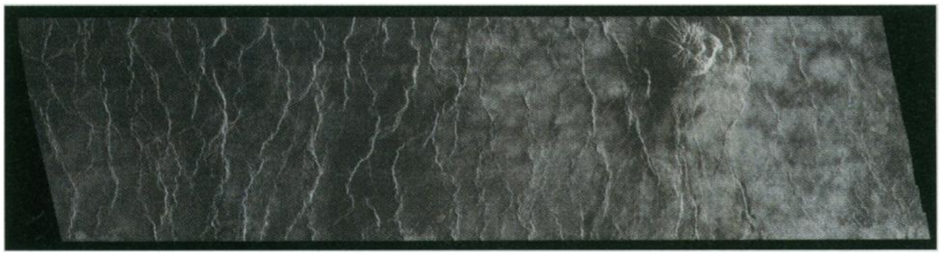
MEETING BRIEFS

Planetary Scientists Sample Ice, Fire, and Dust in Houston

HOUSTON—The annual Lunar and Planetary Science Conference held here last month drew a crowded field of almost 1000 presentations, thanks to the renewed flood of data from planetary probes. Talks ranged from the planetary scale to the microscopic: Researchers modeled the scorching surface of Venus, analyzed motes of comet dust swept to Earth, and calculated the age of Europa's ice-covered ocean.

Venus's Wild Greenhouse

With scorching surface temperatures of 500 degrees Celsius, Venus has always served as the classic warning of what can happen to a planet with a runaway greenhouse. But the climate on Earth's sister planet today may be mild by historical standards. Computer model results reported at the meeting suggest that greenhouse warming on Venus might have sometimes intensified so much that it reshaped the planet's surface, wrinkling its plains and perhaps even softening its rocks and erasing some of its geologic history.



JET PROPULSION LAB

Heat wrinkles. A runaway greenhouse effect may have started a heat wave so intense that it wrinkled this 400-kilometer swath of venusian plain.

"We absolutely have to pay attention to the atmospheric issue" to understand Venus's surface, said planetary geologist James Head of Brown University after hearing the talks. If venusian climate works as some models suggest, he says, "a lot of the global changes we see in the geology could be explained by global climate changes."

The only way to explore this climate history is to build a computer model that can simulate changes in Venus's atmosphere and how they would have affected its surface temperature. When Mark Bullock and David Grinspoon of the University of Colorado, Boulder, did so, they found that venusian climate gyrated wildly after each of the great outpourings of lava that have punctuated its history. The most recent outburst hundreds of millions of years ago spread about 100 million cubic kilometers of lava and created the flat, low-lying plains that cover more than half the planet.

Bullock and Grinspoon found that an eruption episode would have cooled the climate at first, as the water and sulfurous gases released from the lava thickened the clouds and obstructed sunlight. But this cooling would be short-lived, because sulfur is quickly removed from the atmosphere when it combines chemically with surface rock. Then, the heating effect of the water would take over. Water, a powerful greenhouse gas, could moisten the bone-dry atmosphere and strengthen the already intense greenhouse effect of carbon dioxide. In one scenario intended to mimic the most recent plains formation, surface temperatures rose by 60°C, until the water finally leaked out of the top of the atmosphere into space.

"I'm prepared to believe [that venusian] climate is unstable and subject to temperature variations of 100°C or more," says planetary geophysicist Sean Solomon of the Carnegie Institution of Washington's Department of Terrestrial Magnetism, who has looked at how such climate extremes might have left their mark on the solid rock of Venus. In the meeting's next talk, he reported calculations showing that as a pulse of greenhouse warming seeps down into the uppermost crust, the rock expands, creating a hefty compressive stress of 500 bars that could buckle the surface the way summer heat buckles pavement. Once the warming penetrates further and causes the deep crust to expand, the effect at the surface might switch from buckling to a modest stretching.

This stress roller coaster is just what's needed to explain the curious wrinkling of Venus's lava plains, says Solomon. In the Magellan spacecraft's radar images, these plains look like a wind-rippled sea. But geologists had trouble explaining how the roughly parallel ridges formed more or less simultaneously around the globe not long after the plains themselves appeared, as geological indicators suggested. The buckling of the crust would create uniform ridges, and a cycle of eruptions, warming, and tectonic stress would fit the timing, notes Solomon. "If climate works this way," agrees Head, "it in fact could be explaining wrinkle ridges."

More speculatively, Solomon raises the possibility that earlier, larger surges of volcanic activity could have produced even fiercer heating—fierce enough to have erased some venusian geology. If a powerful eruptive episode occurred before the formation of the present plains, it might have heated the surface to roughly 750°C—enough to soften surface rock, he says. Such hot rock, although still brittle to a hammer blow, could ooze over millions of years into a featureless surface, obliterating features created by previous tectonic activity. Subsequent cooling could have set up the crustal stresses that created the distinctive extensional cracks or "ribbons" found on the oldest terrains, such as the much deformed highlands formed some 500 million years ago.

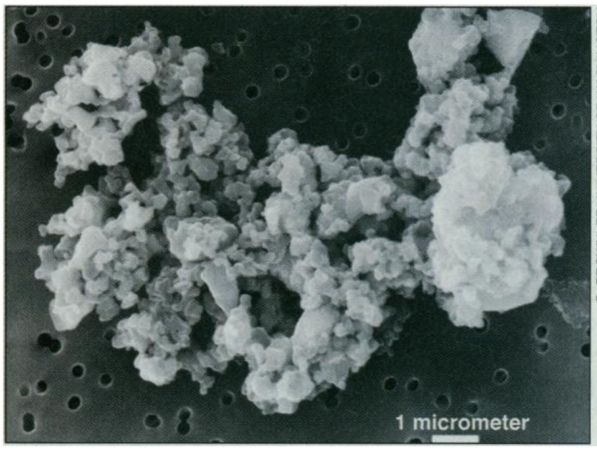
Solomon's scenario would mean that climate alone is responsible for most of the cracks and ridges seen on the oldest parts of Venus's surface. But researchers aren't ready to write off traditional geologic processes. An episode of extreme heat may have helped smooth the surface where the ribbons formed, agrees geologist Vicki L. Hansen of Southern Methodist University in Dallas, but she attributes the ribbons and subsequent crustal folding to the hot plumes of rock she believes raised the ancient highlands. Venus has not erased all of her early history, Hansen says. "As a planet, she's just starting to talk to us."

Harvesting Comet Dust

Planetary geochemists dream of getting their hands on the primordial material that went into making the planets, and comets have always seemed the most likely place to find unaltered remnants of this ancient material. So for 25 years researchers have been collecting interplanetary dust, which filters into Earth's upper atmosphere from space. Some of this dust presumably came from passing comets, although researchers have never been able to prove that specific particles are motes of comet dust. Now, a new analysis has linked interplanetary dust particles (IDPs) collected in the upper atmosphere in 1991 to a particular comet, Schwassmann-Wachmann 3.

"It would be amazing if these particles were from Schwassmann-Wachmann 3," says IDP pioneer Donald Brownlee of the University of Washington, Seattle, "and it looks like they are." If the connection holds up, a comet-IDP connection would be proven, and earth-bound researchers would have a way to gather and compare dust from different comets by sampling the stratosphere at predictable times of the year.

About 40,000 tons of IDPs fall into Earth's atmosphere every year, and in June and July 1991, NASA sent high-flying converted U-2 spy planes to gather some of this rain of dust. Many of the particles collected had the fragile, highly porous structure expected of comet dust. The late Alfred Nier and Dennis Schlutter of the University of Minnesota, Twin Cities campus, found that the particles also had an unusual composition: They were relatively low in helium, but the ratio of the helium-3 isotope to helium-4 was the highest ever found in any IDP.



D. BROWNLEE/UNIVERSITY OF WASHINGTON

Historical mote. Porous dust particles like this one rain down on Earth and may be ancient material from comets.

This odd helium signature prompted Scott Messenger of the National Institute of Standards and Technology and Robert Walker of Washington University in St. Louis to try to identify the dust's source. At the meeting, they reported that they saw several clues pointing to Schwassmann-Wachmann 3. The helium isotopic ratios remain a puzzle, but they reasoned that the low overall helium content meant that the particles had been drifting freely in space only a few years; otherwise, the solar wind would have saturated them with helium. For the dust to make such a quick trip from its source to Earth, it must have been shed from a comet and then swept up when Earth passed through the dust stream a short time later. The dust was also only minimally altered by the heat of atmospheric entry, suggesting that a comet moving relatively slowly with respect to Earth must have been the source.

Using these criteria plus the dates of collection, Messenger and Walker narrowed the field to a single candidate. Only Schwassmann-Wachmann 3's dust stream supplies slow-moving dust to Earth in late May, they found, just in time for the particles to sink down to the stratosphere for collection in June and July.

"It's very exciting," says planetary geochemist Robert Pepin of the University of Minnesota, who adds that "it looks like pretty good circumstantial evidence." Further chemical and isotopic analysis of the 1991 collection, as well as additional atmospheric collections timed to catch dust from specific comets, could firm up the comet-IDP link. A final check will come in 2006. That's when the Stardust spacecraft, to be launched next February, will return a dust sample from comet Wild 2, and the CONTOUR spacecraft will fly by and analyze dust from Schwassmann-Wachmann 3. By then, researchers may already have plenty of that comet's dust on hand for a close, leisurely study of the stuff the world is made of.

Dating Europa's Ocean

From the looks of the many images sent back by the Galileo spacecraft, giant ice floes slipping around on a subterranean ocean formed parts of the tortured surface of Europa. But did the cracking and crumpling happen recently enough that the ocean—and any life it might support—is still there? That question sparked a nagging internal debate among Galileo team members. Now an analysis of the clock used to gauge the age of planetary surfaces has settled the debate to most researchers' satisfaction, indicating that Europa's face—and ocean—are young indeed. The new work makes "a pretty strong case for there being water down there now," says Galileo project scientist Torrence Johnson of the Jet Propulsion Laboratory in Pasadena, California.

At issue is the origin of the impact craters that pock Europa's face. Planetary geologists use crater counts to date surfaces, because older terrains have been exposed longer to the steady rain of asteroid and comet impactors and so have more craters. Just how fast that rain has been falling in the jovian system has been debated among Galileo geologists calculating the ages of the jovian satellite surfaces. Clark Chapman and his colleagues at the Southwest Research Institute (SWRI) in Boulder, Colorado, argue that although asteroid impacts are rare on Europa, comets hit it often enough to have created most of its craters. "There's no way you can get away from relatively young ages for Europa," says Chapman. That would make Europa "currently active," he says, and its ocean still liquid.

But Chapman's Galileo colleague Gerhard Neukum of the German space research agency DLR in Berlin favors asteroids as the dominant cratering agent on Europa. He notes that asteroids dominate cratering on Earth's moon and the size distribution of craters there resembles that of Europa's sister satellites Ganymede and Callisto, so he argues that the far less frequent impacts of asteroids created most of Europa's craters. Neukum concludes that Europa's surface is ancient, 1 billion to 3 billion years old. "I'm in the minority, but I don't care," he says. "If Europa is very young, you would have a very young age for Ganymede. I don't buy it."

Stepping into this fray are the planetary physicists who calculate how impactors get from their sources—the asteroid belt between Mars and Jupiter and the comet clouds beyond Pluto—to their targets. At the meeting, Kevin Zahnle and Luke Dones of NASA's Ames Research Center in Mountain View, California, and Harold Levison of SWRI in Boulder presented their analysis, which is based on the latest computer simulations of how asteroids and comets from the Kuiper Belt just beyond Pluto would reach Europa. They also include the most complete measurements of comet size and abundance, based on the comets seen in the inner solar system.

These researchers conclude that comets could have formed 90% of europan craters and asteroids almost none of them. This means that on average, the surface of Europa would be somewhere between 2 million and 50 million years old, says Zahnle, compared to several billion years for Callisto, which is saturated with craters. And the youngest parts of Europa would be a mere 500,000 years old—too young for an existing ocean to have frozen solid.

The new analysis has changed some minds on the Galileo team. "I thought Gerhard [Neukum] had a plausible argument and should be heard, [but now] the assumptions he makes just aren't supportable," says planetary geologist Alfred McEwen of the University of Arizona, Tucson. "I am now convinced Kevin Zahnle and Clark Chapman have it right." The crater analysis makes a strong circumstantial case that an ocean is now sloshing beneath Europa's ice. But direct confirmation of liquid water will likely have to wait for another spacecraft, sometime in the next millennium.

–Richard A. Kerr