summer 2007

earthscope onSite newsletter

## From The USArray Principal Investigator

The sensors used in modern seismic networks 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. By analyzing seismic recordings, scientists have learned that sources other than earthquakes, including landslides, volcanic eruptions, and underground explosions, also produce signals that can provide important information.

In our science feature, two EarthScope researchers, Thorne Lay of the University of California, Santa Cruz and Charles Ammon of Pennsylvania State University, describe how data from the Transportable Array's Earthquake Recording Stations were used to learn about the underground nuclear explosion detonated in October 2006 by North Korea. This fascinating article explains how the location, time and size of the explosion are determined. Another example of an exotic source of seismic waves is the recent mine collapse in Utah. See the back page for more information. A short article reports on the uplift being recorded by GPS stations near the Yellowstone caldera. Also in this issue, we announce the opening of the EarthScope National Office, and highlight a program that engages students in the geosciences by having them assist with the installation of GPS stations. Updates on the progress of the Transportable Array and the Plate Boundary Observatory are presented in this and every issue of *onSite*.

We value your continued interest in EarthScope. If there is a topic of special interest to you, please let us know by contacting one of the EarthScope *onSite* editors (USArray: dorr@iris.edu or PBO: eriksson@unavco.org).

David W. Simpson
USArray Principal Investigator

featured science:

# USArray and Detection of Underground Nuclear Tests

The Transportable Array's primary scientific objective is to collect seismic recordings from a regularly spaced 70-km (40-mi) grid of sites in the conterminous 48 states and Alaska. These data will be used to determine the structure of the Earth and to advance our understanding of the structure, evolution and dynamics of the North American continent. In addition, the seismic recordings contribute important data for other applications including research on how earthquakes begin and propagate, and the detection and analysis of signals from exotic sources such as landslides, submarine slumps, volcanic eruptions, and large underground explosions.

The Transportable Array has already recorded ground motions produced by one important exotic event – the underground nuclear explosion detonated by North Korea on October 9, 2006. At that time, the network had 240 operating stations (Figure 1). Underground nuclear explosions generate seismic P waves that propagate outward from the source. As the waves spread throughout the Earth's interior, the arrival time and amplitude of the ground motions are recorded by the seismometers. The location and origin time of the explosion can be accurately estimated by combining information from a number of seismic stations. The vibration amplitudes can then be used to estimate the seismic magnitude, or source strength, given prior determinations of how P-wave amplitudes vary with distance from any source. The U.S. Geological Survey used seismic waves recorded primarily at seismic stations in Asia to estimate the location and magnitude of the North Korean event: 41.294°N, 129.094°E (Figure 1) with a P-wave seismic magnitude of 4.2.

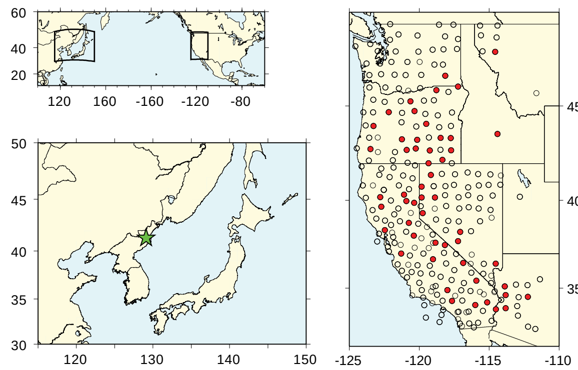



*Figure 1. (Upper left) Outlined regions show event and station map locations. (Lower left) Map showing the location of the North Korean nuclear test (green star). (Right) Locations of TA stations with clear P-wave arrivals (red filled circles), stations with usable, but low signal-to-noise records (dark gray unfilled circles), and stations for which data were not immediately available (light gray circles) for the North Korean test.*

Accurate seismic source locations and event size estimates acquired by various international seismological observation systems play a key role in monitoring nuclear testing treaties and in characterizing the nature of any underground nuclear explosion. Given independent calibration of seismic magnitude versus known explosive yield for buried nuclear explosions in a particular rock environment, the measured seismic magnitude for a new event can be used to estimate the explosion energy once the source is established to be an explosion (Figure 2). The North Korean government announced the detonation of a nuclear device, but even if this had not been the case, analysis of seismic recordings would have distinguished the event from a natural earthquake because the waveforms are different. Based on reported seismic magnitudes ranging from 3.6 to 4.2, the North Korean event is estimated to have a surprisingly low yield of ~0.2-1 kiloton

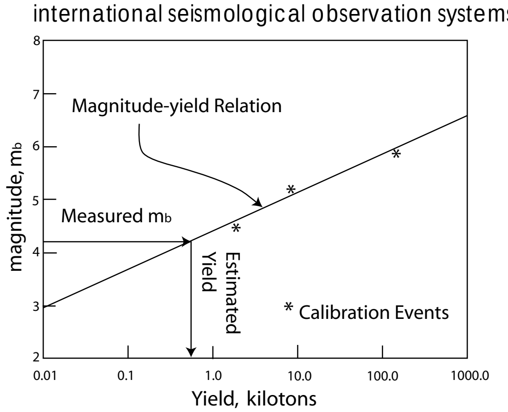


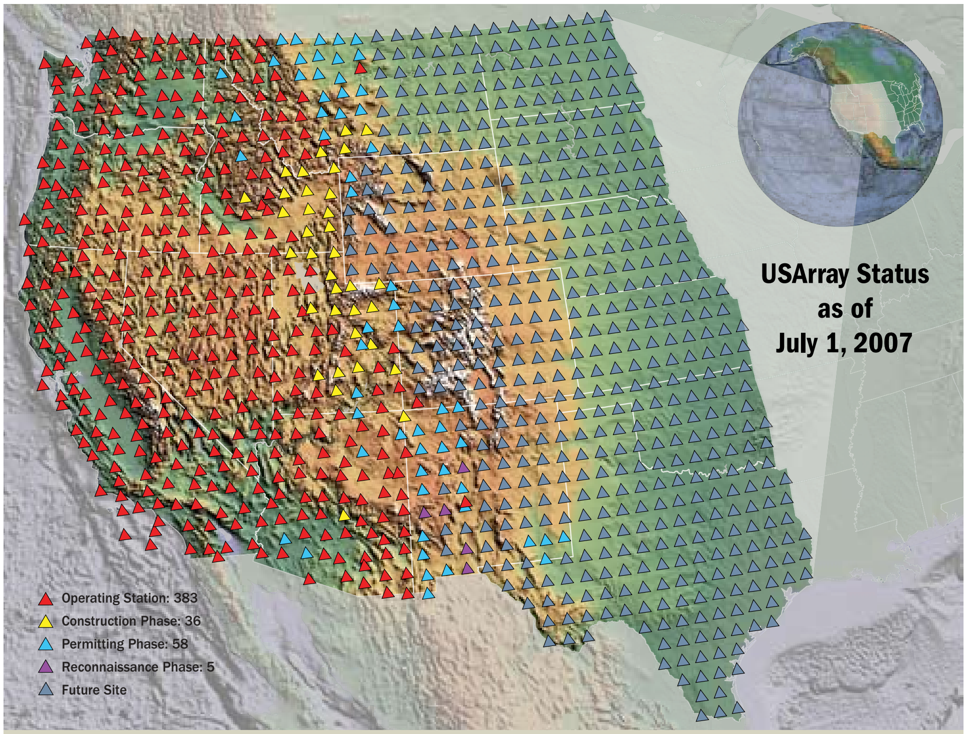

*Figure 2. Schematic diagram of how a measured seismic magnitude for an underground explosion is used to estimated the yield in kilotons (kt) of the explosion device. A calibration curve based on prior measured magnitudes for underground nuclear events with known yields is used. For the North Korean event, yields in the range 0.2-1.0 kt are obtained from various magnitude estimates and calibration curves (the example curve shown here is for hard rock sites at the former Soviet test site in Kazakhstan).*

(continued on the next page)

# project status:
# USArray

## Where is the Transportable Array?

As of July 1, more than 380 earthquake recording stations were operating in eight western states. Installation of the Transportable Array network is complete in California, Oregon, Washington and Nevada with stations located approximately 70 km apart in a grid-like fashion. Coverage is nearly complete in Arizona, with installation of only a few more stations required. While construction crews have been busy in Idaho, Utah, and western Montana, site reconnaissance activities are in full swing in New Mexico, Colorado, Wyoming, central and eastern Montana, and in the Big Bend area of Texas. For the third year in a row, student teams from local universities were trained to perform analytical and field activities to select suitable locations for future seismic stations. This summer, more than 150 sites were successfully identified by eight ambitious teams from Colorado College, the University of Wyoming, Montana Tech, and the University of Texas-El Paso.




**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

*Installing Transportable Array station T18A on the Navajo Nation near Mexican Hat, Utah. The station began operating in June 2007.*

The Transportable Array is one of the world's largest seismic networks. While the stations operate remotely, it takes a lot of effort by a lot of skilled people working behind the scenes to keep everything functioning smoothly. It is rare for all stations in a real-time network such as the Transportable Array to be fully operational at any one period of time, but this did happen. On Friday, July 13, 2007, all 386 certified Transportable Array stations were operating within the uppermost tolerance range! Now, is anyone out there superstitious? ■

# featured science:
# USArray and Detection of Underground Nuclear Tests

(continued from front)

(for comparison, the first nuclear tests by the United States, China and the Soviet Union had yields of ~20 kilotons), prompting speculation that the test was either not fully successful or was intentionally under-loaded with fissile material.

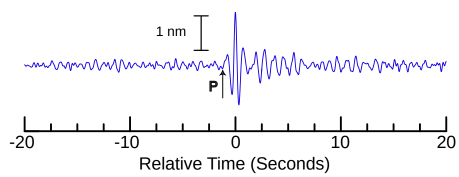


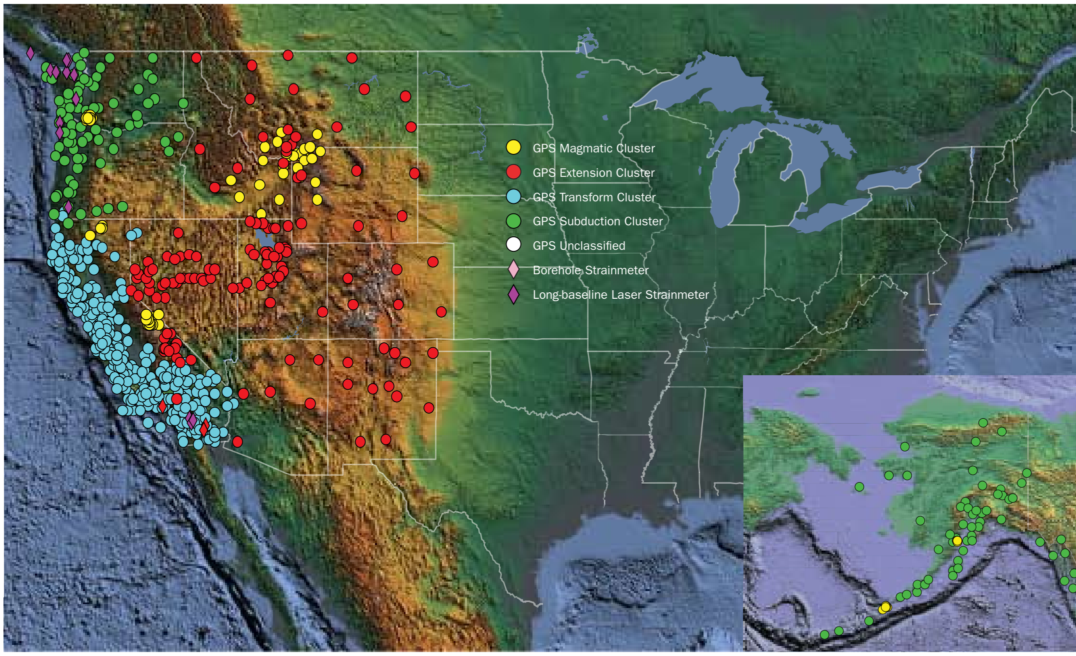

*Figure 3. An averaged sum of P-wave ground displacements from 36 Transportable Array stations for the North Korean event, aligned by picking the peak arrival time. The peak-to-peak amplitude is about 2 x $10^{-9}$ m (2 nm). The first upward motion, indicated by the arrow labeled P, is the compressional P-wave first arrival. This direction of motion is consistent with an explosion source.*

The Transportable Array stations operating in the western U.S. (Figure 1) are 7350-10580 km (4560-6560 mi) from the North Korean test site. At these distances, a magnitude 4.2 event is expected to produce only about two nanometers (two billionths of a meter) of ground displacement, so small that only exceptionally quiet sites could detect the P-wave signals above background noise levels. Approximately 15% of the stations had a clear P-wave signal, with the quietest Transportable Array stations located away from the pounding ocean waves along the Pacific coast. The data from these 36 stations were "stacked," aligned on the same peak arrival and summed, to obtain the averaged trace in Figure 3. While unambiguous seismic identification of the October 9, 2006, event as an explosion requires recordings closer to the source than the Transportable Array stations, this example demonstrates how Transportable Array data can be used for understanding explosions and other exotic sources, in addition to revealing structure under North America. ■

By Thorne Lay, Department of Earth and Planetary Sciences, University of California, Santa Cruz, and Charles J. Ammon, Department of Geosciences, The Pennsylvania State University.

project status:

# Plate Boundary Observatory




## PBO Status as of July 1, 2007:

Magmatic stations: 77

Transform statons: 280

Subduction stations: 131

Extension stations: 133

Borehole strainmeters: 36

Long-baseline laser strainmeters: 3

Eastern Backbone: 8

## PBO REGIONAL OFFICES:

Alaska 907-346-1522

Pacific Northwest 509-933-3221

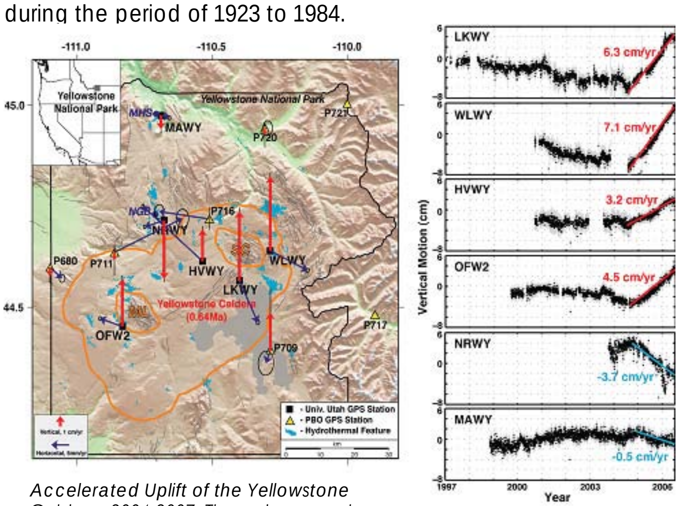
Basin and Range 801-466-4634

Northern California 510-215-8100

Southern California 951-779-6400

## Accelerated Uplift of the Yellowstone Caldera

Starting in mid-2004, permanent GPS stations recorded an episode of unprecedented uplift of the Yellowstone caldera which was associated with an area of subsidence to the northeast of the main volcanic center. (A caldera is a feature formed by the collapse of land following a volcanic eruption.) The deformation continues into 2007, with nearly constant inflation rates of up to 6 centimeters per year. This is about three times the rate of uplift during the period of 1923 to 1984.




*Accelerated Uplift of the Yellowstone Caldera, 2004-2007. The red arrows at permanent GPS stations in Yellowstone National Park show uplift (pointing up) and subsidence (pointing down). From Chang, W., R. Smith, C. Wicks, and C. Puskas, University of Utah.*

New permanent GPS stations of the Plate Boundary Observatory and other pre-existing sites provide new data that researchers at the University of Utah are using to model the type of magma chamber beneath this area. They propose that a new intrusion of magma or pressurization of a deep hydrothermal system is likely causing the observed uplift.

To read a more detailed summary of this study visit http://www.unavco.org/pubs_reports/proposals/2007/facility2007/section3/UNV-GRID-SPREAD-MS_2.pdf. ■

## NSF Establishes the EarthScope National Office

The National Science Foundation, the federal agency that funds EarthScope, recently made an award to Oregon State University to establish the first EarthScope National Office. The purpose of the new office, directed by Dr. Anne Trehu, a professor in OSU's College of Oceanic and Atmospheric Sciences, is to coordinate EarthScope's science planning and education and outreach activities. A major effort will be placed on organizing different types of workshops to increase awareness about Earth science. Some of these workshops will be forums for scientists to discuss research topics, while others will show park rangers, museum specialists and teachers how to incorporate EarthScope into their presentations and educational materials. The EarthScope National Office is designed to be regionally focused and will relocate to another area in three to four years as EarthScope progresses. ■

## Students help build the PBO

From June to September 2007, nine students are helping install the PBO from southern California to Alaska. The program is intended to interest young people in the geosciences by developing technical and professional skills while they learn about the science and construction of EarthScope. For many of the students, this is their second season in the program, which significantly adds to the productivity and efficiency of the installation crews. ■

*On June 13-14, 2007, PBO crews completed the installation of P727, a GPS station near Bishop, California. This was the first GPS installation for students Emily Seider (Whitman College) and Omar Perez (University of Puerto Rico, Mayaguez) who are assisting PBO engineer Summer Miller.*

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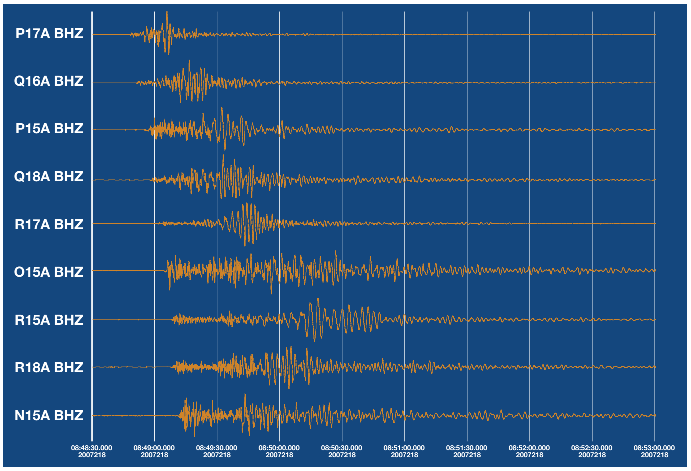
## In the News . . .

As we go to press with this issue, the August 6, 2007, tragedy that trapped six workers in the Crandall Canyon Mine in central Utah is in the news. The ground motion that occurred that day was recorded by numerous EarthScope Transportable Array stations as well as by the University of Utah Seismograph Stations (UUSS) network. While it may take months for officials to conduct their investigation of this event, seismologists have already made some preliminary interpretations of the data recorded by the seismometers. Researchers at the Berkeley Seismological Laboratory determined that the mine collapse was not caused by an earthquake. A press release issued by the University of California-Berkeley is posted at http://www.berkeley.edu/news/media/releases/2007/08/09_minecollapse.shtml. Information has also been posted by the UUSS at http://www.quake.utah.edu/recactivity/utpressrelease.shtml#07080608482 and the US Geological Survey's National Earthquake Information Center at http://earthquake.usgs.gov/eqcenter/eqinthenews/2007/.




*Ground motion from the August 6, 2007, mine collapse in central Utah was recorded by more than 50 EarthScope Transportable Array stations. This figure shows traces from 9 of the stations.*

*EarthScope is funded by the National Science Foundation and conducted in partnership with the US Geological Survey and NASA. EarthScope is being constructed, operated, and maintained as a collaborative effort with UNAVCO Inc., the Incorporated Research Institutions for Seismology, and Stanford University, with contributions from several other national and international organizations. This material is based upon work supported by the National Science Foundation under Grants No. EAR-0323310, EAR-0323309, EAR-0323700, EAR-0323938, EAR-0323311, and EAR-0323704. Any opinions, finding, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.*

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