INTRODUCTION

Fault scarps recently discovered on Airborne Laser Swath Mapping (ALSM; Carter and others, 2001; also known as LiDAR) imagery show late Pleistocene to Holocene movement on the Lake Creek–Boundary Creek fault on the north flank of the Olympic Mountains (figs. 1–6; Haugerud and others, 2003; Polenz and others, 2004; Schasse and others, 2004). Young scarps mapped by Haugerud (2002) along a 30-km-long topographic lineament inferred to mark the fault suggest that it is a potential source of large earthquakes. As part of the effort to assess seismic hazard in the Puget Sound region (for example, Frankel and others, 2002; Kelsey and others, 2004; Sherrod and others, 2004), we mapped the scarps and studied trenches across them to decipher the history of surface-deforming earthquakes on the fault.

Polenz and others (2004) and Schasse and others (2004) referred to the north-dipping fault trending east-west through the valleys of Indian Creek and Little River as the Lake Creek–Boundary Creek fault (fig. 2), whereas Lidke and others (2003) followed Haugerud and others (2003) in referring to it as the Little River fault. Earlier workers (Tabor and Cady, 1978; Dragovich and others, 2002; Schasse, 2003) inferred that the Lake Creek fault of Brown and others (1960) crossing Morse and Siebert Creeks connected with the Boundary Creek fault of Brown and others (1960) in the valleys of Indian Creek and Little River. The Lake Creek–Boundary Creek fault is one of three major, east-west-trending, north-dipping faults on the north flank of the Olympic Mountains (Schasse and Wegmann, 2000; Schasse and Polenz, 2002; Polenz and others, 2004; and Schasse and others, 2004). Polenz and others (2004) noted that because ALSM scarps along the Little River are found on outwash terraces deposited about 13 ka, and are not found in late Pleistocene alluvium thought to closely postdate the outwash, surface faulting on the Lake Creek–Boundary Creek fault may have occurred shortly after 13 ka.

We mapped scarps along the Lake Creek–Boundary Creek fault on high-resolution digital elevation models (DEMs) of topography derived from ALSM data that were processed to remove vegetation (for example, Harding and Berghoff, 2000; Haugerud and Harding, 2001). The ALSM surveys (0.5 pulse/m^2) were flown by Terrapoint LLC during the winters of 2001 and 2002 (fig. 2). Funding and support for data acquisition and processing were provided by the U.S. Geological Survey, the National Aeronautics and Space Administration, and the Puget Sound LiDAR Consortium (http://pugetsoundlidar.ess.washington.edu/). Although some scarp segments about 0.5–2 km long along the fault are remarkably straight and distinct on shaded DEMs (figs. 4 and 6), most scarps displace the ground surface <1 m, and, therefore, are difficult to locate in the dense brush and forest along much of the fault. In at least two of many places where we examined scarps in the field, segments of scarps tens of meters long were cut in hillslopes during logging operations rather than created by faulting. Other subtle steps in topography that might record surface folding or faulting may alternatively have formed through terrace cutting by Little River, gully erosion, or landsliding. Haugerud and others (2003) acknowledged that 10- to 20-m-high scarps along the fault near Lake Sutherland may be old, erosional, fault-line scarps (fig. 2). Like Polenz and others (2004), we could not distinguish fault from landslide scarps in the landslide complex along lower Indian Creek just west of Lake Aldwell; scarps more than 500 m long trending in at least four directions might have either origin. For these reasons, we are confident of a surface-faulting or folding origin and a latest-Pleistocene to Holocene age only for scarps between Lake Aldwell and the easternmost fork of Siebert Creek, a distance of about 22 km (fig. 4).

We excavated five backhoe trenches across scarps of the Lake Creek–Boundary Creek fault at four sites between Tumwater and Siebert Creeks (figs. 4 through 6) to determine the history of surface-deforming earthquakes since glacier recession and alluvial deposition about 11-17 ka (Mosher and Hewitt, 2004; Polenz and others, 2004). The upper 1–3 m of east walls of the trenches were sloped 5º–20º from vertical for safety, whereas west walls were benched. Trench logging at 1:20 scale (methods similar to McCalpin, 1998, p. 56–75) was compiled on photomosaics of 8-m-long sections of trench wall consisting of 1 m by 1 m rectified photo tiles (1,000–1,400 pixels/m). Although the trend and plunge of indicators of fault slip were measured only in the Knee-high trench (sheet 2), upward-splaying fault patterns and inconsistent displacement of successive beds along faults in three of the five trenches suggest significant lateral as well as vertical slip during the surface-faulting or folding events that produced the scarps.

Similar to other data compilations for Holocene faults in the Puget Lowland (Nelson and others, 2002; Nelson and others, 2003; Johnson and others, 2003; Sherrod and others, 2003), we map scarps on ALSM imagery and show primary field and laboratory data from trenches that are being used to develop a latest Pleistocene and Holocene history of large earthquakes on the Lake Creek–Boundary Creek fault. Radiocarbon ages on fragments of wood charcoal (table 1) from two wedges of scarp-derived colluvium in the Minicorners trench (sheet 2) suggest two surface-faulting earthquakes on this part of the Lake Creek–Boundary Creek fault between about 2,000 and 600 years ago. The three youngest of nine ^{14}C ages on charcoal fragments from probable scarp-derived colluvum in the Sapsucker trench (sheet 2), on the scarp 1.2 km to the west, suggest a possible earlier surface-faulting earthquake less than 5,000 years ago. A future report will use the map data to develop a detailed earthquake history for the Lake Creek–Boundary Creek fault.

Adjacent to each trench log is a summary explanation of stratigraphic units and notes about important stratigraphic relations or interpretations of units. Neither the colors (used to show inferred genesis) nor the numbers (used to label stratigraphic units) imply direct chronologic correlation of units from trench to trench. Units on logs are numbered approximately from oldest to youngest and so unit explanations are listed from top to bottom. Although many units overlap in age, unit numbers show how we mapped packages of sediment that were deposited or deformed by similar processes in approximate chronologic sequence.

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FIELD AND LABORATORY DATA FROM AN EARTHQUAKE HISTORY STUDY OF SCARPS OF THE LAKE CREEK–BOUNDARY CREEK FAULT BETWEEN THE ELWHA RIVER AND SIEBERT CREEK, CLALLAM COUNTY, WASHINGTON

By

Alan R. Nelson,[1] Stephen F. Personius,[1] Jason Buck,[2] Lee-Ann Bradley,[1] Ray E. Wells,[3] and Elizabeth R. Schermer[4]

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[1] U.S. Geological Survey, Box 25046, Denver, CO 80225
[2] LACO Associates, 21 West 4th Street, Eureka, CA 95501
[3] U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025
[4] Western Washington University, Department of Geology, Bellingham, WA 98225

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