SHOCK TEMPERATURE RECORDED BY GRAPHITE IN UREILITES FROM ALMAHATA SITTA.

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Introduction: Ureilites are a major group of achondrites that have very high (up to ~8.5 wt.%) carbon contents [1,2]. The origin and history of their carbon phases (mainly graphite and minor diamond) are important for understanding their petrogenesis, and the distribution of carbon in the early solar system. We have been studying the origin of diamonds in ureilites from Almahata Sitta [3,4]. The Almahata Sitta meteorite fell in 2008 from the impact of asteroid 2008 TC_3, and is a polymict breccia with approximately 70% ureilitic clasts [5,6]. These ureilite samples have the lowest degree of terrestrial weathering of any ureilites, which makes them ideal for studying the origin of the carbon phases in ureilites.

In Almahata Sitta (AhS) ureilites 72 and 209b [4], diamonds with crystallite sizes at the nanometric scale (diamond particles < 100 nm) were found associated with nanographite. This same association was found in main group ureilite NWA 7983, and also included micrometric sized diamonds [3,4]. The diamonds in these samples were interpreted to be a product of impact shock from original graphite.

Aim: In order to obtain reliable information on the temperature evolution recorded by the graphite phases in ureilites, we applied a graphite-based geothermometer (applied to chondrites by [7], and to other AhS ureilites by [8]) on non-polished fragments of AhS 209b, AhS 72 and AhS A135A.

In addition, using calibrations by [9,10] based on the ratio of Raman D-bands and G-bands intensities, we were able to determine the crystallite size of graphite. These results could provide crucial information on the thermal history and origin of the graphite and associated diamonds.

Experimental: The Raman spectra of graphite from three ureilitic stones (AhS 209b, AhS 72 and AhS A135A) were collected by Micro-Raman Spectroscopy (MRS). **Fig.1** shows the characteristic peaks positions of the G, D and D' bands of graphite present in the investigated AhS samples. These analyses were performed in order to retrieve the temperature recorded by graphite, hereafter T_{max}, using the approach adopted by [8]. This approach is based on the measurement of the Full Width at Half Maximum (FWHM) of the graphite G band which, by comparison to previous geothermometric approaches, can provide temperatures of high temperature environments (i.e.>900-1000 °C). In addition, the peak position of the graphite Raman spectra and the I(D)/I(G) ratio (I=integrated intensity; D=D band; G=G band) obtained by MRS allowed us to assess the crystallite size of the investigated graphite [8].

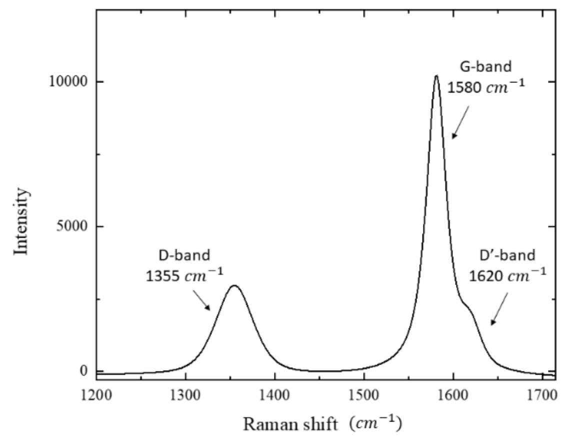

Fig.1 Raman spectrum of graphite in AhS 209B.

Results: The calculated temperatures are close to 1200-1300 °C (±120 °C) slightly higher than 990 (±120) °C reported by [8] on the ureilitic fragment AhS 7. However, if we account for the temperature uncertainties of this approach (i.e. ±120 °C), our data agree with those by [8]. This range of temperatures also agrees with peak equilibration temperatures of ureilites determined by pyroxene thermometry [11,12]. Graphite in our samples is disordered and shows a crystallite size ranging between about 60 and 150 nm in agreement with that observed in [4] by X-ray diffraction.

Conclusion: Combining our results with those of [4,5] we suggest that the mineral association of nanodiamonds, microdiamonds and nanographite in ureilites was produced in an impact event at peak pressures not higher than ~15 GPa (based on olivine mosaicism, see [4]). The temperature obtained from graphite would represent the temperature related to the shock event. Although the obtained temperature is similar to igneous equilibration temperatures of ureilites, the observation that the graphite is nanometric, rather than in the form of large single crystals as in non-shocked ureilites [1,13], argues that it- records shock conditions. This impact shock event could have occurred during the catastrophic disruption of the ureilite parent body.

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