Comets: Mudballs of the Solar System?

Infrared images reveal trails of true grit

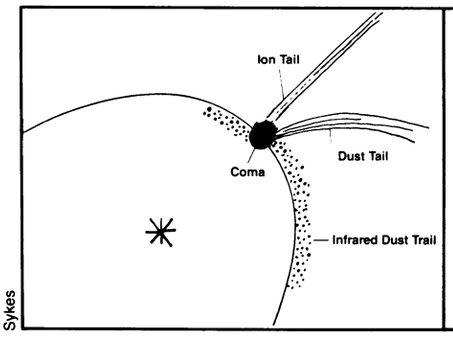
By RON COWEN

For some 40 years, astronomers have thought of comets as huge dirty snowballs — flying icebergs mixed with small amounts of rocky debris, dust and organic goo. Now, two astronomers have muddied that image.

Instead of snowballs, comets may more nearly resemble frozen mudballs, they conclude.

The new finding, based on infrared images of cometary dust, indicates that the primordial recipe for making comets required about equal volumes of rock and ice rather than primarily ice. "It's really a different picture of what the comet nucleus could be," says Mark V. Sykes of the University of Arizona in Tucson.

Intriguingly, the revised rock-to-ice ratio approximates the composition of Pluto and Triton, Neptune's largest moon, he notes. That similarity supports the notion that many comets were formed in the same region of the solar system as Pluto and Triton — and that an agglomeration of comets may well have created these bigger bodies.



Sykes

Comets generally exhibit three features in visible light: the coma, an ion tail and a dust tail. Analyses of data taken by the Infrared Astronomical Satellite now suggest that many comets also sport a dust trail, made up of larger particles that move slowly away from the nucleus and closely follow the orbit of the parent comet.

Astronomers, from the ancient Chinese onward, have scrutinized comets and pondered their meaning. Sykes began his rocky odyssey while a graduate student in 1986, when he spotted an odd feature in several images constructed from data gathered by the Infrared Astronomical Satellite (IRAS) in 1983. Telltale streaks in the images revealed the presence of giant, never-before-seen trails of dust particles associated with three comets that visit the inner solar system every three to seven years. These trails — a phenomenon related to, but separate from, the dust tails comets flaunt in visible light as they move near the sun — consist of larger, pebble-sized debris that scatter sunlight poorly. Because they glow primarily in the infrared, the trails had gone undetected with optical telescopes.

Unaware of the deeper implications of their work, Sykes and his colleagues reported their curious finding in the May 30, 1986 SCIENCE.

A new analysis of the images by Sykes and Russell G. Walker of Jamieson Science and Engineering, Inc., in Scotts Valley, Calif., now reveals a total of 17 infrared dust trails, eight of them associated with comets that pass near the sun an average of once every seven years. Moreover, most of the eight comets were glimpsed by IRAS at their closest approach to the sun, when dust particles heat up and glow brightest in the infrared. The remaining nine trails are not associated with known comets, hinting at the existence of short-period comets not yet discovered.

For Sykes and Walker, these latest findings suggest that all short-period comets — those that pass near the sun at least once every 200 years — have infrared dust trails. The relatively small number of trails so far detected merely suggests that only those comets closest to the sun at any given time would likely reveal the dusty features in infrared images, Sykes says. In addition, the amount of dust in the trails indicates that rocky debris accounts for three-fourths of a comet's mass (ice would provide the other 25 percent) and half its volume, the astronomers reported last November at a meeting of the American Astronomical Society's Division for Planetary Sciences. Sykes and Walker provide further details in the February ICARUS.

Their comet-composition estimate, though consistent with other recent measurements, remains speculative, since no one has ever seen the inside of a comet. Indeed, the chilly surface of a comet reflects too little light for astronomers to observe the object during most of its orbit. Only when it nears the sun does the frozen body burst back into life, sporting three distinct features in visible light — a coma, or cloud of dust and gas surrounding its nucleus; a dust tail, composed of tiny particles less than a millionth of a meter in diameter; and an ion tail, composed of charged gas molecules.

In an effort to account for these tails, and to explain why comets passing close to the sun don't simply burn up, astronomer Fred L. Whipple of the Smithsonian Astrophysical Observatory in Cambridge, Mass., made a now-famous proposal. In 1951, he suggested that comets contain large amounts of ice interspersed with dust — a theory that became known as the dirty snowball model. As a poor heat conductor, ice would enable a comet to withstand the sun's intense radiation, Whipple reasoned. Moreover, he calculated, a blast of heat from the sun would vaporize ice on the surface of a comet, converting some of the frozen material into a jet of gas that could propel dust out of the comet — like sand lashed by a fierce windstorm. Pressure exerted on the dust by solar radiation then sweeps the dust into a tail; charged particles from the sun (the solar wind) sculpt some of the comet's expelled gas into a separate, faint ion tail.

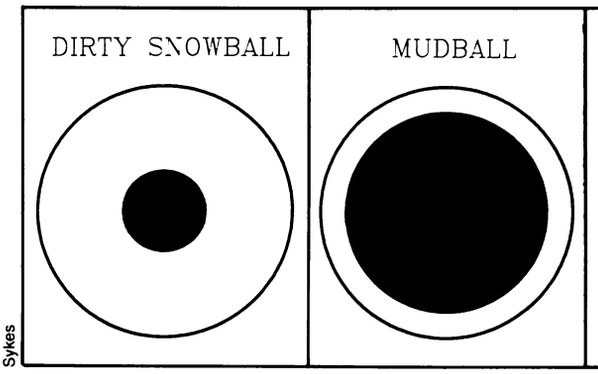
Whipple's enduring model has proven highly successful in explaining several idiosyncrasies about comets. Sykes and his colleagues don't dispute that a comet's nucleus contains a substantial amount of ice. Indeed, the vaporized ice is required to expel the centimeter- to millimeter-size particles that make up the infrared trails observed by IRAS. (Material in the infrared trails moves at one hundredth the speed of the dust in the visible-light tails and follows the orbit of the parent comet more closely.) But the sheer mass in these trails requires a dirtier version of the

comet nucleus than astronomers had envisioned, Sykes says.

Says comet expert Paul R. Weissman of the Jet Propulsion Laboratory in Pasadena, Calif.: "I don't think of this [the new work] as a replacement for the Whipple model, but just that we've added new complexity to go along with new observations."

Weissman notes that the European Space Agency's Giotto spacecraft, which flew within 605 kilometers of Comet Halley's nucleus in 1986, found about three times as much rock as ice in that classic comet. The finding, at first considered an anomaly, agrees with the trail results of Sykes and Walker.

That ratio of rock to ice also matches the density of two denizens of the outer solar system: Pluto and Triton. Researchers have speculated since the early 1980s that short-period comets formed in the same region of the solar system as these bodies – between the present-day orbits of Uranus and Neptune. Previous estimates of comet densities seemed at odds with this notion, but the new report increases support for the theory. "[Our study] adds another piece of information to understanding the origin of short-period comets," Sykes says.



Sykes

Fraction of a comet's nucleus, by mass, consisting of dust (dark areas) and ice under the dirty snowball and the mudball models. Debris and ice would be interspersed throughout the nucleus rather than isolated in separate layers, as depicted for simplicity in these diagrams.

He adds that the infrared dust trails show that comets expel more mass than researchers had estimated from previous observations. "Suddenly we have a whole lot more mass being lost than visible-light images had indicated," Sykes notes.

That realization, he says, leads to two tantalizing, though highly speculative implications. First, although researchers estimate that short-period comets last for tens of thousands of years, these celestial bodies may in fact waste away in half that time. And second, if the population of short-period comets remains fairly constant despite their shorter lifetime, then their proposed home base – an as yet unseen region of the outer solar system known as the Kuiper belt (SN: 4/21/90, p.248) – must have a far bigger reservoir of new comets than scientists had imagined.

On a murkier note, Sykes and Weissman observe that the origin of the gritty debris in the infrared trails remains a puzzle. Researches don't know whether these particles are fragments of the comet's crust or represent the basic building blocks of the comet's interior.

In the meantime, Sykes intends to keep searching for more of the dusty trails – both in IRAS data and in images taken by future infrared missions. Discovering many more such trails would substantiate the claim that all short-period comets are indeed mudballs.

To do this, Sykes faces the arduous task of scanning thousands more infrared images. Tracking dust is a dirty business, but someone has to do it. □

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the research report, published in the *New England Journal of Medicine,* Shaywitz and her coauthors define dyslexia as a discrepancy score representing the difference between actual reading achievement and achievement predicted on the basis of measures of intelligence. The researchers examined the progress of achievement by certain students from grades 1 to 3 and grade 5 – and came up with certain questionable conclusions.

While one may predict "reading retardation" (mild or severe) on this basis, *dyslexia cannot be defined – or diagnosed – in this manner.* Dyslexia is not simply reading below one's IQ level; it is much more than just reading retardation. It is a language communication disability reflecting problems with words – in reading, spelling, writing, speaking and listening. Thus, a reading achievement test and an IQ test alone cannot determine the existence or nonexistence of dyslexia. The researchers' definition is much too broad and general, and children in the study could have problems for a whole variety of reasons.

The researchers stated that only 28 percent of the children classified as dyslexic in grade 1 were also classified as dyslexic in grade 3, and they went on to say that as many as two-thirds of the children given this diagnosis early will not meet the criteria in two years. Of course not, given their definition of dyslexia. Because of maturational and developmental factors and behaviors, any attempt at diagnosing dyslexia before age 8 is fraught with the possibility of misdiagnosis. Any experienced early-childhood teacher knows that some children learn to read more quickly than others, but that the latter may surpass the former as time goes on. Such teachers know that many young students tend to reverse letters, may be confused about laterality, confuse words that are similar in appearance or sound, and are likely to have difficulties with sequencing. These experienced teachers also know that as young children mature and develop and move up through the grades, such behaviors tend to disappear as a result of natural maturation – which is obviously what happened to the students in Shaywitz's study. *Those first-grade children who no longer had dyslexia by third grade never had it in the first place.*

When dyslexic symptoms persist beyond that time when most childhood developmental conditions mature, then immediate steps should be taken toward positive identification and remediation should be provided if the child is found to have dyslexia. My concern is that after reading about Shaywitz's study, parents and educators may fall into the "he'll grow out of it" trap, and the child who is truly dyslexic will not receive the necessary understanding and services to alleviate the dyslexia.

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In the eye of the beholder

In "Hubble: A universe without end" (SN: 2/1/92, p.79), Capella is identified as "the sixth brightest star in the universe." This seems to imply that only five stars in the entire universe are brighter than Capella in absolute terms. Actually, Capella is the sixth brightest star in the universe only in terms of apparent magnitude; to our eyes, it is the sixth brightest star in the sky. In terms of absolute magnitude, there are many millions of stars brighter than Capella in the universe at large.

Michael D. Hartl
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Why not add DAD?

Did I detect a slight smile between the lines of "The diagnostic deluge" (SN: 1/18/92, p.44)? In that spirit, I would like to propose another addition to the guide to mental disorders. I call it DAD, for Disorder Addiction Disorder, which seems to afflict those compiling mental disorder manuals.

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CORRECTIONS

In "Dim galaxies shed light on early cosmos" (SN: 1/18/92, p.36), the low-surface-brightness galaxies discovered by Stacy S. McGaugh and his colleagues produced their first glimmers of starlight sometime in the past few hundred million years, not in the past few hundred thousand years as stated. Such a time period still means that starbirth in these galaxies "switched on" very recently, astronomically speaking.

The map included in "Desert sands yield ancient trading center" (SN: 2/15/92, p.100) was published circa A.D. 1550, not A.D. 150 as stated in information provided by the researchers. However, the map was constructed entirely from latitude and longitude estimates of Ptolemy, a geographer and mathematician who lived during the second century A.D.