THE BULK PROPERTIES OF BUNBURRA ROCKHOLE: RESULTS OF MICRO-CT SCAN ANALYSIS.

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Introduction: The Bunburra Rockhole meteorite (BR) represents a rare recovered sample where the orbit was simultaneously recorded. It was collected following observations by the Desert Fireball Network [1], from the Nullarbor Desert in Western Australia in October 2008. Fall position was calculated following analysis of the fireball and calculation of dark flight trajectory, and samples were recovered within 100m of the predicted fall site. Initial analysis of the meteorite showed it to be a basaltic achondrite, similar in texture, modal mineralogy, and mineral chemistry to a 'normal' eucrite [2-5], but with an anomalous oxygen isotope ratio [2] (i.e. different from the Howardite-Eucrite-Diogenite family believed to originate from asteroid (4)Vesta [6]). With a $\Delta^{17}O$ value of -0.112, it is clear that BR lies significantly off the Howardite-Eucrite-Diogenite mass fractionation line. Oxygen is also more variable than in a typical non-cumulate eucrite [2], and dynamically it is difficult to connect the measured orbital parameters to the Vestoids, further supporting an origin distinct from (4)Vesta.

As part of an ongoing consortium study to better understand the petrogenesis of this unusual meteorite, we have collected microCT scans of the recovered samples, to characterize the internal structure, and map the mineralogy prior based on density contrast prior to any more detailed destructive analysis. Such data is useful for planning further analysis, but it is also helpful in analyzing the observed fireball data, allowing us to better understand the relationship between fireball behavior and meteorite type. Analysis of the distribution of fractures within the main masses may also allow us to determine the size-frequency distribution of potential 'fragments', and establish a link between fragmentation based on fireball observations and recovered meteorite samples.

Method: BR consists of two separate recovered samples: a 150 g piece (referred to as BR1), and a 174 g piece (BR2). Both samples were scanned in the Natural History Museum, London, using a cone beam projection HMXST 225 system and reconstructed using CT-PRO 2.0 (Metris X-Tek, Tring, UK). Analysis of the resulting scans was carried out using Blob3D [7], and VG Studio Max 2.0 (Volume Graphics, Heidelberg, Germany). Data volumes for a given scan are in the range 50-70 GB, and voxel size on the order of ~30 µm.

Results: Figure 1 and 2 show one horizontal scan through BR2 and BR1 respectively. They illustrate the typical features observed. Both samples are brecciated at scales ranging from 10's µm up to a centimeter, with clasts grouped into three broad lithological sub-types based on grainsize. These differing textures can be clearly seen in both scans (compare bottom right to top left in Figure 1). Samples also show infrequent curvilinear cracks - the 3D density model provided by the micro-CT scan makes it a simple matter to delineate individual 'fragments' within the BR1 and BR2. In addition, the density contrast between pyroxene and plagioclase allows those minerals to be clearly discriminated. Smaller grains of higher density material (primarily chromite [2]) are scattered throughout the sample - one is visible at centre-top in the scan in Figure 1. Additionally, the glassy fusion crust can be clearly seen in the scans (see Figure 1 top-right sample boundary).

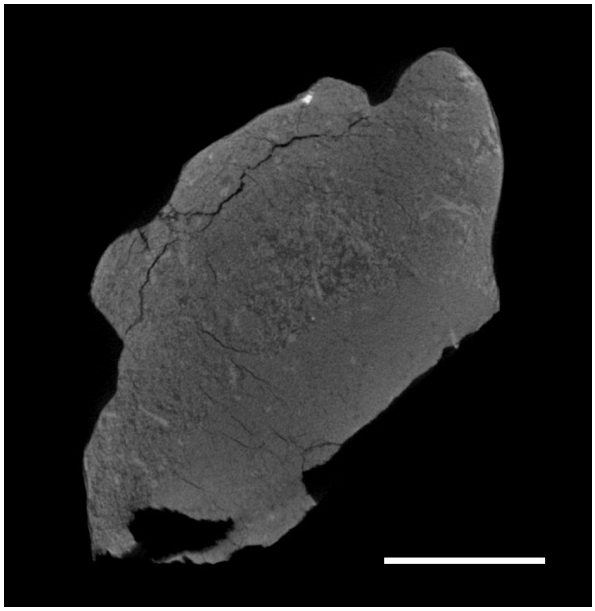

Figure 1: A representative X-ray slice through BR2. The scale bar is 5mm.

In Figure 3 we show a perspective cutaway section through BR1, illustrating the 3D nature of the cracks and brecciation. At this scale the nature of the contacts between different lithological sub-types are not clearly visible.

Discussion: Deriving a 3D model for our meteorites allows us to constrain density, at 2.7 g/cm^3. Detailed analysis of the micro-CT data is ongoing. Imagery, 3D models, and comparison with fireball data and meteorite composition will be presented fully at the conference. Physically, the outer surface shows a 'scalloped' shape, typical of the effects of reentry. The surface of both samples is covered in pristine fusion crust, except for one freshly broken section on BR2, covering about 11% of the surface (no fragment was recovered near to the fall position, despite thorough searching: there is the slight suggestion of the early development of a secondary fusion crust on this surface, indicating that this break probably occurred at some altitude).

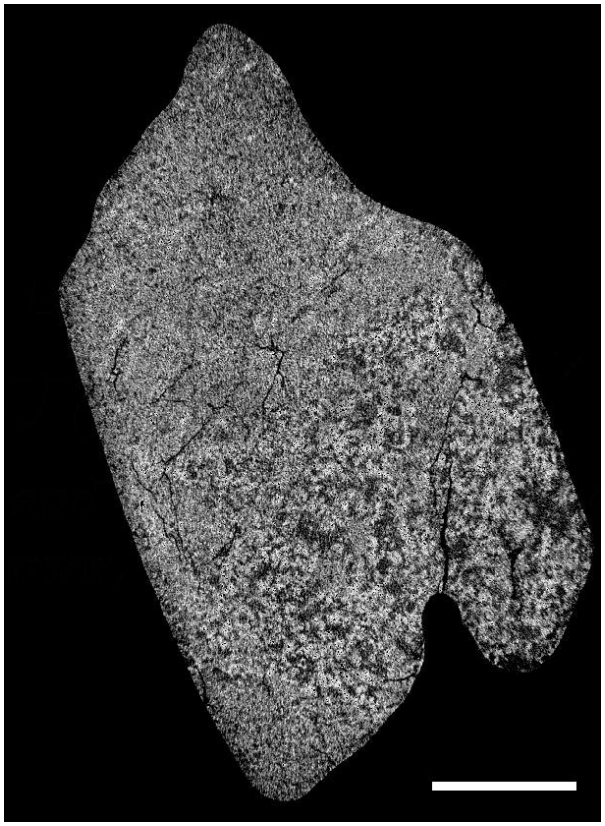

Figure 2: A representative X-ray slice through BR1. The scale bar 5mm. This image is stretched compared to figure 1, to highlight the brecciated texture; the absolute density variations are the same.

Preliminary micro-CT analysis indicates several features; the amount by volume of high density material, such as the chromite, is small (<0.05 % by volume) within both samples. Additionally, the cracks seen within the samples do not represent relic features from the assembly of the breccia. They do not follow the boundaries between the various fabrics, and must be more recent in nature. For this reason it may be possible to relate them to the fragmentation behaviour of the object as it entered the atmosphere.

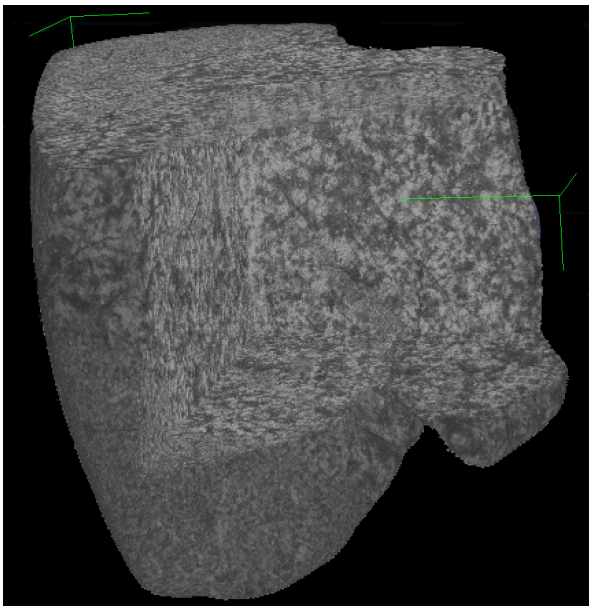

Figure 3: A 3D perspective cutaway view of BR1. The variety of lithologies, delineated by grain-size, can be clearly seen in this model.

References: [1] www.desertfireballnetwork.org. [2] Bland P. A. et. al. (2009) *Science, 325,* 1525-1527. [3] Bland P. A. et. al. (2008) *LPSC XXXX,* #1664 on CD ROM. [4] Benedix G. K. et. al. (2009) *LPSC XXXXI* (this volume). [5] Spivak-Birndorf L. J. et. al. (2009) *LPSC XXXXI* (this volume). [6] Binzel R. P. and Xu S. (1993) *Science*, 260, 186-191. [7] Ketcham, R. A. (2005) *Geosphere*, 1, 32-41.