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Metamorphic and magmatic overprint of garnet pyroxenites/peridotite from the Beni Bousera massif (Northern Morocco): Mineralogical, chemical and textural records

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A detailed mineralogical and textural study of two garnet pyroxenites of the Beni Bousera massif, the garnet clinopyroxenite (GP) and the garnet clinopyroxenite containing graphite pseudomorphs after diamond (GGP), indicates a strong metamorphic overprint associated with the massif exhumation. In both pyroxenites, the primary assemblage [Cpx(I) + garnet +/- Opx] records temperatures in excess of 1200°C. Along the exhumation path, Cpx(I) has decomposed according to an overall reaction:
Cpx(I) = 0.55-0.60 Cpx(II) + 0.30-0.35 Opx + 0.03-0.05 Gt + 0.03-0.5 Pl.
This breakdown reaction occurred under sub-solidus conditions in at least two stages, which led first to pyroxene exsolution lamellae and second to garnet crystallization at the expense of the newly formed Cpx lamellae. These secondary garnets have grown in the 850-950°C temperature range. We show that these conditions are below the blocking temperature of the Mg-Fe exchange between garnet and pyroxene (ca. 1050°C) and above the blocking temperature of Mg-Fe interdiffusion in garnet.
Consequently, the original composition of these secondary garnets has not been modified upon further cooling; equilibrium with the appropriate lamellar pyroxene can be used to retrieve meaningful P-T couples. This is however not the case for pairs of pyroxene inclusion and their porphyroclastic garnet host, formed earlier in the Beni Bousera history (i.e. at higher grade) and for which decoupling between Al diffusion and (Mg,Fe) interdiffusion in pyroxene has occurred. It appears that conventional thermobarometric approaches will fail at deciphering reliable exhumation scenario for the Beni Bousera massif at the lithospheric scale.
The late evolution of the Beni Bousera massif is recorded in the pyroxenites by the decomposition of primary garnet porphyroclasts into symplectite intergrowths at around 800-850°C below 10 kbar. These late conditions coincide with two major events, (1) the increase of the water activity in GP as shown by the crystallization of pargasitic amphibole which suggest the proximity from crustal units and (2) a temperature increase up to ca. 1050°C at most, which led to partial melting in both GP and GGP in the presence of water. Input from advective heat is likely responsible for that late temperature increase by about 200°C at lower crustal levels (ca. 25 km depth). This thermal event is can be seen as a pulse since it is followed by efficient/rapid cooling in order to prevent the formation of plagioclase-bearing peridotites in the Beni Bousera massif.
Detailed chemical inspection of Gt–Cpx–Opx inclusions in the graphite pseudomorphs using LA-ICP-MS ablation, FEG-SEM and the electron microprobe indicates that (1) these silicates are genetically related to the same minerals in the bulk rocks and (2) they were chemically isolated from the bulk rock (included in diamond and/or graphite). A garnet-bearing peridotite found in the vicinity of garnet websterite layers has also been investigated to complement the P-T path of the Beni Bousera massif on the high-pressure side. This sample turned out to result from mechanical mixing between spinel peridotite and garnet websterite and appeared therefore as useless for further P-T derivation.