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Thermal interaction of the lithosphere and asthenosphere revealed from evolution of spatial and temporal internal variations of temperature and pressure in orogenic peridotite complexes

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Dynamics of interaction between lithosphere and asthenosphere in their boundary zones (LABZ) plays an important role in transferring heat, material, and momentum from the earth's interior to the surface. Orogenic peridotites are expected to provide direct and high-resolution information for better understanding processes taking place in the boundary zone. However, their exhumation processes obscure intact information on dynamics operating in-situ in LABZ while they could be driven and affected by processes taking place in and beneath the LABZ. This issue causes confusions in specification of timings of magmatism determining whole-rock chemical characteristics and exhumation of peridotite complexes related to deformation and subsolidus reactions. Bodinier et al. (2008) pointed out two possible formation scenarios for plagioclase peridotites: subsolidus reaction from spinel peridotites and open magmatic processes in the plagioclase peridotite facies. It is very crucial in the context of lithosphere-asthenosphere interaction to specify which was the case. In order to resolve this issue, it is imperative to clarify spatial and temporal change of pressure and temperature within orogenic peridotite complexes, which can provide valuable constraints on the LABZ dynamics by exploiting the advantage of size of orogenic peridotite complexes.

We have been examining internal variations of thermal and decompression history of world orogenic peridotite complexes. This paper focuses on the Ronda complex, where extensive melt-related processes were documented between the spinel tectonite (SP) and granular peridotite (GP) domains (e.g., Van der Wal and VIssers, 1996; Lenoir et al., 2001), while subsolidus or deformation-related origins of plagioclase in mafic rocks has been reported at several localities (Bodinier et al., 2008; Hidas et al., 2013). Modes of occurrence of plagioclase and grain-scale zoning in constituent minerals in both peridotites and pyroxenites from the western section of the plagioclase tectonite (PT) domain clearly show that most of plagioclase grains are of subsolidus origin with several exceptions. There is a systematic variation in exsolution texture in pyroxenes: thin, long, and numerous lamellae of orthopyroxene in the SP–GP domains and thick, short, and sporadic lamellae in the PT domain. There is systematic southward coarsening of products of breakdown reaction of garnet in mafic rocks from ST to GP domains with appearance of olivine-plagioclase intergrowth in GP. These data indicate that the entire complex was heated with decreasing effect of heating towards the SP domains without direct involvement of magmatism during the ascent through the spinel-plagioclase facies boundary after a cooling event. This suggests twofold lithosphere-asthenosphere interactions: one responsible for the formation of recrystallization front in the spinel facies depth with negligible thermal effect to the ST domain and the other for heating in the plagioclase facies depth and probably related to exhumation of the complex. The depth of final heating is shallower than that documented for the Horoman complex and orogenic peridotite bodies in Pyrénées, where such heating during decompression took place in the garnet – spinel facies. The contrasted modes of thermal perturbation may imply different mechanisms of lithosphere-asthenosphere interaction, such as active upwelling vs. passive upwelling.