17  TremorScope: Imaging the Deep Workings of the San Andreas Fault
Roland Bürgmann, Richard Allen, Pascal Audet, Douglas Dreger, Robert Nadeau, Barbara Romanowicz, Taka’aki Taira, Margaret Hellweg

17.1 Introduction

Until recently, active fault zones were thought to deform via seismic earthquake slip in the upper, brittle section of the crust, and by steady, aseismic shear below. However, in the last few years, this view has been shaken by seismological observations of seismic tremor deep in the roots of active fault zones. First recognized on subduction zones in Japan and the Pacific Northwest, tremor has also been found to be very active on a short section of the San Andreas to the southeast of one of the most densely monitored fault segments in the world, near Parkfield (Nadeau and Dolenc, 2005). This deep (20-30 km) zone of activity is located right below the nucleation zone of the great 1857 Fort Tejon earthquake. Thus, understanding the temporally and spatially complex faulting process in this zone may help us better understand the conditions that lead to such large ruptures.

17.2 The Project Plan

Although the tremor source region is away from existing seismic networks in and around Parkfield, early studies of the deep tremor have led to dramatic revisions in our views about how faults behave at depth (e.g., Nadeau and Guilhem, 2009; Thomas, Nadeau and Bürgmann, 2009; Shelly, 2010; Shelly and Hardebeck, 2010). These studies reveal behavior of faulting in the deep crust that is complex and dramatically different from the “normal” earthquakes that occur in the shallow crust. By adding seismic stations around the tremor source zone, we will complement the existing monitoring around Parkfield. The result, the TremorScope network, will sharpen our ability to explore this fascinating natural laboratory of active lower crustal faulting.

The proposed network consists of eight new stations to be centered on the tremor source (Figure 2.33). Four sites will have borehole installations and an accelerometer at the surface. The target is to install the equipment in boreholes that are 300 m deep. Each hole will have a three-component set of gimballed, 2 Hz geophones cemented at the bottom that will be digitized at the surface. In three boreholes, a Guralp downhole sensor package, consisting of a three-component broadband seismometer, a three-component accelerometer and a digitizer, will also be deployed. The other four stations will be surface installations consisting of a broadband seismometer, an accelerometer and a digitizer. At all locations, data will be logged onsite and forwarded to Berkeley for real-time processing. The data will be used in real-time earthquake monitoring (see Operations Section 8), as well as for tremor studies. The borehole sites (CASS, SCN, NC.PBP and NC.PPG) will be at some distance from the tremor source centroid, to offer low-noise, high quality recordings that offer good constraints on the tremor locations and depth. The four surface stations, closer to the tremor centroid, will have broadband seismometers, accelerometers and digitizers, as well as data loggers.

The project began in January 2011. We have ordered equipment and found sites for the stations (Figure 2.33). During the summer, we will be performing telemetry tests. We expect to install the stations in the fall of 2011.

17.3 Perspectives

Data from the TremorScope project will improve earthquake monitoring in the region south of Parkfield. Insights from the project will also contribute to understanding tremor and slip in other regions of the world where such phenomena have been observed, but are not nearly as accessible. Should a great San Andreas earthquake occur during this experiment, the network would also provide unprecedented and exciting insights into the seismic rupture process.

17.4 Acknowledgements

This work is funded by grant 2754 from the Gordon and Betty Moore Foundation.

17.5 References


Figure 2.33: Planned locations for TremorScope stations. Gold stars: Tremor locations. Colored squares: TremorScope sites. NC.PBP and NC.PPG are currently operated by the USGS Menlo Park and have short period vertical geophones and analog telemetry. Sites Cass, SCS, NC.PBP and NC.PPG will be borehole stations. SCN and SCS are collocated with PBO GPS stations. Telemetry will go via radio to Carr Hill, Hogs Canyon Comm. or Black Mountain Comm.