Melting texture and microdiamonds preserved in graphite pseudomorphs from the Beni Bousera peridotites massif, Morocco

This poster participates in OSP

Outstanding Student Poster Contest

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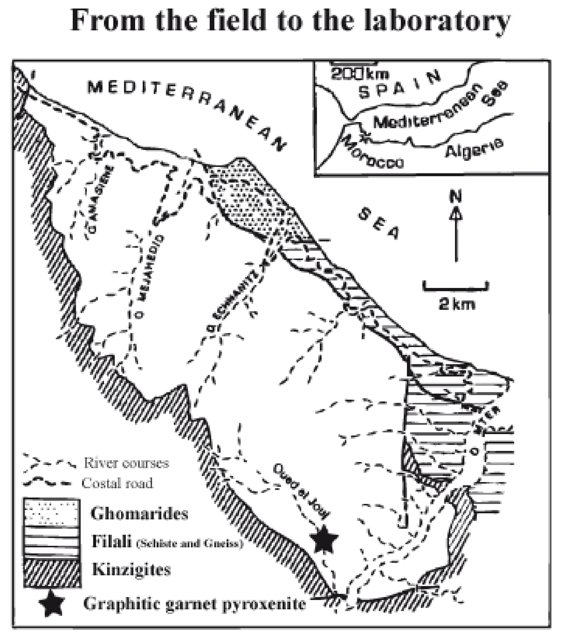
Abstract

Over 30 graphite aggregates that represent pseudomorphs after diamond were manually extracted from a garnet pyroxenite layer in the Beni Bousera peridotite massif, northern Morocco. The inclusions present in the aggregates were characterized by combining scanning electron microscopy, micro-Raman spectroscopy and cathodoluminescence. Large composite clinopyroxene–orthopyroxene–garnet inclusions (ca. 500 mm across) are common in the core of the graphite aggregates. Silicate films with a thickness of a few micrometres ubiquitously occur intercalated between graphite flakes. They are of basaltic composition and are interpreted as partial melts formed by in situ melting of the large composite inclusions and, possibly, of the host pyroxenite, during the Beni Bousera massif uplift. In addition, various solid inclusions composed of chlorides, sulphates and carbonates are found to be evenly distributed irrespective of the graphite aggregate texture (coarse in the core, in some instances fine-grained on the rim). Diamond crystals, 0.5–2 mm in size, were also observed in several aggregates, apparently included in large graphite flakes, and were characterized using cathodoluminescence and Raman micro-spectroscopies. They are interpreted as relics of large mantle-stage diamonds, now heavily graphitized. This finding confirms earlier propositions that the graphite aggregates in Beni Bousera and Ronda garnet pyroxenites are pseudomorphs after diamond and raises questions on the kinetics of graphitization.

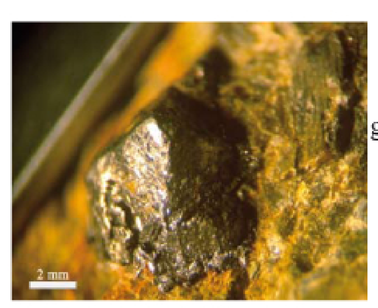
Introduction

From the field to the laboratory



The occurrence of graphitic garnet pyroxenites in the ultramafic massif at Beni Bousera, Morocco

The graphitic garnet pyroxenites (GGP) mafic layers outcropping in the streambed of oued el Jouj



Photograph of a cubo-octahedral graphite aggregate (ca. 1mm across) still attached to the host garnet pyroxenite and displaying {111} faces (four-fold axis piercing toward the upper left)

- *We report on the nature of micro-inclusions in graphite pseudomorphs after diamond.*
- *We establish the presence of residual microdiamond and textural evidences for partial melting are found.*

NB: no cutting nor polishing diamonds were used in this study

Conclusions

Micro-diamonds are included in large graphite flakes from the core of the aggregates. They are interpreted as relics of the original diamond ,which survived to graphitization. The presence of these microdiamonds confirms that the graphite aggregates in Beni Bousera (and probably Ronda) garnet pyroxenites are indeed pseudomorphs after diamond.

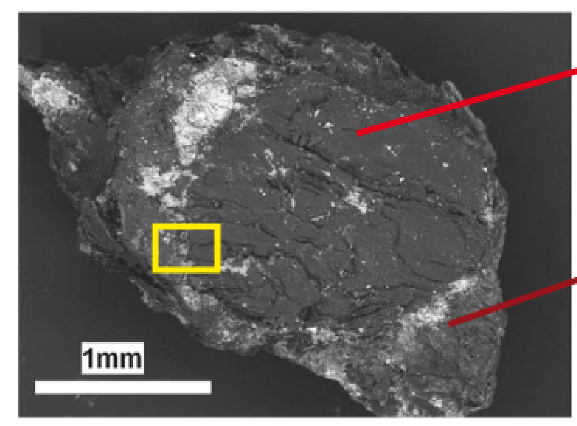
Graphite aggregates in garnet pyroxenite from Beni Bousera reveal (1) deep-seated origin of the host rock and (2) a partial melting event.

The temperature in the Beni Bousera massif has reached values as high as ca. 1100°C which led to partial melting of the graphite-garnet pyroxenite, during the Beni Bousera massif uplift. The preservation of microdiamonds under such conditions raises questions on the graphitization kinetics of large diamonds.

Results

Morphology, petrology and texture of the graphite aggregates

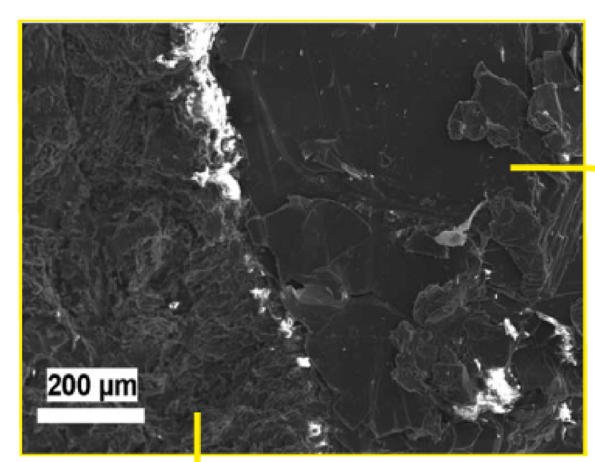
FE-SEM images (BSE mode, no coating) of graphite pseudomorphs extracted from the garnet pyroxenite host-rock and broken manually with a metal needle into two pieces.

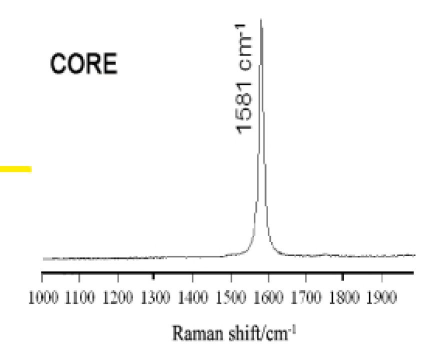


Large graphite flakes (>500µm across) exposed in the centre of the aggregate. This large-flakes zone is rimmed by insulating silicate matter.

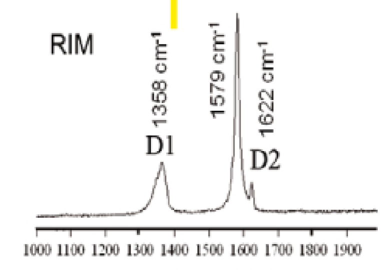
The bottom right apex of the aggregate is composed of smaller graphite grains (<100µm)

Contact between large graphite flakes (Core) and the outer rim of the aggregate made of graphite grains with shorter graphene planes (10-50 µm)



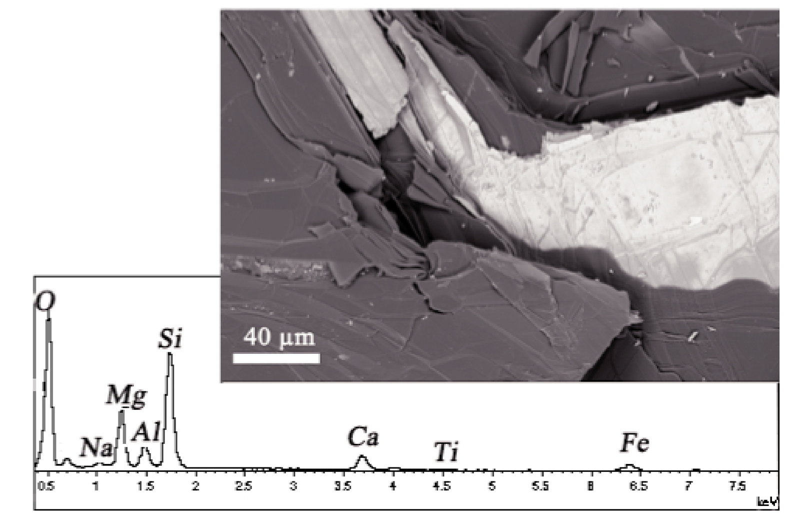


Large flakes, ca.500µm (Core) display Raman spectra of perfectly ordered graphite with no measurable defect band

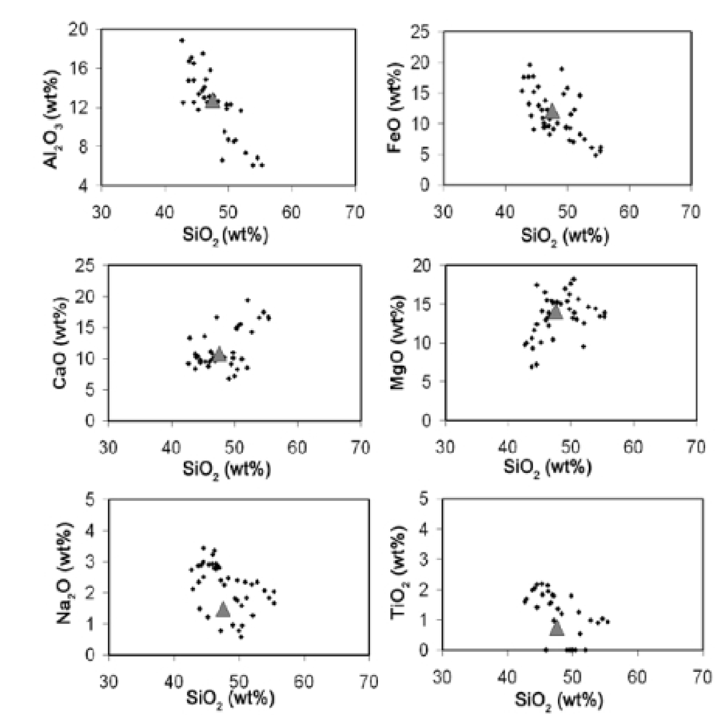


The smaller graphite flakes found toward the specimen rim show defect bands (D1 and D2) centred around 1358 and 1622 cm^{-1}

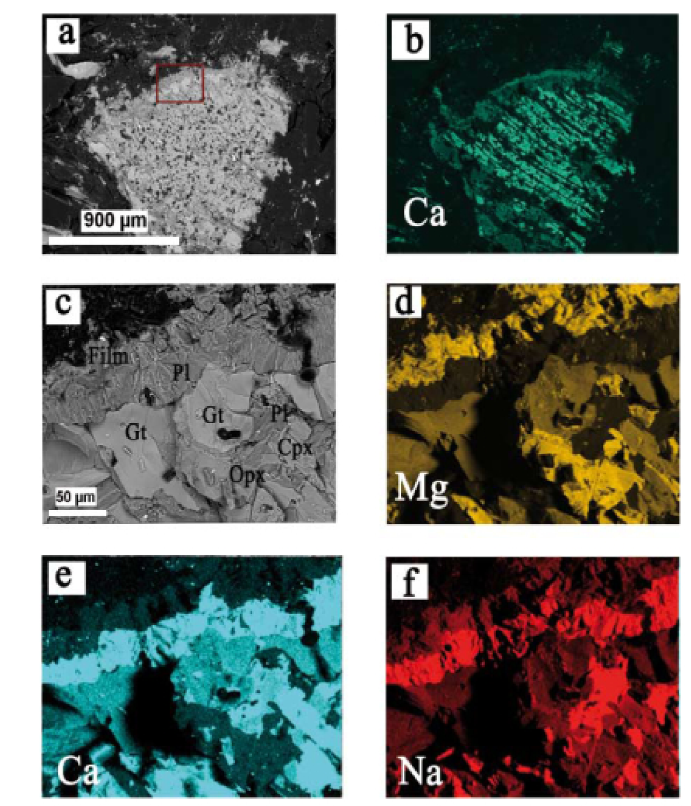
Intercalated silicate film inclusions



FE-SEM image (BSE mode on uncoated sample) of a thin film of insulting material (high brightness due to electron accumulation) intercalated between stacks of (001) graphitic planes. The thin film is displayed on the EDS spectrum, which shows SiO2, MgO, Al2O3 and CaO as main oxide constituents.



Semi-quantitative oxide content (EDS) of the silicate films compared to the average bulk composition of the graphitic garnet pyroxenite (Triangles: Pearson et al., 1993) plotted against SiO2 content.



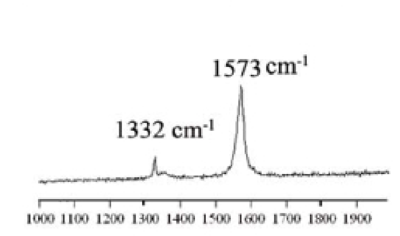
SEM imaging and elemental X-ray mapping on a macro-inclusion (ca. 1 mm) in the core of a graphite aggregate. (a) BSE image after gold-palladium coating. (b) The CaKa1 X-ray map outlines striped texture composed of orthopyroxene lamellae (dark) exsolved within a clinopyroxene grain (white stripes) as well as a thin plagioclase-rich symplectite rim. (c) Enlargement of the symplectite rim, BSE image (Gt, garnet; Opx, orthopyroxene; Cpx, clinopyroxene; Pl, plagioclase; Film, thin silicate film). The exact location of this zone is indicated on (a). (d) Mg X-ray map emphasizes (bright) both Opx and film whereas the Ca map (e) outlines both cpx and plagioclase, so does the Na X-ray map (f).

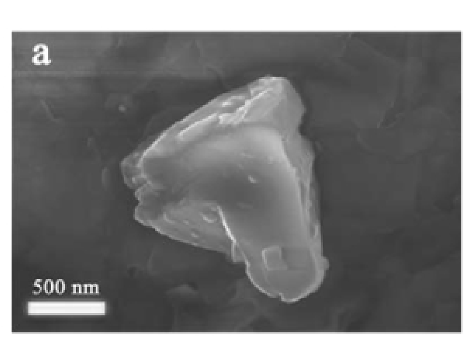
- *The silicate films display a major-element composition (semi-quantitative) which falls close to the average pyroxenite whole-rock composition of Pearson et al. (1993).*
- *Textural relationships within a graphite aggregate indicate that the film arises from partly retrogressed pyroxene-garnet inclusions, which appear to be the melt source.*
- *The widespread distribution of these films all over the graphite aggregate suggests that part of the included films may also originate from melting of the host-rock minerals.*

Diamond micro-crystals

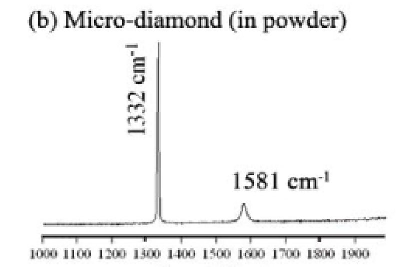
FE-SEM images (SE in-lens) of diamond micro-crystals and corresponding micro-Raman

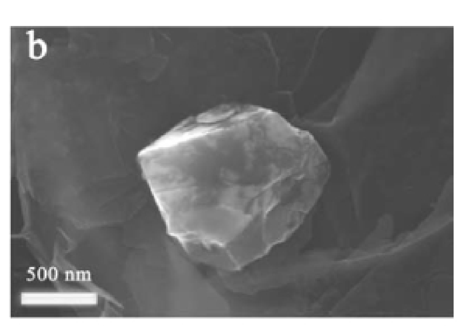
(a) Micro-diamond (in powder)





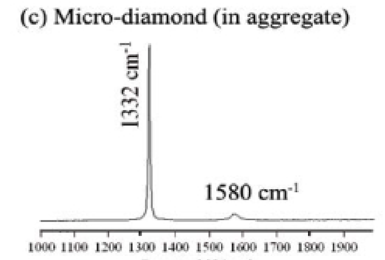
(b) Micro-diamond (in powder)

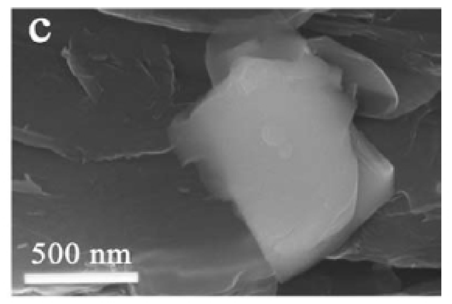




Two diamond micro-crystals from graphite aggregates ground to powder

(c) Micro-diamond (in aggregate)



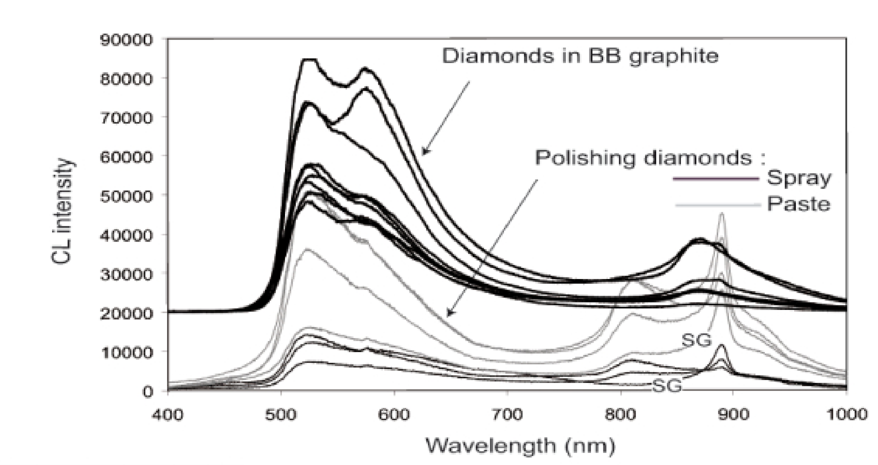


Freshly broken aggregate, with the preservation of original textural relation between micro-diamond (bright) and host graphite aggregate (dark flakes)

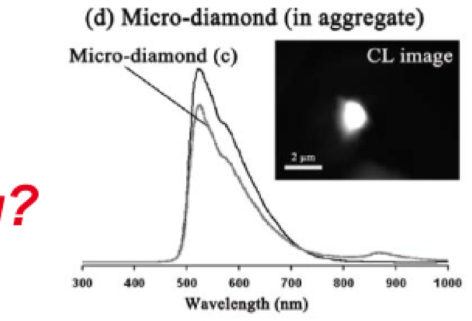
Are these diamonds artefact or rock-forming?

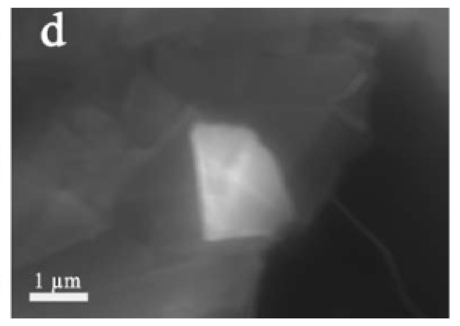
The cathodoluminescence study

Comparison between CL emission spectra of a polishing diamond population (spray and paste used at ENS) and diamond inclusions in their graphite host (top spectra), in the 400–1000 nm wavelength range. The spectrum of two polishing diamond single grains is also displayed, noted SG on the Figure.



(d) Micro-diamond (in aggregate)





Example of diamond grain located using CL with the corresponding CL image and spectrum compared to that of the diamond displayed (c)

From the cathodoluminescence spectra:

- *It is shown that polishing diamonds and microdiamonds in BB graphite are different.*
- *We contend that microdiamonds observed in graphite, formed in situ and are no contamination material. CL is an interesting tool for such discrimination.*

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