GEOCHEMICAL ANALYSIS OF THE TEANAWAY FORMATION, CENTRAL CASCADES, WASHINGTON. EVIDENCE TO SUPPORT SLAB BREAKOFF AFTER ACCRETION OF SILETZIA

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ABSTRACT

The Teanaway Formation is a bimodal Eocene (ca. 49-46 Ma) volcanic sequence located in the central Cascades, Washington State. The Teanaway Formation uncomfortably overlies the Swauk Formation and conformably underlies the Roslyn Formation. The age of the Teanaway Formation overlaps a time of extension in the central Cascades of Washington. This formation consists of a diverse assemblage of volcanic and minor sedimentary rocks, primarily basalt, basaltic andesite, and andesite, with small amounts of rhyolite and dacite. The Teanaway Formation features an extensive swarm of basalt and diabase dikes that intrude the underlying Swauk Formation. It is interpreted that the dikes are feeders for the overlying lava flows. This study utilized whole-rock geochemical analysis from 11 Teanaway Formation samples located near the east bank of Cle Elum Lake. The aim of this study is to interpret the magmatic affinities and volcanic development of the Teanaway Formation. Major elements from the Teanaway Formation indicate a primarily intermediate, subalkaline, tholeiitic, and medium-K compositions. Samples are primarily basaltic andesites. Ba/Nb ratios range between 33 and 111. K2O/Nb ratios range between 0.06 and 0.23. Sr/Nb ratios range between 17 and 79. These samples predominantly plot in fields defined by mid-ocean ridge basalts (MORB) on several tectonic discrimination diagrams. These new findings support previous results from three different localities in the Teanaway Formation. The high Ba/Nb ratios and medium-K affinities are similar to modern arc settings. The tholeiitic, K2O/Nb , and Sr/Nb ratios are indicative of transitional arc and MORB settings. The major and trace element data – as well as samples plotting predominantly in MORB fields on tectonic discrimination diagrams – suggests magma generation from both decompression melting and subduction. This supports the generation of the Teanaway Formation as a slab breakoff after the accretion of Siletzia.

INTRODUCTION

- The Teanaway Formation is a bimodal Eocene (ca. 49-46 Ma) volcanic sequence located in the central Cascades, Washington State.
- The Teanaway Formation uncomfortably overlies the sedimentary rocks of the Swauk Formation and conformably underlies the sedimentary rocks of the Roslyn Formation.
- The age of the Teanaway Formation overlaps a time of extension in the central Cascades of Washington.
- This study utilized whole-rock geochemical analysis from 11 Teanaway Formation samples located near the east bank of Cle Elum Lake.
- The aim of this study is to interpret the magmatic affinities and volcanic development of the Teanaway Formation.

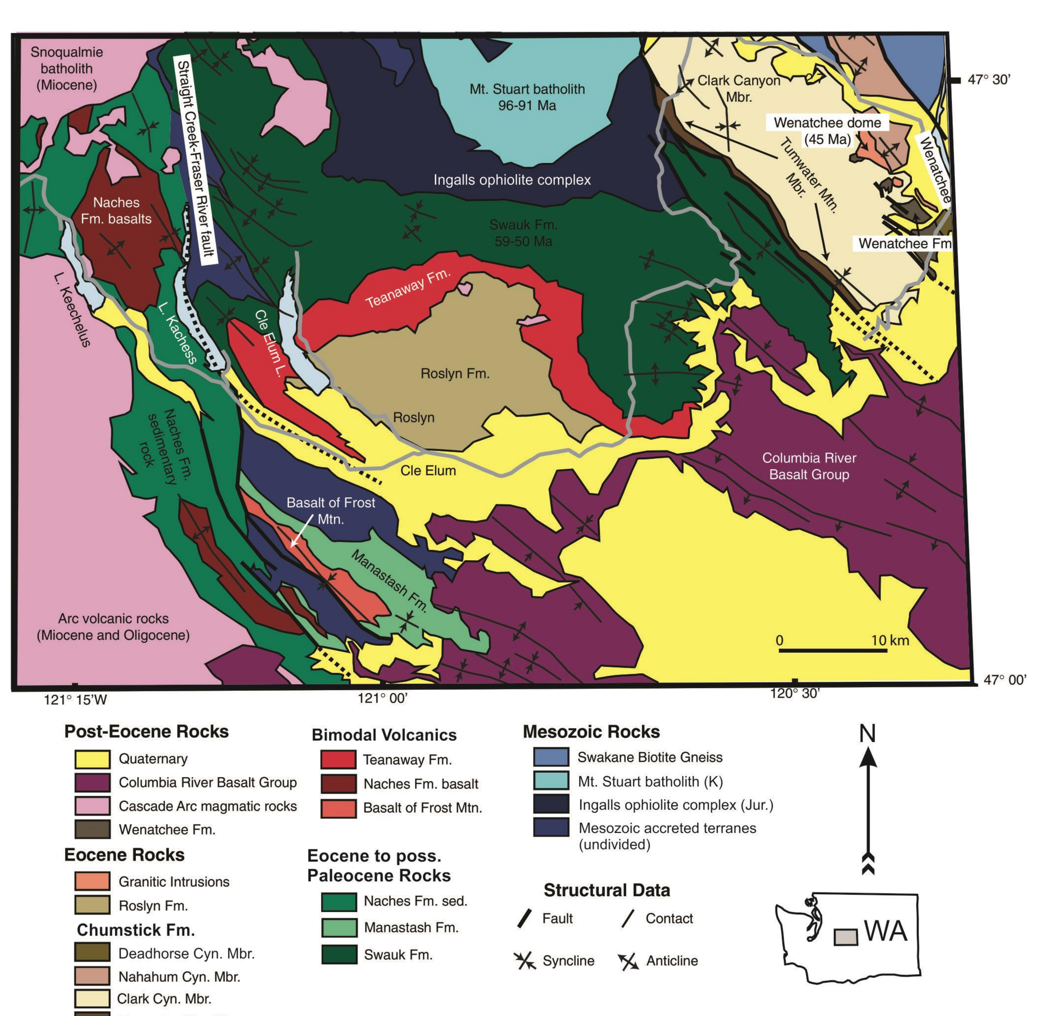

Fig. 1. Geologic map of the Eocene sedimentary and volcanic rocks located in the central Cascades, Washington. The map is modified from Eddy et al., (2017). Note the location of the Teanaway Formation on the map.

INTRODUCTION CONTINUED

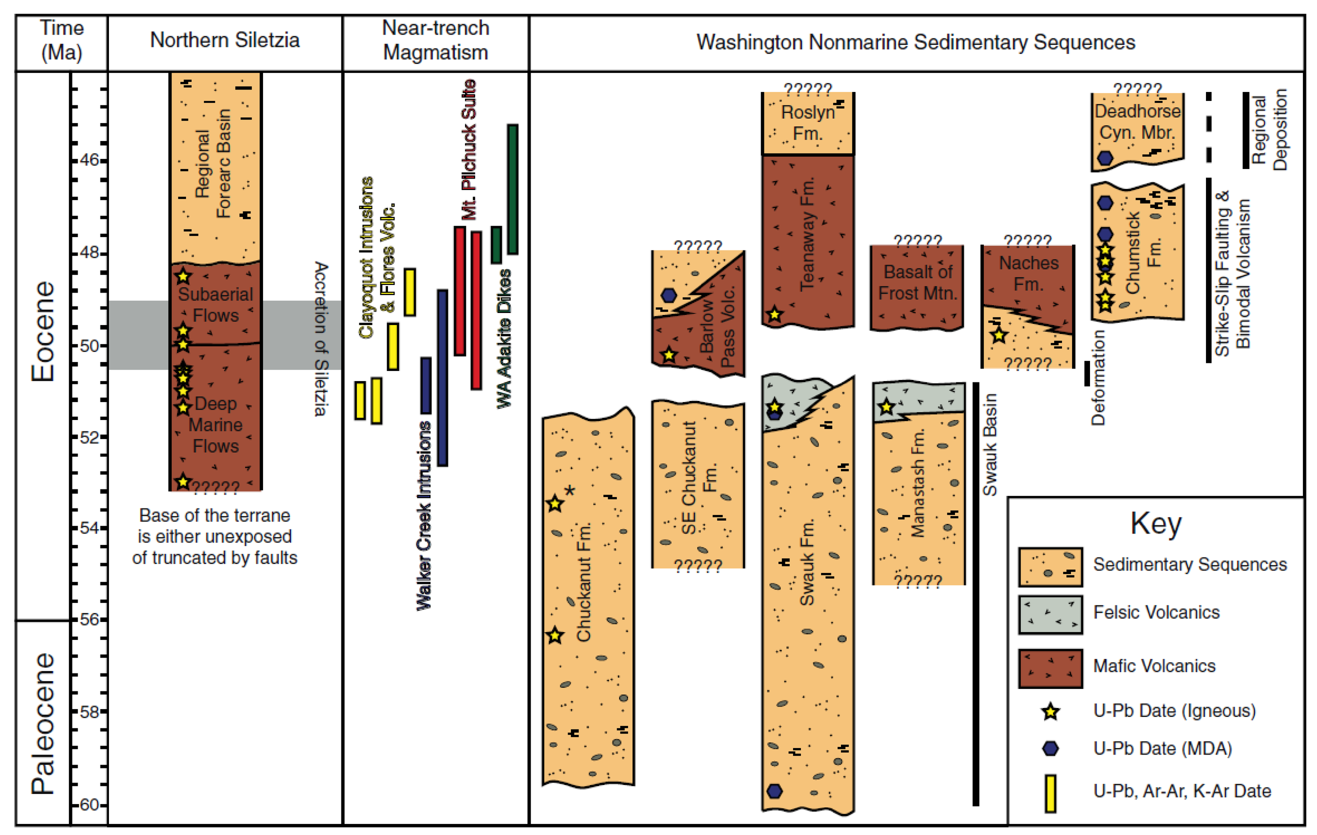

Fig. 2. Temporal evolution of the sedimentary sequences in central Cascades, Washington, compared to available geochronology from northern Siletzia and near-trench magmatism in western Washington and southern Vancouver Island. Adapted from Eddy et al. (2017). Note the stratigraphic position of the Teanaway Formation within Eocene sedimentary rocks.

METHODS

- Eleven (11) Teanaway Formation samples were analyzed for major and trace elements using X-ray fluorescence (XRF) and inductively coupled plasma-mass spectrometry (ICP-MS) at Hamilton Analytical Laboratory in collaboration with Rensselaer Polytechnic Institute.
- XRF were conducted using a Thermo Scientific ARL PERFORM'X spectrometer, operating at an accelerating voltage of 45 kV and a current of 45 mA.
- The system undergoes recalibration every 10 months using approximately 70 certified reference standards. Instrument drift was monitored with five different certified reference standards. Reproducibility of certified reference standards by the XRF at Hamilton Analytical Laboratory has uncertainties <0.3%.
- After XRF analysis, fused glass pellet for the 11 unknowns analyzed for laser ablation ICP-MS using a Varian 820 ICP-MS and Photon Machines Analyte 193 (G1) ablation station. Drift was corrected by analyzing an in-house monitor calibrated with the 18 certified reference standards. Conrey et al. (2023) states this method results in 5 to 10% relative standard deviation for unknown elements; and they state this method results in relative standard deviations which are similar to traditional acid solution ICP-MS procedures (Conrey et al., 2023).
- Hamilton Analytical Laboratory determined LOI for all 11 samples by heating them overnight in silica crucibles at 900°C.

RESULTS

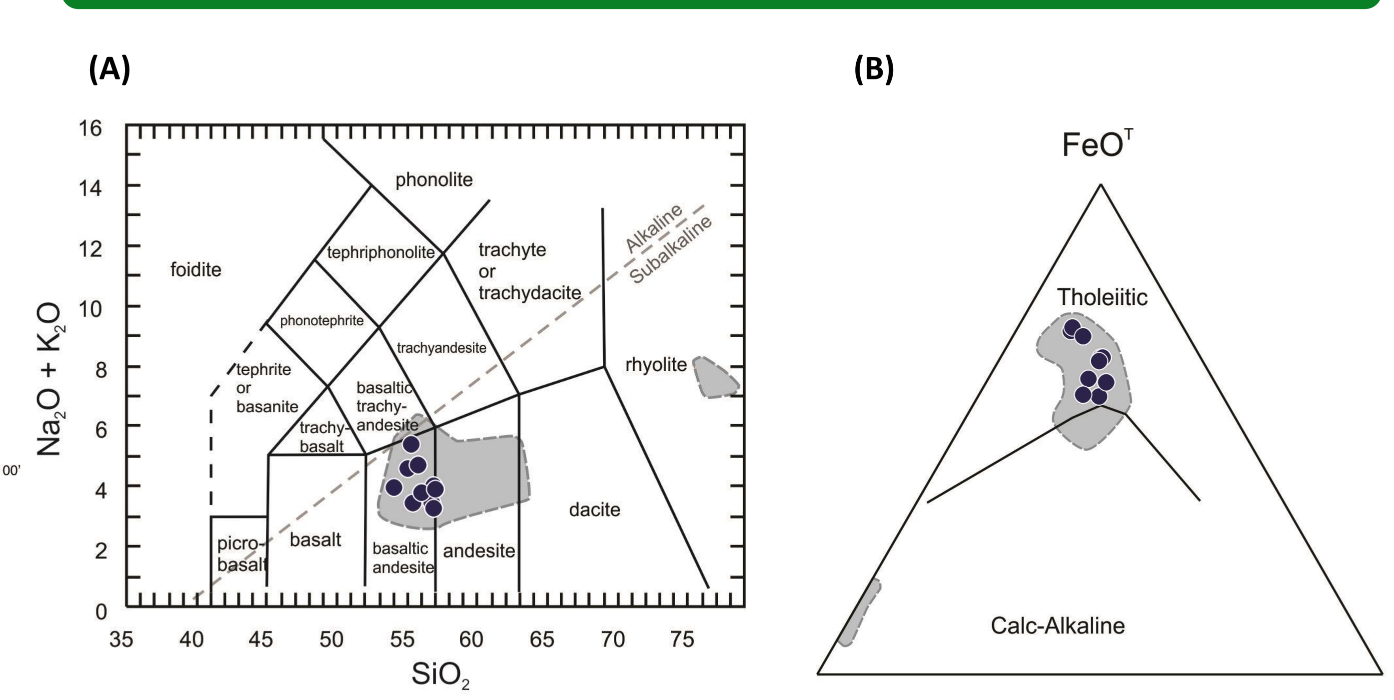

Fig. 3. (A) Teanaway Formation samples plotted on the total alkali vs. silica diagram of La Maître et al. (2002). Field is Teanaway Formation samples from previous studies. **(B)** AFM diagram for Teanaway Formation samples. (A = alkalis; F = iron; M = magnesium). Field is Teanaway Formation samples from previous studies.

RESULTS CONTINUED

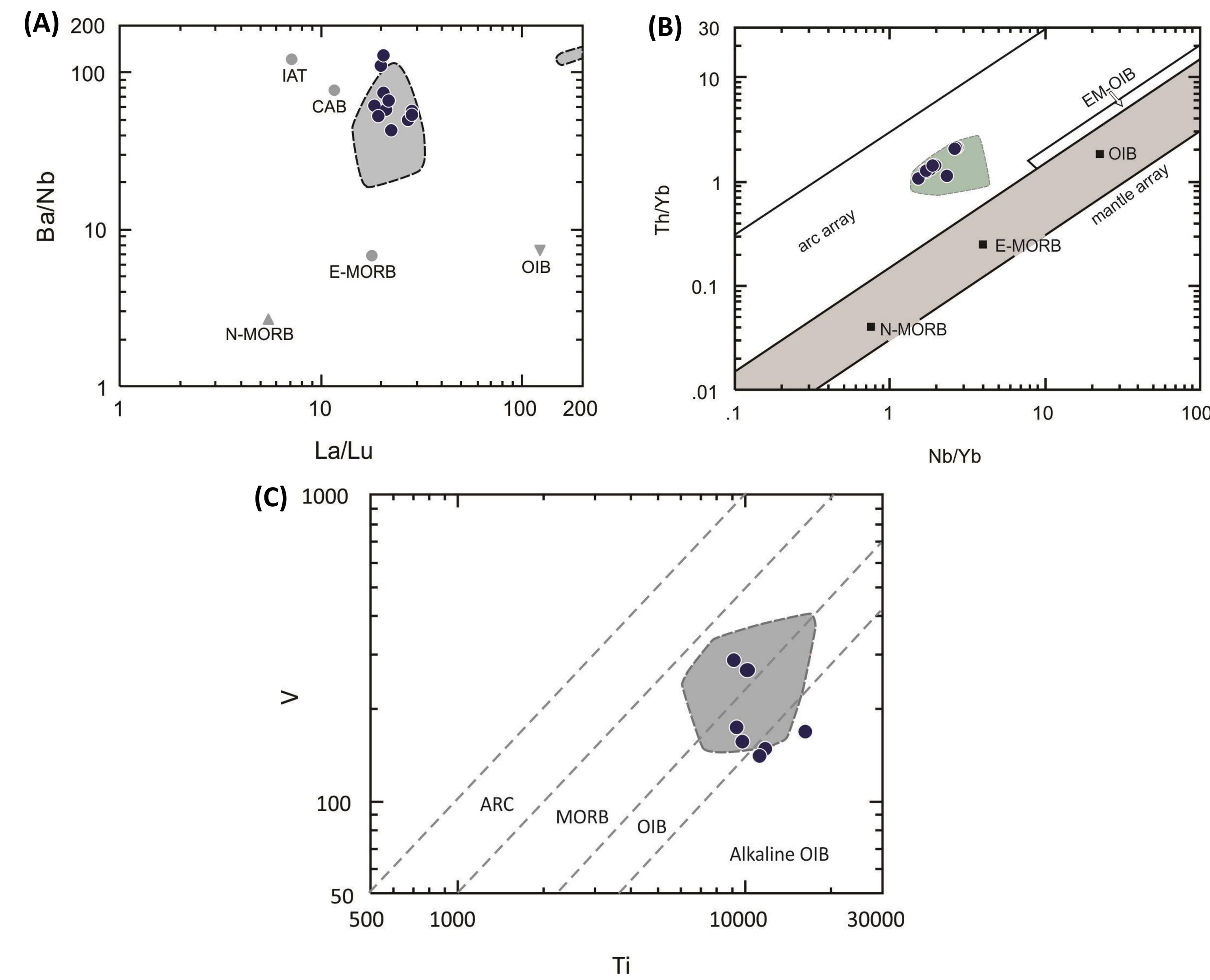

Fig. 4. (A) Teanaway Formation samples plotted on the Ba/Nb vs. La/Lu diagram. Fields are the Teanaway Formation samples from previous studies. CAB = calc-alkaline basalt; E-MORB = enriched mid-ocean ridge basalt; IAT = island arc tholeiite; N-MORB = normal mid-ocean ridge basalt; OIB = ocean island basalt. Values are from McDonough & Sun (1995) and Pearce et al. (1995). **(B)** Teanaway Formation samples plotted on the Th/Yb vs. Nb/Yb diagram of Pearce (1982, 2008). Field is Teanaway Formation samples from previous studies. **(C)** Teanaway Formation samples plotted on tectonic discrimination diagrams of Shervais (2022). Field is the Teanaway Formation samples from previous studies.

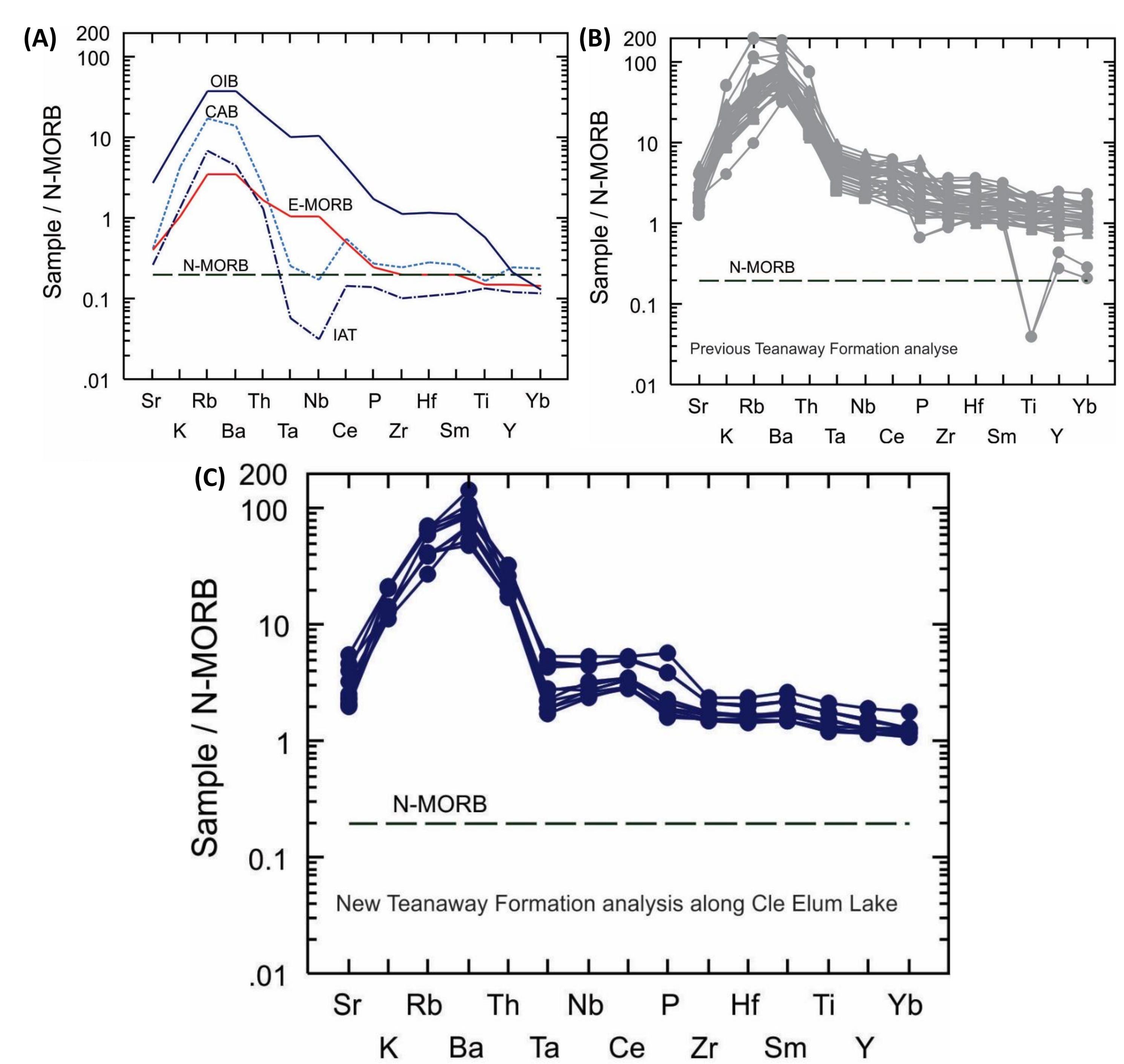

Fig. 5. (A) N-MORB normalization diagrams for modern reference suite. **(B)** Teanaway Formation samples from previous studies. **(C)** New Teanaway Formation samples along the eastern back of Cle Elum Lake. Normalized values are from McDonough & Sun (1995) and Pearce et al. (1995). CAB = calc-alkaline basalt; E-MORB = enriched mid-ocean ridge basalt; IAT = island arc tholeiite; N-MORB = normal mid-ocean ridge basalt; OIB = ocean island basalt.

DISCUSSION/CONCLUSION

- Major elements from the Teanaway Formation indicate a primarily intermediate, subalkaline, tholeiitic, and medium-K compositions (Fig. 3A & 3B).
- Samples are primarily basaltic andesites (Fig. 3A).
- Ba/Nb ratios range between 30 and 120 which plot near the average compositions of Island arc tholeiite (IAT) and calc-alkaline basalt (CAB; Fig. 4A).
- The La/Lu ratios range from 15 to 31 (Fig. 4A).
- The Teanaway Formation plots in the arc array on the Th/Yb – Nb/Yb tectonic discrimination diagram of Pearce, (2008; Fig 4B).
- The samples plot on the mid-ocean ridge basalt (MORB) and ocean island basalt (OIB) field on the V-Ti discrimination diagram of Shervais, (2022; Fig. 4C).
- The samples are enriched in Rb, Ba, and Th while depleted in Ta and Nb (Fig. 5C).
- The Teanaway Formation samples exhibit magmatic enrichment on the ratio diagrams and mid-ocean ridge basalt (MORB) normalized diagrams (Fig 4A, 4B, & 5).
- The major and trace element data – as well as samples plotting in MORB fields on some tectonic discrimination diagrams – suggests magma generation from both decompression melting and subduction (Fig. 3, 4, & 5).
- This supports the generation of the Teanaway Formation as a slab breakoff after the accretion of Siletzia (Fig. 6).

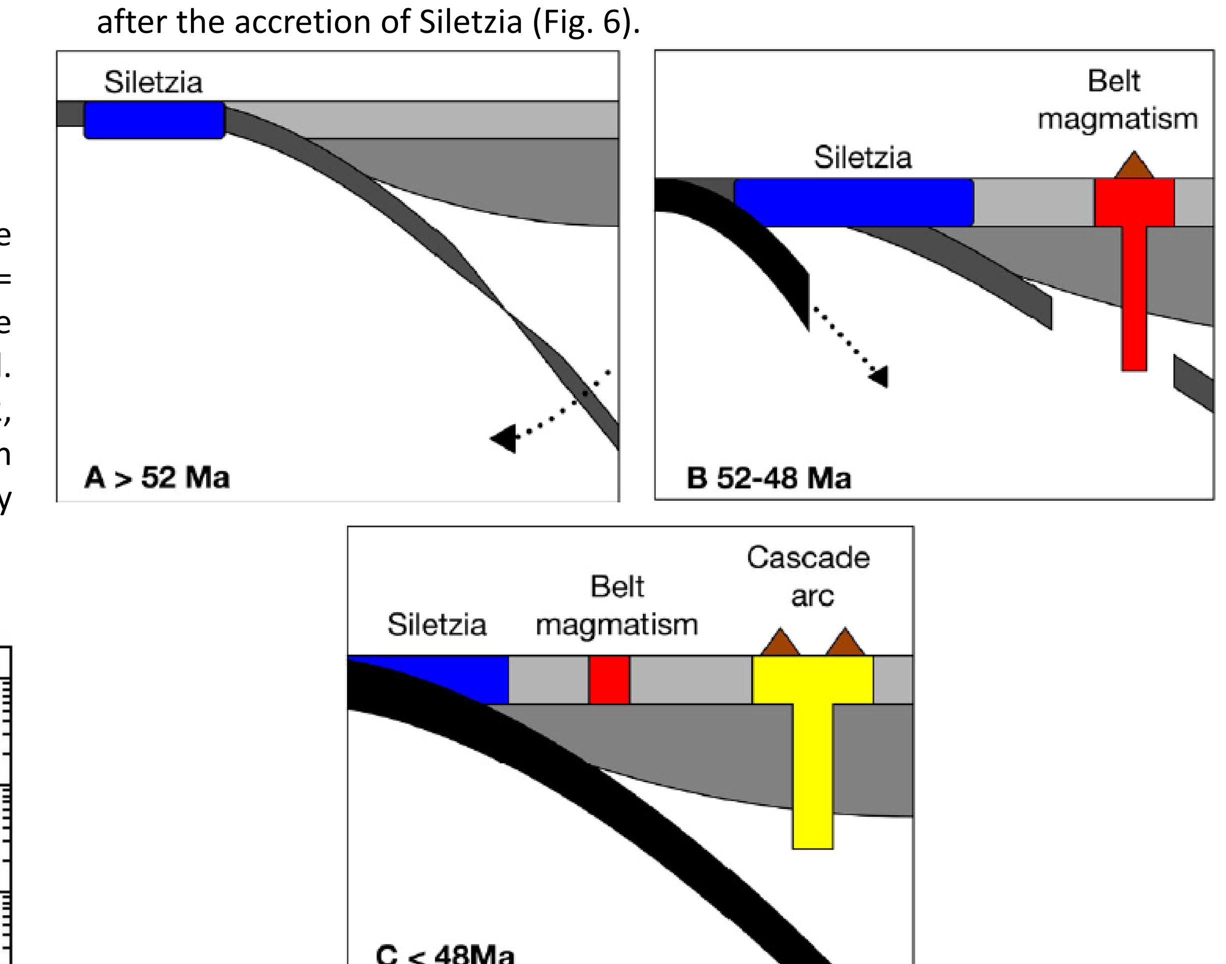

Figure 6. Proposed tectonic setting and origin of the Teanaway Formation modified from Kant et al., (2018).

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