ATMOSPHERIC COLLECTION OF EXTRATERRESTRIAL DUST AT THE HALLEY VI RESEARCH STATION, ANTARCTICA. L.S. Alesbrook, P.J. Wozniakiewicz, A.E. Jones, M.C. Price, H.A. Ishii and J.P. Bradley, N. Brough. School of Physical Sciences, Ingram Building, University of Kent, Canterbury, CT2 7NH, UK. Department of Earth Sciences, Natural History Museum, London, SW7 5BD, UK. British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, UK. Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, 1680 East West Road, POST 602, Honolulu, HI 96822, USA. *Email: pjw@kent.ac.uk.

Introduction: Through analyses of their contents, extraterrestrial materials provide vital evidence of the conditions and processes occurring on the parent bodies from which they originate. Although historically larger meteorites have been the focus of such research due to the ease of analysis and preparation, significant improvements in analytical technology mean that a wealth of information can now be obtained from even the smallest of dust particles. It is estimated that ~40,000 tonnes of extraterrestrial material arrives at the Earth each year in the form of dust (particles less than a few mm in diameter). Although ~10% of the arriving flux of extraterrestrial dust is believed to survive atmospheric entry and reach the Earth's surface as micrometeorites, its collection is complicated in most locations by the vast abundance of background natural and anthropogenic terrestrial dust. Given that the flux of micrometeorites greatly exceeds that of larger meteorites, and that they likely sample more parent bodies, these dust particles have the potential to provide a more complete picture of the content of, and processes occurring in, the solar system. Developing methods of collection for these samples therefore has been, and continues to be, of vital importance to the field of solar system science.

Several successful collections have employed magnetic separation techniques to extract micrometeorites from, for example, deep sea sediments, ancient rocks and salts, exploiting the common occurrence of Fe-Ni metal in several types of extraterrestrial materials. More complete collections have been performed by choosing locations where the abundance of terrestrial contaminants is highly reduced, for example the Antarctic (with collections being made from ice, snow, well water and glacial moraines) and the stratosphere. Antarctic samples have typically been accumulating for tens to thousands of years and consequently they often exhibit evidence of terrestrial alteration, and knowledge of individual particle arrival times are, at best, ±years or ±decades, meaning links to celestial events like meteor showers cannot be made. While stratospheric collections do not suffer such terrestrial alteration and can be performed to coincide with meteor showers, they also suffer contamination by the silicone oil typically used in this method. Stratospheric flights utilizing oil-free polyurethane foam as a collection surface have successfully collected IDPs but resulted in significant particle fragmentation.

In an effort to overcome these issues, in 2012 we initiated collections using high volume air samplers to capture particles directly from the atmosphere (at ground level) on 8 by 10 inch, 5 μm laser etched polycarbonate membrane filters held in acrylic frames. This first attempt took place in the mid-Paciﬁc on Kwajalein Atoll where we had expected low levels of terrestrial background dust due to its vast distance (>1000 miles) from the nearest continent and associated dust, and the existence of trade winds blowing clean, ocean air directly over the sampling location. Our surveys of these filters, however, revealed more contamination than anticipated, making the analysis of every grain collected impossible. Despite this, all cosmic spherule candidates (with their characteristic spherical morphologies) >5 μm were identiﬁed and studied in detail, revealing several examples that exhibited textures and compositions consistent with an extraterrestrial origin.

Having verified the capability of this collection, similar collections are now being performed. Here we describe our next iteration of this collection at Halley VI research station.

Fig. 1: CASLab viewed in the distance from the Halley VI research Station [Image: Nick Owens/BAS].

Method: The Antarctic collection was performed in collaboration with the British Antarctic Survey,
making use of existing equipment in the Clean Air Sector Laboratory (CASLab) at Halley VI Research Station, located on the Brunt ice shelf [Fig. 1]. Being located ~1 km upwind of the main station, CASLab has been designed specifically to allow sampling of clean atmosphere. We therefore anticipated that these collections will contain minimal terrestrial contamination and enable us to survey all types of particle (not just spherules) collected in order to search for extraterrestrial candidates. The collection was performed between February and July 2015 and subsequently stored frozen until pickup, being delivered to the University of Kent for study in Summer 2016.

During the collection period, filters were changed weekly. Filters were designed to fold for storage, with the collection surfaces facing inwards to seal and prevent contamination. Initial flow rates were set at 1m³ per minute and, unlike the previous Kwajalein collections, suffered minimal flow rate degradation during the week. This shows there are far less (terrestrial) particles being collected that ultimately obstruct the filters, suggesting a vast improvement in the choice of location. As a consequence, the total volume of air sampled by each Antarctic filter is typically >2x that sampled by each Kwajalein filter.

In order to study particles on the filters upon their return, it is necessary to concentrate particles into a smaller, surveyable area. To achieve this, filters are mounted collection-side-up, with their center above a small, 2cm diameter nozzle attached to a vacuum pump. A small amount of slack in the filter enables the vacuum system to gently pull the filter downwards in the center. The filters exposed sides are then carefully sprayed with high purity water, which flows towards the center, taking with it any particles on the surface. Following condensing, the populated area is attached to an aluminium stub ready for examination via scanning electron microscope (SEM).

**Results:** To date, two filters from the Antarctic collection have been prepared and are in the processes of being surveyed by SEM. Images have revealed that moving to this cleaner environment has indeed resulted in a significant reduction in the number of particles collected on each filter, making the examination of every particle identified in our surveys possible. During our initial surveys, we have identified a number of porous, CP IDP-like aggregate particles for which imaging and chemical analyses are ongoing. We have also noted the presence of an abundance of spherules. This includes a large number that are <5 μm in diameter. EDX analyses show that many of these are AlSi dominated. Although several examples in this size range were observed on previous Kwajalein filters, the number on Antarctic filters is far greater. The increase in abundance on the Antarctic filters is likely a result of the larger volume of air sampled by each filter, a reduction in the total number of particle present (making it easier to spot smaller particles) and perhaps an increase in local abundance due to the polar vortex.

The primary contaminants identified on the Antarctic filters are aluminium metal and oxides (of varying morphologies), tin flakes, metal sulphides (Al, Fe), lead-rich particles, and barium salts - all of which have previously been identified on Kwajalein filters.

**Future Work:** We are continuing to survey these and further filters. Several of the Antarctic filters include dates previously sampled by Kwajalein filters (which were performed between May and August 2012) and we intend to compare the population of spherules on both in order to investigate whether similar variations in abundance over time exist. During the Antarctic collections, the Earth also passed through the dust streams of three comets whose particles have been identified as having a high probability of surviving atmospheric entry (26P/Grigg-Skjellerup, 73P/SchwassmannWachmann 3 and 7P/Pons-Winnecke [16]). We therefore also intend to investigate whether the Antarctic filters show any evidence of increased abundances of extraterrestrial candidates that may be related to these streams. We also aim to compare our findings with similar collections that are currently being performed by our, and other, groups: Collections are currently underway at Mauna Loa Observatory, Hawaii, [17] and the U.S. South Pole Station [18].

**Acknowledgements:** We thank the BAS for supporting and performing the collection of micrometeorites at Halley VI Research Station.