Materials Science

Ivan Amato reports from Boston at a meeting of the Materials Research Society

Crystal growers seek bacterial know-how . . .

Three species of sulfur-absorbing bacteria discovered last year hold a magnetic attraction for Brigid R. Heywood, a crystal engineer at the University of Bath, England. Inside these creatures, minuscule chains of crystal particles called magnetosomes serve as compasses that point the way to relatively safe and nutrient-rich habitats.

Such biological innovation would fascinate virtually any nature lover. But for Heywood and her co-workers, the microbes' crystal-making powers prove even more enchanting. For one thing, the newly identified bacteria—which live in salty, sulfur-ridden waters and sediments — make their magnetosomes out of iron sulfide, a magnetic mineral known as greigite (Fe_3S_4). Previously, only magnetite (Fe_3O_4), or iron oxide, had been seen in magnetosome-making microbes.

Further surprises have emerged from studies of the greigite crystals under high-resolution microscopes. All of these crystals fall within a remarkably small range of sizes — 50 to 90 nanometers — and each bacterial species grows its crystals in a specific shape, report Heywood and her colleagues in Bath and at California Polytechnic State University in San Luis Obispo. For example, the smallest rod-shaped species produces crisp-edged, cubo-octohedral crystals, which feature both hexagonal and square faces. A larger rod-shaped species has rectangular crystals with flat ends, truncated corners and irregular sides. The third species, which congregates in mulberry-like colonies, uses a puzzling combination of two mineral types — greigite and nonmagnetic pyrite (FeS_2).

All three species somehow control the precipitation of crystals at the molecular level, Heywood says. Moreover, they do this at ambient temperatures and under normal biological conditions. Scientists, in contrast, must use rugged chemical conditions and searing temperatures to make greigite crystals. Heywood hopes to uncover the cellular crystal-making processes of these organisms, and then mimic those processes in the lab. In the long run, she suggests, such work might help materials scientists to literally grow minerals and ceramics into lenses, engine blocks or components with specific magnetic, electrical or optical properties.

. . . and bigger crystals in space

The date March 30, 1992, already means a lot to chemical engineer Albert Sacco Jr., of the Worcester (Mass.) Polytechnic Institute. That's when shuttle flight STS-53 is scheduled to launch crystallization experiments dreamed up eight years ago by Sacco and a now-deceased friend. Moreover, as a mission-specialist candidate, Sacco himself may fly into space that day.

The experiments involve zeolites, a class of labyrinthine crystals with catalytic, porous networks, used in such technological applications as "cracking" large petroleum molecules into the smaller ones that make up gasoline. On Earth, gravity, vibrations, temperature fluctuations and other factors limit chemists to growing micron-sized zeolite particles.

Space, in theory, should be nearly free of crystal-wrecking factors. But previous efforts to grow crystals in space have yielded mixed results, Sacco says. In most cases, more tiny crystals formed rather than a few larger crystals.

He and his co-workers have now developed a chemical trick, which they hope will enhance crystal growth at the expense of crystal number. By adding metal-binding molecules such as tetraethanolamine (TEA) to the crystallization solution, the researchers can continuously regulate the amount of an aluminum-containing zeolite constituent, Sacco says. TEA grabs on to these constituents and, like a time-release capsule, frees only small amounts of them at a time. The freed aluminum constituents, he says, add to an already initiated zeolite crystal more readily than they help to initiate a new crystal.

Space Sciences

Blob tectonics on Venus

Planetary scientists have debated for more than a decade whether some form of the plate tectonics that shaped Earth also molded the surface of Venus. Now two researchers suggest that some of the most dramatic features on Venus result not from plate tectonics, but from a process they call "blob tectonics."

On Earth, the Hawaiian Islands and some other island chains represent one classic manifestation of plate tectonics. Such island chains apparently formed when a "hot spot"—a plume of hot rock rising from the planet's interior — broke through the crustal plate overhead. Over millions of years, towering volcanic peaks arose, which got carried away by the moving plate. As proposed by Robert R. Herrick and Roger J. Phillips of Southern Methodist University in Dallas, blob tectonics would involve gigantic, single "blobs" of hot materials rising like bubbles. These deformed and sometimes punched through a stationary Venusian surface, the Dallas scientists suggest.

Four examples of such blobs may underlie Aphrodite Terra, a hilly region that stretches at least 10,000 kilometers along Venus' equator, Herrick and Phillips say. Beta Regio, one of the first features on the planet identified as volcanic in origin, may offer another candidate site for blob tectonics.

"A basic tenet of this model is that tectonism and magmatism [the formation of molten material] at Beta Regio and western Aphrodite are dominated by the evolution of plume heads or blobs as they rise to the base of the lithosphere and spread laterally," the authors write in the November GEOPHYSICAL RESEARCH LETTERS. The lithosphere contains the planet's crust and the uppermost mantle.

One clue to the presence of four separate blobs at Aphrodite Terra comes from variations in the planet's gravity, which indicate regions of lower-density materials in the mantle at different depths. The density measurements — made by tracking the rises and dips in altitude of the orbiting U.S. satellites Pioneer Venus (which reached Venus in 1978) and Magellan (which arrived last August) — show one less-dense area about 15 km down in a circular area roughly 2,500 km across. A second area lies 70 km down in an elliptical shape some 3,500 km long; a third appears as a 2,500 km circle at a depth of 80 km, and a fourth lies about 100 km below the surface, forming a circular feature 3,000 km across.

If the theory is correct, Magellan's sharp radar images will reveal specific surface features resulting from rising, individual blobs, Phillips says. He and other Magellan scientists are looking for elevated regions cracked by faults in more than one direction and areas that lack meteorite impact craters, as if existing craters have been covered by massive volcanic flows.

Phillips says processing of Magellan's radar images of western Aphrodite Terra should begin later this month at NASA's Jet Propulsion Laboratory in Pasadena, Calif. Magellan will not image Beta Regio until next spring.

Galileo's quick look at Venus

Scientists have finally received the pictures of Venus' atmosphere taken in February by the Galileo spacecraft as it whipped around the planet—one of a series of maneuvers that will give Galileo the speed needed to propel it to Jupiter, where it should arrive in 1995.

Many spacecraft have looked at Venus' clouds, but Magellan both photographed the cloud tops and recorded near-infrared emissions from deeper clouds. The lower cloud patterns differ distinctly from those at the top, report Galileo scientists analyzing the images radioed to Earth from the craft on Nov. 19 to 21. The near-infrared images revealed convection zones within clouds due to rising heat, while the cloud tops appeared fluffier—due to reflected sunlight—in the visible-light photos.