2010 SCEC ANNUAL REPORT - GPS and CHIRP Surveys of the Imperial and Cerro Prieto Faults, Mexico **David Sandwell, PI ($**10,000**)**

Proposed Tasks:

1) We proposed to fully analyze the data from the three GPS surveys of the Imperial Valley performed in 2009 and perform repeated surveys of selected monuments as necessary. In addition we proposed to extend the survey area to the Mexican section of the Imperial Fault and Cerro Prieto geothermal area. The Mexican surveys would be performed in collaboration with Javier Gonzales and graduate students from CICESE, Ensenada Mexico.

2) We proposed to explore the possibility of investigating the paleoseismic history of the northern end of the Cerro Prieto fault using a towed CHIRP to image the upper 10 m of sediment.

3) We proposed that the surveys would be a component of an SIO/SDSU graduate course taught each year. The course focuses on application of InSAR and GPS methods to tectonic deformation in the Salton Trough region of Southern California.

Revised Tasks:

Our proposed work plan was revised in two important ways. First we cancelled the CHIRP investigation because we were unable to obtain permission to use the CFE geothermal pond. In January, 2010 we asked the director of the Cerro Prieto Geothermal Plant (Ing. Sergio Miguel Miranda Vega) for permission to use their geothermal pond. The response on Feb 8, 2010 from Mr. Vega of CFE was negative because of safety concerns (see attached letter).

Second, we revised our GPS survey plans because of the M7.2 El Major-Cucapah earthquake. We were already collaborating with CICESE scientists on the GPS surveys of the Mexicali region for measuring interseismic deformation. When the earthquake occurred we revised the plan to perform surveys relevant co-seismic and post-seismic deformation. The $5k not used for the CHIRP survey was used on these extended GPS surveys.

Progress:

During the past year we have completed the following three field campaigns:

1) Brawley Seismic Zone (Field Surveys by UCSD graduate students led by Brendan Crowell)

During the 2009-2010 field season rapid-static GPS surveys have been performed throughout the Imperial and Coachella Valleys looking at strain partitioning throughout the Brawley Seismic Zone (Figure 1). Comparing the results of the three rapid-static surveys to SCEC's CMM, which contains velocities through 2003, we were able to

identify a large strain signal that we associate with the 2005 Obsidian Buttes Seismic Swarm along the southern bank of the Salton Sea. Through field observations, we were able to identify a northeast trending fault centered along the strain anomaly that had a visible surface trace over 10 km that we call the Obsidian Buttes Fault. We performed a slip inversion to find that the strain anomaly was associated with a fault-averaged increase of 9 mm/yr of left-lateral motion over the period between 2003-2009. From the results of the slip inversion, we concluded that motion along this fault will actually raise the static stress levels along the southern San Andreas Fault by 0.1 MPa/yr. We presented the findings at the 2009 AGU Fall Meeting and have just submitted the results to Geophysical Research Letters [Crowell et al., 2010].

Since the previous surveys, we have been trying to develop a more thorough and consistent data set throughout the Brawley Seismic Zone. In January, 2010, we started surveying a dense array of monuments with half mile spacing around the Obsidian Buttes Fault and through the Mesquite Basin to try and fully capture strain transfer through the Brawley Seismic Zone (Figure 1). Unfortunately, the Easter Sunday, Mw 7.2 Sierra El Mayor earthquake occurred, significantly moving all of the monuments that we have surveyed throughout the past 4 months, so all of these measurements will need to be redone to properly assess interseismic coupling of the faults. However, we do have a great opportunity to look at triggered slip along the Obsidian Buttes and Imperial Faults with a very dense array of measurements.

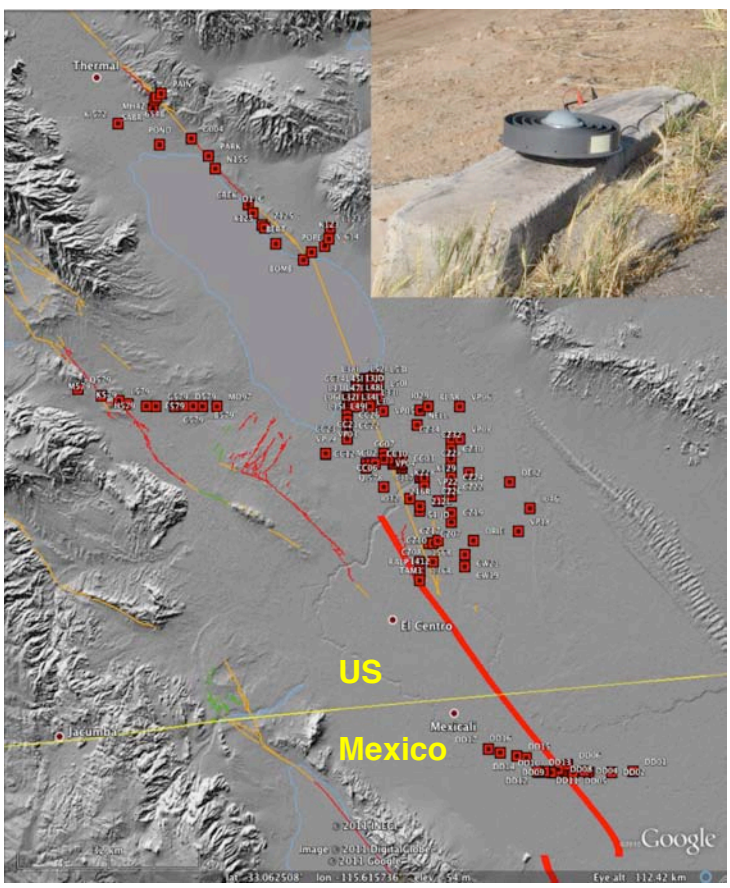

Figure 1: Map showing the GPS monuments surveyed for investigating interseismic deformation prior to the M7.2 El Major-Cucapah earthquake. The sites north of the US-Mexico border were existing monuments. The sites south of the border are 17 new sites installed under this investigation. The new monuments consist of stainless steel couplers cemented into existing concrete structures (inset). This approach minimizes setup time and error. These 17 sites were installed prior to the earthquake but were surveyed (twice) after the earthquake.

2) Imperial Fault, Baja California (Field Surveys by SIO faculty and students in collaboration with CICESE faculty and staff)

During the 2009-2010 field season we installed a 17 GPS monuments across the Imperial Fault near Mexicali to monitor interseismic displacements. This is the DD-line (Figure 1) The monuments were installed in January of 2010 and surveyed twice in May of 2010.

3) Field response to the April 4, M7.2 El Major Earthquake (Field Surveys by SIO faculty and students in collaboration with CICESE and UC Riverside faculty and staff)

We have spent a significant effort performing GPS field surveys following the April 4, 2010 M7.2 El Major-Cucapah Earthquake (Figures 2 and 3). This work continues our SCEC-funded analysis of the interseismic deformation of the Imperial and Cerro Prieto faults. David Sandwell, Yuri Fialko, Matt Wei, and Xiaopeng Tong have spent a considerable amount of time collecting GPS campaign data in Mexico. This work was performed in collaboration with scientists at CICESE (Alejandro Gonzales, and Javier Gonzales) as well as scientists at UC Riverside (Mike Floyd, Garreth Funning, and Brad Lipovsky). This response is unique since the there are no permanently operating GPS stations south of the US border and the USGS field program cannot extend south of the border. GPS progress and plans are being coordinated at SIO and the survey plans can be found at ftp://topex.ucsd.edu/pub/baja_eq/ EL_MAJOR_GPS.kmz

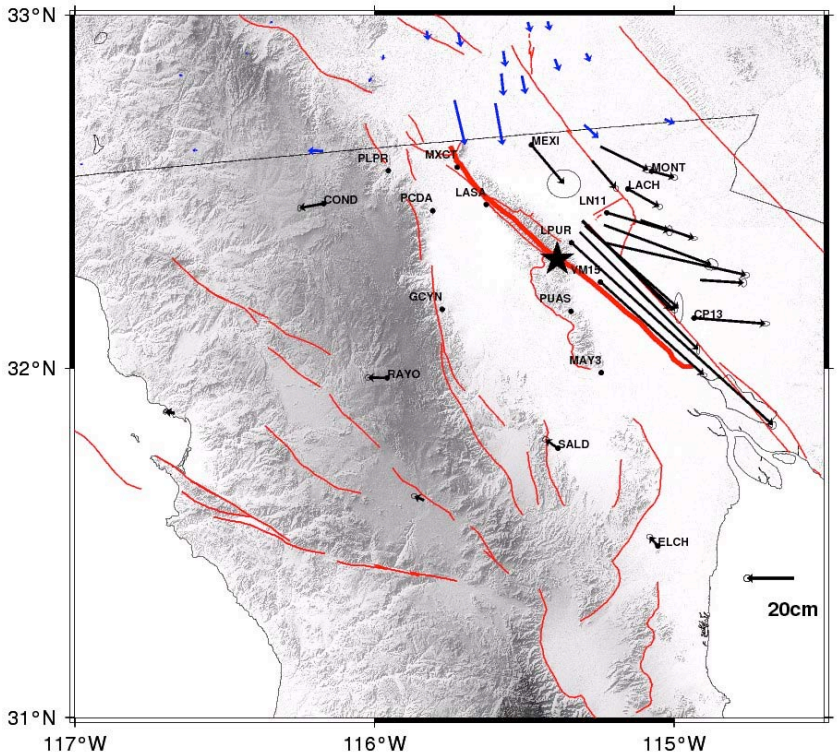

Figure 2. Coseismic displacement vectors (black arrows) from campaign GPS surveys following the M7.2 El Major Cucupah earthquake.

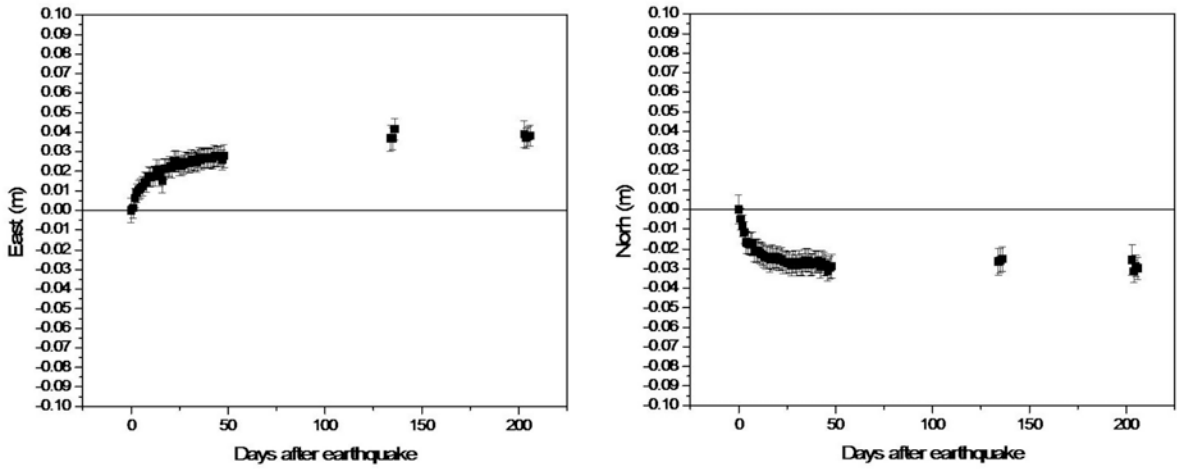

Figure 3. Repeated GPS measurements at a GPS site LPUR following the M7.2 El Major Cucapah earthquake. Measurements began less than 24 hours after the earthquake and continued for approximately 50 days. Surveys have been repeated 4 more times at approximately 60-day intervals to capture the postseismic signal. Results for the two most recent surveys are not shown.

Abstracts and Publications:

Crowell, B.W., Y. Bock, and D.T. Sandwell (2009), Interseismic Strain Accumulation in the Imperial Valley and Implications for Triggering of Large Earthquakes in Southern California, Eos Trans. AGU, 90(54), Fall Meet. Suppl., Abstract T33E-02.

Crowell, B.W. and Y. Bock (2008), Near Real-Time Processing and Archiving of GPS Surveys for Crustal Motion Monitoring, Eos Trans. AGU, 89(53), Fall Meet. Suppl., Abstract G41C-0637.

Crowell, B.W., Y. Bock, D.T. Sandwell, Y. Fialko and R.B. Lohman (2008), Near real-time processing of results from the 2008 Imperial Valley, California, GPS survey, (2008 SCEC Annual Meeting poster 2-030).

Fialko, Y., A. Gonzalez, J J Gonzalez-Garcia, S. Barbot, S. Leprince, D. T. Sandwell, D. Agnew, Static Rupture Model of the 2010 M7.2 El Mayor-Cucapah Earthquake from ALOS, ENVISAT, SPOT and GPS Data, Abstract T53B-2124, presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Gonzalez, A, J J Gonzalez-Garcia, D T Sandwell, Y Fialko, D Agnew, B. Lipovsky, J. Fletcher, F. A. Nava Pichardo, GPS coseismic and postseismic surface displacements of the El Mayor-Cucapah earthquake, Abstract T53B-2125, presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Sandwell, D T , R. Mellors, X. Tong, M. Wei, P. Wessel, GMTSAR Software for Rapid Assessment of Earthquakes, G13A-0651, presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Wei, M., D. Sandwell, Y. Fialko, and R. Bilham Slip on faults in the Imperial Valley triggered by the 4 April 2010 Mw 7.2 El Mayor-Cucapah earthquake revealed by InSAR *Geophys. Res. Lett.,* doi:10.1029/2010GL045235, in press. (accepted 19 November 2010)

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Subdirección de Generación
Gerencia de Proyectos Geotermoélctricos
Residencia General de Cerro Prieto

"2010. AÑO BICENTENARIO"

OFICIO No: HAA00-SMMV-092/2010
FECHA: 08 de febrero de 2010

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En atención a su carta con fecha del 25 de Enero del presente, donde nos solicita autorización, para realizar una investigación de **REFLEXIÓN ACÚSTICA,** en la Laguna de Evaporación del Campo Geotérmico de Cerro Prieto, con fondos de National Sciences Foundation, le comunicamos que no es posible llevarlo a cabo, debido a que, por programas de operación de ésta, continuamente se ejecutan obras de rehabilitación y dragado, lo que dificulta su navegación y los problemas de seguridad asociados se incrementan.

Sin embargo, sabemos que existe en la extensión de la falla Cerro Prieto y el Delta del Río Colorado, sitios más seguros que el propuesto, donde podrán llevar a cabo estudios similares sin afectar la operación del Campo Geotérmico.

Sin más por el momento le enviamos un cordial saludo.

A t e n t a m e n t e

Pa
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Residente General de Cerro Prieto
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