

Supplement I – Isotope data

As discussed in the text, local basement rocks are not dramatically different from Shasta area lavas in terms of Sr-Nd-Pb isotopic compositions. Appendix Figure A1 illustrates this point using present-day (no age correction) data from the Trinity ophiolite (ultramafic and cross-cutting gabbroic rocks; Jacobsen et al., 1984; Gruau et al., 1991, 1995; 1998; Lécuyer et al., 1990; this study), and plutonic (mostly granitoid) rocks of the Klamath Mtns. (S. Oregon and N. California; Allen and Barnes, 2006; Barnes, personal communication, 2017). As Pb isotopic data have not been reported for the Trinity Ophiolite, new Pb and Sr isotopic data were obtained from the Catherine Lake gabbroic complex and intruded peridotite (cf. Appendix Table A7).

Notable features of the data include the following: [1] although there are significant ranges in Sr and Nd isotopic compositions of Trinity and Klamath rocks, most samples with elevated Sr and Nd contents approach or overlap Shasta lavas (Bacon et al., 1997; Grove et al., 2002, 2005; this study) with regard to Sr and Nd isotopic compositions. Shasta dacites (excluding the earliest Sargent's Ridge sequence) have the lowest $^{87}\text{Sr}/^{86}\text{Sr}$ ratios and highest Sr contents. Sr isotopic similarity of the HMA lavas to these latter dacites supports the involvement of such a dacite mixing component in their formation. [2] Involvement of more radiogenic basement rocks cannot be ruled out, but because of their generally low Sr contents, such rocks would have small leverage on the proposed HMA mixture. [3] Likewise, the wide range in Nd isotopic composition for ultramafic rocks of the Trinity ophiolite will have negligible impact on composition of the proposed HMA mixture owing to the very low Nd contents of such rocks and their proportionally small contribution. [4] Available Pb isotopic data for Trinity rocks essentially overlap with the least radiogenic Shasta lavas (mostly dacites), but in any case would also have imperceptible impact on composition of the HMA mixture owing to their low Pb contents. Bulk rock Pb isotopic data are not available for felsic crustal rocks of the Klamath terranes.

Supplement II – HMA melt inclusions

Here we provide further comments regarding the data of Ruscitto et al. (2011) for melt inclusions (MIs) in HMA olivines. These fall into two categories depending on the composition of the host olivines, that cluster near Fo₉₃ and Fo₈₇. As discussed in the main text, the former are considered to be xenocrysts. The latter are essentially in equilibrium with the HMA-type liquid, and the compositions of HMA-type MIs in such olivines are similar to that of the groundmass in our sample MS-16-04.

Corrections for post-entrapment crystallization (PEC) of HMA MIs were accomplished by incremental addition of calculated equilibrium olivine until this matched the composition of the host olivines. Details of this correction depend on the redox state of the liquids or, specifically, the molar Fe³⁺/(total Fe) ratio (i.e., denoted as 'X-fe³'). Ruscitto et al. (2011) assume a value of X-fe³ = 0.3 (equivalent to redox conditions near the Ni-NiO + 1.5 redox buffer. We find some of the HMA MIs to be saturated in the host olivine composition at X-fe³ values below 0.2 (i.e., not as oxidized as they assumed). Accordingly, we performed similar calculations with variable X-fe³ values between 0.05 and 0.15. Figure A2 illustrates the uncorrected MI compositions and the resulting corrected compositions for two values of X-fe³. We note that choice of X-fe³ in this range does not have a dramatic effect on the calculated MI composition and, for the HMA-type MIs, our results are similar to those of Ruscitto et al. (2011).

MIs in the Fo₉₃ olivines differ significantly in composition from the HMA-type MIs. In general, they are more mafic liquids with lower SiO₂ and K₂O and higher MgO and CaO than the HMA-type MIs, leading Ruscitto et al. (2011) to describe them as 'primitive basaltic andesite' or PBA-type MIs. In detail they display striking variations in concentrations of trace elements (e.g., Cr: 154 to 4170 ppm; B: 1.4 to 20.4 ppm; and >100% variation for many other elements). We would describe them as including high-Ca basaltic to basaltic andesite bulk compositions, but for consistency retain the PBA acronym for these MIs. In our view, they cannot represent a common magma type for this region of the Cascades given their heterogeneity and the absence of any known eruptive equivalents. For PEC corrections of these MIs, Ruscitto et al. (2011) attempted to compensate for diffusional processes in the host olivines, assuming that the original

content of ΣFe as FeO^* was constant at 7.02 wt.% (compared to analyzed FeO^* contents near 4%). This required large (~20%) additions of equilibrium olivine and resulted in 'corrected' compositions having nearly double the actual analyzed MgO contents. For our purposes, we repeated the PEC corrections as described above. Figure A3 illustrates for selected major elements the average PBA composition computed for a range of X-fe3 values, as well as the individual MI compositions for X-fe3 = 0.15; these are compared with [a] the average of PEC-corrected PBA-type MIs presented by Ruscitto et al. (2011) and [b] compositions of the HMA-type MIs.

Our interpretations of the two MI populations and their host olivines are discussed in the main text. Our average compositions for the two MI populations are provided in Table 2, where they are compared to the averages from Ruscitto et al. (2011). A final comment concerns estimated trapping temperatures for these MIs. In Figure A4, it can be seen that olivine-melt equilibration Ts (here using the method of Sugawara [2000]) calculated for both HMA-type and PBA-type MIs at two different redox states are similar to those reported by Ruscitto et al. (2011), and confirm lower Ts for the HMA-type MIs.

In Figure A5, we compare ratios of P2O5/TiO2 vs. K2O/TiO2 for the two MI populations using data of Ruscitto et al. (2011). These elements are considered to be incompatible in olivine, and these ratios are unaffected by the PEC corrections. We note the overlap between all but two HMA-type MIs and the groundmass or bulk rock compositions of Shasta HMA lava. In contrast, most PBA-type MIs are distinct from all Shasta lavas. Shasta dacites have distinctly higher K2O/TiO2 than the basalts, and HMA lava and MIs are intermediate between these magma types.

Figure A6 shows how our proposed mixture of high-Sr dacite with calcalkaline basalt differs from the mixture of a fractionated, low-Sr dacite with PBA as proposed by Ruscitto et al (2011). Key observations include: [1] in panels (a) and (b) the HMA-type MIs lie within the field for Shasta dacites and straddle our dacite-basalt mixing line; [2] the HMA bulk lavas are shifted away from this mixing line toward the origin, consistent with addition of ultramafic components; and [3] in panel (c), sparse Cl data for the MIs suggest that dacite-basalt mixtures will define a positive sloped trend at high angle to the mixing trend of Ruscitto et al. (2011). It is also evident from (c) that mixtures of PBA-type liquids with either dacite or local basalts appear unlikely to produce liquids of

HMA-type. Finally, we note that the dacite end member used by Ruscitto et al. (2011) happens to be of Sargents Ridge age, hence is unlikely to be a realistic end member based on available isotopic data discussed in Supplement I.

Additional reference (also included in main text):

- Brouxel, M., and Lapierre, H. (1988) Geochemical study of an early Paleozoic island-arc-bacl-arc basin system. Part 1. The Trinity Ophiolite (northern California). Geological Society of America Bulletin, 100, 1111-1119.
- Gruau, G., Lécuyer, C., Bernard-Griffiths, J., Morin, N. (1991) Origin and petrogenesis of the Trinity Ophiolite Complex (California): New constraints from REE and Nd isotope data. In: Menzies, M.A., Dupuy, C., and Nicolas, A. (Eds.) Orogenic lherzolites and mantle processes. Oxford University Press, Journal of Petrology Special Vol., 229-242.
- Gruau, G., Bernard-Griffiths, J., Lécuyer, C., Henin, O., Macé, J., and Cannat, M. (1995) Extreme Nd isotopic variation in the Trinity Ophiolite Complex and the role of melt/rock reactions in the oceanic lithosphere. Contributions to Mineralogy and Petrology, 121, 337-350.
- Hugo, R.C., Bernsen, S., Breen, K., and Ruzicka, A. (2015). Phase analysis of large EDS datasets with Matlab. Microscopy and Microanalysis 21 supplement S3, 2023-2024. doi:10.1017/S1431927615010892.
- Lécuyer, C., Brouxel, M., and Albarède, F. (1990) Elemental fluxes during hydrothermal alteration of the Trinity ophiolite (California, U.S.A.) by seawater. Chemical Geology, 89, 87-115.
- Sugawara, T. (2000) Empirical relationships between temperature, pressure, and MgO content in olivine and pyroxene saturated liquid. Journal of Geophysical Research, 105, 8457-8472.

Captions to Supplemental Tables:

Supplemental Table A1. Compositions of HMA whole rock samples from Whaleback quarry (S-17 location).

Supplemental Table A2. Representative analyses of pyroxenes. Distance (in μm) along analysis traverses increases towards rim.

Supplemental Table A3. Representative olivines. Distance (in μm) along analysis traverses increases towards rim.

Supplemental Table A4. Representative spinels. 'Pyx grd or rim' = groundmass pyroxene or located in rim of pyroxene crystals; 'xenocryst = host' is olivine seen in inset of Fig. 11a.

Supplemental Table A5: Representative analyses of feldspar crystals.

Supplemental Table A6. Representative trace element data for Type 1 clinopyroxenes

Supplemental Table A7. Additional whole rock analyses for samples of Trinity Ophiolite and Shasta area lavas