Plate Boundary Observatory Working Group
for the Central and Northern San Andreas Fault System
PBO-WG-CNSA

Introduction

Our proposal focuses on the San Andreas fault system in central and northern California. In particular, we wish to investigate the deformation and seismicity associated with the locked and creeping segments of the fault system. We are interested in transient features associated with seismic and aseismic events, as well as the kinematics of secular deformation. In this region, major earthquakes threaten important population centers. The occurrence of frequent moderate earthquakes within 10 km of the surface afford the opportunity to obtain near-field source information. We have access to the transition between the locked and creeping segments of the San Andreas fault. And, existing instrumentation and data provide a base for achievement of the goals listed below.

We are proposing Global Positioning System (GPS) and Borehole Strain (BHS) instrumentation for the San Andreas fault system central and northern California. The instrument numbers in this proposal are predicated on the assumption that there will be 200 to 300 GPS instruments and 50 to 75 BHS instruments available for this area.

The area under discussion extends from the Mendocino triple junction on the north to south of Parkfield (Fig. 1). The area is comprised of five sub-regions with differing tectonic styles. From north to south, these are: the Mendocino Triple Junction, Northern San Andreas Fault System, San Francisco Bay Area, Central Creeping San Andreas Fault, Parkfield. In the next few sections of this white paper, we will present the science goals we can be address by PBO in this region, then discuss each of these sub-regions.

Science Goals

- Detect episodic inter-seismic deformation events and subsequent strain redistribution, particularly in regions of transition from fully locked to partially creeping faults of the San Andreas Fault system (e.g. Hayward-Rodgers Creek, San Andreas north of San Juan Bautista, Parkfield…).
  [Methods: BHSM, CGPS, SGPS, BHSeismic]
- Observe all phases of the earthquake deformation cycle (pre-, co-, post, and inter-seismic motions) on selected target fault segments with dense networks (e.g. all major SF Bay Area faults, Parkfield). In particular, capture earthquake nucleation and nucleation of aseismic fault failure in the near-field of these events.
  [Methods: CGPS, BHSM]
- Measure slip partitioning among major faults of the San Andreas System.
  [Methods: CGPS, SGPS]

- Determine depth distribution of inter-seismic slip for high hazard faults (e.g. N. Hayward fault).
  [Methods: CGPS, SGPS]

Design philosophy

We believe that for both strain and GPS experiments, but particularly for strain experiments, the best experiment design is one that includes multiple instruments at relatively dense spacing. We would like to install the strain meters in clusters of 5 instruments minimum. Spacing within each cluster will vary depending upon logistics and geophysical objectives, but will be on the order of 2 to 10 km. The spacing of the GPS stations will be optimized in each array to address the primary scientific objectives for each region. The spacing will vary from dense profiles with stations every 5 km, to a broadly spaced arrays with a distributed spacing of 25km. Although the total number of instruments that will be available from PBO is large relative to previously available resources, it will still not be adequate to optimally instrument the entire area of Northern and Central California. Therefore the requests described below represent a compromise between a thin distribution of instruments that would sparsely cover the entire region without adequately covering any region, and a dense instrumentation in just a few areas.

Mendocino Triple Junction

Request: 40 GPS 10 Strain

The Mendocino Triple Junction lies at the intersection of the Gorda, Pacific and North America plates. It is the transition zone where the strike slip motion typical of the San Andreas system terminates against the subduction to the north. This area is one of the most seismically active areas in California. Magnitude 6+ events are relatively common here, making it an attractive area for investigations of time dependent phenomena. However, much of the activity occurs offshore. Currently there are 39 GPS stations that have been surveyed in campaign mode is this area. We propose to add both strain and GPS instrumentation.

Northern San Andreas Fault System

Request: 40 GPS 5 Strain

The Northern San Andreas fault system extends from the Mendocino triple junction south to Point Reyes. It includes the San Andreas fault zone, which is mostly offshore through the area, and the parallel Maacama and Bartlett Springs fault zones to the east. Most current microseismicity occurs on the Maacama and Bartlett Springs faults. For example, the UC Berkeley catalog contains only one M 3.0 or greater event in 1998 and none in 1999 along the San Andreas fault itself. The San Andreas fault last ruptured in a M 7.7 event in 1906. The long term slip rates and current strain accumulation rates on the faults are thought to be: San Andreas, 20-25 mm/yr; Maacama, 10-15 mm/yr and Bartlett

Springs, 3-10 mm/yr. There will not be sufficient resources to properly instrument this entire area. Therefore we are planning to use a few instruments, one strain cluster plus GPS, to fully instrument one section of this area. The focus of the experiment has not yet been decided.

Following the 1989 Loma Prieta earthquake surface creep was accelerated in the northern portion of the creeping segment. Similarly enhanced creep following the M 7 1838 SAF earthquake could be implicated to have helped trigger the great M 8 1857 earthquake rupturing southward from Parkfield. Both the mechanics of creep in general and the interaction across the creeping segment are quite interesting. This is one area where creepmeters would be particularly suitable.

San Francisco Bay Area

Request: 100 GPS 25 Strain

The San Francisco Bay area is a transition region between the three locked fault zones to the north and the creeping single San Andreas fault zone to the south. We include the San Juan Bautista-Hollister area as part of the SF Bay. Faults in the SF Bay area display a mix of creeping and locked behavior. Seismicity is also mixed in this area, with some faults having very little microseismicity and some quite a lot. The region is densely populated and heavily built-up. The region is high on the list of sites world-wide with the largest numbers of people living close to hazardous fault. For all of these reasons, we propose putting a significant fraction of the resources available in this area. For the strain instruments, there will be several targets: the creeping-locked transition zone near San Juan Bautista that continues to produce interesting time-dependent signals; the Hayward fault is a highly hazardous fault that is simultaneously creeping and locked (though probably not the same fault patches at the same time).

Central Creeping San Andreas Fault

Request: 10 GPS 5 Strain

Between Hollister and Parkfield, the San Andreas fault is creeping, i.e. slipping continuously and aseismically. It produces abundant microseismicity, but probably rarely produces events above Magnitude 6. At the surface the creep is often episodic, occurring in small jumps of few millimeters or less. It is believed that this episodic behavior transitions to a more continuous motion at depth. Macroscopically, the deformation appears rigid-block like with the two sides of the fault sliding past each other continuously and no evidence of strain accumulation. Based on the apparent simplicity of the section, the low population density, and the low probability of large earthquakes, we propose few instruments for this section.

Parkfield Area

Request: 40 GPS 15 Strain

Monitoring at Parkfield began in 1966 after the most recent in a series of 5 moderate earthquakes that have occurred there since 1857. The earthquakes have occurred about every 22 years and look remarkably similar. Parkfield became the classic example for repeating earthquakes and the characteristic earthquake model. Within the next few years, a 4-km deep hole is likely to be drilled into the fault zone which should provide measurements of fault properties both in the creeping zone and areas of small, repeating earthquakes. There are nearly 50 strong motion instruments in the area. Parkfield offers PBO a unique opportunity: A rich set of complementary instruments (Drill hole, strong motion, creep, other geophysical); a rich source of time dependent signals; and, a high probability of a moderate earthquake during the life of PBO.

Central and Northern California Background Instrumentation

Request: 20 GPS 0 Strain

Thus far we have discussed the various parts of Central and Northern California in isolation. We anticipate that when we start the detailed work of siting the stations, we will find some significant holes between the sub-regions. Therefore we are requesting a few receivers that will be used to tie the other experiments together or to fill in other kinds of gaps.

Requested resources

Total request: 250 GPS 60 Strain

Glossary

BHSeismic	Bore hole seismometers
BHSM	Bore hole strain meters
CGPS	Continuous GPS
GPS	Global Positioning System
PBO	Plate Boundary Observatory
SGPS	Survey-mode GPS
PBO-WG-CNSA	Plate Boundary Observatory Working for Central and Northern San Andreas

Plate Boundary Observatory Working Group for Central and Northern San Andreas

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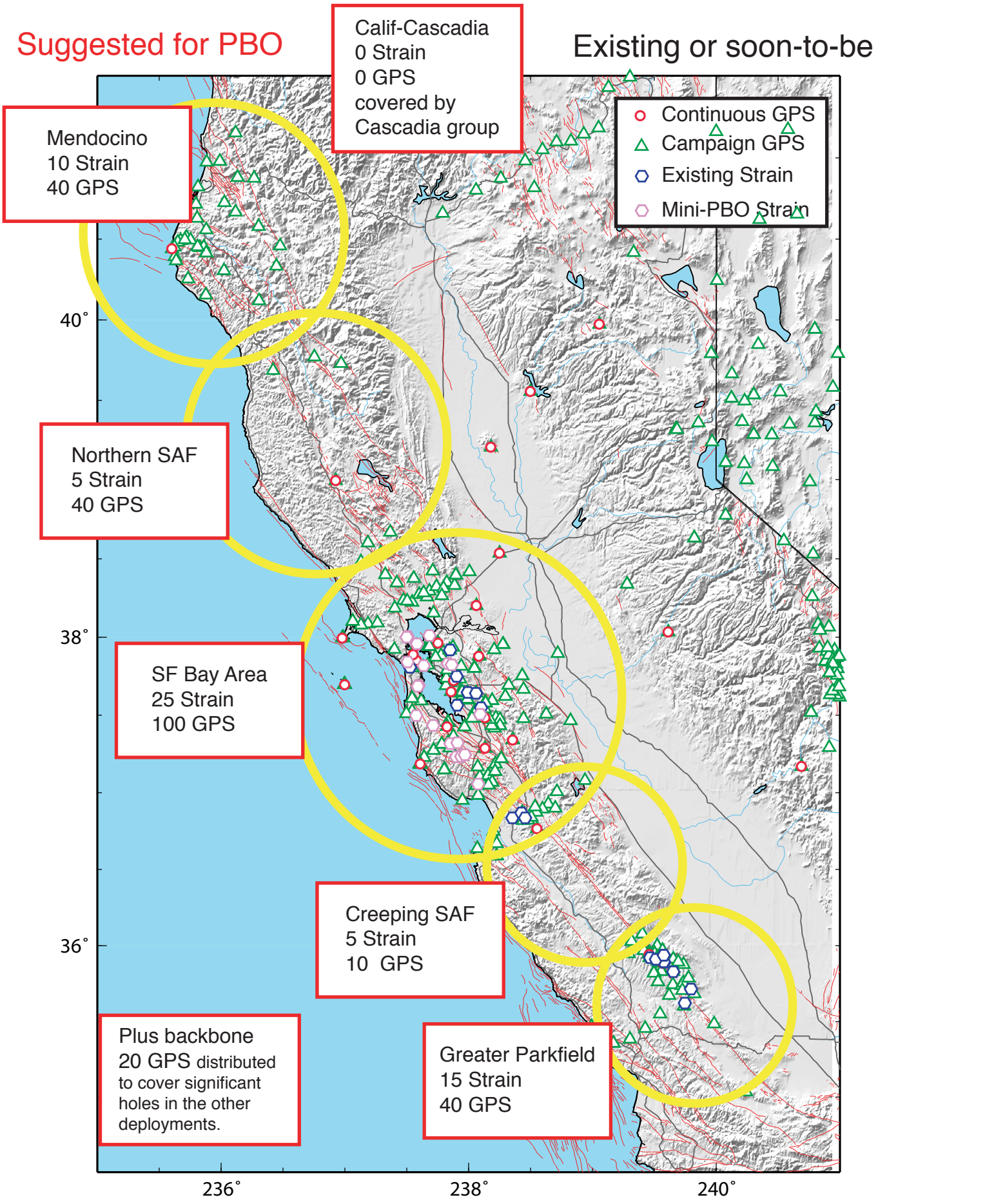
Suggested for PBO
Existing or soon-to-be
Calif-Cascadia
0 Strain
0 GPS
covered by
Cascadia group
Mendocino
10 Strain
40 GPS
Northern SAF
5 Strain
40 GPS
SF Bay Area
25 Strain
100 GPS
Creeping SAF
5 Strain
10 GPS
Plus backbone
20 GPS distributed
to cover significant
holes in the other
deployments.
Greater Parkfield
15 Strain
40 GPS
Continuous GPS
Campaign GPS
Existing Strain
Mini-PBO Strain
40˚
38˚
36˚
236˚
238˚
240˚