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Figures S1 to S9

The equation of isotopic mixing model

Introduction

This supplementary information contains all of the Supplementary figures with captions fot this manuscript. The description of olivine maximum fractionation model is provided with Fig. S6. The equation of mixing between isotopic endmembers and its explanation is also provided. Supplementary tables are provided as separated spreadsheets (.xlsx).

1 Supplementary figures

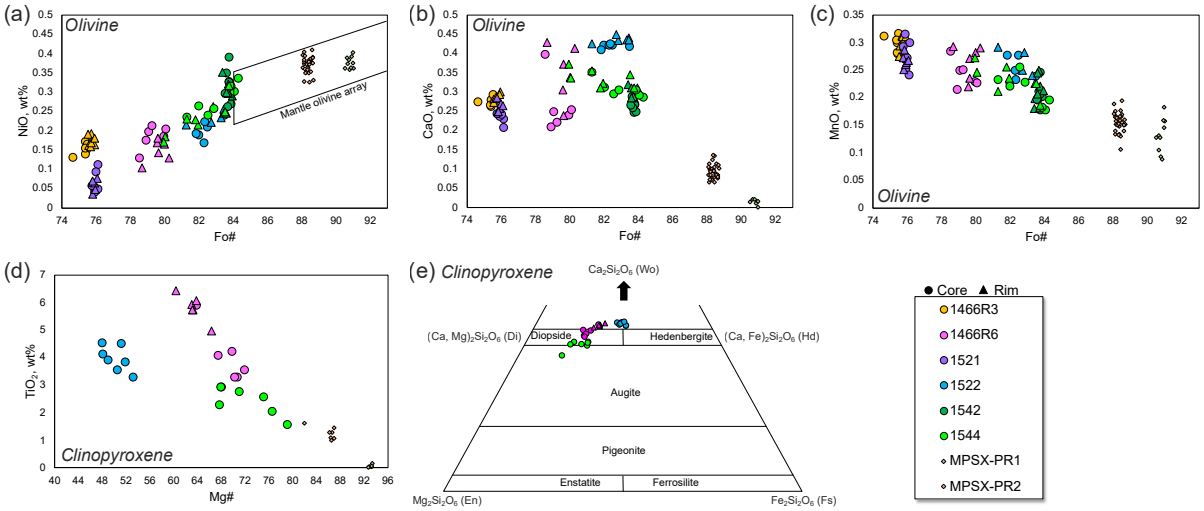

Fig. S1. Mineral compositions of olivine (a)–(c) and clinopyroxene (d)–(e). (a) Forsterite number (Fo#: Mg# = Mg/(Mg+Fe^{2+}) for atomic ratio of olivine) vs NiO content of olivine. Mantle olivine array is after Takahashi *et al.* (1987). (b) Fo# vs CaO content of olivine. (c) Fo# vs MnO content of olivine. (d) Mg# vs TiO_2 content of clinopyroxene. (e) Ca–Mg–Fe pyroxene classification diagram from Morimoto (1988). Peridotite xenoliths in the 6K#1466R6-001 and R7-003 basalts are from Mikuni *et al.* (2022).

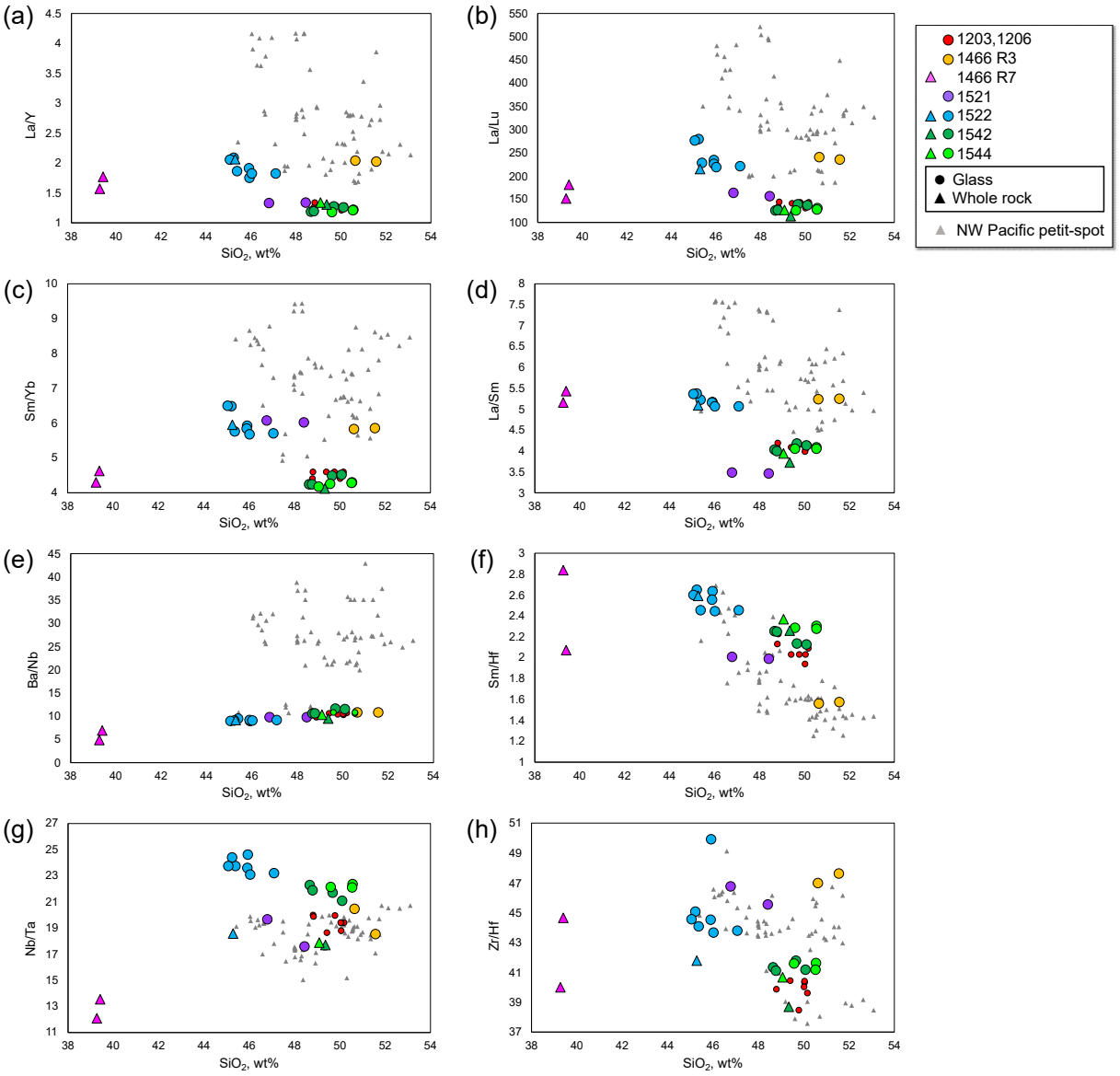

Fig. S2. Selected trace-element ratios against SiO_2 content.

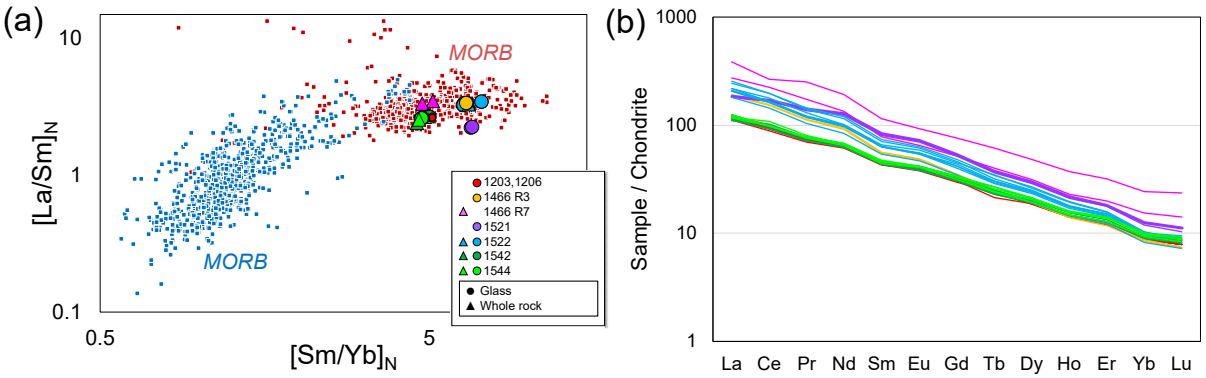

Fig. S3. The REEs characteristics of the western Pacific petit-spot basalts. (a) CI Chondrite normalized Sm/Yb and La/Sm variations. Chondrite value is after Sun and McDonough (1989). (b) CI Chondrite normalized REE patterns. The color of each line corresponds to the symbols of petit-spot basalts in (a). The data of OIB and MORB are from Stracke et al. (2022) as "Expert datasets" in GEOROC database (`https://georoc.eu/georoc/new-start.asp`).

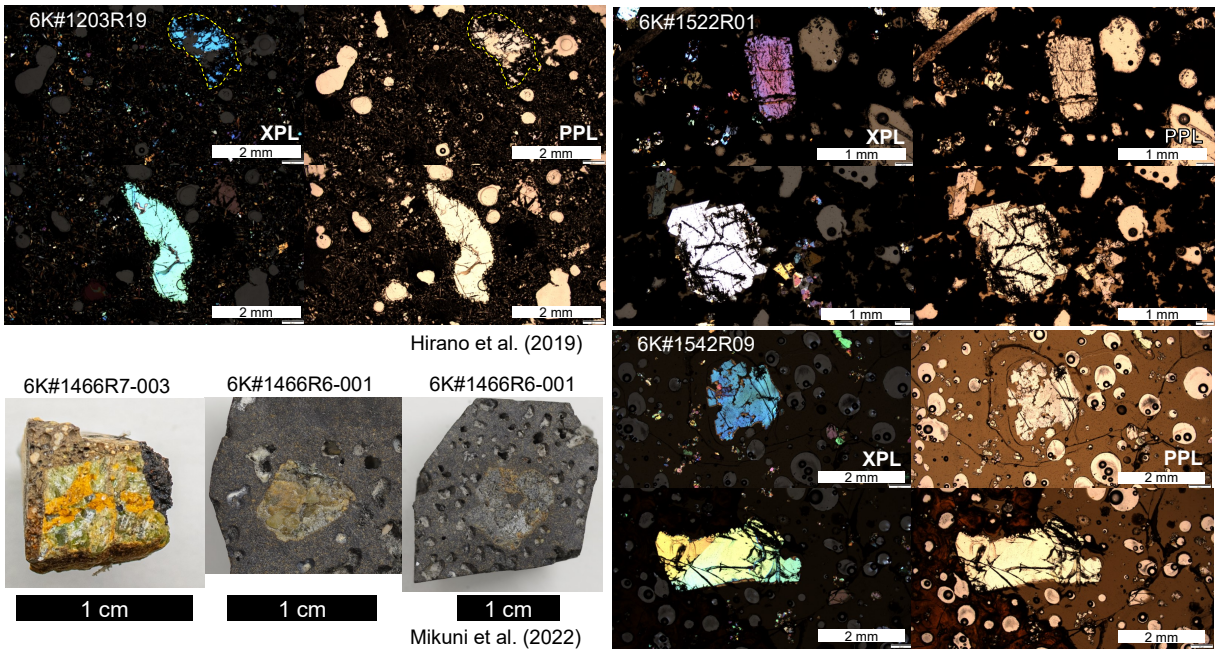

Fig. S4. Photomicrographs and photos of xenocrysts and xenoliths in this study samples.

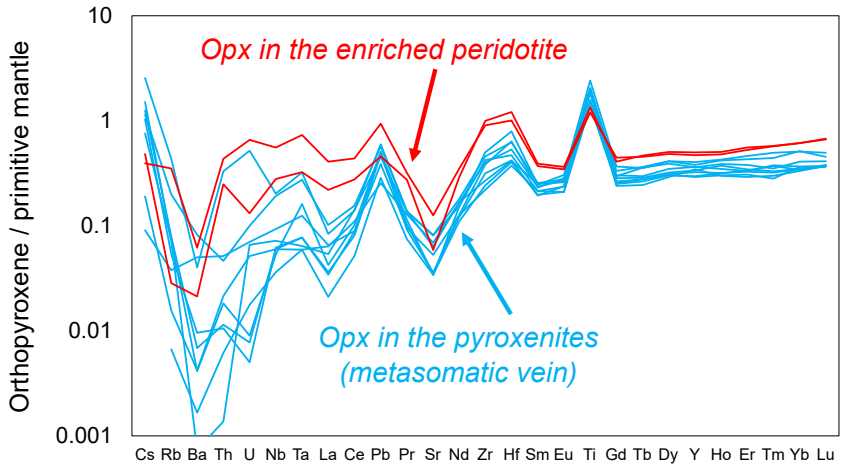

Fig. S5. Primitive mantle-normalized trace-element compositions of orthopyroxene in the metasomatized ultramafic xenoliths. The enriched peridotite and the pyroxenite xenoliths were reported from the petit-spot knoll in this study area (investigated by the 6K#1466R6-001, R7-001 and R7-003 dives). The data are provided in Mikuni *et al.* (2022).

Olivine maximum fractionation model

Primary composition of selected samples were calculated using "olivine maximum fractionation model" generally based on the method of Machida *et al.* (2008) to check the primitiveness of the 6K#1522 petit-spot basalts. First, we calculated the composition of olivine in equilibrium with the analyzed melt (glass) composition by the exchange partition coefficients of Fe–Mg (${K_d^{Fe-Mg}}_{olivine-melt}$) and Ni–Mg (${K_d^{Ni-Mg}}_{olivine-melt}$) from Takahashi (1986) as described below. Then, the calculated composition of olivine were added to the analyzed melt composition in a weight ratio of 1:99. This procedure was repeated until the NiO content and Fo# of olivine reached the "mantle olivine array" (Takahashi, 1986). Assumption in the calculation are as follows:

${K_d^{Fe-Mg}}_{olivine-melt} = 0.27 + 0.03(N_{melt}^{MgO} + 0.33 N_{melt}^{FeO})$,

${K_d^{Ni-Mg}}_{olivine-melt} = 2.8 - 0.033(N_{melt}^{MgO} + 0.33 N_{melt}^{FeO})$,

$Fe^{3+}/(Fe^{2+} + Fe^{3+})$ is constant of 0.1.

N_{melt}^{MgO} and N_{melt}^{FeO} are molar fraction of MgO and FeO of melt, respectively.

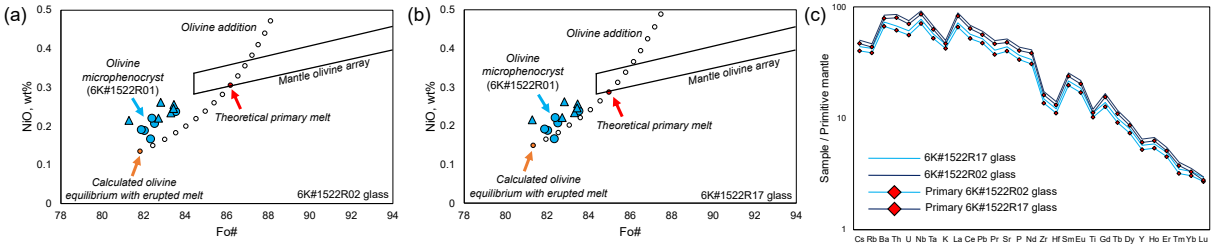

Fig. S6. he olivine maximum fractionation model. Selected two samples of 6K#1522R02 (a) and 6K#1522R17 (b) were back-calculated to "mantle olivine array" by addition of olivine. (c) Primitive mantle normalized trace-element patterns of analyzed values and calculated primary magma.

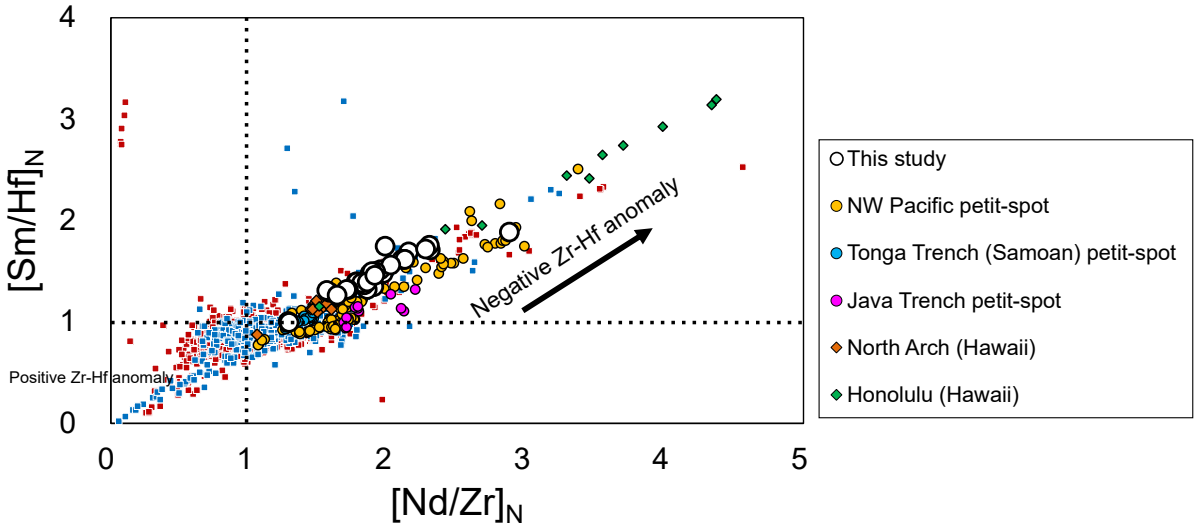

Fig. S7. Primitive mantle normalized Nd/Zr vs Sm/Hf diagram. Compiled data and references are as follows: NW Pacific petit-spots; Hirano and Machida (2022), petit-spots off Tonga Trench; Reinhard *et al.* (2019), petit-spots off Java Trench; Taneja *et al.* (2016) and Falloon *et al.* (2022), Hawaiian North Arch lavas and Honolulu volcanics; Clague and Frey (1982), Clague *et al.* (1990), and Yang *et al.* (2003). Data of OIB and MORB are from Stracke et al. (2022) as "Expert datasets" in GEOROC database (`https://georoc.eu/georoc/new-start.asp`).

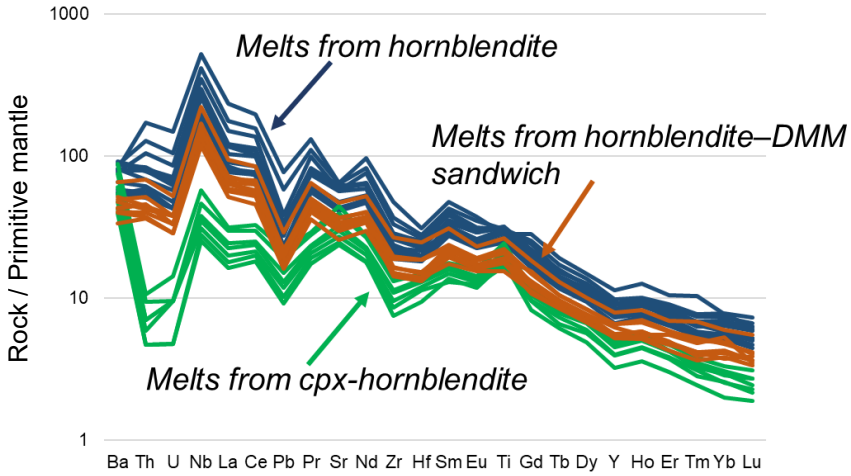

Fig. S8. Primitive mantle normalized trace element patterns of the produced melts from experiments of Pilet *et al.* (2008). Dark blue lines, green lines, and brown lines are melts from hornblendite, cpx-hornblendite, and hornblendite–DMM sandwich, respectively. Details are described in Pilet *et al.* (2008).

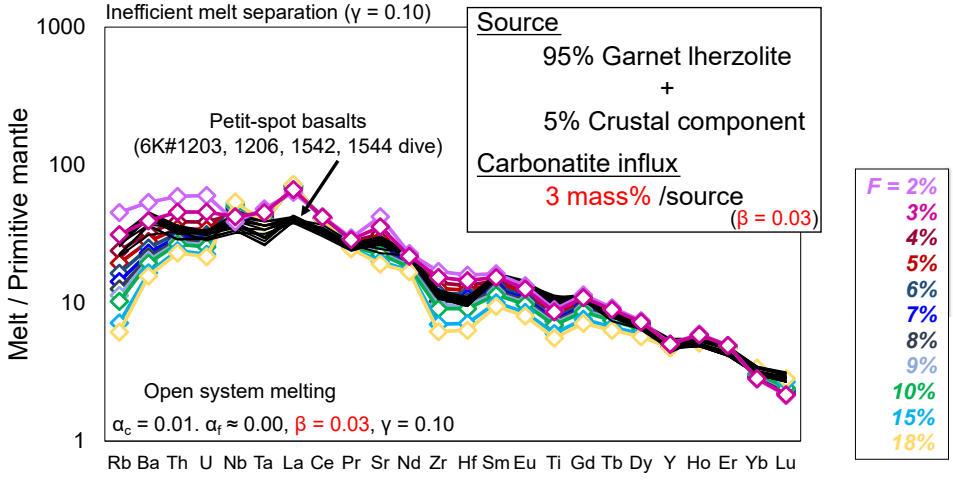

Fig. S9. Geochemical modeling for primitive mantle (PM, Sun and McDonough, 1989)-normalized the trace-element pattern for each degree of melting. The calculated melts are partial melts of 5% crustal component-bearing garnet lherzolite with 3% carbonatite influx to a given mass of the source ($\beta = 0.03$). Melt-separation rate (γ) is 0.1. The trace-element composition of the western Pacific petit-spot basalts from the 6K#1203, 1206, 1542, and 1544 dives are shown as black lines for comparison. Critical melt fraction (α_c) is 0.01. The source and melting modes are same as the model of Fig, 11d.

isotopic mixing model

The mixing line between HIMU and EM1 of Fig. 9 in the main text is described as the following equation: $R_m = \frac{R_a f y + R_b (1-y)(1-f)}{yf + (1-y)(1-f)}$,

where R_a, R_b, and R_m are the isotopic ratios of component a, component b, and the mixture, respectively. f is a mixing ratio, and y is the ratio of concentration: $\frac{C_a}{C_a + C_b}$.

References

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Takahashi, E., Uto, K., and Schilling, J.-G.: Primary magma compositions and Mg/Fe ratios of their mantle residues along Mid Atlantic Ridge 29N to 73N, Technical Report of ISEI Okayama University Series A, Okayma University, 1–4, 1987.

Other references cited in the Supplementary information are listed in the main text.