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

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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% SiO₂) that has low concentrations of K₂O 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, ⁴⁰Ar/³⁹Ar 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 Stratovolcano (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% SiO₂).

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 crystallization of olivine and plagioclase. Changes with time at North Sister however, reflect deeper processes; compatible crystallization of olivine and plagioclase.

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

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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 K₂O/Na₂O, K₂O content and CO₂ 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 carbonateous to hydrous pelites at ≥3 GPa are ultrapotassic phonolites and granites (64-76 wt% SiO₂) and have K₂O/Na₂O of 9-2 because of residual cpx with jadeite. The effect of CO₂ is to stabilize residual jadeite, to lower SiO₂, 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 XCO₂>0.5, hybridization of the carbonated pelite melts with refractory mantle produces highly subsilicic kama-fugites, conserving K/Na ratios, and with XCO₂<0.7 as characteristic of primitive melts. The essential role of CO₂ is to reduce the olivine saturation volume and to shift the olivine-cpx-opx cotectic to lower SiO₂. 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% SiO₂, 12-27 wt% MgO, and CaO/Al₂O₃ = 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.