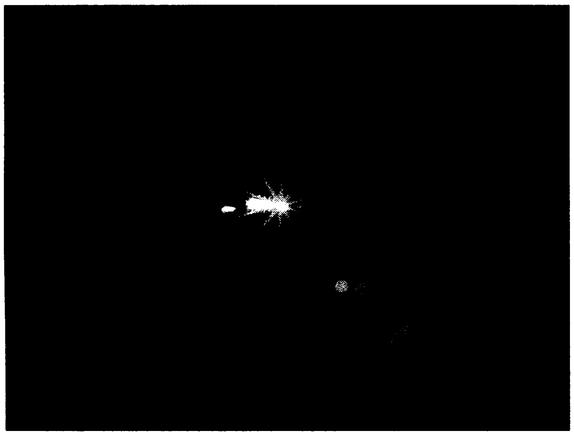


LAWRENCE LIVERMORE NATIONAL LAB

Perfect target. A microsphere compresses deuterium when shot by a laser, triggering a fusion reaction. The smoothness of the sphere walls ensures that the reaction takes place.

To make the drops smaller, Kim and his colleagues blow them apart. They extend an exquisitely thin electrode through the nozzle so its tip sticks into the drops as they form. They then inject electrons into the liquid. The electrons' negative charges repel one another, breaking the drop apart; surface tension holds the new nanodroplets together. "It's like making the liquid heavier so smaller drops will form," says Kim. And as these small drops fall, the alcohol evaporates and they solidify.

Kim believes these nanospheres may be useful in constructing exotic semiconductor structures known as quantum dots that trap electrons and other charged particles, forcing them to emit light at very restricted wavelengths. Researchers at electronics companies worldwide are pursuing these exotic dots for use as tunable semiconductor lasers and light-emitting diodes. The most common method now used to make such dots is to etch them from a semiconductor surface, one by one, using an electron beam. But this technique is both slow and expensive, says Chris Palmstrom, a materials scientist at the University of Minnesota.

An alternative method tested by Kim places nanospheres on the surface of the semiconductor to act as a stencil. Instead of electron beams carving the dots, this technique uses chemicals that eat away the semiconductor surface but leave the nanospheres—and therefore the dot-sized areas of semiconductor underneath—unscathed. Such a method "would be a convenient way of making quantum dots," says Palmstrom. But the ability to arrange these dots into patterns suitable for electronic devices "has not yet been demonstrated," says Kim.

Even if this application, or some of the other proposed uses for the spheres, fails to pan out, it's clear that the new bridges formed between microsphere fabricators have already ignited imaginations. "We're just seeing the beginning of learning how to synthesize solid and hollow spheres," says David Wilcox, a materials engineer at the University of Illinois, Urbana-Champaign, who helped organize the Boston session. At the microsphere production company PQ Corporation in Valley Forge, Pennsylvania, for example, hollow-microsphere expert Jim Hagarman says he intends to adopt a version of the drop-drying technique in order to make microspheres with a variety of new components. And some of these tiny orbs could well have a large impact.

–Robert F. Service

SEISMOLOGY

Biggest Deep Quakes May Need Help

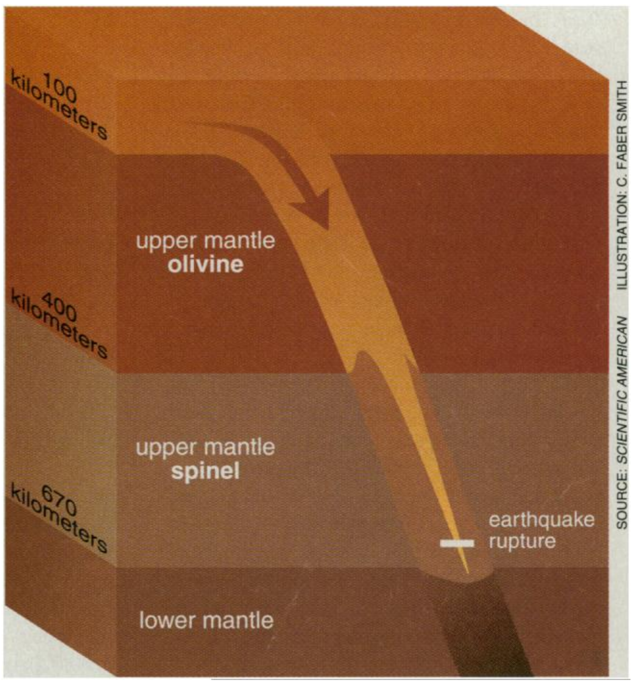
Earth's deepest earthquakes, buried more than 400 kilometers below the surface, can't match the threat to lives and property from temblors on the San Andreas. But these quakes, which take place in slabs of tectonic plate descending into the mantle, have always meant big trouble for theorists. The latest one—the biggest on record—has kept up that tradition.

Before the magnitude 8.3 quake struck 636 kilometers beneath Bolivia last June, seismologists thought they finally had a promising answer to a paradox posed by the deepest earthquakes: By rights, they shouldn't happen at all, because the enormous temperatures and pressures at such depths should allow rock to dissipate stress by flowing quietly rather than fracturing suddenly, as it does in earthquakes near the surface. By proposing that the fractures take place when rock abruptly changes to a denser crystal form, weakening the slab, the mechanism seemed to explain the paradoxical rupturing.

The Bolivian earthquake raises doubts about that seemingly neat solution to the paradox. "I think there's a basic geometrical problem" with the mechanism, says seismologist Paul Silver of the Carnegie Institution of Washington's Department of Terrestrial Magnetism, who voiced his doubts at last month's meeting of the American Geophysical Union in San Francisco. The problem is that the proposed mechanism, called transformational faulting, implies that the deepest quakes should be confined to a thin layer at the center of a descending slab—and the Bolivian quake was just too big to fit. To Silver, that discrepancy is "serious enough that we have to consider alternatives."

But not all his colleagues agree. Among them is Harry Green, a mineral physicist at the University of California, Riverside, who has provided much of the experimental evidence for transformational faulting. "The mechanism is not dead," he says. Still, many researchers suspect that it may need help, at least to explain really big quakes like the one under Bolivia.

Until the Bolivian earthquake, transformational faulting seemed to have everything going for it. The idea is that, at the pressures found below about 400 kilometers, the olivine that makes up much of a descending slab can transform suddenly into a form called spinel that is stable at high pressures. That sudden transformation occurs in proliferating "microcracks" that weaken the rock until a spinel-filled fracture forms. And because the new spinel has exceedingly fine crystals, it lubricates the fracture, enabling it to slip and generate an earthquake. The mechanism worked in laboratory experiments (*Science*, 26 April 1991, p. 510), and since then seismologists analyzing signals from deep quakes saw signs that



SOURCE: *SCIENTIFIC AMERICAN* ILLUSTRATION: C. FABER SMITH

Awkward fit. Last June's Bolivia earthquake, deep in a descending tectonic slab, was too big to fit in the narrow olivine wedge thought to be the slab's quake-prone region.

the quakes were only taking place where there is still olivine.

At a depth of 400 kilometers, that includes much of the thickness of the slab. But by the time the slab reaches depths of 600 kilometers and more, untransformed olivine, capable of breeding deep quakes, should linger only in a layer perhaps 10 kilometers thick at the center of the slab, where it is coolest. And there's the rub. The rupture that generated the massive Bolivian quake extended across a plane measuring 30 by 50 kilometers. And the increasing abundance of modern seismographs in South America and around the world allowed seismologists to pin down the large rupture's precise orientation—it cut more or less horizontally across the steeply inclined slab, extending well beyond the supposed olivine layer.

One possible explanation is that the slab and its shrinking olivine core have somehow crumpled and thickened at that depth. Stephen Kirby of the U.S. Geological Survey in Menlo Park, California, suggested at the AGU meeting that they might have done so as the slab ran into the more resistant lower mantle, which begins at 670 kilometers. But Silver is skeptical. He argues that the fuzzy images of slabs revealed by seismic waves suggest they deform only in the lower mantle, and when they do, it is by accordion-like folding, not by thickening. Even if a slab did thicken, says Silver, the heat generated by the deformation would wipe out the olivine core before it was thick enough to generate a quake like the one beneath Bolivia.

Seismologist Hiroo Kanamori of the California Institute of Technology offered another alternative. "It's very possible," he says, "that the rupture was triggered by some mechanism" like transformational faulting within a thin slab core, then sustained outside the core by some other means. And Kanamori thinks he sees a possible mechanism: "If frictional melting occurs on the rupture, it is probably possible to sustain faulting over a large zone. I think melting is very likely; it's very difficult not to melt" the fault as its two sides slide by each other under high pressure.

That would make for two mechanisms, at least, to explain the deepest earthquakes, which "doesn't seem very economical" to Silver. He and Charles Meade of Carnegie's Geophysical Laboratory are pursuing the possibility that a single alternative mechanism—the failure at great depth of faults formed millions of years ago when the rock was still at the surface—is at work. Green, however, is setting up new lab experiments to test Kanamori's proposal that a fracture touched off by transformational faulting can continue to propagate through unfavorable conditions. Either way, the Bolivian earthquake has left its mark. "The earth has spoken," Green says. "I think it's going to be productive."

–**Richard A. Kerr**

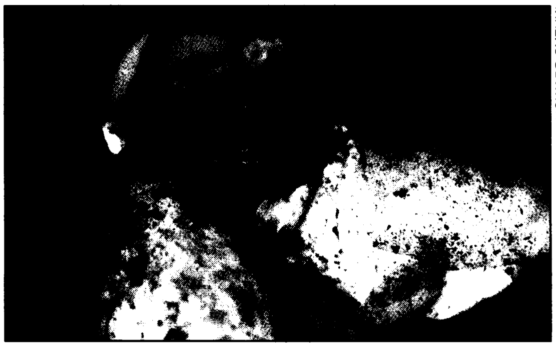
ZOOLOGY

St. Louis Meeting Showcases "Creature Features"

The 92-year-old American Society of Zoologists (ASZ) is preparing for a metamorphosis that will expand its focus from organism-level research to comparative studies ranging from the molecular to the ecosystem level. To mark the change, society officials hope to adopt a new name—the Society of Integrative and Comparative Biology—this year. But hints of change could already be seen in the ASZ's annual meeting, held in St. Louis from 4 to 8 January, where symposia spanned topics from DNA sequencing to ecological experiments.

New Evidence About Feminized Alligators

To the casual eye, the young male alligators dwelling in Florida's Lake Apopka may look perfectly normal. But they aren't: They have low levels of testosterone, high levels of estrogen, and unusually small penises. They've been feminized, apparently due to a major pesticide spill in the lake in 1980. Their plight has often been considered one of the best documented examples of the effects of environmental estrogens, compounds that mimic the female hormone estrogen. But just which chemicals are at fault, and how they exert their unfortunate effects on the alligators, has been something of a mystery.


HOWARD SUZUKI

Anti-androgen victim? If male, this Lake Apopka alligator hatchling may be sexually abnormal.

But new evidence presented at a special ASZ symposium on environmental endocrine disrupters by toxicologist L. Earl Gray of the Environmental Protection Agency (EPA) now suggests that the alligators aren't suffering from an excess of estrogenlike compounds after all. The culprit in Lake Apopka may instead be a compound called *p,p'*-DDE that exerts its feminizing effects by blocking the effects of androgen, the male hormone. *p,p'*-DDE had been linked to the alligators' hormonal problems before, but researchers had been puzzled by the fact that the compound's chemical activity was not similar to estrogen's. "Now I can explain what I'm seeing," says reproductive endocrinologist Louis Guillette Jr. of the University of Florida, who has been studying the Lake Apopka alligators with his co-workers. "DDE is not an estrogen, but an endocrine disrupter."

Other compounds considered to be environmental estrogens have been linked to feminized fish in British rivers and birds in the Great Lakes, and some researchers have been concerned that the chemicals also pose a risk to humans. These connections have been controversial, however (*Science*, 15 July 1994, p. 308), and the work of Gray and his colleagues will further complicate efforts to pin down the reproductive effects of environmental contaminants, because it implies that assessing the estrogenic effects of a suspicious compound is not sufficient; researchers must also probe whether the chemical blocks androgens, says Guillette.

Gray and colleagues didn't start out working on Lake Apopka animals. Rather, for the past few years, they have been studying Vinclozolin, a pesticide that blocks the effects of natural androgen by binding to the receptor through which the hormone works. Male rats exposed to Vinclozolin in utero have delayed puberty and malformed reproductive organs. In his ASZ talk, Gray explained that his work took a new direction when he heard Guillette speak about the Lake Apopka alligators at a meeting last April—and realized that they had abnormalities that "looked just like our Vinclozolin rats." Gray went home and began experiments to find out whether *p,p'*-DDE might also act as an anti-androgen. The results suggest it does.

Gray and his collaborators, William Kelce and Susan Laws, also of EPA, and Elizabeth Wilson of the University of North Carolina, showed that *p,p'*-DDE binds to both human and rat androgen receptors, blocking binding by natural androgens like testosterone. The team also showed that *p,p'*-DDE prevents androgens from turning on the genes they normally activate. Finally, they showed that young male rats treated with *p,p'*-DDE have delayed puberty.

And *p,p'*-DDE may not be the only envi-