PALEONTOLOGY

A Fossil Treasure Trove Hidden in Goethe's City

A dedicated team is working to preserve every detail of a unique fossil record of the past 2 million years

WEIMAR, GERMANY—The dead beast's bones remain tangled in unlikely contortions, bearing witness to the power of the floodwaters that probably took its life. The remains are still half-encased in the sand that has preserved the partial skeleton for more than 1 million years. Today, technician John-Albrecht Keiler of the Senckenberg Research Station for Quaternary Paleontology works painstakingly with tweezers and needle-thin brushes to extract the leg of a large hippopotamus—40% bigger than today's species—from its long imprisonment. Keiler and his colleagues will document the positions of the bones as they uncover them, careful to record details that may be important to future researchers who want to understand the life and death of this animal and its contemporaries.

Roar from ages past. The largest cheetah ever found was uncovered at Untermassfeld, south of Weimar.

Such detail is what makes the collections of this research station the gold standard for mammalian paleontology. Although most people associate this small city in the center of Germany with great thinkers such as Goethe, Schiller, and Nietzsche, paleontologists will always link Weimar with saber-toothed cats, steppe mammoths, large hippos, and giant hyenas.

The hills and valleys of Thuringia contain one of the richest mammalian fossil records in Europe. Excavated since the late 17th century, the area has yielded tens of thousands of fossils, ranging from complete rhino skeletons to minuscule molars from ancient rodents. This wealth of material is now housed in a modest pair of 19th century apartment buildings a few minutes' walk from the house where Goethe lived. The carefully cataloged collections of the research station are a treasure trove for researchers hoping to piece together the natural history of Eurasia: how animals and plants migrated and gave rise to new species and how climate and other environmental changes led to their decline and disappearance. "The collections there are extremely valuable and unique. It is astonishing, really, that in that small area are some of the best-quality mammal localities in Europe," says evolutionary biologist Adrian Lister of University College London.

The research station, which is a branch of the Senckenberg research institute in Frankfurt, has just published the latest in an ongoing series of monographs—the fourth since 1997—describing one of its prime fossil sites. The institute's director, Ralf-Dietrich Kahlke, eagerly shows off the 800-page tome, dense with detailed drawings, photographs, and quantitative data from more than 20 years of excavations at a sandpit near the village of Untermassfeld.

The monograph is an invaluable contribution to the quaternary paleontology community, says Dick Mol, a mammoth expert at the Rotterdam Museum of Natural History in the Netherlands. Previous volumes enabled Mol and his team to more precisely date and classify fossils dredged from the North Sea. "That was possible only because we had the detailed descriptions of [Ralf-Dietrich] Kahlke," he says. Lister agrees. The Untermassfeld site "is fabulously rich. We need a series of fossils to understand how things changed with time, and [Untermassfeld] is the best we have from that period."

Bones of contention. The research station is built on a tradition of fossil-hunting that stretches back more than 3 centuries. When a quarry worker in the nearby town of Burgtonna found "a lot of strange large bones" in 1695, it caused quite a stir at the court of the local duke, Friedrich II of Saxe-Coburg-Gotha. The bones were far too big to belong to any locally known species, and most of the duke's medical experts argued that they were a "trick of nature." But the historiographer Wilhelm Ernst Tentzel, who was writing a contemporary history of the duchy, disagreed. He believed that the bones belonged to an elephant. Perhaps, he argued at the time, the animal had been part of Hannibal's army that crossed the Alps in 218 B.C. but had escaped and then wandered north.

Tentzel was right about the animal but way off on the date. According to modern studies, the bones are those of a woodland elephant that lived 110,000 years before Hannibal's invasion of Roman Italy. Part of the disputed skeleton is still on display at a museum in Gotha, just west of Weimar.

For most of the 300 years since the famous elephant dispute, the rich fossil fields in local quarries were plundered by private collectors. Incredibly lifelike imprints of oak leaves, acorns, apple cores, and skeletons turned up in the local travertine stone. In the early 1960s, as excavations strained the capacity of the local museum, a young geologist named Hans-Dietrich Kahlke (Ralf-Dietrich's father) asked the East German authorities to establish an institute dedicated to quaternary paleontology, the study of the past 1.8 million years.

As a child, Kahlke Sr. collected fossils locally with his father, but he first honed his paleontology skills in England just after World War II. As a teenage prisoner of war, he was caught by military police having fled his camp for London. He explained to his interrogators that he was there to see the fossils at the Natural History Museum. When he claimed he would repeat his offense the next time he had a chance, they arranged for him to study at a local technical college and make a few authorized trips to London.

When he returned to Weimar, Kahlke found a job at the local museum of prehistory, earned doctorates in archaeology and natural science, and began his own excavations. Kahlke was given leave to start a separate institute in 1962, and, as the East German regime did not consider paleontology a political threat, he was allowed more contact with Western scientists than many colleagues in other fields. Those connections served him well after German reunification. When the institute was slated for closure along with hundreds of other East German research facilities, Kahlke and his son, Ralf-Dietrich, who by then was also working at the institute, appealed to paleontology colleagues around the world for help. The response from more

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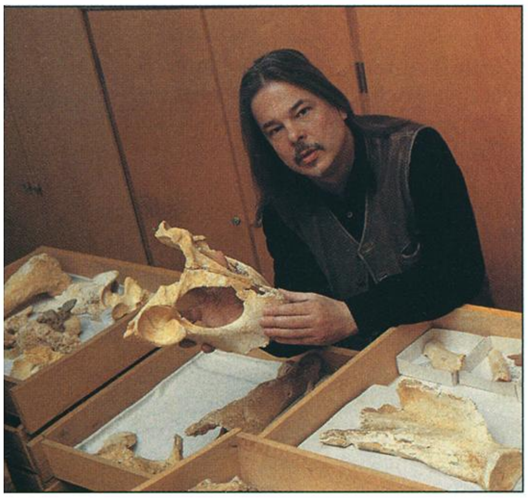


Ancient riches. Ralf-Dietrich Kahlke oversees one of the world's largest collections of fossil mammals.

than 100 institutes helped persuade the government to save the institute, and it became part of the University of Jena.

But the match was not an ideal one. The elder Kahlke retired and Ralf-Dietrich became director, but as the only paleontologists at the university, the Weimar researchers had trouble securing enough funding. "We were going under," the younger Kahlke says.

Again colleagues came to the rescue. Senckenberg Museum director Fritz Steininger, an Austrian paleontologist who used the Weimar collection, helped persuade the German Science Council and the state governments that the Weimar research would complement the work at Senckenberg, which had few specialists in the quaternary period. In January 2000, the institute became a research station outpost of the Senckenberg.

The full picture. To understand ancient climates and ecosystems, paleontologists need more than isolated bones of hulking mammals. The Weimar researchers are careful to document the smallest details: One lab holds millions of tiny snail shells, another, thousands of peppercorn-sized rodent teeth. The fossils, carefully sifted from tons of sediment, are important clues to the state of the ecosystem at the time the animals lived and can also help assign dates to large fossils from sites with fewer geologic time signatures, micromammal expert Lutz Christian Maul explains.

It is the large fossils, however, that pose the most pressing practical challenge. Like its local forerunner, the institute is running out of space. In the building that houses the main collection, ceilings are braced by huge metal supports resembling overgrown car jacks. To ease the strain, the institute sorts its collection partly by weight, with the heaviest fossils on the lower floors. Although the structure is well built, Kahlke says, "it was not designed for storing tons and tons of elephant bones." Despite the difficult conditions, the institute is a model of conservation, says Mol: "Ralf and his team are an example for how other teams should behave with their fossils."

Indeed, Ralf-Dietrich Kahlke is keenly aware of his legacy to future generations of researchers: One of the reasons the institute employs a full-time artist and photographer is to document excavations and fossils for the monographs. "Our views will change, but the bones will not change," Kahlke says. "Documentation keeps its value forever. No one can have more information about the excavated sites than we have included in the monograph." It is a legacy he hopes may last at least another 300 years.

–GRETCHEN VOGEL

MEETING ASTROBIOLOGY SCIENCE CONFERENCE

Astrobiologists Try to 'Follow the Water to Life'

MOUNTAIN VIEW, CALIFORNIA—That slogan, expressed by a speaker at the biannual Astrobiology Science Conference held 8 to 11 April here at NASA's Ames Research Center, unified most of the talks heard by more than 700 astronomers, biologists, chemists, geologists, planetary scientists, and even virologists. Among the topics raised within the cavernous 60-meter-high Hangar One—which once housed a pre–World War II Navy dirigible—were the liquid milieu in which the first cells may have formed and the effects of water and ice on an Arctic impact crater.

A Fresh Start for Life?

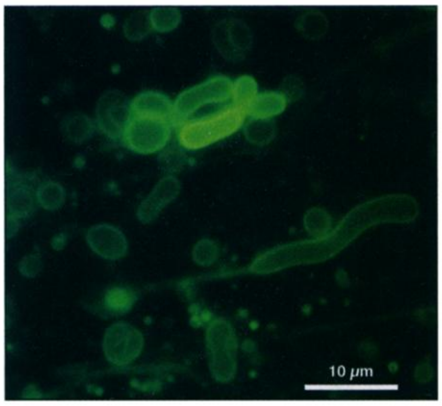
Salty water is a comforting home for life today, but it probably was too harsh for the first cells. That's the surprising conclusion of new laboratory studies, which found that primitive membranes and chains of basic genetic material assemble far more easily in fresh water. The research suggests that life arose in ponds on the earliest continents, rather than in tide pools or the deep sea, as many researchers have assumed.

Despite the uncertainties that still shroud the chemistry of the young Earth, "this is a real wake-up call," says mineralogist Robert Hazen of the Carnegie Institution of Washington in Washington, D.C. "We've assumed that life formed in the ocean, but encapsulation in freshwater bodies on land appears more likely."

In a popular origin scenario, life required an enclosed membrane, or vesicle, to protect and confine the first chemical chains capable of copying themselves. The simplest vesicles are made of amphiphiles—long molecules with a head that latches to water and an oily, carbon-rich tail that repels water. Two layers of amphiphiles can naturally bind together to form a sandwich: The water-loving heads point outward, and the oily chains link together inside. If this bilayer wraps into a tiny blob, a bare-bones vesicle is born.

A team led by astrochemist Jason Dworkin of NASA Ames showed last year that such vesicles can arise from the icy ingredients in comets and interstellar space. Ultraviolet light transforms carbon-rich ices into simple hydrocarbons, such as fatty acids, in space. Then, the hydrocarbons coalesce into vesicles when exposed to water on Earth. In this way, the team reasoned, cosmic seeding of early Earth supplied the organics needed to build the first cells. But to explore just where that might have happened, team member David Deamer, a biochemist at the University of California, Santa Cruz, decided to test the reactions in various solutions in his lab.

In one experiment, graduate student Charles Apel found that stable vesicles formed in water and a dash of alcohol. However, when he added sodium chloride or ions of magnesium or calcium—at levels less than the saltiness of today's ocean—the



They're fresh. Simple membranes, such as these made in the lab, break up in salt water.

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