2006 SCEC Annual Report: SCEC Borehole Instrumentation Program

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Summary:

The primary goal of the borehole instrumentation project is to facilitate an increase in the number of borehole sensors being installed in southern California, maintain the existing SCEC borehole stations, and to ensure quality data is being recorded, archived, and disseminated. The highlight of the 2006 program was the collaboration with the NSF Earthscope PBO program, involving the addition of 6-component seismic packages installed in the strainmeter wells in the Anza region. The SCEC program provided the resources for an additional three channels to ensure that strong motion is recorded in each of the Anza strainmeter boreholes.

A map showing current borehole stations in southern California is shown in Figure 1. Through these collaborative efforts six stations came online in the past year at Keenwild, Pinon Flat, Santa Rosa, Ford Ranch, Pathfinder Ranch, and Sky Oaks. The SCEC borehole program continues to take advantage of the national and regional seismic network infrastructure. In the case of these new stations, the data flows to the UNAVCO PBO operations center in Colorado, and then back to the regional CISN network in Southern California. The data then become part of the routine network processing, and are seamlessly integrated into the Southern California Earthquake Data Center.

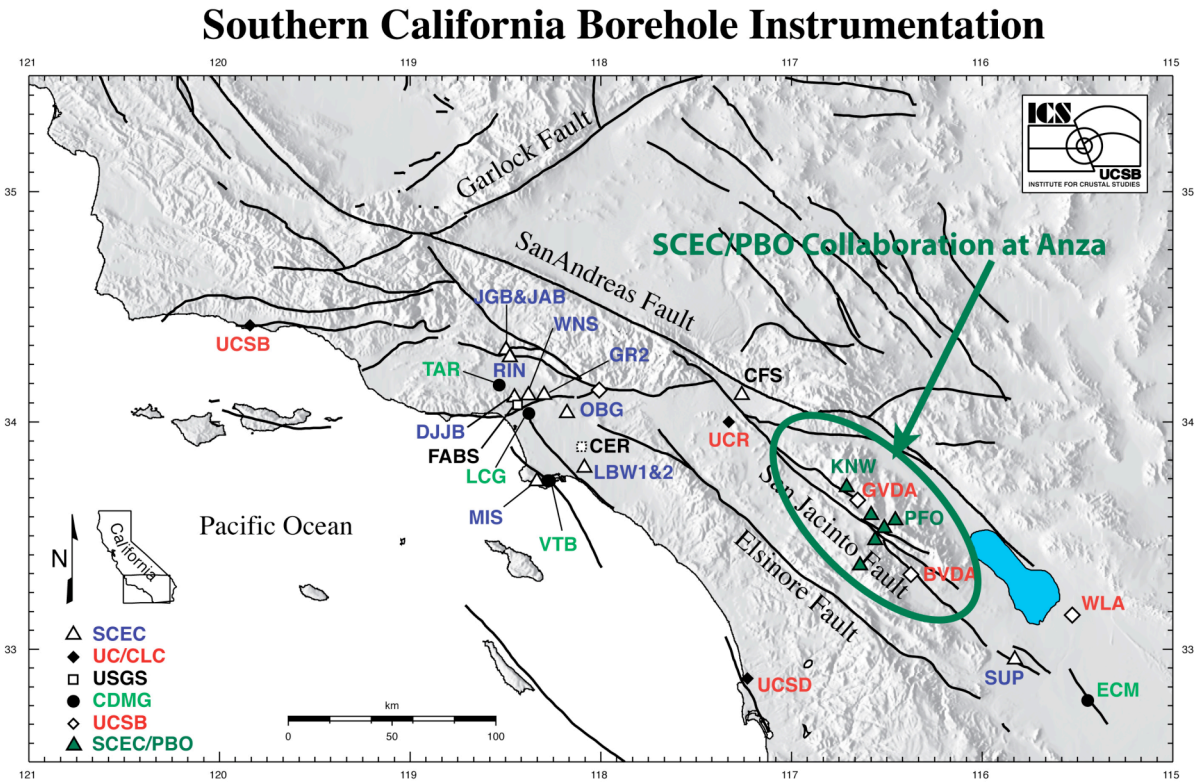

Figure 1. Location of Borehole Sites in Southern California

The operations and maintenance of the borehole stations requires an active role in assisting with the maintenance of network and data center operations, as related to the borehole stations. Continuous real-time data exchange between Caltech and UCSB, established last year, allows for quality control of the data. Collaboration with the NSF NEES program and the cyber infrastructure that has been put in place at UCSB through this program facilitates this data exchange.

Collaboration with the EarthScope program

Continuing the long tradition of collaboration, cost sharing, and stretching the value of the SCEC dollar, this past year exemplified this type of activity and six new borehole stations came online to the network. The sites, all located along the Anza segment of the San Jacinto fault, are installed within the same well as the PBO strainmeter package. The seismic package is typically grouted in the open hole, 10-20 meters above the strainmeter. Figure 2 shows the location of the six new sites along with the location of the existing Garner Valley site.

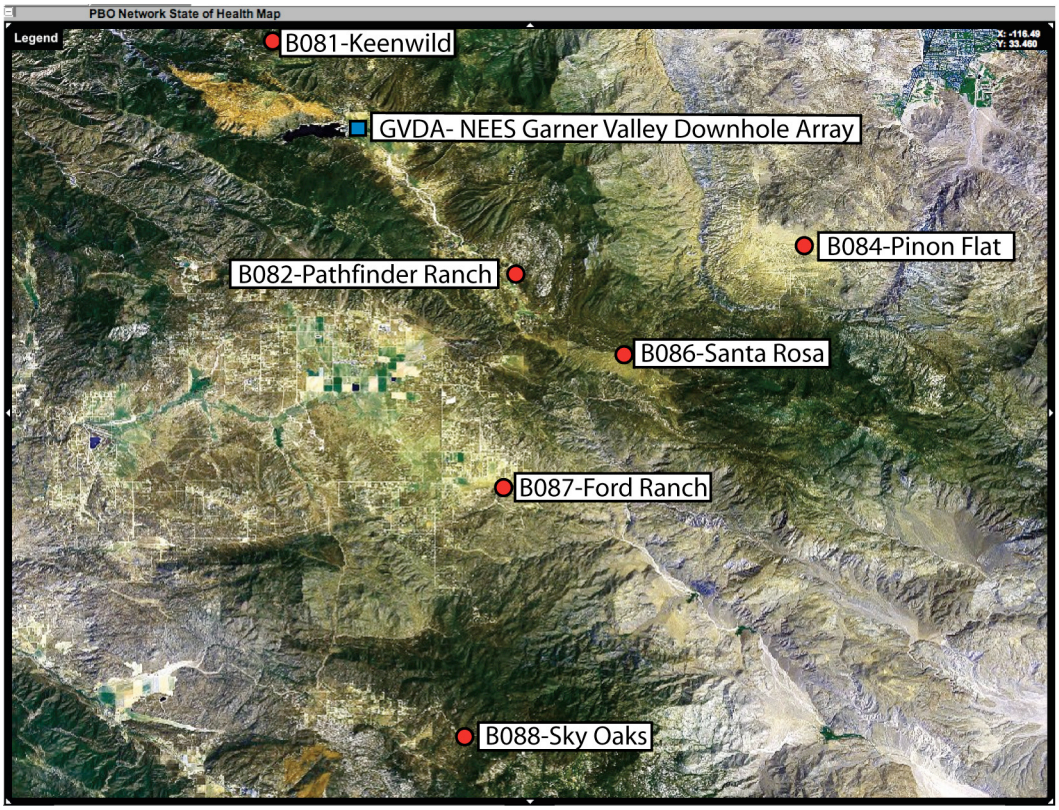

Figure 2. The Anza region and new EarthScope PBO borehole sites with both weak- and strong-motion seismic sensors.

Data from the six new stations is transmitted in real-time from the sites, and provides very high quality, low-noise waveforms at low magnitudes. An example of the data that comes from the PBO/SCEC stations in the Anza region and fed into the regional network is shown in Figures 3 and 4. The data from these stations is being used to locate earthquakes at Caltech/USGS Pasadena as can be seen when the products button is pressed and waveforms selected using

CISN display (Figure 3 and 4). The phase picks from these stations determined by the CISN analysts at Caltech are shown in Figure 4. These picks are archived in the Southern California Earthquake Data Center just like any other network station. It is likely that the inclusion of these new stations into the regional network will lower the detection threshold and lower limit of the catalog in this region. Data from these stations also provide input to shake map for larger events via the strong-motion components of the borehole sensor packages.

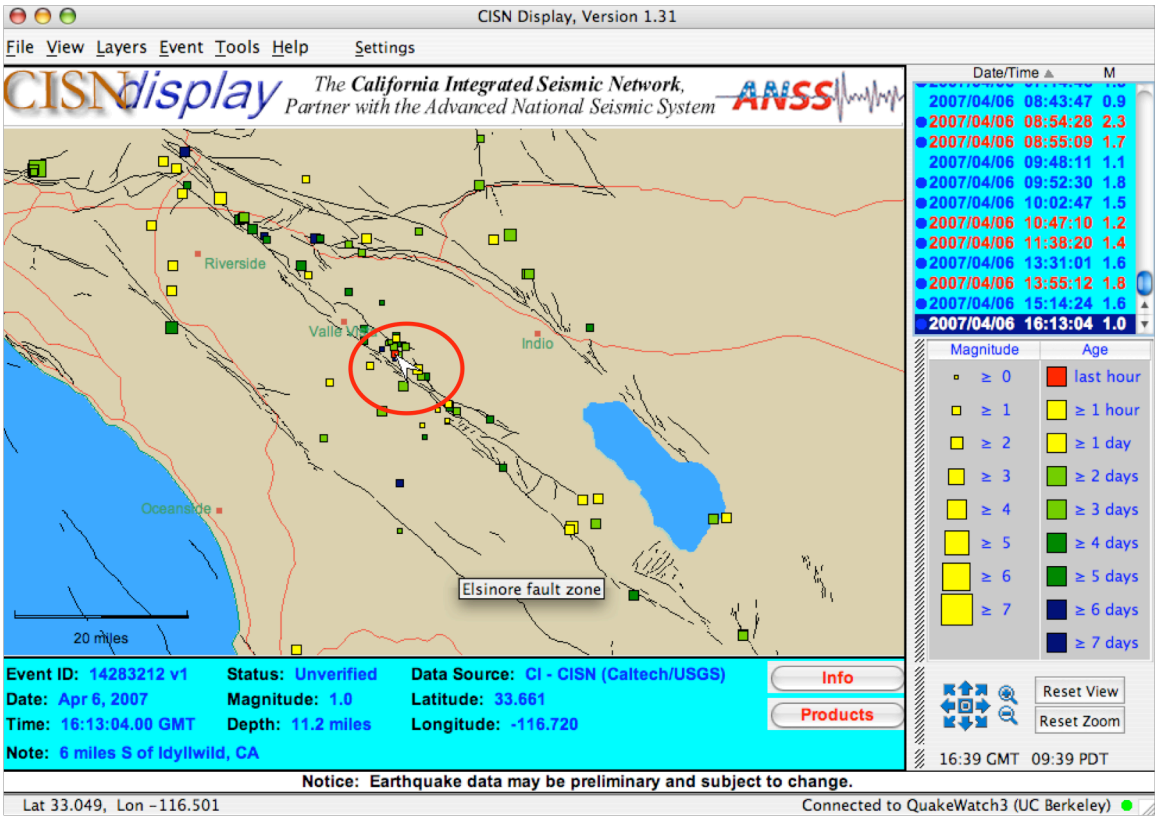

Figure 3. CISN Display showing an M1.0 event in the Anza region.

Collaboration with the NEES program

The NEES program at UCSB has provided the infrastructure to allow for real-time monitoring of the SCEC borehole stations in southern California. This capability has been extremely useful in quality control of the data and in the maintenance and operations of the borehole stations. Figure 5 shows an example of this capability where data from three of the new PBO/SCEC stations is shown. In this example waveforms from a small M1.2 event located at the northern end of the Borrego Valley are selected from the orbserver at UCSB that collects the data in real-time from UNAVCO in Colorado. Even at distances of 25-35 km from the event the small magnitude event still has good signal to noise on all three components of motion. The NEES tools that allow for real-time waveform monitoring are extremely useful in the operations and maintenance of all the SCEC stations.

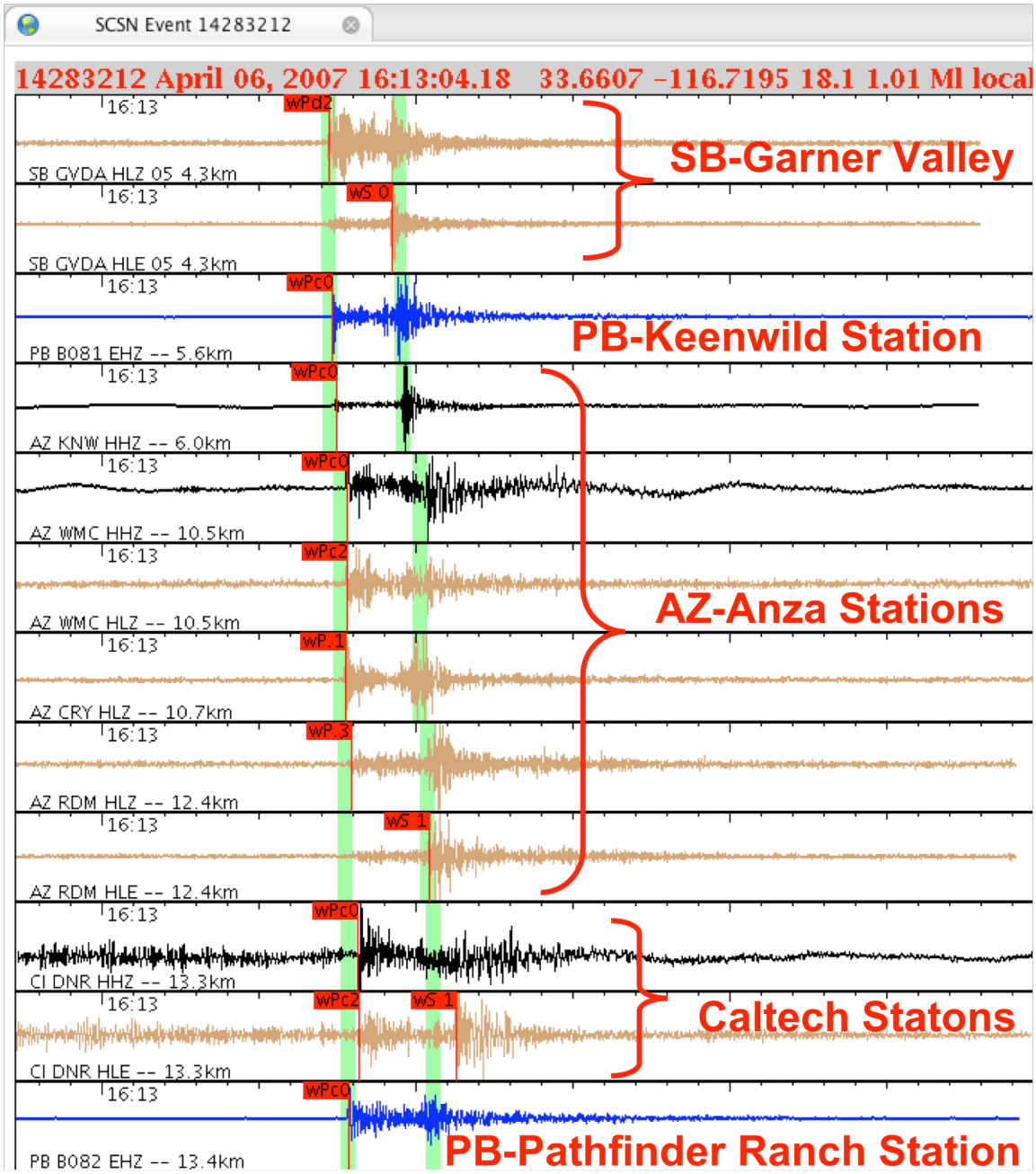

Figure 4. The waveform products page from CISN showing the use of PBO/SCEC borehole stations (blue) in locating earthquakes.

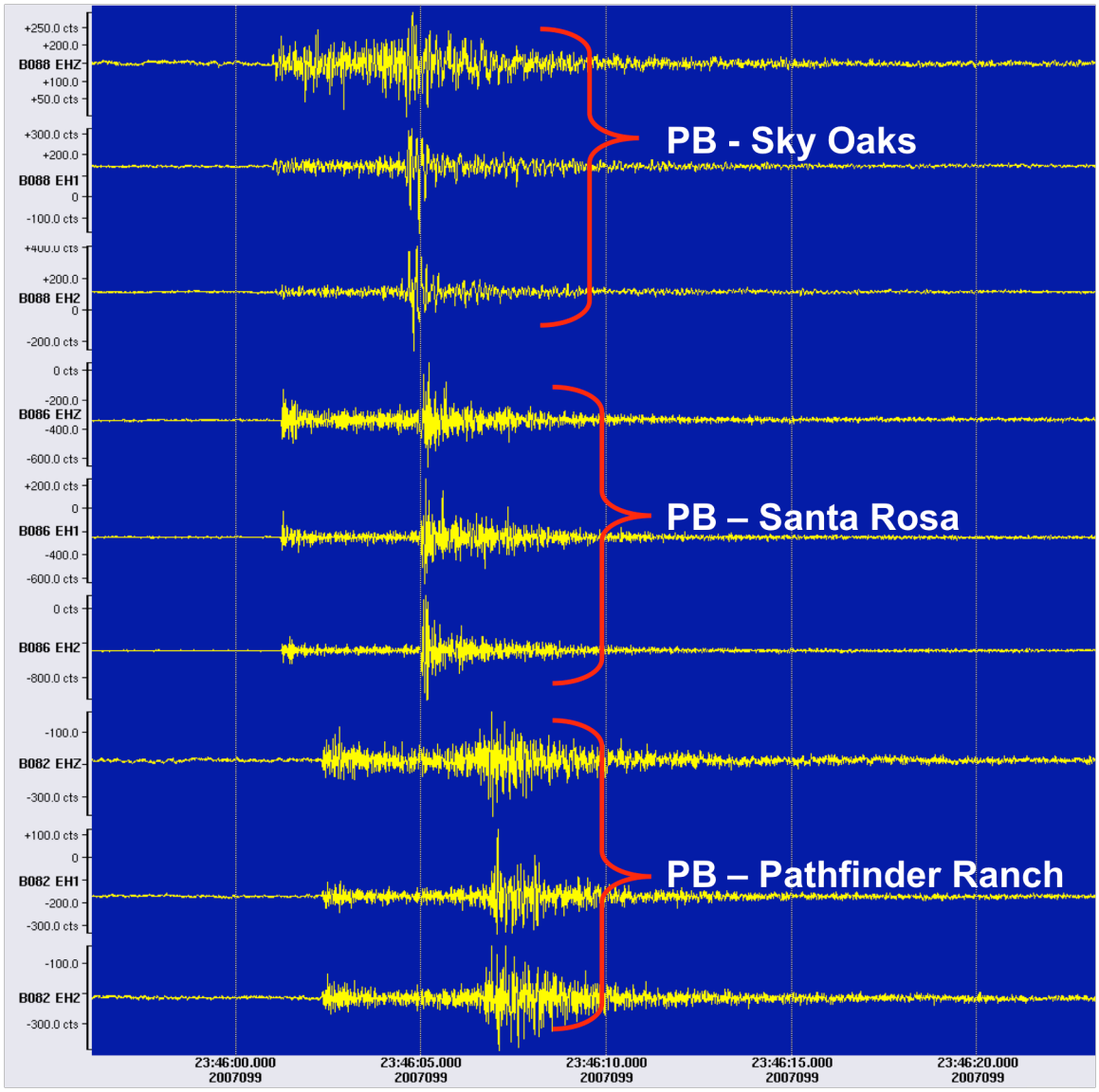

Figure 5. Real-time data from borehole sites displayed from the local orbserver at UCSB for quality control purpose. A magnitude 1.2 event at 25-35 km distance recorded on the PBO/SCEC borehole stations. 25 seconds of 3-component data from the Sky Oaks, Santa Rosa, and Pathfinder sites is shown.

2006 SCEC Publications:

Tsuda, K., and J. H. Steidl (2006). Nonlinear site response from the 2003 and 2005 Miyagi-Oki earthquakes, *Earth, Planets, and Space*, **58**, 1593-1597.

Assimaki, D., W. Li, J. H. Steidl, K. Tsuda (2007). Site amplification and attenuation via downhole seismogram inversion: A comparative study of the Miyaagi-Oki aftershock sequence, *Bulletin of the Seismological Society of America*, in review.