THE CRANFIELD METEORITE: AN H3-5 (REGOLITH?) BRECCIA. L. C. Welzenbach[1], M. D. Fries[2], G. Costin[3], R.C. Greenwood[1], W. J. Cooke[4], D. Moser[5], S. Hicks[5] E. Rasmussen[6], C. E. Satterwhite[7], K. Righter[2], D. Sheikh[8], A. M. Ruzicka[8], M. L. Hutson[8], R.Vargas[9], M. Stream[10], S. A. Eckley[7], R. A. Zeigler[2], F. M. McCubbin[2], [1]The Open University, Milton Keynes UK (lwf2@rice.edu), [2]NASA-JSC, Houston TX, [3]Rice University, Houston TX, [4]NASA-MSFC, Huntsville AL, [5]Jacobs-ESSCA Group, NASA-MSFC, Huntsville AL, [6]Phoenix AZ, [7]Jacobs-JETS, NASA-JSC, Houston TX, [8]Portland State University, Portland OR, [9]Hartford CT, [10]Riverside CA.

Introduction: On April 27, 2022 at 8:03 a.m. CDT (1303 GMT) 74 eyewitnesses from Arkansas, Louisiana and Mississippi reported a bolide and sonic booms (AMS Event 2022-2591) [1]. NASA- Marshall Space Flight Center (MSFC) Meteoroid Environment Office reported that the bolide was produced by a 40 kg object of approximately 0.3 meters in diameter, moving at approximately 56,327 kph. GOES GLM observations show that the object broke apart 34 miles above the ground (Fig. 1).

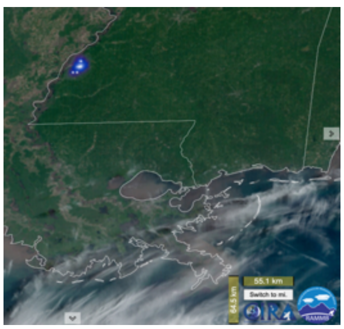

Figure 1: NOAA image of the bolide captured by the GOES Geostationary Lightening Mapper. Each event captures data for trajectory, velocity and light curve (energy). https://neo-bolide.ndc.nasa.gov/#/

Camera-based observations were used by NASA MSFC Meteoroid Environment Office to calculate the trajectory and azimuth of the bolide from first appearance to its terminus (Fig. 2).

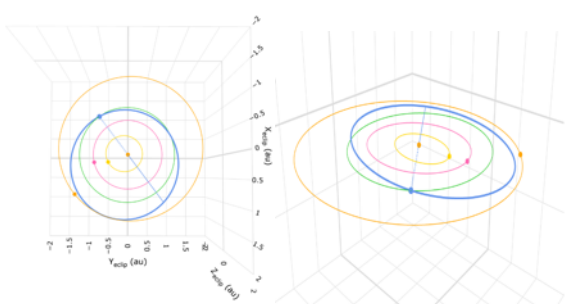

Figure 2: Angle of entry is 42.5⁰, 12.8 km/s bolide speed from GLM provide an orbital solution for the meteoroid, illustrated above shows an Apollo-type body (most common) for the given location axis and eccentricity.

Strewnfield Model: *Doppler radar signatures.* Four nearby weather radars in the NOAA NEXRAD network detected signatures of falling meteorites in eleven radar sweeps (composite of all reflectivity in blue, Fig. 3 top) [2]. The first detection occurred 73 seconds after bolide terminus at an altitude of 11,257 m, with the full range of detections occurring between 2,115 and 13,704 m above sea level (ASL). The last detection occurred 4 minutes 45 seconds after terminus.

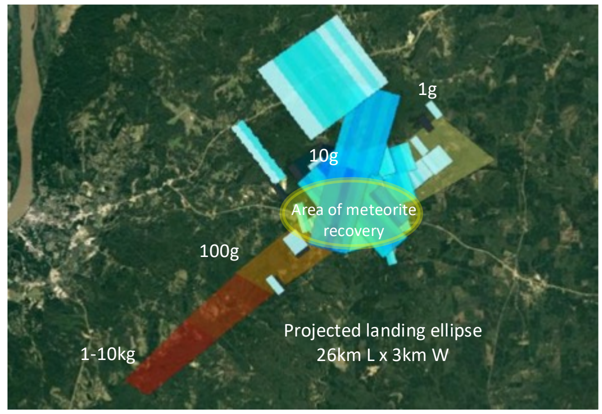

Figure 3: Radar returns overlay the dark flight model showing predicted masses 10g or less in yellow, 10-100g in orange and greater than 100g orange to red. Yellow defines area where all masses recovered from April 30- June 2, 2022.

Meteorite recovery. On April 30, 2022 the first two meteorites were recovered 16.9 km east of Natchez, MS on the shoulder (31°33'06.1"N 91°11'36.6"W) and median (31°33'08.9"N 91°11'25.9"W) of U.S. Hwy 84E. More than 15 stones, many as fragments, totaling 598g have been reported [3]. Some material of unknown mass remains with anonymous finders.

Figure 4: Left-N1 intact, nearly fully fusion crusted stone insitu on the shoulder along U.S. Hwy 84E. Right- N2 fragment, found in grass of the median, showing brecciated texture.

Classification and description: The two stones, N1 (41.31g) (Fig. 4 left) and N2 (37.64g) (Fig. 4 right), were collected 30 April prior to 1 May rain, cleanly, using baked-out aluminum foil and bagged in Teflon for transport. Both fragments were processed at NASA JSC and scanned by XCT with the Nikon XTH 320 (Fig. 5) as part of a larger ongoing advanced curation project.

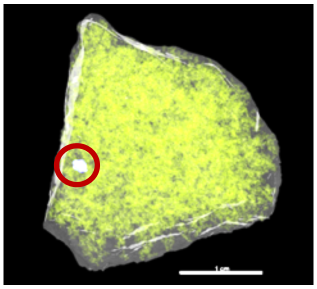

Figure 5: Whole sample N1, transparent to show high Z phases in green and possible phosphate grain circled in red. XCT settings were 145 kv, 138 µA, 20.0W, 2.50 mm Al filter. Voxel size = 21.55 microns.

Oxygen isotopes were measured at the Open University giving the following results: $\delta^{17}O$ 2.74 ‰; $\delta^{18}O$ 3.94 ‰; $\Delta^{17}O$ 0.69 ‰ (the $\Delta^{17}O$ value was calculated using a slope of 0.52) (Fig. 6).

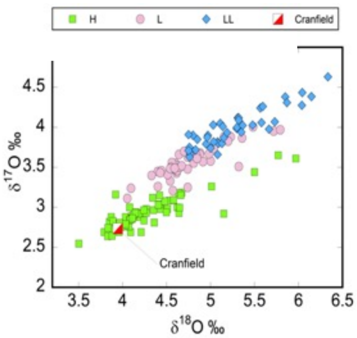

Figure 6: Single Oxygen isotope composition of Cranfield determined on a homogenized bulk powder from sample N2.

Fragments totaling 7.1g were also submitted to Cascadia Meteorite Laboratory at Portland State University, which collected the preliminary data used for classification [3]. The magnetic susceptibility was measured as Log X=5.4, consistent with H chondrites, matching corresponding compositional data.

Macroscopic description: The exposed interior is friable (Fig. 4 right, finely fractured and reveals two lithologies; a dark gray matrix with abundant finely disseminated metal (Lithology 1-Fig. 7 top), mixed with irregular light gray to white clasts ranging from millimeters to centimeters across (Lithology 2-Fig. 7 bottom).

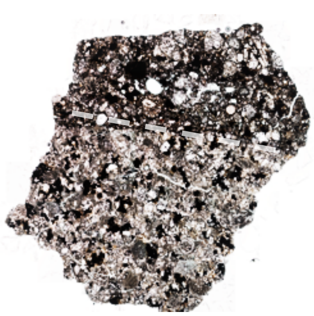

Figure 7: Cranfield thin section (Cascadia sample CML 1526-2B) with Lithology 1 (dark) matrix material above the dashed line and Lithology 2 (light) clast below.

Petrography and mineralogy: Lithology 1 (dark) is a heterogenous matrix (Fig. 8) of well-defined chondrules (Av. diameter 444±177 µm, n=26), sub-rounded to angular isolated mineral grains and lithic fragments (both zoned and unzoned) surrounded by fine-grained silicates, Fe-Ni metal, troilite, chlorapatite and merrillite. Spinel grains are present in several chondrules. Chondrules display a wide range of textures and compositions (olivine Fa17.2±8.0; low-Ca pyroxene Fs11.6±5.5, Wo0.8±0.4). Most olivine grains exhibit only undulose extinction, but some include evidence of incipient melting and infilled planar fractures suggesting a shock stage of S3. Chondrules contain a turbid, devitrified mesostasis, and a few preserve a primary glassy mesostasis suggesting a moderate subtype between 3.4-3.6.

Lithology 2 (light) clasts exhibit larger (<= 600 µm), well-defined equilibrated (Olivine Fa18.3±0.2, N=19; Low-Ca pyroxene Fs15.9±0.1Wo1.1±0.2) chondrules, fewer but larger Fe/Ni metal and sulfide grains, the latter of which contains silicate inclusions. Abundant feldspathic-chromite assemblages, metal and silicate melt clasts with igneous textures are also observed. Secondary sodic feldspar (Av. ~20 µm across), and merrillite are present.

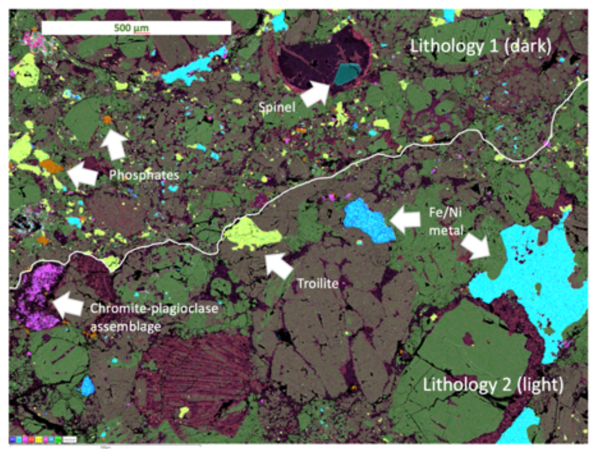

Figure 8: SEM element map of Cranfield (Cascadia sample CML 1526-2B) with Lithology 1(dark) above the white line and Lithology 2 (light) below.

Discussion: The light/dark clast to matrix characteristics, distinct metamorphic grade between lithologies and a variety of impact-related textures of grains and chondrules within each lithology suggest a regolith breccia origin. However, few samples are available for study at present, constraining a catalog of clast types, and refinement of shock stage, although images of meteorite fragments collected suggest that there may be xenolithic clasts present. Samples from N1 are currently being analyzed for noble gases and cosmic ray exposure age.

References: [1] Hankey M. F. et al. 1997. American Meteor Society Event 2022-2591.[2] Fries, M. and Fries, J., 2010. *Meteoritics & Planetary Science*, 45(9),1476-1487. [3] Meteoritical Bulletin 111 (2023).