Strain Signals Associated with the January 2007 Cascadia Episodic Tremor and Slip Event as Recorded on PBO Borehole Strainmeters


Abstract

The Plate Boundary Observatory (PBO) was designed to study the strain fields resulting from the tectonic deformation at active plate boundaries, including The Episodic Tremor and Slip (ETS) events in the Cascadia subduction zone. As yet, it is not known whether the same source causes both the seismically-measured tremor and the geodetically-measured slow slip. In September 2005, the first ETS-related strain event was recorded on two of the borehole strainmeters located on the Olympic Peninsula. During the next anticipated ETS event in January 2007, thirteen PBO borehole strainmeters were operational. Preliminary analyses of the 1 Hz data on station B018 (near Delphi, WA) show a strain event beginning around January 16, 2007. The event first manifests as a slow event, and then as an E-W extension. The strain changes are roughly concurrent with the onset of strong tremor in the southern part of the Puget Sound and with geodetic changes recorded on the regional GPS network and the teleseismic events recorded on the Northern Olympic Peninsula show a slow event that begins around January 26, 2007, later than at B018. The event first shows up as an E-W compression and then as shear. The timing of the event at B018 is consistent with the migration of the two event-epicenters. The availability of 20 Hz strainmeter data will allow for better evaluation of the timing of the slow slip event than is possible from the GPS data and may reveal strain associated with the tremor.

Study Location:

Map showing the locations of PBO borehole strainmeters in Canada, Washington, Oregon, and British Columbia, with some of the GPS sites currently installed and operating stations. Blue squares are planned stations. Stations B04 and B16 are labelled because they are used in the analyses at right. Map modified from Unavco/PBO website.

Goal:

Our goal is to incorporate the strainmeter data into geodetic models of slow slip. To do this we need to calibrate the instruments from instrument strain to formation strain. Finally we can compare the strainmeter data to simple dip models.

Glawnid Tensor Strainmeter

Strainmeter measures horizontal extension on variable capacitance sensors from which the total horizontal strain tensor can be determined. Three of the gauges are oriented at 120 degrees intervals and the fourth gauge is perpendicular to one of the other three gauges. Resolution of the sensors is 1 microstrain, the sampling rate is 20Hz and the depth of installation is between 500 and 800 feet.

Figure showing the relative gauge amplitudes are plotted with respect to B018 based on Love and Rayleigh wave phases from 3 teleseismic events. Nominal calibration used by PBO, and the values determined at B004 and B018. Preliminary analyses of station B018 show a shear event before B004 indicating the slip event migrated to the north.

Conclusions - Instrments

Strainmeters clearly recorded the January 2007 Cascadia slow slip event. Strainmeters record the the time history of slow slip events which is useful for refining geodetic models. Strainmeters are capable of recording large teleseismic events, and moderate size events. Ratio of Kural's shear coupling is smaller than what PBO is using in instrument strain, shear appears larger than it is.