THE PROCESSING OF GRAPHITE IN UREILITES OBSERVED BY RAMAN SPECTROSCOPY.

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Introduction: With up to 8.55 wt% carbon [1], ureilites are the most carbon-rich meteorites. Graphite is the most abundant carbon allotrope, typically located in interstitial sites between silicate grains. Main group ureilites have experienced varying degrees of shock processing, altering their texture [e.g., 2]. Understanding the carbon mineralogy is crucial for interpretations regarding the processing of the ureilite parent body (UPB) [e.g., 3, 4], the debated origin of diamonds [e.g., 5–7], and graphite-based geothermometry [e.g., 8].

Methods: Raman spectra were obtained in 14 samples with a IDR-Micro-532 micro-Raman spectrometer. A Nd:YAG laser with a wavelength of 532 nm, and a laser power of 1.1 mW on the sample surface was used. An analysis consisted of a measurement time of 10 s with 5 accumulations. The statistical evaluation included baseline subtraction, peak identification, and the extraction of selected parameters (e.g., G band position and FWHM).

Results: Based on the texture, the investigated samples can be catergorized into coarse-grained and fine-grained ureilites. The G band positions of graphite in coarse-grained ureilites cluster in a confined range between 1580–1583 cm^{-1}, corresponding to crystalline graphite. Shock indicators in olivine [cf. 9] suggest that these coarse-grained samples have experienced relatively low shock pressures up to 15–20 GPa. In contrast, the Raman signatures obtained in fine-grained ureilties show a large variability and significantly higher G band positions/FWHMs, which can be attributed to a high degree of crystallographic disorder. Overall, the G band position and the G band FWHM show a nearly linear positive correlation.

Discussion: A strong correlation between the texture (coarse-grained and fine-grained) and the Raman signature of graphite (crystalline graphite and disordered graphite/poorly graphitized carbon) can be observed. This raises the question, which underlying process is responsible for the increased crystallographic disorder present in graphite in fine-grained ureilites? One key observation is that the carbon phases in fine-grained ureilites often occur in textural units, which resemble the shape of graphite grains found in coarse-grained ureilites. This suggests that graphite was highly crystalline in the first place, and was subsequently replaced/modified by parent body processing. The resulting carbon phases in fine-grained ureilites are considerably more diverse compared to coarse-grained ureilites, where graphite is by far the dominant carbon allotrope. Most likely, the underlying mechanism is related to the same process, which lead to mosaicism and the visible fragmentation of silicates. In this case, the process should be related to post-accretionary shock, induced by high velocity impacts. Yet, it is unclear whether disordered graphite is a direct product of the transformation from highly crystalline graphite, or if disordered graphite might also result from the back-transformation of diamond.

Conclusion: The parent body processing of ureilties has a significant effect on the carbon mineralogy. The G band parameters of graphite in fine-grained and coarse-grained ureilites form two clusters, which plot on a nearly linear trend reflecting crystallographic order. Presumably, the underlying process is related to the post-accretionary shock processing of the ureilite parent body.

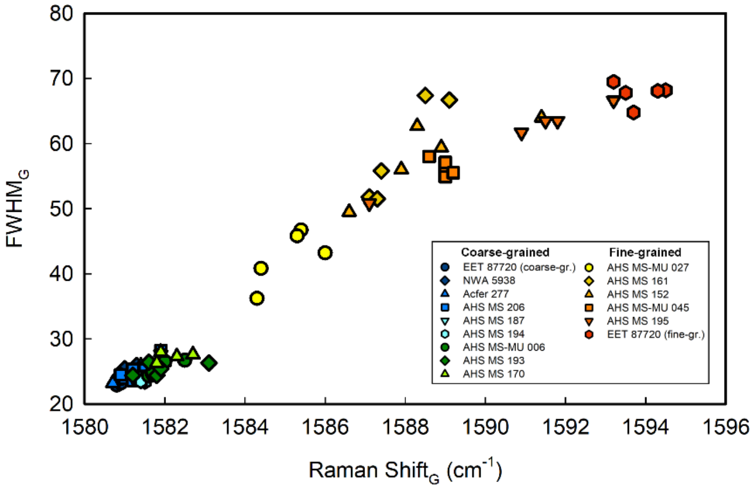

Fig.1: Raman spectra (G band parameter) of graphite in ureilites.

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