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Advanced SEM/EDS Analysis using Stage Control and an annular Silicon Drift Detector: Applications in Impact Studies from Centimetre below Micrometre Scale

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Introduction: Imaging of ever smaller structures, in situ within large samples, requires low electron beam energy (HV<6 kV) to enhance spatial resolution, and therefore also the use of low energy X-ray lines for element analysis. To separate significantly overlapping peaks e.g. N-K (392 eV) and Ti-Ll (395 eV), the incorporation of line deconvolution algorithms in energy dispersive X-ray software is of crucial importance.

Methods: Without adequate X-ray count statistics, deconvolution is unlikely to be effective. We therefore used an annular Silicon Drift Detector (SDD), the Bruker XFlash® 5060F which is placed between the pole piece and sample. High take-off angle and collection of X-rays from four different directions allow data collection across samples with substantial surface topography. Automated stage control and spectrum imaging allow large data sets to be acquired within a short time.

Applications: (A) Large area, high resolution images (with tiling or stitching of neighbouring areas) is useful for understanding processes in the formation of tektites [1], revealing flow textures and layering, without destructive section preparation. Coalescence textures formed during the transition from melt to solid, surface pitting produced by micro-impact collisions in the impact plume, and surface etching by chemical attack in the impact plume, or later weathering, can all be revealed.
(B) Spectrum imaging of the matrix in the impact melt breccia of the Chicxulub impact crater (Yaxcopoil-1 borehole, Unit 5 861.72 m) reveals secondary mineral formation, such as NaCl (<500 nm) and Fe-Ti-oxides (<150 nm) associated with garnet resorption. It documents the role of multiple episodes of precipitation of Mg-rich phyllosilicates as well as the formation and dissolution of accessory minerals in a relatively high temperature (>300°C) hydrothermal event [2].
(C) In experimental hypervelocity impact craters, spectrum images readily find locations of projectile residue throughout all the complex topography. The very high count rate at even low beam energy and current reveals inhomogeneous compositions and textures below micrometre scale [3]. These results help us understand preservation and modification of structure and composition in the fine-grained cometary dust aggregates which made aluminium foil craters on the Stardust spacecraft during its encounter with comet Wild 2.

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References: [1] K.T. Howard 2011. Geological Society of London: 573-591. [2] M. Nelson et al. 2012. GCA 86: 1–20. [3] A. T. Kearsley et al. 2013. Submitted to LPSC #1910.