Geochemical, Geophysical and Morphological Results from the Chilean Southern Volcanic Zone: The Role of Fluids in Generating the Highest Magmatic Output

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In the Collaborative Research Center (SFB574), which studies the role of volatiles and fluids in subduction zones, we have compiled a comprehensive geochemical data set from the Chilean Southern Volcanic Zone. Here we focus on the middle volcanic front (MVF from 34.5-38°S) and the southern volcanic front (SVF from 38-43°S). We also have data from the behind the VF (BVF) volcanism in Argentina. This data set is augmented by calculations of volcano volume, a seismic profile from the forearc through the VF between 39-40°S and geophysical studies offshore the SVF. On the Sr vs Nd isotope diagram, the MVF almost completely overlaps the BVF samples. On Pb isotope diagrams, the MVF falls on the radiogenic end of the positive backarc array. On $^{206}Pb/^{204}Pb$ vs Sr and Nd isotope diagrams, the unradiogenic end of the BVF array has an EMORB type composition, suggesting an EMORB type of mantle wedge composition. The VF lavas can be explained largely by two component mixing of trench sediments (+/- subducting slab) and an EMORB type of mantle wedge. Combined with higher erupted volumes over shorter time scales for the SVF compared to the MVF (Völker et al., 2011, JVGR), the higher fluid mobile to fluid immobile (e.g. U/Th, Pb/Ce and Ba/Nb) ratios point to a higher fluid flux, whereas the lower more to less immobile incompatible (e.g. La/Yb, La/Sm, Th/Yb, Ta/Yb) element ratios are consistent with higher degrees of melting. On the Sr vs Nd and $^{206}Pb/^{204}Pb$ vs Sr and Nd isotope ratio diagrams, the SVF is shifted to higher Sr and Nd isotope ratios. We interpret these variations to indicate derivation of the fluids from seawater altered oceanic crust and/or mantle and sediments. The Pb isotopic composition of the SVF is identical to the MVF and is clearly dominated by the composition of the trench sediments. Delta ^{18}O of olivine correlates inversely with U/Th and Nd isotope ratios, extending to lower and higher d18O than found in olivines in mantle peridotites. The low $d^{18}O$ and high U/Th and Nd isotope component present in the SVF (in Llaima and Villarrica) is interpreted to reflect fluids derived from hydrothermally altered oceanic crust and serpentinized upper mantle of the incoming plate, whereas the high $d^{18}O$ endmember primarily in the MVF points to fluids derived from subducted sediments. Beneath the VF between 39-40°S, where Villarrica, one of South America's most active volcanoes, is located, a low-velocity seismic anomaly, together with high Vp/Vs ratios, is interpreted to reflect greater fluid ascent above the subducting Valdivia Fracture Zone. The combined morphologic (volume), geochemical and geophysical data suggest an enhanced fluid presence beneath much of the SVF (Llaima, Villarrica and Puyehue Volcanoes), probably caused by a stronger hydration of the incoming plate around and between the Valdivia and Chiloe Fracture Zones.