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.

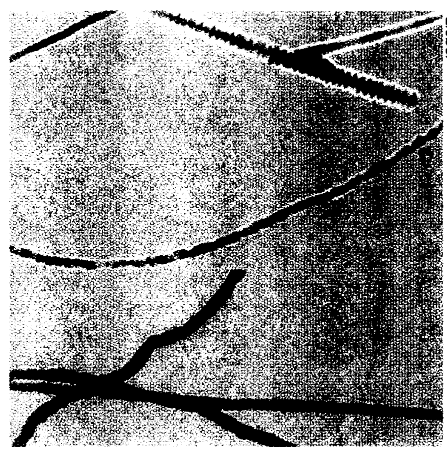
In addition to silicon carbide, the researchers produced titanium, niobium, iron, and boron carbide rods, reports Charles M. Lieber of Harvard University in the June 29 NATURE. Each compound showed useful electrical or mechanical properties.

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.