


TREASURES FROM

A mammal's jawbone and forgotten frog fossils may help paleontologists solve mysteries of Africa's past.

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PHOTOGRAPHY COURTESY OF PAT O'CONNOR AND NANCY STEVENS

▲ MYSTERY BONE Researchers found the jawbone of gondwanathere, a 6-inch-long rodent-like animal that lived during the Cretaceous, in what is now Tanzania.

The dusty trucks pulled off the road — a feat that would be impossible if it hadn't been the dry season — and parked near the Songwe River, the muddy vein that cuts through the southwest region of Tanzania. Dry heat had pushed the temperature up to the mid-90s, and locals warned of crocodiles in the basin. But for a pair of Ohio University researchers, the possibility of finding fossil evidence that might answer some of paleontology's big mysteries outweighed the risks.

Patrick O'Connor and Nancy Stevens were trekking through a region relatively unexplored for fossil remains. Tanzania's sloping grasslands are speckled with scrub brush and small trees, which leaves little exposed rock to investigate. But indigenous rock, red sandstone, preserves remains from the Cretaceous and Paleogene periods that paleontologists like O'Connor and Stevens are hoping to find. "When my colleagues and I were organizing this field expedition we said, 'If we find anything here, it's going to be huge,'" O'Connor says.

Working along the river was an effective modus operandi. Over time, the Songwe had burrowed through the rock, eroding and exposing deep red walls now waiting to be examined. This sedimentary record was full of crevices, but were there fossils encased in the rock?

"We found bones within 10 minutes from getting out of the trucks," O'Connor says, his voice tinged with astonishment even more than a year later. Among those first findings were bone fragments of turtle, dinosaur, and crocodile — and the jawbone of a small mammal known as a gondwanathere. The rodent-like animal was only about 6 inches long when it scurried the Earth, but the discovery of its jaw may give great insight into how the continents were interconnected during the Cretaceous, a time 144 million to 65 million years ago when mammals like the gondwanathere were minor players compared to the dinosaurs and other reptiles that dominated the planet.

"Finding a jaw like this on the continent of Africa in the Cretaceous is quite rare," he says, holding a cast of the gondwanathere jawbone in his outstretched palm. The bone itself could easily get lost in the cushion of a couch along with some pocket change, but it also could prove

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that during the Cretaceous, these mammals lived not only on India, South America, and Madagascar, but also Africa. It's a new development for theories on continental drift, as Africa's location during the Cretaceous could shed light on how early animals and plants arrived at their modern locations.

AFRICAN ATMOSPHERE

On the hallway walls of the Life Sciences building at Ohio University, man and beast get equal play. Detailed posters of a human knee joint mingle with drawings of a cross-sectioned pig, and O'Connor's office adds to the mosaic. Black trays of fossilized dinosaur vertebrae and ribs sitting on bubble wrap occupy every available level space. A white placard rests on the bones and reads "Please Do Not Touch, Extremely Fragile."

O'Connor, an assistant professor of anatomical sciences and vertebrate paleontology in the College of Osteopathic Medicine, says his venture into paleontology was serendipitous when a professor encouraged him to travel with him to Madagascar in 1996. "I'm not one of those people who can say I've wanted to work with dinosaurs since I was 3 years old," he says. "It's not how I first got into it." Today, however, O'Connor's enthusiasm for things of old is contagious as he discusses his work at a desk stacked with piles of research articles and surrounded by carts of fossils.

Everything in the room is dwarfed by the large world map on the wall where Africa is center stage, all other continents severed by the map's borders. O'Connor motions to it as he speaks intently about his work on the continent and the time period he studies. In the Mesozoic Era, all of the southern hemisphere continents, including Africa, were merged into one supercontinent known as Gondwana, which began separating during the middle of the Jurassic, the Cretaceous' famous predecessor. Like a hand, waterways began to reach out and separate land, flora, and fauna and commit them to permanent homes. The fossil remains that scientists find reflect the changing landscape in which these animals lived during the fragmentation. Until recently, paleontologists had found fossil evidence of gondwanatheres on most of the southern continents except Africa, which led them to believe that Africa had split off from the supercontinent earlier than others, and that its residents had developed separately. "It's a theory really based on negative evidence," O'Connor says, explaining that much of subequatorial Africa has yet to be explored for Cretaceous-age vertebrates.

▲ BIG DIG Ohio University scientist Pat O'Connor (right) excavates a dinosaur fossil with Remigius Chami, a University of Dar es Salaam graduate student, during a field expedition to Tanzania.

▲ EARTHLY SECRETS Researchers carefully extract ancient bones from the red earth; Ohio University evolutionary morphologist Nancy Stevens pursues signs of the past.

This theory is one widely accepted by most modern-day geologists and paleontologists, according to David Krause, a professor at Stony Brook University in New York, who has been conducting field work since 1969. In 1996, he worked with O'Connor and Stevens when they joined his paleontological expedition on the island of Madagascar off the east coast of Africa. Like O'Connor, he's interested in the arrangement of continents during the Cretaceous. He believes that discoveries like the gondwanathere specimen may play an important role in deciphering how the continents of the southern hemisphere maintained connections with one another. Any disruption of these connections, such as Gondwana's separation, meant isolation, he adds,

and the position of Africa can help determine where land-restricted animals existed at the time.

Inspired by his work in Madagascar with Krause, O'Connor was interested in further exploring the Cretaceous period in Africa. Before he could venture to the continent, he had to find areas that contained Cretaceous deposits, he explains, and old geology maps from the 1940s, 1950s, and 1960s were helpful guides. He reaches to the side of his desk and pulls out a few colorful scrolls. "We went through all these old maps and found out where people thought Cretaceous sediments were."

A map from 1952, with different colors for corresponding sediments, pointed to the southwest part of Tanzania. O'Connor and Michael Gottfried, a collaborator from Michigan State University, were encouraged when they saw in the footnotes of one map referencing Tanzania, "Reptile bones found here." As fossil finds are secondary to the work of geologists, they may not always provide such details in their reports. "To them, it's often not a big deal. But to us, it's great," O'Connor says.

Is it possible to find the rocks that geologists documented in 1952? Armed with maps, O'Connor ventured to Tanzania, describing the first expedition as "exploratory." He and Gottfried traveled to Tanzania's capital Dar es Salaam, on the eastern coast, a year before to make arrangements.

"It's not like you can just show up with your rock hammer and go," O'Connor says. The crew went through a lengthy petitioning process, applied for visas, and received their vaccinations — yellow fever, hepatitis A, and typhoid fever to name a few. That first summer in 2002, they were delayed in customs for a week waiting in a web of paperwork. But local officials proved to be helpful, and the group finally settled on a coffee plantation about 20 miles outside town that was close enough to the Songwe for river walking.

When the team collected the jawbone on one of the early prospecting expeditions, he didn't even know what it was. "When we found it, we thought it was interesting," he says, "but we couldn't even see the teeth (because of the encasing sediment)." The group agreed to take it back, and appropriately labeled it "mystery bone."

Back at Ohio University that fall, O'Connor received a phone call from the person who was preparing the fossils at Stony Brook University. "She said, 'You're not going to believe this, but it's a mammal jaw,'" he recalls. O'Connor was caught off guard: The only prior African Cretaceous mammals on record were fragments of isolated teeth and bone.

"The big significance of the gondwanathere jaw is that we need to re-evaluate our biogeographic hypotheses now, because it looks like we have gondwanatheres on the African continent too," he says.

The jawbone leads O'Connor to two hypotheses. The first is that Africa was not as isolated as previously theorized. "It could mean there were persistent land connections between Africa and other parts of Gondwana that allowed dispersal," he says. Or, this finding could age the gondwanatheres as much older than previously thought. The mammals in Tanzania could have been present before the landmasses separated. O'Connor says both theories will get closer scrutiny as more fossil evidence from Africa is discovered.

Along with the Cretaceous discoveries, other fossils began to emerge. "We knew we had some fossils that didn't belong in the Cretaceous," he says. It soon became evident that these fossils were from a younger time period. A self-admitted "Cretaceous-focused" paleontologist, O'Connor knew these younger fossils would be of interest to fellow researcher and crew member Nancy Stevens.

SNAPSHOTS OF THE PAST

"These are the tools of the trade," Stevens says, laying a photo on her desk from her trip to Tanzania with O'Connor and the other researchers. The photo shows a basic paleontologist's toolbox, which appears to be a hodgepodge of other professionals' instruments. Brushes and white plaster casts may be more commonly found in a studio, but they allude to the art of extracting fossils. Ice picks, rock hammers, and Global Positioning Systems offer proof that the hunt is hard work. "You spend a lot of time crossing a lot of rock," she says.

Stevens started traversing rocks in Madagascar when she was still in graduate school. The isolated island attracted many scientists and, in turn, a boon of paleontological information began to emerge — piquing Stevens' curiosity for other lands.

"Once a body of evidence had been collected from Madagascar, a lot of people started speculating what was across the Mozambique Channel," she says.

While she was enthusiastic to join O'Connor and Gottfried's expedition to Tanzania looking for Cretaceous vertebrates, Stevens' research actually focuses on a different time period. "The Paleogene is a time that is relatively unknown from deposits in sub-Saharan Africa," she says. The Cretaceous Period's successor, the Paleogene Epoch, marks the evolution of mammals from a variety of small forms to diverse organisms that could dominate land, water, and air.

Along with geologist Eric Roberts and her other collaborators, Gottfried and O'Connor, Stevens is looking for Paleogene creatures in the thickest sedimentary package in the East African Rift System, with deposits more than six miles deep preserving many pockets for fossils to settle. "It provides us with a number of snapshots into the past," she says.

So far, these snapshots have included several small mammal and other vertebrate specimens, along with invertebrates and

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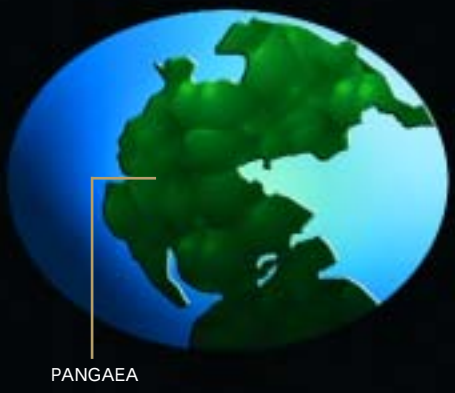
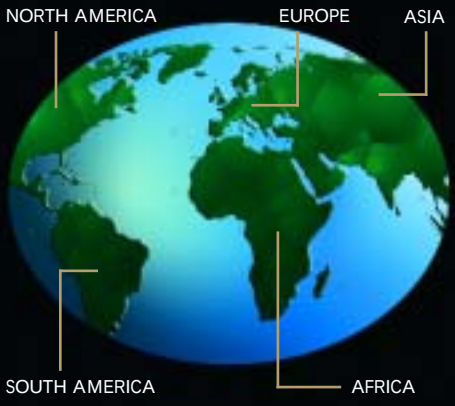
continental history



▲ TRIASSIC EARTH
Between 250–206 million years ago, the Earth's continents were joined together in one supercontinent called Pangaea. Since the land was joined, animals — including dinosaurs — were free to migrate in all directions, as no oceans stopped travel.

▲ JURASSIC EARTH
Between 206–144 million years ago, Pangaea began to split into separate continents due to continental drift. The gaps filled with ocean waters, creating barriers that prevented animal migration to certain parts of the Earth. This continued during the Cretaceous Period.



▲ EARTH TODAY
By the Cretaceous Period (144–65 million years ago), the continents had almost reached the positions they hold today. As a result of such wide spans between land masses, each continent contained its own unique habitat and unique animal life, similar to life on Earth today.

plant remains. Last summer, while working farther up the Songwe river, Stevens saw something exposed in the rocks along the red river bed. "I thought to myself, 'These look like tiny fingers or toes," she says. After a little more elbow grease and hand quarrying, the specimen was removed. It was not until it had been prepared in the laboratory that Stevens realized she had found the articulated end of a frog limb. Citing the leg as "the most complete specimen from this Paleogene locality to date," Stevens hopes finds such as the frog will fill in a past that is very underrepresented.

An evolutionary morphologist, Stevens studies animals that live today and compares them with fossils she unearths, which is why she also finds Tanzania interesting. This region preserves one of the few known sub-Saharan Paleogene deposits providing a window into what was occurring in the whole continent of Africa at that time. "Interestingly, it could shed light on the evolution of some of the mammals we see today on Africa," she says.

These findings are not only applicable to the fauna of continental Africa, she adds. Comparisons can be drawn between Tanzania and Madagascar, which were once attached. Madagascar is known for having many species that are found nowhere else. "This kind of endemicity has made Madagascar the darling of biogeographers for many, many years," Stevens said.

Scientists have long wondered how animals arrived there — theories have ranged from land bridges to mounds of floating vegetation — and Tanzania could provide some clues. But just as many of the living species on Madagascar are threatened by habitat loss, the delicate fossils of Tanzania are eroding out of the rocky walls of the Songwe Valley, threatening to take their secrets with them.

"We have a rapidly disappearing puzzle that we want to solve," Stevens says. "One of my hopes is that looking in this critical Paleogene interval in Tanzania, we may be able to shed light on the origins of modern groups, including the unique Malagasy fauna."

SAME PLACE, DIFFERENT TIMES

Back in her office, Stevens muses over her summers spent trailblazing the paleontological path in Africa. "Imagine if you looked out your window and saw people picking through your backyard with tools," she says with a smile. "They must think we're nuts."

But over the last few years, the paleontologists and their African hosts have developed relationships that are about more than fossil digs. Through the Madagascar Ankizy Fund, Stevens and O'Connor have worked with Krause, who started the nonprofit organization, to bring healthcare and education to parts of the island, including the construction of new schools. It is this connection to the African community that Stevens fondly recalls as she picks through the photographic and fossil evidence that occupies her desk and reaches for another picture. This one is a snapshot of her and two girls with braided hair who cling to Stevens' brightly printed skirt.

The scientific community also is welcoming O'Connor and Stevens' contributions and new findings on the African continent. To support their research this past summer, The National Geographic Society once again awarded funding to O'Connor and Gottfried, and Stevens has received grants from the LSB Leakey Foundation and Ohio University.

From his fossil-dotted office, O'Connor recounts an important part of the scientific process: sharing findings with fellow paleontologists. The team already has published some findings from Tanzania, including in the *Journal of Vertebrate Paleontology*. Stevens will be presenting a talk on the new Paleogene fauna in November to the Society of Vertebrate Paleontology, and hopes that the discoveries will be of interest to other scientists in the field. O'Connor has presented a paper to the same society on the new Cretaceous fossils, including the gondwanathere jaw. He reports that other paleontologists have eagerly responded to the news of what the team has uncovered in the dusty red earth of sub-Saharan Africa, walking along the Songwe where few scientists venture. "People were excited," he says. "It's not just the four of us working on this project that think Africa is the big question mark." ▲

More information about the research of Stevens and O'Connor can be found at the Department of Biomedical Sciences Web site, *http://www.oucom.ohiou.edu/dbms/*.