makers have gradually increased the current capacity of Nb_3Sn, 900 MHz "is right on the edge of the ability of niobium-tin to carry current," says Steven Van Sciver, director of magnet science and technology at the U.S. National High Magnetic Field Laboratory (NHMFL) at Florida State University, in Tallahassee.

A second limiting factor is the electromagnetic force, which pushes outward on the coil. That puts a tensile load on the individual strands, which increases with field strength, current, and the radius of curvature of the coil. Because 21-T magnets create a force far beyond what the Nb_3Sn alloy can resist, magnetmakers must reinforce the subcoils, typically with bands of stainless steel wires.

Then there are a host of engineering details that must be resolved. It's a slow process, says Van Sciver, involving gradual improvements in such things as winding techniques and the epoxy resins used to fill the voids in the coils. Oxford Instruments spokesperson John Kearns agrees, although he says proprietary concerns prevent him from providing details: "It's just par for the course when you're pushing the forefront of a technology."

Both the Florida lab and the National Research Institute for Metals (NRIM) in Tsukuba, Japan, are working on 900-MHz NMRs, but as a steppingstone to more powerful machines. Rather than one coil, NMR magnets use a series of coils nested within coils, "like juice cans nested within coffee cans," says Van Sciver. Lab scientists hope to use stronger coils made from new materials within or in place of the innermost coils of the magnets in their 900-MHz machines to reach the next level. NRIM has set its sights on a 1000-MHz, or 1-gigahertz (GHz), machine, which would require a field of 23.5 T, while NHMFL is aiming for a 25-T magnet to power a 1.066-GHz machine. NRIM is also planning to wrap wires with the Nb_3Sn conductor around a tantalum core for strength. "It will be a more compact magnet," says Tsukasa Kiyoshi, who heads the NRIM group. The technique is also expected to improve the efficiency of the coil-winding operation and lower costs.

Oxford officials say the company expects to deliver the magnet to PNNL by the end of the year, while the NHMFL group hopes its 900-MHz machine will be ready by the end of 1999. Next year NRIM also hopes to produce a 920-MHz machine using an improved Nb_3Sn wire for the innermost coil. A test coil made of the new wire recently set a world-record field of 21.7 T for niobium-tin alloys. The national labs are making their machines for in-house use, but both also have corporate partners.

From there it will be on to 1 GHz. Both labs plan to replace the innermost Nb_3Sn coil of the magnets with another material. For this inner coil, the NHMFL group is relying on a bismuth oxide, a high-temperature superconductor already proven capable of carrying sufficient current under a high magnetic field. The outer Nb_3Sn coils will generate 20 T, with another 5 T coming from the inner bismuth coil. Unfortunately, the bismuth "is more challenging [to work with] than niobium-tin by a significant factor," Van Sciver says.

The Japanese are also working with the bismuth compound. But they are hedging their bets by developing a niobium-aluminum material that also promises to come close to carrying sufficient capacity under a high field to use in a 1-GHz NMR. "We'll develop [both alternatives] and then evaluate them," says Kiyoshi.

Van Sciver says his lab hasn't yet committed to a target date, but Kiyoshi hopes to have a working 1-GHz, 23-T machine by early in 2002. Ellis describes that as "indeed optimistic." And that 1-GHz milestone is far from marking the end of the road. "I'm looking forward to 2 GHz," says Griffin.

–DENNIS NORMILE

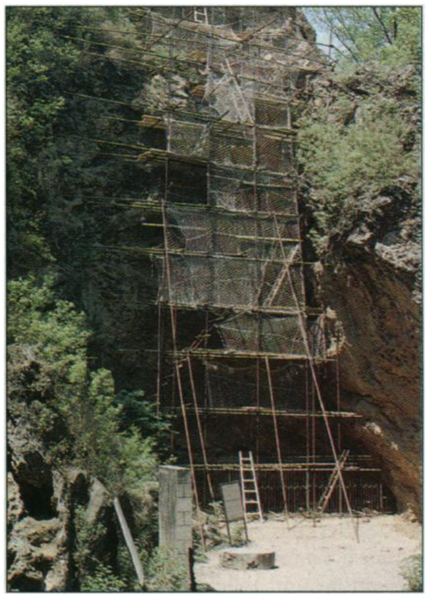
ARCHAEOLOGY

Geological Analysis Damps Ancient Chinese Fires

Studies of sediments at Zhoukoudian, China—long considered the site of the first use of fire—suggest that any flames there were not kindled by human hands

When and where did our human ancestors stop running from fire and start guarding and preserving it as a vital tool for survival? For the last half-century, nearly every archaeology textbook has offered a simple answer to that question: 500,000 years ago, in Zhoukoudian, China, where Peking man—*Homo erectus*—huddled around a hearth tending kindling and roasting deer.

But that answer is now up for revision, according to a reanalysis of the Zhoukoudian site presented on page 251 of this issue by an international team. "In a sense, we spoil the story," says the lead author, structural biologist Steve Weiner of the Weizmann Institute for Science in Rehovot, Israel. Applying a battery of techniques, Weiner and his colleagues did confirm that there are some burnt bones at the site about 30 miles southwest of Beijing, but those might have been burned naturally. And they found no evidence of controlled use of fire: no hearths, no ashes, and none of the unique chemical signatures expected from fires.



In search of fire. Researchers worked atop a scaffold to study the Zhoukoudian site in China.

S. WEINER / WEIZMANN INSTITUTE FOR SCIENCE

The signs of fire at Zhoukoudian are now no clearer than at dozens of older sites around the world. "The bones are burnt, but we don't have the smoking gun: the fireplaces which people assumed to have been there," says co-author geoarchaeologist Paul Goldberg of Boston University. That means there's no strong evidence of fire use until about 300,000 years ago and none definitively associated with *H. erectus*, the hominid that began to spread through Asia and into cold northern latitudes starting about 1.8 million years ago. Researchers must now consider that this colonization may have happened without fire. "We now have to reconsider *H. erectus*, their migrations, and their capability," says Huang Weiwen, an archaeologist at the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) in Beijing, who has worked extensively at Zhoukoudian.

The site was first excavated in the 1920s and '30s, when researchers found hominid fossils, stone tools, burnt bones, and what they described as ancient hearths preserved as layers of ash up to several meters thick. It all seemed to add up to solid evidence of human control of fire; some researchers even concluded that the thick ash layers represented continuous occupation over thousands of years.

The new study is the "first really systematic investigation since the early excavations," notes anthropologist Rick Potts at the National Museum of Natural History in Washington, D.C. In 1996 and 1997, Weiner's team revisited the site, a sheer cliff cut into the hillside, perching on a 10-story-high scaffolding for their analysis. They focused on layers 10 and 4, previously noted for putative king-sized hearths. They cleaned the exposure, studied the sediments microscopically, and used infrared spectrometry onsite to analyze the chemical constituents of sediments and fossil bone. In the lab, they confirmed that a small number of bones were burned. But the sediments contained no ash or siliceous aggregates, soil-derived minerals that are cemented together in trees and stay intact after burning—and should be present at the site of almost any wood fire. The thick layers aren't ash at all, but accumulations of organic material, much of it laid down under water, says Weiner.

The team did find stone tools closely associated with burnt mammal bones. And more of these bones came from large animals than small, a proportion considered consistent with human activity, because people are more likely to roast horse than mice for dinner. But although this clearly indicates the presence of fire somewhere nearby, it doesn't convince most researchers that humans rather than nature sparked the flames. That's part of the reason why even older purported evidence of fire—up to 1.8 million years old—from sites in Africa and Asia has been considered “dubious,” says paleoanthropologist Philip Rightmire at the State University of New York, Binghamton. “The whole thing is [now] ambiguous, and that's the normal situation,” adds anthropologist Lewis Binford of Southern Methodist University in Dallas, who visited Zhoukoudian briefly in the 1980s and first challenged the interpretation of hearths.

The paper also raises questions about whether humans actually lived at the site, because the researchers describe it not as a traditional cave but as the enlargement of a vertical fault, open to the sky. “This is an important reinterpretation,” says Potts. “It means that, who knows, maybe it wasn't a home.” Anthropologist Alison Brooks at George Washington University in Washington, D.C., who has also worked at the site, goes further: “It wouldn't have been a shelter, it would have been a trap.” Taken together, the evidence “brings Zhoukoudian a good deal more in line with sites from around the world, with a low fingerprint of human activity,” says anthropologist Chris Stringer of the Natural History Museum in London.

The first strong evidence of purposeful use of fire is now associated with much younger humans. “This puts it forward at least to *H. heidelbergensis* and may push it forward to Neandertal,” says Brooks. A leading candidate may be Vértesszöllös, Hungary, an *H. heidelbergensis* site between 400,000 and 200,000 years old, where burned bone is arranged in a radial pattern as if around a campfire. “That spatial evidence is missing for Zhoukoudian,” says Potts.

Still, some scientists advise against drawing sweeping conclusions from this single study. “The researchers were limited by the area they sampled,” far from the center of the cave, points out Huang. “Therefore, it is not an ideal place to detect the evidence of controlled fire use,” adds Gao Xing, an archaeologist formerly with the IVPP and now at the University of Arizona, Tucson.

Nonetheless, ambiguity at Zhoukoudian raises questions about whether *H. erectus* anywhere used fire, Stringer says. Yet the species somehow survived in Zhoukoudian's temperate climate and colonized lands even farther north. The absence of fire suggests that *H. erectus* was much less advanced, argues Brooks. But other recent discoveries have suggested that the species was a sophisticated toolmaker, points out Huang, and perhaps even traveled by boat (*Science*, 13 March, p. 1635). For now, the dampened flame at Zhoukoudian has thrown these ancient humans into deeper shadow. “This work is another new beginning, but it is not enough to answer all the questions we are curious to know,” says Huang.

–BERNICE WUETHRICH

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MEETING SOCIETY FOR DEVELOPMENTAL BIOLOGY

How Embryos Shape Up

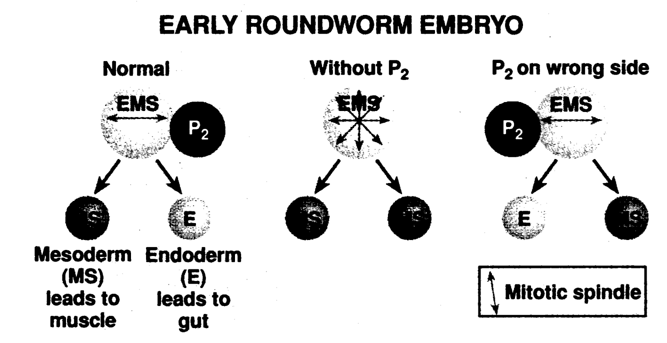
About 800 biologists gathered at Stanford University from 20 to 25 June for the 57th annual meeting of the Society for Developmental Biology. Study organisms ranged from flies to mice to plants, but there was plenty of common ground, including a new pathway by which signaling molecules can shape the early embryo and a new gene that helps specify right from left.

WNT Takes a New Path

In development, as in so much of biology these days, the gene's the thing: Researchers probe which genes turn on and off as embryos develop and which signaling molecules push the genetic switches. But surprising results presented at the meeting show that at least one classic signal, the wingless (WNT) protein, can guide development without touching those switches. At a crucial moment in development, WNT triggers an early cell to divide asymmetrically into two daughter cells, which later give rise to different sets of tissues. The new results, reported in a plenary session by developmental geneticist Bruce Bowerman of the University of Oregon, Eugene, and his colleagues, suggest that WNT does so by bypassing the genes and acting directly on the cell's internal skeleton.

The result establishes a new modus operandi in developmental biology signaling pathways. WNT, which is perhaps best known for helping to create pattern in insect appendages, manages this feat at least in part by sending a signal down a chain of molecules to the nucleus of its target cell, where it activates specific genes. Now, says Norbert Perrimon, a developmental geneticist at Harvard Medical School in Boston, “Bruce has provided some really convincing data that proteins in the WNT pathway directly control the cytoskeleton without [turning on genes].” The finding also makes developmental researchers reconsider the cytoskeleton. “The cytoskeleton [as] a direct signaling target has not been on people's radar screens,” says William Talbot, a developmental geneticist at New York University's Skirball Institute of Biomolecular Medicine. “Normally you get a signal, figure out how it gets to the nucleus, and then you think you're done. Certainly we have to think about the cytoskeleton now.”

Bowerman made his discovery in the roundworm *Caenorhabditis elegans*, where researchers had already shown that at the four-cell stage of development, one cell, called P_2, delivers an important message via the WNT pathway to its neighbor cell, called EMS because it gives rise to both en-



Division with a difference. Only after getting a message from a nearby P_2 cell can the EMS cell divide so that one daughter can become endoderm.

SOURCE: B. BOWERMAN