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X-ray Microtomography of Martian Meteorites and Implications for Mars Sample Return

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Martian meteorites are some of the rarest and most scientifically interesting meteorite samples available for study, providing unique insights into the formation and geological evolution of Mars. With such rare and valuable material it is imperative to ensure that the most suitable samples are selected for each scientific study, particularly when material may be compromised or even completely destroyed during those analyses. X-ray micro CT-scanning is completely non-destructive and requires no sample preparation. The technique provides detailed insights into the mineralogical and textural characteristics of geological materials that would otherwise be determined using optical and/or electron microscopy with the necessary destructive and invasive sample preparation of a polished section or block.

We have been carrying out a systematic study of Martian meteorites in the Natural History Museum Collection as part of a detailed curatorial and research program. Our results indicate that the level of detail that can be obtained using micro-CT rivals that using traditional electron microscopy, with the added advantage that three dimensional data is generated. For all samples it is possible to determine and delineate between different mineral phases including olivine, pyroxene, feldspar glass and opaque phases. Cracks and voids are also easily detected; an important result for samples which potentially contain trapped pockets of Martian atmosphere such as Tissint. Depending on sample size, different phases are resolvable down to a scale of $\sim$5 micrometres.

The complete lack of sample preparation required and the non-destructive nature of X-ray microtomography means that it could prove an extremely powerful tool during initial investigations of samples returned from Mars for Planetary Protection and preliminary mineralogical and textural characterisation. Indeed, if a sample container could be designed with an X-ray transparent ‘window’, it should be possible to determine both the physical integrity of the sample container and determine the physical and compositional properties of the sample within the container. This would be highly advantageous – samples would be contained in their pristine state whilst in the container (provided the sample container is still fully sealed), thus preserving their scientific integrity and samples with characteristics of interest could be selected for rapid biohazard assessment. This has important implications for design of both spacecraft hardware and future Sample Receiving Facilities.