Cascade volcanic arc of southern Washington: The early years

RUSSELL C. EVARTS

U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025, USA (revarts@usgs.gov)

Three geochemically distinct suites of subaerially erupted basalts were produced in close proximity during the first 2 m.y. of Cascade arc volcanism in southwestern Washington:

Kalama River Basalt (KRB)

Ol±pl-phyric low-K tholeiite formed a large shield volcano about 39 Ma; unexposed source vents probably lie buried south of Mount St. Helens. These flows overlie mafic to silicic volcanic and volcaniclastic rocks representing the earliest activity of the Cascade arc. KRB basalts are products of extensive (Mg#=71-43) shallow-level differentiation of primitive basalt (MgO=11 wt %, K_2O=0.10 wt %, Ni = 230 ppm, Cr = 400 ppm). Incompatible-element ratios (Ba/La<9, Ba/Nb<10, La/Ta=14, Zr/Y>4.4, $(La/Yb)_n$=2.2-2.7, Ba/Zr<1, Zr/Nb=11-13) indicate genesis of parental magmas by melting of EMORB-source asthenospheric(?) mantle with no subduction-zone input.

Wolf Point Basalt (WPB)

Ol±cpx-phyric basalt and basaltic andesites (Mg#=74-54) erupted from scattered vents in the arc about 39-38 Ma, shortly after cessation of KRB volcanism. Primitive basalts (MgO=9.5-11.0%) vary widely in K_2O (0.3-2.6%) and incompatible-element ratios (Ba/La=4-13, Ba/Nb=8-44, La/Ta=32-101, Zr/Y=4-14, $(La/Yb)_n$=3.9-18.2, Ba/Zr=0.6-2.8, Zr/Nb=7-26), probably reflecting varying contributions from slab fluids; quartz xenocrysts in some basaltic andesites record crustal contamination of mantle-derived basalts.

Grays River Volcanics

Cpx±ol-phyric high-TiO_2 (2.2-3.9%) basalts erupted from fissure vents in the adjacent forearc. They overlap in age with the other two nearby suites (40-37 Ma). They are more evolved than KRB and WPB lavas (Mg#=57-35) and carry a strong OIB-type chemical signature (Ba/Nb=4-6, Zr/Y=6-8, Ba/Zr<1.1, Zr/Nb=4-6).

The close spatial and temporal juxtaposition of diverse late middle Eocene mafic lavas – and the implied juxtaposition of oceanic and arc-type mantle sources - indicates an exceptionally complex tectonic environment for the infant Cascade arc of SW Washington. This complexity may reflect a combination of subduction of a segment of the Kula-Farallon ridge, overriding of a hotspot, breakup of the subducting slab, and intra-arc rifting.

Geochemical profiling, Nomarski imaging, and crystal size distribution analysis of mixed magmas from Lassen Peak, CA

M.J. SALISBURY[1], W.A. BOHRSON[1] AND M.A. CLYNNE[2]

[1]Dept. of Geological Sciences. CWU, Ellensburg, WA 98926 (morgan@geology.cwu.edu; bohrson@geology.cwu.edu)
[2]USGS, 345 Middlefield Rd., Menlo Park, CA 94025 (mclynne@usgs.gov)

Plagioclase crystals from a suite of mixed rocks from the 1915 Lassen Peak eruption were analyzed using a combination of imaging and geochemical techniques. Measurements of plagioclase from four rock types (dark andesite, quenched andesitic inclusions, black dacite, light dacite), produced by variable mixing between intruding basaltic andesite and reservoir dacite reveal insight into magma mixing and eruption dynamics. Crystal size distribution (CSD) analysis of the four rock types reveals three plagioclase populations: phenocrysts (0.5–3.0mm), microphenocrysts (0.1–0.5mm), and microlites (<0.1mm). CSD slopes identify distinct nucleation and growth environments for each population. Independent of rock type, plagioclase phenocrysts appear to have crystallized under near equilibrium conditions characterized by relatively slow growth and nucleation rates as indicated by gentle CSD slopes. Only unreacted phenocrysts (i.e., those relatively unaffected by the temperature increase from mixing) were used for size and chemical analysis in order to assess pre-mixing conditions. CSD slopes of the microphenocryst and microlites are steeper, respectively, indicating non-equilibrium nucleation and growth. Major element analysis confirmed plagioclase populations to be independent of host whole-rock composition: phenocrysts An_{29-40}; microphenocrysts An_{59-82}; microlites An_{40-67}. Nomarski imaging was correlated with major element traverses, elucidating the growth characteristics of plagioclase populations. Near-homogenous compositions and relatively simple growth textures suggest that the pre-mixing reservoir was relatively thermally and chemically isolated prior to the 1915 event. Following mafic recharge and initial mixing, temperatures in the hybrid magma caused nucleation of the An-rich microphenocryst population; steeper CSDs and acicular morphology indicate rapid nucleation and growth at undercooled conditions. Microlites show correlations with whole-rock composition and were likely nucleated in the mixed magmas shortly before eruption.