

Winter 2014

EarthScope News

Call for Speakers

The EarthScope National Office is now accepting nominations for its 2014-2015 Speaker Series.

Each of the five selected Speakers will present his or her EarthScope related research findings at five colleges and universities over the 2014-2015 academic year. Travel expenses for speakers are supported by the EarthScope National Office.

For more information on qualifications and to submit a nomination, please visit www.earthscope.org/speakers.

Workshop for Interpretive Professionals

28-30 April, 2014 - Anchorage, Alaska

The EarthScope National Office will host a three-day workshop for interpretive professionals at the Alaska Science Center in Anchorage. The workshop will feature expert presentations and collaborative activities to help participants use EarthScope findings to convey the story of the geologic setting, landscape, and natural hazards of the region. The workshop will focus on the 1964 Great Alaskan Earthquake and include a field trip to view evidence and damage from the event in Anchorage and the surrounding area.

For more information or to apply for this workshop, visit www.earthscope.org/workshops/spring2014interpretive

USArray Reaches the East Coast

Maureen Long, Yale University, and Vadim Levin, Rutgers University

On October 1st 2013 the seismic and magnetotelluric observatory network USArray, which is a key element of the EarthScope project, reached an important milestone – the final Transportable Array (TA) station installation in the contiguous United States. TA stations record seismic waves from earthquakes, as well as mining blasts, meteorite impacts, hurricanes, tornadoes, and even breaking surf along the coasts. Similar to a large telescope scanning the sky, the EarthScope Transportable Array will have completed the first-ever high-resolution “scan” of the contiguous United States by 2015.

The EarthScope Project aims to build a new level of understanding of the structure and history of the North American continent. Its inter-related scientific goals include: a) understanding the present-day structure and properties of geological features at depth; b) understanding the history of these features; and c) understanding the mechanisms that shape geologic features, form mineral resources, and give rise to natural hazards. Using a variety of geophysical methods researchers can explore Earth's interior structure (Figure 2) and evaluate basic physical properties of the materials that make up the Earth. By linking the geology and features seen on the Earth's surface to these new images of the Earth's interior, the complicated geologic history of the continent can be unraveled. Additionally, comparisons between areas where geological processes are obviously active (such as California and the Pacific Northwest) and areas where they are apparently dormant (such as the mid-continent plains and the Appalachian mountains), provide a way to understand ongoing tectonic processes and reconstruct past events. The USArray network moved from west to east, and has now successfully covered the entire contiguous US and parts of Canada. Data collected have already yielded transformative findings, both anticipated and unforeseen. For example, detailed images of the Juan de Fuca/Farallon slab sinking into the mantle beneath the western part of the continent has inspired new views of the tectonic history of North America. The clear evidence of warm and electrically conductive material trailing west from Yellowstone further supports a hot spot interpretation. The near-circular pattern of upper mantle anisotropy beneath the western US is now defined in fine detail, allowing a more comprehensive assessment of mantle dynamics. Multitudes of small earthquakes have been detected illuminating geological activity of the shallow crust. Among the unexpected findings, one of the most notable and exciting is the phenomenon of the episodic tremor and slip beneath Cascadia.

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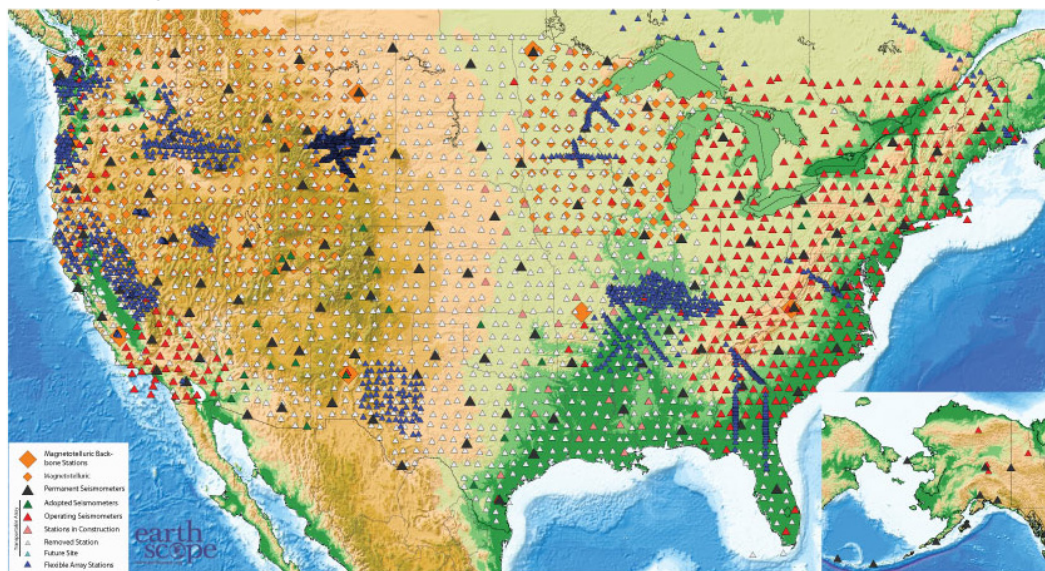


Figure 1. Stations of the Transportable Array (active stations in red, previous locations in white), Magnetotelluric Array (orange), along with historic and current Flexible Array (FA) seismic experiments (blue).

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USArray in the East - Imaging a not-so-passive margin

For a region where tectonic forces last acted nearly 200 million years ago, the eastern margin of North America displays remarkable vigor with rugged topography, substantial earthquakes (e.g., the M=5.8 earthquake in Mineral, VA in August 2011), and even relatively recent (~40 Ma) volcanic activity. The East Coast of the US and Canada is considered a passive (inactive) continental margin. It records two full supercontinent cycles of formation and destruction of mountains linked to the separating and re-assembling of past continents. The geologic signatures of these events are preserved in the rocks of the Appalachians, within the sediments of the coastal plain, and in the deeply buried rocks of the continental mass. By revealing the details of the deep structure beneath the continent and linking them to surface features, the EarthScope project will help address long-standing puzzles in the region, such as the reasons the Appalachian mountains are so high 200 Ma after their formation, and the role pre-existing structures play in controlling subsequent tectonic events. Home to nearly 40% of the North American population, this region is also a locus of significant levels of risk from natural hazards, both abrupt (earthquakes, hurricanes) and gradual (sea level rise).

Looking ahead - The best of EarthScope is yet to come

The great success of EarthScope in the western United States underscores even greater potential for the future. In two years, the main technical goal of EarthScope's seismic Transportable Array (TA) will be accomplished; observations of seismic waves crossing the North American continent will be obtained every 75 km over its entire mid-section. In addition to the synoptic imaging provided by the TA, more detailed imaging will result from targeted experiments using the Flexible Array (FA), including ongoing and upcoming experiments in eastern North America. FA experiments focus on important individual scientific targets, including the Mississippi Embayment, the New Madrid and Wabash Valley seismic zones, the Appalachian Mountains, and ancient suture zones in the southeastern and northeastern US (extending into the Superior Province of Canada). The eastern margin of the continent also provides a compelling target for other types of investigations such as the magnetotelluric (MT) component of USArray. As the USArray dataset in the lower 48 states is completed, EarthScope scientists anticipate that the resolution of the subsurface structure will improve by nearly an order of magnitude. Figure 2 illustrates this well, with regions already sampled displaying small-scale structure lacking in our "view" further east. A new comprehensive view of the North American continent and the mantle beneath it will most likely challenge the current thinking about the formation and destruction of continents, the longevity of mountain ranges, and the birth and demise of ocean basins. On the practical level, our understanding of where to look for natural resources, how to mitigate seismic hazards, and how high to raise near-shore houses will all be impacted. The key to understanding our societal future may very well lie in our tectonic past.

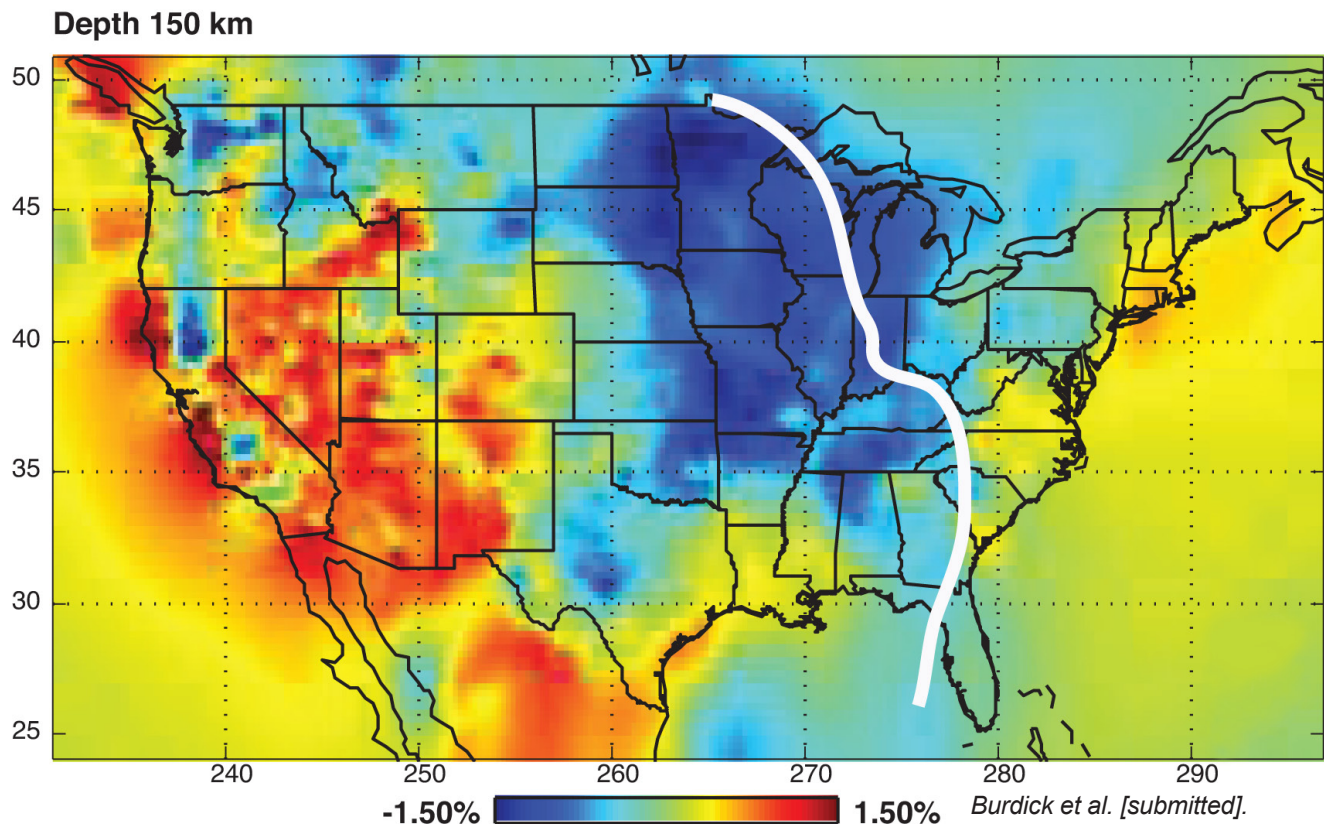


Figure 2. Upper mantle structure at a depth of 150 km from the P wave tomography model of. Colors indicate wavespeed variations from a background model, with relatively faster regions indicated in blue and relatively slower regions indicated in red. The thick white line indicates the approximate eastward extent of the well-resolved region of the model. West of this line, TA data have been included in the inversion; east of this line, the model resolution will be improved in the future.

Hitting Hot Water with PBO Borehole Strainmeters in the Yellowstone Caldera

Glen Mattioli and David Mencin, UNAVCO

Data from the Yellowstone Gladwin Tensor strainmeter (GTSM) network are improving the understanding of the structure of the Yellowstone Caldera. In 2009, network operators at UNAVCO noticed a signal in the Yellowstone strainmeter network that was ultimately identified as a lake-seiche in Yellowstone Lake. Strain observations from these seiches coupled with model output provide evidence for the presence of partially molten material in the upper crust. This is consistent with seismic tomography studies that inferred 10%–30% melt fraction in the upper crust, providing independent evidence for the melt.

UNAVCO brought the Yellowstone Caldera network of the Plate Boundary Observatory (PBO) back up to five sites in September–October of this year with the installation of site B950, a GTSM near Norris Geyser Basin in Yellowstone National Park. This was the culmination of an effort that began three years earlier when lightning struck site B205, causing the downhole instrumentation irreparable damage. Drilling the new site was not without some hot spot antics; the drilling crew abandoned a first hole, B949, at a depth of 500 feet when temperature logs revealed groundwater at 86 C, well above the maximum temperature limit for the GTSM instrument. A second hole, B950, was drilled within 15 feet of B949, to a depth of 370 feet. The normal suite of PBO borehole geophysics instrumentation was installed at a temperature of 59 C. In addition a steel temperature pipe was installed in the B949 borehole to allow for future temperature measurements to depth of up to 497 feet.

PBO GPS sites and boreholes, which contain strainmeters, seismometers and tiltmeters, represent the complete geodetic assets used in the Yellowstone Volcano Observatory. The UNAVCO drilling in Yellowstone (7 boreholes in 2007–2008 plus 2 in 2013) represent the only scientific drilling to these depths in the Park since 1967–1968 when the USGS drilled 13 boreholes to depths ranging from 215 to 1088 feet. Detailed notes, temperature and geophysical logs, water, and cutting samples were collected during drilling, adding valuable physical data products alongside data from the instrumentation. More information about PBO Borehole Strainmeter Data Products can be found at: <http://pbo.unavco.org/data/bsm>.



Happy New Year from UNAVCO!

Hot New Science

In each *inSights*, we highlight a few recent EarthScope-related publications. Please submit your latest publications to earthscope@asu.edu

Anja Schleicher, Ben van der Pluijm, L. N. W. (2013). Smart Clays: SAFOD Samples Confirm the Key Role of Newly-formed Clays in Shallow Fault Zones. In American Geophysical Union Fall Meeting





Catherine D. de Groot-Hedlin, Michael A.H. Hedlin, K. T. W. (2013). Detection of gravity waves across the USArray: A case study. *Earth and Planetary Science Letters*

Frohlich, C., & Brunt, M. (2013). Two-year survey of earthquakes and injection/production wells in the Eagle Ford Shale, Texas, prior to the 20 October 2011 earthquake. *Earth and Planetary Science Letters*, 379, 56–63. doi:10.1016/j.epsl.2013.07.025

Merino, M., Keller, G. R., Stein, S., & Stein, C. (2013). Variations in Mid-Centroid Rift magma volumes consistent with microplate evolution. *Geophysical Research Letters*, 40(8), 1513–1516. doi:10.1002/grl.50295

Robert W. Porritt, Richard M. Allen, F. F. P. (2013). Seismic imaging east of the Rocky Mountains with USArray. *Earth and Planetary Science Letters*

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inSights is a quarterly publication showcasing exciting scientific findings, developments, and news relevant to the EarthScope program. Contact earthscope@asu.edu to be added or deleted from the hardcopy mailing list; electronic copies are available at www.earthscope.org. Editor: Devon Baumbach ASU/EarthScope National Office.

New Flexible Array Video Series

Geology might not be the first thing that comes to mind if you heard the names SESAME, CAFÉ, SUGAR, and OIINK, but these are just a few examples of the acronyms for focused research projects utilizing the USArray's FlexArray (FA) and GPS instruments that are part of EarthScope. The FA allows for higher resolution examination of a select region to answer specific questions such as: Why did the mid-continental rift fail? How does the Cascadia subduction system work? How do mountain building events affect plate interiors? What is the actual subsurface geometry of the San Andreas Fault, how deep are the surrounding sediments, and how do they effect the behavior of the fault? These are just a few of the many questions that researchers are exploring.

The EarthScope National Office is proud to announce the introduction of a video series highlighting several of these projects. Go to earthscope.org/science/fieldstudies to watch episodes and learn more.

