

What is earthscope ?

www.earthscope.org

WHAT EarthScope is a grand science experiment exploring the structure and evolution of the North American continent.

WHY EarthScope produces fundamental scientific knowledge that can also be applied to societal relevance and interest. EarthScope benefits preparedness, response, and risk resiliency from hazards, earthquake early warning, volcanic eruptions, and volcanic ash plume warnings. It contributes to understanding induced seismicity, ground changes due to fluid injections and extraction, soil moisture measurements, snow depth measurements, assessing forest fire potential, and tracking space weather.

WHO The complexity of geologic processes requires contributions from investigators across the Earth sciences, working both as individuals and as members of multidisciplinary collaborative teams. EarthScope also has a broad network of informal educators at national, state, and local parks and monuments, and its data and understanding are essential for Earth science education. EarthScope has an open access data policy and a suite of data users from the commercial and government sector.

HOW EarthScope is gathering scientific information from its multi-disciplinary observatories.

USArray The USArray is a network of seismic instruments placed throughout the United States and Canada. This network includes a transportable array of 400 seismometers currently positioned in the eastern US (heading to Alaska in 2014) as well as additional seismometry arrays for focused regional studies and a magnetotelluric array for measuring electric and magnetic fields emanating from Earth's interior. These data can be used to address questions in earthquake physics, volcanic processes, core-mantle interactions, active deformation and tectonics, continental structure and evolution, geodynamics, and crustal fluids.
USArray is maintained by IRIS at www.usarray.org

The Plate Boundary Observatory PBO is a geodetic observatory that uses GPS, borehole geophysics, laser strainmeters, tiltmeters, and meteorological instruments to study changes along the Pacific and North American plate boundary, changes along faults, volcanoes, and other solid Earth structures. It can also be used to measure changes in the atmosphere, ice mass in glaciers and ice sheets, and water mass in the surface (e.g. soil moisture and snow depth) and subsurface (e.g. aquifers).
PBO is maintained by UNAVCO at http://pbo.unavco.org

San Andreas Fault Observatory at Depth A 3-kilometer deep hole drilled into the San Andreas Fault. SAFOD provided the first opportunity to directly observe the conditions along a fault under which earthquakes occur and to collect rocks and fluids from the fault zone for laboratory study. Core samples from SAFOD are housed and maintained by the Gulf Coast Core Repository at Texas A&M (http://iodp.tamu.edu/curation/gcr/index.html).

EarthScope is supported by the National Science Foundation and has numerous partners including the USGS and NASA, and an active scientific community.

UNAVCO IRIS NSF NASA USGS


Education and Public Outreach

Events EarthScope science has been represented at the local scale through the Speaker Series and monthly public science education nights; nationally at events such as the US Science and Engineering Festival; and globally in conjunction with The Great Shakeout.

Workshops The EarthScope National Office has hosted eight regional workshops for informal educators. These workshops have been an invaluable resource for informal educators as they educate the public on Earth science topics. Many other EarthScope-sanctioned workshops have been conducted across the country and have had participants from both informal and formal education realms.

Educational Content EarthScope's science targets are ideally suited for place based Earth science education. EarthScope E&O teams have developed valuable educational materials and assessed their efficiency.

Website The National Office created and maintains a dynamic web presence that includes resources for scientists, educators, and students www.earthscope.org.

Social Media The EarthScope National Office has been a pioneer in utilizing social media resources to build communities within both the scientific community and the public. Find us on Facebook, Twitter, LinkedIn, Pinterest, Google+ and YouTube.

Collaborations EarthScope collaborates with many other organizations such as IRIS, UNAVCO, the USGS, GeoPRISMS, OpenTopography, and SCEC to create educational materials, organize workshops for educators and students, create on-line resources, and disseminate current EarthScope-related discoveries and data.


For more information, contact the EarthScope National Office at
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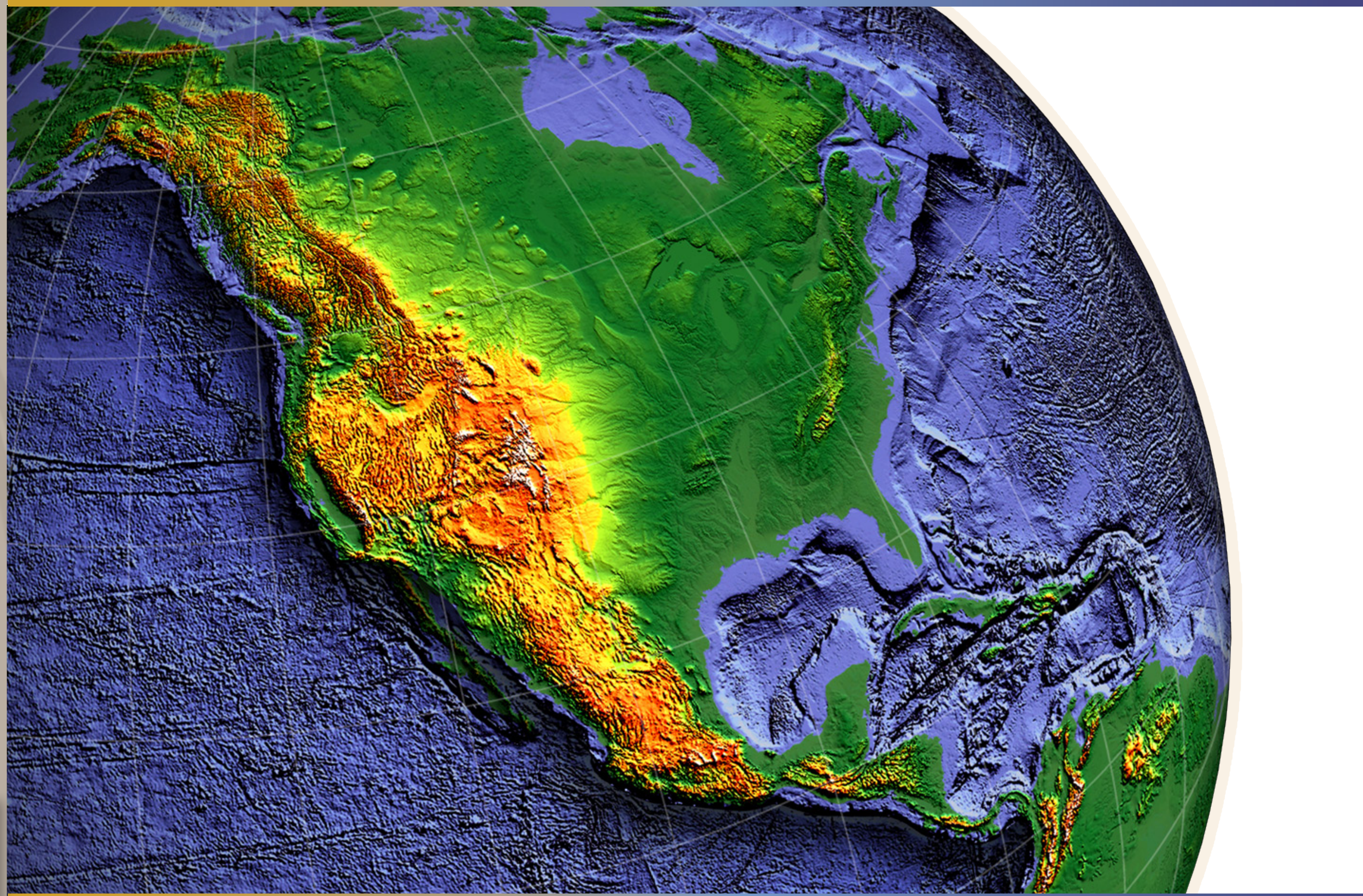
earthscope

www.earthscope.org

Celebrating a Decade of Discovery

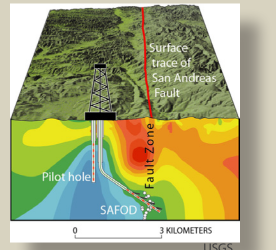


"This has been a spectacular success."
- Physics Today

"The number one most epic project in the Universe..."
- Popular Science

"...the project has revitalized the whole seismology community"
- Physics Today

Exploring an Active Fault

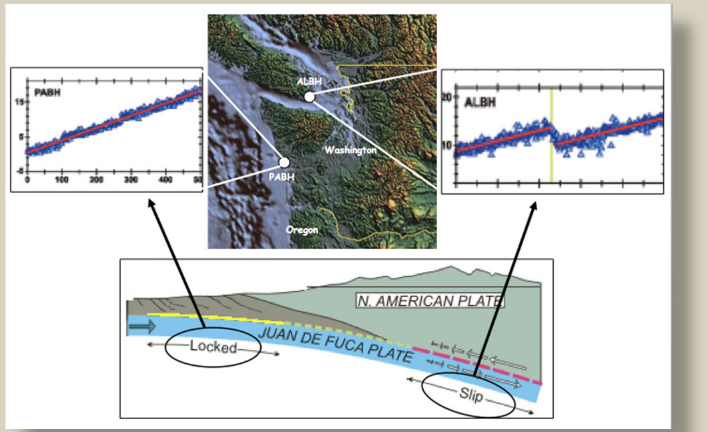


USGS

SAFOD is a 3.2 kilometer drillhole through the San Andreas Fault in California. This deep drilling component of EarthScope addresses fundamental questions about processes that control faulting and earthquake generation within a major plate-boundary fault. Rock and fluid samples from the drillhole supports physical and chemical investigations of the active earthquake zone. Below Left: Cored rocks from across the San Andreas Fault at 3 km depth. Very fine coatings of clay weaken the fault and control earthquake rupture.

What is Episodic Tremor and Slip?

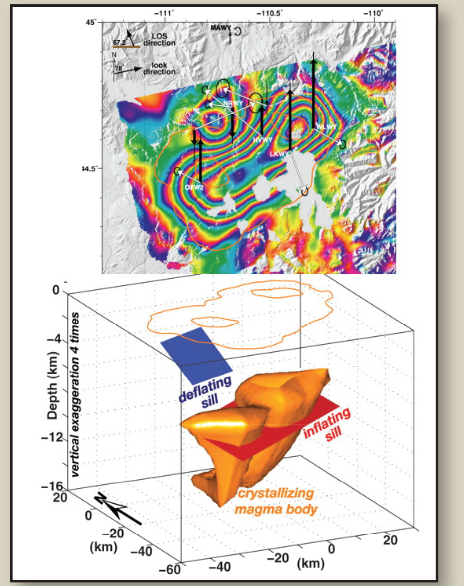
Earthscope instruments have been invaluable in recording and predicting Episodic Tremor and Slip (ETS) events in the Pacific Northwest, an area facing significant earthquake hazards. This newly discovered fault motion gives scientists an unprecedented opportunity to study the fundamental mechanics of the earthquake cycle. Analyses of these slow slip events have also shown that the probable area of strong earthquake shaking extends much closer to major population centers than previously thought.



UNAVCO

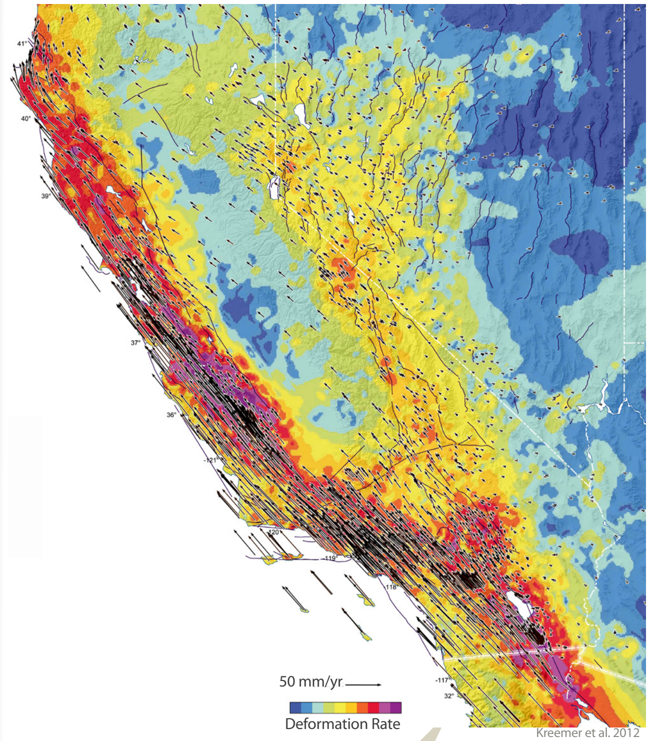
Imaging Volcanic Plumbing

The high resolution of EarthScope data has allowed researchers to image the underground plumbing systems of active volcanoes like Mt. St. Helens and Yellowstone, as well as measure in real-time minute changes in the ground surface that occur as a result of active volcanic processes. A better understanding of the architecture of these complex systems will help scientists assess the threat posed by these active volcanoes. Top Right: Satellite RADAR (INSAR) mapping shows changes in surface elevation above the Yellowstone magma chamber. Bottom Right: a 3D rendering of the magma chamber with two zones where magma is moving along planes, orange outlines Yellowstone caldera.



Chang et al. 2007

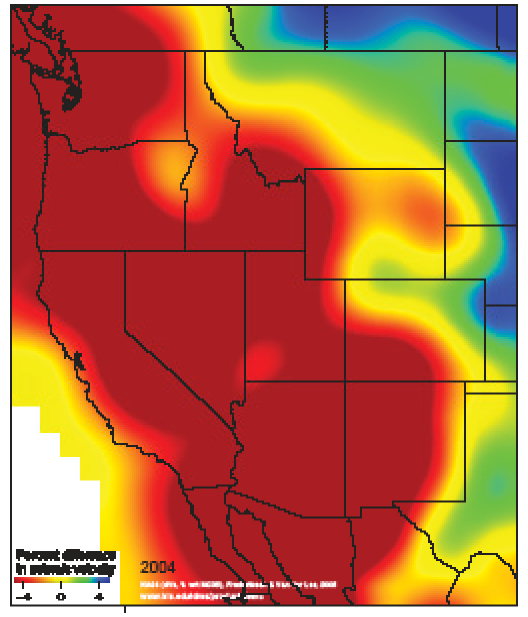
Western US Shearing



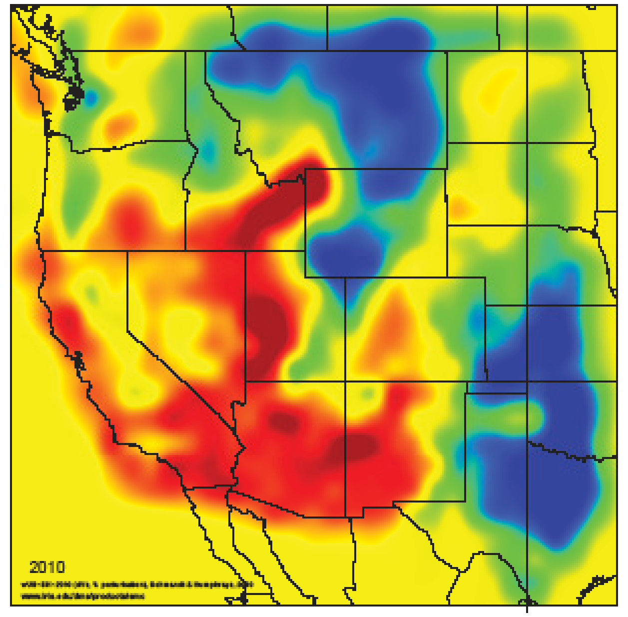
Kreemer et al. 2012

The Western US: Seismic Velocities at 90 km Depth

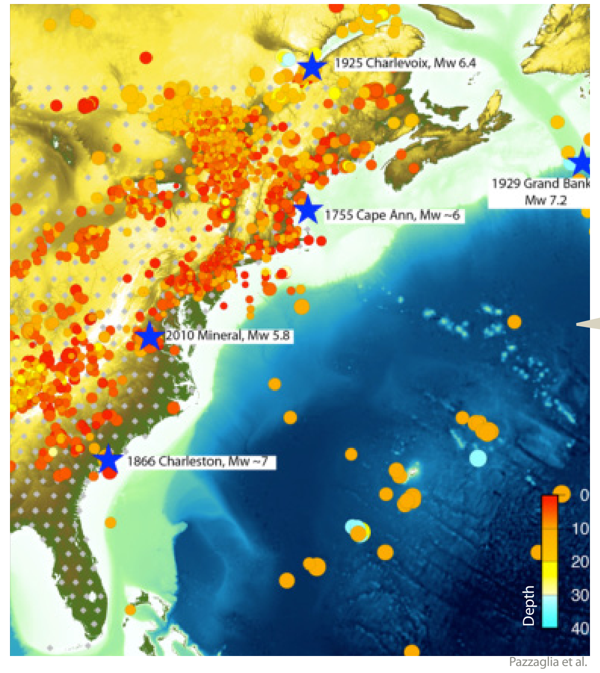
Pre-EarthScope



EarthScope



Eastern Earthquakes 1970-2011



Pazzaglia et al.

Silent Seismicity

The Passive Aggressive Eastern US

The magnitude 5.8 earthquake that struck Mineral, VA on August 23, 2011 serves as a reminder of the all too real, yet seldom discussed seismic hazards of the Eastern and Central United States. The deployment of the Transportable Array over this ancient geologic terrain provides an opportunity to better understand fault structures in the East, while simultaneously improving earthquake awareness and preparedness.

Below, scaffolding surrounds the Washington Monument, damaged by the 2011 quake.

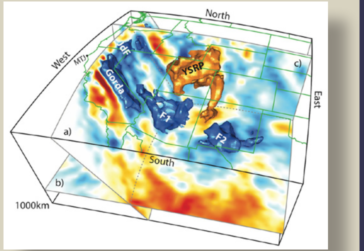

NPS

Doing the Twist - PBO and Continental Deformation

Plate Boundary Observatory GPS stations are actively monitoring real-time distortion of the western United States. Measuring this movement of the terrain leads to a better understanding of how stress is built, released, and transferred between fault zones and surrounding regions. Vector arrows on the map show the annual rate and direction of movement.

The Maps that are Changing the World

The map above illustrates the vast improvement in data quality and quantity provided by EarthScope sensors. At left: a pre-EarthScope map of rock density under the western US. At Right: The same map incorporating data from the EarthScope Arrays. As more data are processed, resolution will continue to improve. Right: A 3D model of the mantle from the same data set.



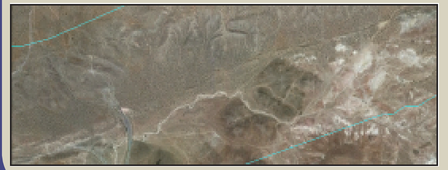
The high density and large geographic footprint of EarthScope's instrument arrays have allowed scientists to map faults deep beneath the earth's surface in unprecedented high definition, leading to better understanding of the evolution of the continent, how energy propagates along fault surfaces, and how fault geometry affects surface shaking.

An Eye in the Sky - Finding Faults with LiDAR

High-resolution mapping with EarthScope LIDAR data has transformed our understanding of the history and frequency of earthquakes in the American west. LIDAR is a powerful tool that can highlight subtle features in the landscape and allow geologists to make critical observations about geologic structures like faults and volcanoes.

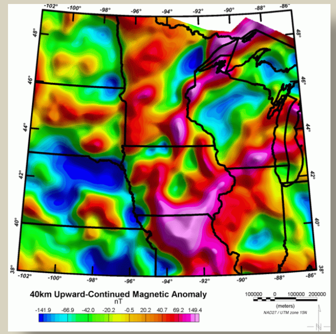
Below Left: Google Earth image of the Garlock Fault between Rt 395 and Trona Rd in California

Below Right: EarthScope LIDAR image of the same area. Red lines show strands of the Garlock Fault.



Breaking Up Is Hard To Do

EarthScope data revealed the presence of an ancient failed rift system, similar to the modern East African Rift, stretching from Lake Superior all the way to Oklahoma and Alabama. The discovery of the extent of the rift was key to solving one the biggest geologic mysteries in the Midwest, explaining the presence of a large gravitational anomaly and masses of volcanic rocks buried below the surface. This map of the anomaly shows the massive scale of the rift, which may be related to breaking apart of North and South America over a billion years ago.

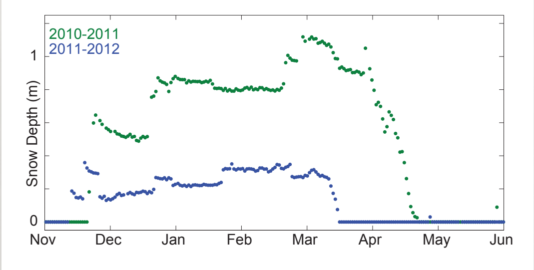


SPREE

Bonus Round! Novel Uses of EarthScope Data

Tracking Drought

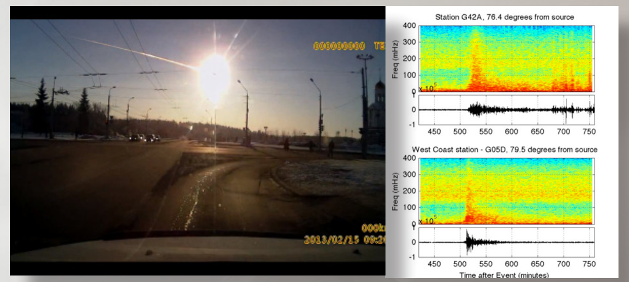
"Background noise" from PBO GPS station signals has been used to measure snow depth, how wet the soil is, and how fast the vegetation is growing. These kinds of data are used by climate scientists to model the water cycle and by water managers to mitigate drought. Right: Two years of snow pack measurements from PBO GPS station P101 near Randolph, UT. The lower levels of snowfall in the winter of 2011-2012 preceded a summer of severe drought in much of the western US.



'Hearing' Meteorites

The TA's pressure sensors recorded the atmospheric shockwave from the explosion of the Chelyabinsk Meteorite on 15 February 2013. The wave crossed the United States at a speed of approximately 270 meters per second, circling the globe and returning to Chelyabinsk in 35 hours.

Right: Recordings of the event from TA stations G42A and G05D. Left: Footage from a vehicle camera records the entry path and disintegration of the meteorite.



Earthquake Early Warning

Streaming data from PBO GPS stations are being used to develop an early warning system in California in collaboration with Caltech, UC Berkeley, and the USGS. Displacement of the stations will be assessed in the first seconds of an earthquake to estimate magnitude and provide vital early data to emergency personnel and the general public. Sensors need to be added in California to shorten the sensor spacing to approximately 12 miles to facilitate timely earthquake early warning.

Right: A GPS antenna in southern California.


USGS

Extreme Weather

The Transportable Array documented ground motion changes due to Hurricane Sandy; the pressure in the eye of the storm was so low that the ground lifted in response. The image below shows the TA sensors and the ground vibrating in the up-down direction (red dots) as the hurricane approaches (offshore concentric circles). As the hurricane approaches, the stations furthest south start vibrating; as it sweeps north, the entire TA lights up with activity, and eventually returns to normal as the hurricane moves on land and loses its energy.