Radioactive alchemy: Diamonds from coal

Superman once made a diamond by squeezing a lump of coal. Now, research suggests he need not have lifted a finger: Coal may already harbor tiny diamond crystals, created naturally by radioactive decay over millions of years.

Tyrone L. Daulton of Argonne (Ill.) National Laboratory and Minoru Ozima of the University of Tokyo discovered nanometer-size diamonds within a coal-like rock from Russia, they report in the March 1 SCIENCE. They propose that the diamonds formed when uranium atoms in the rock underwent fission, breaking up into high-energy ions.

"When the uranium atom decays, it produces two fission fragments. These fission fragments are like bullets fired into the carbon structure. When they tear through the carbon structure, they break bonds between the carbon atoms," says Daulton.

After the fission fragments have passed, the carbon atoms move back together and reform bonds. Sometimes these new bonds pull the carbon atoms into the compact crystal structure of a diamond, suggests Daulton.

This process represents an unusual method of forming diamonds. Most diamonds, especially gem-size stones, develop in the mantle, deep inside the planet. High pressures there squeeze carbon atoms into their most compact form.

In the 1970s, Russian scientists proposed that the uranium naturally present in coal and other carbon-rich rocks could form microscopic diamonds through fission. To test this theory, they examined an unusual rock called carburanium, which contains high percentages of carbon and uranium.

Using X-ray diffraction analysis, the Russian workers failed to find diamonds in the carburanium. Daulton and Ozima, however, analyzed the carburanium with a high-resolution transmission electron microscope, a much more sensitive method. They identified ultrasmall diamonds ranging in size from 2 nanometers to 40 nanometers and containing a few thousand to a few million carbon atoms.

Lest anyone get the idea of mining coal for its diamonds, it would take about a quadrillion (10^{15}) of these nanodiamonds to equal the volume of a 1-carat solitaire.

Stephen E. Haggerty of the University of Massachusetts at Amherst says that Daulton and Ozima "seem to have firmly established that these are diamonds." But Haggerty wonders whether other processes aside from radiation could have created the nanodiamonds.

To resolve the issue, Daulton hopes to test the radiation theory with an experiment using Argonne's linear accelerator. Sending an ion beam into a carbon-rich material may tell whether radioactive decay of uranium can create nanodiamonds in nature. — *R. Monastersky*

Daulton/SCIENCE

Diagram shows a radioactive ion blasting through atomic bonds. The background is a transmission electron microscope image of a nanodiamond.

Fish blend quickly into the background

People may start calling quick-change artists flounders rather than chameleons, thanks to a new study on the camouflage habits of *Bothus ocellatus*.

In less than 8 seconds, these tropical flounders can transform their markings to match even unusual patterns put on the floor of their laboratory tanks, report Vilayanur Ramachandran and his colleagues at the University of California, San Diego. When swimming over sand, the flounder looks like sand. But if the tank has polka dots—no problem, the fish develops a coat of dots.

In the ocean, flounders change their appearance to avoid predators or to sneak up on prey. Although these fish have a reputation for altering their markings or color to blend in with their surroundings, few studies have systematically analyzed such dramatic changes, says Ramachandran.

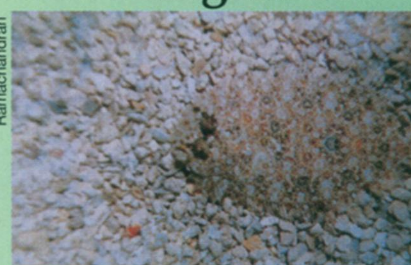
He and his coworkers laid gravel, a checkerboard, a gray sheet, or yellow beach sand at the bottom of tanks. They then put five flounders, one at a time, in each tank. Each fish quickly changed its skin to resemble the floor patterns, the San Diego scientists report in the Feb. 29 NATURE. The fish changed their markings even faster—in as little as 2 seconds—when exposed to a pattern for the second or third time.

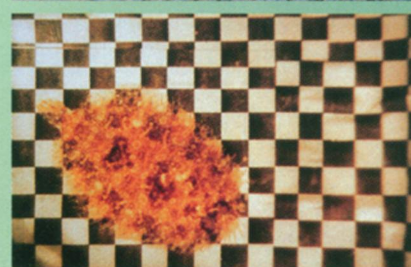
B. ocellatus features at least six types of skin markings, including H-shaped blotches, small dark rings, and small spots, the researchers report. The fish adjust the darkness of these figures to blend into the different backgrounds.

The scientists have yet to examine the neural mechanisms that enable a flounder to alter its spots. However, cells in its visual system may respond specifically to shapes in its environment. These visual cells may then signal pigment cells in the skin to produce large or small splotches, Ramachandran speculates.

The flounders' colors, as well as patterns, change in response to the background, the researchers note.

Ramachandran





These flounders, which have hairlike filaments on their bodies, blend into their backgrounds.

The San Diego group's report refutes a 1988 claim by William M. Saidel of Rutgers University in Camden, N.J., that flounders have little capacity for adaptive pattern changes. However, Russell D. Fernald, a neuroscientist at Stanford University, points out that Saidel studied flounders from the deep, cool waters of New England, where fish may require fewer camouflage outfits.

"I think [the new study] is a modest advancement" in what we know about how flounders change their markings, says Saidel. For example, the study finds that the time the fish take to transform their appearance is at least 30 seconds shorter than previous reports, he says.

Ramachandran is something of a quick-change artist himself. As a neurologist, he normally studies humans. However, he finds the flounder so intriguing that he sometimes takes on the role of ichthyologist. — *T. Adler*