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Petrology of the Earliest Cascade Volcanic Units in Washington: the Northcraft, Tukwila, and Rattlesnake Mountain Formations and Implications for the Evolution of the Cascade Arc

Louisa Cryan
University of Puget Sound

Jeffrey H. Tepper
University of Puget Sound

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Petrology of the Earliest Cascade Volcanic Units in Washington: the Northcraft, Tukwila, and Rattlesnake Mountain Formations and Implications for the Evolution of the Cascade Arc

Louisa Cryan and Jeffrey Tepper

Background

1. Water from slab promotes melting
2. Other fluid mobile elements (Ba, K, H₂O) are added to the mantle (Figure 1)

Question: Does this process gradually enrich the mantle over time?

Geologic Setting

1. Ancestral Cascade magmatism occurred for ~40 million years, until high Cascades magmatism began (Figure 2)
2. Throughout time, Cascades lavas have been predominately basaltic-andesites and andesites, but still range from basalt to dacite
   1. Rhyolitic samples are occasionally found, but aren’t common in the Cascades
3. Compared to other subduction zone arcs, the Cascades has a relatively weak mineralizing system
   1. Sparse hydrous minerals
   2. Low grade mineral deposits
4. Trend of Cascades lavas’ ages throughout the arc, combined with geochemical characteristics suggests slab window influenced early Cascades magmatism, and slab melt contributed to high Cascades lavas

Field Setting of Early Cascade Units

1. Interbedded with predominately deltaic sedimentary units
2. Lack hydrous minerals
3. NF extrusive lavas are commonly aphanitic basaltic-andesites (Figure 3 & 4)
   1. Majority of samples are mineralogically immature
   2. Few have porphyritic textures; occasionally with moderately weathered subhedral medium-grained crystals
4. TF and RM are comprised of tuffs, tuff breccias, and volcanic sandstones

Geochemistry

Early Cascades units:
1. Contain 51.6-70.5% SiO₂ (NF), 56.5-63.0% SiO₂ (TF), 53.2-65.1% SiO₂ (RM) (Figure 5)
2. Are predominately calc-alkaline (Figure 6)
3. Demonstrate typical arc characteristics (Figure 7)
4. Contain significantly lower K₂O than modern Cascades (Figure 8)
5. Generally contain lower MgO, cover smaller range of values compared to modern Cascades
6. Demonstrate lower Ba/Nb ratios than modern Cascades (Figure 9)

Comparison with Modern Cascades

Over time:
1. Frequency of Si-rich lavas increases
2. Crystallization increases
3. Ba/Nb increases
4. Fluids and magma enrichment in LILE increases

Analysis

1. Lack of hydrous minerals + low MgO concentrations
   1. Indicate these lavas’ crystallization at higher pressure than modern lavas
   2. Explain lower LILE values
2. Combined ratio of low LILE and high HFSE indicates less slab melt contribution to early Cascades

Conclusion

1. Slab interaction in Cascades lavas increased over time
2. Early Cascades volcanism occurred at high pressure beneath subducting slab
   1. When the slab tore off, pressure lessened and allowed for decompression melting
   2. Melt combined with fluids being pulled into the subduction zone
   3. Cascades see greater mineralogical maturity and compositional diversity over time

Future Work

1. Separation of samples for U-Pb age analysis via zircon crystals will solidify a date of early Cascades volcanism
2. Literature review will allow for greater contextualization of collected NF, TF, and RM data
3. Organize comprehensive Cascades data by age; analyze for representations of this trend of lava enrichment over time

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