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Boninitic melt percolation makes depleted mantle wedges rich in silica

Antoine Bénard^{1,*}, Dmitri A. Ionov², Oliver Nebel³, and Richard J. Arculus⁴

¹Université Clermont Auvergne, CNRS, IRD, OPGC, Laboratoire Magmas et Volcans, 63000 Clermont-Ferrand, France

²Géosciences, Université de Montpellier, 34095 Montpellier, France

³School of Earth, Atmosphere and Environment, Monash University, 3800 Clayton, VIC, Australia

⁴Research School of Earth Sciences, The Australian National University, 2601 Canberra, ACT, Australia

*antoine.benard@uca.fr

Chen et al. (2023) reported serpentinized, SiO₂-rich ophiolitic peridotites from Central Asia and argued that these were formed by reworking of residual mantle by boninite melts in arc settings. While SiO₂-rich ophiolitic peridotites were reported and linked to subduction zone processes earlier (e.g., Ionov et al., 2017), Chen et al. claimed that boninite percolation is a “viable manner to induce silica enrichment and keep ultra-depleted signature,” as an alternative to the models of Bénard et al. (2017, 2021) for “residual supra-subduction zone (SSZ) peridotites” sampled in island arcs.

Yet, the samples reported by Chen et al. do not fit the petrological features of residual SSZ peridotites. The latter are spinel harzburgites with coarse-grained, protogranular textures reflecting SiO₂-enrichment at high temperature (e.g., Soustelle et al., 2010). Late-stage clinopyroxene and amphibole are rare and occur only as small anhedral grains in true residual SSZ peridotites (≤4% and ≤1%, respectively; Ionov, 2010; Bénard et al., 2017, 2021). By contrast, subhedral amphibole (up to 8%; Chen et al.’s Table S1) and clinopyroxene, as well as large orthopyroxene grains replacing olivine, are common in the samples of Chen et al. (see their Figures 2 and S3). These features rather resemble those of rare composite xenoliths formed by post-melting boninite intrusion (e.g., Bénard et al., 2022).

The samples described by Chen et al. do not fit the geochemical features of residual SSZ peridotites either. They clearly have lower MgO and NiO, but higher SiO₂, CaO, and Na₂O for a given Al₂O₃ content (Figs. 1A–1C), notably leading to much higher Ca/Al (~2–13). Neither metasomatic

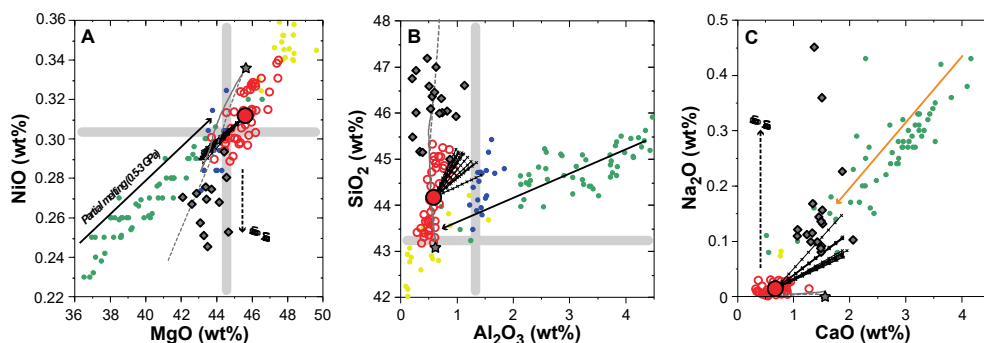


Figure 1. Major oxide compositions of Central Asia peridotites (gray diamonds; Chen et al., 2023), compared with residual SSZ peridotites (red circles; Ionov, 2010; Bénard et al., 2017, 2021). Also shown are residual peridotites from various tectonic settings (green dots—off-craton continental xenoliths; blue dots—abyssal peridotites; yellow dots—cratonic xenoliths), as compiled by Bénard et al. (2021) (see references therein). The post-melting boninite percolation models of Chen et al., using an initial peridotite hypothetically formed by ~20% of flux melting (dark-gray star), are shown with solid and dotted dark-gray lines. The compositions of peridotite residues, calculated for ~20% of H₂O-fluxed melting at 1.25 GPa by Bénard et al. (2021) are shown with light-gray bars in (A) and (B). Nickel contents for the simulations of Chen et al. are calculated using their modeled modal compositions and the averaged NiO measured in each mineral of their samples. Also shown are simple amphibole addition models (thin black lines; each cross marks a 1% addition increment), using the averaged compositions of residual SSZ peridotites (large red dot) and amphibole in each sample from Chen et al.

additions of amphibole nor small-scale post-melting modifications previously identified in residual SSZ peridotites (including serpentinization) can account for these geochemical differences (Figs. 1A–1C; Bénard et al., 2021) or explain the compositions of mineral phases, like spinel showing much wider Mg# and Cr# ranges in the samples of Chen et al. than in ‘residual SSZ peridotites’ (e.g., Figure 2 in Bénard et al. 2022).

The boninite percolation model presented by Chen et al. does not reproduce the composition of true residual SSZ peridotites in a consistent way, nor does it account for the high CaO and Na₂O contents of their ophiolite samples (Fig. 1C). Notably, the elevated Cr₂O₃, the nearly constant MnO, and the relatively wide FeO_T range (~7.25–8.75 wt%; Bénard et al., 2021) in residual SSZ peridotites are not predicted by the models. Other chemical elements useful for comparisons with residual SSZ peridotites are absent from their models (e.g., Ni; Fig. 1A), while the composition of the initial peridotite cannot be reconciled with the results of earlier H₂O-fluxed melting models (Figs. 1A and 1B; Bénard et al., 2021).

In summary, the process proposed by Chen et al. is not viable to produce residual SSZ peridotites. Therefore, the extent to which post-melting boninite percolation can modulate the geochemistry of mantle wedges, as suggested by Chen et al., remains undetermined.

REFERENCES CITED

- Bénard, A., Arculus, R.J., Nebel, O., Ionov, D.A., and McAlpine, S.R.B., 2017, Silica-enriched mantle sources of subalkaline picrite-boninite-andesite island arc magmas: *Geochimica et Cosmochimica Acta*, v. 199, p. 287–303, <https://doi.org/10.1016/j.gca.2016.09.030>.
- Bénard, A., Müntener, O., Pilet, S., Arculus, R.J., and Nebel, O., 2021, Silica-rich spinel harzburgite residues formed by fractional hybridization-melting of the intra-oceanic supra-subduction zone mantle: New evidence from TUBAF seamount peridotites: *Geochimica et Cosmochimica Acta*, v. 293, p. 477–506, <https://doi.org/10.1016/j.gca.2020.11.001>.
- Bénard, A., Le Losq, C., Müntener, O., Robyr, M., Nebel, O., Arculus, R.J., and Ionov, D.A., 2022, Spinel harzburgite-derived silicate melts forming sulfide-bearing orthopyroxenite in the lithosphere. Part 1: Partition coefficients and volatile evolution accompanying fluid- and redox-induced sulfide formation: *Frontiers of Earth Science*, v. 10, <https://doi.org/10.3389/feart.2022.867979>.
- Chen, M., Zheng, J., Dai, H.-K., Xiong, Q., Sun, M., Buslov, M. M., Zhou, X., and Liu, J., 2023, Boninitic melt percolation makes depleted mantle wedges rich in silica: *Geology*, v. 51, p. 791–795, <https://doi.org/10.1130/G51050.1>.
- Ionov, D.A., 2010, Petrology of mantle wedge lithosphere: New data on supra-subduction zone peridotite xenoliths from the andesitic Avacha volcano, Kamchatka: *Journal of Petrology*, v. 51, p. 327–361, <https://doi.org/10.1093/ptrology/egp090>.
- Ionov, D.A., Bigot, F., and Braga, R., 2017, The provenance of the lithospheric mantle in continental collision zones: Petrology and geochemistry of peridotites in the Ulten-Nonsberg Zone (Eastern Alps): *Journal of Petrology*, v. 58, p. 1451–1472, <https://doi.org/10.1093/ptrology/egx061>.
- Soustelle, V., Tommasi, A., Demouchy, S., and Ionov, D.A., 2010, Deformation and fluid-rock interaction in the supra-subduction mantle: Microstructures and water contents in peridotite xenoliths from the Avacha volcano, Kamchatka: *Journal of Petrology*, v. 51, p. 363–394, <https://doi.org/10.1093/ptrology/egp085>.