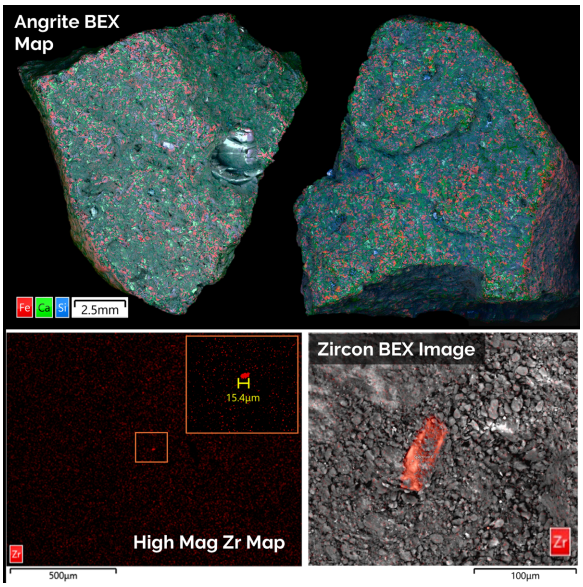
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High-Quality X-ray Mapping of Pristine Extraterrestrial Samples: A New SEM Workflow Leveraging the BEX Technique

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Here, we present a new approach for discovering rare phases within highly topographic, unprepared, and uncoated samples. Our method uses SEM-BEX (combined backscattered electron and X-ray imaging), demonstrated on an angrite meteorite (a rare group of achondrite meteorites), to show how the technique can exceed the capabilities of EDS when analysing delicate or rare samples with high-topography and low-signal beam conditions [1,2,3].

Backscattered electron and X-ray mapping was performed at 15 kV and 4 nA under variable-pressure conditions (35 Pa) to mitigate charging. The BEX detector geometry, positioned beneath the pole piece, reduces X-ray shadowing from uneven surface topography and enhances X-ray mapping speeds under these compromised beam conditions. This enabled >4.5 cm² of high-resolution (2.5 µm pixel size) elemental mapping to be acquired in just four hours.

This high-resolution dataset revealed ten <50 µm zircon grains dispersed across the sample surface. This would represent the first documented occurrence of zircon within angrites. Quantitative EDS confirmed zircon composition for multiple grains. These non-destructive large-area maps will now guide targeted FIB lift-out for subsequent isotopic analyses, including U–Pb geochronology. Thus, a targeted method for removing minute volumes of sample for destructive chemical and/or isotopic analyses has been made practical.

Our work demonstrates a highly effective workflow for the analysis of returned samples and other extraterrestrial materials, showing how advances in instrumentation and mapping techniques can unlock critical mineralogical information while fully preserving sample integrity. With its high flexibility and user-friendly SEM interface, BEX is a strong candidate for widespread mineralogical and elemental characterisation within extraterrestrial sample-analysis workflows.

[1] Buckman et al. (2025), *Journal of Microscopy*, *298*(3), pp.254-261.

[2] Webb et al. (2025), *Scientific Reports* (15), 44361.

[3] Menke et al. (2025), *arXiv preprint arXiv:2512.09466*.