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UK CAN: UK Cosmochemical Analysis Network for the study of returned samples from space

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Abstract

The UK Cosmochemical Analysis Network (UK CAN) is an association of laboratory-based astronomers centred in four institutions within the UK. Our research complements ground- and space-based astronomy, using microscopes and microprobes, rather than telescopes and spacecraft. As cosmochemists, we study the abundance, distribution, isotopic composition and interactions of the elements within the cosmos. Working together, using state-of-the-art instrumentation, we are developing sample handling, distribution and measurement protocols for the complete analysis of sub-milligram quantities of sub-micron-sized grains, to enable the UK to play a strong part in analysis of materials returned by space missions.

1. Introduction

Even though we have learned much about asteroids, Mars and comets through study of meteorites, one of the goals of planetary scientists is to analyse material returned directly from planetary bodies by space missions. Following the long hiatus since return of lunar material in the 1970s, there have been two successful sample return missions: *Genesis*, which collected the solar wind, and *Stardust*, which captured dust grains from the coma of comet Wild-2 and also from the interstellar medium. JAXA's *Hayabusa* returns to Earth in June 2010, but it is uncertain how much material was acquired from asteroid Itokawa. International space agencies (including, but not exclusively, ESA, NASA and JAXA) have forward-looking and ambitious plans for inter-planetary space exploration which provide a timely framework in which to develop techniques and instrumentation for future sample return missions. Planned missions include *OSIRIS-REX* (a NASA mission to an asteroid), *Phobos* (a Russian mission to Mars' satellite) and *Hayabusa 2* (a JAXA mission to an asteroid). ESA's asteroid sample return mission (*Marco Polo*) is currently on the back burner. The return of material from Mars remains the focus of the international mars community. Just as important as current and planned sample return missions are the technological developments that are advancing the analytical precision and spatial resolution of instrumentation, allowing analysis of fine-scale detail within components from meteorites and cosmic dust.

Impetus for the formation of UK CAN comes from several directions, the main one of which is the return of extraterrestrial material to Earth from space missions. The potential return of material from asteroid Itokawa brings into sharp focus an issue that is a problem for analysts: the limited amount of material available from sample return missions. One of the ways around this problem is for groups of colleagues to form consortia, based on their skills and expertise. In the UK, we have taken this idea one stage further, and are using our consortium to bid for government funds to purchase a new generation of instrumentation. Our consortium is the UK CAN: the **UK** **C**osmochemical **A**nalysis **N**etwork. This is an integrated system for the development, implementation and application of new analytical technologies for the laboratory analysis of extraterrestrial material, particularly material returned from space missions.

Most of the material returned by space missions will be very fine-grained, from 10s of microns to submicron in size, and available in very limited quantities. These materials will be distributed to the international community, and results from their analysis will form the platform on which the next generation of planetary exploration will be planned. Material will only be awarded to the teams that can reliably and precisely obtain the greatest amount of information from the widest range of analytical techniques using the minimum amount of material; they will inevitably be selected to perform the first measurements. The nature of research on

extraterrestrial material is multidisciplinary, requiring an array of analytical approaches to tackle each problem. The UK CAN is developing a new generation of instrumentation in order to analyse material returned from space missions, as well as to continue to be at the international forefront of laboratory-based astronomy and allow the UK to compete effectively for returned samples.

2. Members of the UK CAN

The three centres that form the nucleus of the UK CAN are the biggest groups of planetary scientists in the UK, at the Open University (Milton Keynes), the University of Manchester (Manchester) and in London, a research group (Impact and Astromaterials Research Centre, IARC) based at the Natural History Museum and Imperial College. These three centres have many years of experience in the analysis of extraterrestrial materials.

3. Instrumentation

As laboratory-based astronomers, we employ a variety of techniques to analyse extraterrestrial materials. Texture and mineralogy are initially determined by optical microscopy, after which structure and major, minor, trace element and isotopic chemistries are determined, using a range of instrumentation. Techniques include optical and electron microscopy; electron, ion, proton, and X-ray probes; stable and radioactive isotope and organic mass spectrometry (using electron impact, thermal, resonance, acceleration or plasma ionisation); optical, IR, UV, Mössbauer, NMR and Raman spectroscopy. These instruments are becoming increasing precise, using ever smaller amounts of material, to approach the limit of single atom analysis, permitting the study of the smallest samples and allowing subtle effects of zonation, overgrowths and alteration to be traced.

No one laboratory can hope to master (or afford, or even house) all the different techniques and instrumentation that might be applied to a single grain of extraterrestrial material. The three centres that form the UK CAN have developed complementary skills and instrumentation suites. The NHM-IC specialises in elemental and structural imaging and analysis, using optical, electron- and X-ray beam instrumentation. It also houses one of the world's finest meteorite collections. The Open University uses gas source mass spectrometry to make high precision isotopic and molecular analyses of small samples, and the University of Manchester uses ion microprobes to determine isotopic and elemental compositions at very high spatial resolutions. Together, the staff and instrumentation of UK CAN form a combination that is much greater than the sum of its parts. Through collaboration, UK CAN instrumentation is also available for use by other members of the planetary science community, and forms a training and teaching network for students at all levels.

4. Summary

The UK CAN is a consortium of experienced meteoriticists who have honed their experimental techniques to the levels required for the analysis of submicrogram-sized specimens. We have built our collaboration into a coherent whole, one that provides a UK-wide facility for extraterrestrial sample analysis. The UK CAN is also a training ground for PhD students. Over the coming years, we hope to develop the consortium into EU CAN, extending our network across Europe.

We hope that by building the UK CAN, we are readying the UK to play an efficient and effective role in the analysis of material returned from space missions. Further information can be obtained from: http://www.open.ac.uk/science/ukcan/

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