edited by GRETCHEN VOGEL

## How to Avoid Running Out of Steam

On the surface, geothermal energy seems like a gift from nature. "You just drill a hole and let the steam out," says Gillian Foulger, a geophysicist at the University of Durham in England.

But nature has a habit of hiding her riches: It's not easy to figure out how much steam remains untapped, and misjudging the size of a reservoir can be costly. For instance, the steam production of The Geysers, a geothermal field near Santa Rosa, California, that provides electricity for 1.7 million homes, has dropped 10% annually since the mid-1980s—much faster than many power companies expected. "They've had to tear down brand-new power plants," says Bruce Julian, a seismologist with the U.S. Geological Survey in Menlo Park, California.

In the 15 January issue of *Geophysical Research Letters*, Julian and Foulger report on a new, relatively cheap way to map reservoirs: seismic tomography, a technique often used to image Earth's crust and mantle.

The team compared the speeds of two waves produced by an earthquake. S-waves are relatively unaffected by the type of rock they ripple through. But P-waves, which travel by compression (like shudders passing down a line of braking rail cars), slow down in more compressible material.


USGS

**Boiling away.** The Geysers field.

Because rock filled with steam is more compressible than that filled with water, slow P-waves should identify where the hot water has boiled away. Foulger and Julian have studied when P- and S-waves from 146 earthquakes arrived at 22 seismograph stations surrounding The Geysers, and they report that seismic tomography can act as a sort of fuel gauge, monitoring the emptying of a reservoir. Between 1991 and 1994, the ratio of P- to S-wave speeds dropped in the area of greatest steam extraction, showing that the cracks and pores in the rock were filling with steam as the hot water—the "fuel" of the reservoir—boiled away.

The technique could also help in the search for new reservoirs, says UNOCAL Corp. geophysicist Bill Cumming. "They have demonstrated that you can see [underlying] processes," he adds, "and that would be of interest in any geothermal field."

## Stand By for a Comet's Media Aftershocks

Comet Shoemaker-Levy 9 broke up and crashed into Jupiter more than 3 years ago, but shock waves from the impacts are only just beginning to hit Earth. In the coming weeks, the media will rock the United States with a slew of extraterrestrial impacts, described in everything from a *New Yorker* piece to a TV miniseries.

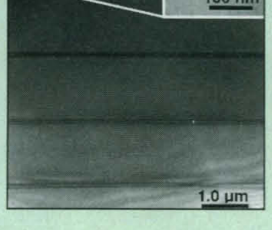
The *New Yorker* unleashed the first blast in a muted but provocative article in the 27 January issue by science writer Timothy Ferris titled "Is This the End?" After detailing the flood, fire, darkness, cold, and famine thought to have followed the great impact 65 million years ago at the end of the age of the dinosaurs, Ferris concludes that "scientists are seriously worried." They worry not so much about another once-in-a-hundred-million-years global catastrophe as about the more frequent city-killer.

NBC's miniseries *Asteroid*, airing 16 and 17 February, has those in abundance, although the science is shaky, according to impact specialist William Bottke of the California Institute of Technology. But two documentaries later this month—a two-parter on The Discovery Channel and a National Geographic Special on NBC—could make up for that with less special effects and more hard facts. And if you want more Earth-shattering explosions and impact hazard statistics, there's always the movies. Two impact films—*Armageddon* and *Deep Impact*—begin shooting this spring.

Whether all the media attention will educate the public to the very real threat from the skies is not yet clear. It could do worse than focus attention on plans for finding most of the thousand or more kilometer-size objects thought to cross Earth's orbit, says David Morrison of NASA's Ames Research Center in Mountain View, California. A 1995 report found that new-technology telescopes could identify almost all potential Earth impacters within 10 years at a price of $5 million per year—the equivalent of one smash-'em-up feature film.

**Micromeasure.** Scientists in Canada have developed the world's smallest ruler—so tiny that it recently made the *Guinness Book of World Records*. The 5-micrometer ruler *(below)* has a large purpose, however: to help researchers calibrate transmission electron microscopes (TEM) for the ultraprecise world of microelectronics.

Developed by physicists John McCafferey and Jean-Marc Baribeau of the Canadian National Research Council's Institute of Microstructural Sciences, the ruler is a slice from a single-crystal wafer grown from alternate layers of silicon and silicon-germanium alloy. When viewed under a TEM, the layers show up as dark stripes on a light background. The smallest division is just 18 atoms thick—an extremely precise standard researchers can use to measure features of computer chips or other microelectronics.



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Although some might say the development takes downsizing to an extreme, Jon Gerrard, Canada's secretary of state for science and R&D, would disagree. "Any way you measure it," he says, "this tiny ruler is no small achievement."

## Where Do Ph.D.s Go?

Women scientists and engineers with doctoral degrees are more likely than men to work in academia as opposed to business or industry, says a report from the U.S. National Science Foundation (NSF) titled "Women, Minorities, and Persons With Disabilities in Science and Engineering: 1996." The same preference was evident among blacks, Hispanics, and American Indians, who, like women, are far less represented in science and engineering than in the population as a whole. By contrast, nearly half of the Asian doctoral scientists and engineers were employed in business or industry—the highest percentage of any group measured.

The differences, says NSF's Joan Burrelli, are mostly due to the fact that women and "underrepresented" minorities earn more doctorates in the social sciences—fields in which industry jobs are scarce. Asians, however, earn more doctorates in computer science, math, and engineering.

But even within fields, "there's still a small tendency for women to go toward [academia]," she says. "Whether it is real or not, there is apparently a perception that industry is less favorable [to women and minorities]."