

## **Cascadia Tremor Depths Constrained by S Minus P Times**

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A key to understanding Episodic Tremor and Slip (ETS) is obtaining accurate tremor depths. In Shikoku, Japan this has been done using S minus P times observed by stacking many hundreds of low-frequency events (LFEs) that are postulated to compose the tremor. In Japan, the tremor sources occur at (or at least very near) the plate interface. In Cascadia, however, LFEs have not yet been detected, and tremor locations scatter over tens of km. It has not been clear whether this represents uncertainty or true variability.

We have developed a method for determining S minus P times that works best using arrays recording tremor that is traveling nearly vertically. For observations across the three arrays deployed to observe the July, 2004 Cascadia ETS, the S minus P times range from about 4 to 7 s. By adding these S minus P time constraints to our method of estimating tremor locations using cross correlation of seismogram envelope functions, we greatly reduce both the uncertainty and scatter in source depth. Our preliminary analysis indicates that, similar to Japan, the Cascadia tremor sources are coming from locations at, or at least very near, the plate interface. In addition, polarization analysis of tremor seismograms indicates that the tremor focal mechanism is consistent with slip on the plate boundary in the direction of relative plate motion. Together this suggests that tremor and geodetically observed slip are both manifestations of the same process corresponding to the two plates slipping past each other along the plate boundary.