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Geophysical and Geochemical Constraints on Magma Storage Depths along the Cascade Arc: Knowns and Unknowns

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The stratovolcanoes of the Cascade arc stretch from Lassen Volcanic Center in northern California, through Oregon and Washington, to the Garibaldi Volcanic Belt in British Columbia. Studies in recent years have reviewed differences in the distribution and eruptive volumes of vents, geochemical compositions and heat flux along strike (amongst other characteristics), including identification of a factor of two variation in the flux of mantle-derived basalt along the arc. We wish to identify whether these along-arc changes in magma flux are manifested as changes in crustal storage conditions along the arc (a mantle control), or whether magma storage is controlled by crustal processes (e.g. extension state, lithological or rheological boundaries). We compile available geophysical constraints on magma storage depths (InSAR, seismics, magnotellurics) for each major edifice, and compare these to pressures calculated using mineral-only barometers applied to compilations of clinopyroxene and amphibole compositions, and melt inclusion saturation pressures where available. This compilation highlights the variable amount of data available for different edifices, with abundant geochemical and geophysical data available for some systems (e.g. Lassen Volcanic Center and Mount St. Helens), but very limited data available for others (e.g., Glacier Peak and the volcanoes of the Garibaldi Volcanic belt, Mount Jefferson, The Three Sisters).

The available data suggests magma storage depths are remarkably constant along the arc, with seismic, geodetic and petrological estimates lying within the upper 200 ± 100 MPa of the crust. This compilation is consistent with previous work suggesting widespread shallow magma storage within the upper crust in many arcs. We also see no clear offset in magma storage between arc segments that are in extension, transpression, or compression, although uncertainties in depth estimates limit our ability to make finer scale evaluations of storage pressures. We hypothesize that deeper magma storage may be recorded by cinder cones on the periphery of the large edifices throughout the Cascades. Testing this hypothesis requires detailed evaluation of the contribution of the vapour bubble to the total CO_2 budget of olivine-hosted melt inclusions, as the majority of published studies measured only the glass phase (so may be underestimating saturation pressure).