A Tectonic Synthesis of the Straight Creek / Fraser River Fault

By Christian Oakley | Pacific Lutheran University Department of Geosciences | christian.oakley@plu.edu
Mentor: Dr Peter Davis | Pacific Lutheran University Department of Geosciences

Abstract

The Straight Creek Fault (SCF) / Fraser River Fault is a major structure in the Pacific Northwest, that has never had a full synthesis of it's history constructed. This capstone's intention is to collect papers discussing the geologic history of the Pacific Northwest then combine them into one history of the SCF. This research showed that the fault rate of movement is within known boundaries for strike-slip faults. The fault began to move between 45mya and 50mya, and stopped around 35mya at a rate of 0.8cm/yr to 1.4cm/yr. These rates are determined by measuring significant geologic structures that cross-cut the SCF, as well as examining large mapping initiatives from US and Canadian geologists. During this research, there were found to be some mapping errors along the America/Canadian border, as well as around the southern end of the SCF. To get a more accurate view of the fault, a USGS/GAC initiative to map the border is needed to reevaluate the geologic structures which cross it.

Intro

Knowing the tectonic history of the planet is a useful endeavor. If we know how the land formed, we can predict natural disasters, find mineral resources, and better plan urban developments. This is especially important in a geologically turbulent area like the pacific northwest, and one of the largest formations in the region, the Straight Creek Fault.

Research Question

What then does the totality of the data say about the history of the Straight Creek Fault, and does it support or refute the current view of it's tectonic history?

Background

The Straight Creek Fault is a strike-slip fault that runs from southern Washington to southern Canada where it is known as the Fraser River Fault. Even with the most conservative estimates, the fault is large compared to other strike-slip faults (Sylvester, 1988). Because of its large size, it is a significant structure in the history of the Pacific Northwest. As important a fault as it is, there has never been a single complete view of the fault's history.
A period of interest surrounding the fault include the Eocene Extension period. During this period, the Pacific Northwest saw around 100km of extension, with northward translation from strike-slip fault motion (Umhoefer & Miller, 1996).

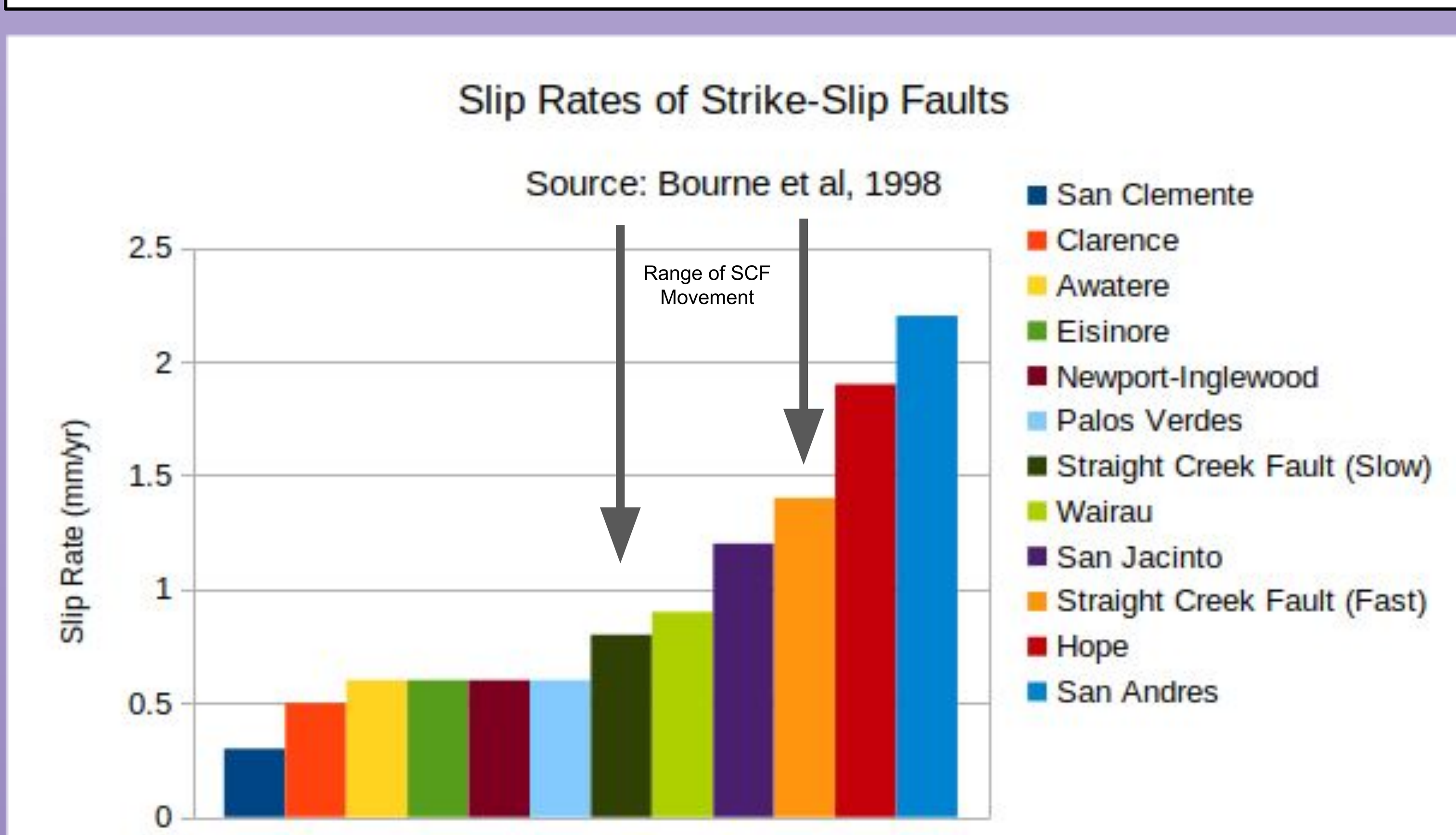

Fig B: Strike-slip fault movement rates compared, including SCF rates

Methods

This project is highly research based. The method used was to synthesize a plurality of data from many different academic sources, then compare the results to determine the most likely answer.

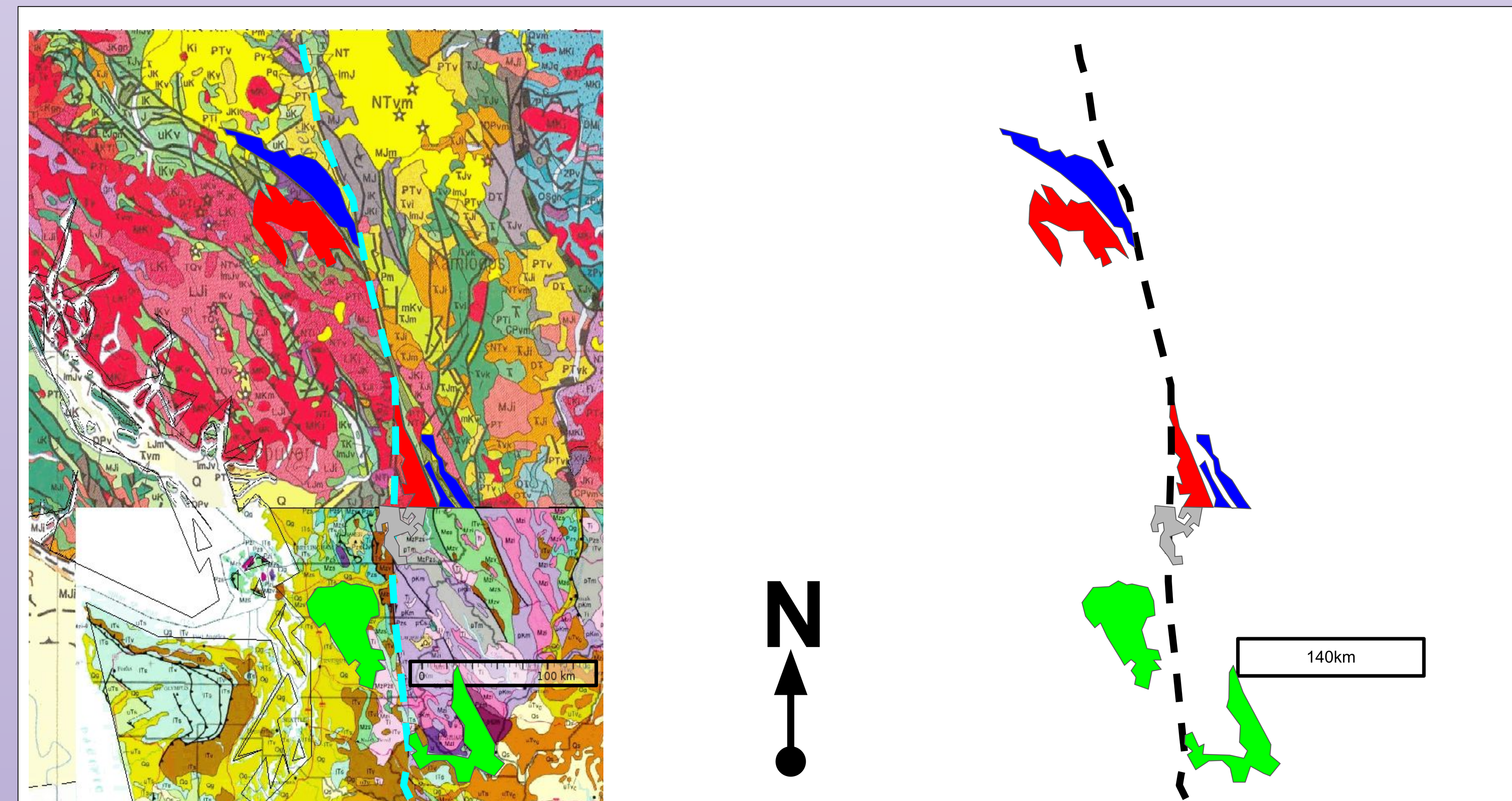

Fig A: Highlighted structures used to determine range of fault motion; Below,

Structure	Source	Hypothesized Offset (appx)	Color (Above)
Bridge River -> Bridge River	Monger & Journeay, 1992	80km	Red
Methow -> Methow	Monger & Journeay, 1992	80km	Blue
Chuckanut -> Teanaway River Block	Eddy et al, 2016	125km	Green
Cache Creek -> Spences Bridge	Monger & Journeay, 1992	140km	Not shown
Bridge River -> Cascade Metamorphic Core	Monger & Journeay, 1992	140km	Not shown
Settler Schists -> Chiwuakum Schists	Misch, 1977	190km	Not shown
Granitic Plutons	Umhoefer & Miller, 1996	No offset, used to mark when fault stopped movement	Grey

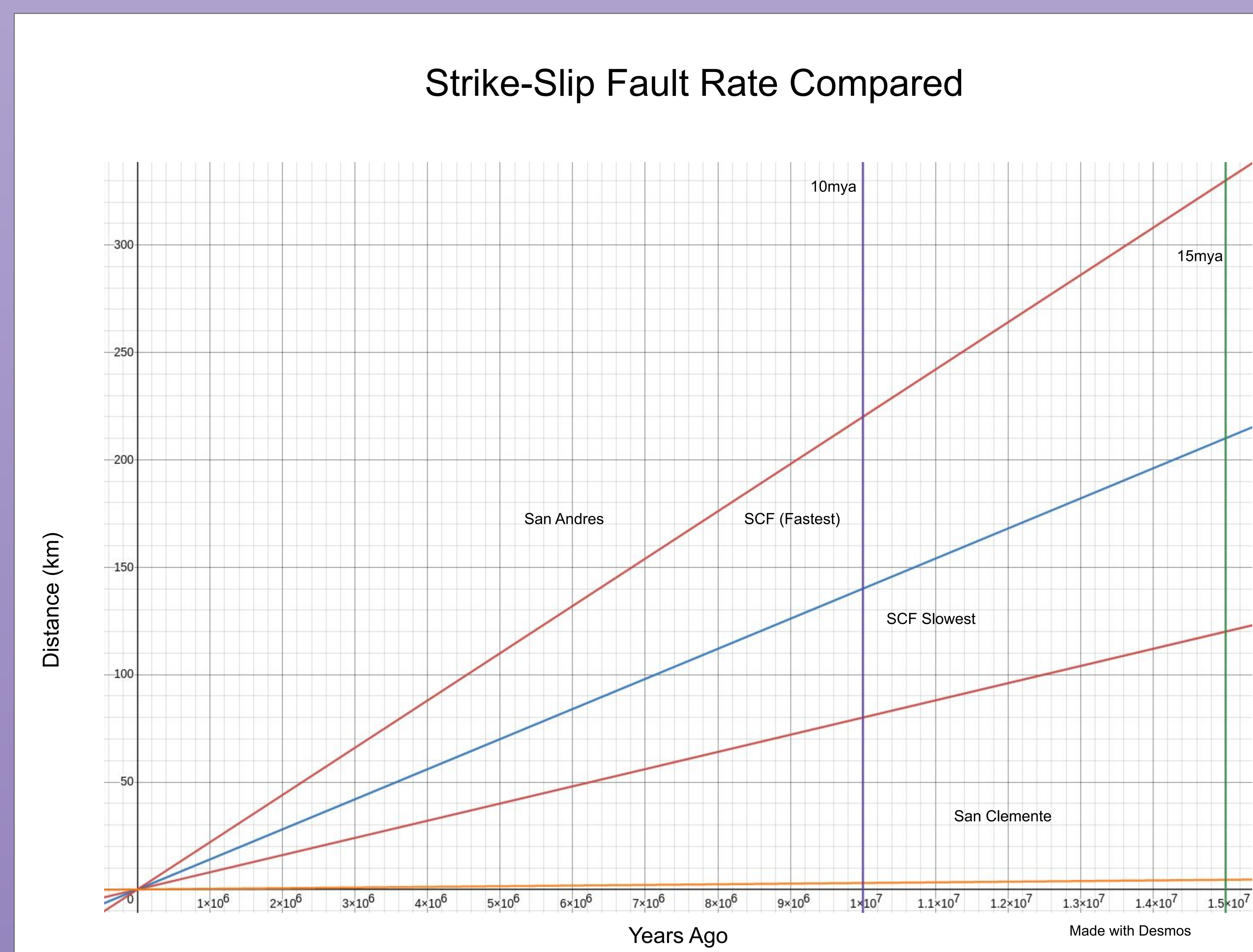

Fig C: Rates of movement plotted on a graph of time vs distance

Results

- Total length: At least ~347km according to Tabor and Monger & Journey
- Movement began between 50ma to 45ma after the Sauk Basin deposition
- Movement Stopped 35mya because of granitic plutons that intruded over the fault
- The fault's rate of movement was between 0.8 and 1.4 cm a year over a period of 10 to 15 million years.

Discussion

The length of the fault determined by mapping done by American (Tabor 1994) and Canadian geologists (Monger & Journey 1994) in the 1990s. The length of the fault is ~347km at the shortest, but continues to extend north as the fault interacts with the Northern Rocky Mountain Trench Fault Zone (Price & Carmichael 1986).
The start of the fault movement is constrained by the Eocene Extension period, sedimentary rocks deposited by extensional faulting in the Swauk Basin can be dated to this time and they are the oldest rocks that are cross-cut by the SCF.
Movement of the fault stopped by 35mya. This is shown by a series of granitic plutons that seal the fault (Umhoefer & Miller, 1996). These plutons are the oldest rocks that cross over SCF, and are not cut by fault movement.
The fault's offset is determined by finding similar geologic structures on each side of the fault, determining that they were once the same structure, and then measuring the distance between them. Some of these structures are listed on the table in fig A. While the range is wide, the trend goes from a large offset in the south, moving towards smaller offsets in the north. This implies the fault movement originated in the south (Bourne et al. 1998).
Since the fault's offset is known, and the period of movement is known, we can calculate the rates of movement of the SCF (shown in fig B and fig C).
One problem discovered is an inconsistency in mapping across the US - Canadian border. Maps were found to not line up and slightly different results were seen from researchers from each country.

Conclusion

The Straight Creek Fault is still an unexplored structure in the history of the Pacific Northwest. While there is still ambiguity in the specifics of the fault, this may be due to the inconsistencies in mapping across the border. A next step for the pacific northwest could be a collaborative project between USGS and GAC geologists to map the structures in the Pacific Northwest using modern technology.

Acknowledgements

Many thanks to the Pacific Lutheran University Geology department for the opportunity to work on such an interesting project. Special thanks to Dr. Peter Davis for all his support and knowledge on this project, as well as Dr. Michael Turzewski for all of his support. And finally, thanks to all of the capstone students for their advice and peer review.

Bibliography

Bourne, S. J., P. C. England, and B. Parsons (1998), The motion of crustal blocks driven by flow of the lower lithosphere and implications for slip rates of continental strike-slip faults, Nature, 391(6668), 655–659, doi:10.1038/35556.

Brown, E. H. (1987). Structural geology and accretionary history of the Northwest Cascades System, Washington and British Columbia. Geological Society of America Bulletin, 99(2), 201. https://doi.org/10.1130/0016-7606(1987)99<201:sgaaho>2.0.co;2

Chamberlain, V. E., & Lambert, R. S. J. (1987). Comment and reply on "Geometric test for late cretaceous–paleogene intracontinental transform faulting in the Canadian Cordillera." Geology, 15(2), 185. https://doi.org/10.1130/0091-7613(1987)15<185:carogt>2.0.co;2

Crosson, R. S., M. L. Jacobson, J. C. Yount, J. A. Vance, and R. B. Miller (1983), GEOLOGIC CONSTRAINTS ON THE MOVEMENT HISTORY OF THE STRAIGHT CREEK FAULT, in Proceedings of workshop XIV earthquake hazards of the puget sound region, Washington, convened under auspices of National Earthquake Hazards Reduction Program, 13-15 October 1980, Lake Wilderness, Washington, pp. 302–306, U.S. Dept. of the Interior, Geological Survey, Menlo Park, CA.

Davis, P. (2019). New insights on syntectonic emplacement of the Hicks butte pluton in the central cascades of Washington State. Geological Society of America Abstracts with Programs. https://doi.org/10.1130/abs/2019cd-329688

Davis, P., and M. Stubbs (2017), Perspective on lateral terrane translation from syntectonic emplacement of the Hicks butte pluton in the central cascades of Washington State, Geological Society of America, 2017 annual meeting & exposition. Seattle, WA, United States, doi:10.1130/abs/2017am-306311.

Eddy, M. P., S. A. Bowring, P. J. Umhoefer, R. B. Miller, N. M. McLean, and E. E. Donaghy (2015), High-resolution temporal and stratigraphic record of Siletzia's accretion and triple junction migration from nonmarine sedimentary basins in Central and Western Washington, Geological Society of America Bulletin, 128(3-4), 425–441, doi:10.1130/b31335.1.

Eddy, M. P., Umhoefer, P. J., Miller, R. B., Donaghy, E. E., Gundersen, M., & Senes, F. I. (2017). Sedimentary, volcanic, and structural processes during triple-junction migration: Insights from the Paleogene record in Central Washington. From the Puget Lowland to East of the Cascade RangeGeologic Excursions in the Pacific Northwest. https://doi.org/10.1130/2017.0049(07)

Jones, A. G., Kurtz, R. D., Boerner, D. E., Craven, J. A., McNeice, G. W., Gough, D. I., DeLaurier, J. M., & Ellis, R. G. (1992). Electromagnetic constraints on strike-slip fault geometry—the Fraser River Fault System. Geology, 20(6), 561. https://doi.org/10.1130/0091-7613(1992)020<0561:ecossf>2.3.co;2

Kleinspehn, K. L. (1985). Cretaceous sedimentation and tectonics, Tyaughton–Methow Basin, southwestern British Columbia. Canadian Journal of Earth Sciences, 22(2), 154–174. https://doi.org/10.1139/e85-014

Monger, J. W., & Journeay, J. M. (1994). Guide to the geology and tectonic evolution of the Southern Coast Mountains. https://doi.org/10.4095/194829

Porter, A. (2013). Sunset on Copper Ridge, North Cascades National Park. Flickr. Retrieved April 26, 2022, from https://www.flickr.com/photos/northwesternimages/9505345293.

Price, R. A., & Carmichael, D. M. (1986). Geometric test for Late Cretaceous-Paleogene intracontinental transform faulting in the Canadian Cordillera. Geology, 14(6), 468. https://doi.org/10.1130/0091-7613(1986)14<468:gtflci>2.0.co;2

Senes, F. I. (2019). Deformation, sandstone detrital zircon ages, and provenance in and near the Eocene Leavenworth Fault Zone, Washington. https://doi.org/10.31979/etd.ptrc-788e

Stewar, J. H., and J. C. Crowell (1992), Strike-slip tectonics in the Cordilleran region, Western United States, The Cordilleran Orogen, 609–628, doi:10.1130/dnag-gna-g3.609.

Sylvester, A. G. (1988), Strike-slip faults, Geological Society of America Bulletin, 100(11), 1666–1703, doi:10.1130/0016-7606(1988)100<1666:ssf>2.3.co;2.

Tabor, R. W. (1994), Late mesozoic and possible early tertiary accretion in western Washington State: The Helena-Haystack Mélange and the Darrington-Devils Mountain Fault Zone, Geological Society of America Bulletin, 106(2), 217–232, doi:10.1130/0016-7606(1994)106<0217:lmapet>2.3.co;2.

Tabor, R. W., V. A. Frizzel, J. A. Vance, and C. W. Naeser (1984), Ages and stratigraphy of lower and middle tertiary sedimentary and volcanic rocks of the Central Cascades, Washington: Application to the tectonic history of the Straight Creek Fault, Geological Society of America Bulletin, 95(1), 26, doi:10.1130/0016-7606(1984)95<26:aasola>2.0.co;2.

Tepper, J. H., & Eddy, M. P. (2017). The cause(s) of widespread Eocene magmatism in the Pacific Northwest: Insights from geochemistry and geochronology of igneous rocks in Washington. Geological Society of America Abstracts with Programs. https://doi.org/10.1130/abs/2017am-301043

Trexler, J. H., & Bourgeois, J. (1985). Evidence for mid-Cretaceous wrench-faulting in the Methow Basin, Washington: Tectonostratigraphic setting of the Virginian Ridge Formation. Tectonics, 4(4), 379–394. https://doi.org/10.1029/tc004i004p00379

Umhoefer, P. J., & Miller, R. B. (1996). Mid-Cretaceous thrusting in the southern coast belt, British Columbia and Washington, after strike-slip fault reconstruction. Tectonics, 15(3), 545–565. https://doi.org/10.1029/95tc03498