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Collecting Dust in the Upper Stratosphere at high latitudes: Constraints on the Compositions of Cosmic Dust Particles

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Abstract

A newly developed collector, DUSTER [1], was launched from Longyearbyen (Svalbard, Norway) on June 2008. This balloon-borne, autonomous instrument was in the stratosphere for 3.5 days at 37 ± 1 km altitude where it continuously sampled the ambient stratosphere during a 55-hour period. At any given time the upper stratosphere may contain, in continually variable amounts, solid dust particles of a natural terrestrial origin (*i.e.* mostly volcanic dust), anthropogenic origins (*i.e* coal- and oil-burning power plants, airplane exhaust, reentering space debris) and natural extraterrestrial debris (interplanetary dust particles (IDPs), micrometeorites, meteoric dust). In addition to these solid dust particles, the upper stratosphere may contain condensed aerosols (*e.g.* sulfuric acid).

Each collected solid dust particle is fully characterized, *viz*. size, shape (irregular, sphere), morphology (aggregate, massive), and chemical composition (i.e. silicates, carbonates, oxides) and organic materials using a combination of field-emission scanning electron microscopy (FESEM) and energy dispersive X-Ray analyses (EDX), and micro-infrared and micro-Raman spectroscopy. This database will provide a well-documented inventory of the solid dust in the upper stratosphere as a function of time, altitude and longitude. Very few of such comprehensive records exist, yet knowing the chemical and physical properties of this stratospheric dust will be useful to assess global climate change and upper-troposphere/lower stratosphere exchange models [2]. This inventory will also benefit the laboratory studies of aggregate IDPs that are dust from active comets and primitive asteroids. Since the 1970's the study of IDPs collected in the lower stratosphere struggled to assess contamination by submicron stratospheric dust and condensed aerosols.

Here we report our continuing characterization of the dust from this DUSTER flight. More than half of the grains are between 0.5 µm and 10 µm; there are two, low-Ca,Na silicate spheres >100 µm [2]. The 10 - 100 µm gap is filled by only a single ~20-µm aggregate particle. Many grains <10 µm have carbonate compositions (EDX, µ-IR). They also include three, ~2-µm, compact aggregates of nanometer-scale Sn-oxide, probably SnO_2, grains [Fig. 1].

Tin-oxide grains, identified (electron diffraction) as Sn_2O_3 and Sn_3O_4, arranged in a compact, ~400 x ~200 nm cluster [Fig. 2] were present in a chondritic aggregate IDP [3]. Their appearance was consistent with the aggregate nature of the IDP but which is not unambiguous proof of an indigenous origin. Still, the tin-oxide grains fit the volatile element distribution pattern of IDPs [3]. Absent data for nanometer-scale tin-oxides present in the stratosphere, the possibility of contamination by particle-particle collision was not explored. This probably first report by DUSTER of small Sn-oxide grain clusters in the upper stratosphere shows that knowledge of the chemical and physical properties of the upper stratospheric dust population will indeed have the potential to impact on other research than atmospheric science.

Figures

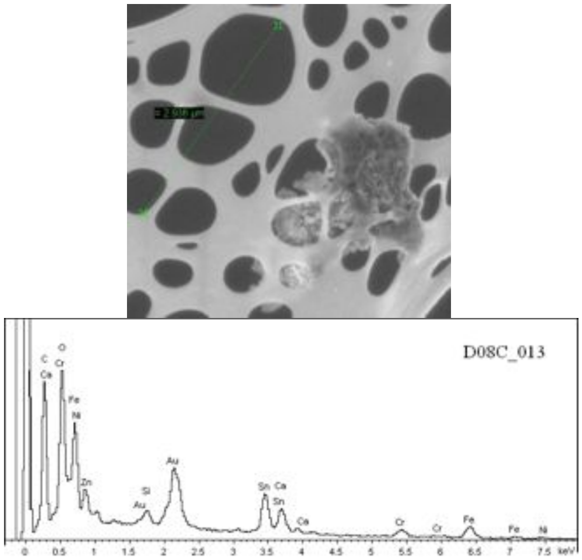

Figure 1: Scanning electron microscope image of a Sn-rich grain D08C_013 collected by DUSTER2008 flight. Below the Energy dispersive X-ray spectrum of this grain. Cr, Fe, Ni and Au are chemical contaminants [2].

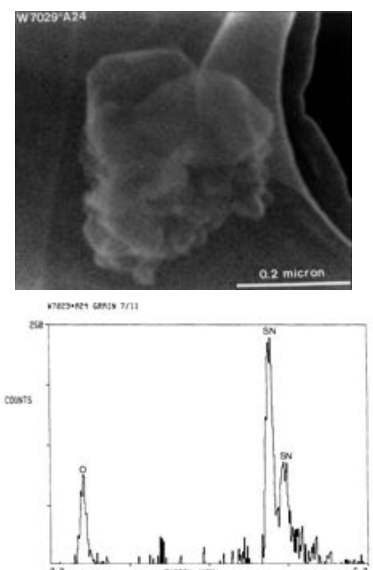

Figure 2: Scanning electron microscope image of tin oxide grains in chondritic IDP W7029*A24. Below the background subtracted Window-less energy dispersive spectrum (range 5 keV) to eliminate carbon X-rays generated from the holey carbon support film (reproduced from Ref 1; courtesy The Meteoritical Society).

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