Dear Editors, dear Andréa Tommasi, dear Jacques Précigout,

First of all, the authors want to thank both reviewers, Andréa Tommasi and Jacques Précigout, for their detailed and constructive comments, which help to improve the manuscript. The authors decided to reply in one statement because the major remarks of both referees largely overlap or complement each other. In general, all proposed changes and comments of both reviewers were considered in the revised version of the manuscript. The changes tracked by line number are in the second part of this reply. However, at first we will briefly comment on the main points of criticism.

According to both reviewers, the three main points of criticism are:

(1) The nature of metasomatism: Refertilizing or late stage, fluid-rich melt?
(2) The timing of the metasomatism and its effect on deformation.
(3) The insufficient quantification of the olivine grain size.

The nature of metasomatism:

We agree with both reviewers, that the irregular grain/phase boundaries and grain shapes as well as extensive phase mixing are robust microstructural evidence for metasomatism in the entire NW Ronda shear zone. A metasomatism of parts of the investigated mylonite unit by refertilizing melts was postulated by Soustelle et al. (2009). This process was adapted in the original manuscript for our transect. However, both reviewers reject the interpretation of a refertilizing melt because of low syn-kinematic temperature estimates (800–900 °C, 1.95–2.00 GPa (Garrido et al. (2011)) and the missing modal change to increased fertile components. The authors agree with both objections and discuss the nature of the metasomatism in the reviewed version by taking into account the suggestions made by the reviewers. Following the annotations made by Andréa Tommasi, the microstructural similarity as well as the matching PT-estimations for the grt/spl-mylonites from Rondas counterpart from the Morrocan limb of the Gibraltar arc, the Beni Bousera peridotite massif, point to a consistent genesis. Frets et al. (2012, 2014) suggested a metasomatism of small fractions of fluids or highly evolved melts, which did not reset the quilibrium temperatures in Beni Bousera. Matching all observations made in our samples, the authors agree, that the metasomatism is most likely attributable to highly evolved melt. A fluid-driven metasmomatism as proposed for the plagioclase-tectonite unit in Ronda by Hidas et al. (2016) is in the authors opinion less likely because of the low abundance of amphibole in the dominant mixed matrix and the absence of ultramylonites, which were obsereved to form by fluid-rock reactions. Based on these observations, the rewritten section 5.1 “Microstructural implications – Formation” now includes a discussion and evaluation of the different potential metasomatic agents. In this regard, the authors agree with Jacques Précigouts remark of the small geochemical data base for a geochemically based model of the shear zone’s evolution. To resolve the geochemical trend in detail, an additional study would be needed with the focus on the transitional area between the mylonite and tectonite unit. According to Jacques Précigouts suggestions, the reviewed discussion was focused on the microstructural evidence.

The timing of the metasomatism and its effect on deformation:

The rewritten section 5.2 “Microstructural implications – Deformation” now discusses the timing of the metasomatic event and its effect on the deformation. Microstructural similarities especially of the film/wedge-shaped orthopyroxenes in the mylonitic part of the shear zone to mylonites and ultramylonites investigated by Dijkstra et al. (2002) and Hidas et al. (2016) indicate a syn-kinematic metasomatism with dissolution-precipitation reactions being active. This assumption is supported by Frets et al. (2014), who argued for the corresponding grt/spl-mylonites of Beni Bousera for syn- to late kinematic metasomatism. As both reviewers criticize an overinterpretation of the data in terms of the importance of the metasomatic event for the genesis of the NW Ronda shear zone, the discussion was fundamentally shortened in this regard. Therefore, the main focus of section 5.2 lies now on the active deformation mechanisms (dislocation creep, dissolution-precipitation creep), the dominant deformation mechanism (dislocation creep) and the potential impact of phase mixing and melt presence on the deformation. The authors agree that an irrevocable argument for the trigger of the shear zone by metasomatic processes cannot be given. However, the comparison with other upper mantle shear zones (section 5.4) indicates a general strong relation between reactions and localized deformation in the upper mantle. With the data presented, the NW Ronda shear zone lines up or at least does not contradict this picture.

The insufficient quantification of the olivine grain size:

The complete data was reprocessed to quantify the original olivine grain size using the method suggested by Andréa Tommasi. The new data were added to the microstructural data of figure 3 and of supplementary data S2. However, even with a larger spread and coarser grain sizes, olivine follows the general trend of constant grain sizes in the entire mylonite unit formerly reported by Johanesen & Platt (2015). Moreover, Frets et al. (2014) report for the Grt/Spl-mylonite unit of Beni Bousera a similar range of mean olivine grain size (90-160 µm). The statistics of 7375 olivine grains analyzed in the mixed matrix and the consistency with the published data indicate a robust data set of constant olivine grain size over the entire mylonite unit with local variations but no obvious trend.

Detailed list of corrections for comments by Andréa Tommasi, sorted by line numbers. In the authors answers the first line number refers to reviewed manuscript without changes marked, second line number to the version with changes marked.

Additional comments:

1. The introduction and discussion sections have repetitions and may be significantly shortened, so that there will be more space to present the data, which in the present form of the ms. is largely presented as Supplementary material. The section of the amphibole-bearing veins is also not essential to the article.

   Both sections were revised and reworked. Parts were shortened and the complete CPO data was included in the results section. The authors decided to leave the section on amphibole-bearing veins (4.1.3) in the manuscript to make readers aware of this feature which is potentially interesting to investigate late-stage fluid-peridotite interaction and was not described so far.

2. Please add a map of the Sierra Bermeja massif with foliations and lineations. Even if you focus on the microstructures, the structural context is important. In general, the description of the structural data is too vague. The orientation of the mylonitic foliations is much more varied then stated in l. 115 - their trend follows on average that of the limits between the tectonometamorphic domains, see maps from Darot (1973) and data reported in later studies (Obata, Van der Wal et al 1993, 1996, Soustelle et al. 2009…). Same for the lineations.

   A structural map of the Sierra Bermeja massif including foliation, lineations and major faults was added to figure 1. The studied area of Soustelle et al. 2009 was indicated in this map. The section on the structural data was rewritten to clarify the variations in the foliation/lineation and the dominant orientation of both in the area of investigation (ll. 139/ 156, ll. 225/ 251).

3. The description of the sampling referring to the shear zone boundary is not always clear. Better state that the samples were collected at increasing distance from the northeastern limit of the massif. This limit is not necessarily the limit of the shear zone as the contact between the peridotites and the Jubrique unit may have been reworked. Similarly, in line 371, the use of distal may lead to confusion.

    Shear zone boundary (SFZ) was changed to NW boundary of the Ronda peridotite massif (NW-B). The abbreviation was necessary for graph axes titles etc.. The use of “proximal” and “distal” was avoided in the complete manuscript.

4. How do the area fractions of porphyroclasts and matrix vary as a function of distance along the transect? This information might allow to better evaluate the continuity (or not) of the evolution of the deformation conditions along the transect.

    Descriptions and discussions of the variations for the abundances of porphyroclasts and the proportion of recrystallized matrix respectively are added in lines 392/ 440, 435/ 485 and 653/ 709.

5. How are the limits between porphyroclasts tails and the matrix defined? Is it really important to discriminate between these two microstructural domains?

    Neoblast tails of pyroxene porphyroclasts are characterized by a phase (pyroxene dominated, amphibole-bearing), grain shape (equaxial), grain size (coarse) composition and CPOs (AG- and B- type). All these microstructural characteristics differ distinctly from the surrounding mylonitic matrix with ol-dominated, mostly amph-absent composition, elongated grain shape, smaller grain size and strong A-type CPOs. Therefore, their limits are defined by all these microstructural parameters which enable an easy distinguishment between matrix and tails.

6. To discuss the variations in olivine CPO patterns along the transect as it is done lines 331-335 and 550-555, the full dataset needs to be presented in the article. It is stated in the text that A-type patterns dominate. Yet most figures presented in the main text show AG-type patterns.

    The complete CPO data was added as figure 4.

7. Deformation mechanisms in the matrix: please complete this point by showing and discussing the internal deformation of the neoblasts... If they deformed by dislocation creep, as stated in the ms., they should display, to some extent, a substructure (GNDs) consistent with this deformation.

    A GND reconstruction map for the mylonitic mixed matrix was added in figure 7 corroborating dislocation creep as dominant deformation mechanism

8. CPOs in the recrystallization tails: do the observations hint for inheritance of orientations from the porphyroclasts?

    Yes, there is a strong inheritance for opx neoblasts and a slightly weaker one for cpx. Description and discussion were added in lines 418/ 468, 464/ 515 and 677/ 734.

9. Line 558: What are the observations that indicate that deformation was enhanced by the presence of melts in the early stages of shearing? Why early stages?

For the discussion of the timing of the metasomatism please see above in the discussion of the main points of criticism. The potential effects of melt-presence in the studied rocks on the deformation and its microstructural implications are discussed in reworked section 5.2. The authors therein agree, that the initiation of strain localization cannot be conclusively attributed to the investigated metasomatic event. However, the comparison to other upper mantle shear zone shows a strong association of reactions, phase mixing and shear zones.

10. Line 559: Piezometric data cannot document the activation of a grain size sensitive mechanism. At best, given all the uncertainty and hypotheses inherent to this method, it allows an estimate of the active stresses. And this estimate is only valid if grain size reduction is controlled by dislocation creep, since these are the conditions prevailing in the experiments used for the calibration.

    Correct, the paragraph was changed accordingly (ll. 722/ 779) .

11. Line 560: Where does the evidence for GBS is shown?

    Evidence for GBS is tricky and in most cases no distinctive feature for GBS. Therefore, we refer to the research of Précigout et al. (2007) who argued for DisGBS as dominant deformation mechanism (ll. 724/ 782).

12. Not all pyroxenites in Ronda were interpreted as resulting from replacement of previous gt-pyroxenites by melt-rick reaction. An important volume of pyroxenites was interpreted as formed by partial (reactive) crystallization of percolating melts. Moreover, in the mylonites, gt-pyroxenites predominate (Garrido and Bodinier 1999).

    Very correct. Thanks for the annotation, the text was changed accordingly (ll. 619/ 674).

13. Referencing is imprecise in some places. For instance, Passchier and Trow (1996) is not the best citation for viscoplastic anisotropy due to crystal orientation.

    Citations have been checked and updated (e.g., l. 44/ 52). The authors would like to thank both reviewers for their paper suggestions.

14. Lack of cross-cutting relations between gt-mylonites and sp-tectonites was also reported by Soustelle et al (2009).

    Thanks for the hint, the citation for Soustelle et al. (2009) was added (l. 128/ 145).

Minor comments / questions:

- In all figures presenting CPO the color bars indicating the intensities of the contours are missing.

    Numbers of grains and color bars for ODFs were added to all orientation figures.

- In fig. 2 it is impossible to see the elongated opx porphyroclasts. Yet they are clearly visible in the field. Moreover, due to serpentinization and fine-grained nature of these peridotites, to define in the field variations in mineralogical composition is very difficult. Is this figure really useful?

Figure 2 was dismissed.

- In figure 3, the microstructure of the tectonite is not visible.

Contrast of tectonite overview has been increased in figure 2.

- Line 150: the peridotite solidus is not a temperature, it depends on temperature and pressure, and composition, volatiles…

Of course. In this regard it is just a citation of the estimated T conditions. P conditions were added (l 152/ 176).

- What are the arguments (=observations) used to define an intergrowth between olivine and pyroxenes (line 313)?

Highly lobate boundaries to bordering olivines and weird shaped protrusions (see figure 7; l 333/ 379).

- What do the arrows in Fig. 12 mean? In Soustelle et al. (2009), only in two samples the analyzed pyroxenes were clearly identified as secondary, that is, resulting from partial crystallization from melts. In addition, the area concerned by this study is not indicated in Fig.1 as stated in the figure caption.

Arrow description was added in figure 13. In figure 1 area of Soustelle et al. (2006) was added.