Imaging the Partitioning and Localization of the Pacific - North America Plate Boundary: Completing the Circuit in Northern California and Southern Oregon

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Through much of the western U.S., plate boundary strain is accommodated in two relatively localized fault/shear zones (Figure 1). In southern and central California, plate motion occurs primarily on components of the San Andreas fault system with most of the remaining ~1/4 of the plate motion occurring on the Eastern California Shear Zone (ECSZ) and related structures (Dokka and Travis, 1990; Dixon, et al., 2000; Gan et al., 2000; Miller et al., 2001; Malservisi et al., 2001). In northern California identifying the plate boundary location and structure is more difficult. North of the San Francisco Bay region, GPS and related studies indicate that ~70% of the plate motion occurs within a zone that is the northern extension of the San Andreas fault system, although the specific faults in this region are not as well defined (Freymueller et al., 1999; Kelsey and Carver, 1988). Near the Mendocino triple junction the distribution of Pacific – North America plate motion is poorly constrained. There is a similar south to north variation along the ECSZ component of the plate boundary. Through Owens Valley, until the approximate latitude of Reno, NV, plate boundary deformation is observed through seismicity and GPS studies to be relatively localized within the ECSZ and the Walker Lane. The magnitude of the plate motions accommodated in this eastern belt seem to be relatively constant at ~ 11-13 mm/yr. (Dixon, et al., 2000; Gan et al., 2000; Miller et al., 2001; Thatcher et al., 1999). How Pacific – North America plate motion is distributed north of the Walker Lane segment of the ECSZ and how this eastern belt of the plate boundary links to the plate margin are outstanding problems which can be addressed through coupled Earthscope activities (Figure 1.).

Several important questions must be considered in resolving these fundamental tectonic problems. First, if the ECSZ plate boundary component is a northward propagating structure (related to MTJ migration?) then the lack of an obvious surface expression of the shear zone may simply reflect the relatively immature stage of plate boundary development north of Reno. Second, recent volcanism in northeastern California and southeastern Oregon may obscure the surface evidence of deformation. Third, crustal deformation associated with the migration of the MTJ, as proposed in the Mendocino Crustal Conveyor model (Furlong and Govers, 1999), will complicate patterns of plate boundary deformation in a region centered around the MTJ. Determining the partitioning of plate motion among the components of the plate boundary is therefore that much more difficult. Finally, the transition from Cascadia subduction to San Andreas translation that occurs at the MTJ as it migrates can be relatively easily accommodated along the plate margin. However, the inboard component of the plate boundary cannot so easily make that transition. That is, motion along the ECSZ represents a significant fraction of the Pacific – North America motion (~ 1/4) while north of the MTJ plate interaction is Juan de Fuca – North America. Since the kinematics of the plate boundary change, it is unclear how the motion between the Sierra block and North America along the northern ECSZ accommodates that change.
Figure 1. Plate boundary structures through western U.S. Shaded regions show areas of localized plate boundary strain (San Andreas Fault System and the Eastern California Shear Zone). Area labeled with "?" is proposed study area of uncertain plate boundary location and localization. Moment tensor (Harvard CMT) is for the August 10, 2001 M5.5 Portola event.
Several of the components of Earthscope are critical to resolving this first order problem.

**PBO:**
- Although seismicity in the region is diffuse, earthquakes such as the 8/10/2001 M5.5 event near Portola, CA show slip planes consistent with Pacific – North America motion (Fig. 1), compatible with GPS observations further south in the ECSZ. Thus a focused effort under the PBO component using GPS (continuous plus campaign) will help image the location of this plate boundary deformation and the degree to which this strain is localized. This aspect would supplement existing and ongoing GPS experiments that tend to bound the region.

**InSAR:**
- The likely diffuse nature of deformation in the region, the lack of obvious throughgoing fault structures, and the relatively dry climate make this an InSAR target. The coupling of InSAR with GPS studies should provide complementary information.

**USArray:**
- In a region such as this where seismicity does not define the plate boundary structures, determining crustal and upper mantle structure is important. Focused passive experiments can provide crustal structure (e.g. receiver function), upper mantle deformation (e.g. shear-wave splitting), and images of the 3-D geometry of the subducting Gorda plate.

**Geology, Geomorphology, Paleoseismology, Geodynamic Modeling**
- Just as no single Earthscope component is sufficient to resolve this first order problem, the core Earthscope tools themselves are also insufficient to provide the solution. The plate boundary structures in western North America represent an evolutionary process of development and modification. The primary Earthscope tools provide ‘instantaneous’ snapshots of the plate boundary processes but don’t describe the evolution in time and space. This will require the incorporation of geologically based observations and modeling. Paleoseismology on targeted structures coupled with field geomorphology will define the scale and timing of deformation in the region. Focused geomorph/modeling using detailed analysis of high resolution DEMs coupled with landscape evolution modeling provide a means to explicitly incorporate time scales that span geophysical observations and geological mapping. Finally, coupling these complementary but quite disparate (in temporal and spatial scales) approaches requires the development of integrated lithospheric scale geodynamical models. This fully integrated approach should lead to both the delineation of the location of plate deformation, but also help to define the processes by which such a partitioned plate boundary structure evolves over the relevant range of time scales.

Each of these components serve complementary roles in providing observations or effectively using the data gathered under Earthscope. Understanding the connectivity of major parts of the Pacific – North America plate boundary through the western U.S. is a first order problem which has not, to date, been resolved because of the necessity for such interdisciplinary studies. Under Earthscope, integrated with geological and modeling studies, this will be possible.

**References Cited**


