FINAL TECHNICAL REPORT

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UPPER-PLATE EARTHQUAKES ON THE WESTERN LITTLE SALMON FAULT AND CONTEMPORANEOUS SUBSIDENCE OF SOUTHERN HUMBOLDT BAY OVER THE PAST 3,600 YEARS, NORTHWESTERN CALIFORNIA

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ABSTRACT

Along the southeastern side of Humboldt Bay the Little Salmon fault, a >100-km-long fault zone in the old-and-thrust belt of the southern Cascadia subduction zone, includes three northwest-striking imbricate thrust faults that deform intertidal deposits and terraces along the bay margin. The bay deposits contain tidal marsh soils abruptly overlain by intertidal mud interpreted to record sudden subsidence caused by plate-boundary earthquakes. Previous work on the western Little Salmon fault identified three earthquakes in the past 2,000 years with 3.6- to 4.5-m of slip per event providing a late Holocene slip rate estimate of 5.5 mm/yr (Carver and Burke, 1988). However, it remains unclear whether the Little Salmon fault ruptures independently from the southern Cascadia subduction zone. At the Swiss Hall site we investigated the western trace of the fault where a 1- to 1.5-m-high moletrack scarp projects into the bay and deforms late Holocene intertidal sediment. Estuarine strata that lap onto the scarp include three peaty soils containing tidal marsh diatoms that are progressively folded with increasing depth and form a westfacing monocline. An angular unconformity separates the sequence of soils from a thick (0.7 m) overlying deposit of tidal flat mud. Normal faults in the hanging wall offset the entire sedimentary package in the scarp. We identify 3- to 4-slip events on the western Little Salmon fault during the past 1,800 to 2,300 years. Growth of the scarp occurs through folding above a shallow, low angle, blind thrust fault. The most recent earthquake occurred less than 460 years ago and disrupted the scarp along bending-moment normal faults in the hanging wall. These data provide a slip rate estimate of 2.9- to 6.9mm/yr with 1.3- to 4.1-m of slip per event.

At Hookton Slough, I- to 2-km west of the Swiss Hall site, we identified five buried soils that record submergence of tidal marshes along a I -km reach of the estuary. The three oldest buried soils are each capped by sand deposits that include multiple, fining-upward beds and have textures similar to sand flats and tidal channels present in the 6-km distance between the slough and South Spit, a late Holocene barrier spit separating the bay from the open ocean. Fossil diatom assemblages indicate that sudden relative sealevel rise led to submergence and burial of some soils. Based on evidence for sudden, enduring environmental shifts that drowned broad areas of former tidal marshes and the presence of sand layers sharply overlying the soils, we conclude that the three oldest soils record coseismic subsidence and sand deposits that cap the soils record tsunami inundation as far as 6-km southeast of the barrier spit. Evidence for a tectonic origin for the youngest two buried soils is less conclusive. Consistent radiocarbon ages allow correlation of soils C and D at Hookton Slough, buried about 1,830 to 2,040 and 2,040-2,3 10 years ago, respectively, with two soils that are folded within the fault scarp at the Swiss Hall site. Stratigraphic relationships in the scarp along with the widespread distribution of these buried soils suggests that, at least for some earthquakes that ruptured the Little Salmon fault, coseismic subsidence of the footwall extended to the west several thousand meters and was coincident with generation of large tsunamis. Whether coseismic subsidence 1 - to 2-km west of the fault was induced primarily by upper-plate deformation or by slip on the southern Cascadia subduction zone is unclear. The occurrence of large tsunamis coincident with subsidence supports the interpretation that slip on the Little Salmon fault accompanied megathrust earthquakes. However, comparisons of radiocarbon-derived earthquake histories along the Cascadia margin suggest that if the penultimate Little Salmon event and a prior event around 2, 100 years ago were triggered by plate-interface events, then those events were confined to a southern segment of the Cascadia plate boundary.