Preliminary geodetic observations of motions along the Rodgers Creek and Maacama Faults

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Field area and background

We aim to assess the seismic hazard associated with the Rodgers Creek and Maacama Faults north of San Francisco Bay. We focus more specifically on the area between San Pablo Bay and Clear Lake (see Figure 1), encompassing the cities of Petaluma, Santa Rosa, Sebastopol and Healdsburg. Our goal is to quantify, by measurement with GPS, all types of surface deformation, including surface creep, to constrain and improve models of fault motions.

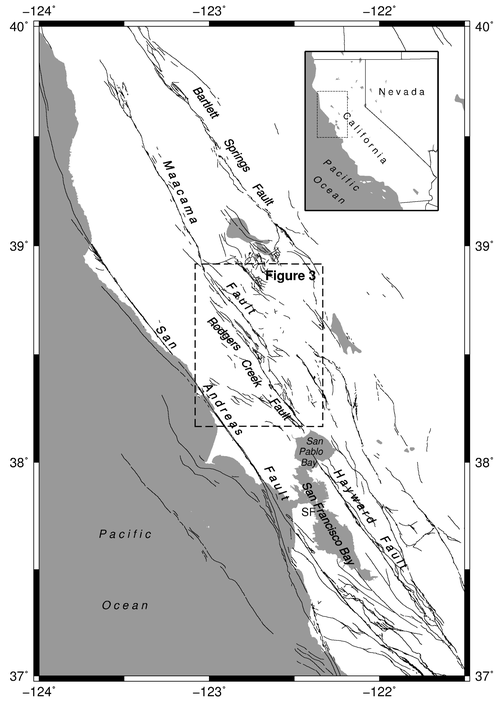

Figure 1: *Tectonic overview of California. Our focus is on the northern extension of the Hayward Fault in the San Francisco Bay area, the Rodgers Creek and Maacama Faults. All faults in this and proceeding figures are from U.S. Geological Survey and California Geological Survey (2009).*

We have measured and will measure the position of current monuments such as National Geodetic Survey, US Geological Survey and California Department of Transportation marks, and pins or the like placed for other more recent surveys. Many of these are destroyed or unsuitable for satellite observation. Therefore reconnaissance work is a significant part of the process of developing and observing our GPS survey network.

Importantly, The Geysers geothermal area flanks the north-east side of the Maacama Fault as it begins in a step-over from the Rodgers Creek Fault between Santa Rosa and Healdsburg (see Figure 3). If we are to model the fault motions correctly, we must also account for the deformation of The Geysers that is not associated with plate boundary tectonics.

GPS results to date

Survey site data

Several GPS surveys have been performed in the area for a variety of purposes. Four surveys were conducted in 1994 (two), 1995 and 1996 in and around The Geysers area (*Mossop and Segall*, 1997). A few sites near Santa Rosa and Healdsburg were occupied as part of the GeoEarthScope Northern California survey in 2007. All of these data are publicly available through UNAVCO.

The University of Utah conducted surveys in The Geysers in 2000, 2001 (twice) and 2006 (*Gettings et al.*, 2002) and we have been able to obtain these data. We conducted a further survey of The Geysers in September 2009.

We have also conducted surveys along the Rodgers Creek and Maacama Faults step-over between Petaluma and Healdsburg in the mid-summers of 2008 and 2009 (blue velocity vectors in Figure 3).

Figure 2: Top-left *Existing marks, ideally plated by the US Geological Survey or National Geodetic Survey (formerly US Coast & Geodetic Survey) are sought to measure.* Top-right *Brad walks away from a new overnight occupation of site DIVD in The Geysers area in September 2009.* Bottom-left *Brad secures the tripod among shrubs.* Bottom-right *Gareth and Brad defy the slopes to occupy a mark above the road.*

Continuous site data

Furthermore since 2004, Plate Boundary Observatory (PBO) sites have existed and are incorporated into our results (red velocity vectors in Figure 3). Currently these are included by intermittent processing at the epochs of the main surveys. As this work progresses, we will combine our solution with fully continuous GPS velocities rigorously at the raw observation or velocity level.

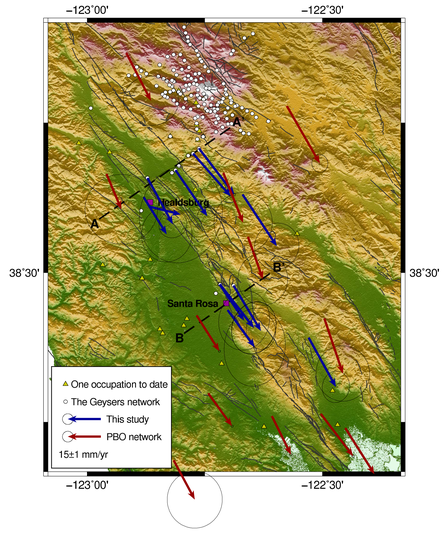

Figure 3: *Velocity solution obtained in this work to date. Only 13 sites that are not included in The Geysers network have been occupied more than once (blue velocity vectors). White dots indicate GPS sites measured by Mossop and Segall (1997) and Gettings et al. (2002), combined. These velocity data are vital to the problem to be solved here as deformation in The Geysers heavily dominates and overprints any fault-related strain on the north-east side of the Maacama Fault.*

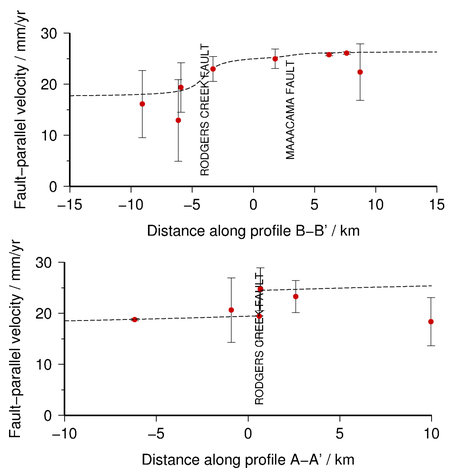

Figure 4: *Fault-perpendicular profiles showing preliminary estimates of relative motion across the fault zone.* Top *Dashed line is the velocity profile expected for a one-dimensional elastic dislocation with a locking depth of 1 km, and 8 mm/yr of motion across the Rodgers Creek Fault and 2 mm/yr across the Maacama Fault.* Bottom *Dashed line shows expected velocity profile with a fault locked to a depth of 10 km and a total displacement rate of 10 mm/yr of which 5 mm/yr is accommodated as creep on the fault plane.*

Figure 5: *Zoomed view of the alignment array at Fountain Grove Parkway, Santa Rosa. Sites RFGI and RFGO have equated velocities which are shown with respect to RFGE, on the south-west side of the fault. Ground imagery courtesy of Google Earth and the City of Santa Rosa.*

Field focus for 2010 and beyond

This summer and beyond we will be embarking on several further weeks of field work to achieve the following goals:

1. Reoccupy sites measured in the summers of 2008 and 2009;
2. Continue to densify and expand the current network, especially in respect of other known and available GPS data sources;
3. Seek to expand the network further north to encompass the Maacama Fault's northward extension;
4. Investigate the reliability of geodetic marks closer to San Pablo Bay for the question of connectivity between the Hayward and Rodgers Creek Faults;
5. Continue to measure sites in The Geysers for accurate modeling of deformation not associated with plate boundary tectonics.

We will also be seeking to acquire GPS data from other sources such as the California Department of Transportation that have been taken place in the last ten years for incorporation into our solution. Access to such data will also benefit our network expansion reconnaissance work.

References

Gettings, P., R. N. Harris, R. G. Allis, and D. S. Chapman (2002), Gravity signals at The Geysers geothermal system, in *Proc. Twenty-Seventh Workshop on Geothermal Reservoir Engineering*, Stanford University.

Mossop, A., and P. Segall (1997), Subsidence at The Geysers geothermal field, N. California from a comparison of GPS and leveling surveys, *Geophys. Res. Lett.*, *24*(14), 1839–1842, doi: 10.1029/97GL51792.

U.S. Geological Survey and California Geological Survey (2009), Quaternary fault and fold database for the United States, from USGS website: http://earthquake.usgs.gov/regional/qfaults/.