2007 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 2007 program was the continued collaboration with the NSF EarthScope PBO program in the Anza region. Data from these newly installed stations was integrated into the network processing in southern California in 2006 and real-time feeds of the data sent to UCSB for quality assurance monitoring. In 2007 we continued monitoring these new borehole stations, and visited many of the sites to try and improve the noise floor on the strong motion channels. In addition to these PBO stations, some of the other borehole stations in southern California were also visited for maintenance during 2007, and all of these stations were monitored at UCSB for data quality.

A map showing current borehole stations in southern California is shown in Figure 1. Through the PBO/SCEC collaborative effort another of these borehole stations was installed in 2007, the Tripp Flats site (see figure 2). As with the other stations, the data from this station will flow to the UNAVCO PBO operations center in Colorado, and then back to the regional CISN network in Southern California. The data will then becomes part of the routine network processing, and are seamlessly integrated into the Southern California Earthquake Data Center. In addition, the real-time data will also flow to UCSB for quality control.

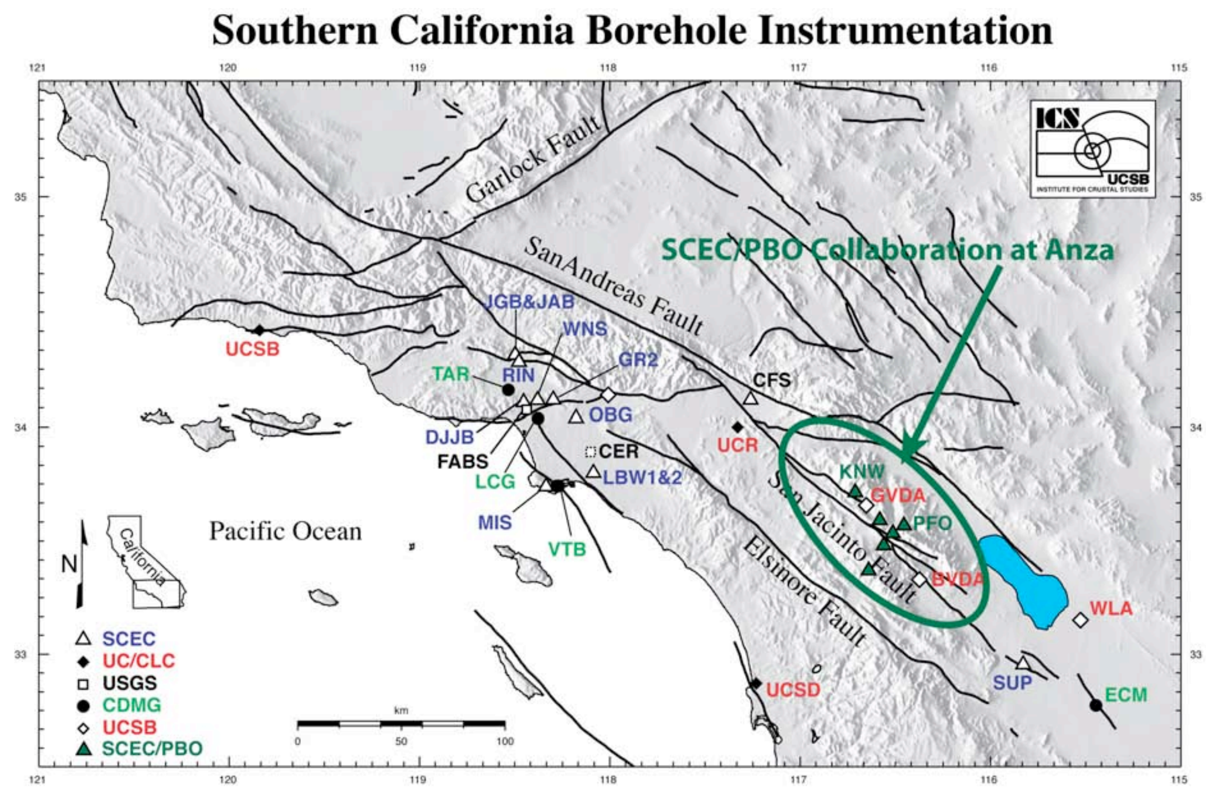

Figure 1. Location of Borehole Sites in Southern California

The operations and maintenance of all the borehole stations requires an active role in assisting with the maintenance of network and data center operations. The continuous real-time data exchange between Caltech and UCSB 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.

SCEC/EarthScope Collaboration for 2007:

Continuing the long tradition of collaboration, cost sharing, and stretching the value of the SCEC dollar, the new site installed for 2007 is another PBO-Anza borehole station that includes both the accelerometer (SCEC fund provided for this) and weak motion seismometer. The site compliments the other stations installed in the previous year under this collaboration, all located along the Anza segment of the San Jacinto fault. These stations are installed within the same well as the PBO strainmeter package and permanently grouted in place. The seismic package is typically grouted in the open hole, 10-20 meters above the strainmeter. Figure 2 shows the location of the seven sites along with the location of the existing Garner Valley NEES borehole site.

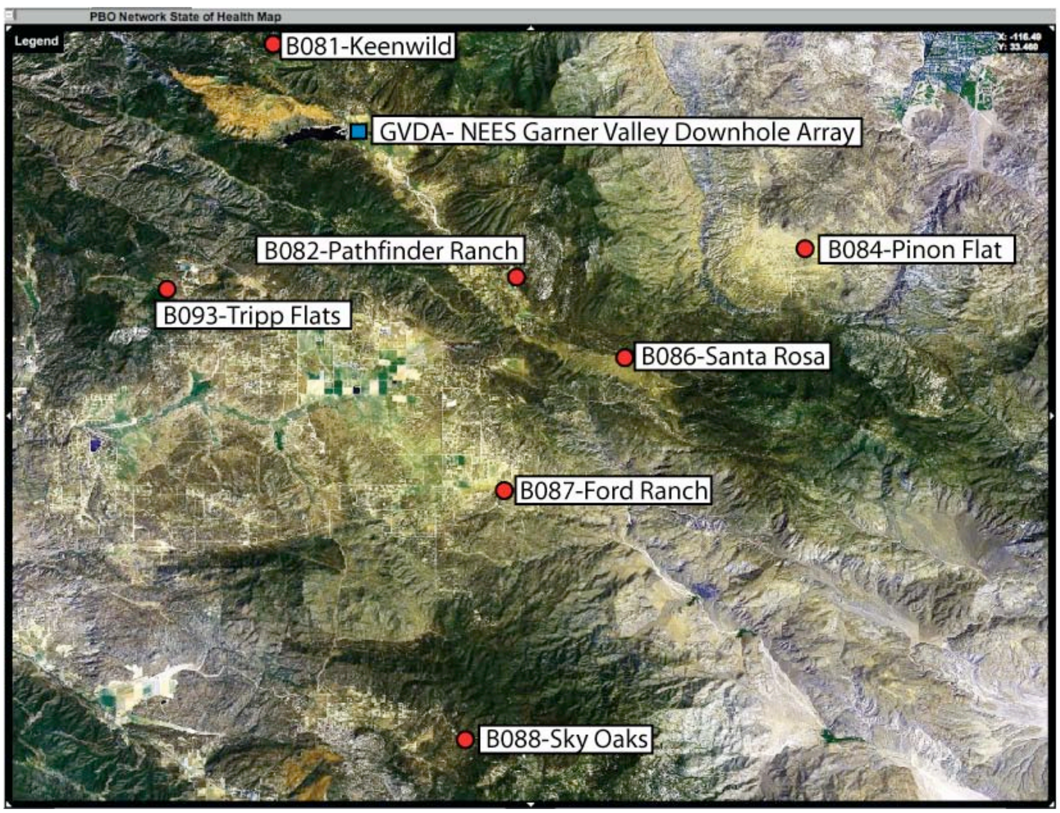

Figure 2. The Anza region and EarthScope PBO borehole sites with both weak- and strong-motion seismic sensors. The Tripp Flats site was installed this past year.

The station coverage with these seven sites is now quite good along the Anza segment of the San Jacinto fault. The Tripp Flats site fills in the Northwest quadrant. This data is not yet integrated into the network operations, but should as part of the 2008 SCEC borehole program. Data from these seven PBO stations is will provide very high quality, low-noise waveforms at low magnitudes. The data from the previous six stations is being used to locate earthquakes at Caltech/USGS Pasadena. The phase picks from these stations determined by the CISN analysts at Caltech are archived in the Southern California Earthquake Data Center just like any other network station. The inclusion of these stations into the regional network has lowered the detection threshold and lower limit of the catalog in this region (Hauksson, Personal comm. 2008).

Some of the initial problems with the PBO borehole installations were resolved in 2007 with site visits to the various PBO Anza stations (Figure 3). In looking at the real-time data from the PBO sites, it became clear that some of the accelerometer channels were not functioning correctly. This problem was corrected by installing DC/DC power converters at the wellhead to power the accelerometers directly off the battery through the converter, instead of using the datalogger. The longer run of cable for the borehole instruments requires a slightly higher voltage be applied at the surface. Once these converters were installed, many of the issues with these channels were fixed (Figure 4).

Figure 3. PBO Anza stations Ford Ranch (left) and Pathfinder Ranch (right) visited in 2007 to resolve power configuration issues with the MEMS accelerometer installations.

Figure 4. Typical PBO installation (left) and the installation of inline power conditioning (right) to correct problems with the MEMS accelerometer performance.

In figure 5, the observations from an M1.8 event are shown at some of the PBO stations. Our initial hope was that the MEMS accelerometers would be as good as the week motion instruments at the small end, and also provide us with the high end up to +/- 3g of acceleration. As can be seen in figure 5, the MEMS accelerometer is not going to be useful for the very small events, which was a disappointment, given the higher frequency response of these units. The MEMS performance above a M3 earthquake is adequate, and by the time the weak motion sensors clip, the MEMS performance will have good signal to noise, so the pairing of these two sensors will cover the entire range of motions, up to the +/- 3g limit of the MEMS.

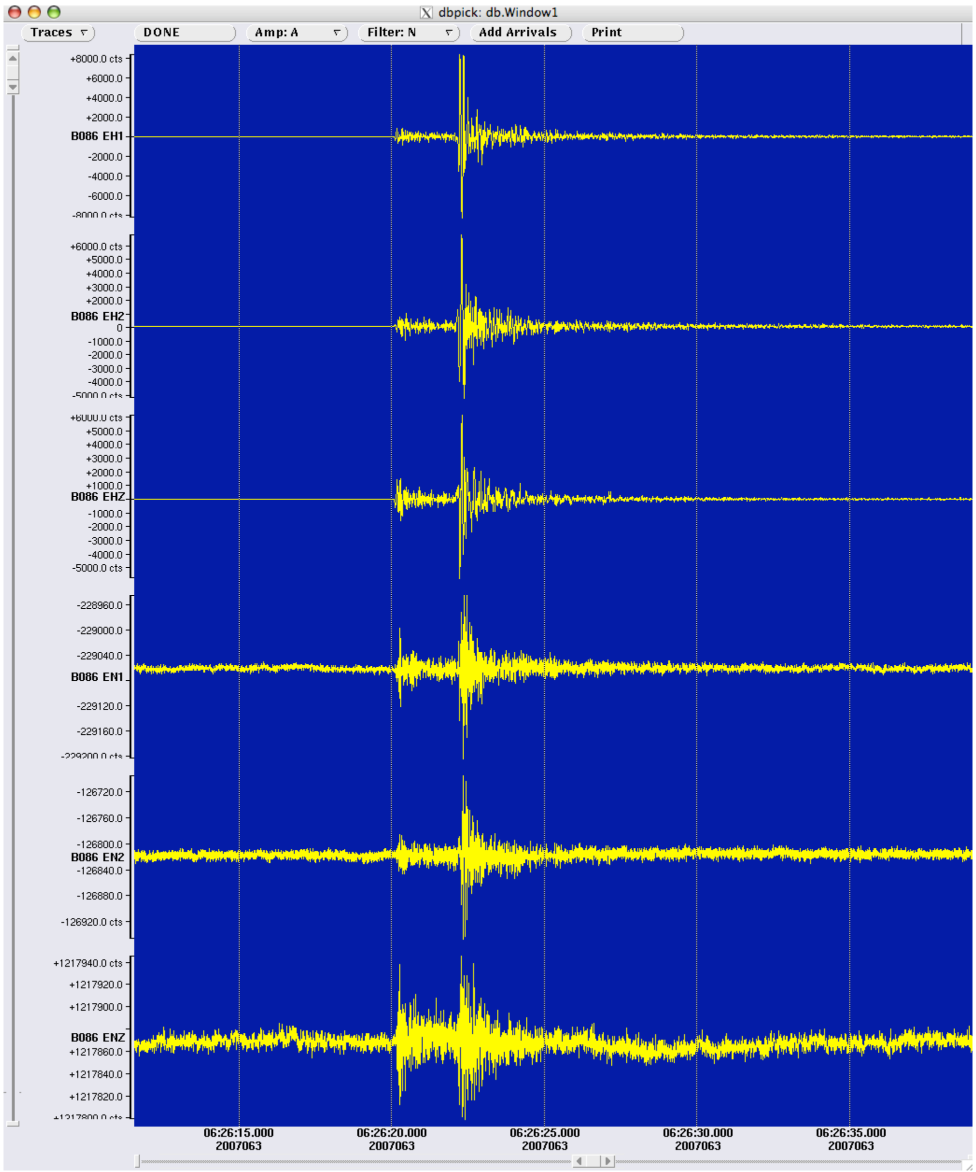

Figure 5. M1.8 Earthquake recorded at the PBO-Anza Santa Rosa station. Top three traces are the weak-motion velocity sensor, bottom three traces are the strong motion MEMS accelerometer.

There remain other PBO-Anza stations where the noise level on the accelerometers is even higher on individual channels than what is shown in Figure 5. Initial troubleshooting at the stations was not successful in correcting these problems. Further field troubleshooting will be required to improve these channels, but they have been confirmed to be functioning and will certainly have enough signal at the M3+ event level, before the weak-motion sensors begin to clip.

Other 2007 Activities:

From time to time problems arise with the borehole stations that require field visits to diagnose and fix. At the Jensen filtration plant, the data stopped being transmitted from the Jensen generator building free field and borehole station (JGB). A site visit revealed that the directional antenna had been broken off, and replacing this brought the station back online. It was replaced with a lower profile antenna to avoid a repeat of this problem.

Another problem that was noticed in 2007 was a mix up in the channel configuration at the WNS site. This site had been reinstalled in 2006 after a long outage due to construction at the school. A vertical and horizontal channel had been mistakenly wired incorrectly when the sensor was reinstalled, and this was not spotted until later, when examination of event data made it clear that the channels were swapped. This was corrected during a field visit to the site in early 2007.

2007 SCEC Publications:

Assimaki, D., W. Li, J. H. Steidl, K. Tsuda (2007). Site amplification and attenuation via downhole array seismogram inversion: A comparative study of the 2003 Miyaagi-Oki aftershock sequence, *Bulletin of the Seismological Society of America*, **98**, pp.301-330.

Assimaki, D., W. Li, J. H. Steidl, J. Schmedes (2008). Modeling nonlinear site response uncertainty in broadband ground motion simulations for the Los Angeles basin, *Bulletin of the Seismological Society of America*, in review.