# Control of episodic tremor and slip by high-pressurized fluids: a new constraint from ScSp waves

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1. Introduction
High-pressurized fluids are thought to play an important role in controlling episodic tremor and slow slip (ETS) in subduction zones [e.g., Shelly et al., 2006; Audet et al., 2009]. Therefore, constraining the along-dip distribution of ETS is necessary to better understand its source mechanism, and particularly the role played by fluids in ETS generation. Here, we report clear observations of coherent *ScSp* phases with a dense seismic array in western Shikoku, Japan. To reproduce these observations, we performed numerical simulations of elastic-wave propagation using a finite difference method (FDM) that incorporated a three-dimensional structural model. The combination of coherent *ScSp* phases and numerical simulations allows us to investigate the depth dependence of Poisson’s ratios within the LVZ, and to quantitatively estimate local changes in fluid pressure in the ETS zone.
2. Data and Method
We deployed a dense linear seismic array from October 2011 to April 2013 on western Shikoku Island, SW Japan. We also used permanent stations near the array from the Hi-net network, operated by the National Research Institute for Earth Science and Disaster Prevention [Okada et al., 2004], and stations of the Japan Meteorological Agency. During the deployment period, we visually inspected seismograms of Mw ≥6 deep earthquakes with focal depths greater than 90 km and epicentral distances D < 25°. Using the transverse components of rotated seismograms from the array, we shifted the *ScS* phases relative to the arrival at the station having the highest S/N ratio by cross-correlating the *ScS* phase from the station with other *ScS* waveforms to achieve the maximum correlations. The vertical component data at each station were then time shifted by the corresponding time lags, relative to the station.
3. Results and Discussion
Based on comparisons of transverse and vertical component waveform data, we found clear, coherent signals arriving before *ScS* on the vertical components of most stations in the array. The travel time differences between *ScS* and *ScSp* increase along the direction of subduction. This means that the *ScS-to-ScSp* conversion point deepens to the northwest, indicating in turn that the converted waveforms propagate from the top of the subducting PHS Plate. Then, we simulated the propagation of synthetic *ScSp* waveforms using the JIVSM model [Koketsu et al., 2012]. However, the calculated *ScS* -*ScSp* travel time differences were systematically smaller than predicted by our observations. To improve the goodness of fit, we partitioned the LVZ into shallower and deeper parts around the upper corner of the mantle wedge, because the travel time difference between the observed and simulated waveforms was larger at the northern stations, toward which the LVZ is subducting. This change gave two different *S*-wave velocities in the LVZ. We conducted a grid search over the three-parameter space defined by two velocities, and the layer thickness *h* of the LVZ. To quantify the fit, we averaged the cross-correlation coefficients between observed and simulated *ScSp* phases. From the grid search results, the Vp/Vs ratio must be higher beneath the mantle wedge corner than at shallow depths, regardless of the assumed LVZ thickness. In the best model, Vp/Vs ratios within the subducting oceanic crust increase by 0.3 beneath the mantle wedge corner, where ETS has been observed. This high-Vp/Vs layer indicates the presence of high-pressurized fluids

 

confined at ETS source depths. Based on extrapolation of laboratory measurements [Peacock et al., 2011], we infer that the observed changes in Vp/Vs ratios correspond to an increase in fluid pressure of ~20 MPa relative to the updip, locked zone (Figure 1).

Keywords: episodic tremor and slow slip, ScSp phase, high-pressurized fluid