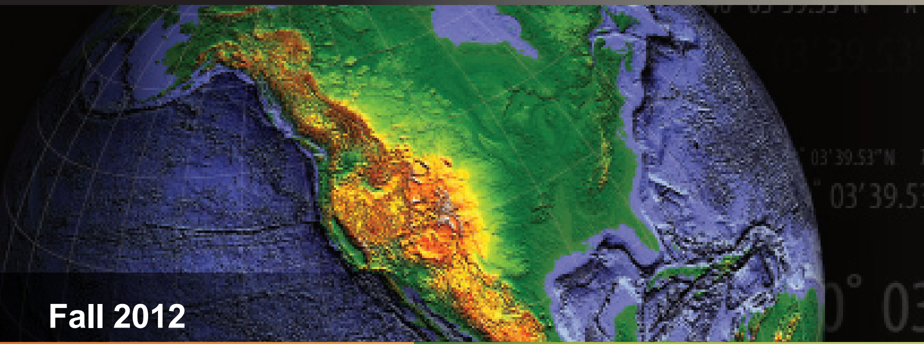

inSights
the EarthScope newsletter

Fall 2012

EarthScope News

EarthScope South Carolina Interpretive Workshop

EarthScope will be hosting a Workshop for Interpretive Professionals at the College of Charleston in South Carolina, January 14-16, 2013. This workshop will feature expert presentations and collaborative activities to help participants use EarthScope findings to convey the story of the geologic setting, landscapes, and natural hazards of the region.
If you are interested in attending, please visit http://www.earthscope.org/workshops/SEregional

GeoPrisms/EarthScope to host Early Career Investigators Luncheon at AGU

December 4, 2012, 11:30 – 1:30 pm
Bayview Room, Grand Hyatt

Early Career Investigators (ECIs) are invited to join us to discuss research interests and explore potential collaboration based on shared GeoPRISMS and EarthScope geographic locations and themes, and develop collaborations prior to NSF proposal deadlines in July 2013. http://www.geoprisms.org/agu-mini-workshops.html

Congratulations to 2012 EarthScope Speaker Series presenter Terry Plank on being named a 2012 MacArthur Fellow!

Understanding Continental Evolution using data from the Transportable Array

Dr. Hersh Gilbert, Purdue University

Do high mountains possess thick roots of low-density crust that keep them afloat in the denser mantle, or do zones of low-density mantle provide the necessary buoyancy for high peaks to remain elevated? The former case predicts that areas of thick and thin crust would correlate with areas of high and low elevations whereas no such correlation would be expected in the latter. Active research by seismologists using EarthScope data seeks to refine the answers to these questions and other fundamental geologic concepts. The long history of deformation and tectonism within North America has created a diverse landscape comprised of expansive plains, mountain ranges, and elevated plateaus making it an ideal locale to study continental evolution. Improving our understanding of the evolution of the various tectonic regions across North America requires well-resolved observations of crustal thickness. To understand the role played by preexisting features in modifying crustal structure it is necessary to determine the structure of the crust within and across the boundaries of crustal blocks, or terranes, that accreted together to form North America. Further studying crustal structures within and surrounding tectonic provinces can illustrate the crustal response to specific tectonic events.

The extensive, dense, and nearly regular sampling of the USArray Transportable Array (TA) facilitates investigating structures across boundaries throughout the continent as the area sampled by the array expands. This sampling allows investigations across terrane boundaries and disparate tectonic environments in a single framework, enabling direct comparisons of features from different regions. Results from analyzing TA data reveal that the crust in the western portion of the United States varies in thickness from less than 30 km to more than 50 km (Figure 1). The thinnest crust lies in the southern Basin and Range in southwest Arizona and the thickest crust lies in the Rocky Mountains in Colorado. Variable crustal thicknesses characterize most of the major tectonic provinces in the western United States including both the Rocky Mountains and Basin and Range. Some changes in crustal structure coincide with terrane boundaries, yet other portions of these boundaries are not associated with observed crustal structures. While thick crust underlies some areas of high elevation, other elevated areas possess thinner crust. Therefore no simple correlation appears between crustal thickness and surface elevation. This observation suggests that variations in both mantle density and crustal thickness support surface elevations.

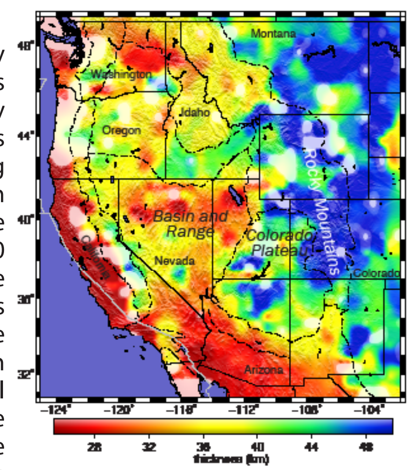

Figure 1. Map of western US crustal thicknesses modified from Gilbert (2012). Dashed lines outline physiographic provinces (including the Basin and Range and Rocky Mountains). Note changes in crustal thickness both within and between physiographic provinces.

A continuous image of crustal structure of North America from its tectonically active western margin to its more stable eastern coast illustrates how a stable craton forms from disparate terranes that amalgamated together during multiple episodes of accretion (Figure 2). Over recent geologic history the central and eastern portions of North America have been tectonically quiet compared to the western portion of North America. Still, similar questions about continental evolution need to be addressed to better understand how the central portion of the continent developed. Thin layers of Paleozoic strata overlie crystalline basement across much of the interior continental platform of North America, hiding the nature and location of sutures between Proterozic terranes. Boundaries between terranes in the central and eastern parts of the United States therefore need to be investigated seismically. This research will illuminate whether differences between terranes persisted following accretion or if the process of "cratonization" removed any differences that existed.

Continued on next page

Continental Evolution, continued from previous page

The sampling of the TA through the central portion of North America is providing some of the initial detailed images of the upper mantle of the cratonic interior of this continent. Investigating structures within the lithosphere will also help identify processes that drive uplift and subsidence of intracratonic domes and basins. The thinner crust observed within the Ozark Plateau than beneath the western portion of the Illinois Basin suggests that buoyant mantle and dense lower crust may play a role in keeping the plateau high and basin low (Figure 3). This comprehensive view of the crust of North America provided by the Transportable Array allows us to see that both the crust and mantle contribute to surface elevations throughout the continent.

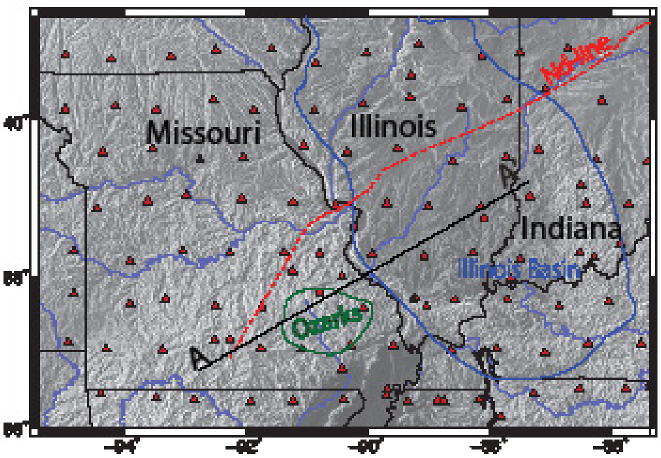

Figure 2. Map of TA stations and tectonic features in the central US. The Ozark Dome within the Ozark Plateau is outlined in green, the Illinois Basin is outlined in blue, and 1.55 Ga accretionary boundary shown as a dashed red line. The Nd line separates crust with a Nd model age older than 1.55 Ga to the northwest from crust with a Nd model age younger than 1.55 Ga to the southeast. Location of cross section A-A' presented in Figure 3 is plotted as a black line.

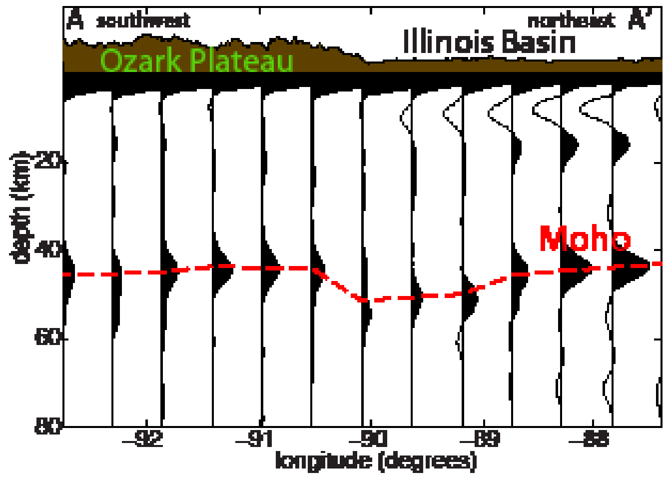

Figure 3. Receiver function cross-section of crustal structure spanning from the Ozark Plateau to the Illinois Basin. Receiver function signals marking the depth of the Moho, located at the base of the crust, are marked by a dashed red line. Note thicker crust, where the Moho deepens, at the southwestern portion of the Illinois Basin.

PBO GPS Updates

By Glen Mattioli, UNAVCO

Currently, there are 1120 GPS sites and 28 tilt meters, as well as numerous other strainmeters actively measuring deformation. In 2008, PBO became the steward of 209 existing GPS sites from the SCIGN, BARD, BARGEN networks. One of the most comprehensive upgrades was conducted at VNDP (Vandenberg Air Force Base), an IGS reference frame station, which significantly improved the state of health and data quality. The VNDP upgrade yielded significant improvements in data quality.

New GPS stations (far right) at Vandenberg AFB have been installed, replacing outdated systems (near right)

USArray Status

By Perle Dorr, IRIS

Since its inception in FY2004, the Transportable Array (TA) has commissioned more than 1450 sites. Stations are now operating in a swath from Louisiana and Florida in the south to Wisconsin and Michigan in the north. A station was also installed near the epicenter of last year's Mineral, Virginia, earthquake before the scheduled TA footprint arrived to provide continuity of data acquisition as some portable sensors are removed from the area. About 950 TA stations have been decommissioned after two years of service; however, some 50 stations have been "adopted" and continue to operate with new owners. Locations for the remaining 200 sites in the Mid-Atlantic and northeastern states and in Quebec, Canada, were identified this summer by eight teams of students from nine universities. Data quality and reliability of TA stations remain high as sites are installed in different geologic regions; data availability consistently exceeds 95%. Four Flexible Array (FA) experiments are currently deployed within the footprint of the TA; one experiment is in the field in Oregon and Idaho. The permanent magnetotelluric (MT) observatory continues to telemeter raw data from its seven stations and dozens of additional sites in the Mid-Continent Rift region have been occupied this summer by the transportable MT array. Outreach activities and products include a new issue of the landowner publication onSite, content development for the Active Earth Monitor in collaboration with the EarthScope National Office and PBO, creation of wave visualization movies, and interaction with local and regional news media. IRIS's new monthly webinar series featured several presentations on topics related to EarthScope and USArray.

Right -TA Station R58B was installed in August in Mineral, Virginia, near the epicenter of last year's magnitude 5.8 earthquake. This site has both a broadband seismometer and a strong motion accelerometer and will operate for about 2½ years. The installation was observed by a small group of visitors including the Virginia state geologist, geoscience researchers from James Madison University in Harrisonburg, Virginia, and staff from IRIS Headquarters.

EarthScope National Office Hosts EarthCube Conference

Sixty scientists met at Arizona State University on October 29 and 30 and discussed the current state and future potential for the cyberinfrastructure that facilitates scientific discovery and the realization of EarthScope's science objectives. The workshop provided timely and necessary guidance in the planning of EarthCube, a broader geoscience initiative in cyberinfrastructure at the National Science Foundation. EarthCube is a bold, new NSF activity that aims to create a data and knowledge management system for the 21st Century.

While EarthScope's existing cyberinfrastructure resources are powerful and continue to improve in response to technological advances and scientific usage, they are insufficient to meet the diverse needs of the entire EarthScope community. The EarthScope Cyberinfrastructure Strategic Plan identified several key challenges: (a) data complexity and diversity, including different data representations, semantic issues, and even differences in time scales; (b) vertical and horizontal integration (within and across disciplines) of data products and services; (c) efficient handling of large volumes of data; (d) the need for effective visualization, analysis, and simulation tools that handle realistic geologic complexity; (e) tools to enable both specialists and non-specialists to discover and retrieve relevant data from many different geological and geophysical resources; and (f) long-term archival and maintenance of data, tools, and other relevant resources.

The workshop was convened by the EarthScope Cyberinfrastructure subcommittee: Mike Gurnis (chair), Ramon Arrowsmith (Director of ESNO), Lucy Flesh (Purdue), Shanan Peters (University of Wisconsin), Doug Walker (University of Kansas), John Louie (University Nevada Reno), Fran Boler (UNAVCO), and Tim Ahern (IRIS). The participants shared ideas and were inspired by numerous interesting presentations. For a full report from the conference, go to the on-line version at www.earthscope.org.

By Dr. Mike Gurnis, Caltech

EarthScope at GSA

EarthScope will be widely represented at the 2012 Geologic Society of America conference in Charlotte, North Carolina November 4-7. Talks and posters using EarthScope related research will be included in the following sessions:

November 4
- 29 - Recent Advances in Geoscience Education (Posters)
- 24 - Geophysics: Advances in Characterizing the Earth using Geophysical Techniques - From the Near-Surface to the Deep Earth (Posters)

November 5
- 65 - Geoscience Education: EarthScope, Outreach, & Program Evaluation

November 6
- 170 - T54 Combining Geophysics and Geology: The George P. Woollard Award Session(Posters)
- 171 - T55 Dynamic Views of North America from EarthScope-Related Research (Digital Posters)
- 154 - T170 Central Virginia Earthquakes of 2011: Geology, Geophysics, and Significance for Seismic Hazards in Eastern North America

November 7
- 221 - T133 Getting to the Root of It - Metamorphism, Tectonics, and Crustal Evolution
- 215/241 - T53 EarthScope and Geoprisms in Eastern North America: Ongoing Endeavors and a Look Ahead
- 243 - T76 Teaching Teachers: Examples of Successful Geoscience Content Courses and Workshops for Pre-Service and in-Service Teachers (Posters)

Hot New Science

We are updating our EarthScope bibliography. In each **inSights**, we will highlight a few recent publications of EarthScope results. Please submit your latest publications to earthscope@asu.edu

Hadizadeh, J., Mittempergher, S., Gratier, J.-P., Renard, F., Di Toro, G., Richard, J., & Babaie, H. A. (2012). A microstructural study of fault rocks from the SAFOD: Implications for the deformation mechanisms and strength of the creeping segment of the San Andreas Fault. *Journal of Structural Geology.* doi:10.1016/j.jsg.2012.04.011

Larson, K. M., Löfgren, J. S., & Haas, R. (2012). Coastal sea level measurements using a single geodetic GPS receiver. *Advances in Space Research*. doi:10.1016/j.asr.2012.04.017

Hodgkinson, K.; Mencin, D.; Borsa, A.; Henderson, B.; Johnson, W. (2012). Tsunami Signals Recorded By Plate Boundary Observatory Borehole Strainmeters. *EGU General Assembly*

Reid, M. R., Bouchet, R. A., Blichert-Toft, J., Levander, A., Liu, K., Miller, M. S., & Ramos, F. C. (2012). Melting under the Colorado Plateau, USA. *Geology*, 40(5), 387–390. doi:10.1130/G32619.1

Blackburn, T. J., Bowring, S. A, Perron, J. T., Mahan, K. H., Dudas, F. O., & Barnhart, K. R. (2012). An exhumation history of continents over billion-year time scales. *Science* (New York, N.Y.), 335(6064), 73–6. doi:10.1126/science.1213496

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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 Baumback ASU/EarthScope National Office.

The New and Improved EarthScope National Office

The EarthScope National Office has a new home within ASU. The grand opening for the Interdisciplinary Science and Technology Building (ISTB 4) was on September 19, 2012. ISTB 4 is the largest research facility at Arizona State University at 293,000 square feet. In addition to being a cutting-edge research facility with laboratories, offices, classrooms, and a 3-D theater, it houses extensive public outreach, K-12 education spaces, and allows visitors to see research as it's happening. The $185 million, seven-story building is home to the School of Earth and Space Exploration along with departments from the Fulton Schools of Engineering. We welcome EarthScope researchers to visit our office at ASU. Tempe is a wonderful place to visit. If you would like to employ our services please contact us at earthscope@asu.edu

Left to Right: ESNO team members next to the EarthScope Display, IRIS Earthquake Channel, a PBO GPS station shown in cross section, a SAFOD core replica and SAFOD borehole strainmeter DS150, and the internal components of a digital seismometer. These components form part of the EarthScope National Office exhibit and are prominently displayed in ASU's ISTB4 first floor. Not shown are the IRIS Active Earth Monitor and "Make-A-Quake."