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# After temperature, $H_2O$ modulates mantle wedge melting in the Central Southern Volcanic Zone of the Andean arc (Chile)

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The $H_2O$ content of mafic arc magmas varies despite a common average value of 4 wt.%. This is observed in the Central Southern Volcanic Zone (Chile), where amphibole occurs sporadically (e.g. Mocho Choshuenco, Calbuco). We address this question at a local scale by comparing mafic melt compositions at Mocho Choshuenco (amphibole-bearing, 39.93°S) and Villarrica (amphibole-free, 39.42°S) using olivine-hosted melt inclusions (major, trace and volatile data) and whole-rock geochemical data. As both volcanoes are only 57 km apart along the arc front, several first-order parameters are broadly constant, including crustal thickness, subducted sediment composition, slab convergence rate and slab dip. This implies similar mantle and slab thermal structures beneath them, allowing the role of $H_2O$ to be isolated.

Amphibole stability depends not only on melt $H_2O$ contents, but also on other melt compositional parameters and pressure. Major element compositions of both volcanoes strongly overlap, particularly $Na_2O$ and $SiO_2$, key controls on amphibole stability. Moreover, geobarometric data indicate overlapping pressure range for the magma reservoirs (2-4 kbar), likely controlled by the Intracrustal Discontinuity, leaving $H_2O$ as the most plausible explanation for contrasting amphibole stability.

Indeed, melt inclusion compositions and multiple petrological hygrometers indicate that Mocho Choshuenco magmas contain more $H_2O$ than at Villarrica. Extending the comparison ~190 km southwards yields the same pattern: Calbuco (amphibole-bearing) displays higher $H_2O$ contents similar to Mocho Choshuenco, whereas Osorno (amphibole-free andesites) resembles Villarrica with lower values, consistent with their respective phase equilibria.

As olivine crystallizes early and its melt inclusions are mostly closed during ascent, we interpret this variability as primary and inherited from mantle-derived melts. Therefore, the measured $H_2O$ represents minimum values if the parental magmas reached volatile saturation. $Nd_6$ overlaps in these four volcanoes, indicating a similar extent of mantle partial melting (F). Consequently, variable $H_2O$ for similar F likely reflects modest source temperature variations within the mantle wedge, whose thermal structure is primarily controlled by lithospheric thickness.

Together, these results demonstrate that small thermal differences in the mantle wedge can generate significant variability in primary melt $H_2O$, thereby modulating amphibole stability and magmatic evolution at the local scale.