CARLETONMOOREITE (Ni_3Si) IN SHOCKED DIAMOND-BEARING KENNA UREILITE.

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Introduction: The origin and history of carbon phases (up to ~8.5 wt.%) in ureilites are important for understanding their petrogenesis and the distribution of carbon in the early solar system. Ureilites are a major group of achondrites [1, 2], which consist of ultramafic rocks, mainly composed of olivine and pigeonite, and minor carbon (mostly graphite and diamond) [3]. Recent studies on ureilites [4, 5, 6] stated that the coexistence of large monocrystalline diamonds, nanodiamonds together with nanographite in ureilites could be explained by the transformation from graphite enhanced by the catalysis of Fe-Ni-C liquid during impact shock events.

Sample and methodology: This study was performed on the Kenna meteorite, which is an ureilite recovered in February 1972 near the town of Kenna, Roosvelt County, New Mexico (USA). In order to obtain reliable information on the carbon-bearing aggregates (diamond, graphite, and minor phases) contained in the Kenna ureilite, we adopted the same experimental approach by [4, 5, 6]. 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 estimate the pressure (by textural features of silicates) and temperature (by graphite geothermometry [7, 8]) conditions undergone by this meteorite.

Results and Discussion: In addition to olivine and pigeonite, within the carbon-bearing areas we identified microdiamonds (up to about 10 μm in size), nanographite and magnetite. During our investigation, for the first time in ureilites, and as a second finding in a natural sample, the Ni_3Si phase, called carletonmooreite (IMA 2018-068), was found. It was originally discovered in 2018 within the Norton County aubrite meteorite [9,10].

The shock features observed in the silicate minerals as well as the presence of microdiamonds and nanographite indicate that Kenna underwent a shock event with a peak pressure of at least 15 GPa. Temperatures estimated using a graphite geothermometer are close to 1180 °C. Thus, Kenna is a medium-shocked ureilite, yet it contains microdiamonds, which are typically found in highly shocked carbon-bearing meteorites, instead of the more common nanodiamonds. This can be explained by a relatively long shock event duration (in the order of few seconds) and/or by the catalytic effect of Fe-Ni phases (e.g., carletonmooreite) known to favor the diamond crystallization.

Conclusions: Combining our results, with those in [4, 5, 6], we confirm that the mineral association constituted by nanodiamonds, microdiamonds, and nanographite found in ureilites was produced by impact(s) at peak pressures no lower than ~15 GPa [4]. The nanometric size of graphite and carletonmooreite indicates that they record shock conditions which occurred during impact events involving the ureilite parent body. Then, the temperature obtained from graphite would represent the temperature related to the shock event. The presence of carletonmooreite (Ni_3Si) in the Kenna sample also highlights the important role that Fe-Ni phases can play in diamond growth.

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