

Metamorphic and magmatic overprint of garnet pyroxenites 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 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.

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 a major event: 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. The partial melting is evidenced by the presence of silicate films preserved in the graphite aggregates and the occurrence of interstitial amphibole and plagioclase.

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).

Ocean Geochemistry and Paleoproxies: Deep ocean carbonate ion through six glacial-interglacial cycles

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The presence of carbonate cycles in deep ocean sediments has been the subject of longstanding debate with much recent work supporting the view that changes in carbonate ion are responsible. Estimates of palaeo-carbonate ocean chemistry from boron incorporation in foraminifera provide important evidence. [CO₃²⁻] estimates also play a role in paleothermometry with debate as to the roles of ocean chemistry versus dissolution. Here we present data of behaviour of epifaunal and infaunal benthic species, factors influencing porewater [CO₃²⁻], and possibly boron coordination and emerging proxies. This is followed by evidence for elevated alkalinity in the glacial ocean with emphasis on sites within Circumpolar Deep Water.