Collecting Comet Samples by ER-2 Aircraft: Cosmic Dust Collection During the Draconid Meteor Shower in October 2012

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Introduction. Many tons of dust grains, including samples of asteroids and comets, fall from space into the Earth's atmosphere each day. NASA periodically collects some of these particles from the Earth's stratosphere using sticky collectors mounted on NASA's high-flying aircraft (figure 1).

Figure 1.– The ER-2 (right) and a photo from the flight of October 16, 2012, taken over Los Angeles, CA, at 70,000 ft., looking west toward Santa Barbara and the Channel Islands.

Sometimes, especially when the Earth experiences a known meteor shower, a special opportunity is presented to associate cosmic dust particles with a known source. NASA JSC's Cosmic Dust Collection Program has made special attempts to collect dust from particular meteor showers and asteroid families when flights can be planned well in advance. However, it has rarely been possible to make collections on very short notice. In 2012, the Draconid meteor shower presented that opportunity (figure 2). The Draconid meteor shower, originating from Comet 21P/Giacobini-Zinner, has produced both outbursts and storms several times during the last century, but the 2012 event was not predicted to be much of a show. Because of these predictions, the Cosmic Dust team had not targeted a stratospheric collection effort for the Draconids, despite the fact that they have one of the slowest atmospheric entry velocities (23 km/s) of any comet shower, and thus offer significant possibilities of successful dust capture. However, radar measurements obtained by the Canadian Meteor Orbit Radar during the 2012 Draconids shower indicated a meteor storm did occur October 8 with a peak at 16:38 (±5 min) UTC for a total duration of ~2 hours.

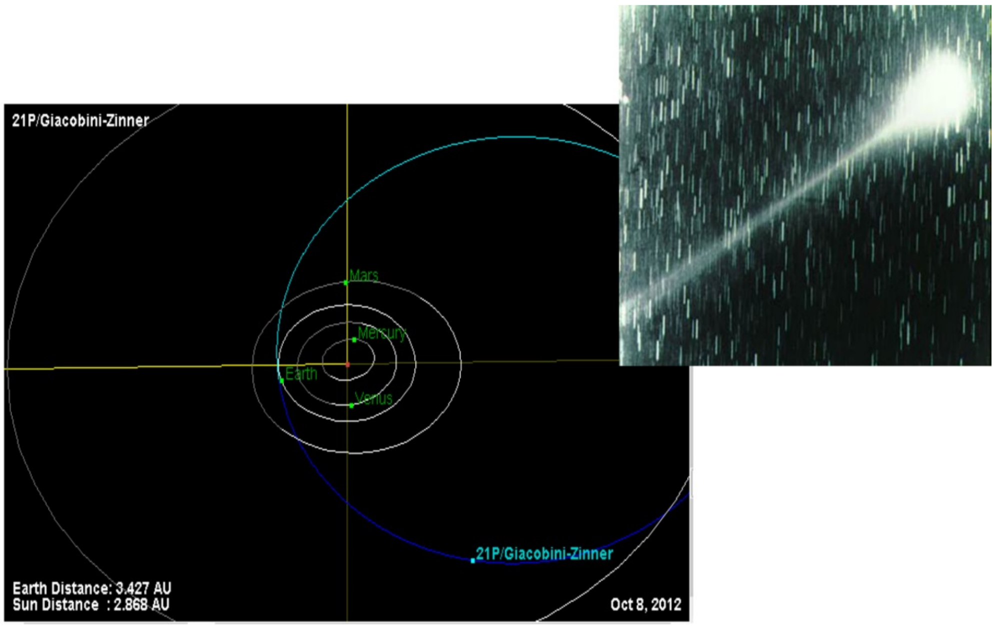

Figure 2.– Orbit of Giacobani-Zinner (upper right), showing where the Earth crossed the orbital path October 8, 2012. This image is from the Jet Propulsion Laboratory's (JPL's) Small-Body Database Browser.

Meteor Observations. The Canadian Meteor Orbit Radar (CMOR) is an automated radar meteor echo detection and orbital measurement system operating at 29.85 MHz. CMOR records ~5000 orbits per day for meteoroids with mass $>10^{-7}$ kg on average. At Draconids entry speeds (23 km/s), the radar typically detects particles with diameters >500 µm. The Draconids shower flux measured by CMOR in 2012 was the highest shower flux measured during the entire operational lifetime of CMOR (1999–present). The CMOR team reported that the peak flux was more than an order of magnitude higher than that measured by CMOR in the 2005 or 2011 Draconids outbursts. The equivalent Zenithal Hourly Rate (ZHR) (for 5-min bins) was in excess of 5000 at the peak. Data from the radar also allowed the team to calculate a variety of the shower's attributes, including that the storm appears to have been particularly rich in smaller meteoroids.

Collection Efforts. The large and small area collectors L2094, L2095, L2096, L2097, U2153, and U2154, were flown from October 15 to 17, 2012. Each flight accumulated between 7 and 8 hours of collection time (figure 3). The small collectors (U2153 and U2154) received an additional 5.7 hours October 11.

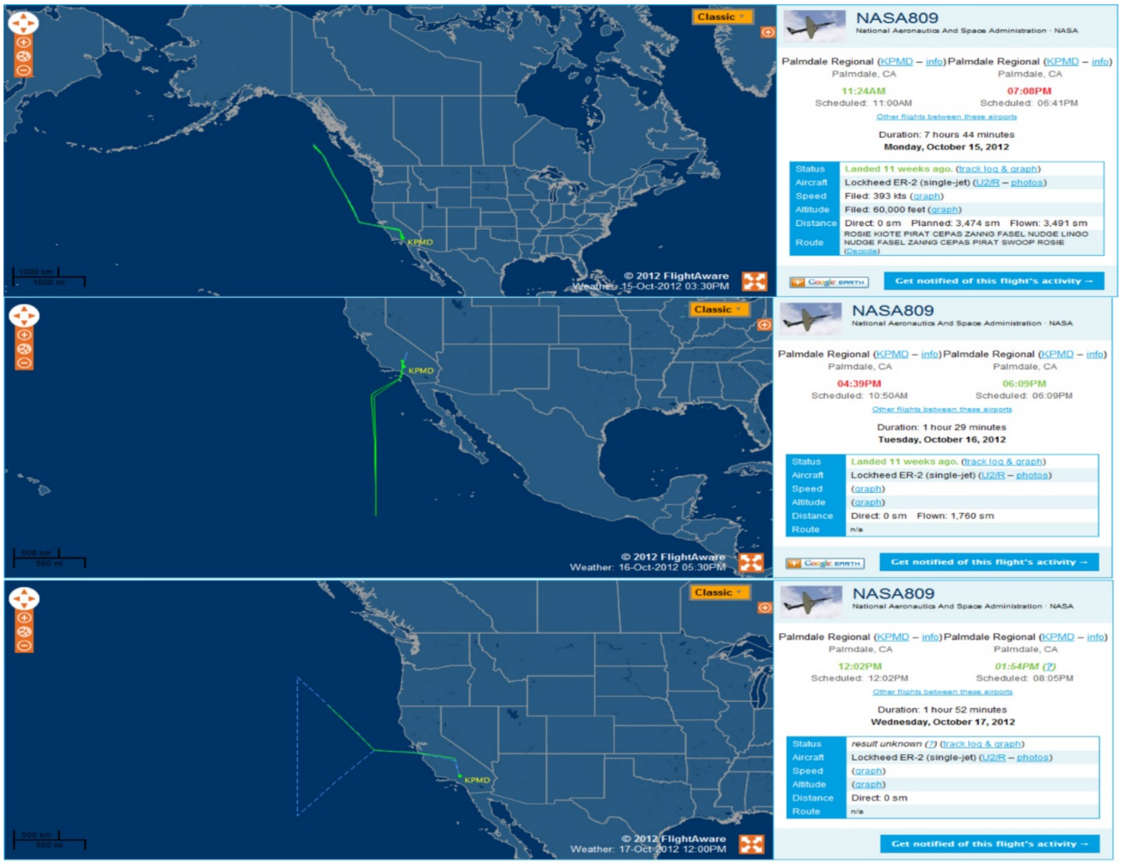

Figure 3.– Flight data from FlightAware data for aircraft ER-2 NASA809 October 15–17, 2012, showing the aircraft flight path during sample collection.

Preliminary Examination. JSC's Cosmic Dust Laboratory received the ER-2 flight collectors in late October 2012. Upon first review, we noted that one pair of large collectors (L2096 and L2097) had suffered an O-ring failure and possible ground contamination; collection was stopped after 15.1 hours. Preliminary examination of L2094 and L2095 revealed a low concentration of particulate matter on the surface of the collectors due to the short collection period (approximately 23 hours).

The harvest of likely particles from the various collection surfaces has begun. An example of each cluster particle is examined as well as a subset of all interesting individual grains. Using a scanning electron microscope (SEM), energy-dispersive X-ray spectra (EDX) are collected for each grain. Several examples of *potential* Giacobini-Zinner grains are shown in figure 4. If successful, this collection effort will essentially be a comet coma sample return mission accomplished at a tiny fraction of the cost of a spacecraft mission.

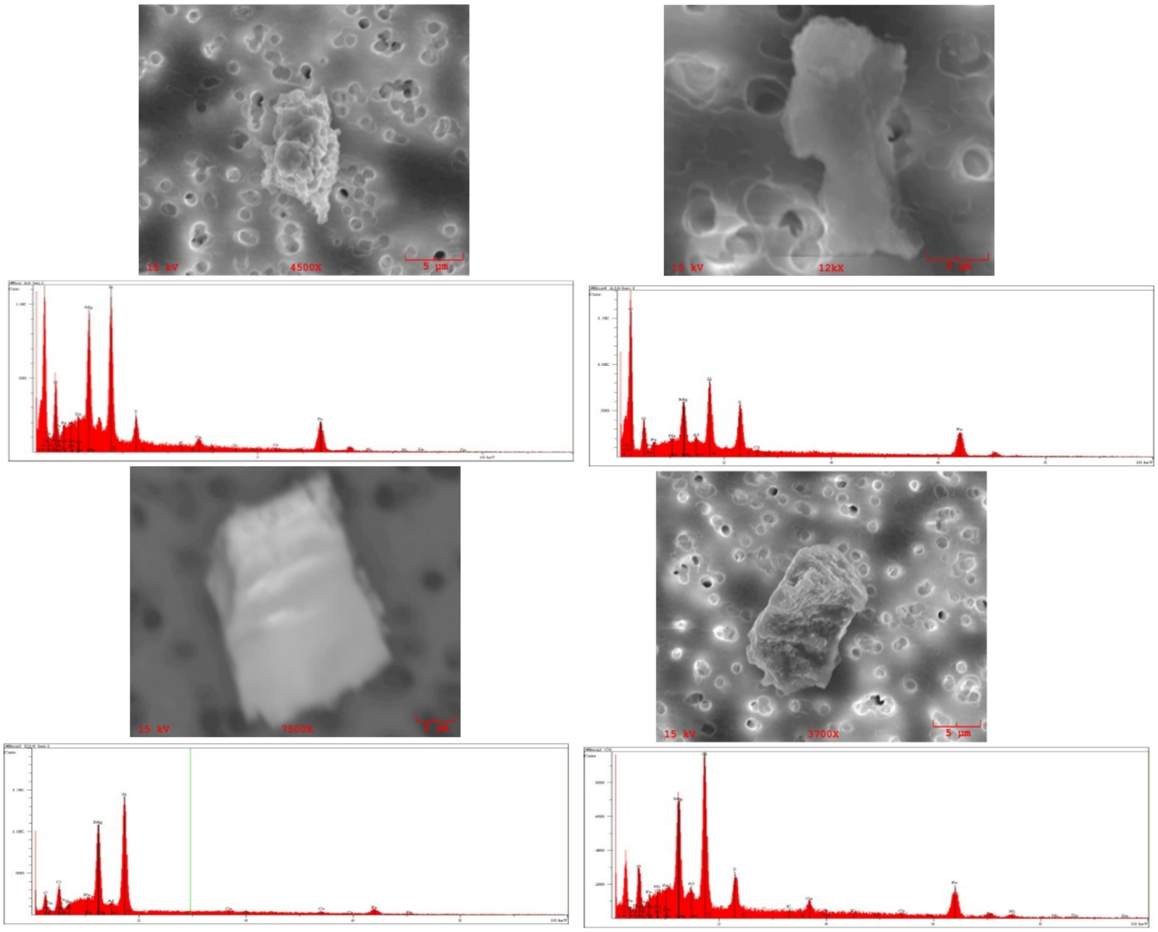

Figure 4.– SEM images and EDX spectra for four particles harvested from collector L2094. These EDX spectra are consistent with an extraterrestrial origin.

GeoLab: A Geological Workstation for Future Missions

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The GeoLab glovebox was, until November 2012, fully integrated into NASA's Deep Space Habitat (DSH) Analog Testbed (figure 1). The conceptual design for GeoLab came from several sources, including current research instruments (Microgravity Science Glovebox) used on the International Space Station, existing Astromaterials Curation Laboratory hardware and clean room procedures, and mission scenarios developed for earlier programs.

GeoLab allowed NASA scientists to test science operations related to contained sample examination during simulated exploration missions. The team demonstrated science operations that enhance the