fall 2006

earth scope

onSite newsletter

featured science:

PBO at Mount St. Helens: Monitoring an Erupting Volcano in Action

In May 1980, David Johnston was stationed 5 miles north of Mount St. Helens, on the ridge that now bears his name, measuring the distance to the volcano every 30 minutes to an accuracy of +/-1 inch. In the days leading up to the eruption, the volcano bulged toward him at over a foot per day - an enormous speed for a geologic process. David lost his life when the volcano's north flank exploded on May 18, 1980.

Volcanologists knew the danger of an eruption was high because of intense seismic activity beneath Mount St. Helens during the spring. But the relatively crude techniques then available couldn't help much in pinpointing the expected time of an eruption. Since then, the satellite-based Global Positioning System (GPS) has revolutionized earth science with its ability to track crustal movements of tenths of an inch per year, allowing volcanologists to predict eruptions safely and remotely. The Plate Boundary Observatory (PBO), part of the National Science Foundation's EarthScope initiative, has built a modern GPS network at Mount St. Helens.

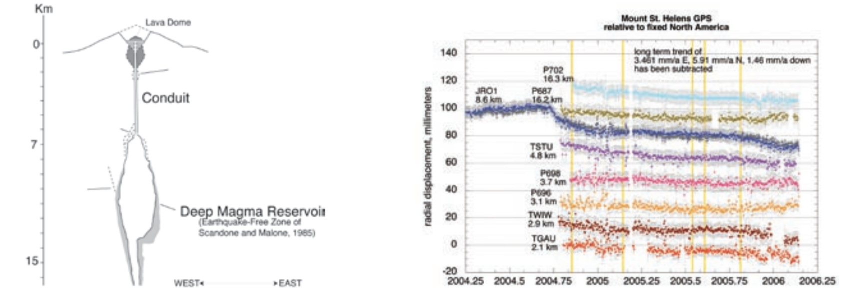
UNAVCO PBO Engineer working on a GPS monument on Mt. St. Helens in response to the volcanic unrest in 2004.

When PBO sites were being chosen in 2000, no one really expected Mount St. Helens to erupt again. Instead, Mount St. Helens was selected as a target because it had erupted more frequently than any other Cascade volcano in geologically recent time, and also because subtle fluctuations in the depth, rate, and orientation of microearthquakes suggested the volcano was still actively readjusting to life after the 1980 eruption.

In late September 2004, a swarm of small earthquakes beneath Mount St. Helens surprised everyone by intensifying quickly, culminating in a small eruption on October 1. At that time, the only continuous GPS station near Mount St. Helens was the USGS-operated site at Johnston Ridge. Fortunately, PBO was able to adjust priorities quickly and sent crews and equipment to install 7 additional stations during early October 2004, working with USGS personnel high on the erupting volcano in winter weather.

Today, 16 GPS stations on and around Mount St. Helens provide routine reports of their positions daily, accurate to one-twentieth of an inch, aiding geologists as they learn how volcanoes behave before erupting. Several stations have moved in toward the crater about half an inch per year as molten rock (magma) empties from a subsurface chamber and extrudes into the craters. Because the movement is greatest at stations 3 to 5 miles from the crater, it's clear that the top of the emptying chamber is at least 3 miles below the surface. This movement would have been undetectable in 1980. (For information on how GPS instruments work please visit http://unavco.org/edu_outreach/edu_outreach.html.)

Some volcano deformation also takes place even more rapidly; to measure this movement, PBO is installing 4 borehole strainmeters around Mount St. Helens. Cemented into drillholes as deep as 800 feet, borehole strainmeters detect minute expansion and contraction (as small as 1 part per billion), with readings taken 20



Left: Schematic cross-section of Mount Saint Helens. Courtesy of USGS (E. Roeloffs). Right: Data plot of radial displacements on Mt. St. Helens. Courtesy of USGS (E. Roeloffs).

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From The Plate Boundary Observatory Principal Investigator

The Global Positioning System (GPS) is one of the marvels of our modern world. It is used in all kinds of position-related applications including construction, government, and transportation, to name a few. It is perhaps less well known that GPS also is a scientific tool. The outer layer of the Earth is composed of fairly rigid ocean and continental plates separated by zones where these plates interact. It is this interaction that produces earthquakes and volcanoes. GPS can be used to measure the plate positions with a precision of a few millimeters allowing us to directly observe the motion and deformation of the plates.

This issue of onSite describes how very precise GPS measurements are being used to study two subduction zones, i.e. areas where oceanic plates are moving under other large plates, in which the Earth's crust is being melted and extruded in volcanoes. The Aleutian and Cascade arcs are areas of volcanoes that include more than ten percent of the world's active volcanoes, in a chain running from northern California to Russia.

Through the NSF-funded EarthScope program, UNAVCO is installing the Plate Boundary Observatory (PBO), a large network of GPS, strainmeter, and seismic stations located throughout the United States. Never before has such an attempt been taken to study the complex interplay between tectonic forces of moving plates, seismic activity from earthquakes, and magmatic (volcanic) processes in a subduction zone. As a consequence of the PBO measurements, one day all of our lives may be a little safer.

The next newsletter, Winter 2006, will provide an update on USArray activities. If there is a topic of special interest to you, please let us know by contacting one of the EarthScope onSite editors (PBO: barbour@unavco.org or USArray: dorr@iris.edu).

William H. Prescott

William Prescott
Plate Boundary Observatory Principal Investigator

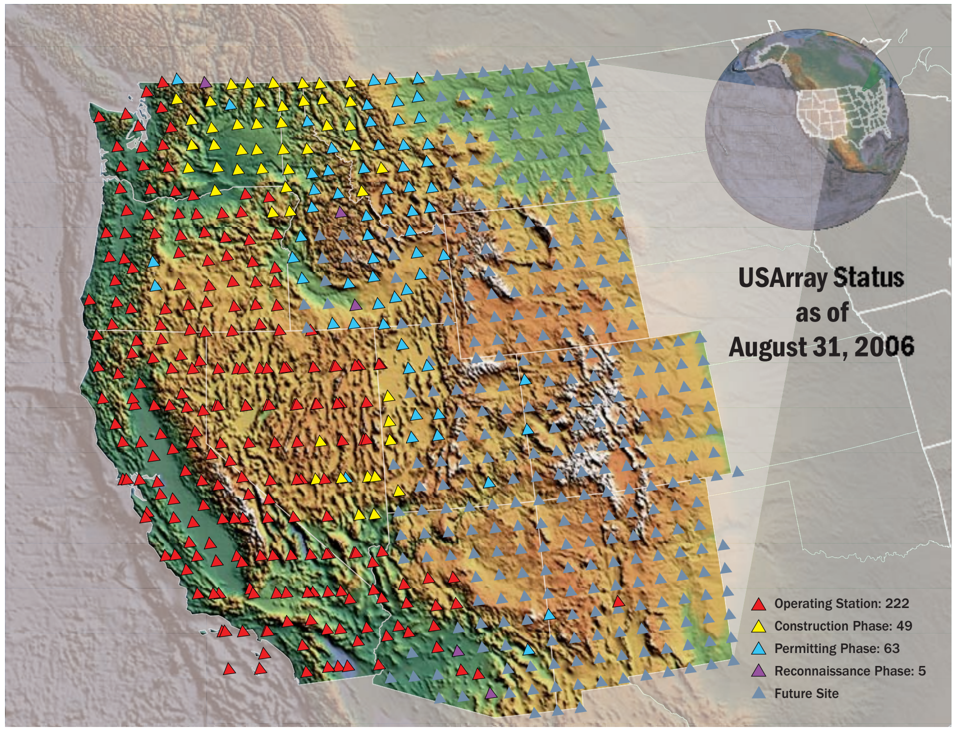
project status: USArray

Where is the Transportable Array?

The Transportable Array crews had a very busy and very productive summer. Twenty new earthquake monitoring stations in Oregon became operational in July and August, bringing the total number of stations to 220. The array is now nearly complete in Oregon. We also had seven teams of students traveling across Idaho, Utah, and western Montana seeking high-quality sites for future seismic stations. These energetic interns, equipped with laptop computers, hand-held GPS units, and digital cameras, located more than 100 sites in these three states. Permits for some of these locations have already been obtained and station construction is underway.

Our construction and installation teams are currently working in Washington, Idaho and western Montana to install as many stations as possible before winter arrives. When the snows begin to fall, the crews will move further south to construct stations in southern Idaho, Utah, Nevada, and Arizona.

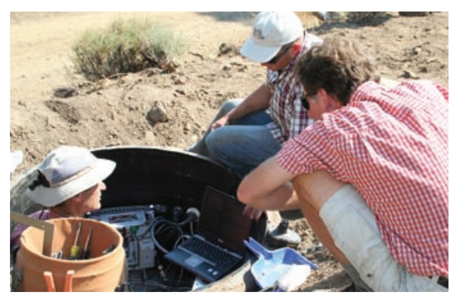
Each station's three sensors record the earth's motion in the north-south, east-west, and vertical directions, taking measurements 40 times per second. These data are transmitted in real-time to the Array Network Facility in La Jolla, California, and archived at the IRIS Data Management Center in Seattle, Washington. Currently, 1.3 terabytes (1,300,000,000,000 bytes) of data from Transportable Array stations have been collected. On average, a 300-page book is about 1 megabyte (1,000,000 bytes), so the amount of seismic data collected thus far is equivalent to more than 1 million books; for comparison, the Library of Congress has 29 million books. The Data Management Center has also sent the research community and the general public about 0.5 terabyte (500,000,000,000 bytes) of EarthScope seismic data in almost 100 million individual seismograms. ■



REAL-TIME STATION STATUS: To view a map of current Transportable Array stations, visit http://www.earthscope.org and click on 'Current Status'.

To view seismograms recorded at a USArray station, go to http://usarray.seis.sc.edu/ and enter the station code. You can also enter a zip code to view the recordings from the USArray station closest to that area.

TRANSPORTABLE ARRAY COORDINATING OFFICE: usarray@iris.edu 1-800-504-0357



Right: Installing instrumentation for Transportable Array Station E06A near Yakima, Washington.

featured science: PBO at Mount St. Helens: Monitoring an Erupting Volcano in Action

(Continued from front)

times per second. Borehole strainmeters complement GPS by providing more frequent measurements at a higher resolution. PBO strainmeters on Mount St. Helens will be 3 to 5 miles from the crater, but scientists anticipate that they will be sensitive enough to detect deformation as magma enters and leaves the deep chamber; they have already detected the motion from an earthquake 5,800 miles away in Tonga.

The PBO boreholes at Mount St. Helens also include tiltmeters and downhole seismometers. The borehole environment is much quieter than the existing surface seismometer installations and allows smaller earthquakes to be recorded. Compared to shallow USGS tiltmeters in the crater, the borehole tiltmeters will be more sensitive to deep magma movements, owing to their stable borehole environments and greater distance from the magma chamber.

The geodetic networks installed on Mount St. Helens by PBO and the USGS can be viewed as prototypes for future geodetic instrumentation of hazardous volcanoes. Compared to the situation in 1980, the data will be much more accurate, more instruments will survive eruptions, and volcanologists' lives will not be endangered. ■

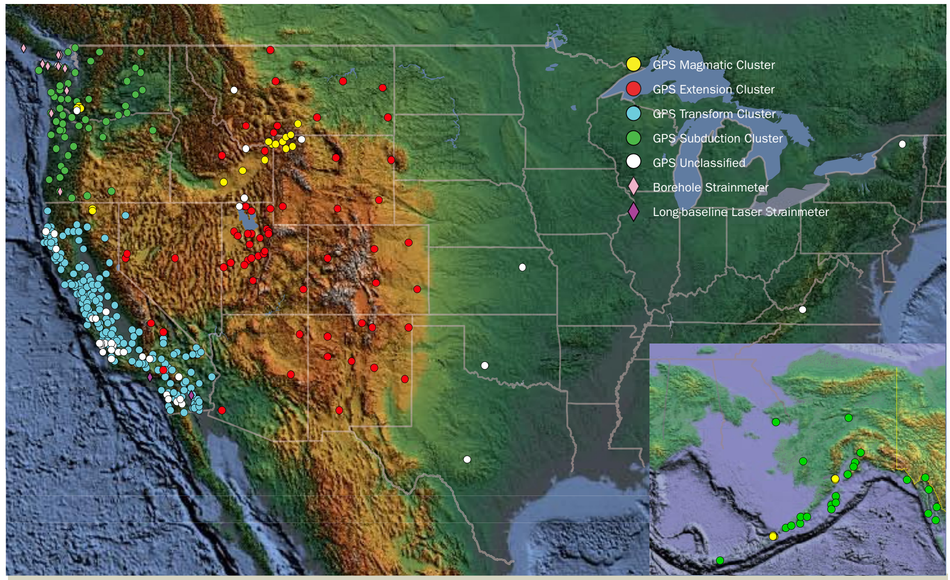
Special Guest Contributor: Evelyn Roeloffs, USGS

project status:

Plate Boundary Observatory

Thanks to helpful landowners and hardworking staff members, PBO continues toward the goal of installing 852 instruments by September 2008. As of August 31, 2006, there have been 859 GPS station reconnaissance visits, 803 GPS permits submitted, 525 GPS permits accepted, 426 GPS stations installed, and 19 borehole and 2 long-baseline strainmeters installed. ■

For more information on the PBO project, please visit the PBO website at http://pbo.unavco.org/.



PBO STATUS AS OF AUGUST 31, 2006:

Magmatic stations: 59
Transform stations: 220
Subduction stations: 105
Extension stations: 75
Borehole strainmeters: 20
Long-baseline laser strainmeters: 3

PBO REGIONAL OFFICES:

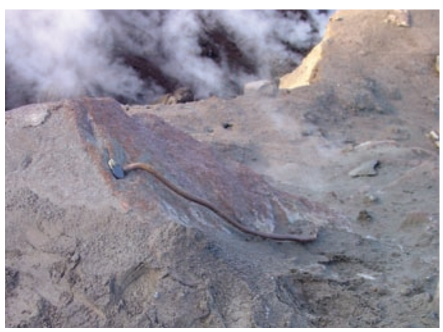
Alaska 907-346-1522
Pacific Northwest 509-933-3221
Basin and Range 801-466-4634
Northern California 510-215-8100
Southern California 951-779-6400

On The Move: Uncharted Alaskan Territory

UNAVCO will install a total of 128 PBO GPS stations all over Alaska with particular focus on the Kenai Peninsula, the Aleutian Trench, the Denali fault, and southeast Alaska. These areas were chosen to better understand deformation associated with but occurring after the 1964 Good Friday M9.4 earthquake; subduction-related volcanism and deformation along the Aleutian Trench; and the rate of strike-slip motion along the Denali fault.

Because of the extreme Alaskan winter season, the majority of the outdoor work takes place during the summer months. Work this summer focused on Unimak Island and Augustine Volcano, both part of the Aleutian chain. Unimak Island, the easternmost and largest island in the chain, is home to several volcanoes. The Unimak Island reconnaissance crew was fortunate this summer to have a rare stretch of ideal weather and no bear encounters. Once permits are finalized UNAVCO will install the Unimak Island instruments during the summer of 2008.

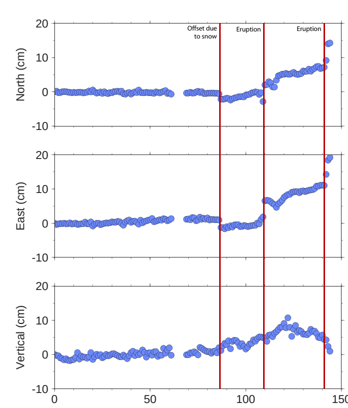
The second major work this summer was the installation of new GPS stations on St. Augustine Volcano, a stratovolcano located in the southern Cook Inlet, The first eruption since 1986 began last May with an increase in deformation and number of earthquakes. After inflating for several months, Augustine erupted on January 11, 2006, with a series of explosions that sent ash high into the atmosphere, forcing jets to alter their routes.



Two GPS stations were destroyed as a result of the recent eruptions. AV05 stopped reporting data in mid-January. Above are the remains of this Augustine GPS station without a trace of the hut, solar panels, or batteries. Image courtesy of USGS.

UNAVCO installed 5 PBO EarthScope GPS sites on Mt. St. Augustine in 2004.

UNAVCO engineers returned to Augustine in September 2006 to install five more GPS stations. Capturing daily, and even hourly, deformation data of volcanoes on such a precise scale brings a new dimension to magmatic research and hazard response. Scientists are poring over the high-quality data to understand not only the volcano's current status, but also to look for clues to its future. As of September 30, 2006, UNAVCO has completed 140 reconnaissance trips and installed a total of 68 GPS stations in Alaska. ■



A GPS station located closest to the summit (AV05) showed a vertical inflation of about 5 cm in a single day.

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UNAVCO Pacific Northwest Engineer Ken Austin drilling holes to install an EarthScope permanent GPS station at Coldwater Peak, adjacent to Mt. St. Helens volcano (September 2006).

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