 to correct calibration errors in the original report; we retain the best known value for each analysis.

This database is a valuable research tool for geoscientists with interests ranging from volcano-specific processes to whole-arc data synthesis. Because the database is an intrinsic part of GeoDIVA, it will also help consolidate all of Alaska's volcano information in one place. Our sample database currently holds more than 11,000 samples; the geochemical database holds 6,159 published and unpublished analyses. We estimate that fewer than 100 published analyses remain to be entered.

We are currently refining our web interface to query the data and return results of analysis values and metadata in useable formats for our end users. We are also wrapping up the data entry of previously published data, and looking forward to adding individual electron microprobe analyses of tephra grains in support of the upcoming tephra database (described elsewhere in this report).



A graph made using data from AVO's geochemical database. The gray dots represent values from thousands of published Aleutian samples, the colored symbols are values from Chiginagak volcano rock units.

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ALASKA VOLCANO OBSERVATORY (AVO) GEODIVA DATABASE

AVO/DGGS staff design, populate, maintain, and distribute the Geologic Database of Information on Volcanoes in Alaska (GeoDIVA). GeoDIVA maintains complete, flexible, timely, and accurate geologic and geographic information on Pleistocene and younger volcanoes in Alaska. This data supports scientific investigation, crisis response, and public information in a dynamic, digital format. GeoDIVA is the most comprehensive and up-to-date source of information for Alaska volcanoes available. This database is also the back-end of the public and internal websites of AVO.

The database has been developed in modules, and uses more than 360 tables in MySQL. We replaced our primary database server in 2013 when the previous server experienced a catastrophic failure. A backup server was in place at the time, so there was no loss in data delivery. GeoDIVA grows by continual feeding of new data into existing modules and by episodic surges of growth as new modules come on line. See the table below for completed, in progress, and planned modules.

Module	Status	Notes
Bibliography	Maintenance mode	Contains ~4,800 references
Basic volcano information	Maintenance mode	145 major volcanoes, 178 sub-features; update of descriptive text planned in 2014
Eruption history information	Maintenance mode	Information and references for 440 historical eruptions
Images	Maintenance mode	More than 21,000 images
Geologic sample information	Maintenance mode	11,273 samples and metadata
Geochemistry	Data loading nearly complete; user interfaces under construction	6,159 whole rock and water chemistry analyses
Petrology	Data created and loaded intermittently	Intent is to build an Aleutian-Arc-wide collection of thin section descriptions and images
GIS data	Flexible holding database built, not populated	Awaits personnel time to inventory existing GIS data
Hand-sample storage	Maintenance mode	More than 8,200 samples archived
Ash - Is it falling?	Maintenance mode	Website and database for citizen ashfall reporting
Internal logs and contacts	Updates planned to logs' "look and feel"; full text search planned	Supports internal AVO communications
Vent Inventory	Nearly published	See separate briefing paper
Satellite observations	Planning and test construction	See separate briefing paper
Tephra data	Planning and test construction	See separate briefing paper
Geochronology	Schema built	Lesser priority than geochemistry, vents, satellite observations, and tephra

Our internal calendar stores duty person assignments and personnel leave information in GeoDIVA MySQL tables and is available via our internal website. We have recently updated the internal calendar to interface with Google and Outlook. This greatly improves the calendar's functionality to AVO staff.

In calendar year 2014, in addition to the maintenance of the modules listed, we plan to overhaul the text of our volcano descriptions. This update will allow us to subdivide the descriptive text into categories (e.g. "hazards" or "historical seismicity"), as well as use wiki-style referencing and inline images. We anticipate this will not only improve and expand the content we deliver but also increase the readability of the basic volcano information on our website.

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