Look into the Seeds of Time

Joanne Baker, *et al.*

Science **314**, 1707 (2006);
DOI: 10.1126/science.314.5806.1707

INTRODUCTION

Look into the Seeds of Time

COMETS ARE FABLED HARBINGERS OF DOOM, BUT MANY OF US WILL REMEMBER more fondly the peaceful visits of comets Hayakutake and Hale-Bopp to our skies in 1996 and 1997. These wanderers of our solar system spend most of their time in its cold outer reaches, only occasionally venturing near Earth's orbit. As they veer close to the Sun, ice and dust from their small nuclei are swept out by the radiation and solar wind into a fuzzy halo, or coma, and a long tail.

Comets are thought to harbor relatively pristine detritus from the rubble disk out of which the planets grew. In just over a year, two space missions have given us a close look at the materials that make up different comets. First, Deep Impact fired a projectile into the nucleus of comet 9P/Tempel 1, ejecting a huge plume that was studied remotely (see *Science*, 14 October 2005). Now, as described in this issue, Stardust has retrieved direct samples of the coma of comet 81P/Wild 2.

Comet Wild 2 originally hails from the Kuiper belt, beyond Neptune, but was recently perturbed into an orbit between Mars and Jupiter that is within the reach of spacecraft. After its launch in 1999, Stardust sneaked up on the comet in 2004, then returned its precious cargo to Earth in a capsule on 15 January 2006. Bringing back materials from a known extraterrestrial source, as with the Apollo samples from the Moon, is critical for deciphering the history of our solar system and interpreting our other extraterrestrial samples: meteorites and cosmic dust particles.

Stardust's goal rested largely on two technical achievements. First the spacecraft had to be slowed so that it could engage with the comet. A clever trajectory enabled it to pass within 240 km of the nucleus at a speed of just 6 km/s, albeit six times faster than a bullet. To catch the comet particles, a special lightweight material called aerogel was developed and molded into a detector grid. Aerogel, the lightest solid known, is a foamed glass that has the density of air (see the cover). Particles were gently brought to a standstill as they tunneled through it without much heating or alteration, leaving carrot-shaped tracks. Thousands of tiny particles were trapped, most of them smaller than a micrometer in size.

Analysis of the tiny samples by many international teams shows that many particles are mixtures of minerals, mostly silicates. The lack of amorphous grains is one surprise, because such materials are seen in interstellar space. Isotopically, the comet specks resemble rocks from the inner solar system; virtually no grains that pre-date the Sun were seen. A single grain contains minerals produced at high temperatures, in a region close to the Sun, and with isotope ratios similar to those of some meteorites. Thus, material has been mixed across the solar system, from the innermost portion to the outer regions of the Kuiper belt where this comet originated.

Although this mixing makes it difficult to explain comet histories, it also means that the Stardust samples might tell us much more about how planets formed. The first rock samples brought back to Earth from anywhere beyond the Moon, the tiny Stardust grains may contain the building blocks of the entire solar system.

–JOANNE BAKER

Stardust

CONTENTS

Perspectives

1708 Whence Comets?
M. F. A'Hearn

1709 NASA Returns Rocks from a Comet
D. S. Burnett

Research Article

1711 Comet 81P/Wild 2 Under a Microscope
D. Brownlee et al.

Reports

1716 Impact Features on Stardust: Implications for Comet 81P/Wild 2 Dust
F. Hörz et al.

1720 Organics Captured from Comet 81P/Wild 2 by the Stardust Spacecraft
S. A. Sandford et al.

1724 Isotopic Compositions of Cometary Matter Returned by Stardust
K. D. McKeegan et al.

1728 Infrared Spectroscopy of Comet 81P/Wild 2 Samples Returned by Stardust
L. P. Keller et al.

1731 Elemental Compositions of Comet 81P/Wild 2 Samples Collected by Stardust
G. J. Flynn et al.

1735 Mineralogy and Petrology of Comet 81P/Wild 2 Nucleus Samples
M. E. Zolensky et al.

Science

CREDIT: NASA