# Materials Science

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

## Mollusk teaches ceramics to scientists

Red abalones fashion calcium carbonate—the stuff of chalk—into complex arrangements that yield rugged shells up to 40 times more fracture resistant than the blackboard implement. Scientists at the University of Washington in Seattle aim to mimic the mollusks' material-making approach for designing synthetic ceramics that can take a beating.

A close look at an abalone shell reveals two layers, both made of calcium carbonate but organized into different microstructures with different properties. The rough outside layer derives from a mineral form known as calcite. But it is the aragonite form found in the inner, nacreous layer that makes the shell remarkably resistant to breakage.

An even closer look at this layer's architecture shows why. The nacreous layer has a laminated, brick-and-mortar structure, says Mehmet Sarikaya, who is conducting the work with Katie E. Gunnison and Ilhan A. Aksay. The micron-wide bricks are made of tiny, high-quality calcium carbonate crystals. For mortar, the abalone secretes its own version of Superglue made of a concoction of organic compounds whose formula the researchers now seek to unravel.

By deliberately stressing abalone shells and then examining the resulting microcracks with electron microscopes, the scientists have observed at least five possible toughening mechanisms. The most important of these, suggesting ways of toughening synthetic materials, are the sliding of adjacent calcium carbonate layers and the formation of crack-bridging "ligaments" in the organic mortar layers, Sarikaya says.

With abalone shell as their model, Aksay and colleague Mehrdad Yasrebi have assembled a synthetic, multilayered structure using the tough ceramic material boron carbide for the bricks and aluminum as the mortar. Scientists term such ceramic-metal composites "cermets." Preliminary results indicate that this cermet is up to 40 percent more fracture resistant than conventional, less structured arrangements of the same materials, Sarikaya says.

## Getting the creeps out of superconductors

Researchers still don't know just how a certain class of ceramic superconductors can carry electricity resistance-free at far less frigid temperatures than any previously discovered superconductors. Nonetheless, materials scientists continue to chip away at fabrication problems that threaten to keep these remarkable ceramics from becoming useful in some potentially far-reaching items — such as superconducting electrical power lines — featured on many a technological wish list.

R. Bruce van Dover and E. Michael Gyorgy of AT&T Bell Laboratories in Murray Hill, N.J., separately report bombarding thin films of an yttrium-barium-copper-oxide superconductor with neutrons and protons, respectively. The micro-flack generates imperfections in the ceramic, which researchers know are necessary to counter the so-called flux-creep problem. Without a good distribution of the imperfections, lines of magnetic energy tend to creep around in a superconductor's crystal lattice, impeding electrical current.

Bombarding nearly perfect single crystals of the oxide in this way enables them to carry up to 100 times more current than untreated crystals, van Dover and Gyorgy say. Leonardo Civale of IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y., reports similar results using proton bombardment.

Other AT&T researchers, led by Sungho Jin, report another way of getting the defects into small grains of the same material. Using a sequence of heating and cooling steps to convert a precursor ceramic into the oxide, Jin's team obtains micron-sized grains that carry about 10 times more current than similar grains made by other methods.

# Space Sciences

## Venus volcanism: Another hint

Add another item to the list of evidence some scientists cite as indicating that cloud-engulfed Venus remains a volcanically active planet.

In 1983, Larry W. Esposito of the University of Colorado in Boulder reported that the ultraviolet spectrometer aboard the Pioneer Venus spacecraft had measured a steady drop in the amount of sulfur dioxide in the planet's cloud tops (SN: 10/1/83, p.213). He interpreted this as a possible sign that a large volcanic eruption had injected the sulfur compound into the atmosphere shortly before the Venus-orbiting craft reached its target five years earlier, and that the amount of the gas had gradually declined ever since. Now, Paul G. Steffes of the Georgia Institute of Technology in Atlanta reports that, in addition to the cloud-top measurements, "we have evidence for the first time that levels of sulfur dioxide have been dropping off in the atmosphere below the clouds."

Venus' major cloud layer lies about 48 kilometers above the planet's surface, Steffes notes. The evidence for a declining amount of sulfur dioxide beneath it was detected by Steffes and Jon M. Jenkins of Georgia Tech, together with Michael J. Klein of Jet Propulsion Laboratory in Pasadena, Calif. The data consist of radio emissions from Venus with wavelengths of 1.3 centimeters, detected with the 43-meter radiotelescope of the National Radio Astronomy Observatory in Green Bank, W. Va., and the 70-meter NASA radiotelescope at Goldstone, Calif. The emissions pass through Venus' atmosphere on the way to Earth, so an increase in their intensity indicates a decrease in the amount of Venusian sulfur dioxide available to absorb them.

Jenkins and Steffes also report a decline in the amount of sulfuric acid vapor in the Venusian atmosphere, based on the weakening of 13-cm transmissions from the spacecraft. The Earthward radio beam reaches different depths in Venus' atmosphere as the spacecraft moves, so researchers can use it to calculate differences with altitude. The sulfuric acid and sulfur dioxide almost surely have a common source, Steffes says, even without evidence confirming that volcanoes continue erupting on Venus.

Other scientists have reported additional possible signs of volcanic activity there: radar measurements suggesting rough edges on some surface features, indicating they are too young geologically for erosion to have smoothed them; and radio emissions interpreted by some researchers (though others disagree) as evidence of lightning, similar to that observed over some eruptions on Earth. None of these findings provides sufficient evidence to prove the existence of volcanoes, however, and those of Steffes' group remain inconclusive as well.

Part of the problem is scientists' inability to link either the sulfur dioxide or the sulfuric acid measurements with a particular location on the planet's surface. Sulfur dioxide is widely distributed, and although the sulfuric acid does seem more abundant near the Venusian equator than over the polar regions (suggesting upward atmospheric circulation at the poles and "downwelling" at the equator), the data do not pin down longitudes with any more accuracy than about 40°

NASA's Magellan spacecraft, due to reach Venus next summer with a more powerful transmitter and a much larger antenna than those of Pioneer Venus, should provide the most detailed radar views yet of that planet. Though even Magellan may not locate a surface source for the presently declining atmospheric sulfur dioxide supply, there is a small chance — if volcanoes are indeed still erupting — that it will detect topographic features that differ measurably from those appearing in past radar maps, perhaps indicating fresh lava flows. Magellan scientists hope the craft will last long enough to cover the planet twice, taking about eight months to complete each mapping and perhaps showing differences between them.