spring 2006

earth scope onSite newsletter

A publication for landowners and those interested in the EarthScope Project.

From The Project Director

Welcome!

This new newsletter, *EarthScope onSite*, is designed for those of you who are helping in the operation of EarthScope – a national experiment of unprecedented scale and scope. Our ambitious goal is to understand the structure and formation of continents, and the physical processes that control earthquakes and volcanic eruptions. We hope that you view this newsletter as an on-going gesture of our appreciation for your generosity and cooperation.

We plan to keep you up to date on our progress, and to show you how the instrumentation that you are hosting is advancing our understanding of the geological processes that shape our landscape. Not since the Lewis and Clark expedition 200 years ago, has there been such a comprehensive survey of the North American continent. For the first time, we will be able to measure comprehensively geological processes and make those measurements available for both scientific research and education.

You may also follow our progress and the excitement of our discoveries on the EarthScope website (www.earthscope.org). For those of you with school children, EarthScope data can be a great start to a science fair project! If you would like educational materials for your Scout group or school science club, then please let us know and we will be pleased to assist you.

Once again, thank you for your contributions to making EarthScope a success!

Gregory van der Vink

Gregory E. van der Vink

featured science:

What is EarthScope?

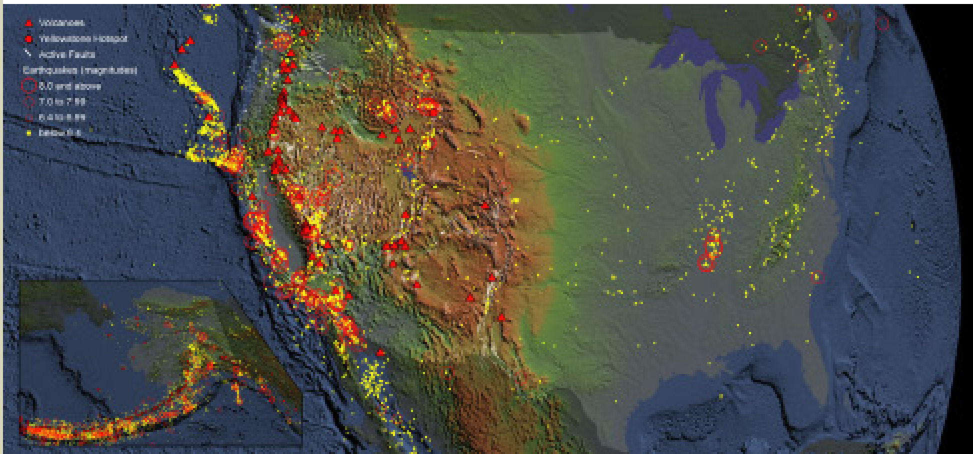
EarthScope is a bold, new experiment that will change our understanding of how plate tectonics works and how continuing natural processes such as earthquakes and volcanoes are creating and shaping the North American continent. The data that EarthScope collects will provide fundamental breakthroughs in our knowledge of geological hazards and will aid in the public's understanding of the dynamic Earth. These data are being collected by thousands of instruments across the country, organized into three groups.

The first group is the San Andreas Fault Observatory at Depth, which is a set of instruments placed 3.2 km (2.3 mi) deep in a borehole, providing the first opportunity to observe directly the conditions under which earthquakes occur. The second group is the Plate Boundary Observatory (PBO), operated by UNAVCO, which includes a network of over 800 continuously recording Global Positioning System receivers, more than 100 borehole strainmeters, and borehole seismic stations being installed throughout the "lower 48", Alaska, and the volcanic islands of the Aleutians. These geodetic stations will measure plate tectonic effects, such as the motion along the San Andreas Fault and eruptions in the Cascade volcanoes.

EarthScope will fundamentally change our view of the planet.

Operated for EarthScope by IRIS, the final set of instruments is the USArray, which includes permanent and temporary seismic stations and temporary magnetotelluric (MT) stations. USArray's more than 400 seismic monitoring stations will leap-frog across the US at an average spacing of 70 km (~43 mi) over the next decade, occupying more than 2000 locations with an average residence time of 24 months and providing a high-resolution image of the mantle underneath the North American continent. In a similar way, the 20 MT stations will occupy hundreds of sites over the course of the experiment, and will provide information on the temperature structure of the continental crust.

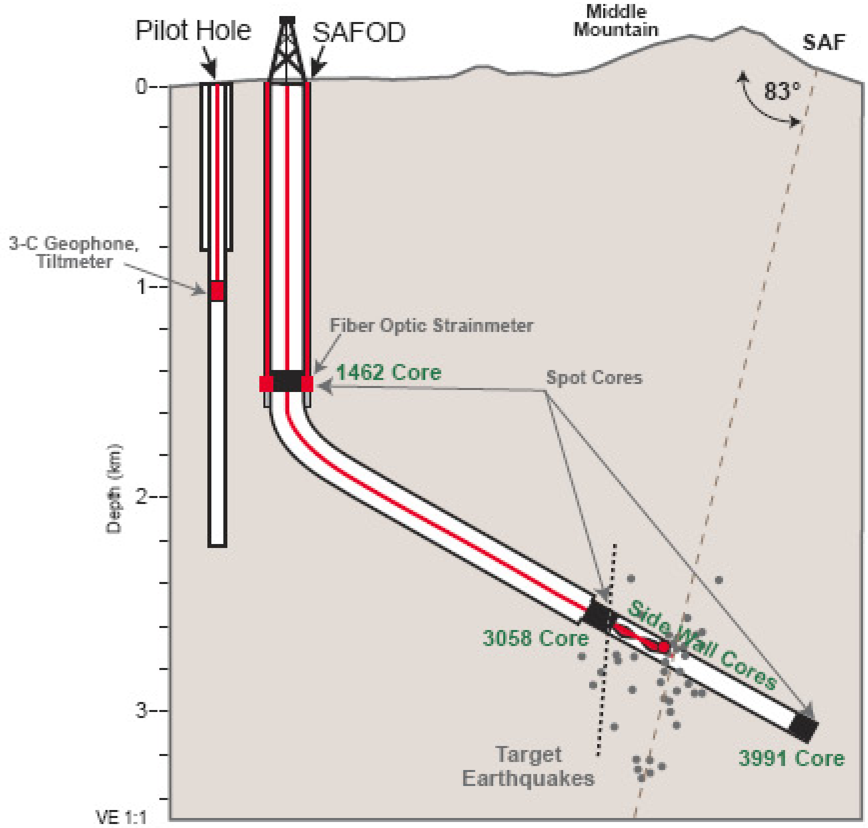
The data from all of these elements of the EarthScope facility are freely available on-line to the public as well as professional geoscientists. Using EarthScope data, scientists have already captured the "breathing" of Augustine Volcano as it erupted, and the subtle movement of Cascadia during the periodic "silent earthquakes". EarthScope data have been used to measure the creeping movement of the San Andreas Fault and to generate high-resolution images of the crust from background "noise". EarthScope has also begun a high-profile effort to support the use of our data in classrooms across the US.



project status:

San Andreas Fault Observatory at Depth

EarthScope includes a unique observatory, designed to give scientists their first direct opportunity to witness the conditions that cause earthquakes. To create the San Andreas Fault Observatory at Depth (SAFOD), we drilled 3.2 km (2.3 mi) into the Earth's crust. Starting on the west side of the San Andreas Fault, the drill hole begins on the Pacific Plate, passes through the fault close to the hypocenter of the 1966 magnitude 6 Parkfield earthquake, and ends on the east side in the North American Plate. Thanks to its unprecedented location, SAFOD will provide new insights into the composition and physical properties of fault zone materials at depth, and the constitutive laws governing fault behavior.

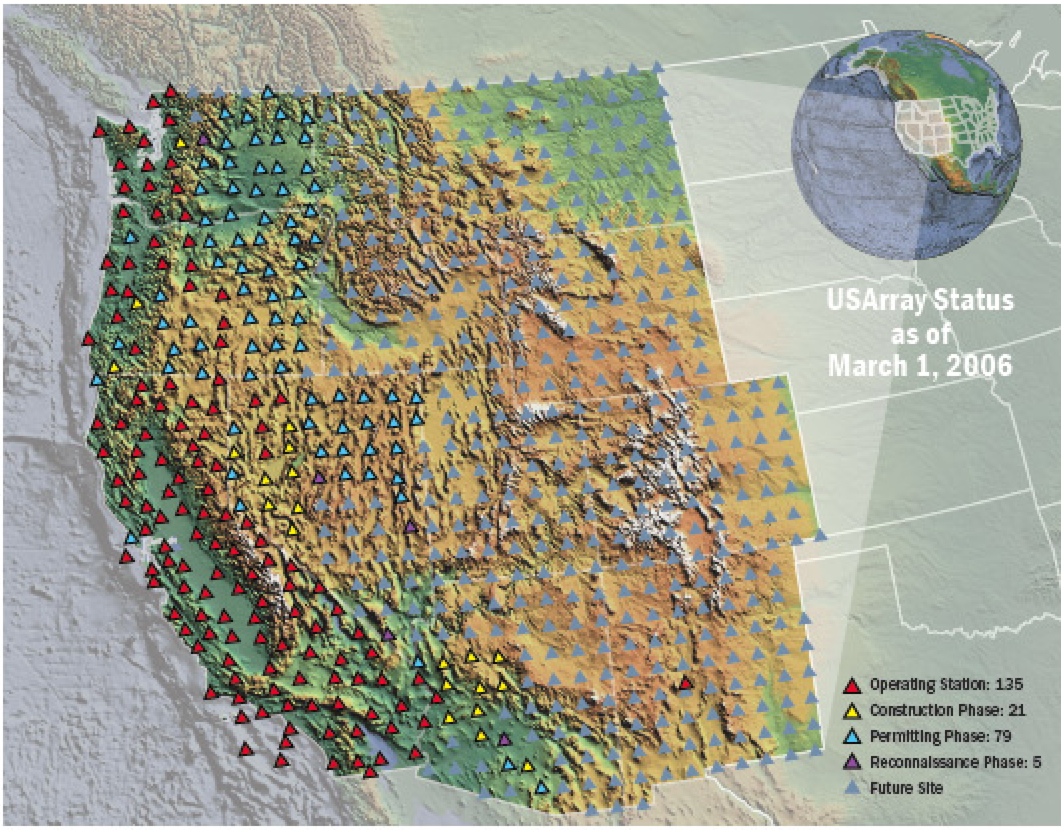


SAFOD is being run in several stages. The directional drilling on the main hole was completed on August 28, 2006. During the drilling phase, samples of the rocks and fluids were obtained, along with 23 m (75 ft) of core. These are currently being analyzed by scientists for clues about the state of the San Andreas Fault Zone. In addition to the physical samples, oil industry standard well logs (including density, porosity, and water saturation) were run to provide a continuous record of the fault zone. The well is currently in an observation phase. Seismometers, geochemistry sensors, and strainmeters have been placed in the well bore and constantly relay their readings to the surface. The high pressure (50 atmospheres) and temperature (93°C; 199°F) at the bottom of the drill hole make maintaining the instruments a technical challenge as great as drilling the well. In 2007, we will re-enter the well to drill a series of cores that will give us a continuous record of the rocks in the San Andreas Fault Zone.

The observatory has already given us some surprising results. The borehole passes through the San Andreas Fault, so we expected the steel tube that lines it (the casing) to bend over time as the fault moved. However, the casing has been offset by 4 mm since drilling was completed, which is a much higher rate than had been anticipated. In addition, the San Andreas Fault appears to bend to the west at depth rather than being purely vertical. Because the amount of energy released by an earthquake depends on the area of the rupture, this may mean that larger earthquakes are possible. The fossils in the sediments have allowed scientists to date the age of the rocks making up the fault zone. Foraminifera (small plankton) associated with the Great Valley Sequence and Inoceramus (a type of mollusk) indicate that the sediments are about 75 million years old.

To see the current status of SAFOD, visit http://www.earthscope.org and click on "Drilling (SAFOD)". ■

project status:
USArray



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


2005 Transportable Array Interns

Where Is the Transportable Array?

The Transportable Array, a dense network of instruments designed to record local, regional, and global earthquakes, is helping scientists learn more about the origin and characteristics of earthquakes, faults, and the structure of the Earth. The array consists of 400 seismic monitoring stations approximately 70 km (~43 mi) apart that will advance across the U.S. from west to east in a leap-frog fashion. Over the next decade, the array will occupy more than 2,000 locations with an average residence time of 24 months.

Field crews are currently installing the first 400 stations. To date, more than 130 seismometers are operating in Washington, Oregon and California. Construction crews are digging holes for the underground stations at numerous sites in Arizona and Nevada. They will be followed by instrument teams who will install the seismometers and communications equipment. Landowners in Arizona, Nevada, Oregon, and Washington are being contacted about the possibility of hosting a monitoring station and reconnaissance teams will soon start preparing for the summer field season.

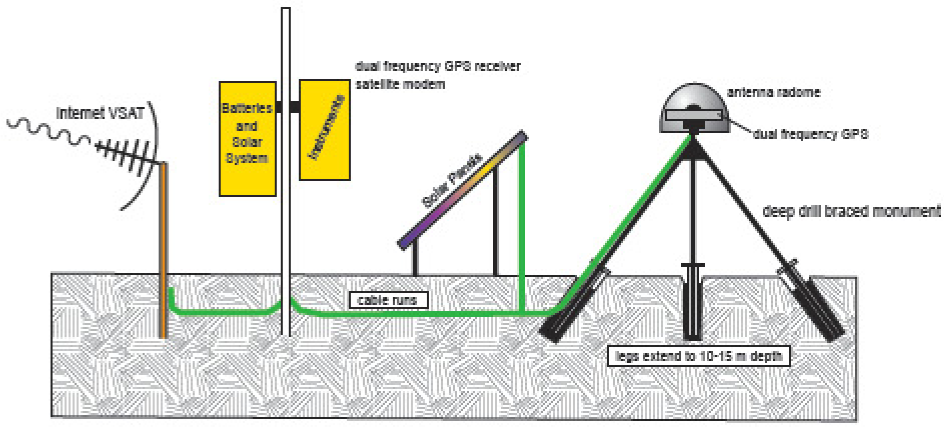
In each issue of *EarthScope onSite*, we will share the progress of the USArray project with you. We want to let you know where the Transportable Array is located as it makes its way across the United States, what data are being recorded, what our scientists are doing, what we are learning, and where you can find additional information about earthquakes and related topics. From time to time, we will print articles that focus on a specific station or earthquake event, or that answer fundamental questions about earthquakes and seismology. If there is a topic of special interest to you, please let us know by contacting the USArray editor (dorr@iris.edu) or the EarthScope Office. ■

On the Move . . .

One of the goals of the EarthScope project is to actively engage students who will become the next generation of Earth scientists. In a pilot program conducted last summer, a group of graduate geoscience students were thoroughly engrossed in analytical studies and field work to identify potential sites for more than 50 Transportable Array stations in Oregon. The interns attended a multi-day workshop to learn about station requirements and geographic information system (GIS) techniques before going out in the field. Once assigned a geographic working area, the students identified locations for further investigation. The student teams then traveled to these potential sites to determine the best locations. After preparing reconnaissance reports to document their findings, a professional seismologist verified the recommendations. This program was extremely successful and proved to be an efficient and cost-effective way to locate a large number of sites while simultaneously providing an exciting learning opportunity for students. We are actively pursuing similar collaborative efforts as the Transportable Array moves into new regions. ■

How are PBO Stations Installed?

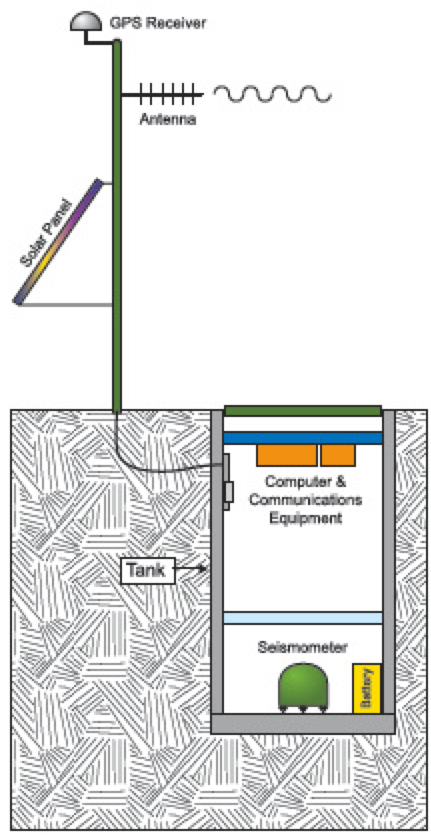
The Plate Boundary Observatory installs two types of geodetic instruments: Global Positioning Systems (GPS) and strainmeters. GPS stations are made up of a GPS antenna mounted on top of a tripod which is deeply anchored into the ground. GPS stations are typically installed in two to three days, depending on type of bedrock material and the length of the tripods legs. For surfaces that consist mostly of solid rock, the tripod leg holes are drilled to about a six-foot depth. Surfaces that are not as solid require leg holes to extend approximately 30-40 ft below ground to ensure minimal movement. Once the leg holes are drilled, steel pipes are placed into the holes and welded together above the surface to create the tripod. The GPS antenna, covered by a weather-proof dome for protection, is leveled on top of the tripod and welded in place. Several feet away from the tripod the GPS receiver and data communications equipment are set up with batteries in an enclosure attached to solar panels for extra power. Data from the PBO GPS station are transmitted via cellular, broadband, or satellite communications to an archive at UNAVCO (www.unavco.org), the organization operating the Plate Boundary Observatory. All cabling between the GPS receiver and the communications equipment are buried under ground. In areas with livestock or wild animals, a fence is build around the station for protection. ■



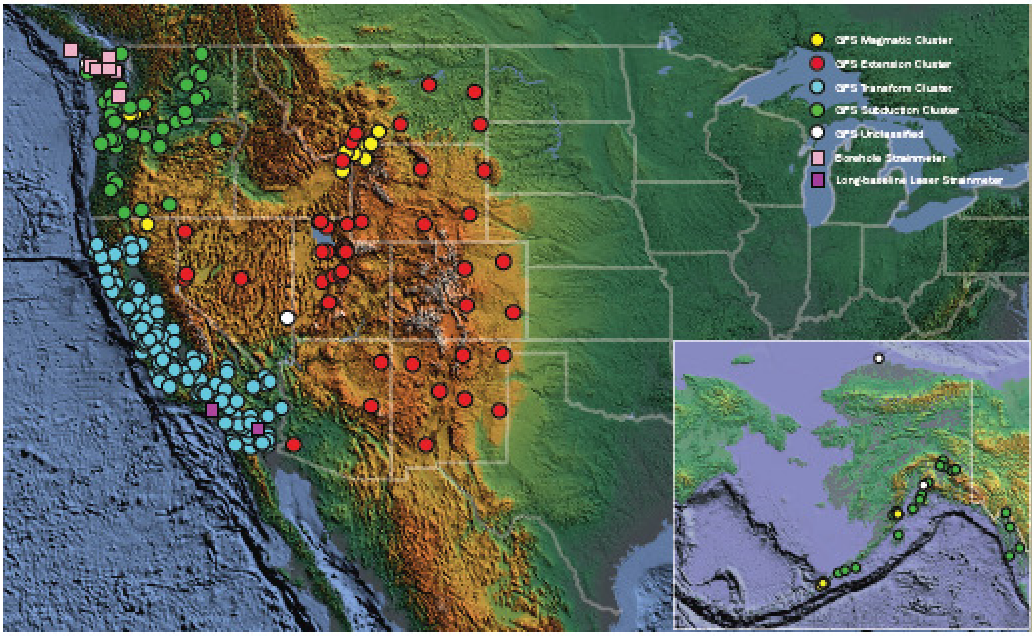
How Does A USArray Seismic Station Work?

An EarthScope USArray earthquake monitoring station consists of a seismometer and some additional electronics and communication equipment buried in a sealed, thermally insulated chamber, or vault, about six feet below the surface. The seismometer detects and measures the Earth's ground motion. These vibrations are similar to sound waves in air, but span a wide frequency range that extends well below the threshold for human hearing. The sensors are extremely sensitive and can pick up a broad spectrum of motions ranging from low-amplitude background vibrations, such as those generated by wind or pounding surf, to signals from local, regional, and distant earthquakes. The sensitivity of the station depends on how quiet the local conditions are – the lower the "background noise" from human and natural sources such as traffic and swaying trees, the more likely the station will be able to detect faint earthquake signals. Sites are chosen to minimize the background noise as much as is practical, while still allowing access for the installation of the equipment.

The seismometer, which is a little larger than a one-gallon paint can, contains delicate moving parts and sophisticated electronics, but operates on a very simple principle. The motion sensor consists of a weight hanging on a spring that is suspended from the frame of the seismometer. When an earthquake occurs, the suspended weight initially remains stationary while the frame moves with the Earth's surface. The relative motion between the weight and the Earth provides a measure of the ground motion. Three sensors are combined in a single package to measure ground motion in three dimensions. Modern seismometers, like those being used by the EarthScope USArray project, use a complex feedback system to measure the ground motion electronically.
The signals are converted to digital records which are then stored on a computer in the vault. These data are transmitted continuously to EarthScope data processing centers by cellular telephone, broadband internet, or satellite communications systems. The type of communications system chosen depends on the conditions at the site and in the surrounding area. Once the data are received at the processing center, they are automatically indexed and immediately sent to the IRIS Data Management Center (http://www.iris.edu/about/DMC) where they are stored and made available via the internet to researchers and the general public. ■



project status:
Plate Boundary Observatory



PBO Status as of March 1, 2006:

Magmatic stations: 33

Transform stations: 159

Subduction stations: 57

Extension stations: 44

Borehole strainmeters: 11

Long-baseline laser strainmeters: 2

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

The EarthScope Plate Boundary Observatory (PBO) project is halfway through its five-year construction phase. Private, municipal, state, and federal landowners play a critical role in this process and have assisted in siting GPS and strainmeter instruments on their land.

Data received from the GPS stations and strainmeters installed around the western U.S. are important in achieving the scientific goals of EarthScope. Using the instruments located on your property, we hope to unravel the answers to questions such as:

- What is the geographic distribution and timing of the deformation of the North American continent?
- How does this relate to the evolution of the plate-boundary?
- What is the geographic distribution and timing of earthquakes?
- How do earthquakes begin?
- How do magma and the inner plumbing of volcanoes interact?
- How can we reduce the hazards of earthquakes and volcanic eruptions?

As part of this series of regular newsletters, we will highlight the scientific discoveries of EarthScope in more detail. EarthScope scientists have already found new and interesting observations from the limited time that these instruments have been operating. In June 2005, the first borehole strainmeter was installed at Hoko Falls, Washington. This instrument captured small-scale deformation of the crust that previously had only been recorded on seismic and GPS instruments. At Parkfield, California, along the San Andreas Fault, five new GPS stations captured detailed deformation directly after the 2004 earthquake. GPS stations on Augustine Volcano, Alaska, and Mt. St. Helens Volcano, Washington, have recorded inflation and deflation of these structures. This information is important for understanding the size, distribution, and movement of magma beneath the surface. See http://pboweb.unavco.org/?pageid=13&newsid=88.

2005 was the year that UNAVCO established itself as the community leader in configuration, drilling, logging, and installation of borehole strainmeters. Borehole strainmeters are instruments that have the potential to change the way we look at Earth's deformation. A total of ten borehole strainmeters and seismometers were installed in the Pacific Northwest, including four instruments in Canada. Three borehole strainmeters were installed between Tacoma, Washington, and Portland, Oregon. Approximately, twenty-five more instruments are scheduled for installation in the Grants Pass and Anza regions of Southern California in 2006. More information on other instruments including borehole and long-baseline strainmeters will be featured in future newsletters.

One of the real success stories of PBO in the last year was the development of UNAVCO-based tools for tracking the state of health of the GPS and strainmeter stations. These tools will soon be made publicly available allowing you to see on-line the status of the instruments located on your property. Now that PBO operations are well underway, the quality, availability, and usefulness of PBO data products will become a more important part of the project. You can find the permanently archived GPS data at http://pboweb.unavco.org/?pageid=88 and strainmeter data and data products on-line at http://pboweb.unavco.org/?pageid=89

At the end of February 2006, GPS field crews completed 663 station reconnaissance visits and submitted 645 permits. Permits accepted, the agreed critical path item for PBO, reached a total of 371 and crews completed the installation of 300 GPS monuments. Strainmeter field crews completed 119 reconnaissance visits and submitted 82 permits. Of those permits, 51 have been accepted and a total of 13 strainmeters have been installed. The strong start to the calendar year places PBO in the position to meet or exceed project goals for 2006!

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

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(www.earthscope.org)

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GPS Station P711 - Madison Junction, WY: Located at 110.9W 44.6W, this instrument records ground movement associated with the Yellowstone Hotspot.

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Revealing Earth's Secrets