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BIGFOOT ARRIVES IN ARIZONA

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Figure 1: Deployment of a seismic station in the "Bigfoot" array, an integral part of the USArray Transportable Seismic Network. Photo courtesy of EarthScope.

This February, workers began installing the first of 59 broadband seismometers (Figure 1) that for the next two years will blanket Arizona on a 70-km (44-mi) grid and record earthquakes from around the world. These stations comprise the Arizona leg of the largest seismic grid ever created, a nationwide project called the USArray Transportable Seismic Network (Figure 2). More evocatively named "Bigfoot", this network consists of 400 seismometers that will march eastward across the entire country during the next decade, eventually occupying over 2000 stations from Alaska to Florida (Figure 3). Analysis of the earthquakes recorded by these instruments will enhance scientists' understanding of earthquake behavior and provide an unprecedented, three-dimensional look at the planet's interior.

USArray is an integral part of EarthScope, the most ambitious earth science project ever mounted. Often referred to as "the Hubble Telescope of earth science", Earthscope's purpose is to construct and deploy a vast and diverse array of instruments across the United States with the coupled objectives of exploring the structure and evolution of the North American continent, understanding

Mission

To inform and advise the public about the geologic character of Arizona in order to increase understanding and encourage prudent development of the State's land, water, mineral, and energy resources.

Activities

Public Information

Inform the public by answering inquiries, preparing and selling maps and reports, maintaining a library, databases, and a website, giving talks, and leading fieldtrips.

Geologic Mapping

Map and describe the origin and character of rock units and their weathering products.

Hazards and Limitations

Investigate geologic hazards and limitations such as earthquakes, land subsidence, flooding, and rock solution that may affect the health and welfare of the public or impact land and resource management.

Energy and Mineral Resources

Describe the origin, distribution, and character of metallic, nonmetallic, and energy resources and identify areas that have potential for future discoveries.

Oil and Gas Conservation Commission

Assist in carrying out the rules, orders, and policies established by the Commission, which regulates the drilling for and production of oil, gas, helium, carbon dioxide, and geothermal resources.

ARIZONA GEOLOGICAL SURVEY
AZGS

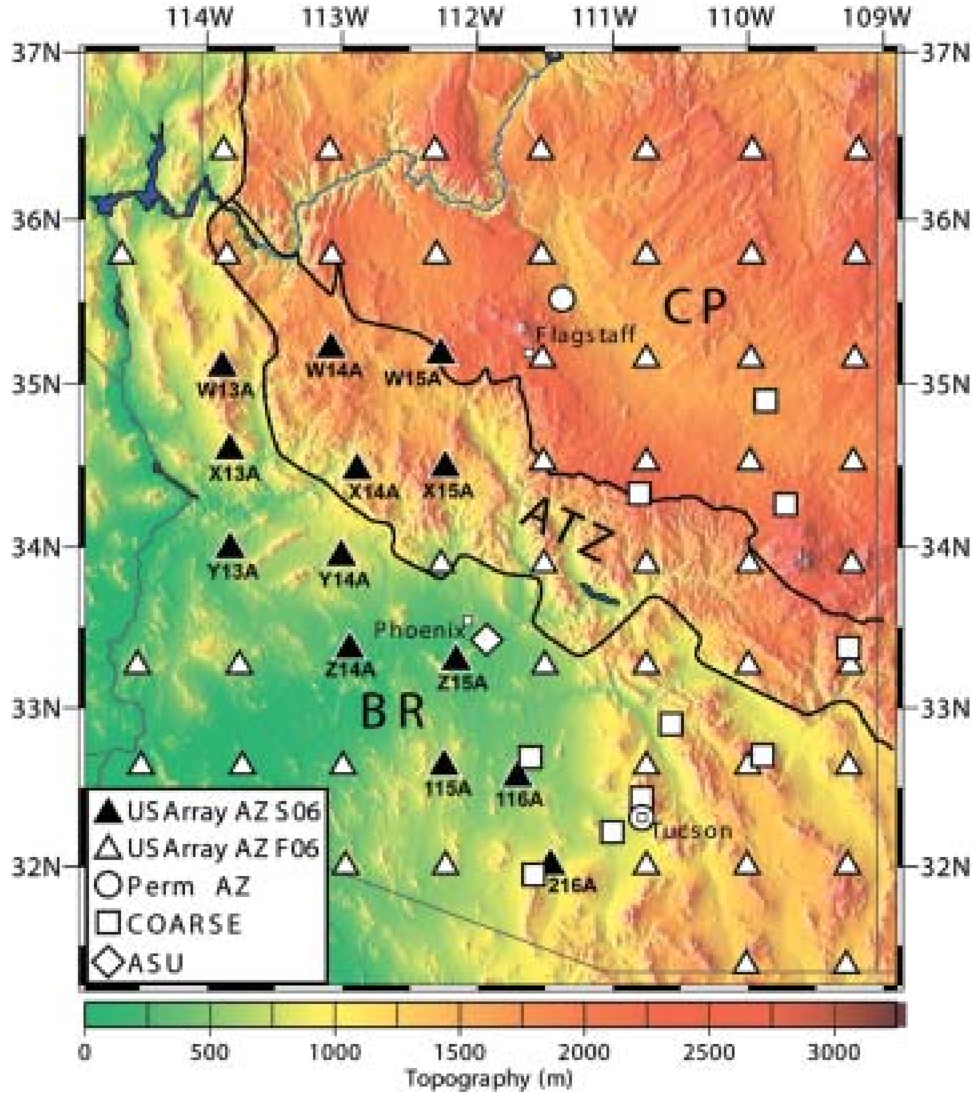

Figure 2: USArray stations in Arizona. The black triangles represent stations that are installed or that will be installed and recording data by the end of March, 2006. The white triangles are stations that will not be installed in Fall 2006. The open circles and the diamond represent permanent seismic stations that are part of other networks and the open squares are temporary stations that are part of the ASU/UA COARSE seismic network (http://asuarray.asu.edu/coarse). The black lines separate the three geographic provinces of Arizona, with CP standing for the Colorado Plateau, ATZ for the Arizona Transition Zone, and BR for the Basin and Range. Map courtesy of Matt Fouch, Arizona State University.

the physical processes that control the behavior of earthquakes and volcanoes, and informing and involving the American public in the exciting discoveries that are happening in earth science.

Funded by over $200 million from the National Science Foundation, EarthScope consists of three fundamental components. The first, known as the San Andreas Fault Observatory at Depth (SAFOD), last year achieved its ambitious goal of drilling through the San Andreas Fault. The borehole crosses it at a depth of 1.9 mi (3.1 km) for the first time allowing geologists to study a fault's architecture and the process of earthquake generation deep beneath the ground where all earthquakes start. The second component, called the Plate Boundary Observatory (PBO), will eventually consist of 875 global positioning system (GPS) stations and 175 borehole strainmeters to monitor the deformation of the North American crust in response to tectonic plate motion both along the west coast and around the potentially active Yellowstone volcanic caldera. USArray, which com-

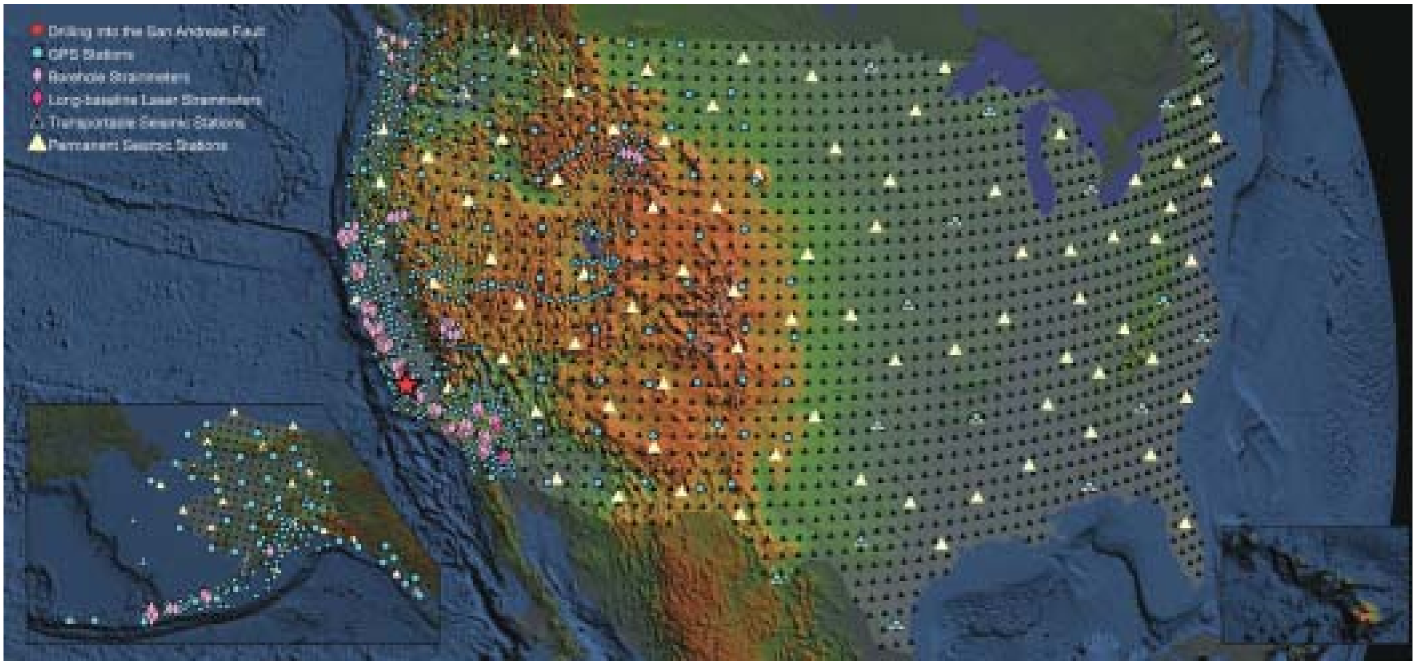

Figure 3: The Arizona leg of Bigfoot is just part of the nationwide EarthScope instrument deployment. The triangles represent the USArray seismic component of EarthScope. Bigfoot seismic stations are shown on this map as black triangles. The larger yellow triangles are the permanent seismic stations. The Plate Boundary Observatory project component consists of the GPS stations (blue circles) and strainmeters (the diamonds), while the drilling site for the San Andreas Fault Observatory drilling is marked by a red star. Map courtesy of EarthScope.

prises the project's third major component will, when fully built, consist of Bigfoot, an additional array of 2400 seismometers (called the Flexible Array) that can be rapidly deployed anywhere in the country for projects such as fully recording the aftershocks of a major earthquake, and an array of 100 permanent seismometers that will provide crucial reference information.

The Bigfoot seismometers are so sensitive that those deployed here in Arizona will be able to detect a very modest magnitude 4.0 earthquake occurring as far away as New Zealand! This extreme sensitivity requires that each instrument be located in an area as free from seismic noise as possible; even the footfalls of people or cows in the vicinity can be recorded. To reduce this background noise, each seismometer is housed at the bottom of a 7-foot-deep vault and placed on a concrete pad (Figure 4). Bigfoot stations are hosted by Arizonans who are eager to further our understanding of the earth's interior and of the processes that have shaped Arizona's magnificent landscape. Ranchers and other private landowners have agreed to host many of the sites, while one of Arizona's first stations (designated site W13A) will be located in Mohave County's Hualapai Mountain Park, offering park visitors an unprecedented chance to learn more about the earth beneath their feet.

Matt Fouch, a seismologist at Arizona State University, is spearheading the deployment of Arizona's 59 Bigfoot stations. ASU's Steve Semken, a specialist in Earth science education, is coordinating outreach and teaching activities to involve schools and communities in the project. A major part of this effort is his extensive engagement with representatives from Arizona's Native American tribes to build support for locating stations on tribal land and to enhance Native American science education by actively involving tribal members in scientific discovery.

Communications equipment located at each station beams the data via cell modem or a small satellite dish to the USArray central data collection and processing center in San Diego, California. After the data are verified there, they are posted on the worldwide web, allowing anyone free access to all Bigfoot data (Figure 5). Amazingly, you will be able to examine the record of a quake at your station of choice within less than an hour of its occurrence.

Arizona scientists will take a leading role in interpreting the data, but it will be available to researchers throughout the world, leveraging additional exciting discoveries. The advantage of deploying the seismometers in a grid is that the earthquake-generated sound waves detected by the network will have traversed innumerable points at all depths beneath Arizona, allowing scientists to obtain a three-dimensional image of Arizona's subsurface in unprecedented detail, from the crust all the way to the earth's core, in a procedure analogous to a medical CT scan. The sound waves travel faster through some earth materials than they do through others, and the temperature of those materials also affects their speed. By using computers to analyze the average wave speeds recorded across the entire grid from numerous earthquakes, seismologists can begin to identify seismically "fast" and seismically "slow" areas beneath our state, culminating in a three-dimensional map that reveals the temperature, composition, and other rock properties below the surface. Previous seismic arrays have provided crude looks at these

Figure 4: Bigfoot seismometers are housed in a well in order to dampen out seismic noise. Photo courtesy of EarthScope.

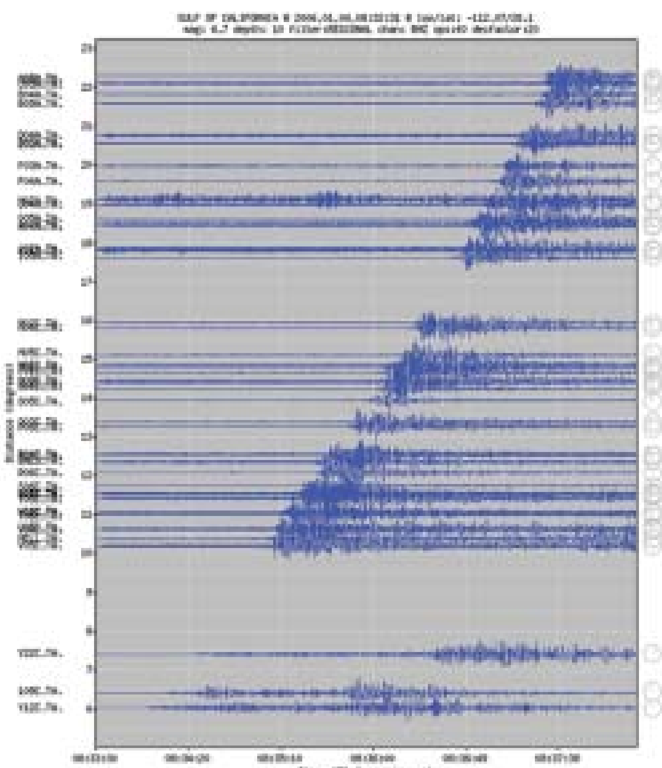

Figure 5: Seismograms recorded at USArray stations from a magnitude 6.7 quake that occured in the Gulf of California on January 4, 2006. Courtesy of the IRIS DMC WILBER II system and Matt Fouch, Arizona State University.

properties averaged over hundreds of kilometers, but Bigfoot will soon allow scientists to bring those properties into dramatically sharper focus, revealing differences in crust and upper mantle structure and rock properties as small as 6.2-31 mi (10–50 km) across.

Bigfoot will also provide detailed insight into local earthquake activity. Although Arizona is not home to abundant, strong earthquakes like those that rock California, smaller ones frequently shake our state. The Bigfoot grid will record these earthquakes in all directions, allowing us to characterize the fault behavior that triggers them with a precision that has until now been impossible to achieve. A few smaller seismic networks previously operated by researchers at Arizona State University and the University of Arizona have detected swarms of microearthquakes, tremors too small for humans to feel, in some areas of the state, hinting at previously unsuspected subsurface tectonic activity. Bigfoot will likely detect more such areas and will provide seismologists with important clues to the processes driving these microearthquakes.

The data derived from the Bigfoot seismic array are guaranteed to excite geoscientists and to enhance their understanding of Arizona's geologic history and the structure and processes of earth's interior. But the project offers just as much excitement for anyone curious about our planet. To view the data and learn more about the project, EarthScope is developing a number of interactive tools, which you can find on their web site (www.earthscope.org).

You can also see what's shaking in your area by logging onto the USArray station monitor (http://usarray.seis.sc.edu/). If you know the station designation of your local seismometer you can type it in; otherwise, you can enter your zip code and the program will find the closest one. Thirteen Bigfoot stations will be installed in western Arizona this February and March. The remaining stations are scheduled to be installed this coming fall. These stations should all be recording until 2008, so be sure to check them out. As Bigfoot stomps its way across Arizona, it will provide you with a new window from which to appreciate the restlessness of our world, including the geological growing pains our state continues to experience.

Lon Abbott and Terri Cook both teach earth science at Prescott College. They, along with many other people, are assisting with the job of locating appropriate places for the installation of the Arizona USArray stations. Lon's research focuses on the history of Colorado Plateau uplift and the landscape responses to that uplift such as the carving of the Grand Canyon. Lon and Terri are the authors of "Hiking the Grand Canyon's Geology," published by Mountaineers Books.

STATE GEOLOGIST'S NOTES

One can reasonably argue that Arizona lives and dies on its geology. Minerals and geo-tourism are major contributors to the economic well-being of the state. Groundwater resources have supported the burgeoning population. Geologic hazards threaten homes and infrastructure.

Newly released figures show Arizona as the leading mineral producing state, with a 2005 valuation of $4.7 billion. Arizona is number one in copper production, third in cement production, and fourth in aggregates (sand and gravel). What's surprising is that California and Texas are first and second in the latter two, with Florida third in aggregate production. All those states have populations many times that of Arizona, which means that the demand for industrial minerals used in construction is being driven at least in part by a booming economy here.

Most Arizonans are more than cognizant of the growing demands for water and the limitations on available resources.

Arizona also hosts millions of visitors eager to enjoy the rich geologic heritage of the "Grand Canyon State."

And last in my short list of issues are hazards. Arizona is subject to floods, debris flows, earthquakes, subsidence, fissures, desiccation cracks, sinkholes, landslides, and in the not too distant geologic past, volcanoes, to name a few. Earth fissures have become a hot topic especially in the past year as development pushes out into areas of fissures that had been viewed as not particularly hazardous because of their previous remoteness.

The Arizona Geological Survey (AZGS) is an active well-regarded agency with a group of outstanding professionals. We are tasked with identifying and evaluating geological resources and in the case of hazards, mitigating them. Working with our colleagues at the Department of Water Resources and the U.S. Geological Survey, AZGS focuses on characterizing the geologic framework that stores the state's water treasure.

But AZGS also does not have the resources to successfully take on all the tasks assigned to us. Cuts in state support over the past dozen years have eroded the Survey's capabilities. Our strategy has to be to partner with other agencies and groups with related interests and expertise. One current such effort is forging an alliance with the Department of Mines and Mineral Resources in Phoenix. To begin, each agency will distribute and sell the others reports and publications through our sales outlets and at conferences. We are setting up office space in Tucson for DMMR use and anticipate having access to space in Phoenix for AZGS use. These early steps should lead to more substantive partnering on mining and mineral projects across the state. Talks are underway with other agencies and groups to forge comparable cooperation.

The second broad initiative we are pursuing is to make all our data digital, put them online, and have them interoperable. This is a daunting challenge so it is one that we will do incrementally. It is imperative for our success in carrying out our mission that we accomplish this as quickly as we can find or reallocate resources.

Lastly, I want to acknowledge my predecessor and long-time colleague Larry D. Fellows, for the wonderful help he's been providing during my transition as Director. Larry was one of the "shining lights" among state geologists when I first joined the ranks at the Utah Geological Survey in 1989, when he served as a mentor and role model for me. He continues to unselfishly offer his time and insights to help ensure the continued vitality and success of the AZGS. The Survey and Arizona are lucky to have him.

M. Lee Allison

NEWS AND NOTES

- Arizona House Bill 2639 would require the AZGS to produce data and maps on earth fissures by January 2007 that would also be incorporated into dynamic Internet Map Services by the Arizona Lands Department. The maps would have to be updated at least every five years.
- AZGS will receive $202,392 in matching funds from the National Cooperative Geologic Mapping Program for mapping in Arizona. Mapping will begin this fall and maps will be completed in the fall of 2007.
- The Arizona Department of Water Resources (ADWR) released the "Regional Groundwater Flow Model of the Tucson Active Management Area, Tucson, Arizona: Simulation and Application." Copies are available at ADWR, 3550 N. Central Ave., Phoenix, AZ 85012, for $30 for either hardcopy or CD.
- Oil and Gas well permits issued by the Arizona Oil and Gas Conservation Commission are posted on the AZGS website.

Publication Ordering Information

You may purchase publications at the AZGS office or by phone, by fax, or by mail. Address mail orders to AZGS Publications, 416 W. Congress St., Suite 100, Tucson, AZ 85701. Orders are shipped by UPS, which requires a street address for delivery. All mail orders must be prepaid by a check or money order payable in U.S. dollars to the Arizona Geological Survey or by Master Card or VISA. Do not send cash. Add 7.6% sales tax to the publication cost for orders purchased or mailed in Arizona. Order by publication number and add these shipping and handling charges to your total order:

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AZGS Website

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