Holocene Great Earthquakes in Cascadia: Seismites to GPS

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Previous vertical geodetic data in Cascadia (leveling and tide gauges) have been interpreted as showing either high spatial variability (e.g. Mitchell et al., 1994) or little variability (e.g. Hyndman and Wang, 1995) in locked zone geometry and or plate coupling along strike. Uplift rates produced from the leveling data are highly subject to errors in regression analysis of sea-level rise from tide gauges. Furthermore, questions about non-tectonic crustal motion related to collapse of a mantle bulge following deglaciation are unresolved, as is the absolute quantity of late Holocene sea-level rise. The variability introduced by these factors is approximately of the same magnitude as the expected vertical signal. Horizontal GPS measurements, will allow us to evaluate spatial variability of the plate coupling signal (if any) without most of these problems. Preliminary GPS campaign data suggest modest coupling and northward transport of a forearc sliver, similar to other oblique subduction zones. Although these data are still in analysis, one potential implication is that locking could extend farther landward than that predicted by earlier thermal/geodetic models. This would eliminate the mechanical difficulties of putting all the strain accumulation in the seaward accretionary wedge, typically weak and aseismic in most subduction zones. In much of central Cascadia, a strong mechanical boundary exists at the seaward edge of the thick basaltic Siletzia terrane beneath the continental shelf. Thermal models have thus far only considered the rheology of the sedimentary accretionary wedge, however the preliminary GPS data suggest the possibility that the "keel" of the Siletzia terrane may be coupled to the subducting plate (deeper, hotter locking), rather than the quartz-rich accretionary wedge rheology. Arc-normal deformation of Siletzia in central Oregon suggests that this may be the case. On the continental shelf overlying the Siletzia terrane, several active blind thrusts have been identified. At Stonewall Bank, rapid growth of an anticline overlying a west-vergent blind reverse fault has led to calculation of a high slip rate for this structure. The rapid deformation of the seaward part of Siletzia suggests that part of the basaltic terrane may be coupled to the subducting plate.

GPS strain measurements can only represent a fraction of one strain cycle. Paleoseismology has the potential to address longer-term history directly using precise dating techniques and substantial field study. The questions of how large and how frequent the megathrust earthquakes are, and how these events occur spatially and temporally remain open. Adams (1990) has established a recurrence interval of about 590+/- 170 years for late Holocene turbidite events in selected basin-floor channels of the Washington and Oregon segments of the Juan de Fuca plate. These events are probably triggered by earthquakes rather than other possible mechanisms. In an upcoming cruise, we will test this hypothesis using new and existing cores and AMS ages to extend the turbidite record in space and time to establish a margin-wide Holocene event stratigraphy. If the same sequence and timing of events can be correlated in all major turbidite channel pathways, then it may be possible to verify Adams' hypothesis that there is a one-to-one correspondence between post-Mazama turbidites and great megathrust earthquakes involving much or all of the subduction zone. It also may be possible to establish a lack of correlation and thereby demonstrate segmentation of the margin.