Characterisation of extraterrestrial samples by Raman and Electron microprobes

Conference or Workshop Item

CHARACTERISATION OF EXTRATERRESTRIAL SAMPLES BY RAMAN AND ELECTRON MICROPROBES.

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Introduction: Returned extraterrestrial samples, planetary, asteroidal or cometary, are so valuable that initial assessment of the most appropriate analytical protocols for each grain is essential. It is particularly important to know the distribution and interrelationships of specific mineral components. Numerous sophisticated microanalysis techniques are now available [1], yet many may damage vulnerable volatile-rich materials, or produce surface contamination, if employed at too early a stage.

How should one characterise individual particles, preferably without exposure to atmosphere, or removal from the capture medium (eg. foil, or aerogel block), before commitment to carefully sequenced 'destructive' analysis?

We suggest that new Raman and electron microprobes may provide the necessary chemical and mineralogical information, with minimal specimen modification.

Techniques employed:

X-ray mapping of uncoated samples. Compositional (backscattered) electron imagery of grain surfaces usually employs a conductive coat of carbon, or may be performed without coating in a low-pressure atmosphere of Ar, or He and Nitrous Oxide. Each system has limitations for samples from which isotopic measurements of noble gases or carbon-bearing phases are required.

We have used an Oxford Instrument eXL X-ray microanalyser on a JSM 840 SEM operating at 20 kiloVolts, 2 nanoAmperes and high vacuum, to create images of small (3mm) uncoated shards of the meteorite Los Angeles 001, supported on a conductive cradle. Rapid energy-dispersive mapping (40 milliseconds, 16,000 point array) was performed for 23 characteristic X-ray energies [2]. The distribution of pyroxenes, feldspathic glass, accessory sulfides and phosphates, and terrestrial contamination by carbonate growth were all easily seen.

Raman microprobe analysis and mapping. The application of Raman techniques to mineral grains impacted into aerogel samples has been previously demonstrated [3] & [4]. We used a JY LabRaman microprobe at the Open University to create a reference library of spectra for silicates, carbonates and oxides, as well as SiC, diamond, and other carbon-bearing phases. Confocal sampling by the LabRaman allows acquisition from a small, well-defined volume, as little as 2 micrometres in diameter. Beam scanning and automated stage-movement permit rastering in 3 dimensions, thereby creating stacked map-slices of a grain. The spatial distribution of each mineral component within a slice can be displayed (figure 1).

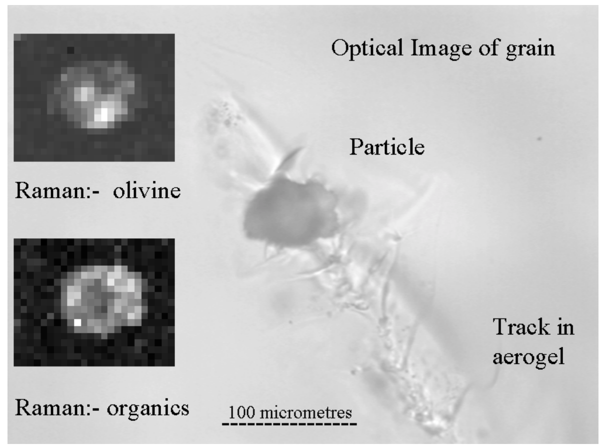

Figure 1. LabRaman maps of olivine and organic matter within particle of Allende, impacted by light gas gun shot into aerogel.

High-resolution maps may take several hours to generate, fortunately our experiments show that continuous irradiation by an 8mW, 514.5nm Argon ion laser at a tightly-focused single point on serpentine yields no appreciable change in Raman spectral properties over a time exceeding twelve minutes.

Conclusions: Modified analytical SEM and modern Raman microprobes have substantial promise for initial, non-destructive characterization of extraterrestrial samples.

References:

[1] Zolensky M. E. et al. (2000) *MAPS*, *35*, 9-29. [2] Graham G. A. et al. (2001) *Proc. 3rd European Conf. Space Debris, in press.* [3] Burchell M. J. et al. (2001) *MAPS, 36*, 209-221. [4] Graham G. A. et al. (2001) *LPS XXXII,* Abstract #1637.