The ~400 ky geochemical and tectonic history of North Sister, a seemingly monotonous mafic volcano in the Central OR Cascade Arc

MARIEK E. SCHMIDT[1] AND ANITA L. GRUNDER[2]

[1]Dept. of Mineral Sciences, Smithsonian Institution, MRC-0119 PO Box 37012, Washington, D.C. 20013-7012 (schmidtm@si.edu)

[2]Dept. of Geosciences, Oregon State University, 104 Wilkinson Hall, Corvallis, OR 97331 (grundera@geo.oregonstate.edu)

Quaternary volcanism in the central Oregon Cascades Arc, is strongly influenced by intra-arc extension and has mainly produced short-lived mafic shield volcanoes and scoria cones. In contrast to these and lying on the arc axis, is the long-lived and mafic composite North Sister Volcano, the oldest and most mafic of the Three Sisters volcanic complex. Over the last ~400 ka, North Sister has erupted a nearly constant basaltic andesite magma (52.5-55 wt% SiO_2) that has low concentrations of K_2O and other incompatible elements. We divide its eruptive history into four central vent stages and a later fissure stage based on changes in eruptive style, unconformities, $^{40}Ar/^{39}Ar$ dating: 1) the Lower Shield (501±117 to 311±106 ka), 2) the Glacial Stage (182±29 to 99±38 ka), 3) the Upper Shield (~80 ka), and 4) the Stratocone (70±40 to 55±37 ka). The through-going >11 km long Matthieu Lakes Fissure (MLF; 76±31 to 11±10 ka) erupted more diverse, yet genetically related magmas (53-59% SiO_2).

Clusters in the compositional data for North Sister correspond with eruptive stages and define compositional groups. Variations in highly compatible elements within compositional groups (e.g. 40 ppm Ni variation within one group) reflect upper crustal recharge and fractional crystallization of olivine and plagioclase. Changes with time at North Sister however, reflect deeper processes; compatible elements such as MgO (5.9 to 4.0%) decrease, and Al_2O_3 and TiO_2 increase, while incompatible elements remain the same or generally decrease (e.g. Ba 302 to 247 ppm). Isotopic variations at North Sister are small, but systematically progress toward more mantle-like isotopic ratios, where $^{87}Sr/^{86}Sr$ decreases (0.70356 to 0.70369), $^{144}Nd/^{143}Nd$ increases (0.51285 to 0.51292). Upper crustal processing cannot account for these variations. Energy-constrained petrologic models to replicate these temporal trends suggest abundant recharge by primitive low K tholeiite with pyroxene-dominant fractional crystallization and little crustal assimilation. This implies that the lower crust is refractory while abundant recharge maintains the constant mafic character of North Sister Volcano.

Primary melts from slab metasomatized mantle – The interplay of metasomatic agent and mantle fertility

M.W. SCHMIDT

ETH Zürich, Switzerland (max.schmidt@erdw.ethz.ch)

Primary melts in subduction zones are thought to be dominantly high Mg-basalts giving rise to the classical basalt-andesite-dacite-rhyolite suites. Nevertheless, large variability of subduction related melts outside this "mainstream" sequence exists, and, although volumetrically minor, these yield key information on the subarc mantle and transfer agent(s) from the slab to the mantle. In principal, two major factors can be identified: the variation of mantle fertility and the composition and volatile content of the transfer agent.

Ultrapotassic magma suites constitute examples where sediment slab melts of various compositions and volatile contents interact with mantle of different fertility. For these, the Intra-Apennine and Roman provinces constitute worldwide endmembers in terms of K_2O/Na_2O, K_2O content and CO_2 degassing, and are associated with carbonatites. Group II kimberlites and many lamproites are geochemically similar, but occur on cratons stable since several 100 Ma.

Melts from fluid-absent melting of carbonaceous to hydrous pelites at >3 GPa are ultrapotassic phonolites and granites (64-76 wt% SiO_2) and have K_2O/Na_2O of 9-2 because of residual cpx with jadeite$_{80}$. The effect of CO_2 is to stabilize residual jadeite, to lower SiO_2, and to increase K/Na. These melts were equilibrated with fertile, with refractory but cpx bearing mantle, and with wherlite. At 3.5 GPa and X_{CO2}>0.5, hybridization of the carbonated pelite melts with refractory mantle produces highly subsilicic kama-fugites, conserving K/Na ratios, and with X_{Mg}>0.7 as characteristic of primitive melts. The essential role of CO_2 is to reduce the olivine saturation volume and to shift the olivine-cpx-opx cotectic to lower SiO_2. Most of the large variation of the Italian ultrapotassic melts and of group II kimberlites and many lamproites is covered by the range of hybrid melts obtained at 1280-1380 °C, which have 38-55 wt% SiO_2, 12-27 wt% MgO, and CaO/Al_2O_3 = 0.9-1.4. This suggests that it is futile to search one primary magma for the Italian suite, but that most eruptive centers are fed by their own local source of variable but distinct composition.

The tectonic situation of central Italy, where plate convergence almost ceased and the slab is tearing off, is well distinct from stable cratons below ancient orogens, but in both cases, slab sediments were introduced into the mantle and once temperatures become high enough, fluid-absent slab sediment melts interact with the mantle of variable composition.