Discovery of a New Mineral from a Cometary Particle

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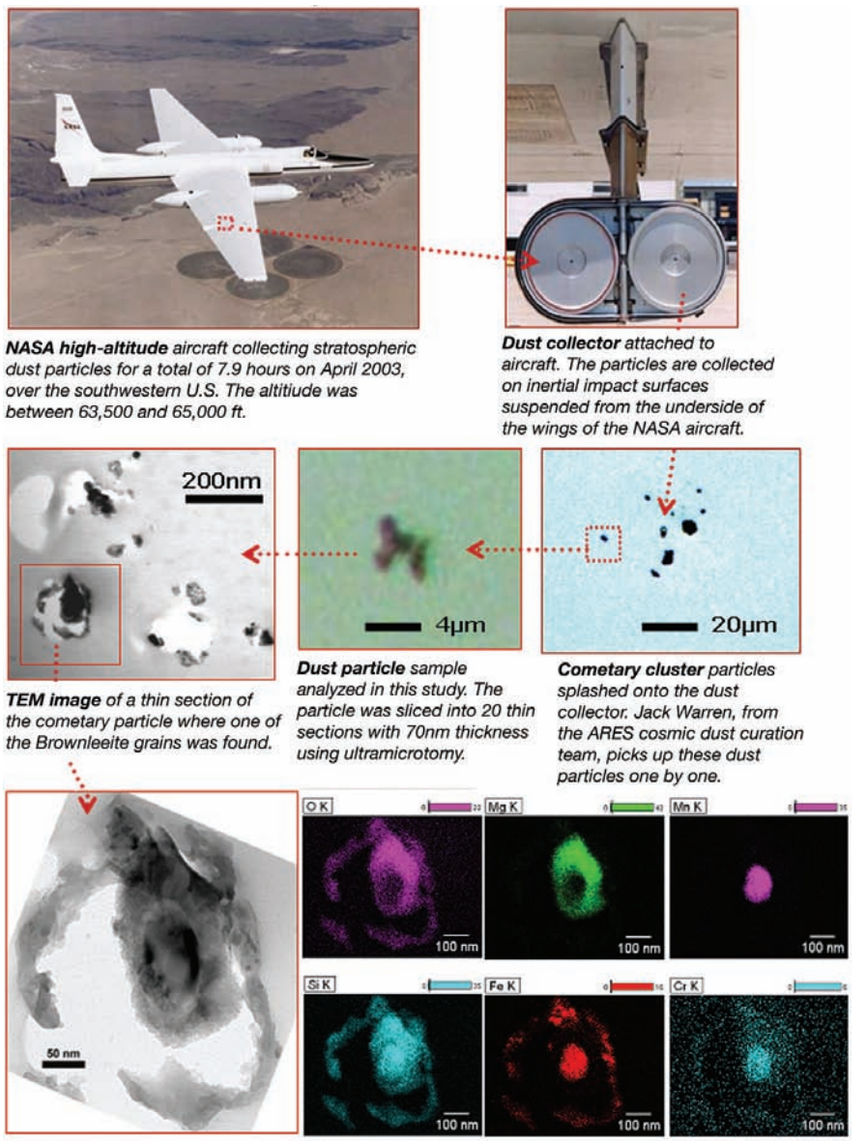
The International Mineralogical Association (IMA) officially recognizes 4,324 minerals. Johnson Space Center Astromaterials Research and Exploration Science (ARES) scientists added one more mineral to the list, the first new mineral ever found in a cometary specimen. This new mineral, a manganese silicide (MnSi) named "Brownleeite," was discovered within a cosmic dust particle that likely originated from a comet – perhaps comet 26P/Grigg-Skjellerup. The Earth accretes about 30,000 tons of dust particles from space each year; these dust particles originate from the disintegration of comets and collisions among asteroids. This cosmic dust is a subject of intense interest because it is composed of the original building blocks of our solar system, the planets, and our own bodies. Since 1982, NASA has routinely used high-altitude research aircraft to collect cosmic dust. However, because of their complex histories in space, the sources of most cosmic dust particles are difficult to determine.

We had an opportunity to collect cosmic dust from a specific source. Comet 26P/Grigg-Skjellerup is a source of dust grains that could be collected in the Earth's stratosphere at a specific time of the year. NASA used a high-altitude aircraft to collect cosmic dust particles from this particular comet dust stream in April 2003. The particles collected at this time contained the new mineral, Brownleeite (figure 1).



NASA high-altitude *aircraft collecting stratospheric dust particles for a total of 7.9 hours on April 2003, over the southwestern U.S. The altitiude was between 63,500 and 65,000 ft.*

Dust collector *attached to aircraft. The particles are collected on inertial impact surfaces suspended from the underside of the wings of the NASA aircraft.*

TEM image *of a thin section of the cometary particle where one of the Brownleeite grains was found.*

Dust particle *sample analyzed in this study. The particle was sliced into 20 thin sections with 70nm thickness using ultramicrotomy.*

Cometary cluster *particles splashed onto the dust collector. Jack Warren, from the ARES cosmic dust curation team, picks up these dust particles one by one.*

Brownleeite crystal *in the core Poikiolitically enclosed by LIME [low-Fe, Mn-enriched] olivine mantle.*

Nanoscale x-ray *elemental imaging by STEM2500SE EDX [energy-dispersive x-ray] system revealing that the Brownleeite grain (left) is free of O and Mg, but contains Mn, Si, Fe, and Cr.*

Fig. 1. *Brownleeite discovery flowchart.*

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continued

The ARES scientists installed, a powerful new transmission electron microscope (TEM), the JEOL [Japan Electron Optics Laboratory] STEM2500SE, at the ARES E-beam facility in 2005. Because of the exceedingly small size of the individual cometary dust components, we used state-of-the-art nano-analysis techniques in the TEM to measure the chemical composition and crystal structure of the Brownleeite. We discovered that one of the dust particles from the comet 26P/Grigg-Skjellerup collection contains three tiny grains (100, 250, and 600 nm in size) of an exotic phase that has never been found in nature before. In fact, no one predicted that this phase was either a cometary component or a phase formed by condensation in the solar nebula.

Recent analysis of material returned by the NASA Stardust mission comet Wild-2 demonstrates that cometary components originate in a wide range of astrophysical environments, including refractory minerals formed at high temperature in the inner solar system; low-temperature organic material from the outer reaches of the solar system or from interstellar molecular clouds; and dust grains from evolved stars whose origins predate the solar system. This new mineral (the Brownleeite) must have formed under rather reducing, oxygen-depleted conditions that were the average for our early solar system. Alternatively, MnSi may have condensed within the high-temperature and chemically heterogeneous ejecta of a supernova explosion. As previously found in meteorites and cosmic dust particles, mineral grains from supernovae can be identified on the basis of their exotic isotopic compositions. We may therefore be able to determine in future, using the ARES NanoSIMS 50L to produce silicon isotopic measurements, whether Brownleeite came from a supernova source.

The IMA-approved new mineral Brownleeite is named after Donald E. Brownlee, a professor of astronomy at the University of Washington, Seattle. Prof. Brownlee founded the field of cosmic dust research and is a principal investigator of the Stardust mission. Of all current sampling techniques developed by Prof. Brownlee, sampling in the Earth's stratosphere is the superior way to obtain the least-altered cosmic dust samples. Our current view and understanding of the early solar system established from cosmic dust studies would not exist without Prof. Brownlee's efforts.

Although Brownleeite has been synthesized and studied by materials scientists as a new-generation semiconductor, it has never been found in nature. There are places somewhere in the universe that are producing Brownleeite; and it is this mineral that is being supplied to the Earth, little by little, as cosmic dust enters our atmosphere.

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