PHOTOGRAMMETRY FOR CREATING HIGH FIDELITY 3-D MODELS OF GEOLOGICAL AND METEORITE SAMPLES. T. A. Harvey[1], K. H. Joy[1], R. H. Jones[1], J. L. MacArthur[1], [1]Department of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL, UK (thomas.harvey@postgrad.manchester.ac.uk).

Introduction: Photogrammetry uses two-dimensional images to determine accurate information about the surface of an object [1]. Using a suite of images with overlapping features, it is possible to generate a three-dimensional model of the object [1]. This approach to research can provide insight about subjects of interest ranging in size from hand specimens to full-scale outcrops in the field. It has been popular among archaeological studies [2], and has also been used for paleontological [3] and outcrop mapping studies [4].

We aim to use photogrammetric methods to create high-fidelity three-dimensional models of meteorite samples collected by the UK-led Lost Meteorites of Antarctica project [5,6]. We will be using the technique as part of our characterization and classification of the recovered meteorites, providing a detailed record of the samples for curation and for determining sample volumes and densities. Sample volumes will be useful for preliminary classification with a combined electrical conductivity, magnetic susceptibility probe [7]. We aim to understand how these properties vary with sample volume and mass. Sample densities are useful for a variety of reasons, for example to better understand gravimetric data from orbiters [8,9], and to understand material properties of planetary bodies [10]. Sample density is difficult to calculate via non-destructive techniques, so being able to calculate sample volume without even touching the sample is highly beneficial.

Most geological studies involve splitting rock samples and performing a range of destructive or semi-destructive analyses. Once completed, it is no longer possible to view the sample as a whole. Through the production of detailed, true-colour, three-dimensional sample models, we preserve an accurate record of the pristine sample (Fig. 1). This is especially important when the sample is small or rare - such as meteorites and extraterrestrial samples returned by missions. Such models, which can be viewed at multiple scales, may be used to help inform decision-making about sample cutting for preliminary analysis or for understanding the spatial relationship between later scientific discoveries. This technique only subjects the sample to visible light, meaning that there is no modification of the surface, a goal which has also been achieved using three-dimensional laser scanning [8].

Three-dimensional models of rare samples are a powerful tool for teaching and outreach [11,12]. Integration with other digital records, such as thin section photos or computed tomography datasets would be a useful way for students or the public to engage with the samples and sample science in a way which is limited if valuable samples cannot be on display.

Method: The sample is placed on a turntable in a controlled light environment to minimize shadows and reflections on the sample surface. Photographs are captured using a high resolution (>25 MP) DSLR camera at 5º rotational intervals. Photographs are captured in RAW format, comprising an unmodified two-dimensional record of the entire sample, and then processed to ensure accurate colour and remove unsuitable images. The images are processed using Agisoft Metashape, a professional software for photogrammetry applications [13], which matches pixels in different images to simulate the camera's position relative to the sample. These pixels are used to produce a sparse three-dimensional point cloud, then a dense three-dimensional point cloud that is verified for accuracy, before being used to produce an ultra-high-quality mesh (Fig. 2). The mesh is a three-dimensional object which comprises the record of the sample shape. The texture of the sample is layered over the mesh to produce the final model [13].

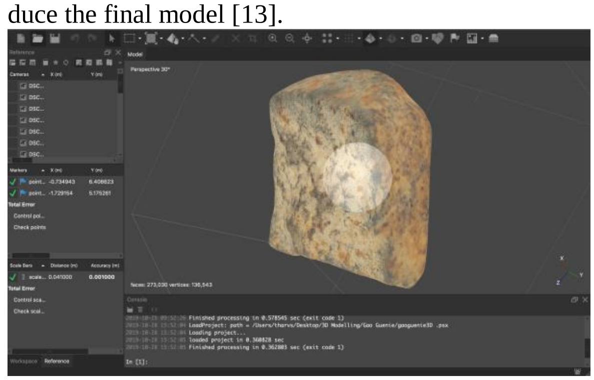

Figure 1: Screenshot of 3-D model of a sample of H5 ordinary chondrite Gao Guenie within the Metashape workspace.

Results: We have examined a range of samples of differing size (terrestrial rocks, impact crater shatter cones, meteorites) and produced high quality models that capture sample exteriors in their entirety (Fig. 1 and Fig. 3). Agisoft Metashape has volume measurement capabilities and allows for model size calibration to known size measurements on the sample surface. Further research into sample surface area and volume measurements is ongoing to understand the uncertainty in measurements derived by this technique.

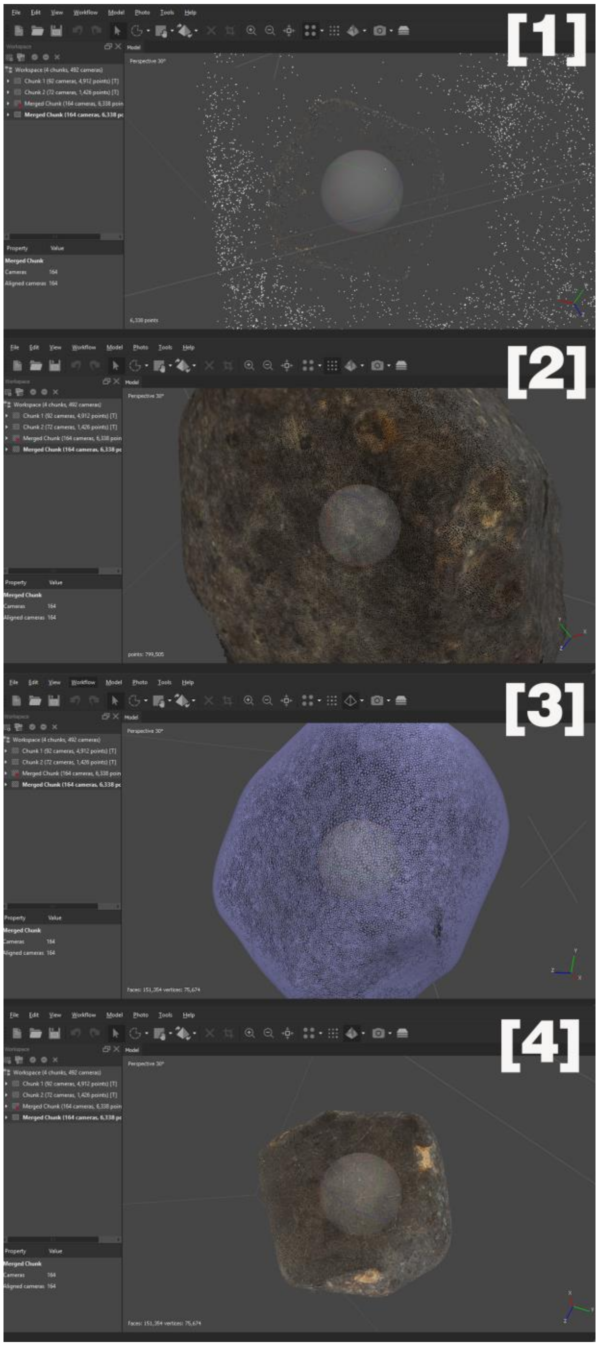

Figure 2: Screenshots of development of 3-D model of a sample of NWA 869 within the Metashape workspace, as described in Method: [1] Sparse point cloud, [2] Dense point cloud, [3] Mesh, [4] Textured Mesh. The circle in the centre is a trackball for manipulating the model.

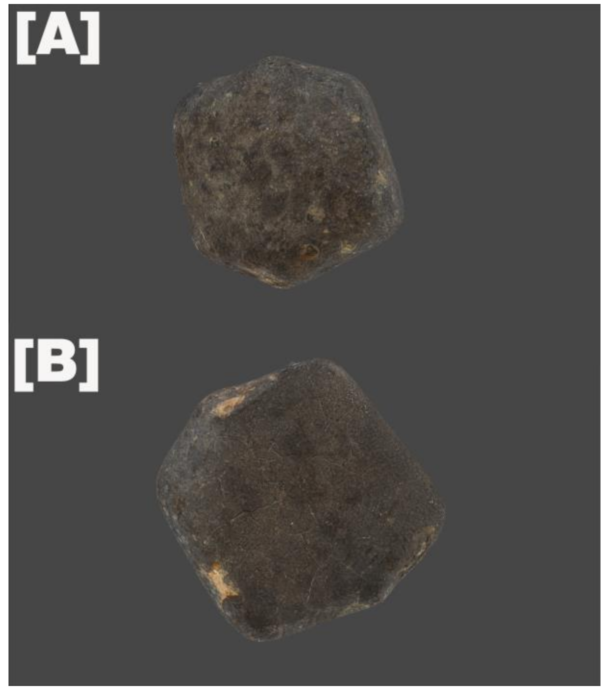

Figure 3: Screenshots of final model of NWA 869: [A] front and [B] back.

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