sodium in the E ring's ice particles. Six percent of the particles are rich in sodium and contain salts such as sodium chloride and sodium bicarbonate, along with smaller amounts of potassium. Cassini has traced the ice grains to a towering plume rising from Enceladus's south pole.

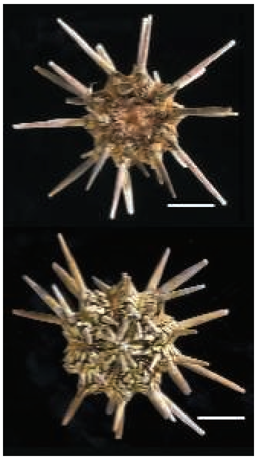
The CDA results are what would be expected if water from a deep ocean makes it to the surface and blasts from the fissures of the south pole, the group says. The salts—resembling terrestrial sea salt—are just the ones that liquid water would extract from rock thought to lie deep within the moon. In a poster presentation, CDA team members headed by dynamicist Jürgen Schmidt of the University of Potsdam in Germany argued that the Enceladus plumes must blast out tiny water droplets, not just water vapor. Only liquid could carry off the salts, they say.

Taken together, the salty ice grains appear to counter earlier arguments that Enceladus's plumes arise from frozen, not liquid, water. Geophysicist Susan Kieffer of the University of Illinois, Urbana-Champaign, had pointed out that liquid water could not possibly hold as much gas as Cassini has found in the plumes, but gas-entrapping water ice called clathrate could. Planetary scientist Andrew Ingersoll of the California Institute of Technology in Pasadena and the Cassini camera team agrees. "She's right," he says, but "it seems to me, Postberg holds the key to having it both ways." The low-sodium particles could have condensed from vapor coming off clathrates, he says, and the high-sodium grains could come from liquid water. Time will tell whether such a compromise will fly.

The Many Dangers of Greenhouse Acid

If global warming has its hungry polar bears, ocean acidification by greenhouse carbon dioxide has its declining coral reefs. But poster children can be misleading. "It is not good to think about coral reefs as epitomizing all issues of acidification," marine biologist Donald Potts of the University of California, Santa Cruz, warned during a session at the meeting. Other speakers showed that marine life is in peril almost across the board.

Geochemist Justin Ries of the University of North Carolina, Chapel Hill, and colleagues reported that most sorts of calcifying organisms—creatures that grow calcium carbonate skeletons or shells—suffered when pH sank much below the 8.2 of surface ocean seawater. They grew 18 species from eight major calcifying groups in the laboratory for 6 months under a range of carbon dioxide concentrations, including levels expected in the next decade, by the end of the century, and beyond.



Ouch. Extreme carbon dioxide levels led to dissolution (*bottom*) of normal sea urchin spines (*top*). Scale bars = 1 cm.

Although some species actually increased calcification with modest increases in carbon dioxide, most species—including periwinkles, oysters, urchins, and calcareous green algae—eventually formed less calcium carbonate under greater acidification. There were exceptions. One species of mussel showed no ill effects, and surprisingly, the crustaceans—an edible shrimp, an American lobster, and a blue crab—actually grew thicker shells under even the most severe acidification. But looking at the types of carbonate formed, the group found that only a tube-building worm could protect itself by producing a greater proportion of a more acid-resistant carbonate mineral.

For "higher" marine animals such as squids and fishes, the problems center on respiration—and both carbon dioxide and oxygen come into play. Marine geochemists Peter Brewer and Edward Peltzer of the Monterey Bay Aquarium Research Institute in Moss Landing, California, pointed out that the higher the ratio of carbon dioxide to oxygen dissolved in seawater, the harder it is for the animals to gather oxygen. Seawater carbon dioxide is going up with rising atmospheric levels, they noted, and dissolved oxygen is decreasing in deeper waters as the warming of surface waters slows ocean circulation.

To demonstrate why that's a risky combination, Brewer showed a video of a remotely operated vehicle they used to trap a small squid at a depth of 700 meters and immerse it in a higher–carbon dioxide, lower-oxygen brew. The squid dropped motionless to the bottom of the test vessel. "We can expect multiple impacts as we go forward into this strange CO_2 world," Brewer observed. **–RICHARD A. KERR**

Snapshots From the Meeting >>

Following martian water. The news from Mars scientists in search of water was mostly upbeat. Radar probing from orbit shows that the Frozen Sea—supposedly dirt-covered ice—"is not ice," but lava, said planetary geophysicist Roger Phillips of Southwest Research Institute in Boulder, Colorado. That's the bad news. More encouragingly, spectroscopist Bethany Ehlmann of Brown University reported spectroscopic signs that something had long ago altered minerals in and around impact craters. That alteration looks typical of hot groundwater. And Alfred McEwen of the University of Arizona, Tucson, showed orbital images of what may be the oldest rock now on the surface. Large impacts probably lifted the so-called megabreccia from deep in the crust. It consists of great boulders embedded in a fine matrix containing water-altered minerals. McEwen's bottom line: "These may be the best places in the solar system to study … clues to the origin(s) of life."

Profound. Jumbled, deep-crustal rock exposed by impacts was once wet and possibly habitable.

Some thermometer. Paleoceanographers analyze microscopic plankton remains from a few square centimeters of sea floor to gauge past ocean temperature at that one spot. But paleoclimatologist Melissa Headley of Scripps Institution of Oceanography in San Diego, California, and her colleagues wanted to read the average temperature at one geologic moment of the whole ocean—top to bottom globally—so they took a 1-kilogram chunk of old glacial ice and measured its krypton and xenon gas content. Because the total amount of the noble gases in the atmosphere and ocean remains constant over time and their solubility in water depends on temperature, the changing amount down an ice core provides a whole-ocean temperature history. Their record suggests that changes in the far south of the Southern Ocean helped drive greenhouse warming at the end of the last ice age, 18,000 years ago. **–R.A.K.**

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