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TECHNICAL COMMENT

Postglacial Offset Along the Seattle Fault

Five reports in the 4 December issue of *Science* discuss the geologic evidence that a large earthquake struck the Seattle area about 1000 years ago (*1, 2*). Although this earthquake was accompanied by at least 7 m of uplift along the Seattle fault, there is a lack of evidence of ground rupture or shaking. Seismic turbidites in Lake Washington could have been produced by motion along other faults in the region. The differential uplift of wave-cut platforms and estuarine deposits used to reconstruct fault movement near Seattle are late Holocene in age. Thus, the location of the fault trace beyond the immediate Seattle area, the long-term rate of uplift, and the frequency of fault motion are not well known.

There is additional evidence that bears directly on the trend and offset rate along the Seattle fault (*3*). With records of the glacial deltas that were part of ice-dammed lakes at the site of Puget Sound about 16,000 years ago (*4*), I reconstructed a domal pattern of postglacial uplift dominated by isostatic uplift. A striking local anomaly in the uplift trend coincides with the crustal discontinuity now named the Seattle fault, and suggests that the southern block was uplifted approximately 9 m relative to the north. Apparently, the minimum fault offset (7 m) for the well-documented earthquake of about 1,000 to 1,100 years ago is broadly comparable to the total uplift for the last 16,000 years. This comparison suggests that episodes of comparable fault movement are either a recent development or that their repeat times are extremely long. This interpretation is consistent with the stratigraphic evidence containing the record of only one earthquake in the past 2000 years (*2*).

I replotted the widely dispersed population of glaciolacustrine control points in order to resolve the net vertical offset (Fig. 1). I chose a line of projection parallel to the maximum slope of the isostatic anomaly and nearly perpendicular to the fault trace. I then subdivided the data set into three geographically restricted clusters, each of which could be projected separately to a line of section crossing the fault.

The amount of net postglacial deformation along the western projection relative to the Black Lake Spillway decreases from 72.7 ± 2 m in the north to about 11.5 ± 2 m in the south, with a nearly uniform regression slope of 0.95 m/km (*5*). The Eldon delta, located near the middle of the projection, lies 9.9 ± 2 m above the regression line and is responsible for most of the residual error. Although linear regression provides a valid first approximation, the control points define a true but irregular paleosurface. The plot is more accurately described as a single line composed of three individual segments, each with a different slope.

Although located as much as 45 km from their counterparts along Hood Canal, glacial deltas from central Puget Sound also define a southward-inclined paleoshoreline with an identical regression slope and with three distinct segments whose locations and slopes are similar. On the basis of the mean regression slope of the central projection, the McKenna Falls delta lies 7.5 m ± 2 m above its expected position. Deltas from the eastern part of the Puget lowland project to a line with a more gentle southerly slope, and one that is less obviously segmented. This difference probably reflects a combination of factors: neotectonic deformation, larger projection errors, and a more complex pattern of glacier loading.

The Seattle fault must lie north of the

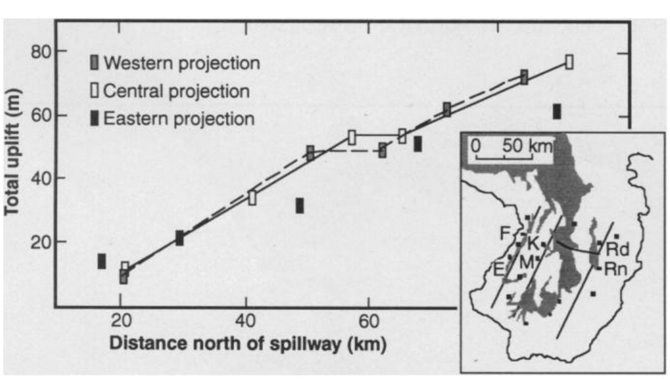

Fig. 1. Net uplift of glaciolacustrine deltas relative to the lake outlet for three parallel projections. Location of deltas (F, Fulton Creek; E, Eldon; K, Kitsap Lake; M, McKenna Falls; Rd, Redmond; and Rn, Renton) and the trace of the Seattle fault (northwest-trending line) are shown on inset map.

Table 1. Net offset on the Seattle fault.

Projection	Estimated vertical offset	
	Maximum (m)	Minimum (m)
West	14.70	9.10
Central	9.90	7.10
East	21.50	No data

uplifted marine platforms at Restoration Point and at Alki Point but south of Winslow, where estuarine peats suggest stable conditions, and south of West Point, which subsided abruptly about 1000 years ago. These constraints permit an extrapolation of the fault trace across the central projection between the Kitsap Lake and McKenna Falls deltas, the western projection between the Eldon and Fulton Creek deltas, and the eastern projection between the Renton and Redmond deltas. The southern delta of each pair lies furthest off the mean uplift trend and is anomalously high relative to its northern counterpart. Where delta pairs lie both north and south of the projected fault trace, estimates of net offset can be obtained by extrapolating the local gradient of southern deltas northward (maximum) and northern deltas southward (minimum). With the use of this approach for the eastern and western projections, and doubling the likely error associated with each control point (± 4 m), I estimate that the net postglacial uplift associated with movement along the Seattle fault probably lies between 3 and 19 m (Table 1). This interpretation does not rule out the possibility that the Seattle fault is one of a series of northwest-trending en-echelon faults that are aligned in an east-west direction.

The synoptic coverage and greater antiquity of the glaciolacustrine record complements the higher spatial and chronological resolution afforded by the much younger estuarine deposits. These two records independently confirm Holocene movement along the Seattle fault.

Robert M. Thorson
Department of Geology and Geophysics,
University of Connecticut,
Storrs, CT 06269

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5. Errors associated with each data point, estimated to be about 2 m, are a result of variations in spillway flow depth and of the elevation of the topset-foreset contact in these rapidly deposited gravelly deltas. Larger errors associated with differential uplift during glacier recession cannot be estimated, but would likely have produced an opposite pattern of differential uplift.
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