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Ureilite Graphite: Shocking implications

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UREILITE GRAPHITE: SHOCKING IMPLICATIONS. C. L. Smith^{1, 2}, I. A. Franchi¹, I. P. Wright¹, M. M. Grady², C. T. Pillinger¹. PSSRI, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK, (C.L.Smith@open.ac.uk), ²Mineralogy Department, The Natural History Museum, London, SW7 5BD, UK.

Introduction: The ureilites are C-rich, ultramafic achondrites whose petrogenesis remains ambiguous. Paradoxically they display both differentiated (e.g. igneous textures) and primitive characteristics (e.g. O mass independent isotope signatures) [1,2].

The carbon in the ureilites clearly plays an important role in their petrogenetic history although its origin is a subject of controversy. It may be a primary feature retained from a carbonaceous chondrite (CC) - like precursor material or it may be a secondary feature injected into the juvenile ureilite parent body (UPB) during a planetesimal scale impact event [3,4]. We have previously reported initial results from a study into ureilite carbon [5]. Here we report new data from both ureilites and terrestrial graphite samples which indicate a clear relationship between the form of ureilite C and its isotopic composition.

Method & Results: Ureilites, and terrestrial graphite samples of known crystallinities (determined by both XRD analysis and Raman spectrography), were analysed using a combination of high-resolution stepped combustion and mass spectrometry [5].

The terrestrial graphite samples show a clear relationship of increasing temperature range over the main release, from 175 to 275°C with increasing crystallinity, and an increase in peak release temperature from 652 to 864°C. The ureilite data show good trends of increasing range in release temperature and $\delta^{13}\text{C}$ against C content. These variations also parallel increasing shock levels in the samples. This variation of decreasing C content and increasing $\delta^{13}\text{C}$ (more accurately range in $\delta^{13}\text{C}$) with release range (i.e. degree of shock) indicates the operation of more than one controlling factor. No obvious correlation between peak release temperature and any other parameters is clear in the ureilite samples suggesting that the release broadening is a function of increasing heterogeneity in the graphite's crystallinity rather than simply increasing crystallinity per se.

Shock may be an appropriate mechanism to increase the heterogeneity of graphite crystallinity as simulations show that although graphite becomes structurally disordered during shock the propagation of the shock wave is complex and heterogeneity occurs even on a very small scale [6].

Discussion: A number of possibilities may account for the relationships seen within the ureilites.

It has been suggested previously that amorphous or semi-ordered ureilite graphite may be a relic of primitive C material inherited from a CC-like precursor material [7]. This being the case low crystallinity C enriched in ^{12}C may be primary ureilite graphite, which

was then mixed with variable amounts of impactor C enriched in ^{13}C . Mixing variations will result in increasing modification of C content and isotopic composition.

Alternatively, modification of the indigenous carbon could occur during high temperature conditions on the UPB (as a result of shock and/or internal heating). These conditions may result in preferential loss of ^{12}C -rich volatiles (CO_2) through interaction of graphite with surrounding material e.g. during smelting reactions. The extent of heating will influence the degree of reaction causing a variation of both $\delta^{13}\text{C}$ and crystallinity in the resulting graphite. If the heating is shock induced then the extent of the reaction will vary with shock level.

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