Utility of borehole strainmeter data to measure transient strain from Cascadia slow-slip event.

John Langbein, USGS, Menlo Park, CA 94025 langbein@usgs.gov

Approximately 25, four-component borehole strainmeters have been installed by the Plate Boundary Observatory to provide high precision and high temporal resolution measurements of transient strain from slow-slip events that occur on the interface of the Cascadia Subduction Zone. Combination of the four components should provide a redundant estimate of changes in the tensor quantities of strain. To date, the data from the GPS network in the Pacific Northwest indicate that these slow-slip events on the northern portion of the subduction zone occur roughly every 14 months with a duration of about 2 weeks. Modeling of GPS data by others (D. Schmidt, personal communication, 2008) suggests that the peak strain change is of the order of 100 nanostrain (ns).

The borehole strainmeter data should complement the GPS data since the strain data are recorded at 20-second intervals and can provide resolution down to less than 0.5 ns. However, these data are compromised in at least two ways: 1) The strain recorded in the instrument is not the strain in the rock that surrounds the instrument; and 2) the time-series of strain changes have a large ambient drift that is characteristic of a random-walk (or worse). Both of these elements affect the accuracy and the precision of the strain data.

To match the strain recorded by the instrument to that in the rock, the strain data are typically compared with a known signal, the Earth Tide. Several assumptions can be made when performing the tidal calibration, but for nearly all of the strainmeters installed by PBO, the simplifying assumption of isotropic coupling to the rock does not provide satisfactory agreement between the predictions of the theoretical Earth Tide and the observations. In many PBO instruments, though, relaxation of the isotropic coupling assumption does provide satisfactory agreement between the theoretical Earth Tide and the strain data. The tensor quantities of the Earth Tide can range between 1 to 15 ns. Typically, one can estimate a calibration matrix such that strain data matches theoretical tide within 2 ns. However, since some of the tensor quantities of strain exhibit a small Earth Tide, this indicates that the strainmeter can not be completely calibrated using the Earth Tide. In addition, for the components that can be calibrated, there is a question of whether the calibration is good over the entire range of strain to 2 ns level or to 13% level (2 ns compared to 15 ns). This becomes critical in determining the accuracy of a recorded strain transient from a slow-slip event.

The drift of the strain data can be seen both in the time and frequency domain. Although the short-term repeatability or precision of these strainmeters is < 0.5 ns for periods of less than a few hours, the longer term wander or drift shows a much larger amplitude that ranges between 10 to more than 50 ns over a 10-day period. This variation in drift appears to be seasonal in some instruments. The largest contributor is transients from large rainfall events. Thus, assessment of the background noise needs to be done carefully since variations in the drift can be the same magnitude as signal from a slow-slip event.

The poster will present examples of processing of raw strainmeter data to convert into tensor strain and the estimates of uncertainties for observed strain changes. This scheme can be used for routine monitoring to detect onset of deformation that might be associated with a Cascadia slow-slip event.