

# Plucking comet dust from Stardust collectors

December 14 2006

---

Ever since NASA's Stardust spacecraft delivered a payload of comet dust to Earth on Jan. 15, 2006, scientists by the hundreds have been clamoring for samples.

The gatekeeper to the dust is University of California, Berkeley, physicist Andrew Westphal, who developed the techniques that he and NASA now use to extract the microscopic dust grains from the aerogel collectors without shattering the aerogel and contaminating the samples.

During the past 11 months, the extraction facility set up by Westphal at UC Berkeley's Space Sciences Laboratory and another at NASA's Johnson Space Center have supplied eager researchers with more than 35 dust motes to poke and prod. That number represents about 10 percent of the larger comet dust grains embedded in the collectors.

Westphal's work is now beginning to pay off: research findings on the dust are announced this week in seven papers in the journal *Science*. They report, among other findings, that the stuff of comets is more diverse than people expected.

"Every test shows these particles to be as different as night and day," said Westphal, a senior fellow and associate director of UC Berkeley's Space Sciences Laboratory (SSL). "Extraterrestrial dust particles collected by high-flying U-2s in the atmosphere, some of which were thought to be from comets, appear to be more homogeneous, so this is a surprise."

Of the seven papers in the current Science, Westphal is coauthor of six. He contributed most to a chemical analysis of the dust grains conducted, in part, at Lawrence Berkeley National Laboratory (LBNL) with the intense X-ray beams of the Advanced Light Source. This work, done in collaboration with UC Berkeley colleagues Christopher Snead, Anna Butterworth and Zack Gainsforth, and LBNL scientists Sirine Fakra, Matthew Marcus, Mary Gilles and Tolek Tyliczszak, gives scientists a better idea of the composition of the early solar system, since the dust particles date from the time of solar system formation more than 4.5 billion years ago.

The study demonstrates, also, that the materials from which our solar system formed must have undergone a considerable amount of mixing while the sun and planets were forming. This is evidenced by the fact that, even though the comet formed in the cold outer reaches of the solar system, it contains some high-temperature minerals that probably formed much closer to the sun.

In particular, the comet dust analysis identified a few grains that contain calcium/aluminum-rich inclusions (CAIs) similar to those found in meteorites known as chondrites. Thought to be the oldest objects in the solar system, chondrites have always been a puzzle because they contain minerals that formed at low temperatures as well as minerals, like CAIs, that must have formed at high temperatures.

This discovery supports a theory of chondrite formation proposed 10 years ago by UC Berkeley astronomers Frank Shu and Hsien "Sienny" Shang in collaboration with Typhoon Lee, an astrophysicist and geochemist at the Academia Sinica's Institute of Earth Sciences in Taiwan. This theory, referred to as the X-wind model of chondrites, says that stars like the sun recycle some of the dust falling into them during formation of the system, melting it and throwing it out from the center in a fiery spray that condenses into small "chondrules," or beads of melted

rock. These beads are pushed by the strong solar wind, called an X-wind, out of the solar system disk and settle into the distant reaches of the solar system, where they eventually combine with colder material to form chondrites, asteroids and planets.

"This is what we have been waiting for almost 10 years now ," said Shang, an astrophysicist with the Institute of Astronomy and Astrophysics at the Academia Sinica who is currently visiting the UC Berkeley Department of Astronomy. "One of the key predictions of our X-wind model of chondrites is that we should be able to find CAI-like stuff from comets. What's important is that they found them, though they were tiny, CAI-like particles."

Shu, an emeritus professor of astronomy at UC Berkeley, stepped down earlier this year after four years as president of Taiwan's National Tsing Hua University and currently is with the physics department at UC San Diego.

During the seven years Stardust sailed to and from its encounter with Comet 81P/Wild 2, Westphal, Snead and Butterworth conceived a way to cut up - but not tear up - the aerogel to get at the comet grains. Taking millimeter-diameter glass rods, they heated and stretched them until their tips became sharp microneedles that could be used like a sewing machine needle to stitch out a wedge they called a keystone. While one micromanipulator would jab the needles downward through the aerogel to cut around the particle tracks, which typically were no thicker than a human hair, another micromanipulator would slice diagonally to sever the keystone at its base.

Finally, they drill two holes in each wedge, stick in tiny, barbed "pickle forks" and pull the wedges away from the tiles. These tiny micromachined fixtures were made for the Stardust project by Christopher Keller, formerly of the Berkeley Sensor and Actuator

Center, and now president of MEMS Precision Instruments. Westphal worked with Johnson Space Center to construct the needed equipment in its Houston facility, mirroring the set-up at UC Berkeley.

Once the Stardust spacecraft parachuted to Earth, the detectors - 132 tiles of a fluffy, smoke-like substance called aerogel - were flown to the space center and housed in clean rooms to prevent contamination. The tiles were removed individually and scanned for comet particles, which were then cut out of the aerogel either there or at UC Berkeley.

In practice, the entire wedge, no more than a few millimeters on a side, was often sent to interested researchers, in particular those planning to zap them with synchrotron X-rays to analyze elemental composition. Other researchers planned to encase the wedges in acrylic and slice the plasticized aerogel and dust simultaneously into 100-nanometer slabs, a process called ultramicrotoming. Alternatively, individual grains were extracted from a keystone - by hand, if they were large enough - and sent off to be microtomed for atomic analysis.

"We had to tailor our extractions to the needs of 30 different analytical techniques, which was incredibly fun," Westphal said.

While Westphal enjoyed the first hectic six months of dust mote extraction, part of NASA's planned preliminary examination period, the process has now slowed down while the agency vets applications to study the remainder of the comet dust. Nevertheless, he and Johnson Space Center scientists have a lot more work to do extracting the precious cargo from the collectors.

"There are probably about 300 trails in the tiles containing comet particles larger than 10 microns," the equivalent of one-tenth the diameter of a human hair, he said. There also are thousands of much smaller particles embedded in the aerogel.

Though Westphal will continue his study of the comet dust, he hopes to devote more of his attention to other Stardust hitchhikers: the much younger and much smaller grains of interstellar dust sprinkled throughout another 130-tile set of aerogel detectors. Through an online project called Stardust@home, members of the public are now looking through scans of these tiles for signs of dust trails. By the time they're identified, Westphal will be an old pro at extracting and studying them.

Source: University of California - Berkeley

Citation: Plucking comet dust from Stardust collectors (2006, December 14) retrieved 10 April 2024 from <https://phys.org/news/2006-12-plucking-comet-stardust-collectors.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.