Temporal and spatial variations in Cascade Arc magmatism: The 35 Ma plutonic record

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Granitoid intrusions in the Cascades preserve a record of variations in the chemistry, production rate, and geographic distribution of magmatism over the 35 Ma history of the arc. At least three factors appear to have contributed to these variations: (1) progressive thickening of the arc crust, (2) along-strike variations in mantle composition and/or the flux of a slab component (SC), and (3) changes in subduction parameters including subduction rate and slab geometry.

Thickening of the Arc Crust

With decreasing age Cascade plutonic and volcanic rocks display lower CaO/Na_2O, a trend that is consistent with thickening of the arc crust (Plank & Langmuir, 1988). To quantify this crustal growth we regressed $CaO/Na_2O_{6.0}$ vs crustal thickness in the Plank & Langmuir dataset and used the results to calculate crustal thicknesses for 11 Cascade batholiths and volcanic centers. The results indicate an increase in crustal thickness from 35±3 km (at 35-25 Ma) to 43±1 km (<3 Ma). We are working to better constrain the timing of thickening, but a significant portion may have occurred between 20-12 Ma, a magmatic hiatus at the surface.

Along-Arc Chemical Variation

Cascade granitoids north of ~48° in Washington display a more-pronounced arc signature (e.g., higher Ba, Sr, Ba/Nb, lower Nb) than intrusions to the south. These differences probably reflect variations in the composition of the mafic (underplated) lower crustal source regions and imply the existence of along-strike variations in SC contribution. Persistence of this “greater SC to the north” pattern for >20 Ma suggests it may reflect subduction geometry (linked to the bend in the arc?) rather than slab composition or age.

Temporal Trends in Granitoid Chemistry

Over the interval 32 to 3 Ma plutons in the Chilliwack batholith show decreasing Ba/Nb and increasing Nb. These trends suggest decreasing SC involvement (and consequent decline in degree of melting) through time, and may reflect the ~5-fold slowing of subduction (Verplanck & Duncan, 1987). One implication of this trend is that earlier Cascade magmatism was not as “hot and dry” as more recent activity.

References

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Location of the Miocene-Pleistocene Cascade arc volcanic front in the Portland Basin

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A discontinuity exists in the Cascade arc volcanic front near the latitude of Portland, Oregon. A westward salient in the volcanic front is defined by Pliocene-Quaternary mafic lavas distributed continuously from the vicinity of Mt. Hood westward into the Portland Basin, and thence discontinuously northeastward to Mt. St. Helens. These lavas, which include both within-plate and arc-like compositions, are called the Boring Lava in the Portland area. The salient is evident also in the distribution of Miocene andesites, which extend west of Mt. Hood toward the Portland Basin but are more areally restricted southward, similar to the Quaternary arc. Limited seismic data suggest the subducting Juan de Fuca plate strikes NNE beneath Mt. St Helens, whereas the plate strikes N-S beneath Mt. Hood, a geometry which requires bending or breaking of the plate at the latitude of the Columbia River.

We have found Miocene (ca. 13-14 Ma) mafic lavas, mapped as Boring Lava by earlier workers, in three locations on the southern and western edges of the Basin. All of the Miocene lavas are arc-like in composition in contrast to the geochemically diverse Boring Lava.

We suggest the Miocene lavas demonstrate the longevity of a salient in the arc front in the Portland area. Plate reconstructions by Doug Wilson show that the most prominent discontinuity in the downgoing plate is a band of pseudo-faults currently subducting northeastward beneath Portland. Fracturing of the plate during repeated southward rift propagation along the Juan de Fuca Ridge generated the band of pseudo-faults. They may represent a fundamental weakness which accommodates the change in strike of the slab at the latitude of the Columbia River. Wilson's plate model suggests the location of the subducting pseudo-fault band hasn't changed since the mid-Miocene, in agreement with our interpretation.

References

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