earth scope

inSights

the EarthScope newsletter

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Continued from front page

events include clusters in the Charlevoix region, the greater New York City area, the Reading-Lancaster seismic zone, and the Central Virginia seismic zone. While it is generally assumed that seismicity is occurring along zones of pre-existing weakness aligned with structures associated with previous plate collisions and rifting, we lack both a comprehensive model to explain the distribution of seismicity, spatially or through time, and the necessary observations to formulate adequate seismic hazard maps.

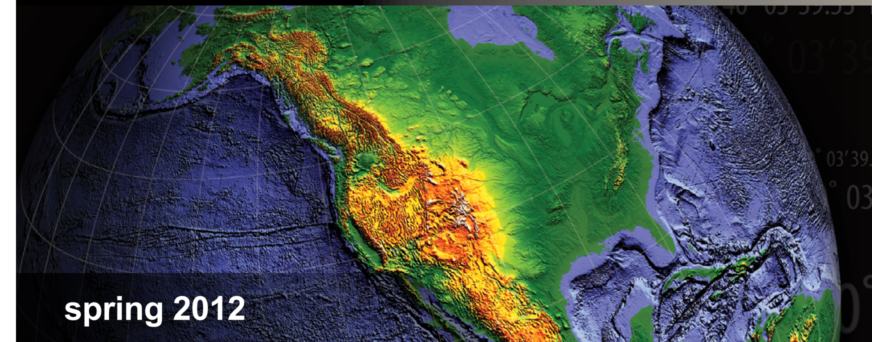
The Mineral earthquake occurred at the northern edge of the Central Virginia Seismic Zone and its relationship to mapped faults is ambiguous. Moment tensor solutions indicate reverse slip along a NE-SW striking SE dipping fault plane. Aftershocks show that the fault extends 7-9 km along strike at depths from 1-7 km. Moderately heavy damage occurred in the epicentral zone of Louisa County southwest of Mineral. Significant damage occurred to many houses and three schools in the epicentral area, with minor damage at the nearby North Anna nuclear power plant. Farther north, the Washington Monument and the Washington National Cathedral were closed pending inspection and repair. Given the major population centers and critical infrastructure located in the northeast corridor of the U.S., better understanding of deformation and stress release on both short and long time scales will have significant societal benefits.

by Frank Pazzaglia et. al. (see online version for more details)

EarthScope Community **Outreach**

The EarthScope National Office has been busy working with the scientific community this fall at the Geological Society of America (GSA) conference in October and the American Geophysical Union (AGU) conference in December. We are excited to report that there were 49 EarthScope-related presentations at GSA and 74 at AGU. EarthScope also hosted a well-attended Town Hall meeting at AGU with NSF EarthScope Program Director, Greg Anderson.

The EarthScope National Office participated in ASU's annual Homecoming Block Party in October and the Earth and Space Exploration Day (see image below), an event hosted by the School of Earth and Space Exploration to engage children in STEM (Science, Technology, Engineering, and Mathematics) disciplines, in November. Through these four community outreach events, EarthScope reached well over 3,000 visitors.



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spring 2012

EarthScope News

Over 115 people attended the EarthScope Town Hall meeting at AGU in 2011. It provided an opportunity to update the community on significant EarthScope developments and for community members to exchange ideas and provide feedback on the EarthScope program.

EarthScope presents a four-day **Workshop for Interpretive Professionals in the Central Appalachian Region** at James Madison University that features presentations by prominent geoscientists and interpretive professionals to help convey the story of the magnificent landscapes, geological stories, and natural hazards of the Central Appalachian Region. Details at http://www.earthscope.org/workshops/appalachians.

In conjunction with the bicentennial of the New Madrid earthquakes of 1811-1812, the **New Madrid Seismic Zone** content set for the Active Earth Monitor is now available. Explore the geologic setting and seismic history of the region, learn about current research being conducted, and read historical accounts from eyewitnesses. For more information, visit http://www.iris.edu/hq/programs/education_and_outreach/museum_displays/active_earth/.

Mineral, VA Earthquake Demonstrates the **Passive Aggressive Margin** of Eastern North America

On August 23, 2011, the Mw 5.8 Mineral, Virginia, earthquake rocked the east coast of the U.S. While moderate in comparison to recent mega-thrust events in Japan, Chile, and Sumatra, and perhaps regular fare to those living on the active plate boundary in the western U.S., this earthquake serves as a reminder that seismic hazards on the east coast are real and not well documented. Ground shaking associated with the event was felt over a larger region of the U.S. than any previous instrumentally recorded earthquake due to efficient energy propagation through crystalline bedrock that underlies much of the eastern margin of the U.S. Felt reports of ground shaking in the U.S. extended from Georgia to Maine and west to Detroit and Chicago. The earthquake was also felt in southeastern Canada from Montreal to Windsor. Observations from temporary portable seismic deployments to record aftershocks in the wake of the earthquake, the installation of two new permanent GPS sites, and the arrival of EarthScope's Transportable Array on the east coast (Figure 1) present new opportunities to better quantify deformation, raise awareness of earthquake hazards, and motivate improved earthquake preparedness in eastern North America.

Community response and open data. Immediately following the earthquake, teams from the USGS, IRIS PASSCAL, Virginia Tech, Lamont-Doherty Earth Observatory, the University of Memphis, and Cornell University deployed instruments to record aftershocks and deformation in the wake of the earthquake. Under the coordination of the USGS, 57 seismometers, with a combination of intermediate- and short-period sensors, were installed at 47 sites. Between August 27 and September 9, 2011, an additional 117 EarthScope Flexible Array "Texans" were deployed as a series of densely spaced linear arrays (200-400 m station spacing over distances of 7 to 12 km) and 30 "Texans" were deployed as 3-component stations in a 60-km linear array. This effort, termed AIDA (Aftershock Imaging with Dense Arrays), is the first time so many densely spaced instruments have been deployed in the wake of a significant event. An important addition to the seismic deployment is two new semi-permanent PBO-quality GPS sites, one on each side of the rupture plane, installed in November 2011.

Nineteen of the seismic stations have real-time telemetry allowing for near real-time location of aftershocks and moment tensor solutions. Thirty-five sensors, a combination of intermediate-period and strong ground motion instruments, are still in the field and will record data through the winter. Data from real-time seismic stations are available through the IRIS DMC. The complete data volume, both real-time and stand-alone seismic stations, and the AIDA data will be archived at the IRIS DMC after completion of the deployment and made available for analysis by the broader community. GPS data will be available from UNAVCO.

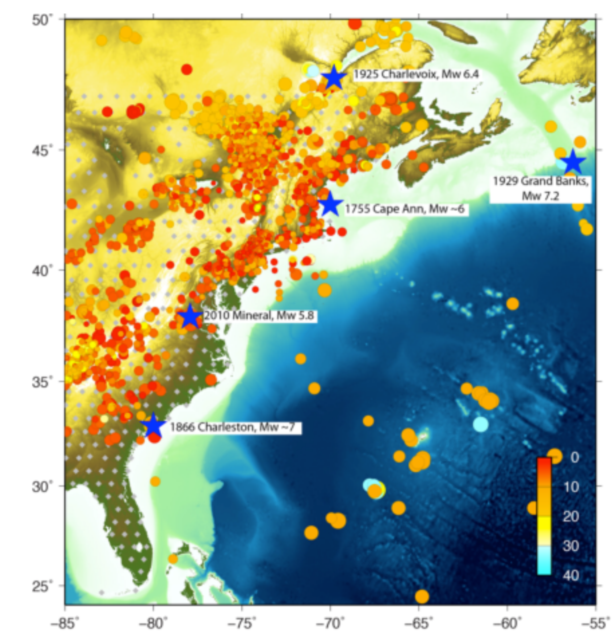

Figure 1: East coast seismicity, 1970-2011. Epicenters from NEIC, LCSN, and CERI catalogs (merged catalogs, no overlap). Historic large magnitude events shown by blue stars. Future USArray TA stations shown by gray diamonds. (Pazzagalia et. al.)

The enigma of passive margin deformation. Passive margins are not tectonically quiescent. Geomorphic and paleoseismic data hint at active but poorly understood tectonic processes. Moderate earthquakes occur in diffuse seismic zones spanning the continental margin. The largest magnitude historical events include the 1929 M 7.2 Grand Banks, 1933 M 7.3 Baffin Bay, 1886 M ~7.0 Charleston, and 1755 M ~6.0 Cape Ann earthquakes. Locally dense concentrations of lower magnitude

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USArray Status

The Transportable Array (TA) continues to roll eastward across the U.S. Having crossed the Mississippi River in March 2011, the TA will reach the Atlantic Coast in February 2012. Thus far, over 1300 sites have been commissioned in 31 states. About 800 of these sites were removed after two years of service; however, some 50 stations have been "adopted" and continue to operate with new owners. Data quality and reliability of TA stations remain high as sites are installed in different geologic regions; data availability consistently exceeds 95%. Recent station design enhancements include the use of a new rotomolded vault and the deployment of an atmospheric acoustic sensor package consisting of a high-performance barometer and an infrasound microphone. The Flexible Array (FA) instrument pool continues to be heavily utilized. In early 2011, it furnished its entire supply of Texan seismometers and a considerable number of additional instruments for the Salton Seismic Imaging Project. This experiment, one of EarthScope's largest, was executed with help from Array Operations Facility staff and numerous student volunteers. The permanent magnetotelluric (MT) observatory continues to telemeter raw data from its seven stations. The MT transportable array completed its multi-year deployment in the northwest quadrant of the US and began operations in the Mid-Continent Rift region. The TA Student Siting Program continues to engage students in EarthScope. Last summer, students identified about 200 sites for future stations across southernmost Canada, the Midwest, and the Southeast. Other outreach activities and products include content development for the Active Earth Monitor in collaboration with the EarthScope National Office, UNAVCO and CERI, creation of wave visualization movies, and interaction with local and regional news media. Filmed in summer 2010, the TA, EarthScope and seismic tomography were prominently featured in the National Geographic Channel special, "X-Ray Earth," that aired in May.

by Perle Dorr, IRIS

Figure 2: An atmospheric acoustic sensor package (enclosure in the lower right houses the ports for the high performance barometer and an infrasound microphone) installed at a Transportable Array station. The data from these sensors are openly distributed in the same manner as all Transportable Array data. (This work is in collaboration with an NSF MRI-R2 grant to the University of California, San Diego.)

SAFOD Status

Since the completion of SAFOD Phase III drilling in September 2007, scientists at laboratories around the world have been analyzing the core retrieved from two actively-creeping fault strands penetrated in the SAFOD borehole. Results from the second round of sample distribution, which included the first large samples of fault core, have yielded at least 14 peer-reviewed papers with an additional four currently in press, and multiple papers are in the process of being submitted. The third round of sample distribution began in December 2011, highlighted by the release of the most requested core recovered in SAFOD drilling. Core G27 is from the Southwest Deforming Zone and places sheared serpentine directly adjacent to a 1.5-m wide sheared gouge zone (Figure 3). Work is underway to distribute these highly desired samples to scientists who will study mineralogy and chemistry, deformation microstructures, permeability, and other mechanical properties. Recent experimental results have shown that the main zone of active slip is extremely weak, with friction $\mu < 0.1$, and that recovery of friction following slip (so called frictional healing) is extremely slow. Detailed analysis of the core has shown the important role of pressure solution, the presence of past seismic activity, and the role of authigenic clay growth and shear fabric on fault behavior. Publications related to SAFOD, along with other Earthscope-related publications, can be found at: http://www.earthscope.org/publications/2011.

by Brett Carpenter, SAFOD

Figure 3: This is a cropped image of core G27 from the Southwest Deforming Zone. Note the transition from black shale, through sheared serpentine, into foliated fault gouge (left to right). (Zoback et al., 2011).

PBO Status

In September 2011, Plate Boundary Observatory field engineers installed a web camera at GPS station P101 to support validation tests for snow effects on reflected GPS signals. Station P101 is installed at Randolph, Utah (see image at left). Previously, web cameras have been added to a small subset of PBO stations as a cost-savings tool for helicopter operations. However, web cameras are now being used for validation testing for snow studies. The Principal Investigator, Dr. Kristine Larson of the University of Colorado, looks at changes in multipath frequencies to estimate changes in snow depth around the monument. The images generated from the installed web cameras will validate the method by comparing actual snow depths with predicted snow depths derived from PBO GPS data. As part of this validation test, two web cameras will eventually be co-located at GPS stations within the PBO network. Stations were selected based on plentiful snowfall, favorable terrain around the monument, and accessibility. The cameras are powered utilizing existing PBO GPS infrastructure and will record images four times a day. The images are downloaded via existing PBO station data communications systems and will be available on the PBO webpage.

by Megan Berg, UNAVCO

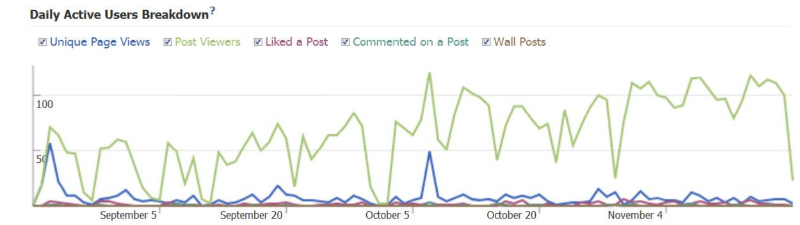
Tales from the Field:

PBO Installation in **Alaska**

When UNAVCO set about building the Earthscope Plate Boundary Observatory (PBO) no challenge was nearly as daunting as the prospect of installing the network of 140 GPS stations in the state of Alaska. The largest state in the Union, Alaska is well known for its rugged terrain, dangerous animals, and numerous other natural hazards. It is also considered one of the most interesting places on the planet for geologists and geophysicists. Within the area instrumented by the Plate Boundary Observatory Project, there are active volcanoes, a subduction zone that has produced some of the largest historical earthquakes and examples of nearly every other tectonic process. This makes it a natural laboratory without parallel that with further study, can possibly lead to answers to many fundamental geological and geophysical questions. Plans for the Plate Boundary Observatory network called for installing stations throughout the state from the Southeast to the North Slope and all the way out to the far western Aleutian Islands. For perspective, it is interesting to note that the Alaska network has both the most western station in the PBO network, AB21 Adak Island (174 W longitude), and the most eastern station in the network, AC66 Amchitka Island (179 E longitude)! The majority of the stations in the network are located far from the few roads in the state, high on ridge tops, or on the flanks of active volcanoes (Figure 4). Travelling over land either by vehicle or on foot to the station locations was impractical for the most part, so it was necessary to use airplanes or helicopters for access. Though physical access to station locations was a major issue for PBO, it was just one of many challenges engineers would have to face and overcome in order for the project to succeed. UNAVCO engineers in Alaska faced a challenging lack of communications infrastructure to get data from remote stations to the data processing facilities in the Lower 48. Things that are taken for granted in the continental U.S., such as cellular telephone networks, wired internet connections, and even dial-up internet access, are all but non-existent in Alaska. Instead, PBO used a combination of radio links from remote stations to more developed areas where internet access was available. In areas where radio networks were not feasible, satellite internet connections provided data telemetry. Powering remote stations was also uniquely challenging in Alaska, since during the winter there is little sunlight for solar power. In the Lower 48 where sunlight is abundant during both the winter and the summer, most stations could be powered by solar arrays with as few as four batteries for energy storage.

Figure 4: Completed GPS station AV40 at Brown Peak on Unimak Island with Shishaldin Volcano in the background. (Max Enders)

by Max Enders, UNAVCO (see online version for the full article)



EarthScope **Social Media** Blitz

Social media sites have emerged as a popular and effective form of communication among all age groups, with more than half of the teenage and adult population belonging to a social network or using social media on a regular basis. This creates an opportunity for Earth science organizations like EarthScope to use the wide reach, functionality and informal environment of social media platforms to create brand recognition, establish trust with users and disseminate scientific information. The systems can be utilized for communicating timely information and are already heavily used by news agencies. They are eminently scalable and can serve any number of users, from a handful to millions, with little cost or performance problems. They can also be used to engage with the public interactively and continue the cycle of discussions, experiments, analyses and conclusions that typify science. We use the extensive logging and interaction capabilities of social media to explore what strategies are most effective for communicating with the EarthScope community and the public, and then constantly update these strategies.

We have developed a multipronged social networking effort to connect with users, including the following:

- EarthScope Listserv has more than 1200 email addresses and is primarily used for announcements
- EarthScope Blog is designed to be a narrative communication of activities underway by the EarthScope National Office, the EarthScope Steering Committee (and its Cyberinfrastructure and Education and Outreach subcommittees) and by our Facility partners and other friends
- EarthScope YouTube channel provides a mechanism to share videos about EarthScope
- EarthScope Facebook page is an active community page. Please "Like" us and contribute to our news feed and content
- EarthScope Twitter feed is a complementary microblogging service

The EarthScope Twitter feed currently has 200 followers and tweets between four to seven times per day during the week. We are "mentioned" or "retweeted" ~two to eight times per day. Currently, this community seems to be primarily composed of users in industry, bloggers, educators and the general public. We continue to grow our user Twitter community primarily through referrals from the EarthScope page, outreach events, follower interactions and retweets.

The EarthScope Facebook page currently has 250 "Likes" and users from 20 countries. We post between four to seven times per day during the week. Currently, this community seems to be primarily composed of scientists and students (graduate and undergraduate). We continue to grow our user community primarily through viral posts, referrals (Google, Twitter, EarthScope mainpage, Yahoo) and EarthScope outreach events.

by Wendy Bohon, ESNO, Arizona State University