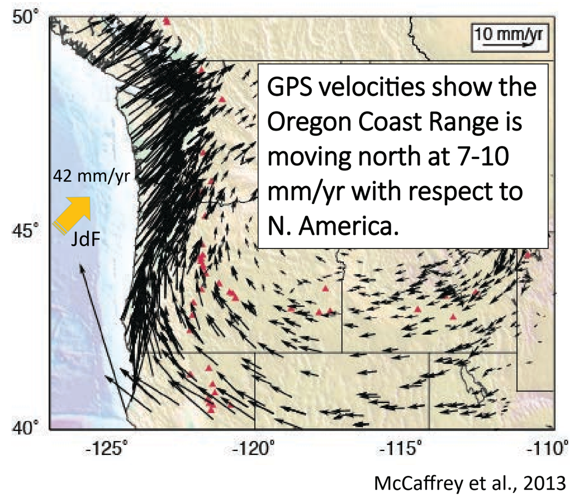
Main Point: The Holocene active Gakes Creek fault passes beneath Scoggins Dam, west of Portland. It is a seismic hazard to the Portland-Hillsboro metro area.

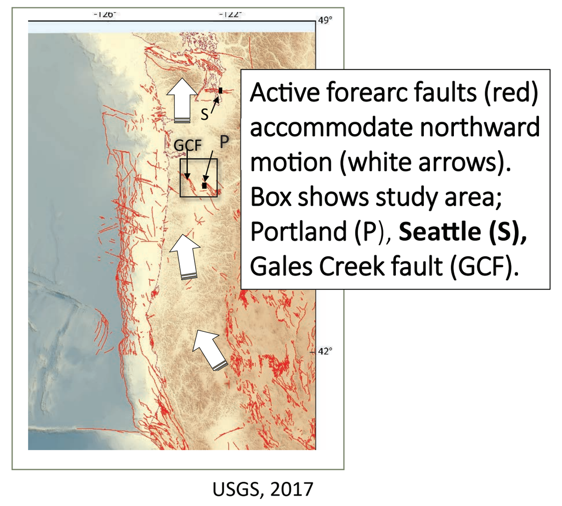
The Gales Creek fault at Scoggins Dam: an active fault in the northwest Oregon Coast Range

R.E. Wells and S.E.K. Bennett, U.S. Geological Survey, Portland, Oregon

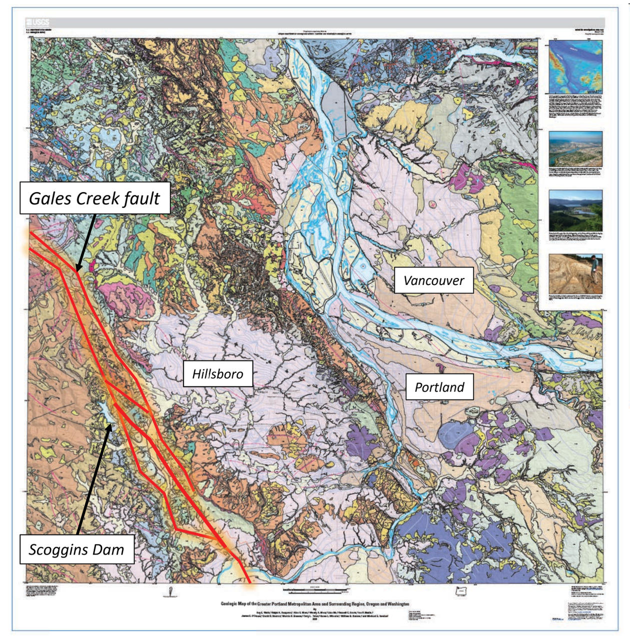
USGS science for a changing world

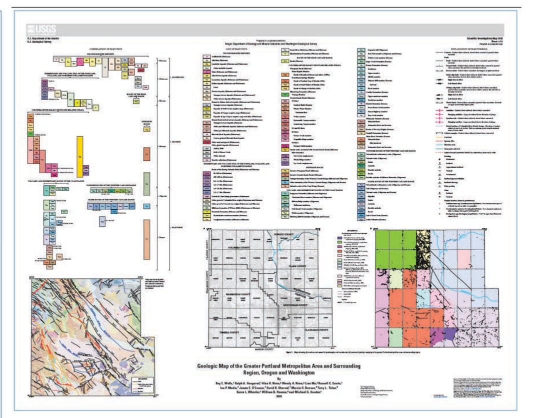
1 The Oregon forearc is moving north. Motion is accommodated by active crustal faults faults, including the Gales Creek fault.





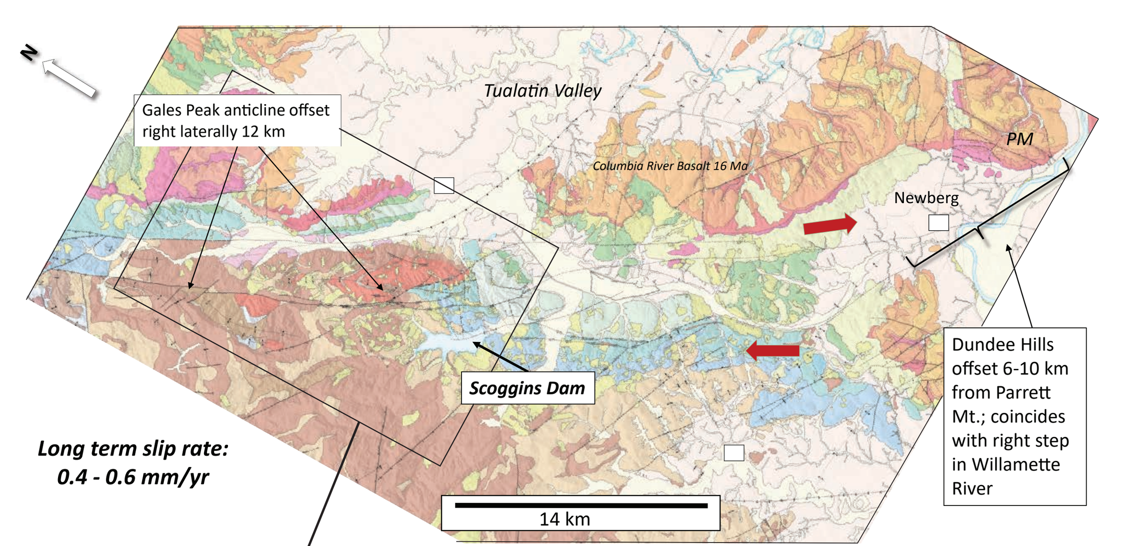
The 70-km-long, NW-striking GCF forms the western margin of the populated Tualatin Valley and passes beneath Scoggins Dam and Henry Hagg Lake, 15 km SW of Hillsboro, Oregon.

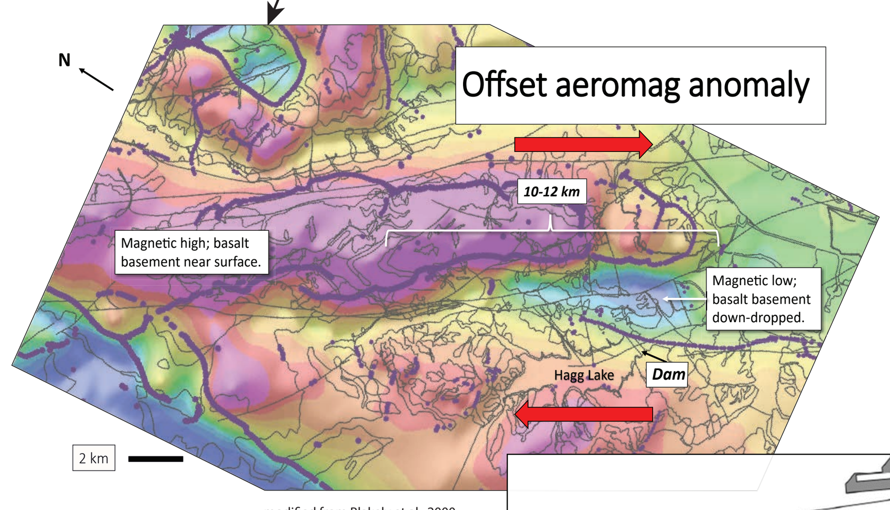


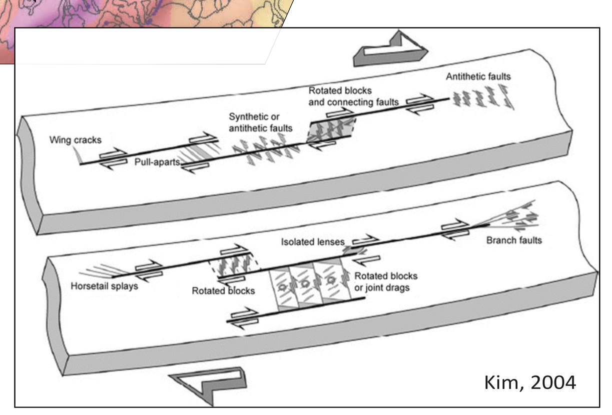


New Portland metro area geologic map (Wells et al., 2020) documents the Gales Creek fault 15 km west of Hillsboro in the Tualatin Valley.

Geology, gravity, and aeromagnetic mapping show 8-12 km of right lateral offset of Eocene basement and Columbia River Basalt.



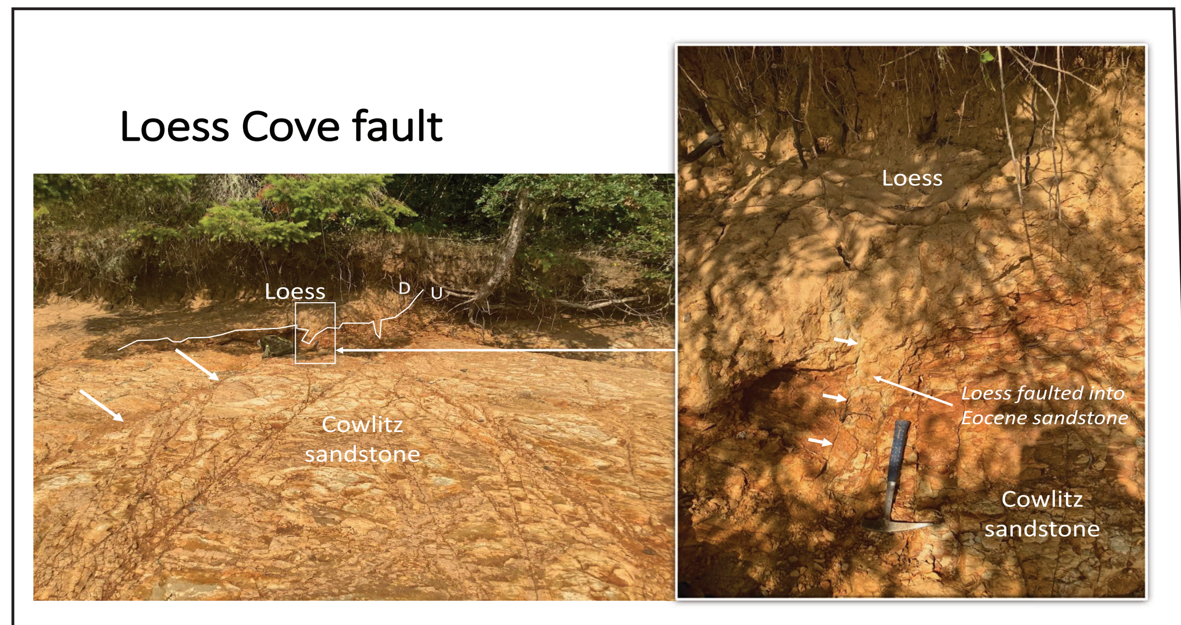


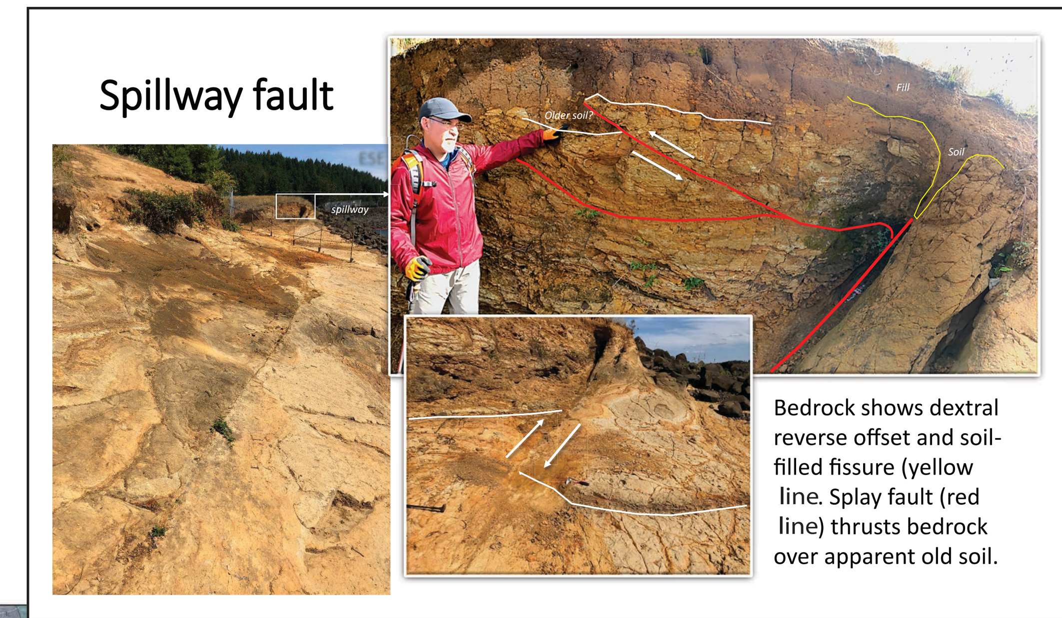


Stepovers between two major fault strands can be complicated, with many cross faults.

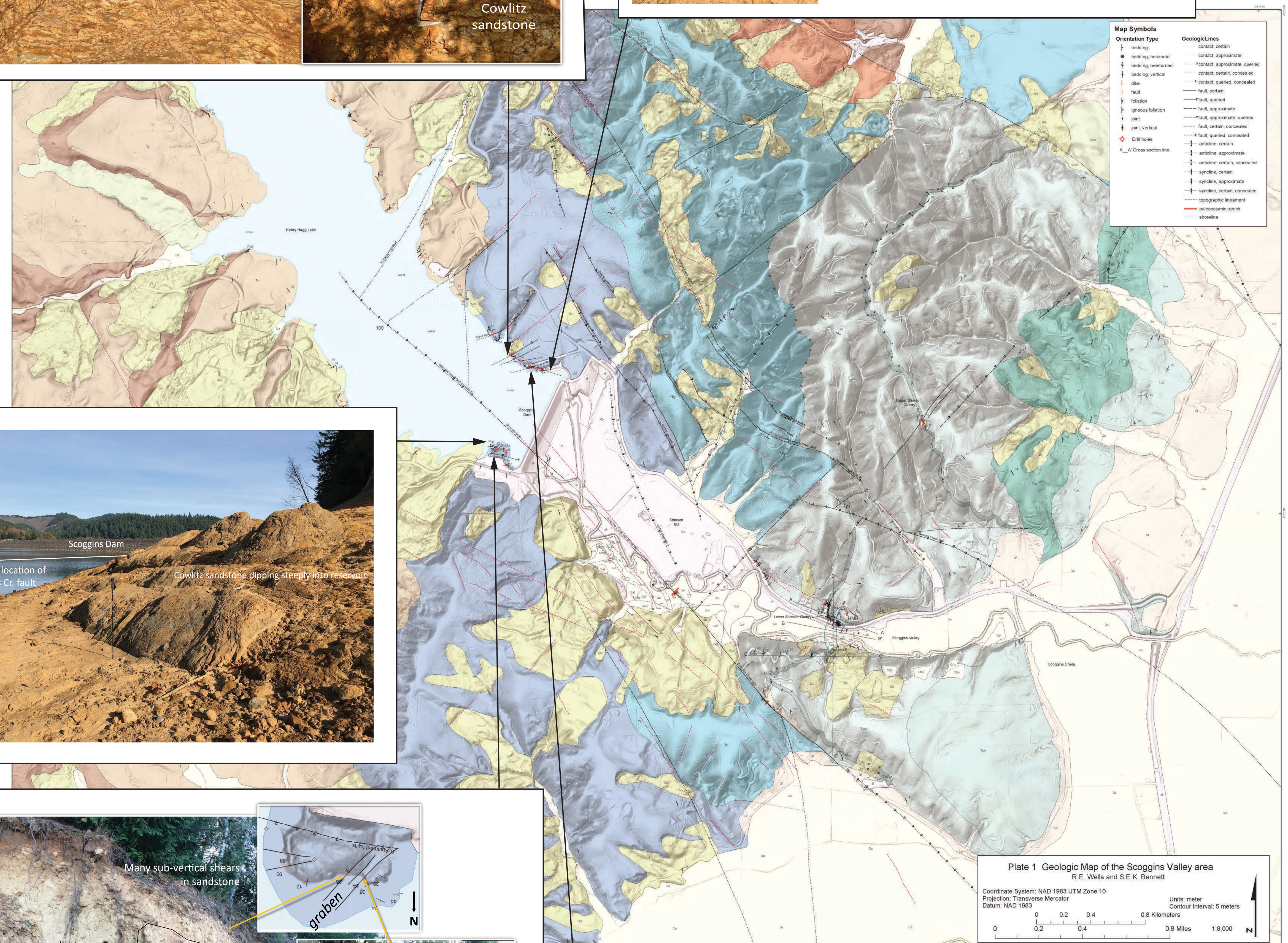
2 In cooperation with the Bureau of Reclamation and Clean Water Services, we remapped the vicinity of Scoggins Dam in greater detail than Wells et al. (2020).

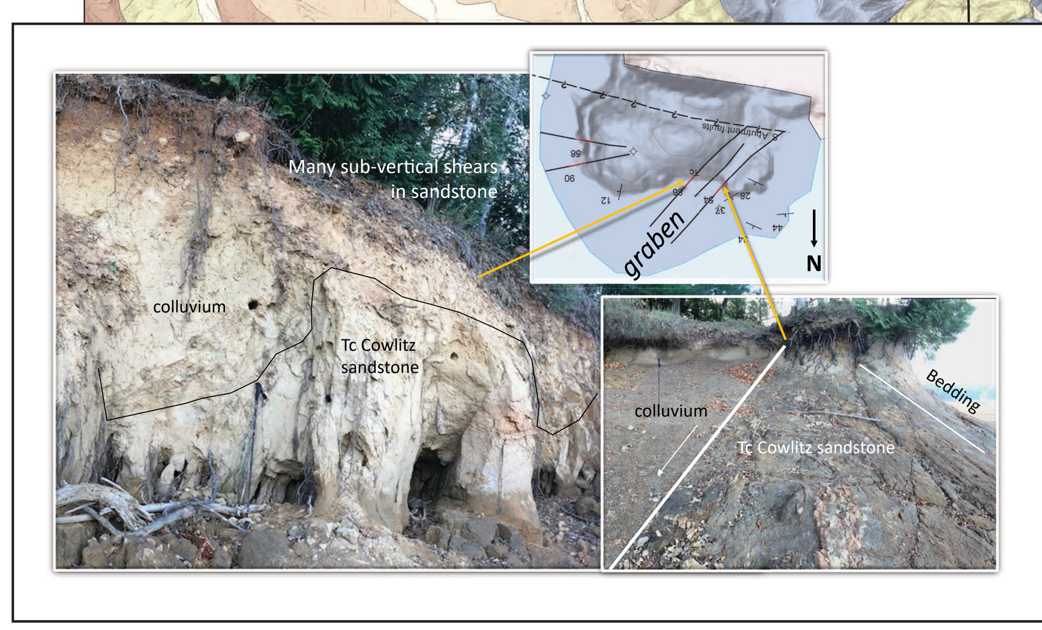
Detailed geologic mapping and trenching of the GCF reveals that Scoggins Dam lies within a complex, 1–2 km-wide right (releasing) step between two major NW-striking NE-striking, sinistral normal-oblique faults and NW-striking dextral faults occur within the stepover and are exposed along the shoreline of Henry Hagg Lake, where thick colluvial soils are stripped by wave action, providing ~20 km of nearly continuous exposure of bedrock and surficial geologic units during low reservoir levels.



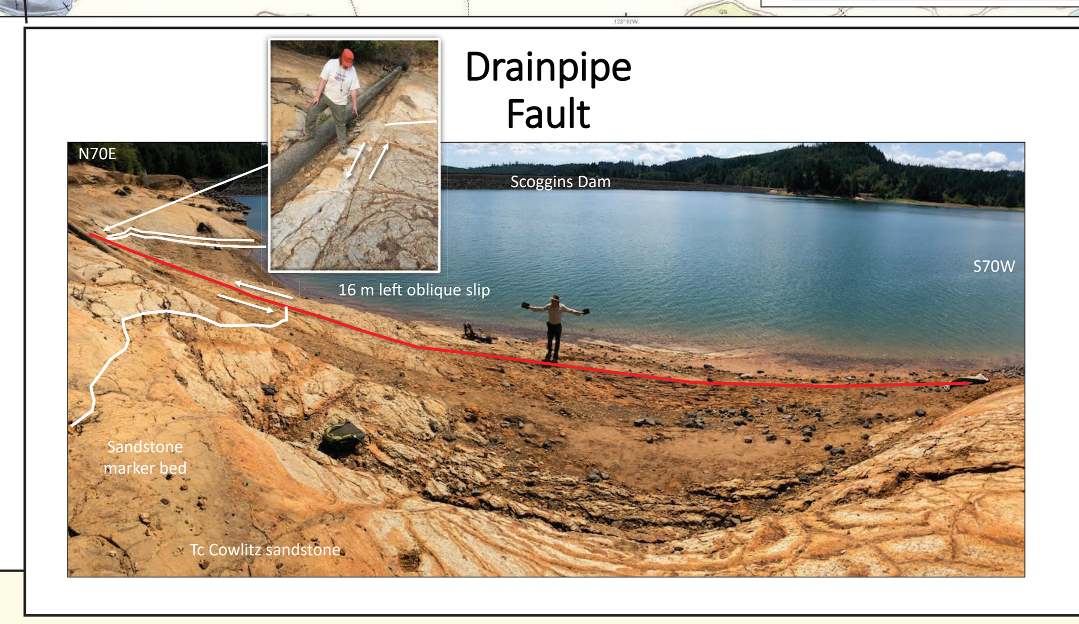


Bedrock shows dextral reverse offset and soil-filled fissure (yellow line). Splay fault (red line) thrusts bedrock over apparent old soil.



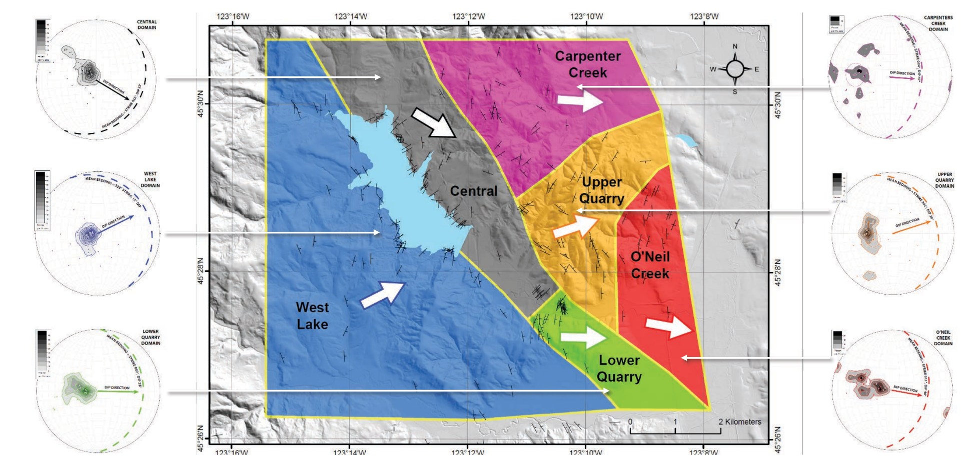


Many of these secondary stepover faults appear to offset soil horizons, although ubiquitous mass wasting complicates their interpretation.

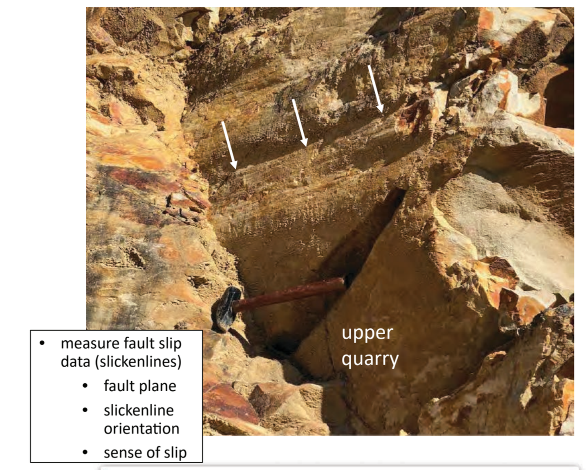


3 Structural Analysis documents right lateral faulting consistent with current stress regime.

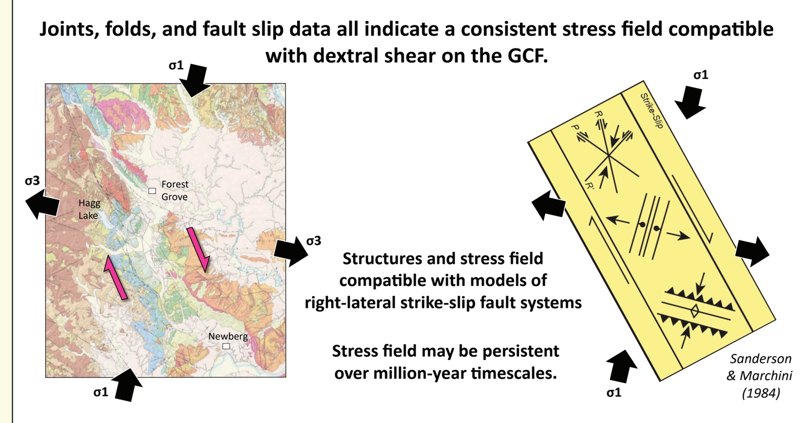
Major faults bound discrete structural domains. Domains within GCF stepover are rotated clockwise.



Measured fault slip directions

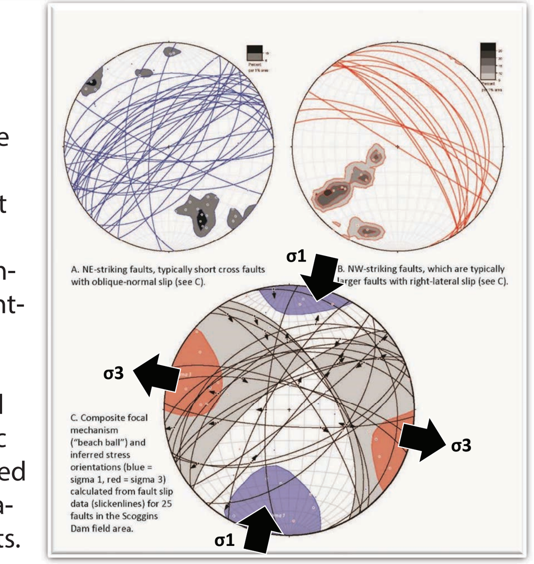


Paleo-stress from fault slip matches current stress field.

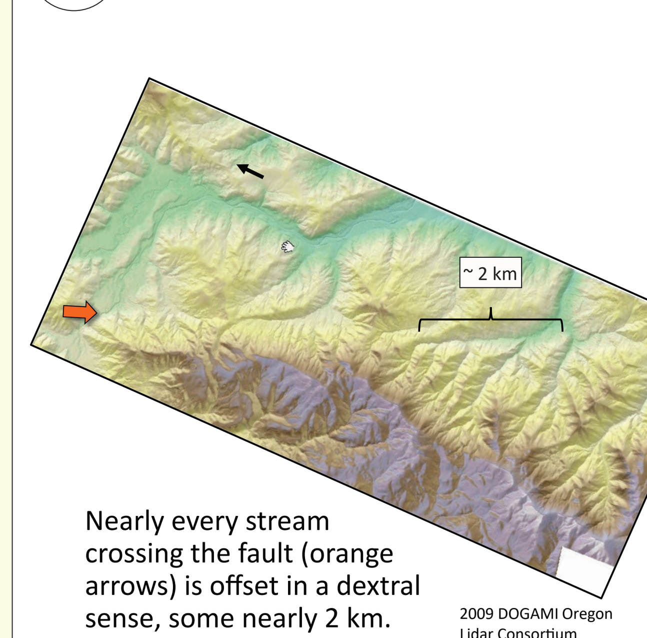


Inversion of slip data from the NW and NE-striking faults in Eocene-Oligocene bedrock at Scoggins Dam suggests that the maximum horizontal compressive stress has been oriented ~N13°E.

This is consistent with dextral offset on the GCF and historic stress field orientations derived from earthquake focal mechanisms and borehole breakouts.

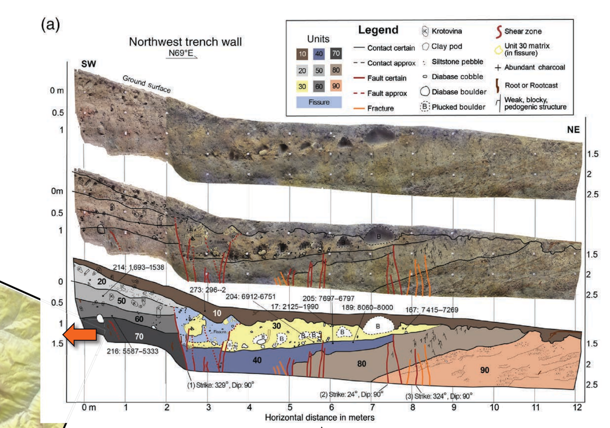


4 The Gales Creek Fault is Holocene active and a seismic hazard to the Portland metro area.



Nearly every stream crossing the fault (orange arrows) is offset in a dextral sense, some nearly 2 km.

2009 DOGAMI Oregon Lidar Consortium



Radiocarbon ages (e.g. sample 215: 2125-1990 yr BP, above) from paleoseismic trench ~ 500 m SE of lidar image bracket *three Holocene earthquakes ~ 1000, 4000, and 8800 years ago* (Horst et al., 2020).

The GCF has evidence for progressive offset continuing into the Holocene (Redwine et al., 2019; trench log of Horst et al., 2020 right).

The paleoseismic studies document multiple Holocene earthquakes at several localities over 20 km of fault length.

With complex fault geometry, Holocene activity on at least 3 major strands, the GCF has potential for large, complex rupture capable of > M7 earthquakes, a significant source of seismic hazard to the greater Hillsboro-Beaverton-Portland metro area.

Summary

1. The NW-striking, 70 km-long, Gales Creek fault forms the western boundary of the populated Tualatin Valley and the greater Portland metro area.

2. 8-12 kilometers of right lateral offset of bedrock have been documented on the GCF.

3. Scoggins Dam and reservoir lie within a right-stepping releasing stepover between the Scoggins Creek and Parson Creek strands of the GCF.

4. The Scoggins Creek and Parson Creek faults have had multiple Holocene surface-rupturing earthquakes at 1000, 4000, and 8800 years ago (Horst et al., 2020).

5. The GCF appears to be capable of a M7+ earthquake, which poses a significant seismic hazard to the western part of the Portland metro area.

6. The Bureau of Reclamation is pursuing a remediation plan to repair or replace Scoggins Dam.

References

Blakely, R.J., Wells, R.E., Tolan, T.L., Beeson, M.H., Tréhu, A.M., and Liberty, L.M., 2000, New aeromagnetic data reveal large strike-slip (?) faults in the northern Willamette Valley, Oregon: Geological Society of America Bulletin, v. 112, no. 7, p. 1225-1233.

McCaffrey, R., King, R.W., Payne, S.J. and Lancaster, M., 2013, Active tectonics of northwestern US inferred from GPS-derived surface velocities, Journal of Geophysical Research: Solid Earth, v. 118(2), pp.709-723.

Horst, Alison E., Streig, Ashley R., Wells, Ray E., and Bershaw, John, 2020, Multiple Holocene Earthquakes on the Gales Creek Fault, Northwest Oregon Fore-Arc, Bulletin of the Seismological Society of America, doi: https://doi.org/10.1785/0120190291.

Redwine, J., Klinger, R.E., Wells, R.E., Sherrod, B.L., Mahan, S.A., Piety, L.A., Howe, J., Besana-Ostman, G., Levinson, R., Chupik, C., Cataldo, K., Nincovich, S.R., and Angster, S.J., 2019, Evidence for an active Gales Creek fault - a dynamic duo active deformation confirmation, Geological Society of America Abstracts with Programs, v.51, no 4.

Sanderson, D.J. & Marchini, W.R.D., 1984, Transpression. Journal of Structural Geology, 6(5), 449-458.

Wells, R.E., Haugerud, R.A., Niem, A.R., Niem, W.A., Ma, Lina, Evarts, R.C., O'Connor, J.E., Madin, I.P., Sherrod, D.R., Beeson, M.H., Tolan, T.L., Wheeler, K.L., Hanson, W.B., and Sawlan, M.G., 2020a, Geologic map of the greater Portland metropolitan area and surrounding region, Oregon and Washington: U.S. Geological Survey Scientific Investigations Map 3443, 2 oversize sheets and 55 p. pamphlet, scale 1:63,360.

Wells R.E., Blakely R.J., Bemis S., 2020b, Northward migration of the Oregon forearc on the Gales Creek fault, Geosphere, v. 16, no. X, p. 1–25, https://doi.org/10.1130/GES02177.1.

Werner, K.S., Graven, E.P., Berkman, T.A., and Parker, M.J., 1991, Direction of maximum horizontal compression in western Oregon determined by borehole breakouts: Tectonics, v. 10, p. 948–958, https:// doi .org /10 .1029 /90TC01288.