Evidence of Faulting within Ureilite Miller Range (MIL) 090980

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Introduction:

- Ureilites are the second largest group of achondrites
- There are no good candidates for the ureilite parent body (UPB) in the asteroid belt.
- Comprised of olivine, pyroxene and carbon-rich aggregates containing crystalline graphite and nano-diamonds [1]. Carbon phases are up to 8.5 wt% of samples [2].
- Origin of diamonds debated, some authors hypothesise a large (Mercury-Mars sized) ureilite parent body with high static pressures [3].
- Alternative theories around the nano-diamonds in particular suggest shock transformation from graphite [1].

Key Points:

- Ureilite MIL090980 contains micro-faults cross-cutting the veins indicating brittle deformation affecting the sample.
- Sample has been affected by shock causing fracturing of the silicate minerals.
- Diamonds are present within the carbon-rich areas.
- Presence of brittle faulting and diamonds suggests the diamonds grew through shock induced growth.

Methods

MIL 090980 was analysed at the University of Glasgow through:

- SEM and optical microscopy (texture)
- EDS (Chemistry)
- EBSD and Raman (Crystallography)

EDS Data

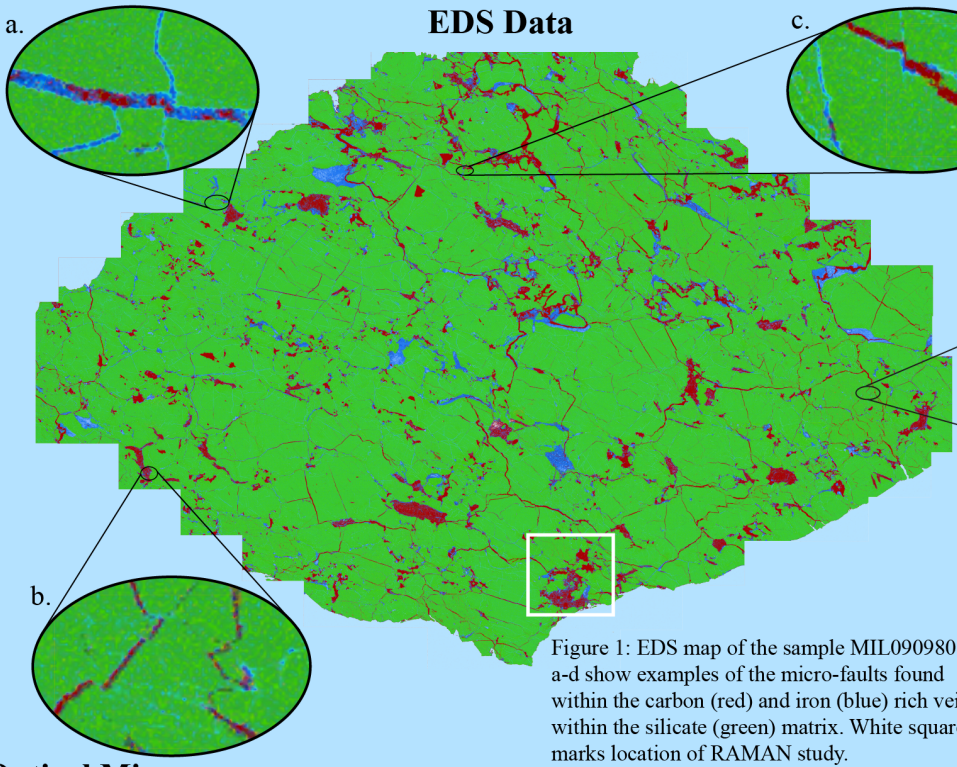

Figure 1: EDS map of the sample MIL090980; a-d show examples of the micro-faults found within the carbon (red) and iron (blue) rich veins within the silicate (green) matrix. White square marks location of RAMAN study.

Optical Microscopy

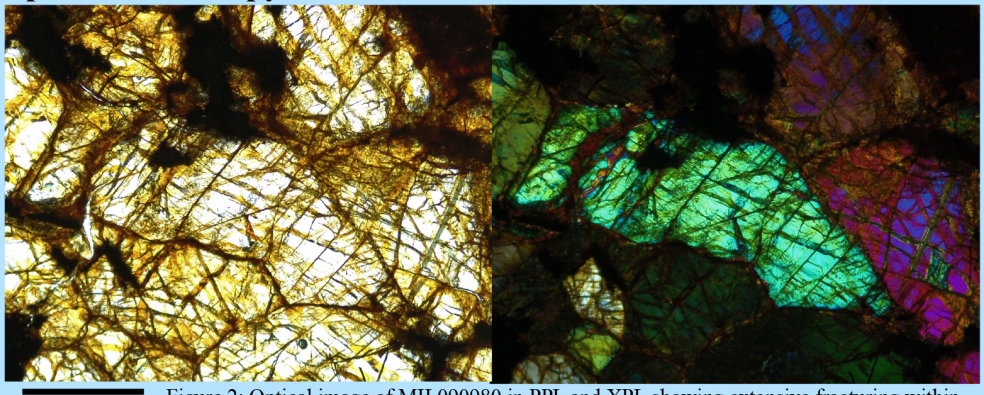

Figure 2: Optical image of MIL090980 in PPL and XPL showing extensive fracturing within silicate minerals.

RAMAN

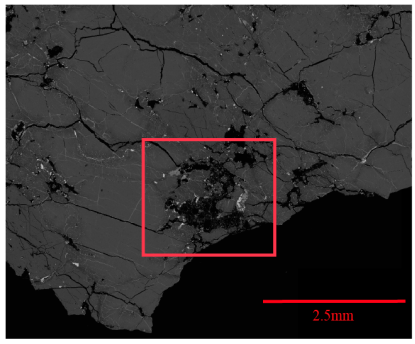

Figure 3a) Back-Scatter Electron image showing location (red square) of RAMAN measurements within carbon-rich region of MIL090980. This area matches location marked with white square on Figure 1.

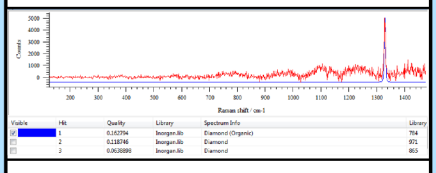

Figure 3b) Measurement of one strong peak at 1331cm^{-1} representing diamond.

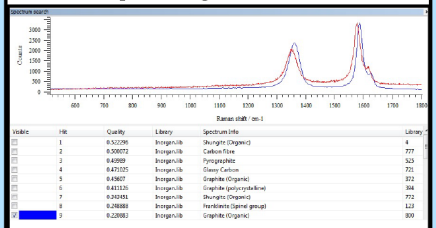

Figure 3c) Measurement of two peaks at 1350cm^{-1} and 1580cm^{-1} representing the D and G bands of graphite.

Results and Discussion

- Figure 1 shows series of veins that pervade the same that are both carbon-rich (red) and iron-rich (blue).
- All veins are displaced by micro-faults, e.g. Figure 1a-d, indicating displacement occurred after vein formation.
- Micro-faults have a prefferred orientation between 90-180° indicating they all formed within the same stress field.
- Optical images (Figure 2) shows the sample has experienced shock due to planar fracturing within olivine.
- Carbon rich mineralogy is comprised of diamond (Figure 3: thin 1330 peak) and graphite (Figure 3: D and G bands at 1350 and 1580 [4]).
- Micro-faults present in the sample (Figure 1) indicate sample was in the brittle deformation zone of the UPB, or that they were generated by shock.
- This ureilite samples a shallow portion of mantle above the brittle-ductile transition.
- Diamonds found in this sample likely shock derived due to shallow depth of formation of the meteorite on the UPB.

References and acknowledgements

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We thank the Smithsonian for loaning the sample to be studied.