A GPS/Strain Cluster in the Cholame Area

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Introduction

Near latitude 36°-N the San Andreas fault undergoes a major change. North of Slack Canyon (Fig. 1) the fault moves in steady creep, apparently aseismic at magnitudes above 4. South of Cholame it does not creep at all at the surface, and is essentially now aseismic at all magnitudes—but not in the past, as it ruptured in the great 1857 earthquake. The fault undergoes a similar transition to the north near the San Juan Bautista, though there this is complicated by the branching of the fault into several separate strands: San Andreas/Hayward/Calaveras. In contrast, the transition around Cholame shows little geometrical complexity: the change in faulting style has to be due to differences in rheology. If we are to claim to understand fault mechanics, we certainly ought to be able to explain this transition—and since we cannot, it would seem an important target for PBO, and of course one that would be synergistic with the SAFOD component of EarthScope.

Part of the transition zone from creeping to locked has been subject to many measurements. But most of these have focussed on the presumed initiation zone of the next Parkfield earthquake, rather than on the broader region. While it is probably true that the short seismic cycle at Parkfield makes this the best place to monitor for an earthquake, it is also true that the probable time interval for it is quite a bit broader than the original statistical estimates suggested. Certainly the existing monitoring at Parkfield should be continued, but it would seem more important for PBO to make measurements to help understand the broader-scale kinematics and dynamics of this transition zone.

Specifically, we propose that the Cholame area is the ideal location to test the following question:

> To what extent do temporal fluctuations in fault slip seen within the creeping and transition zone propagate into the locked section of the fault (that is, the deeper, slipping parts of this section)?

This question has obvious implications for fault mechanics and the issue of how stress transfer affects possible future earthquakes: whether by moving the seismogenic part of the crust closer to failure, or by accelerating the rate of slip at depth.

Outside of the two transition regions (San Juan Bautista and Parkfield) evidence for fluctuations in deformation rate (except postseismically) has been very slight. For Parkfield, analysis of the 2-color EDM, creepmeter, and borehole strain data (Gwyther *et al.*, 1996; Langbein *et al.*, 1999; Gao *et al.*, 2000) suggested accelerated slip over a 10×10 km patch beginning in 1993. But the absence of any data to the southwest (aside from two dilatometer records) meant that it was not possible to see what changes this might have created into and along the locked segment.

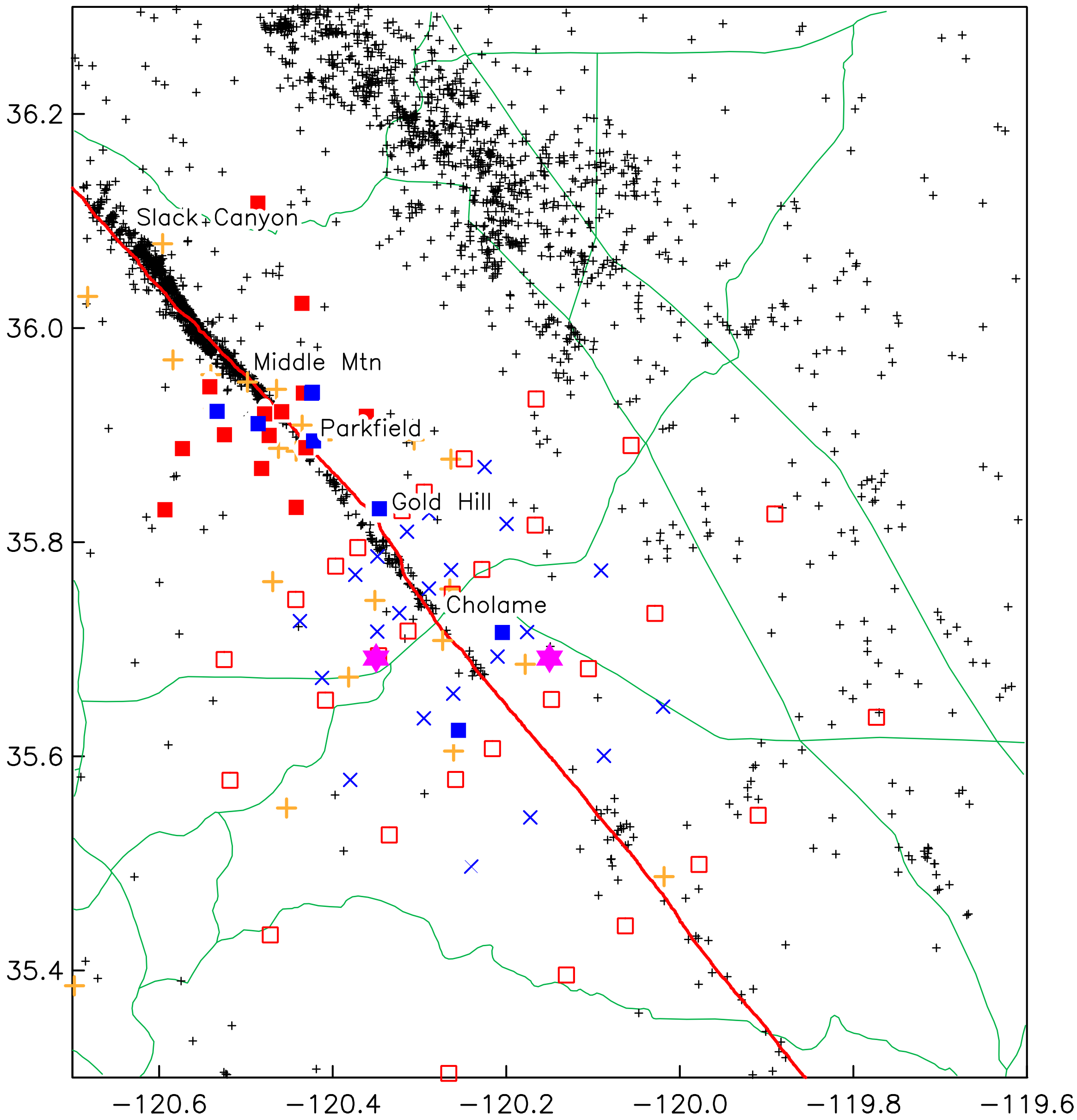

Figure 1. The San Andreas fault in the Cholame area, including microseismicity, roads (green lines), continuous GPS [current and planned] (red squares) survey-mode GPS (orange plusses), and existing borehole strainmeters (blue squares). The proposed GPS and borehole strain are the open squares and crosses respectively; the proposed long-base strainmeters are the two purple stars.

We propose that PBO instrument the region around Cholame to test the extent to which transient slip from the transition zone propagates into the locked zone to the southwest. Again, one advantage of this region is its geometric simplicity; another (on which we would not lay much stress) is that whenever the next Parkfield earthquake does occur, there will be considerable, and justified, interest in any stress transfer triggering a much larger earthquake to the southeast, as appears to have happened in 1857.

Figure 1 shows the deployment we propose: 30 continuous GPS, 22 borehole strainmeters, and 2 long-base strainmeters (single-component). Because in the locked zone we cannot get any closer to the slip zone than the locking depth, the along-fault spacing should be comparable to this depth, about 15 km. We have included some sites closer to the fault to check for possible shallower deformation. At the north end this proposed deployment would merge into the extension of the Parkfield array being proposed by others. It should be continued to the SE far enough that the transition boundary can be regarded as distant, say 80 km. We have shown the GPS sites extending farther from the fault than the borehole strain, as these have the additional purpose of determining the long term deformation; in particular the GPS measurements would be used to decide the amount of fault-normal compression, seen in some data but not in others.

Since a major purpose of this deployment would be to look for transient signals, we have proposed an extensive deployment of borehole strainmeters. We note, however, that much of the evidence for the 1993 Parkfield transient comes from the 2-color EDM system, with its much greater long-term stability. Given that the transients we will be looking for could have time constants of years, and be quite small, we propose that two single-component long base laser strainmeters also be installed as part of this cluster, one on each side of the fault. These instruments, plus the GPS and borehole strain, will give us unmatched sensitivity to transient deformations, providing the best data available for understanding this unique region.

References

S. S. Gao, P. G. Silver, and A. T. Linde, “California: detection of a long-term strain transient,” *J. Geophys. Res.*, 105, pp. 2955-2967 (2000).

R. L. Gwyther, M. T. Gladwin, G. M. Mee, and R. H. G. Hart, “Anomalous shear strain at Parkfield during 1993-94,” *Geophys. Res. Lett.*, 23, pp. 2425-2428 (1996).

J. Langbein, R. L. Gwyther, R. H. G. Hart, and M. T. Gladwin, “Slip-rate increase at Parkfield in 1993 detected by high-precision edm and borehole tensor strainmeters,” *Geophys. Res. Lett.*, 26, pp. 2529-2532 (1999).