CAROLINE: A SEARCH FOR THE SOURCE OF EARTH’S WATER

Geraint H. Jones, Jessica Agarwal, Christopher S. Arridge, Neil Bowles, Mark Burchell, Andrew J. Coates, Michele K. Dougherty, Samuel Duddy, Alan Fitzsimmons, Amara Graps, Henry Hsieh, Carey Lisse, Stephen C. Lowry, Adam Masters, Holger Siersk, Colin Snodgrass, and Cecilia Tubiana, University College London, Holmbury St. Mary, Dorking, Surrey UK. 2Institut fuer Physik und Astronomie Nichtlineare Dynamik, Universitaet Potsdam, Germany. 3Mullard Space Science Laboratory, University College London, UK. 4Atmospheric, Oceanic and Planetary Physics, Department of Physics, University of Oxford. 5Centre for Astrophysics and Planetary Science, University of Kent, Canterbury, UK. 6The Blackett Laboratory, Imperial College London, UK. 7Queen’s University Belfast, UK. 8Southwest Research Institute, Boulder, USA. 9University of Hawaii, USA. 10Johns Hopkins University Applied Physics Laboratory, USA. 11Max Planck Institut fuer Sonnensystemforschung, Katlenburg-Lindau, Germany.

Introduction: The small body population of the Solar System has traditionally been divided into asteroids and comets (with sub-classes of each). Recently a new class of object has been discovered: Main Belt Comets (MBCs), which span this basic divide. These objects appear to have outbursts which are comet-like, but are located in the asteroid belt in stable, low-eccentricity orbits. Since the initial discovery of activity on 133P/Elst-Pizarro in 1996, several more MBCs have been found.

The Caroline mission: Here, we present Caroline: A Search for the Source of Earth’s Water, recently proposed as an M-class mission of ESA’s Cosmic Vision programme. This would follow the successful sample return missions to a comet (81P/Wild 2 by the NASA Stardust mission [2]) and an asteroid (Iokawa by the JAXA Hayabusa mission [3]). Named after the prodigious comet-finder Caroline Herschel (1750-1848), the spacecraft would visit a main belt comet, capture dust from its tail, and safely return it to Earth for detailed laboratory analysis. The proposed target is 133P/Elst-Pizarro – observed over three activity cycles to date, but other MBCs can be reached within the mass and cost constraints.

Scientific Value of MBCs: MBCs are more than just a scientific curiosity - an understanding of their nature and origin offers a chance to better understand the formation processes in the proto-solar disk. Further, the outer asteroid belt, where 133P/Elst-Pizarro is located, has been speculated to be a possible source of the Earth’s water. Thus understanding icy bodies in such a region has a potential to greatly influence our view of the terrestrial planets’ development.

What sort of sample return mission? One of the great strengths of the Stardust mission to comet 81P/Wild 2 was that the spacecraft collected its dust samples by flying through the coma surrounding the comet nucleus. The dust that was collected was thus ejected by the comet; no landing or active sampling system was needed, and the use of aerogel and aluminum foil as collectors was sufficient. Aerogel is a low density, highly porous medium (see [4] for a review of its use as a cosmic dust collection medium in space).

When materials hit it, even at the high speed of the Stardust encounter (6.1 km s⁻¹) the dust tunnels into the aerogel and is captured relatively intact. “Relatively intact” is the key phrase. The dust still experiences a shock of about 900 MPa in aerogel of density 20 kg m⁻³. But the experience of the Stardust mission shows that collecting dust grains in this way can return samples to the laboratory on Earth which can be analyzed by a wide variety of techniques [5]; we propose that this technique be used for Caroline.

Combined analysis methods: Caroline would also carry remote sensing instruments to characterize the nucleus during the encounter, and a dust detector to constrain the nature of the object’s dust coma and tail. MBCs’ activity is suspected to be driven by ices exposed by impacts. Temperature mapping of the surface would help better understand the emission rates from the body and characterize the active areas. Another observation, key to the possible role of MBCs in delivering water to a young terrestrial planet, would be a measurement of the D/H ratio on the body. In parallel with the mission would be a continued programme of astronomical observations of the target, to link the space mission data to remote observations.

Is it feasible? The success of the Stardust mission clearly showed that sample return using collection of dust in aerogel is a viable method of obtaining data from a comet-like body. The costs are modest compared to missions which require a lander and active sample collection. Despite this, the scientific return would be high, shedding light on a wide range of important scientific issues. We propose that if one new sample return mission was to be carried out to a minor body, then it should be to an MBC. Caroline would achieve that goal.