GPS Site Velocities in the San Bernardino Mountains

Angel Torrens-Bonano[1], Ashley Grijalva[2], Elizabeth Upton[3], Adrian Borsa[4], Sally McGill[5]

[1]University of Puerto Rico at Mayagüez, [2]University of Texas at El Paso, [3]Occidental College, [4]University of California at San Diego, [5]California State University San Bernardino

INTRODUCTION

The San Andreas Fault (SAF) is a portion of the plate boundary between the North American plate and the Pacific Plate on the west coast of the United States. This fault has been a principal area of study in the scientific field because of the complexity of the fault. The main area of study of this project is on the San Bernardino Strand (SBS) of the SAF. Prior to this study there was little Global Positioning System (GPS) data for this part of the plate boundary, and our study fills this gap. The site velocities obtained in this project can be used to test models for the best slip rate for the SBS and thus determine how fast the SAF and others parallel faults are moving (see companion poster by Grijalva and others).

Figure 1. Image taken from Google Earth showing western coast of USA and the study area in a yellow box.

DATA COLLECTION

Global Positioning System (GPS) antennas were set up over 25 different benchmarks in the San Bernardino/Riverside area and San Bernardino Mountains. Antennas were set up on spike mounts or tripods centered precisely over the benchmark and carefully leveled. The height was measured or calculated between the bottom of the center of the antenna and the benchmark on the ground. After the GPS equipment was set up, it was left at the site for 5 days, more or less, collecting position data for the precise location of the benchmark. The raw data files were sent to Josh Spinler at University of Arizona to be processed using GAMIT/GLOBK. The data in this poster are from 2010; they are presented here for the first time.

ABSTRACT

The southern part if the San Andreas Fault (SAF) has been locked for almost two centuries now, but because of the elastic behavior of the Earth's crust, the surroundings are moving, and thus accumulating strain along the fault To know how much strain has been accumulated on the San Bernardino Strand (SBS) of the SAF, a Global Positioning System (GPS) campaign was conducted in mid July 2011 collecting from 25 different benchmarks to measure sites positions in and around the San Bernardino Mountains. Combining these positions with positions measured in previous years, we created time series to determine each site's rate and direction of motion. The east and north velocities were combined to obtain a horizontal velocity for each site. All of the sites are moving toward northwest, at rates ranging from 11.6 to 35.1 mm/yr. As expected, stations farther to the west are moving faster (relative to the North American plate) than those to the east side. In the companion presentation, these sites velocities are used to describe the crustal deformation within a transect area across the SAF and other parallel faults to find the combinations of fault slip rates that fit the site velocities well.

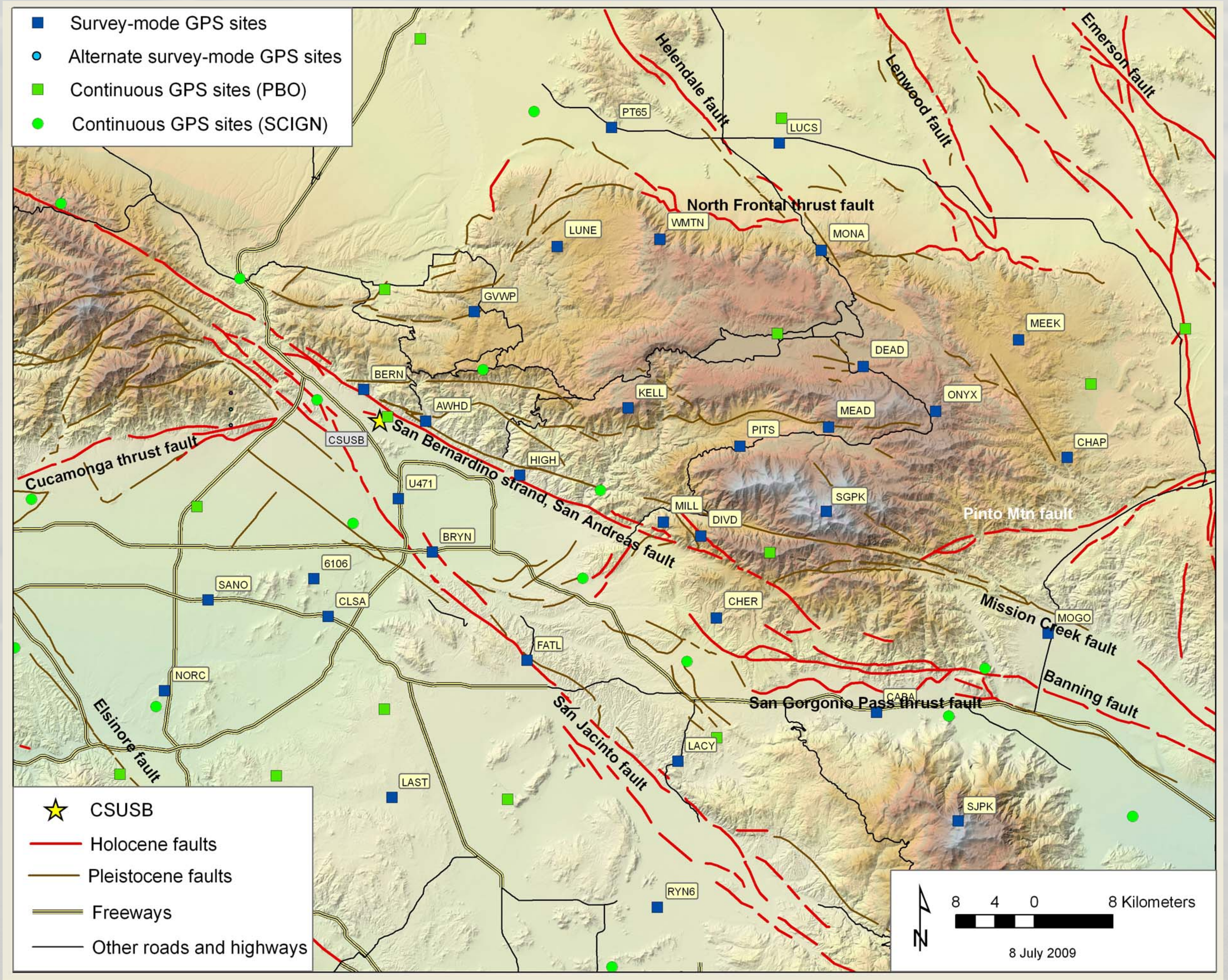


Figure 2. Location of campaign GPS sites (blue squares) and continuous GPS sites (green squares and circles) within the study area.

Figure 3. BRINK benchmark

Figure 4. Emigdio Alaniz (my partner) setting up the GPS equipment

Figure 5. GPS on a tripod at site 7211 at the YMCA Camp Whittle, near Fawnskin, CA.

Figure 6. GPS antenna on a spike mount at the BRINK site.

SITES VELOCITIES

Processed data are used to plot what we call a time series showing the motion of the benchmark over a period of time. Some of the sites have been surveyed since 1993 and others since 2002 giving us a good plot of motion. What we obtain is motion in the north, east and vertical directions. The north and east sre combined using the Pythagorean theorem to obtain the combined horizontal velocity of each benchmark. Results show motion towards the northwest direction, as expected, with a velocity range between 11.6 and 35.1 mm/yr. Sites in the northeastern part of the network are moving slower, and those farther southwest are moving faster.

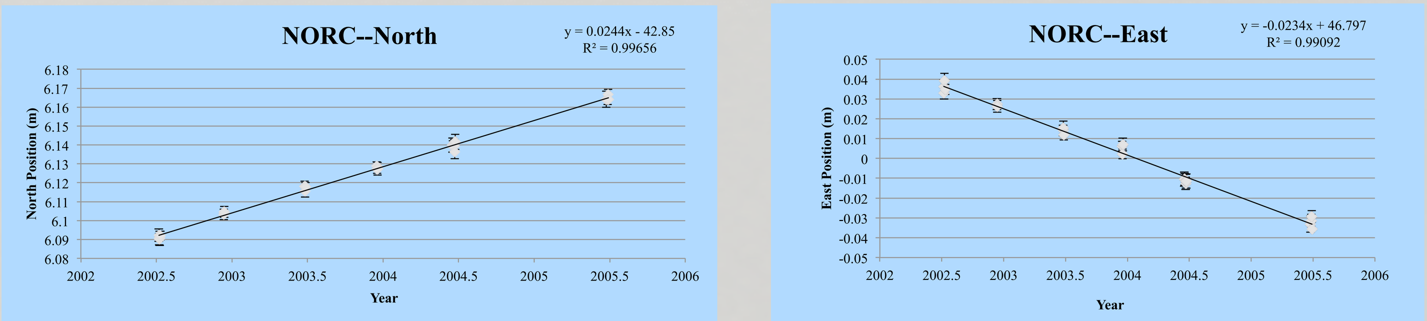


Figure 7. North and East time series for NORC site

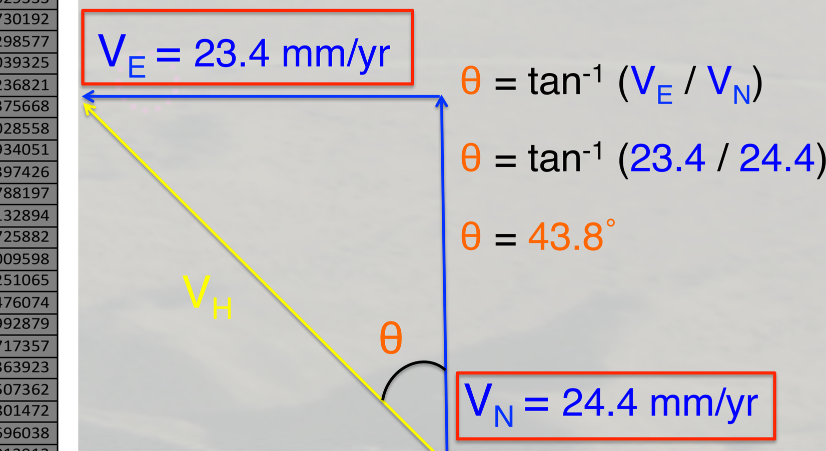
	Velocity (mm/yr)				Direction (degrees)
Stations ID	North	East	Vertical	Horizontal	W°N
6106	23.1	-20.6	-1.2	30.95109045	-41.72581348
7211	7.2	-9.1	-6.3	11.60387866	-51.64868881
AWHD	17	-17	-4.2	24.04163056	-45.00003801
BRYN	19.1	-18.9	-13.6	26.87042984	-44.69848381
CABZ	21.6	-12	-1	24.70951234	-29.05462864
CHER 93-97	18	-14.8	28	23.30321866	-39.4278355
CHER 05-10	16.6	-14.1	21	21.78003673	-40.34452665
CHPA	12	-10.8	-2.2	16.14434886	-41.98724796
CLSA	23.5	-21.8	-6	32.05448487	-42.85087198
DEAD	13	-10	-1	16.40121947	-37.56862376
DIVD	9	-15	-4	17.49285568	-59.03629333
FATL	21	-19.1	0	28.3867927	-42.28730192
GVWP	12.3	-9.9	2	15.78923684	-38.8298577
HIGH	16.2	-17	-0.9	23.48275963	-46.38039325
KELL 93-99	20	-28	-14	34.40930107	-54.46236821
KELL 02-05	8	-18	-1	19.6977156	-66.0375668
K526	21	-20	-3	29	-43.6028558
LACY	15	-22.8	5.7	27.291757	-56.65934051
LAST	22.6	-24.1	0.9	33.03891645	-46.8397426
LUCS	13	-12.9	-2.2	18.31420214	-44.7788197
LUNE	14	-12	0	18.43908891	-40.60132894
MEAD	14	-11	-4	17.80449381	-38.15725882
MEEK 96-98	12	-8	-14	14.4222051	-33.69009598
MEEK 99-10	15	-8	0	17	-28.07251065
MILL	17	-13.7	-1.6	21.83323155	-38.86476074
MONA	12	-9	-3	15	-36.86992879
NORC	24.4	-23.4	-4.6	33.80709985	-44.03717357
ONYX 95-99	13	-11	7	17.02938637	-40.2363923
ONYX 00-07	18	-9	0	20.1246118	-26.56507362
PITS	15.1	-13.5	-1.8	20.25487596	-41.79801472
PT65	13.8	-14.5	-0.9	20.01724257	-46.41696038
RICU	15.4	-4.9	8.2	16.16075493	-17.65013913
RYN6	25.1	-18.9	0	31.42005729	-36.97934144
SANO 93-99	24	-23	1	33.24154028	-43.78116175
SANO 02-10	22	-22	0	31.11269837	-45.00003801
SGPK	12	-12	-2.2	16.97056275	-45.00003801
SJPK	16.1	-16.7	0.3	23.19698256	-46.04801554
WMTN	13	-10	-3	16.40121947	-37.56862376
U471	20.4	-19.6	-8	28.28992754	-43.8542742

Table 1. GPS site velocities from the San Bernardino Mountains

$$V_H = [\,(V_N)^2 + (V_E)^2\,]^{1/2}$$

$$V_H = [\,(24.4)^2 + (23.4)^2\,]^{1/2}$$

$$V_H = 33.8 \text{ mm/yr}$$



$$\theta = \tan^{-1}(V_E / V_N)$$

$$\theta = \tan^{-1}(23.4 / 24.4)$$

$$\theta = 43.8^\circ$$

Figure 8. Calculating the horizontal velocity using Pythagorean Theorem and trigonometry for NORC site.

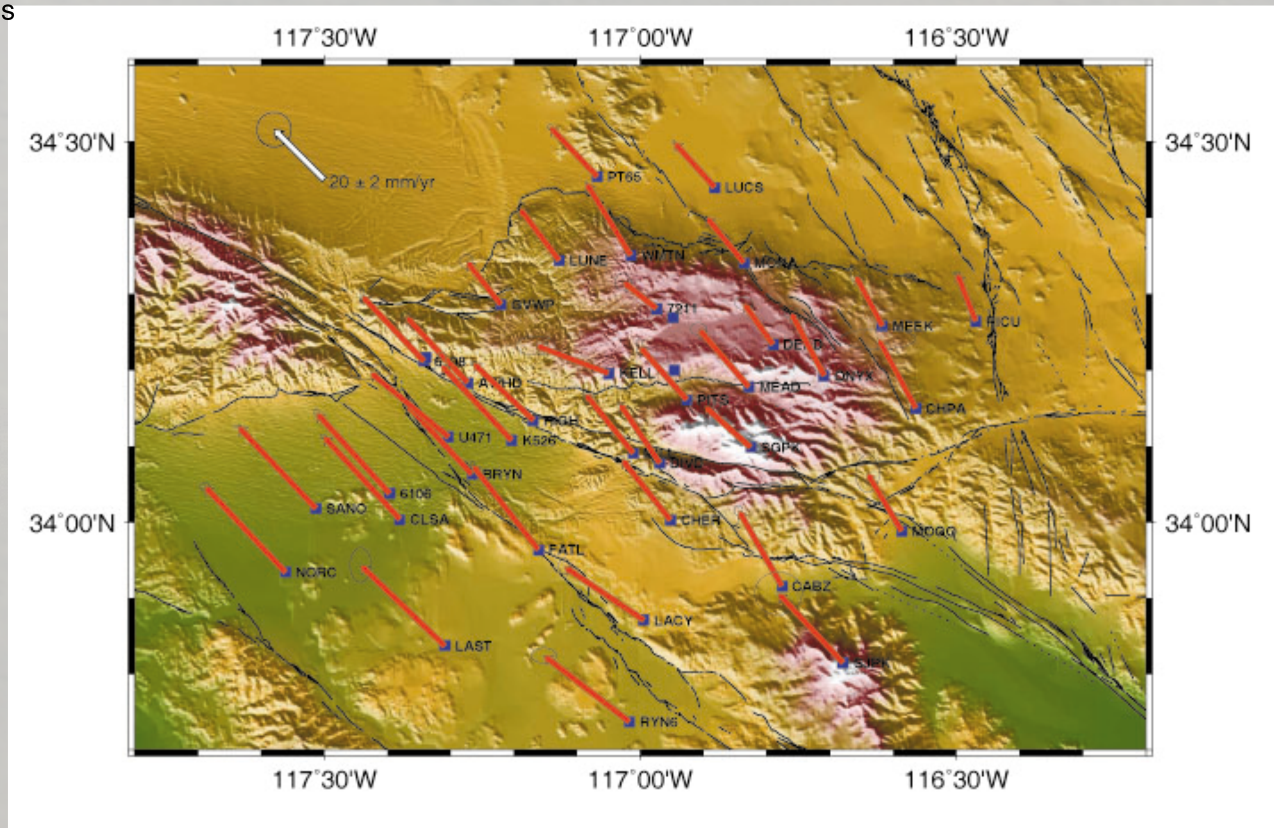


Figure 9. Horizontal velocity vectors for the CSUSB-U0fA network.

Source of image: http://www.sanandreasfault.org/4020_A.jpg