fall 2008

earth scope

onSite
newsletter

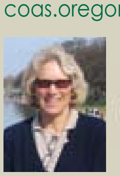
From the EarthScope National Office

With its core facilities completed, the EarthScope Program is shifting towards integrative research, education, and outreach efforts. To stimulate and focus scientific interaction around specific science themes, EarthScope is forming Thematic Working Groups (TWG) open to all scientists. EarthScope is a community of scientists and one way to strengthen the community is by joining a TWG. The TWGs will be introduced at a town hall meeting at the fall AGU meeting and will meet at the EarthScope National Meeting in Boise, Idaho, on May 13-15, 2009.

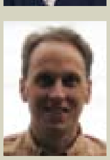
The featured science article presents exciting results from the magnetotelluric (MT) component of the USArray. The regional-scale electrical conductivity estimates from the first EarthScope MT array deployment in the Pacific Northwest provide new constraints on the presence of fluids in the lower crust. These results highlight the importance of integrating the seismic, geodetic, magnetotelluric, and heat flow components of EarthScope for understanding Earth's dynamic processes and deep structure.

The EarthScope community includes educators who bring the excitement of cutting edge research into the classroom. This issue includes reports on two workshops for teachers that illustrate EarthScope's commitment toward Earth science education.

The EarthScope National Office (ESNO) is pleased to work with UNAVCO and IRIS to relate these exciting results to the EarthScope community. If there is a topic of special interest to you, please let us know by contacting earthscope@coas.oregonstate.edu.



Anne M. Tréhu, ESNO Director



Jochen Braunmiller, ESNO *onSite* Editor

featured science:

Magnetotelluric Data Reveal Fluids in Lower Crust of the Basin and Range

Magnetotelluric (MT) data are being acquired in a series of temporary arrays deployed across the continental US as a component of USArray (http://www.iris.edu/USArray/researchers/mf.html). Long-period (10-20,000 s) data were collected from 110 sites covering the Pacific Northwest (Figure 1) in 2006—2007 and are being used to constrain the electrical conductivity structure of the crust and upper mantle to depths exceeding 100 km. Conductivity is particularly sensitive to the presence and connectivity of even small amounts of fluid. These observations provide unique constraints which, together with other geophysical and geological data, can add significantly to our understanding of the composition and physical/chemical state of Earth's interior.

In contrast to traditional long period MT surveys in which sites are concentrated along a few profiles, these MT arrays have occupied sites on a quasi-uniform 70 km grid, allowing regional scale coverage. The large station spacing and the wide range of geologic environments traversed demand three-dimensional (3-D) inversion and interpretation approaches, which are just now becoming available. Figure 2 shows representative and stable results that provide an unprecedented regional scale view of conductivity variations in the lower crust and upper mantle beneath the Pacific Northwest, including the Juan de Fuca subduction zone along the west coast, the Cascade volcanoes, the Columbia Plateau, and the high desert transitioning into the Basin and Range (BR).

The most striking and robust feature revealed by the inversion is an extensive, triangular-shaped area of high conductivity in the lower crust beneath the southeastern part of the array (C1 in Figure 2); the area is bounded to the north by a line running from the coast to the Blue Mountains and includes the Northwest BR province of southeastern Oregon. The conductance of this layer, which is about 15 km thick with a top at roughly 20 km depth, exceeds 3000 S beneath the BR. This lower crustal conductance is comparable to the highest values seen in other tectonically active areas around the world. The high conductivity in this region probably results from fluids – including possibly partial melt at depth – associated with magmatic underplating and BR extension.

The lower crust is much more resistive to the northwest of C1 beneath the Coast Range, Willamette Valley and Puget Lowlands of western Washington and Oregon (R1a in Figure 2), and beneath the Columbia Plateau (R1b in Figure 2). These parts of the crust were derived from a large fragment of thickened oceanic lithosphere that was accreted to North America approximately 48 million years ago. Geological and geodetic studies show this section of crust is strong, accommodating tectonic stresses through rigid block rotations. In contrast, the area to the southeast is actively deforming, suggesting that the crust is weak because of the presence of fluids. An elongated N-S zone of high conductivity beneath the Cascade volcanoes (C2 in Figure 2) breaks up the resistive lower crust

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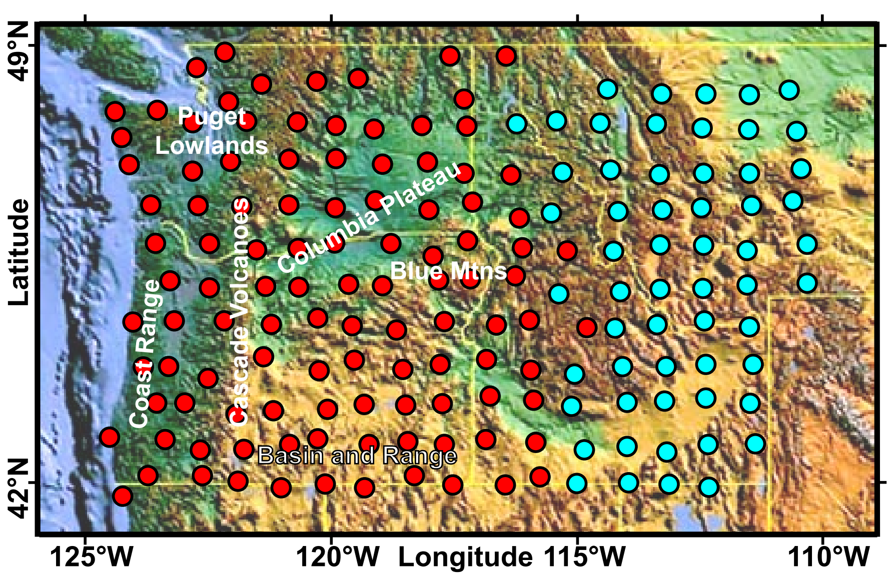


Figure 1: Location of the MT array sites on a topographic base map. Red circles are 2006-2007 sites; blue circles are locations occupied during summer 2008.

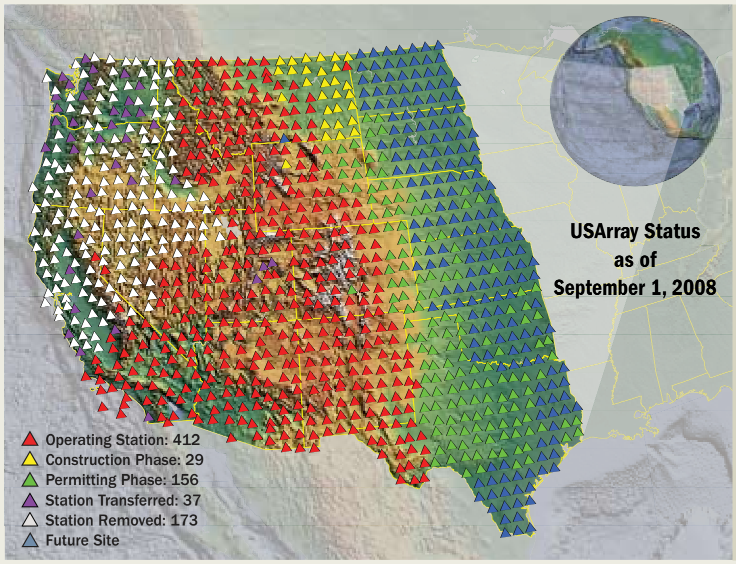
EarthScope: overview and project status

The goals of the EarthScope program are to understand the evolution of the North American continent and the physical processes that control earthquakes and volcanic eruptions. All data are freely available online to scientists, students, and the public. In addition, EarthScope offers a centralized forum for Earth science education at all levels and an excellent opportunity to develop cyberinfrastructure to integrate, distribute, and analyze diverse data sets. Updates of the status of the three facilities are presented here. If you are new to EarthScope, please visit http://www.earthscope.org/observatories for additional background on the facilities. ■

USArray

The summer is a busy time for USArray. The Transportable Array staff worked with 32 students and 10 professors from universities in North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas to locate 325 future sites. While it was challenging to conduct reconnaissance in such a large region in a short amount of time, the work performed by the enthusiastic teams plays an important part in keeping the Transportable Array rolling, as scheduled, across the US. The teams enjoy traveling throughout their assigned area and participating in a nation-wide experiment, but ultimately the program is successful because landowners are willing to host stations on their property.

In the last three months, 57 new stations became operational in Colorado, Wyoming, and Montana as the construction and installation crews made their trek northward. During this time, 47 stations were removed in Washington, Oregon, Idaho, Nevada and Utah, and their seismometers were shipped to sites for installation on the easternmost part of the array. ■



Real-Time Station Status

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

To view seismograms recorded at a USArray station, go to http://usarray.seis.sc.edu/ and enter the station code.

Transportable Array Coordinating Office

usarray@iris.edu
1-800-504-0357

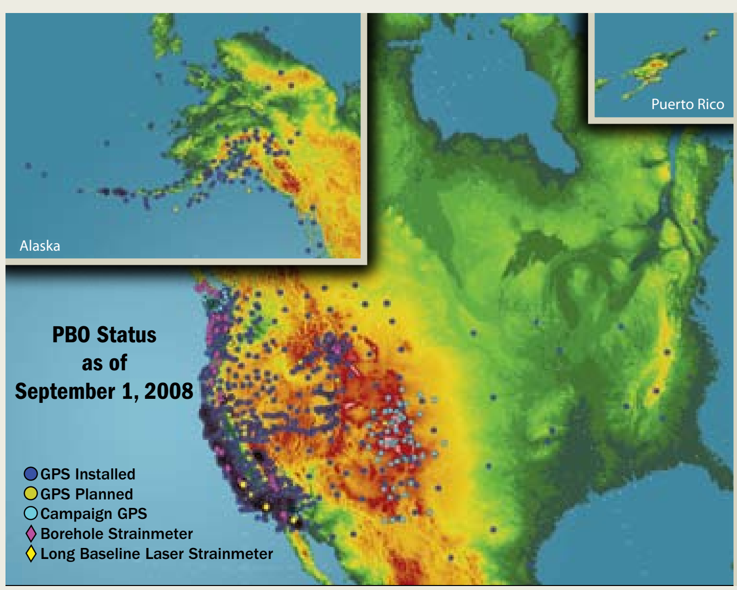
SAFOD

The first sample allocations of the core collected during Phase 3 drilling in 2007 were announced by the National Science Foundation in June. These samples are being distributed to the principal investigators by the Gulf Coast Repository at Texas A&M University. The next round for sample proposals will be due on January 1, 2009.

A borehole seismometer was installed in the pilot hole at a depth of 1039.5 m on March 6, 2008. The experimental deployment, a collaboration between Guralp Systems Ltd. and SAFOD, includes a very broadband velocity sensor, a strong motion sensor, and a 24-bit downhole digitizer. Visit http://www.earthscope.org/highlights/safod_vbb to view a very broadband recording of small earthquakes and non-volcanic tremor. ■

PBO

The Plate Boundary Observatory (PBO) is the largest integrated geodetic and seismic network in the United States. As of September 1, 2008, UNAVCO has completed 864 of the 875 planned GPS stations, 70 of the 103 planned borehole strainmeters and seismometers, all of the 5 planned long baseline laser strainmeters, and 21 of the 26 planned borehole tiltmeter stations. ■



PBO Data Products

All PBO data products are immediately freely available and can be accessed at http://pboweb.unavco.org.

PBO Regional Offices

Alaska
907-346-1523

Pacific Northwest
509-933-3221

Basin and Range
801-466-4634

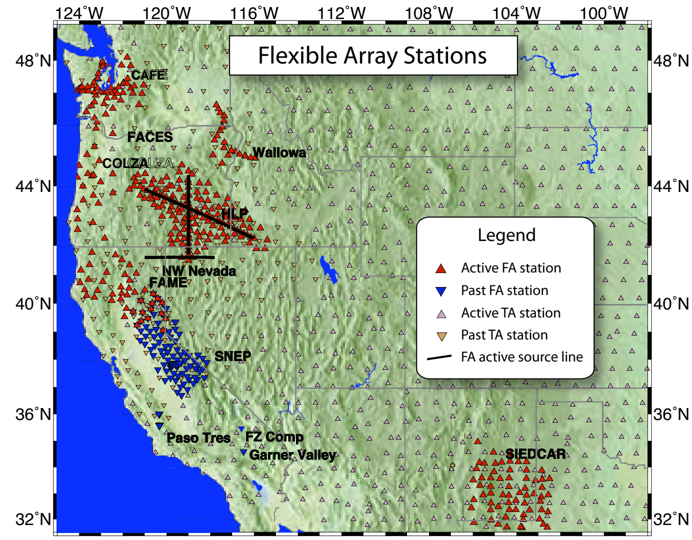
Northern California
510-215-8100

Southern California
951-779-6400

EarthScope News

Flexible Seismic Arrays

The flexible component of USArray allows scientists to conduct focused seismic studies of well-defined scientific problems at a higher resolution. Currently, eight active Flexible Array experiments dot the western half of the US as shown in the figure below. The experiments use several different types of seismometers deployed in dense arrays to develop detailed images of the crust and mantle. For more information about the Flexible Array visit http://www.iris.edu/USArray/. ■



EarthScope Teacher Workshops

Two EarthScope workshops for middle and high school teachers were held this summer in Omaha, Nebraska, and in Albuquerque, New Mexico. Workshop materials are designed to teach about Earth science in ways that incorporate a variety of learning styles and emphasize using actual scientific data available through EarthScope. Teachers who attended are heading back to the classroom armed with new tools to make Earth science come alive for their students. The workshops covered how to use actual EarthScope data in the classroom, as well as basic seismology, GPS, and plate tectonic theory. Activities ranged from the hands on "How to Interpret GPS Time-Series Plots," which involved building gumdrop GPS stations, to "Seismic Wave Basics," including a human chain that experienced different types of seismic waves. ■

featured science: Magnetotelluric Data Reveal Fluids in Lower Crust of the Basin and Range

(continued from front)

of R1. High conductivity beneath the volcanoes most likely reflects the presence of interconnected fluids, in this case released from the subducting Juan de Fuca plate. Significant variations in upper mantle conductivity are also revealed by the inversions, with the most conductive mantle beneath the northern part of the array in the backarc (C3) and the most resistive corresponding to subducting oceanic mantle under the western edge of the array (R2). (For details see Patro and Egbert, *Geophysical Research Letters*, in review).

During the summer of 2008, an additional 60 sites were occupied, extending MT coverage east across Idaho and western Montana (Figure 1). Future deployments are planned for selected targets in the continental US over the next 5 years (see http://www.iris.edu/iris_workshop/usarray_footprint.htm). ■

By Gary D. Egbert and Adam Schultz (College of Oceanic and Atmospheric Sciences, Oregon State University) and Prasanta K. Patro (National Geophysical Research Institute, Hyderabad, India)

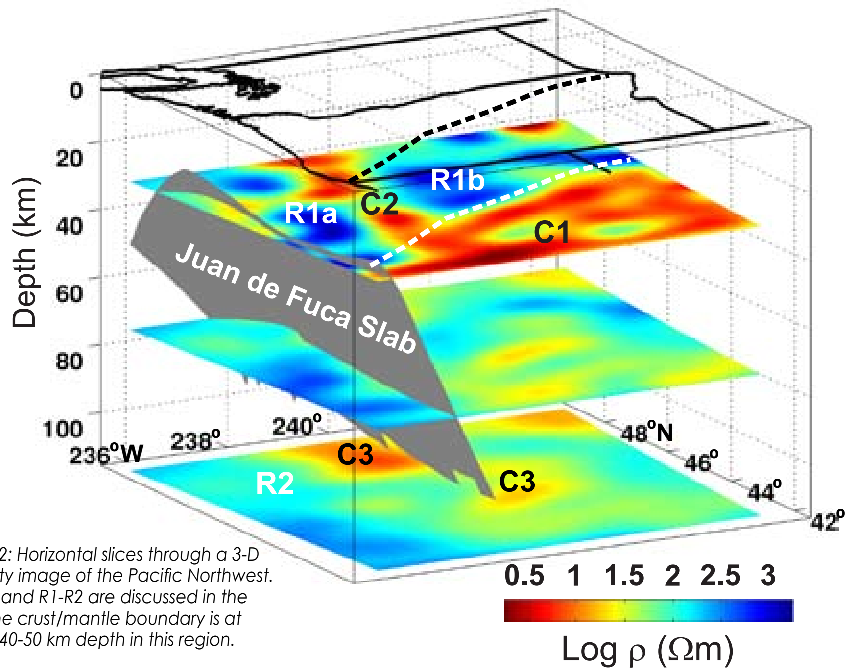


Figure 2: Horizontal slices through a 3-D resistivity image of the Pacific Northwest. C1-C3 and R1-R2 are discussed in the text. The crust/mantle boundary is at about 40-50 km depth in this region.

Glossary

A **magnetotelluric** (MT) station consists of two sets of grounded electrical field measurement lines and a magnetometer. The instruments measure low-frequency natural electric and magnetic field variations at the Earth's surface that are caused by electromagnetic disturbances in the Earth's ionosphere and magnetosphere ("space weather"), or by distant electric storms (see the Summer 2006 issue of *onSite* for more information on MT).

Conductance is the product of conductivity and thickness of a layer. It has units of **Siemens** (S) and is constrained by MT data. The vertical resolution of MT data is at best comparable to burial depth of a layer.

Magmatic underplating is the addition of material to the base of the crust due to crystallization of upward migrating magmas. This process can release highly saline (and electrically conductive) brines, which can be trapped for millions of years in the lower crust.

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EarthScope Science Featured in "Teachers on the Leading Edge"

A teacher explores the forest floor that subsided at Young's Bay south of Astoria, Oregon, during the last great Cascadia subduction zone earthquake on January 26, 1700.

A "Teachers on the Leading Edge" (TOTLE) professional development workshop for middle school Earth science teachers from Oregon and southwest Washington was held July 27 to August 1 at the University of Portland. Working in teams led by community college geology instructors, teachers learned how geoscientists developed our current understanding of Pacific Northwest tectonics and how EarthScope research advances knowledge. Three days of classroom and computer-based studies of active continental margin geology and EarthScope science were reinforced by field trips to investigate Cascadia great earthquakes, tsunamis and volcanic hazards. TOTLE Master Teachers demonstrated lesson plans that put IRIS and UNAVCO educational resources in a regional geologic context and translate EarthScope science, including episodic tremor and slip, for novice learners of Earth science. TOTLE workshops for teachers from Washington State will take place during summer 2009 and 2010 at Pacific Lutheran University in Tacoma. The workshops are funded by a collaborative EarthScope grant from the National Science Foundation to Robert Butler (University of Portland), Beth Pratt-Sitaula (Central Washington University), Jill Whitman (Pacific Lutheran University), and Frank Granshaw (Portland Community College). ■

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