ACTIVE FAULTING ALONG A NEWLY FOUND SEGMENT OF THE SADDLE MOUNTAIN FAULT ZONE, SOUTHEASTERN OLYMPIC MOUNTAINS, WASHINGTON: A PALEOSEISMIC TRENCHING STUDY

WASHINGTON STATE DEPARTMENT OF Natural Resources
Peter Goldmark - Commissioner of Public Lands

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LOCATION MAP

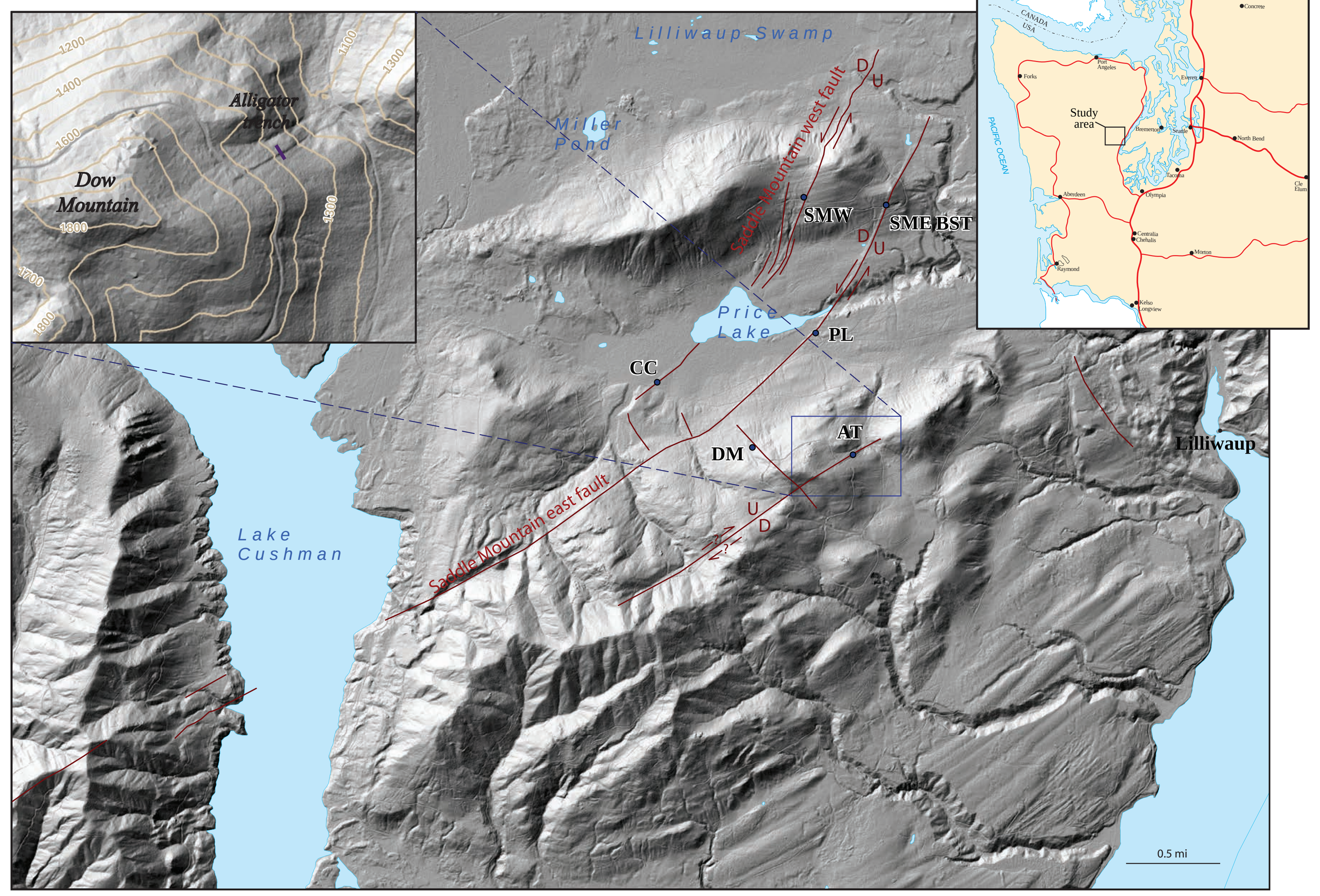
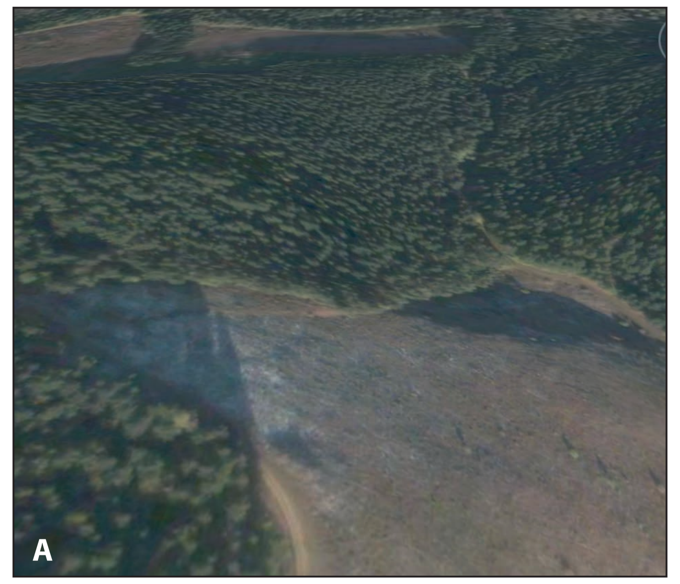


Figure 1. Lidar image of fault scarps, mapped faults, and paleoseismic trenches in the Price Lake area, Mason County. CC = Cargill Creek trench (Witter and others, 2008), DM = Dow Mountain trench, PL = Price Lake trench, SMW = Saddle Mountain west trench, SME = Saddle Mountain east trench (Wilson, 1975), BST = Banana Slug trench (E. A. Barnett, USGS, personal communication, 2008), and AT = Alligator trench (this study). Inset map shows location of the Alligator trench on the southeast-facing scarp (approximately 2.5 m tall), and the extent of the fault scarp along the southern crest of Dow Mountain, where it is approximately 4 to 5 m tall with the same facing direction.



A) Google Earth(TM) oblique air photo of the southeast-facing unnamed fault scarp, visible along treeline in fresh logging cut. View to the north.

B) View of the scarp at the base of the treeline in the upper right portion of the photo (red dashed line). Scarp height near trench location was approximately 2.5 m. Photo by Trevor Contreras.

C) Photo of geologists standing on top of the fault scarp. Viewed to the southwest. Photo by Trevor Contreras.

D) Sub-horizontal slickenline within clay-lined active fault surface. Photo by Elizabeth Schermer.

The Alligator trench was excavated across a LiDAR-detected, southeast-facing Holocene-age fault scarp on a steep hillside near Price Lake in Mason County (Fig. 1). The scarp is visible for approximately 0.5 miles from the top of Dow Mountain northeastward down the hillside (Photos A—C), located southeast of and roughly parallel to the Saddle Mountain East and West fault scarps.

The trench was approximately 20 m long, although only 16 m was logged (Fig. 2). The trench contained two benches approximately 1 m wide on the uphill side for safety, with over 6 m of apparent vertical stratigraphic exposure. However, the down-slope dip of units projected into the trench walls yielded less true stratigraphic exposure, and some contacts were duplicated as a result of benching the face. (see Trenching Profiles; Fig. 3).

The trench was logged on three 1 x 1 m photomosaic sections of trench wall. Stratigraphic units were numbered by interpreted age, oldest to youngest.

The trench exposed a southwest-striking, steeply-dipping fault which offsets bedrock (Eocene Crescent Formation basalt), glacial deposits, soil horizons, and colluvium deposits. The vertical component of bedrock throw across the fault was measured at approximately 3.2 m. No piercing points were discovered to yield the net throw. From slickenlines measured on both the active fault surface and within the fractured bedrock surfaces in the hangingwall, the direction of fault movement is uncertain, although data is highly suggestive that older movement on the fault (measured on fracture surfaces in bedrock adjacent to the active fault surface) was oblique reverse (Figs. 4C and 4D). Holocene-age movement (measured on the clay-lined active fault surface) was sub-horizontal to slope-parallel (Photo D and Figs. 4A and 4B), which implies left-lateral strike-slip offset when coupled with the vertical sense of bedrock offset. However, the scarp facing direction implies right-lateral offset, making the determination of slip direction problematic. Further investigation is necessary to resolve this.

The relationships between faults, colluvium and soil development within the trench give strong evidence for multiple (possibly four) Holocene-age faulting events on this newly found segment of the Saddle Mountain fault system, although there are potentially several possible faulting scenarios and sequences. Age-date testing of charcoal samples obtained from lower soil horizons (Fig. 2) confirm at least two events. Future testing will hopefully further constrain the younger faulting history

The variable thickness of the compact diamicton—interpreted to be lodgment till of the Vashon stade—suggests that deposition of the diamicton occurred after the scarp was partially developed. The presence of preferentially-oriented cobbles and boulders within colluvium directly above a charcoal-rich surface above the compact diamicton adjacent to the fault surface implies that either the colluvium (4a) was deposited in response to a faulting event, or that faulting events after its deposition realigned clasts in portions of the deposit.

Preliminary age estimates of a charcoal fragment from beneath this layer suggest burial after 3,370 +/- years BP. The contacts between the bedrock, diamict and colluvium and the shear fabric within the diamict do not show the same amount of rotation into the fault, suggesting the clasts were preferentially oriented during deposition. Farther from the fault surface what is interpreted to be slope colluvium (4) does not show a preferred orientation of clasts, and is much less indurated. The age of burial, if interpreted to be caused by faulting, has not been seen elsewhere in the Puget Sound.

Directly above unit 4a in the footwall of the fault is a 3 to 5 cm thick soil horizon (4as), that contains abundant charcoal. The presence of colluvium (4b) above this soil indicates a faulting event buried soil 4as. Preliminary age estimates from charcoal sampled from this layer (AT-2) suggest burial occurred sometime after 1,360 +/- 40 BP.

Above unit 4b, there is another possible soil horizon (4bs?), although weakly developed, which lies beneath more colluvium (4c?). The layer contained abundant charcoal, yet some samples had ambiguous origin (i.e. possibly modern). If soil 4bs? does not exist, colluvium 4c? and 4b are derived from the same faulting event. Both colluvium 4b and 4c? are faulted.

Weak soil development (4cs?) at the top of units marked 4c? and 4b, parallel to the fault scarp surface show the ground surface before the last interpreted faulting event. The colluvial wedge (4d?) from this event appears to be derived from faulting as well as slope wash, and fills a fault-parallel stream channel cut into earlier fault-derived colluvial deposits and soil horizons. The stream channel was identified based upon a prism of thinly bedded alluvium (4da?) at the base of a channel-shaped feature present on both uphill and downhill sides of the trench with a downslope axis. The colluvial fill (4d?) within the channel contained abundant cobbles and pebbles at the base of the deposit on the northwest side of the channel, fining to the southeast, implying the source for the material was predominantly from the fault scarp and not upslope.

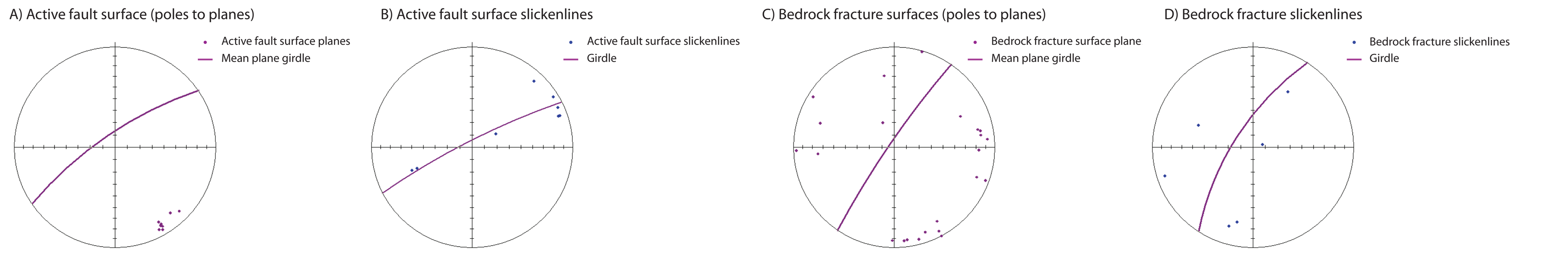
It is interesting to note that few angular clasts of Eocene Crescent Formation Basalt are found within colluvium deposits in the footwall of the fault. This suggests that bedrock was never exposed in the topographic scarp, and faulting-related colluvium was predominantly derived from the overlying diamicton and slope colluvium in the hangingwall.

REFERENCES

Wilson, J. R., 1975, Geology of the Price Lake area, Mason County, Washington: North Carolina State University Master of Science thesis, 79 p., 2 plates.

Witter, R. C.; Givler, R.W.; and Carson, R.J., 2008, Two post-glacial earthquakes on the Saddle Mountain west fault, southeastern Olympic Peninsula, Washington: Bulletin of the Seismological Society of America (December 2008), 98(6):2894-2917.

Figure 4A - 4D: Equal-area stereonet projections of fault data



A)
No. of data = 9
Mean principal orientation = 236/79
Mean resultant direction = 79-326
Mean resultant length = 0.99
(Variance = 0.01)
Calculated. girdle: 10/16
Calculated beta axis: 74-280

B)
No. of data = 8
Mean principal direction = 1-063
Mean resultant direction = 328/38
Mean resultant length = 0.59
(Variance = 0.41)
Calculated. girdle: 243/85

C)
No. of data = 23
Mean principal orientation = 214/86
Mean resultant direction = 54-305
Mean resultant length = 0.40
(Variance = 0.60)
Calculated. girdle: 338/8
Calculated beta axis: 82-248

D)
No. of data = 6
Mean principal direction = 20-218
Mean resultant direction = 145/59
Mean resultant length = 0.61
(Variance = 0.39)
Calculated. girdle: 213/75

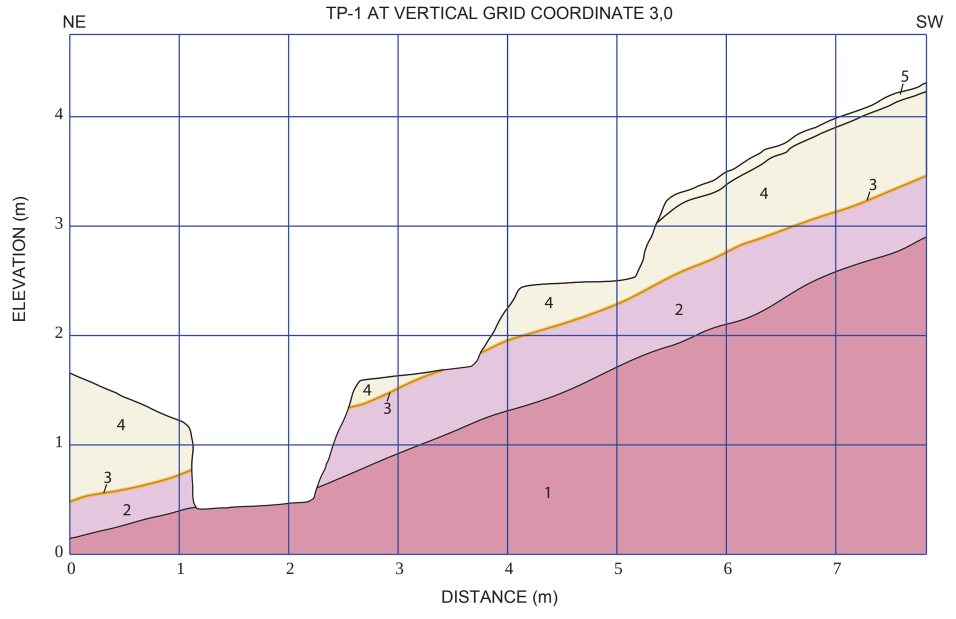
UNIT DESCRIPTION

5 Modern soil
4 Slope colluvium
4a Event colluvium
4as Buried soil
4b Event colluvium
4bs? Possible buried soil horizon
4c? Event colluvium
4cs? Buried soil
4da? Buried channel alluvium
4d? Event/slope colluvium
3 Ancient ground surface above compact diamicton with abundant charcoal
2 Compact diamicton
2a Water-deposited glacial deposits within compact diamicton
1 Eocene Crescent Formation basalt
1b Cataclastic material derived from Eocene Crescent Formation basalt

LEGEND

GS-1 Grab sample location
Projected location of radiocarbon sample
AT-1 Radiocarbon sample location
AT-1 Radiocarbon sample with preliminary lab results
Fault; dashed where inferred; arrows show apparent relative motion
Contact
Large clast
Contact, approximately located
Contact, concealed
Contact, concealed/queried
Benches in trench walls
TP-1 Trench profile locations at vertical grid coordinates

TRENCH PROFILES



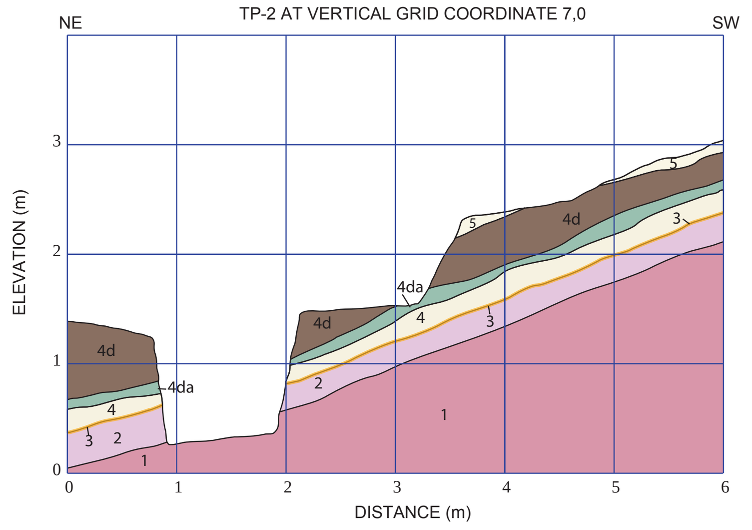
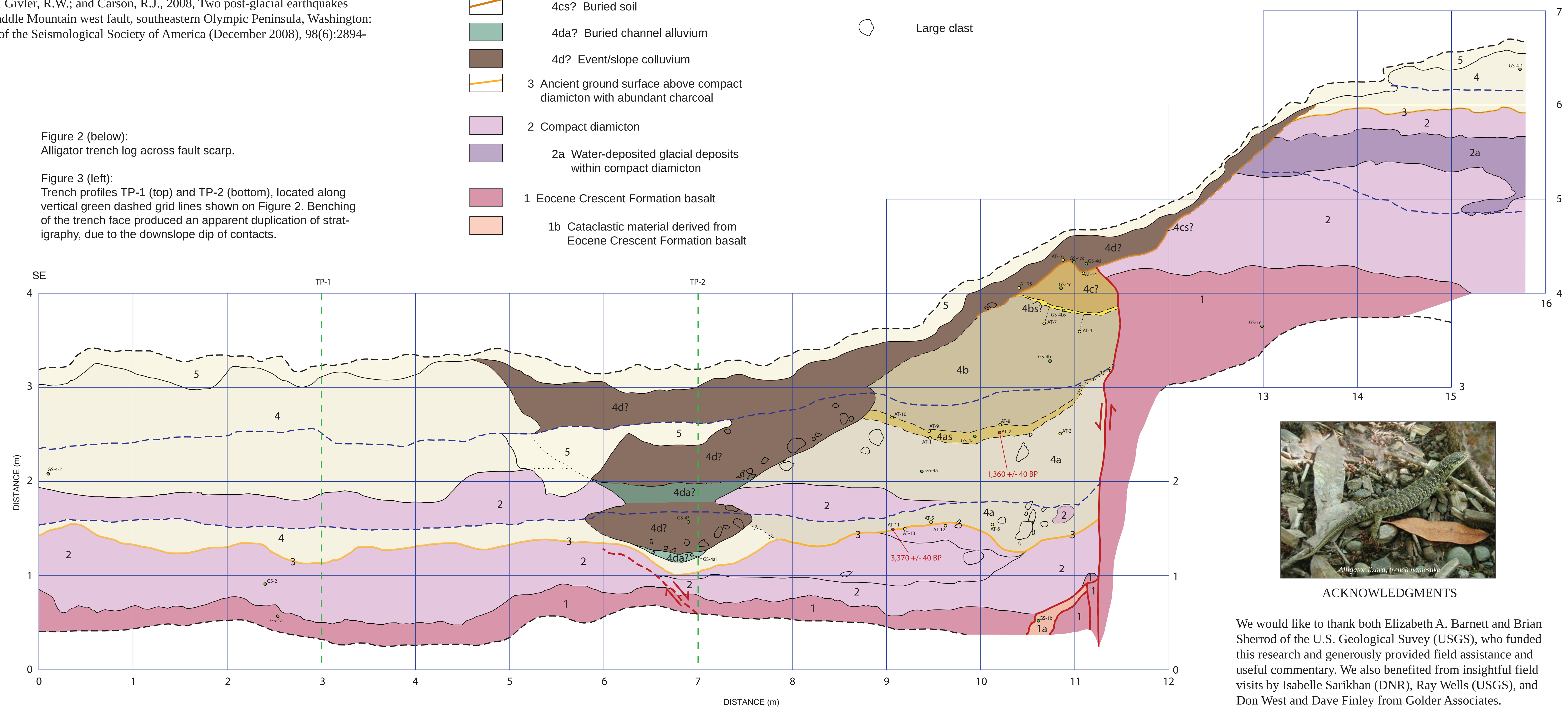


Figure 2 (below):
Alligator trench log across fault scarp.

Figure 3 (left):
Trench profiles TP-1 (top) and TP-2 (bottom), located along vertical green dashed grid lines shown on Figure 2. Benching of the trench face produced an apparent duplication of stratigraphy, due to the downslope dip of contacts.



ACKNOWLEDGMENTS

We would like to thank both Elizabeth A. Barnett and Brian Sherrod of the U.S. Geological Suvey (USGS), who funded this research and generously provided field assistance and useful commentary. We also benefited from insightful field visits by Isabelle Sarikhan (DNR), Ray Wells (USGS), and Don West and Dave Finley from Golder Associates.