CARBON POLYMORPHS IN FRONTIER MOUNTAIN UREILITIC METEORITES: A CORRELATION WITH THE INCREASING DEGREE OF SHOCK?

A. Barbaro[1], M. C. Domeneghetti[2], A.M. Fioretti[3], M. Alvaro[2] and F. Nestola[1]
[1]Department of Geosciences, University of Padova, I-35131 Padova, Italy (barbaroanna08@gmail.com ; fabrizio.nestola@unipd.it), [2]Department of Earth and Environmental Sciences, University of Pavia, 27100 Pavia, Italy (chiara.domeneghetti@unipv.it; matteo.alvaro@unipv.it), [3]Institute of Geosciences and Earth Resources, National Research Council, I-35131 Padova, Italy (anna.fioretti@igg.cnr.it)

Introduction: Carbon phases occur in different kinds of meteorites, spanning from undifferentiated to differentiated ones. In particular, carbon phases are common in ureilites, a still enigmatic group of achondrites. Ureilites are ultramafic rocks, mainly composed of olivine and pyroxene (mainly pigeonite, +/- orthopyroxene and augite) and minor (up to ~8.5 wt.%) carbon phases (mostly graphite and diamond) [1, 2, 3]. The origin and history of carbon phases in ureilites are important for understanding their petrogenesis and the distribution of carbon in the early Solar System. Recent studies on ureilites [4, 5, 6, 7] indicate that the coexistence of large monocrystalline diamonds, nano-diamonds together with nano-graphite is consistent with a transformation of graphite enhanced by the catalysis of Fe-Ni phases during impact shock events.

Sample and methodology: we analysed five olivine-pigeonite ureilitic samples (FRO 95028, FRO 01089, FRO 97013, FRO 01088 and FRO 01012), with different shock degrees. In particular, the shock level of the investigated samples ranges from U-S2 (low shock degree) to U-S6 (very high shock degree) [8]. In order to obtain information on the carbon-bearing aggregates (diamond, graphite, and minor Fe-Ni alloys), we adopted the same experimental approach reported by [4, 5, 6, 7]. In particular, we performed scanning electron microscopy [equipped with energy dispersive spectroscopy (SEM-EDS)], micro-X-ray diffraction (XRD), and micro-Raman spectroscopy (MRS) to characterize the carbon phases and to observe if there is any correlation between the degree of shock recorded by silicates and the presence of the different carbon polymorphs.

Results and Discussion: XRD patterns showed that all investigated samples contain nano-graphite. Besides this phase, sample FRO 95028, with the lowest (S2) shock degree, contains nanodiamond, while samples from S3 to S6 contain both nano- and micro-diamond. The powder diffraction patterns of each of the selected fragments revealed (i) on the highest peak of graphite (at *d*-spacing=3.34Å) an asymmetry which, as reported by [9], is indicative of "compassed graphite" and (ii) on the highest peak of diamond (*d*-spacing 2.06 Å) a shoulder at *d*-spacing 2.18 Å, suggesting the presence of stacking disorder; both (i) and (ii) are considered markers of impact event(s) [9, 10].

For all samples, the graphite geothermometer, based on MRS data [11, 12] provided temperatures in the range of 1291 to 1398°C ±120°C. As it is evident by these results, taking into account the error range of these measurements, in our samples [11, 12] we did not observe a considerable variation of the graphite temperature with the increase of the degree of shock.

Conclusions: XRD results support the formation of micrometer-diamonds found in FRO 01089, FRO 97013, FRO 01088 and FRO 01012 with the assistance of (Fe, Ni)-alloys as catalysts at pressure >10 GPa (S3 shock level recorded by silicates). The formation of polycrystalline diamond, as demonstrated by the results obtained in FRO 95028 low shock ureilite (S2), is allowed at pressure between 5-10 GPa. Application of graphite geothermometer based on MRS data [11] does not show any obvious correlation between temperature and shock stage between low-medium and high shock ureilitic samples.

Acknowledgments: *This research was funded by the PNRA 2018 00247-A project to F. Nestola.*

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