Annual Project Summary

DEEP BOREHOLE TENSOR STRAIN MONITORING, SOUTHERN CALIFORNIA

NEHRP Grant 98-HQ-GR-1019

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II

seismology, geodesy, borehole geophysics

Project Objectives and Approach

This project provides field observations critical to an understanding of fault processes associated with earthquakes along the San Andreas and Sierre Madre faults. Continuous high precision and high resolution borehole tensor strain data provide an essential complement to long baseline interferometry studies (limited to sampling intervals of weeks), GPS studies, and seismic characterisation of faults.

The project continues a program of maintenance and analysis of deep borehole tensor strain instrumentation initiated at Pinon Flat in late 1983, and a further deployment in the San Gabriel mountains region (Coldbrook) in 1996. These instruments consist of a three component plane strain module operating at strain sensitivity of 10^{-10} and support data logging systems. As deployed to date they provide data sampling at 30 minute intervals for transmission via satellite for permanent archive purposes. The instruments provided by this project are unique in the program in that they provide continuous tensor strain data of high quality and sensitivity not achievable by any other instrumentation. These data form a critical complement to GPS and geodetic studies (see Figure 1) in

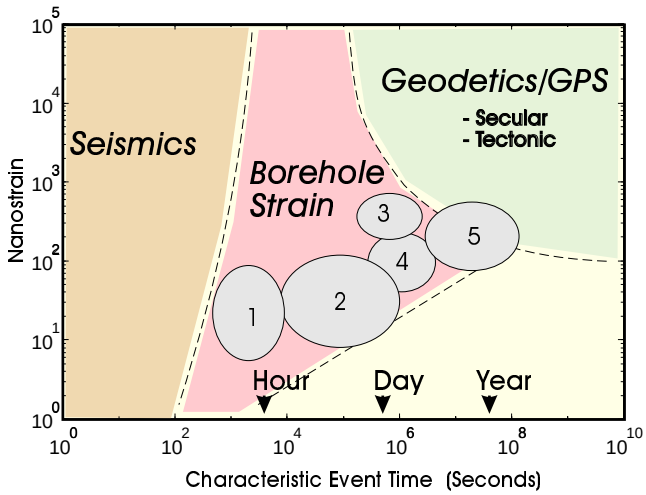

Figure 1. *Effective detection capabilities of seismic,borehole strain, and geodetic instrumentation. The vertical axis is in units of strain, whilst the horizontal axis covers the period band from 1 second to 10^{10} seconds (100 years). GPS instrumentation will lower the boundary of the geodetic domain, but not significantly. For precise monitoring of short term strain rate fluctuations, there is a clear necessity for borehole strain instruments with nanostrain resolution in the minutes - months time scales. Data observed over the past 14 years have included identifiable episodes in the domains shown as 1,..5.*

assessing strain rates and consequent earthquake risk, as well as investigating fault processes associated with earthquake preparation and postseismic relaxation. Data are made available in near real time in the USGS Menlo Park computer system (thebeach:/we/mick/BASEDATA). These data supplement long baseline survey data, and permit real time monitoring for short term strain phenomena.

The **immediate objectives** of the project are

- Maintenance of uphole system integrity at 2 Southern Californian sites, with repair or production of replacement uphole electronics if necessary.
- Manual preparation of raw instrument data for permanent archive.
- Analysis of continuous unique low frequency shear strain data (30 minute samples) and modelling studies based on the constraints of these data
- Near real time alert response to the earthquake studies community when necessary.
- Archive of processed data for access by the earthquake studies community, and provision of near-real time automatically processed data for inclusion in publically accessible web pages linked to the USGS web datasets.

The project is carried out in parallel with maintenance of six further sites (San Juan Bautista, along the Hayward fault and near Parkfield) in Northern California.

Investigations & Results

The Coldrook site is situated in the San Gabriel mountains, and together with three USGS operated borehole dilatometers forms a 4 instrument array in the region between the Sierre Madre and San Andreas faults. The Coldbrook dataset is now two years in length, and borehole recovery processes evident in the data in the form of exponential signals will be removed after the time series is a sufficient length. Raw data processed into horizontal strain components is shown in Figure 2. The large deviation in the data in February 1998 was due to extremely high rainfall with consequent landslip activity near the site. The change in shear strain Gamma2 gradient from March to June 1998 is not associated with rainfall, and is also present on the Chantry dilatometer 15 km to the southwest.

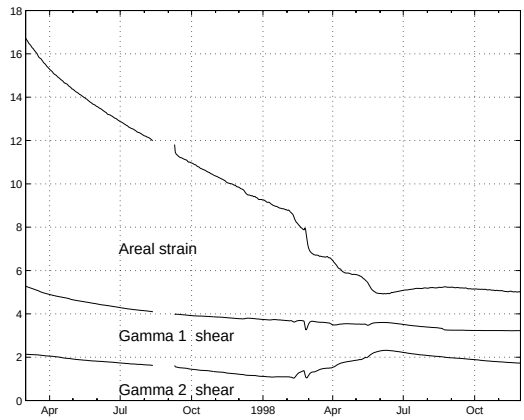

Figure 2 *Raw data processed into areal and shear strains Gamma1,Gamma2 from Coldbrook in the San Gabriel mountains. Curing exponentilas are evident in the data, and after sufficient time (2-3years) will be fitted and removed from the data series.*

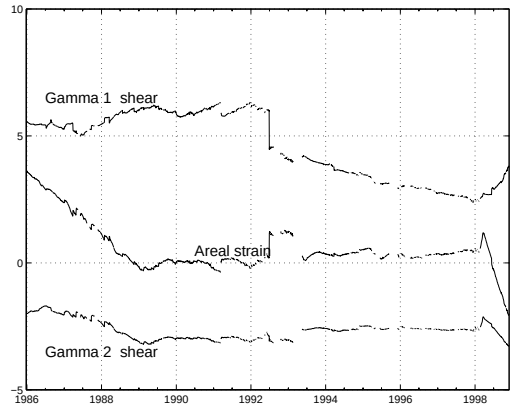

Figure 3 *Pinon Flat strain data*

Data from the Pinon Flat BTSM instrument are shown in Figure 3. The major features are a change in both areal and shear strain rate in 1988-89, and the offset in strain coseismic with the Landers earthquake in 1992. The change of rate in 1988-89 is also evident in the long baseline laser strainmeter at Pinon Flat. A large change in strain rate during 1998 is also clear, and during 1999 we shall be comparing these data with the laser strain data if these become available (no regularly maintained data archive is provided for the laser strainmeter data).

Data Availability

Archived strain data from the Californian sites is stored in both raw component form, and as processed areal and shear strains. A regularly updated archive of data has been maintained in the USGS Menlo Park computer system since 1988. This data is stored in binary files with appended header information (USGS "*bottle*" format).

Data is accessible in *thebeach:/we/mick/BASEDATA*. Automatically processed near-realtime data is available in *thebeach:/we/mick/QUICKCHECK* for users with access to USGS plotting software "*xqp*", and via the USGS crustal deformation web pages in graphical form. Home page for access to all web data from borehole tensor strain instruments is *http://www.dem.csiro.au/~rossg/straincal/straincal.html*

For information on archived data, contact Dr. R. Gwyther (+617 3212 4586, email: *r.gwyther@cat.csiro.au*) or Dr. M.T. Gladwin (+617 3212 4562).

Publications

Recent Publications 1997-98

Langbein, J., R.L. Gwyther and M.T. Gladwin Possible increase in fault slip rate at Parkfield in 1993 as inferred from deformation measurements from 1986 to 1997 *Seis. Res. Lett.* v69(2), p 151, 1998

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Gladwin M.T., R.L. Gwyther and M.Mee High-Precision Continuous Deformation Monitoring of Mine Structures *Proc. 13th Int. Geophys. Conf.*, A.S.E.G., 1998

Gladwin M.T., R.L. Gwyther and R.H.G. Hart. Long-term borehole tensor strain data at Parkfield,CA: Issues of Interpretation *EOS. (Trans. Am. Geo. Un.)* v78(17), p S219, 1997

Gwyther R.L., M.T. Gladwin and R.H.G. Hart Aseismic strain transients with scales of 2km to 6km measured with borehole instruments *EOS. (Trans. Am. Geo. Un.)* 78(17) , p S213, 1997.

Johnston M.J.S., R.Gwyther, R.J. Mueller, A.T. Linde, M.T. Gladwin and G.D. Myren A triggered Slow Earthquake on the San Andreas Fault in April 1996 *EOS. (Trans. Am. Geo. Un.)* v78(17), p S209, 1997

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Gladwin, M.T., Gwyther, R.L., Hart, R.H.G. and Breckenridge K.(1993) Measurements of the strain field associated with episodic creep events on the San Andreas fault at San Juan Bautista, California (1994*). J. Geophys. Res*. Vol 99 (B3), 4559-4565.

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Non-Technical Summary

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