Microscopic diamonds crack geologic mold

Tiny diamond grains, discovered in rocks from southwestern Norway, are forcing geologists to rethink cherished ideas about Earth's continents.

"This is a spectacular discovery. This is a wake-up call," comments geologist Stephen E. Haggerty, a diamond expert at the University of Massachusetts in Amherst.

The diamond fragments were found by Larissa F. Dobrzhinetskaya of the Russian Academy of Science in Moscow, who collaborated with Norwegian, British, and U.S. colleagues. The team discusses its work in the July GEOLOGY.

At only 20 to 80 micrometers in size, the diamonds are too small to see without a microscope. Yet they have dazzled scientists because they formed within the continental crust, an unlikely birthplace for the world's hardest natural mineral.

According to geologic textbooks, diamonds can grow only in Earth's mantle, at depths of 120 kilometers or more. It takes the exceedingly high pressures and temperatures of the mantle—40,000 atmospheres and 900°C—to squeeze carbon into the ultracompact crystal structure of a diamond. The gems reach the surface when explosive volcanic eruptions force them up narrow conduits through the mantle and crust.

The Norwegian diamonds break the standard mold because they do not come from volcanic mantle rocks. Instead, they appear in metamorphic rocks that originally formed as ancient sedimentary deposits at Earth's surface. The layers of sediments were compacted and cooked hundreds of millions of years ago, when another continent rammed into what is now Scandinavia.

Although such continental collisions can metamorphose crustal rocks, they are considered far too docile for making diamonds. At their worst, conditions in the deep crust reach only 15,000 atmospheres and temperatures of 650°C—not nearly enough to mold carbon into diamond, says Haggerty.

Geologists have reported finding examples of diamonds in crustal rocks only twice before, in Kazakhstan in 1990 and in eastern China in 1992. While skeptical researchers may have questioned the earlier reports, the Norwegian discovery will help convince the geoscience community that diamonds can form in crustal rocks.

"This really nails it," says Haggerty.

W. Gary Ernst of Stanford University agrees. "If these are well-documented diamonds, I exult. You can't laugh it off anymore and say it's one of a kind."

To explain the diamonds' presence in crustal rocks, Dobrzhinetskaya suggests that the ancient continental collision forced pieces of the crust down to mantle depths temporarily. Carbon in the sedimentary layers then turned into diamonds before the crustal rocks rose back to the surface.

"I'm convinced that they were brought to depths of 120 km," she says.

While this theory would solve the mystery of how the diamonds formed, it raises another conundrum. Crustal rocks have a much lower density than mantle rocks; therefore, most geologists consider continental rocks too buoyant to be carried down into the mantle.

"We don't think that crustal rocks can go down and come bobbing back up, but a few of them must have," concludes Ernst.

Haggerty, however, suggests that diamonds might have formed without a trip into the mantle. Industrial researchers, he notes, have learned how to grow extremely thin diamond films at very low pressures. Because the microdiamonds from Norway, Kazakhstan, and China are so tiny, they may have formed at pressures found in the crust, Haggerty speculates.

In any case, geologists will have to rewrite some basic textbooks. "We either have a major tectonic problem, or we have an entirely new way of making diamonds," says Haggerty. — *R. Monastersky*

Dobrzhinetskaya

Scanning electron microprobe image of Norwegian diamond grain (above). Arrows show microdiamonds in Kazakhstan rock.

Dobrzhinetskaya

Carbide whiskers shrink to nanometer size

The tiny fibers of silicon carbide used to strengthen airplane wings and mountain bike frames just became a lot tinier. Researchers have created silicon carbide rods less than 30 nanometers in diameter, about one-thousandth the size of those used in high-performance materials today.

Fibers suspended in a ceramic or a metal reinforce the material, creating a strong, lightweight composite. Using a larger number of thinner fibers, which are less likely to contain weakening defects in their crystal structures, provides greater strength and surface area to bond with the ceramic or metal.

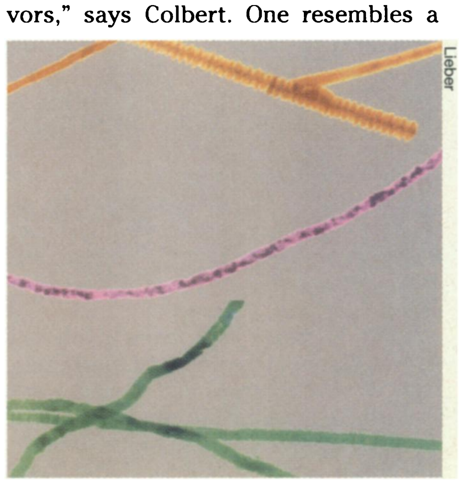
In addition to silicon carbide, the researchers produced titanium, niobium, iron, and boron carbide rods, reports Charles M. Lieber of Harvard University in the June 29 NATURE. Each compound showed useful electrical or mechanical properties.

Eventually, carbide nanorods—rods on the nanometer scale—may serve as sensors, magnetic recording heads, or a component of superconducting materials that could raise their current-carrying capacity, Lieber says. They could also be used as atom-size wires in computer chips or as probes in microscopy, adds Daniel T. Colbert of Rice University in Houston.

Lieber formed the nanorods by exposing carbon nanotubes—basically, elongated buckyballs—to oxide or halide vapor of silicon or a metal. The hollow tubes transformed into solid carbide rods of about the same size. This technique has been used before, but only to make much larger carbide fibers.

"In a way, it was a logical extension," Lieber says. "Silicon oxide is known to react with fibers, but the carbide forms on the surface. It's difficult to penetrate them."

Carbon nanotubes come in two "flavors," says Colbert. One resembles a



Lieber

Colorized image shows titanium carbide (orange), niobium carbide (purple), and silicon carbide (green) nanorods, each about 10 nm in diameter.

tube of graphite capped on the ends by two hemispheres of a buckyball, while the other, slightly larger form consists of 10 to 20 concentric cylinders of carbon. Lieber used the latter as a template for the carbide nanorods.

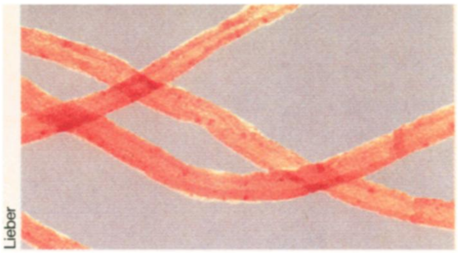
The key to making such small fibers was starting with nanotubes, says Richard E. Smalley of Rice, a codiscoverer of buckyballs who currently works with carbon nanotubes.

"To make a nanometer structure . . . that will survive in the real world, you must construct a surface where the atoms are happy," Smalley says. "We're beginning to learn about nanotubes and how to use them as a . . . template for other elements. Carbon is teaching them how to do it."

Lieber's carbide nanorods were between 2 and 30 nm in diameter and over 1,000 nm long. Although many of the rods were smooth and straight, some of them had unusual shapes. Lieber observed sawtooth titanium carbide nanorods and niobium carbide ones with a helical structure.

The properties and shapes of the nanorods open up many possible applications. Lieber found the niobium carbide nanorods to be superconducting and the iron carbide ones ferromagnetic. Hongjie Dai, a physical chemist who works with Lieber, speculates that passing a current through a corkscrew-shaped nanorod would produce "a very interesting magnetic field profile."

Lieber and his colleagues are continuing to characterize the properties of the nanorods, not an easy task considering the difficulty of handling such small structures. They plan to continue studying possible applications and making nanorods out of different carbides. "In principle, you can make all the carbides that exist," Dai says. — *Corinna Wu*



Lieber

Carbon nanotubes about 10 nm in diameter.

Diet, exercise, genes strengthen bones

Study after study these days touts the benefits of eating right and exercising. But the value of that advice may depend on your genetic inheritance.

A study of a gene associated with the development of strong bones indicates that the importance of exercising and drinking milk varies with the type of vitamin D receptor *(VDR)* gene your cells harbor.

"We found that the combination of dietary calcium intake and exercise can overcome a poor genetic predisposition," says epidemiologist Loran Salamone of the University of Pittsburgh team that conducted the study, "while for those with a beneficial genetic makeup, little activity and low calcium intake didn't adversely affect [bone strength.]"

The finding may help identify women who need to work at developing strong bones.

Through early adulthood, people continually add calcium and strength to their bones, which reach a peak density around age 35. Women rapidly lose bone density after menopause, and their ability to avoid osteoporosis—severe bone loss that can lead to life-threatening fractures—depends upon their bone density before menopause.

In 1994, researchers discovered that the vitamin D receptor is vital to achieving high bone density. But not all vitamin D receptors are the same. The *VDR* gene, which carries the blueprint for making the receptors, comes in two varieties. Both produce functional vitamin D receptors, but one stores calcium in bone a little more efficiently.

People who inherit two copies of the more efficient form of *VDR*—known as *b*—develop high bone densities. Those who inherit two copies of the less efficient gene—known as *B*—have somewhat less strong bones.

Salamone knew that a person's *VDR* gene complement would help determine bone strength, but she figured that factors such as dietary calcium and exercise would also play a role. She and her colleagues studied 470 premenopausal women age 44 to 50. They interviewed the women about their diets, exercise habits, and hormone usage, then analyzed the women's bone density and genetic makeup.

As Salamone reported at a meeting of the Society for Epidemiologic Research in Snowbird, Utah, in June, women with two *B* forms of *VDR* who exercised the most developed 7 percent higher bone density than women with the same genes who exercised the least. Women harboring *B* who had high calcium intake and who exercised enjoyed 10 percent more bone density, but a calcium-rich diet without exercise had no beneficial effect.

Women with the *b* genes developed strong bones regardless of exercise and calcium intake.

"This is a wonderful study," says epidemiologist Marian T. Hannan of the Boston University Arthritis Center. Salamone "has shown that it is possible to make modifiable changes that can have an impact on osteoporosis."

Salamone points out that her study population is white, so she isn't sure how the genes affect black women, who ordinarily have much higher bone density. — *L. Seachrist*

Gene for early, aggressive Alzheimer's

An international team of scientists has discovered a gene for a rare, but very aggressive form of inherited Alzheimer's disease. The gene may be responsible for the majority of familial cases of Alzheimer's that strike before the age of 60.

Alzheimer's usually sets in after age 65, but this early-onset form ravages its victims in midlife, affecting some people as early as their thirties. Even though this gene accounts for only a small percentage of all cases, its discoverers hope their work will aid understanding of the disease in all its forms.

"The gene may not be mutated in other forms of Alzheimer's disease," says team member Peter St. George-Hyslop of the University of Toronto. "But it probably does play some role."

Previously, scientists had noted that mutations in the gene for apolipoprotein E, found on chromosome 19 (SN: 8/14/93, p.108), played a role in some familial cases that begin after age 65. And mutations in the gene for beta-amyloid precursor protein, found on chromosome 21 (SN: 2/23/91, p.117), account for some early-onset cases of Alzheimer's.

To find this third Alzheimer's gene, the team gathered genetic information from 21 families afflicted by the early-onset form of the disease.

In six of those families, the researchers report in the June 29 NATURE, mutations in the *S182* gene on chromosome 14 account for up to 70 percent of all early-onset cases of Alzheimer's. What's more, the mutated gene amounts to a ticking time bomb; virtually all who inherit it will be stricken during midlife.

How the mutation leads to Alzheimer's remains a mystery. The researchers speculate that the protein produced on instructions from the mutated gene may not process beta-amyloid precursor protein correctly.

The finding will enable researchers to explore the function of the gene in animal models, St. George-Hyslop says. And because mutations in *S182* occur in only 6 of the 21 early-onset families, he believes that research will uncover a few more genes associated with Alzheimer's. — *L. Seachrist*