Preparing and Characterizing Carbonaceous Chondrite Standards for Verification of ESA’s ‘PROSPECT’ Package

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1: Introduction: This work was carried out in the context of the planned Russian Luna-27 mission to the lunar surface, for which the European Space Agency (ESA) are providing the ‘PROSPECT’ package which will drill, collect, and analyse samples of icy regolith for water and other volatile species abundances and isotopic compositions. Since carbonaceous chondrites (CCs) are thought to be major contributors to volatiles to the Moon, CCs have been used to produce a set of well-defined meteorite standards, using an array of high precision/high sensitivity instruments available within a modern laboratory setting. These standards will be used to test and refine the ProsPA bench development model (BDM) as it becomes increasingly flight-ready.

2: Sample Acquisition: Large hand specimens of Murchison (CM2) and Allende (CV3) were purchased from a well-known and trusted source in September 2016.

<table>
<thead>
<tr>
<th>Murchison</th>
<th>Allende</th>
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<td>CM2</td>
<td>CV3</td>
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<tr>
<td>Fall (Sept. 28th, 1969, Australia)</td>
<td>Fall (Feb. 8th, 1969, Mexico)</td>
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Original Collected Mass: > 100 kg

Acquired Mass: 57.54 g

Acquired Mass: 692 g

3: Optical Petrography: polished mounts of both meteorites were prepared as 1 inch diameter blocks and photographed up to 20x magnification and then mapped using an SEM to characterise the mineralogy and clasts within the samples.

4: Sample Homogenisation: several grams powdered using agate mortars and pestles (+ several grams as chips for additional analyses to check powdering process did not introduce terrestrial contaminants).

5: Analytical Techniques: A range of custom-built and commercial laboratory instruments were used to measure multiple isotope systems in different ways, ensuring reproducibility.

6: Carbon and Nitrogen: Repeat analyses of aliquots of the same powdered standard materials are both highly reproducible (internally, using the same technique) and also give identical results (within error) between different techniques (e.g. EA-irms and Finesse results are comparable to each other). Further, there is good agreement with literature data [1,2].

7: Conclusions:

• Results from these new carbonaceous chondrite standards are both self-consistent between different techniques and reproducible after multiple analyses on the same instrument, and in agreement with previous literature data.

• The ‘internal’ reproducibility of these standard powders is of greater importance than their agreement with previous literature data from the perspective of their primary intended use as standards with which to test the performance of the ESA ‘ProsPA’ miniaturised chemical laboratory development models.

• However, having an integrated approach, where multiple isotope systems are measured within the same individual stones means that the results are directly comparable to each other and can be considered together, within a scientific context in addition to their primary intended use.

• This scientific importance is enhanced by the contextual information gained through X-ray CT scanning, especially considering the relatively rare large sizes of these samples.

• The large sample masses purchased for these standards means that material can be curated for future use, either as standards for other instrument verification studies, or in their own right as scientific samples. Therefore, the data and sample processing records and media derived from this characterisation study form the basis of what is anticipated to be a useful resource for the wider community long into the future.

References