

Reviewer #1 (Theodoros Ntaflos)

Major and specific comments

1. Chapter 5.1 Mineral major and trace elements: a more detailed mineralogical description is needed.

We think that this chapter contains all the information on the major element composition of the constituent phases that are necessary to reconstruct the melt-rock reaction. We do not have trace element compositions in this manuscript.

2. Page 7, line 6: why the accelerating voltage vary from 15 to 20 kV?

The analyses were carried out in the same EPMA lab at the University of Granada in two sessions that were distant from each other in time (in 2012 and 2017). There is no special reason for changing the accelerating voltage between sessions but, during this period, minor modifications in the analytical conditions have been implemented by the EPMA operator in the analysis of geological materials. We applied the routine procedure in each session. Considering that the mineralogical composition and other physical characteristics of the Oran xenoliths are similar, using 15 or 20 kV accelerating voltage does not have any negative impact on the quality of obtained major element data.

3. Page 7, line 12: Plagioclase up to 0.8% is high. Explain the origin of this plagioclase

Most Oran mantle xenoliths are plagioclase free, and in those ones where this phase was observed, the modal content typically ranges 0.1-0.2%. There are two samples, HAM-011 and HAM-009, where somewhat higher plagioclase content was detected (0.4 and 0.8%, respectively; Table 1). In these xenoliths, plagioclase is interstitial and usually occurs close to spinel and pyroxenes, typical for dominantly subsolidus formation of plagioclase upon the destabilization of spinel at shallow mantle levels. Observations support the shallow mantle origin of plagioclase-bearing lherzolites from the Oran volcanic field. This transformation reaction, however, is highly dependent on the bulk rock composition (e.g., Borghini et al., 2010, 2011) and, considering the mainly harzburgitic model contents, it is not surprising that the presence of plagioclase is not that common among the studied samples even though possibly some may have also partly equilibrated in shallow mantle levels. We updated the description of plagioclase petrography in the revised manuscript: “...*These occurrences and the observed modal content of plagioclase is nevertheless compatible with dominantly subsolidus origin of plagioclase at the expense of spinel (e.g., Rampone et al., 1993;Borghini et al., 2010 and references therein)...*”

References cited in the answer:

Borghini, G., Fumagalli, P., and Rampone, E.: The Stability of Plagioclase in the Upper Mantle: Subsidius Experiments on Fertile and Depleted Lherzolite, *Journal of Petrology*, 51, 229-254, 10.1093/petrology/egp079, 2010.

Borghini, G., Fumagalli, P., and Rampone, E.: The geobarometric significance of plagioclase in mantle peridotites: A link between nature and experiments, *Lithos*, 126, 42-53, 10.1016/j.lithos.2011.05.012, 2011.

4. Page 10, line 30: *Opx with 2.5 wt% CaO is unusual for a mantle xenolith. Probably there are thin cpx exsolution lamellae. Check it.*

We appreciate spotting this error in the database. Indeed, large orthopyroxene crystals often contain lamellae of clinopyroxene in their cores (page 8, lines 15-17 in the original manuscript). In this sample, the typical range of CaO in orthopyroxene does not exceed 0.7 wt% and the outlier analysis was taken in the core of orthopyroxene, so we agree with the reviewer that it must correspond to a mixed analysis contaminated by clinopyroxene lamellae. Consequently, we removed this analysis from the database.

5. Table 2: *Thought there are calculated whole rock major element compositions there is a systematic inverse CaO/Al₂O₃ ratio. The CaO/Al₂O₃ ratio in non-metasomatized mantle peridotites is <1. In the case of Table 2, with exception of sample SOU-003, is the ratio CaO/Al₂O₃>1. Explain why. This is not consistent with reaction with undersaturated melts.*

Most Oran mantle xenoliths—including the coarse-grained peridotites (e.g., page 13, lines 2-3 of the original manuscript)—display petrographic and/or geochemical signatures of melts and various degrees of melt-rock reaction. We propose that the microstructure of the studied mantle xenoliths record both the geochemical evolution of the upwards migrating melt in the SCLM and the lateral heterogeneities in the function of distance to the melt conduits, hence differences of time-integrated melt-rock ratio. The replacement of orthopyroxene by clinopyroxene ± olivine (e.g., presented on the example of xenolith DZ-003 in Fig. 3b) is explained by wehrlitization, which is ascribed to melt-rock reaction either by carbonatitic or undersaturated silicate melts in the literature. Carbonatitic melts result in high whole-rock CaO/Al₂O₃, Na₂O/Al₂O₃ values, LILE enrichment, and formation of apatite and jadeitic clinopyroxene (e.g., Yaxley et al., 1991).

Although in the Oran mantle xenoliths, the CaO/Al₂O₃ ratios are indeed identical to the proposed one for carbonatite metasomatism, the low Na₂O/Al₂O₃ (<0.02-0.17; Table 2 vs. expected 0.44-0.49 in Yaxley et al., 1991), the lack of apatite and the low Na₂O content of clinopyroxene (0.92-1.59 wt.%; page 11, line 2 vs. expected 1.5-2.5 wt% in Fig. 2 of Yaxley et al., 1991) rule out that wehrlitization was due to interaction with carbonatites. This is particularly the case of the coarse-grained wehrlite sample SOU-003, where—in addition to the low Na₂O/Al₂O₃ ratio (<0.02, Table 2), the low Na₂O content of clinopyroxene (0.8-1.0 wt%; Table S1) and the lack of apatite—the CaO/Al₂O₃ is very low, as the Reviewer also pointed out.

Based on the observations we think that the interaction with silicate melt is justified and we favor this model in the manuscript rather than carbonatitic melts. Consequently, the microstructure of the Oran mantle xenoliths can be explained by the evolution of the silicate melt from primitive to evolved compositions during upward migration in the lithospheric mantle column, which was presented in the manuscript with sufficient details in page 15, line 17 onward in the original version. We nevertheless added more details to this chapter in the revised manuscript to exclude the interaction with carbonatite melts as: “...*Unlike the expected high Na₂O/Al₂O₃ values accompanied with the presence of apatite and jadeitic clinopyroxene in wehrlites related to carbonatites (Na₂O/Al₂O₃ in whole rock: 0.44-0.49, Na₂O in Cpx: 1.5-2.5*

wt.%; Yaxley et al., 1991; Raffone et al., 2009), the Oran xenoliths have petrographic and geochemical signatures ($\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$ in whole rock: <0.02-0.17; Na_2O in Cpx: 0.92-1.59 wt.%; Table 2, Table S1) typical of mantle wall rocks that interacted with melts relatively close to magma conduits or porous flow channels (Bodinier et al., 1990; Ionov et al., 2005)... ”

Reference cited in the answer:

Yaxley, G. M., Crawford, A. J., and Green, D. H.: Evidence for carbonatite metasomatism in spinel peridotite xenoliths from western Victoria, Australia., *Earth and Planetary Science Letters*, 107, 305-317, 1991.