Crustal block kinematics and strain localization in the Pacific Northwest

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Investigations

2003 campaign. We occupied over 100 GPS sites in southern Oregon, northern California, NW Nevada, and SW Idaho in for 2 weeks July of 2003 (Figure 1). Participants in the field work were:

- R. McCaffrey - RPI
- G. Sella - Northwestern
- C. Stevens - Geographic Data Technology
- J. Vollick - RPI undergrad
- E. Robey - RPI grad
- K. Fixx - RPI undergrad
- J. Schowalter - RPI undergrad
- C. McCaffrey - volunteer
- B. Walton - volunteer
- M. Nabelek - volunteer
- T. Williams - Humboldt State U.

Results

We processed GPS data using the GAMIT/GLOBK software analysis package (King and Bock, 2002; Herring 1998). In addition to our campaign data we processed data from several of the continuous sites in the region. We obtained and processed GPS data from the HARN campaigns in Oregon, Idaho, Nevada, and California in 1998 and 1999. Using these data, we estimated site positions and velocities in the ITRF2000 reference frame. The velocities are rotated about a NA-ITRF2000 pole that aligns them with North America (Figure 2).

To locate the boundary between the Sierra block and Oregon we plotted the velocities in both reference frames (Figure 3). In theory sites on a particular block should not move in the reference frame of that block and so this exercise should allow us to find the boundary. However, other causes of site velocities can hinder this simple effort - most notably the Cascadia subduction zone causes a large eastward velocity at many sites.

To estimate the effect of the subduction zone we used the locking model of McCaffrey et al. (2003) (Figure 4), based on fitting hundreds of GPS velocities, to remove the subduction induced velocities from our sites. We also removed the Sierra block motion and Oregon block motion, resulting in relatively small residual velocities over much of the region (Figure 5). The fits to the data suggest that our block boundaries and rotations are approximately correct although we have few constraints near the coast.

Future work

We plan to continue processing the GPS data and also to incorporate data collected by Todd Williams and Jeff Freymueller. We will also use this velocity field to analyze the transition from predominantly shearing to the south to rotation in the north. We will make additional measurements in the summer of 2004 with NSF funds to clean up uncertainties and to expand the velocity field. This work will constitute the MS research of Jesse Vollick (Figure 6)

Non-technical summary

Our measurements with the Global Positioning System are showing the motions and deformation of Oregon that are caused by tectonic forces acting on it. We are finding that the motion is largely a rigid-body rotation possibly caused by a push from the Basin and range to the southeast, from California to the south, or from drag of the subducted seafloor beneath. The rigid rotation of Oregon is consistent with its lack of seismicity, at least as compared to Washington State. The rotating Oregon block appears to rotate clockwise relative to the Sierra block about a point offshore the Mendocino Triple Junction. This relative rotation will cause shearing and contraction in Northern California.

Data availability

Raw and rinex GPS data and log sheets are all archived at UNAVCO.

References

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- McCaffrey, R., A. Qamar, C. Williams, Z. Ning, R. W. King, and C. W. Stevens, Geodetic constraints on fault coupling and block motions in Cascadia (abstract), Geological Society of America, Seattle WA, 127-13, 2003.

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Figures

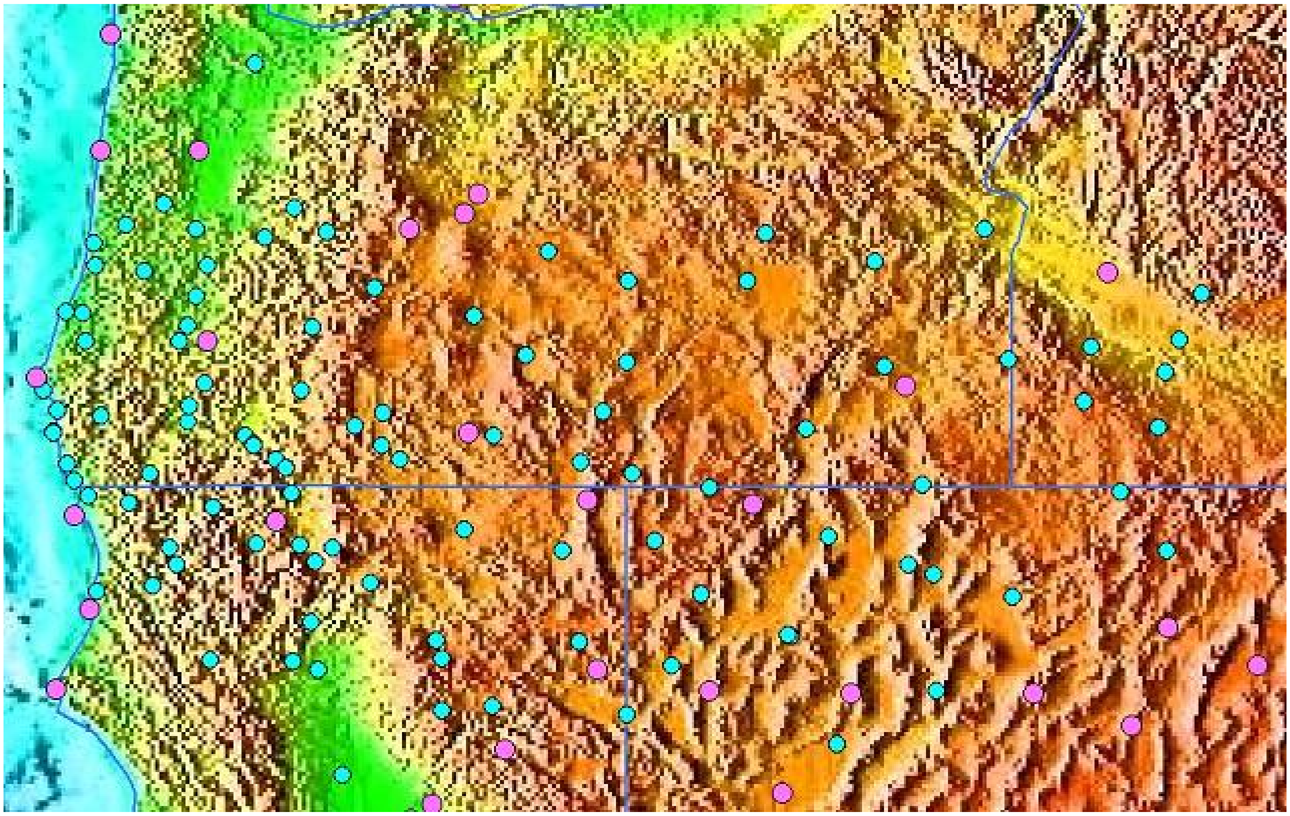


Figure 1. GPS sites occupied during 2003. Large purple dots are continuous GPS sites and small blue dots are our campaign sites.

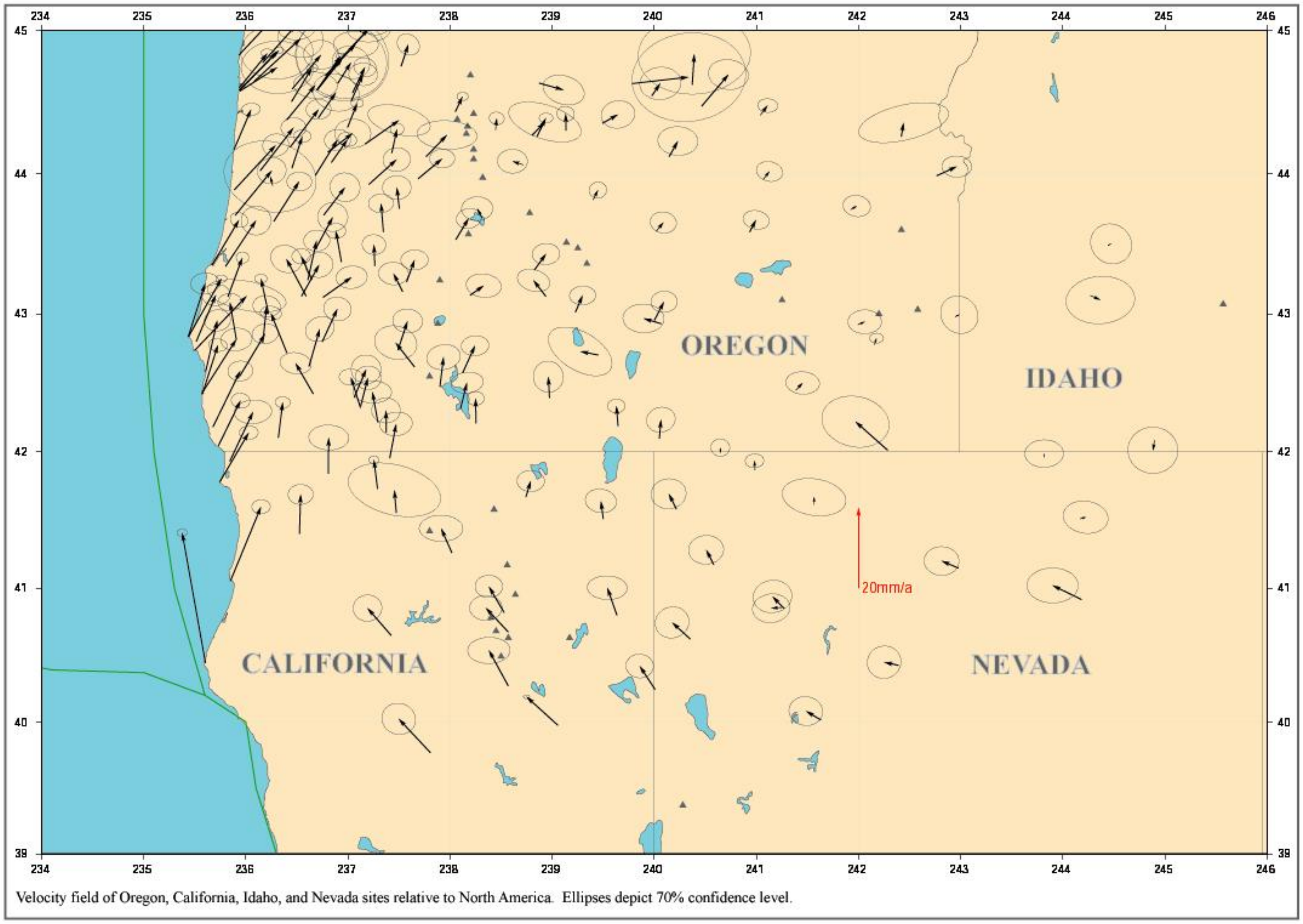


Figure 2. Velocities (in mm/year) relative to North America.

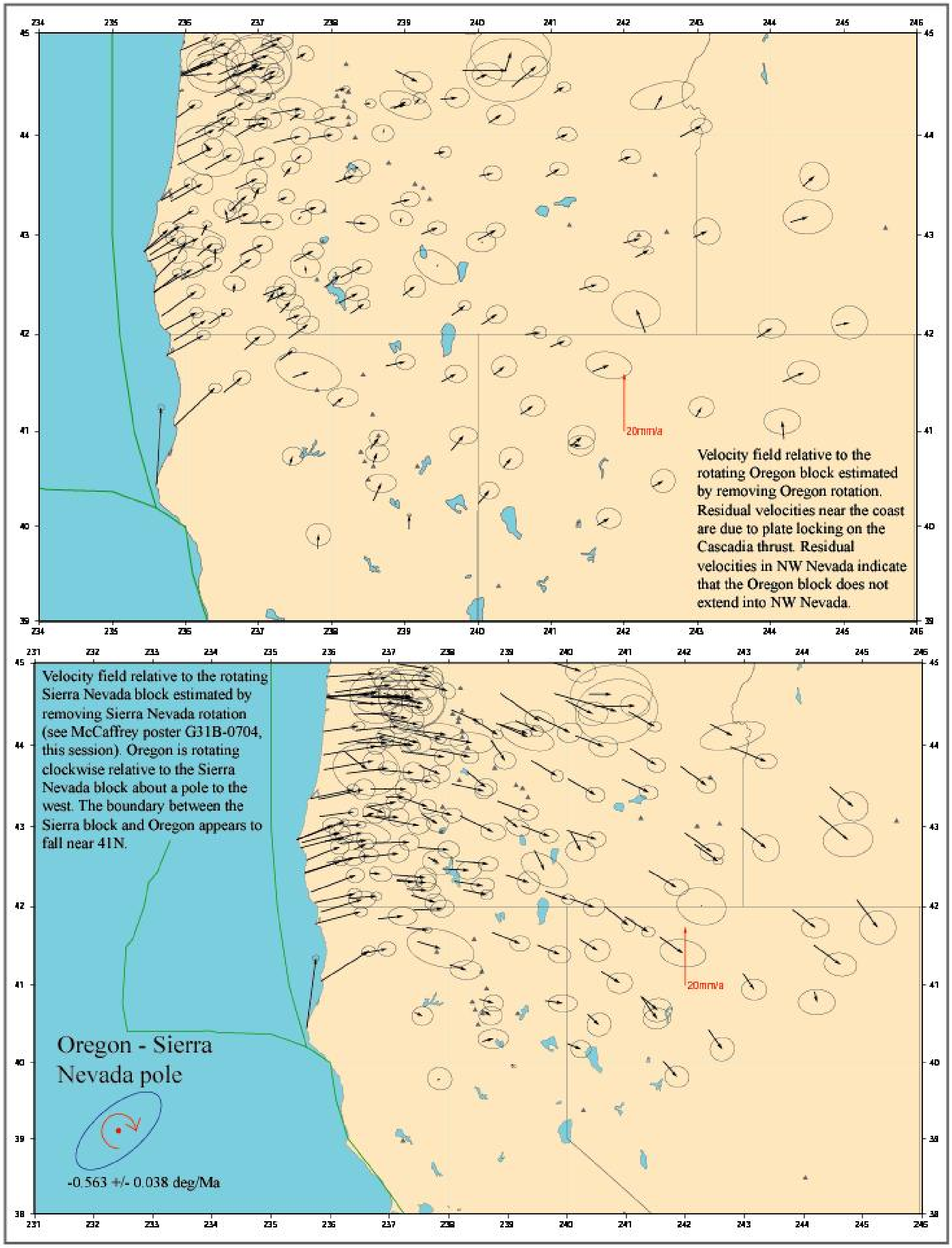
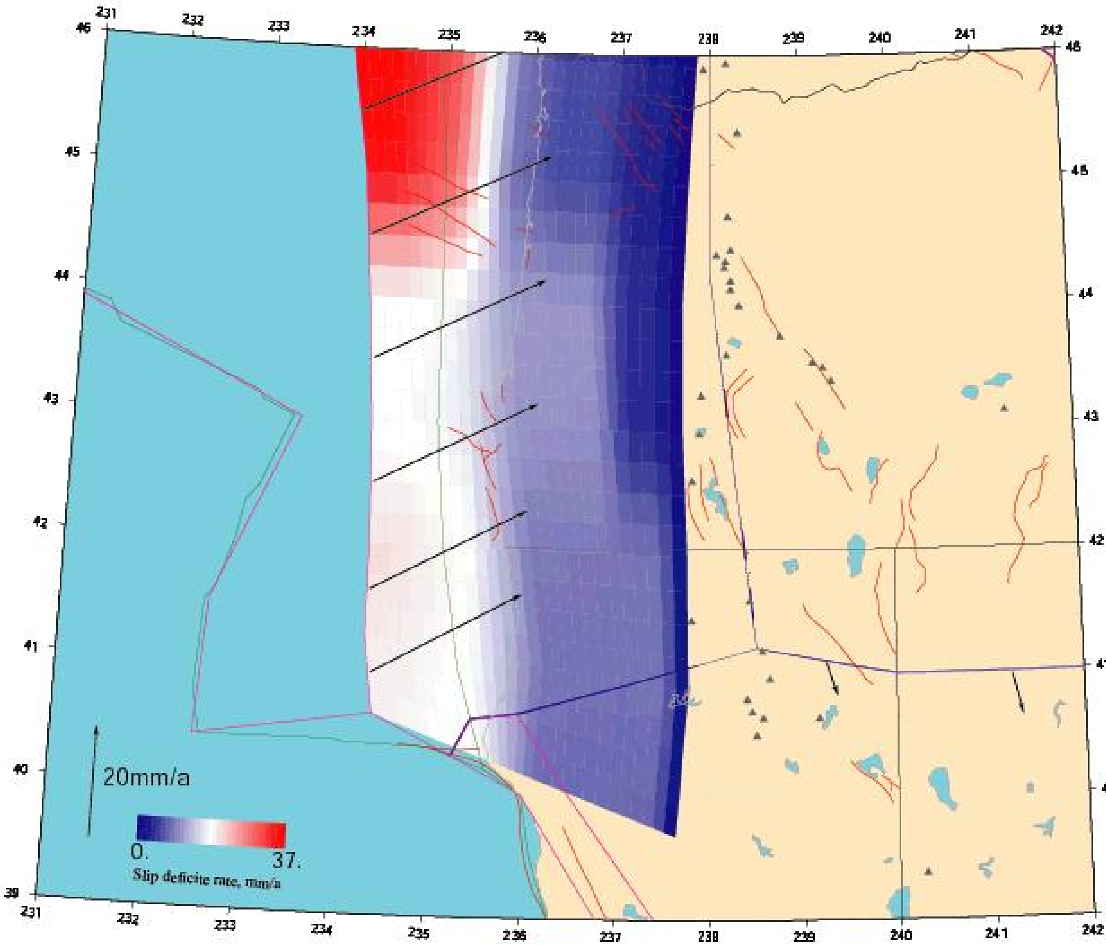
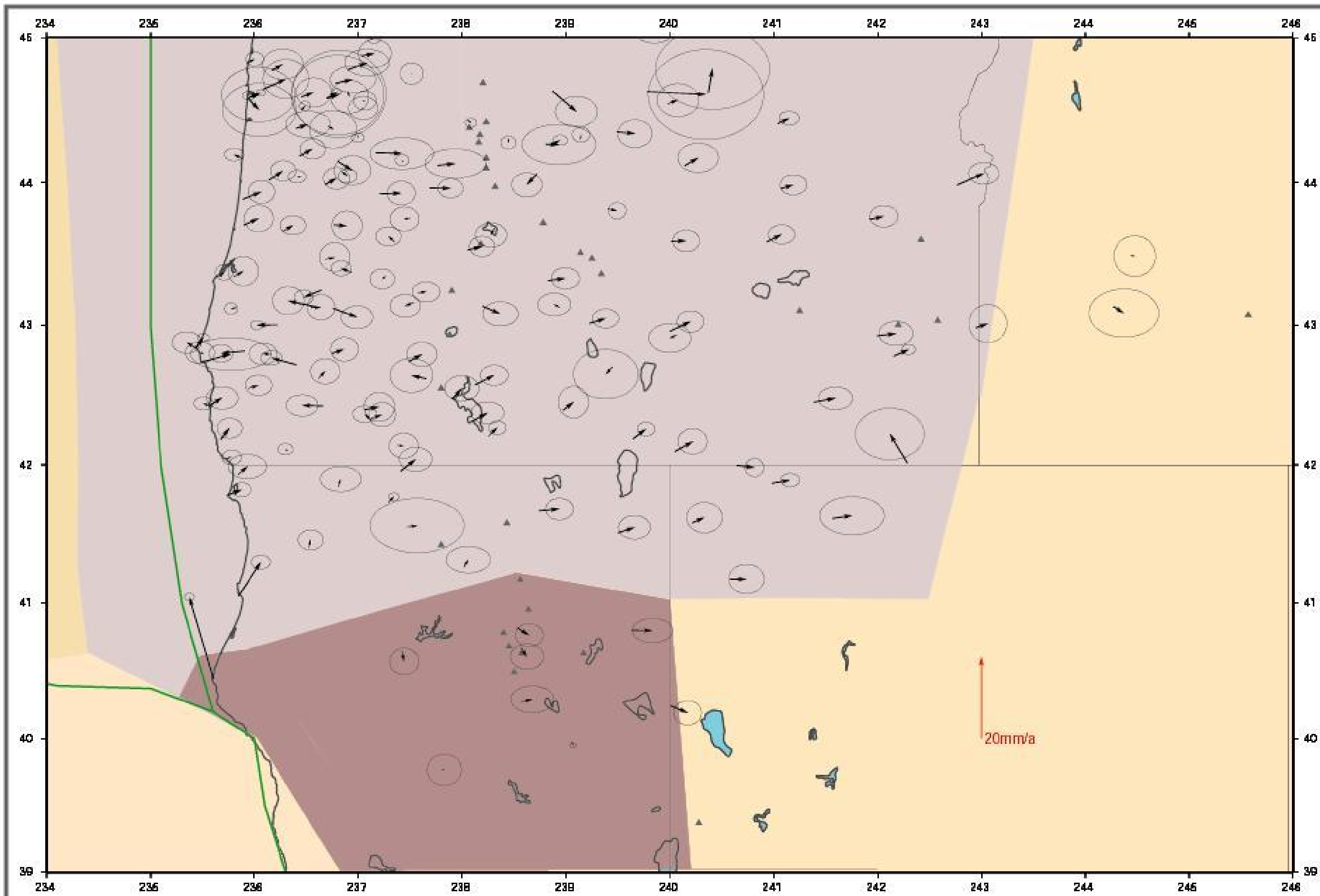


Figure 3. (Top) GPS site velocities relative to the rotating Oregon block. (Bottom) Velocities relative to Sierra block. Error ellipses are 70% confidence. The bottom distribution of velocities indicates that Oregon rotates relative to the Sierra block about a pole offshore.



Distribution of plate locking at the southern Cascadia margin used to correct for locking strain. The locking model is based on GPS results from southern Oregon (McCaffrey et al., 2003).

Figure 4.



Residual velocity field after removing rotations of the Oregon and Sierra Nevada blocks and coupling strain at the Cascadia subduction zone. Each colored region represents a rotating block. Plate coupling model used for Cascadia is shown.

Figure 5.

Figure 6. Student Jesse Vollick setting up at a coastal GPS mark in southern Oregon.