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Kinematics and timing of the San Juan fault in northern Cascadia: Implications for Eocene terrane accretion of Siletzia

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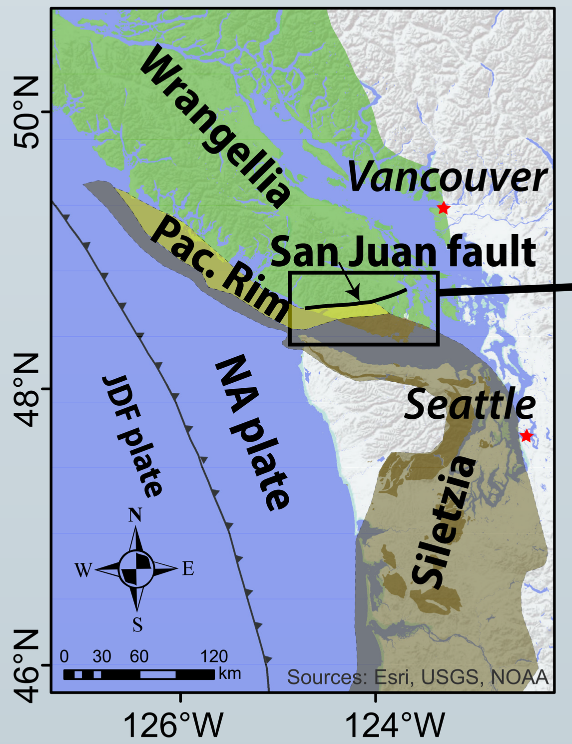
Introduction

• The San Juan fault (SJF) juxtaposes the Wrangellia terrane against the Pacific (Pac.) Rim terrane in the northern Cascadia forearc (e.g. Massey, 2005).

• The SJF is proposed to have accommodated accretion of the Pac. Rim to Wrangellia via thrusting and/or right-lateral faulting (Johnson, 1984; Rusmore and Cowan,1985).

• It is then thought to have been reactivated as a left-lateral fault during Eocene accretion of Siletzia terrane (e.g., England and Calon ,1991).

• However, no direct observations of the SJF, its kinematics, or timing of slip have been published that confirm the hypothesis that the SJF was reactivated during the Eocene terrane accretion.

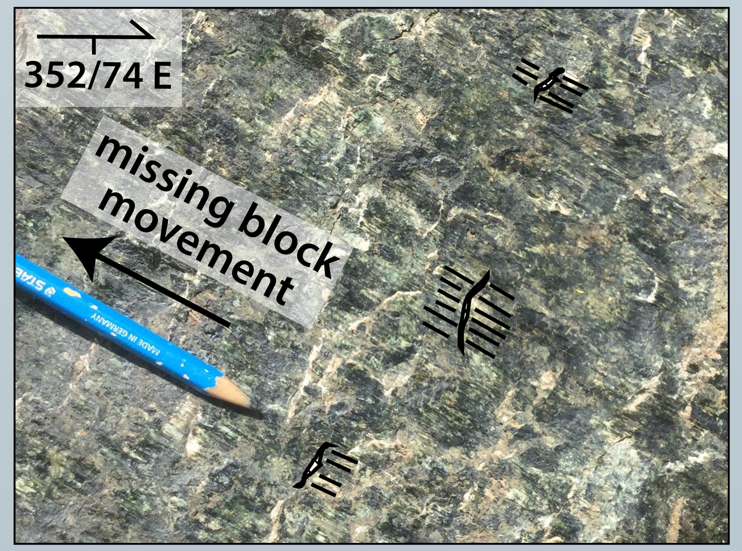


Kinematic Analysis and Structural Mapping

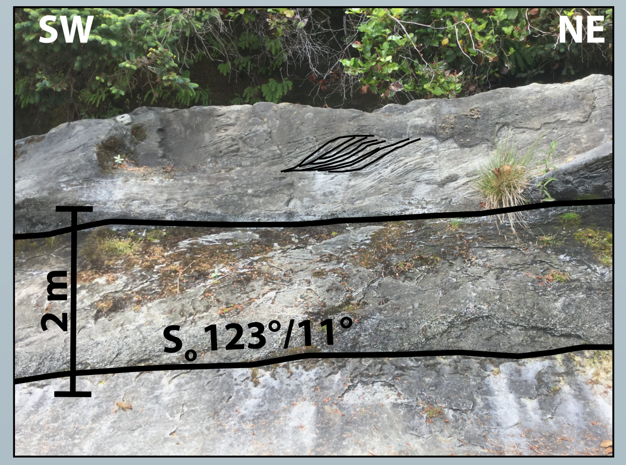
• To test this hypothesis, we measured ~ 500 fault slickenlines (example at right) along the SJF, which we map as a ~1 km wide distributed brittle fault zone with a 20-m-thick fault core.

• We used kinematic inversions of these slickenline measurements using FaultKin 7.5 (Allmendinger, 2016) to model pseudo fault-plane solutions (as lower hemisphere stereonet projections) for the SJF and faults crosscutting overlying strata (e.g., Marrett & Allmendinger, 1990).

• We mapped, collected kinematics data, and dated strata that are hypothesized to nonconformably overlie the SJF (e.g., Massey, 2005) to determine the timing of fault slip and different kinematics on the SJF.



Overlying Carmanah Group Biostratigraphy



• We mapped sequences of medium-coarse grained sandstone that non-conformably overlie the SJF.

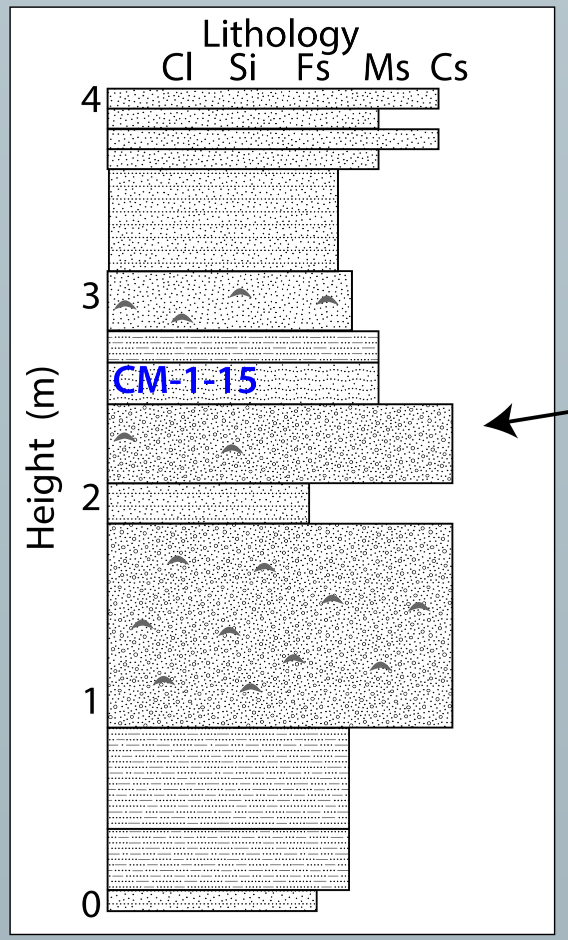
• Channels, hummocky cross-stratification (right), and shell lag deposits are indicative of a marine shelf depositional environment.

• *Cibicides sp.* benthic foraminifer identified in six samples across stratigraphic column (at right) showing sequence of fossiliferous fine to coarse grained sandstone.

• Correlates with other faunal units overlying the SJF.

• These fauna indicate outer shelf depositional environment that shallows to inner neritic near top of section.

• $^{87}Sr/^{86}Sr$ isotope age of specimens in sample CM-1-15: *34.3–33.3 Ma* (late Eocene/early Oligocene boundary), which correleates with the lower Oligocene Carmanah Group (Oc) (Johns et al., 2012).



Grain size abbreviations; Cl: Clay; Si: Silt; Fs: Fine sand; Ms: Medium sand; Cs: Coarse sand.

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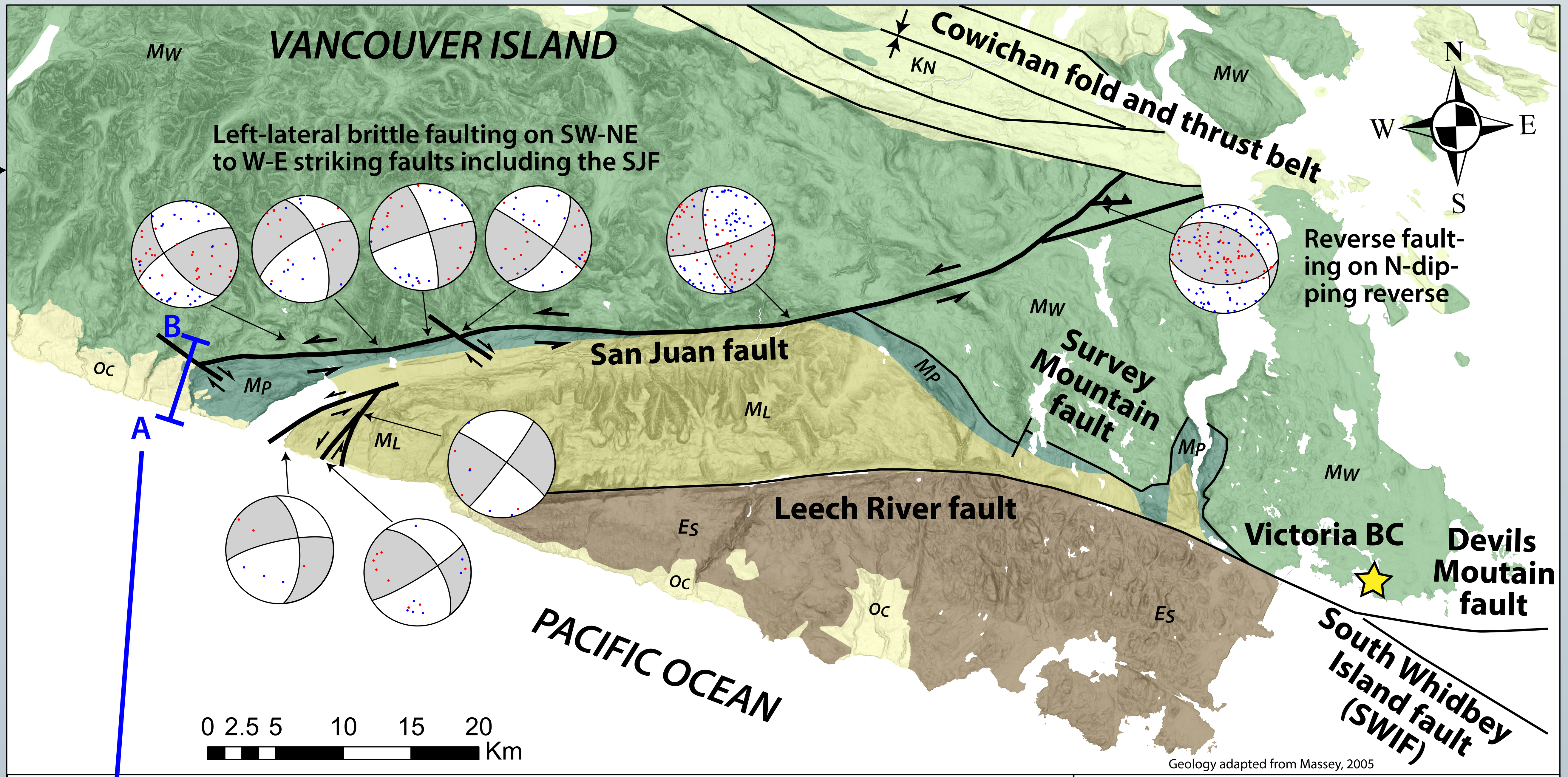
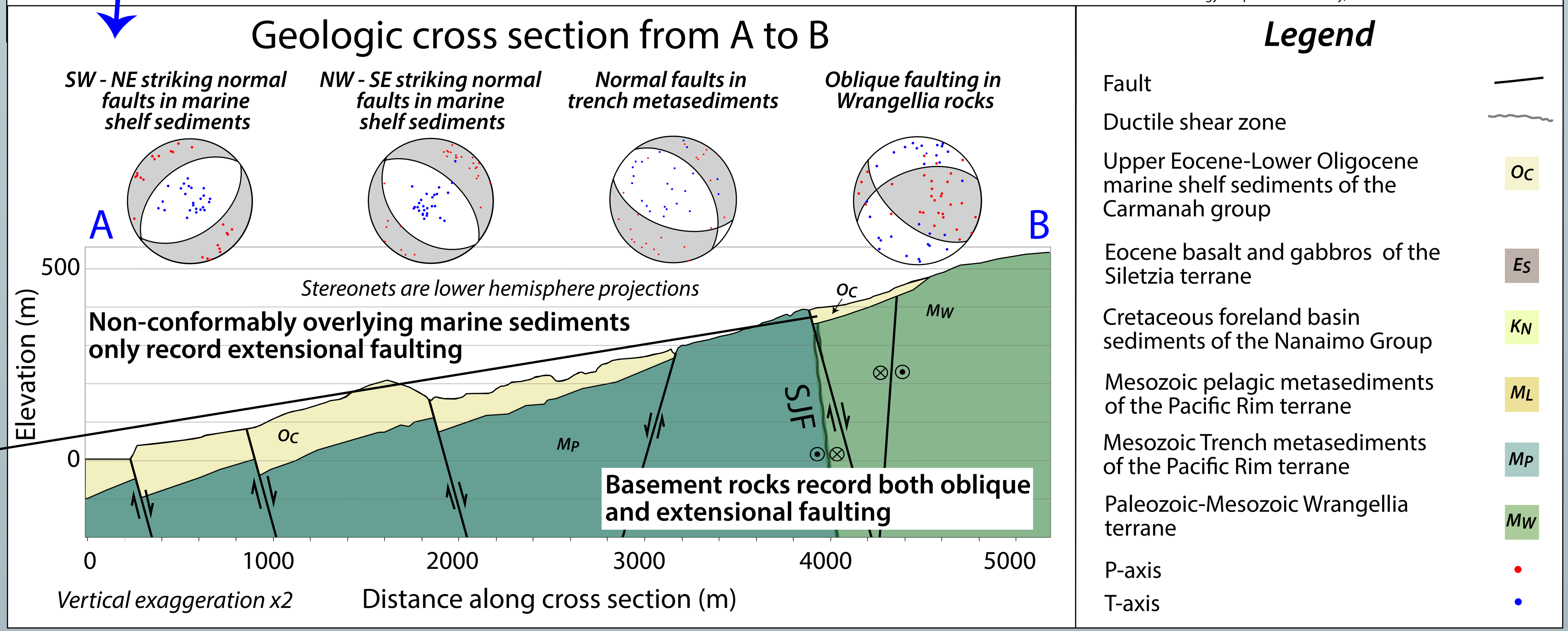
Results



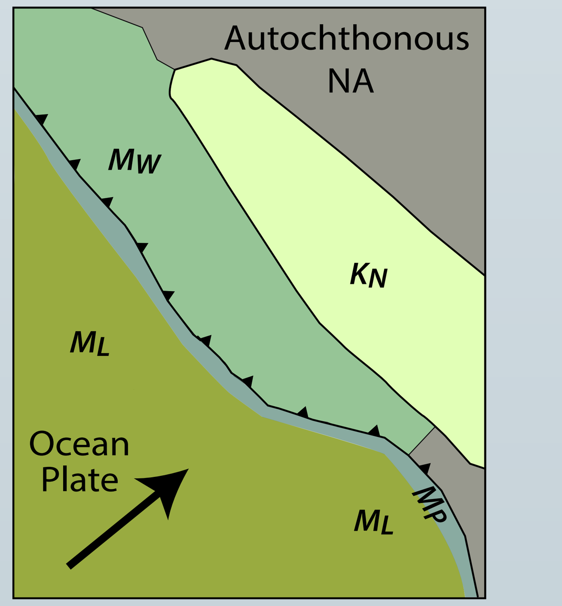


• *Brittle left-lateral slip occurs on the SJF before the deposition of the Upper-Eocene / Lower Oligocene marine shelf sediments.*

• *Maximum shortening axes on left-lateral and oblique faults are compatible with SSW-NNE shortening on the Eocene Cowichan fold and thrust belt (CFTB).*

• *Faults that cross-cut Upper Eocene - Lower Oligocene Carmanah Group marine shelf sediments only indicate NW-SE and NE-SW extension indicating left-lateral slip ceased before marine sediment deposition.*

Tectonic implications

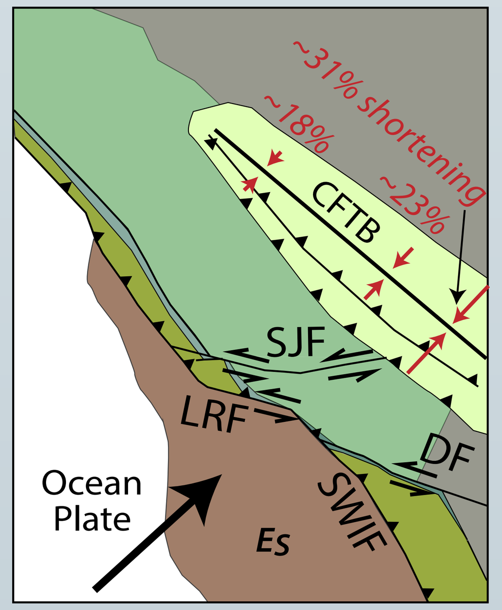


Paleocene: Underthrusting of Pac. Rim terrane

• Paleogeography of northern Cascadia is poorly constrained but previous research suggests:

• Subduction of Kula / Farallon plates and underthrusting of trench sediments and pelagic sediments (e.g., Rusmore & Cowan,1986).

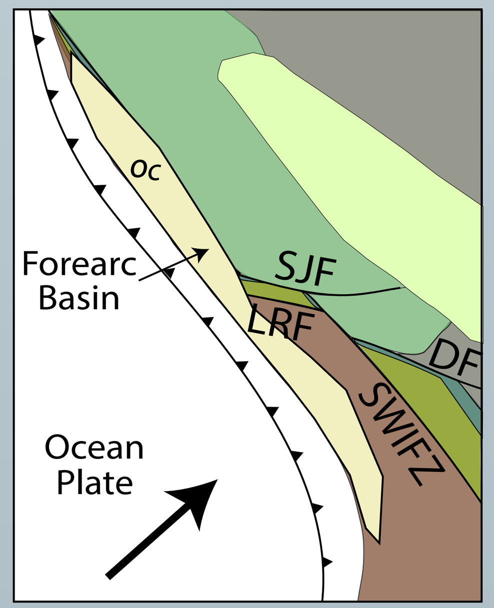
• Termination of Wrangellia south of this latitude may suggest an embayment along subduction zone south of Wrangellia (e.g., Wyld et al., 2006).



Eocene: Left-lateral slip on the SJF

• Eocene left-lateral slip on the SJF, related to the formation of the CFTB, is due to accretion of Siletzia as an indenter (e.g., Johnson & Acton, 2003; Wells et al., 2014; Nelson et al., 2017).

• NW along-strike reduction in crustal shortening recorded in CFTB (England and Calon, 1991), and Eocene oblique left-lateral slip on the Devils Mountain fault (DF; Personius et al., 2014) and Leech River fault (LRF; Fairchild and Cowan, 1982), are consistent with accretion of Siletzia indenter south of the SJF.

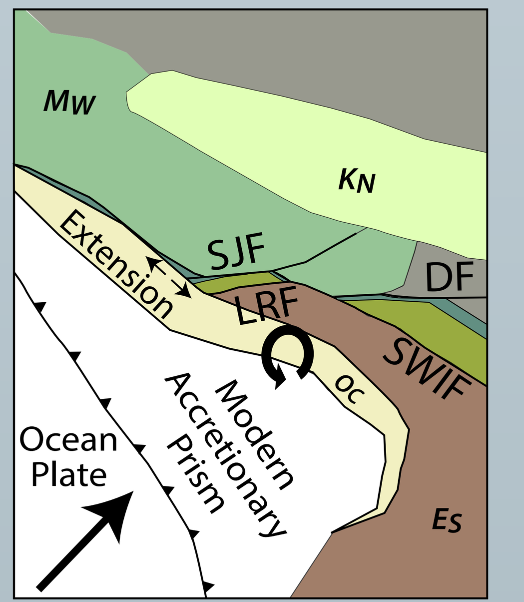


Oligocene: Left-lateral slip on the SJF ceases.

• Subduction zone moves outboard of Siletzia (e.g., Wells et al., 2014)

• Deposition of marine shelf and slope sediments (Carmanah group) in the forearc (e.g., Garver and Brandon, 1994).

• Extensional faulting in the Carmanah group during basin formation?



Miocene to Modern: Extensional faulting in Carmanah Group

• ~22° of post-Oligocene counterclockwise rotation of northern Cascadia (Finley, 2019).

• Counterclockwise rotation of southern Vancouver Island with respect to northern Vancouver Island may have induced NW-SE extension along the west coast of Vancouver Island (e.g., Johnston & Acton, 2003) resulting in normal faulting in the Carmanaha group.

References
• Allmendinger, R. W. (2016), FaultKin 7.5 for Mac OS X Windows and Linux,31.
• Brandon, M. T., Roden-Tice, M. K., and J.I. Garver (1998), Late Cenozoic exhumation of the Cascadia accretionary wedge in the Olympic Mountains.
• England, T. D. J., and T. J. Calon (1991), The Cowichan fold and thrust system, Vancouver Island, southwestern British Columbia.
• Fairchild, L. H., and D. S. Cowan (1982), Structure, petrology, and tectonic history of the Leech River complex northwest of Victoria, Vancouver Island.
• Finley, T., K. Morell, L. Leonard, C. Regalla, S. T. Johnston, and W. Zhang (2019), Ongoing oroclinal bending in the cascadia forearc and its relation to concave-outboard plate margin geometry.
• Garver, J. I., and M. T. Brandon (1994), Erosional denudation of the British Columbia Coast Ranges as determined from fission-track ages of detrital zircon from the Tofino basin, Olympic Peninsula, Washington,.
• Johns, M. J., J. A. Trotter, C. R. Barnes, and Y. R. Narayan (2012), Biostratigraphic, strontium isotopic, and geologic constraints on the landward movement and fragmentation of terranes within the Tofino Basin, British Columbia.
• Johnson, S. Y. (1984), Evidence for a margin-truncating transcurrent fault (pre-late Eocene) in western Washington.
• Johnston, S. T., and S. Acton (2003), The Eocene Southern Vancouver Island Orocline a response to seamount accretion and the cause of fold-and-thrust belt and extensional basin formation.
• Marrett, R. and R.W. Allmendinger (1990), Kinematic analysis of fault-slip data.
• Massey, N. W. D., D. G. MacIntyre, P. J. Desjardins, and R. T. Cooney (2005), Digital geology map of British Columbia.
• Nelson, A. R., S. F. Personius, R. E. Wells, E. R. Schermer, L.-A. Bradley, J. Buck, and N. Reitman (2017), Holocene earthquakes of Magnitude 7 during westward escape of the Olympic Mountains, Washington.
• Personius, S. F., R. W. Briggs, A. R. Nelson, E. R. Schermer, J. Z. Maharrey, B. L. Sherrod, S. A. Spaulding, and L.-A. Bradley (2014), Holocene earthquakes and right-lateral slip on the left-lateral Darrington–Devils Mountain fault zone, northern Puget Sound, Washington
• Rusmore, M. E., and D. S. Cowan (1985), Jurassic–Cretaceous rock units along the southern edge of the Wrangellia terrane on Vancouver Island.
• Wells, R. E., D. Bukry, R. Friedman, D. Pyle, R. Duncan, P. Haeussler, and J. Wooden (2014), Geologic history of Siletzia, a large igneous province in the Oregon and Washington Coast Range: Correlation to the geomagnetic polarity time scale and implications for a long-lived Yellowstone hotspot.
• Wyld, S. J., P. J. Umhoefer, J. E. Wright, J. Haggart, R. Enkin, and J. Monger (2006), Reconstructing northern Cordilleran terranes along known Cretaceous and Cenozoic strike-slip faults: Implications for the Baja British Columbia hypothesis and other models.