Interim Report

Analysis of the particulate samples captured by Montana Space Grant Consortium passive high altitude particle experiment flown on September 2, 2007

Prepared for
Dr. William Hiscock
Director of the Montana Space Grant Consortium
Montana State University

and

Dr. T. Gregory Guzik
Director of the High Altitude Student Platform
Louisiana State University

By

Jayson Nissen and Jennifer Susan Hane

April 9, 2008

Overview

In 2007, the Montana Space Grant Consortium BOREALIS team at Montana State University designed and constructed a device designed to capture dust particles in the upper stratosphere. This device was flown on Louisiana State University's NASA-sponsored High Altitude Student Platform (HASP) on September 2, 2007. The team was particularly interested in capturing materials of extraterrestrial origin for analysis and comparison with previous collections made by other parties. The flight occurred at a favorable time for this purpose, as the Perseid meteor shower had peaked on August 13, and the rare Aurigid shower had peaked on September 1. It is possible that as a result of these showers, the density of meteoritic particles in the upper atmosphere was greater than usual at the time of the flight.

The basic design of the particle capture device is that of a box with hinged lids, containing a layer of PDMS (polydimethyl siloxane, or silicone fluid) to trap any particles that fall into it. The box is designed to be sealed during ascent and descent to prevent contamination by terrestrial materials. During the HASP flight the lids of the box were successfully opened when the platform reached its cruising altitude of ~124000 ft. The box remained in collection mode for approximately twelve hours until the command was sent to close the lids. When the box was recovered it was found to have sealed successfully; it maintained this seal until it was opened for fluid removal.

Sample Preparation

The particle capture box is evenly divided into two sections, each with its own lid. After the box was recovered, the team opened one of these sections inside a clean room. Hexane was poured into the box to dissolve the PDMS. When the PDMS had softened sufficiently, it was poured from the box into a glass vacuum bottle. Some of the thicker fluid was removed with the help of a lint-free swab. The BOREALIS team removed approximately three quarters of the fluid contained in that section of the box in this manner.

Once in the vacuum bottle, the fluid was shipped to Jack Warren, the team's contact at the Cosmic Dust Laboratory at the Johnson Space Center in Houston. Jack examined a portion of the fluid under an optical microscope and used a glass needle to remove approximately 60 particles which he believed had a high probability of being cosmic in nature. These particles were mounted on glass slides. Eighteen of the particles Jack removed are spheres. The remainder of the fluid was dissolved in additional hexane and passed through a single filter. These materials were re-shipped to the team at MSU for analysis.

Analysis of Sample

The BOREALIS team's subsequent analyses of the samples were performed on a Field Emission Scanning Electron Microscope (FEM). This microscope is the property

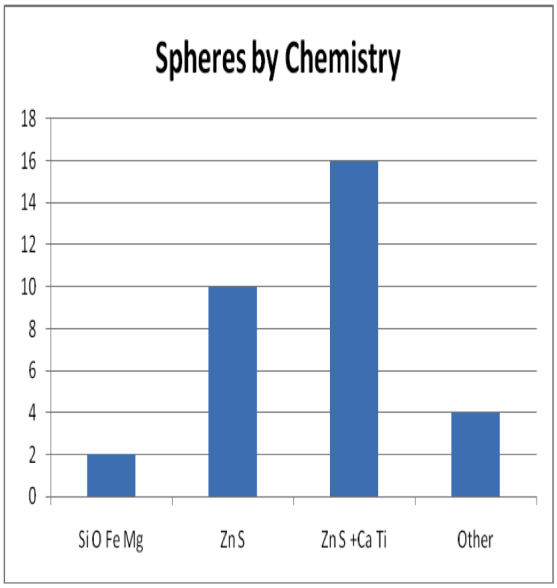
of the Image and Chemical Analysis Laboratory (ICAL) on the MSU campus. It allows for high-resolution imaging and quantitative chemical analysis via X-ray detection. More information on this microscope may be found at the web address given below:

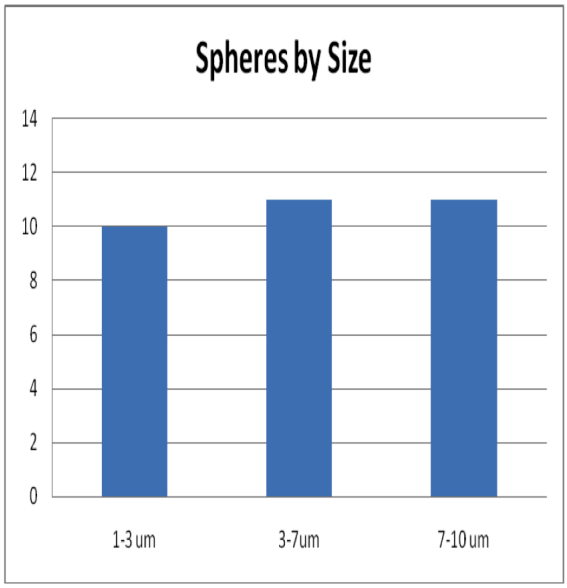
http://www.physics.montana.edu/ical/pages/analysis.htm

The analysis is still ongoing and this report provides an update of our progress. All of the particles which have been analyzed so far were located on the filter which Jack Warren prepared. Below we provide images and x-ray analysis of several particles. The sample filter was sputter-coated with iridium to reduce static charge build up caused by the analytical technique. Particles are located, identified and imaged under high vacuum. The chemical analysis is then conducted under the variable pressure mode of the FEM at a pressure of 29-32 Pascals.

Particle Distribution

Approximately 20% of the filter surface area has been surveyed using the FEM in the imaging mode. In this mode we imaged and registered the location of any spherical particles observed. These particles were then later subjected to chemical analysis.





The following graphs illustrate the distribution of the 32 identified particles by their size and chemical composition. These spherical particles are evenly distributed through the range of 1-10 μm. Approximately 20 spherical particles larger than 10 μm were isolated by Jack Warren but none have been found on the filter. The particles that we have analyzed can be placed into three general categories. We believe that the particles in the first category are silicates containing traces of Fe and Mg. Two particles of this type have been identified. In the second category, which consist of miscellaneous particles, two particles containing predominately Al and O have been found. We believe that these

two aluminum oxide spheres originated from the exhaust of solid fuel rockets. Since aluminum oxide spheres are only abundant in the upper atmosphere, the team considers them to be a strong indication that the capture fluid contains particles which were collected at altitude, not merely contamination from the terrestrial environment. The most abundant particles all appear to contain Zn and S with or without Ca and Ti.

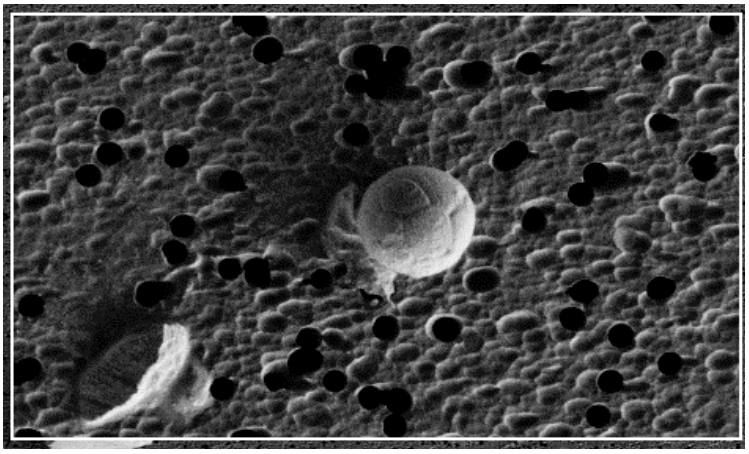
Particles of Interest

Below we present images and x-ray spectra for each of the different particles types described above. In the case of the x-ray analysis both the particle spectrum (shown as magenta) and the background spectrum (shown as blue) of the filter have been overlaid. When the intensity of the particle peak for a given element is significantly greater than that of the background then we assume that the particle contains that element. It should be noted however that the relative peak heights for the different elements are not directly proportional to atomic abundance.

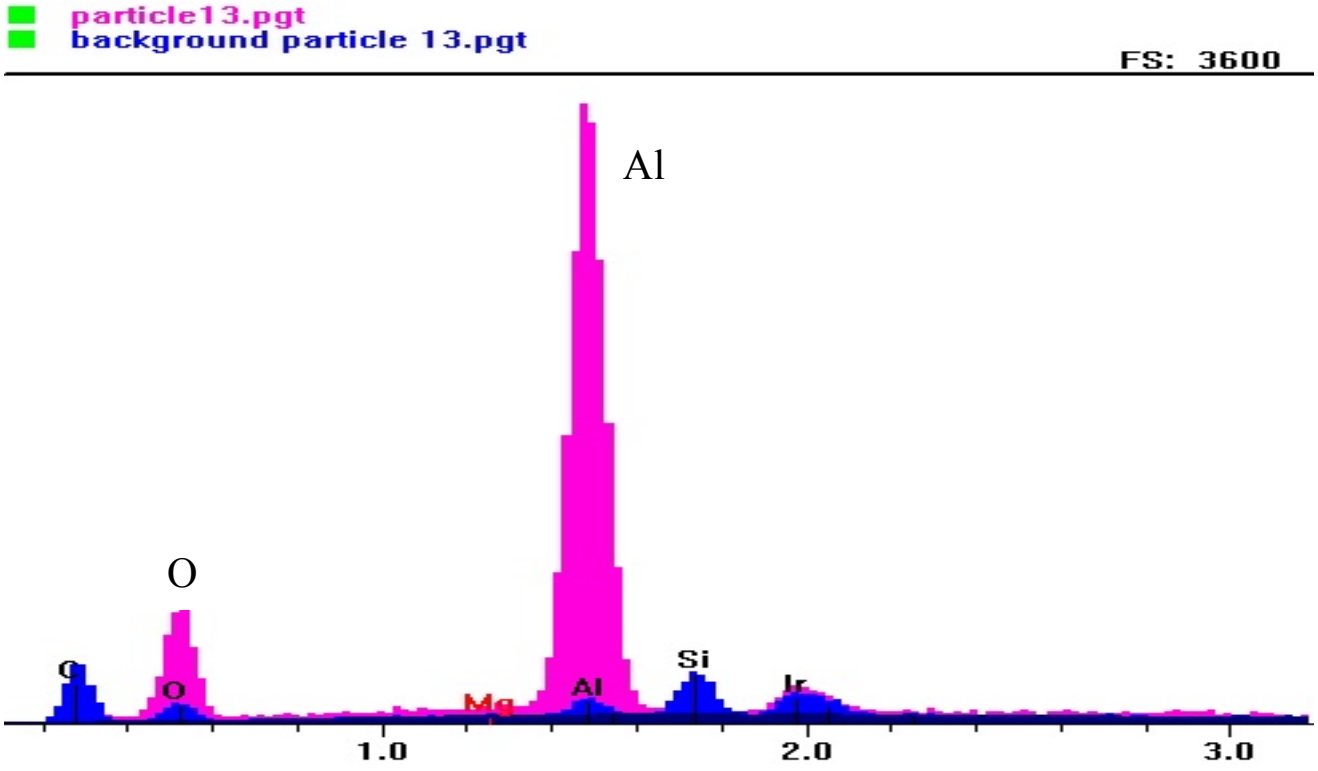
The first particle that we discuss is labeled as Particle 13. The fact that the chemical composition of this particle is dominated by Al and O, along with the topology of its surface, gives a high probability of its being Al_2O_3, a rocket exhaust constituent. The collection of this particle is common during high altitude particle collection and is evidence that the HASP project successfully collected particulates from the upper atmosphere

Particle 13 Al O Sphere, 5µm;

Particle 13 Image:



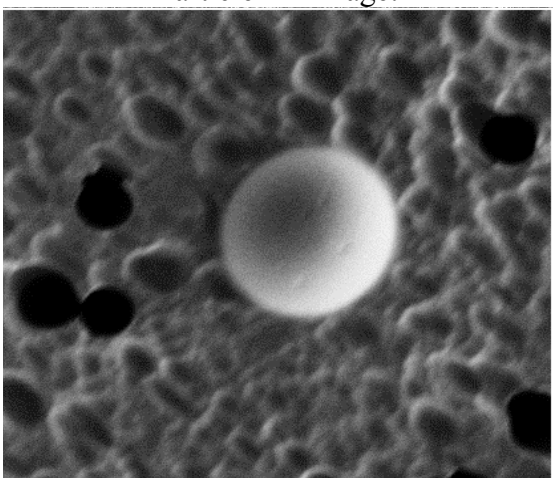
Particle 13 Analysis:



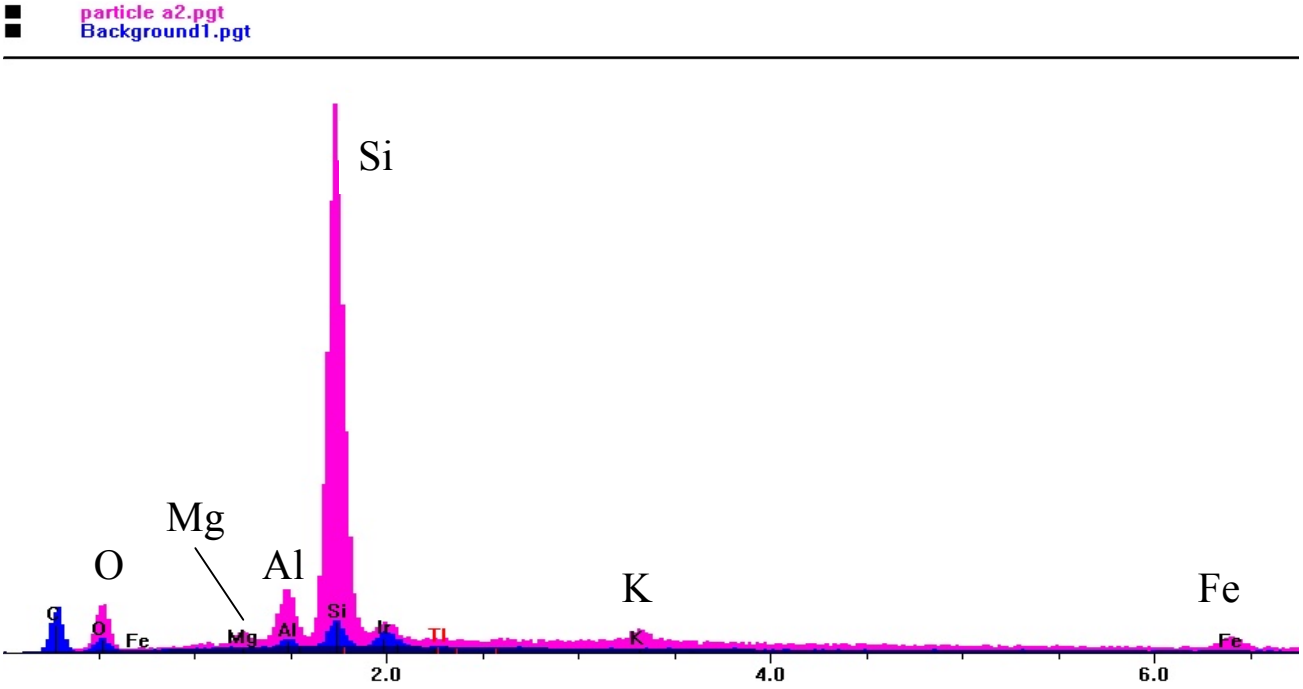
The next particle discussed is labeled particle A2. The spectral overlay indicates the particle is composed of Si and O along with the metals Fe, Mg, Al and K. This particle's 2µm size, chemical composition and smooth round surface make it the most probable particle to be of cosmic origin.

<u>Particle A2 (Si, O, Fe, Mg, Al Sphere) 2µm,</u>

Particle A2 Image:



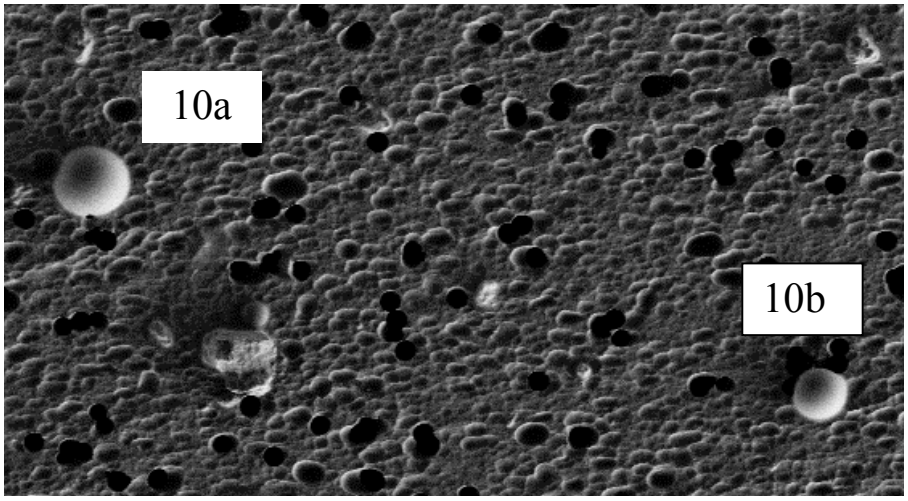
Particle A2 Analysis:



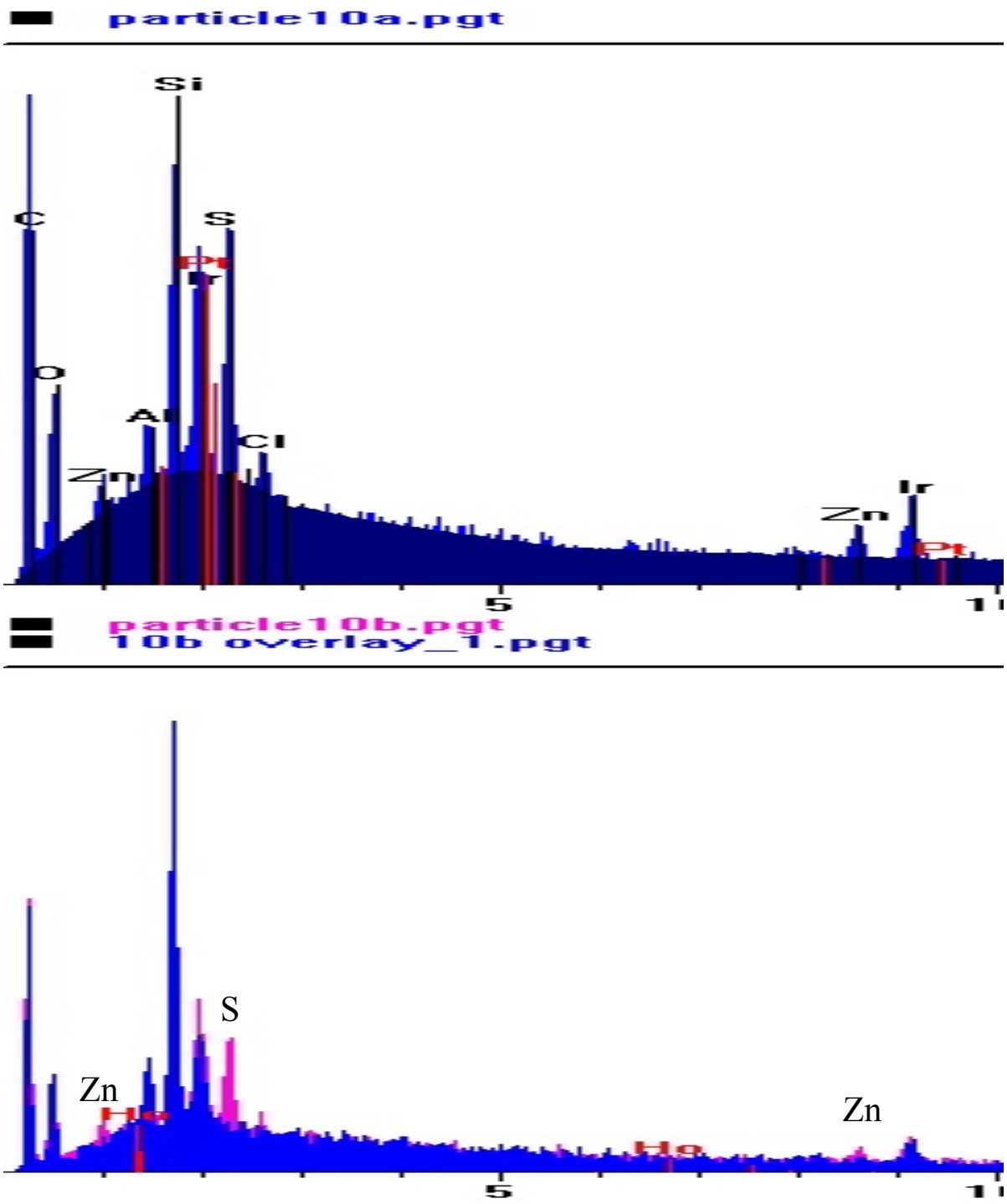
The final pair of particles discussed is labeled 10a and 10b. The x-ray analysis of these particles is not as definitive as those shown above but it appears that these particles contain Zn and S.

<u>Particles 10a (4µm) and 10b (2 µm)(Zn and S)</u>

Particle 10a/10b image:



Particle 10a/10b analysis:



Conclusion

At this point approximately ten percent of our entire sample has been processed and analyzed. Thirty-two spheres have been identified with two having a chemical composition similar to that of known cosmic dust samples. Complete analysis of the sample may reveal particles associated with the Aurigid Meteor Shower.