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 17 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 PRO-quality GPS sites, one on each side of the rupture, 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. 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 recorded during the deployment and made available for analysis by the broader community, GPS data will be available from UNAVCO.

EarthScope presents a four-day Workshop for Interpreters of the Seismic Zone

The Mineral earthquake occurred at the northern edge of the Central Appalachian Seismic Zone and its relationship to mapped faults is ambiguous. The Mineral earthquake occurred at the northern edge of the Central Appalachian 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 of 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. Further 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)
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. 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.

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 use them from the second round of sample distribution, which included the

Southeast. Other outreach activities and products include content development for the Active 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 Southwest. 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 media. Filmed in summer 2010, the TA and seismic tomography were prominently featured in the National Geographic Channel special, "X-Ray Earth," that aired in May.

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 boreholes. 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 sections from the Southwest Deforming Zone and planes sheared serpentine directly adjacent to a 3.5-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 mechanics and physical 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 fractional 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/.

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-saving 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 multihap 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.

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 discoveries, experiments and conclusions that typify scientific research. The extensive logging and interaction capabilities of social media allow 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 1,200 email addresses and is primarily used by students.
- 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 to see the latest 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, 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 258 “Like”ers 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 (graduates and undergraduates). We are interested in growing our user community primarily through viral posts, referrals (Google, Twitter, EarthScope marpaige, Yahoo) and EarthScope outreach events.

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