Integrating temporal and spatial patterns of Quaternary Cascades eruptions with geochemistry, tomography and heat flow

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Volcanism in the Cascades arc, USA, is episodic in both space and time. The modulation of time-varying mantle melt influx by crustal magmatic plumbing drives much of this unsteadiness. However the relative contributions of source time-variation versus crustal control are poorly constrained. Here we synthesize a number of datasets relevant to Holocene and Quaternary Cascades magmatism, to identify patterns in preserved eruptions and validate models for crustal magma transport.

Our database contains >2200 published Quaternary Cascades volcanic vent locations, vent types, ages, and major element geochemistry of erupted lavas. Major element geochemistry is obtained from USGS professional papers and the American Volcanic and Intrusive Rock Database (NAVDAT). We also include arc-wide heat flow data, modeled seismic tomography and crust thickness beneath vents. Eruption ages are less well constrained than other parameters, and we focus on variation between major geologic Epochs and their subdivisions.

We perform Spectral Clustering on vent locations to define volcanic centers for each Epoch and for the entire Quaternary. Centers found through Spectral Clustering reproduce the major loci of volcanism in the cascades, and identify time-varying structure in the number and distribution of monogenetic eruptions. Concentric zonation of SiO2 content within many clusters reflects a bimodal distribution of eruptions, between compositionally evolved central vent eruptions and mafic regional monogenetic vents. There is significant North-South structure in vent type and distribution that correlates with variations in heat flow and average crustal shear velocity.

Although precise eruption ages for the complete dataset are not currently available, certain volcanic centers are quite well constrained and allow further analysis. The time history of eruptions <400 ka at Mazama, OR, shows that the spatial distribution of eruptions does not follow a Poisson distribution when well-resolved in time, but rather clusters around an evolved center. Monogenetic eruptions preceding the 7.8 ka Crater Lake eruption define a spatial and temporal pattern that is consistent with stress focusing of rising dikes by a growing and pressurizing magma chamber over 20-25 kyr.

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