spring 2010

earthscope onSite

news from USArray

From the USArray Director

With this issue, we are introducing a new, updated look and content that explains in straightforward terms fundamental concepts about seismology, the status of USArray activities, and science discoveries enabled by EarthScope instruments.

Building on an exciting discovery revealed as a result of instruments deployed in the Pacific Northwest before and during the early years of EarthScope, the cover story highlights the return of Transportable Array seismic stations to Cascadia to learn more about Episodic Tremor and Slip events and potential hazards associated with the movement of the tectonic plates in that region. We also report on recent earthquakes in the Midwest and how scarcity of seismic stations in the area made it difficult to determine exactly where these events occurred. The last page shows a compilation of seismograms, or a record section, from the earthquake in Chile. Record sections help scientists better understand how seismic waves travel in time and distance through the Earth. If you like to look at seismic waves recorded at a seismic station, this issue includes an article on the basics of reading a seismogram and provides a list of interesting web sites where you can learn more about EarthScope, seismology and related geoscience subjects.

Our goal for *onSite* is to provide informative and appealing stories and news about USArray and seismology, in particular, and the EarthScope program, in general. We value your continued interest and greatly appreciate your contribution to expanding our knowledge of the structure and formation of continents and the physical processes that control earthquakes and volcanic eruptions. If there is a topic of special interest to you, please let us know by contacting the editor at onsite@iris.edu or the USArray office.

Bob Woodward
USArray Director

featured science:

Using Episodic Tremor and Slip to Characterize Earthquakes in Cascadia

Every 14 months the Pacific Northwest experiences slow slip on a fault that is the equivalent of about a magnitude 6.5 earthquake. While a typical earthquake of this magnitude happens in less than 10 seconds, the duration of these slip events is two to several weeks. The implications of this phenomenon, which was discovered only about ten years ago, are not yet well understood.

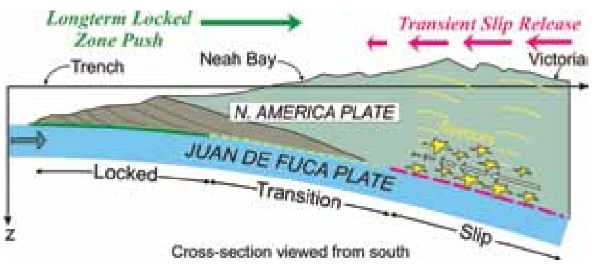


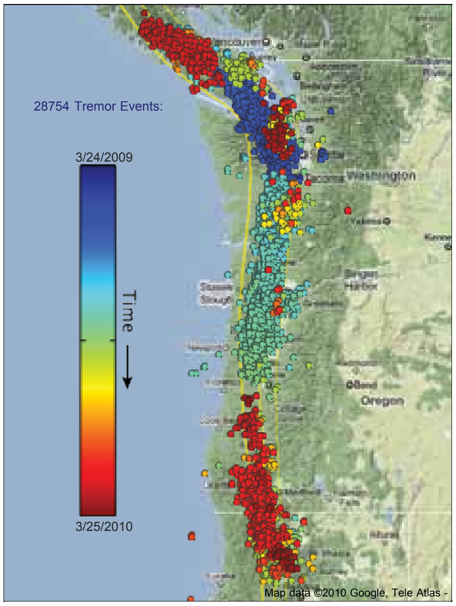
Figure 1-1. Courtesy of H. Dragert, Geological Survey of Canada

The Cascadia subduction zone, where the Juan de Fuca plate moves beneath the North American plate (or subducts) at a rate of 3-4 cm/year, extends 1100 km from Northern California to central British Columbia, Canada. These plates slide past each other along the solid green, dashed yellow, and dashed red line in Figure 1-1. Every 500 years, on average, a magnitude 9 earthquake occurs along this plate boundary; the last one was about 300 years ago in January 1700. The slip during these earthquakes, occurring on the "locked" zone in the figure, is thought to accommodate most, if not all, of the relative motion between the North American plate and the Juan de Fuca plate. Down dip of this locked zone (red dashed lines), the plates must still slide past each other. However, instead of rupturing in devastating earthquakes, much of that slip appears to be occurring during Episodic Tremor and Slip (ETS) events (labeled "slip" in the figure).

Before EarthScope, observations of "silent earthquakes," as they were known at the time, were based on sparsely sampled geodetic and seismic observations in and around the best-instrumented part of Cascadia near Puget Sound and Vancouver Island. It was not known whether this phenomenon occurred all along the plate boundary. Facilitated by new data obtained from instruments installed during the first phase of EarthScope, we now know that nearly the entire plate margin regularly exhibits ETS.

These enhanced observational capabilities have also supported the discovery of many short-lived tremor events and enabled near real-time identification and location of tremor as it initiates and propagates along the plate boundary. The migration of these tremor events is tracked daily as shown in Figure 1-2. Nearly 60 major ETS events have been imaged using data from seismic and geodetic instruments. Further analyses of these data are helping to model how far east on the subducting Juan de Fuca plate the next megathrust earthquake could occur. These ETS events suggest that future rupture could extend down to 25 km depth, or ~60 km inland of the Pacific coast, far closer to Washington State's major metropolitan region than previously thought.

Figure 1-2.Locations of tremor during the year ending March 25, 2010, color coded by the date the tremor occurred (see www.pnsn.org/tremor).



Undoubtedly, EarthScope has been vital to the advancement of the science of Episodic Tremor and Slip. These data are playing such an invaluable role in constructing a detailed estimate of future ruptures that more than two dozen Transportable Array stations are being returned to Cascadia to resume recording observations for five more years. With time and the recording of more ETS events, scientists will develop a more complete picture of the dynamics and hazards posed to Cascadia. ■

By Timothy I. Melbourne, Central Washington University and Kenneth C. Creager, University of Washington.

USArray Operating Stations as of April 8, 2010

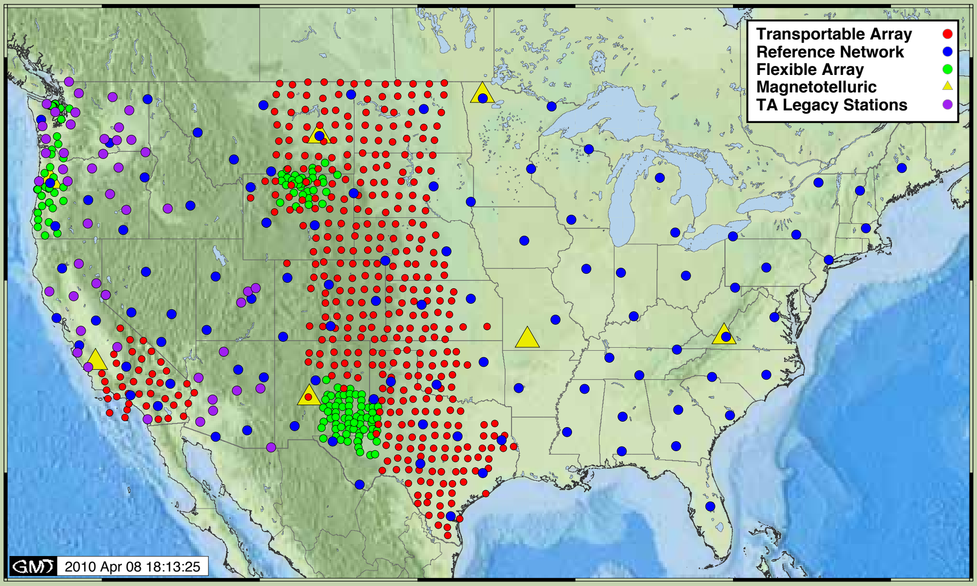
REAL-TIME STATION STATUS: To view a map of current Transportable Array stations, visit www.earthscope.org and click on the "EarthScope Today" map.

To view seismograms recorded at a USArray station, go to www.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.

To select a station from a map and view its seismograms, go to www.iris.edu/activeearth/content/es_TA_status.phtml. Click on a station location (red dot) and view today's or yesterday's data.

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

Where is USArray?



featured science:

The Midwest Wakes Up to... Earthquakes!

On February 10, 2010, at 4:00 am in the morning, a magnitude 3.8 earthquake lightly shook northern Illinois in the area near Virgil and Lily Lake. The quake was felt by many people in Chicago, more than 40 miles away, and as far away as several neighboring states.

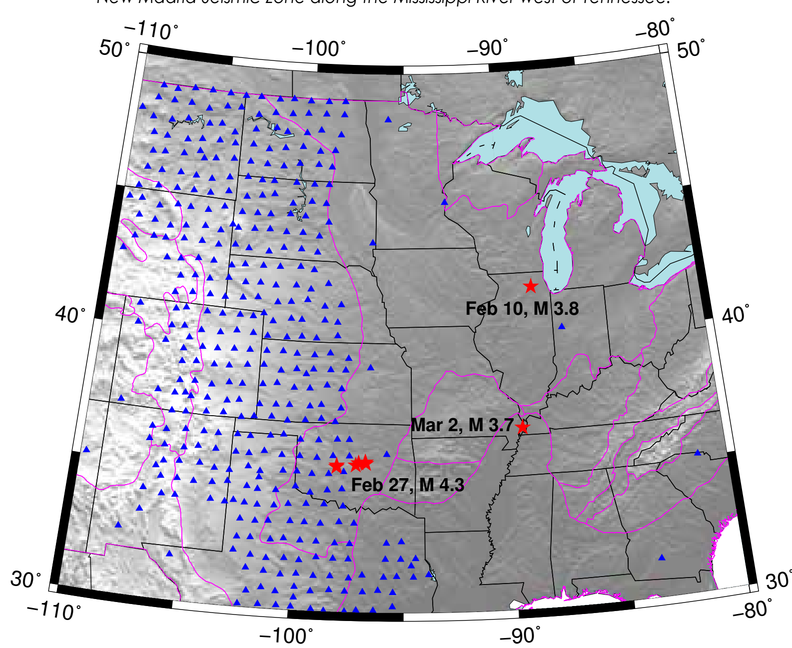
Initially, it was thought that the epicenter was by Hampshire, but the location was difficult to determine because of the scarcity of professional seismic stations in northern Illinois and surrounding states. Therefore the US Geological Survey, the authoritative government agency responsible for locating earthquakes, included recordings from educational seismometers residing in regional middle schools and universities to constrain the location of the event. As this information became available, the earthquake's epicenter and magnitude were revised two or three times before it was determined that the event occurred in Virgil.

This relatively small earthquake caused the public and the media to wonder how the event might be related to other small earthquakes in the Midwest, such as those that more frequently occur in the New Madrid Seismic Zone just south of Illinois or the series of six events that occurred recently in Oklahoma (see Figure 2-1). Scientific analyses of geological observations revealed that both Oklahoma and northern Illinois became part of North America around 1.7 billion years ago. The area was tectonically active for most of the subsequent few hundreds of millions of years – much in the same way that the western US has been growing in extent and height for the past 200 million years or so. But the Midwest has been relatively stable since a large volcanic event, the so-called mid-continent rift, occurred about one billion years ago. It is possible that some of the scars from this earlier tectonic activity now host the small earthquakes that occur from time to time throughout the Midwest. While these earthquakes relieve small amounts of stress in the relatively stable crust, the cause of small earthquakes in places like Illinois and Oklahoma, and those in the more active New Madrid Seismic Zone, is not entirely understood. The earthquakes in these parts of the Midwest may or may not have a similar origin.

As EarthScope and the Transportable Array move into and through the Midwest, scientists hope to learn more about the region's hidden ancient fault scars as well as the underlying, relatively rigid mantle. This knowledge will improve earthquake location and characterization in the Midwest and contribute to our understanding of the formation and evolution of the North American continent and the processes that cause earthquakes and volcanism. ■

By Suzan van der Lee and Xiaoting Lou, Department of Earth and Planetary Sciences, Northwestern University.

Figure 2-1. The locations of recent earthquakes in the Midwest are shown by red stars. The blue triangles are Transportable Array stations and the purple lines mark areas of similar geology and topography. The earthquake that occurred on March 2 lies in the New Madrid Seismic Zone along the Mississippi River west of Tennessee.



learn more about:
Web Sites

USArray
www.usarray.org
The web site for the seismic component of EarthScope.

EarthScope
www.earthscope.org
The web site for the EarthScope program.

IRIS Education and Outreach
www.iris.edu/hq/programs/education_and_outreach
Seismology-related classroom activites, information sheets, professional development for educators, seismographs in schools program and more.

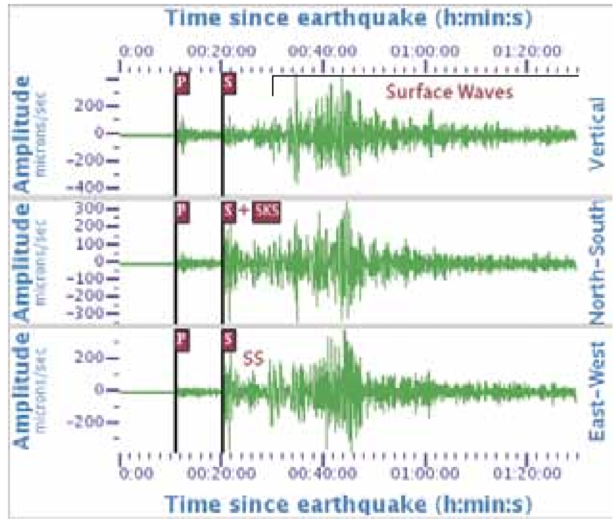
Seismic Monitor
www.iris.edu/seismon
Near-real-time, interactive map of earthquakes and seismic stations worldwide.

USGS Latest Earthquakes
www.earthquake.usgs.gov/earthquakes/recenteqsus/
Easy-to-view map of recent earthquakes in specific regions of the United States.

onSite
www.usarray.org/researchers/pubs
Download previous issues of *onSite*.

ask a seismologist:
How Do I Read a Seismogram?

Seismograms are records of motions that travel as seismic waves within the Earth. All seismic waves are variations of two types: P and S. Interpreting these waves teaches us much about the Earth.

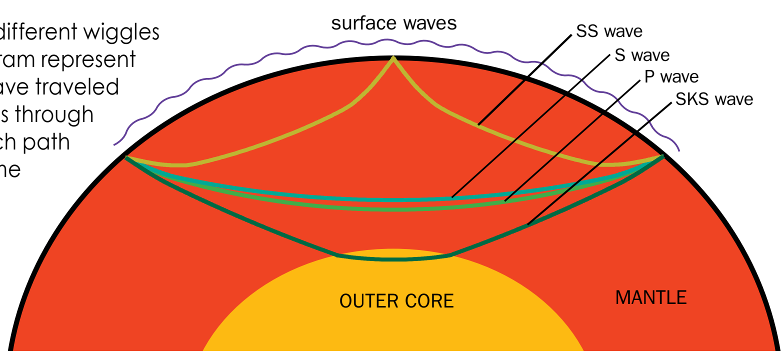


Seismograms from the magnitude 8.8 earthquake off the coast of Chile on February 27, 2010, as recorded by Transportable Array station 631A in Del Rio, Texas. The data are displayed by the Rapid Earthquake Viewer (http://rev.seis.sc.edu/).

Pick up a stick. Now close your eyes and start bending the stick. At some point the stick is going to break. How do you know when the stick breaks if you can't see it? First, you hear the stick break. What you just experienced is a P wave. When earthquakes occur, they cause compressional waves, or P waves, that behave just like the sound of the breaking stick. The snap pushes on the air, which pushes the next bit of air, and so on, all the way to your eardrum. Second, you feel the stick break. This is an S wave. Unlike P waves, S waves travel in a direction that is perpendicular to the motion at any point. You cannot hear the S waves because they only propagate through rigid materials – not in air or water. In the figure above, you can see the P and S waves labeled on the seismograms that recorded the Earth's motions in all directions (vertical, or up and down; north-south; and east-west) at a given location.

The paths that the P and S waves take through the Earth are shown in the figure below. There are many other waves that are recorded in the seismograms because the P and S waves break up into many different paths as they travel through the Earth. As you can see, some waves *reflect* off of the surface, like the SS wave. This is like an echo off of a canyon wall. Some waves pass through the Earth's core, like the SKS wave, bending as they pass between layers. The waves with the largest heights, or amplitudes, and which are the most spread out in time, are the rumbling *surface waves*. Sometimes waves travel different paths but arrive at the same time, like with the S and SKS waves shown here.

All of the different wiggles on a seismogram represent waves that have traveled different paths through the Earth. Each path is given a name composed of a series of letters that characterize how the wave traveled. The individual waves are very useful to geoscientists because they sample different regions of our planet. This allows us to learn more about the Earth's deep structure in regions where we will never be able to drill because the temperatures and pressures are too great. It is the Earth's structure that holds the key to extremely important unanswered questions about what our planet is made of, how it changes and evolves over time, and what the mechanisms are by which the continents move about the surface as part of the system of Plate Tectonics. By interpreting the many different P and S waves from many seismograms such as the ones shown here, we will have a much better idea of the geology of North America from the crust to the core. ■



The paths of the P, S. SKS, SS, and surface waves through the Earth.

By Michael Wysession, Department of Earth & Planetary Sciences, Washington University, St. Louis, Missouri.

earthscope

onSite

news from USArray

Incorporated Research
Institutions for Seismology
1200 New York Avenue, NW, Suite 800
Washington, DC 20005

EarthScope facilities are funded by the National Science Foundation and are being operated and maintained as a collaborative effort by UNAVCO Inc. and the Incorporated Research Institutions for Seismology with contributions from the US Geological Survey and several other national and international organizations. The EarthScope National Office at Oregon State University is supported by Grant No. EAR-0719204. This material is based upon work supported by the National Science Foundation under Grants No. EAR-0733069, EAR-0443178, EAR-0732947, EAR-0323700, EAR-0323938, and EAR-0323704. Any opinions, findings, 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.

***onSite* is published twice a year by the Incorporated Research Institutions for Seismology (www.iris.edu)**

To be added to or deleted from the mailing list, please send an email stating the action you wish us to take to: onsite@iris.edu or contact the *onSite* Editor, IRIS, 1200 New York Avenue, NW, Suite 800, Washington, DC 20005, Tel: 202-682-2220, Fax: 202-682-2444. Be sure to include your name, complete mailing address, telephone number, and email address.

Editor

Perle M. Dorr
dorr@iris.edu

Designer

Rick Callender
callender@iris.edu

US Ground Motion From Chile Earthquake

This figure shows the vertical movement from waves travelling from the February 27, 2010, magnitude 8.8 Chile earthquake at 407 Transportable Array stations (green rectangle). The stations recorded about 1 cm of ground motion. Note the paths of the surface waves as they travel multiple times around the Earth. ■

Image courtesy of Rick Aster, New Mexico Tech.