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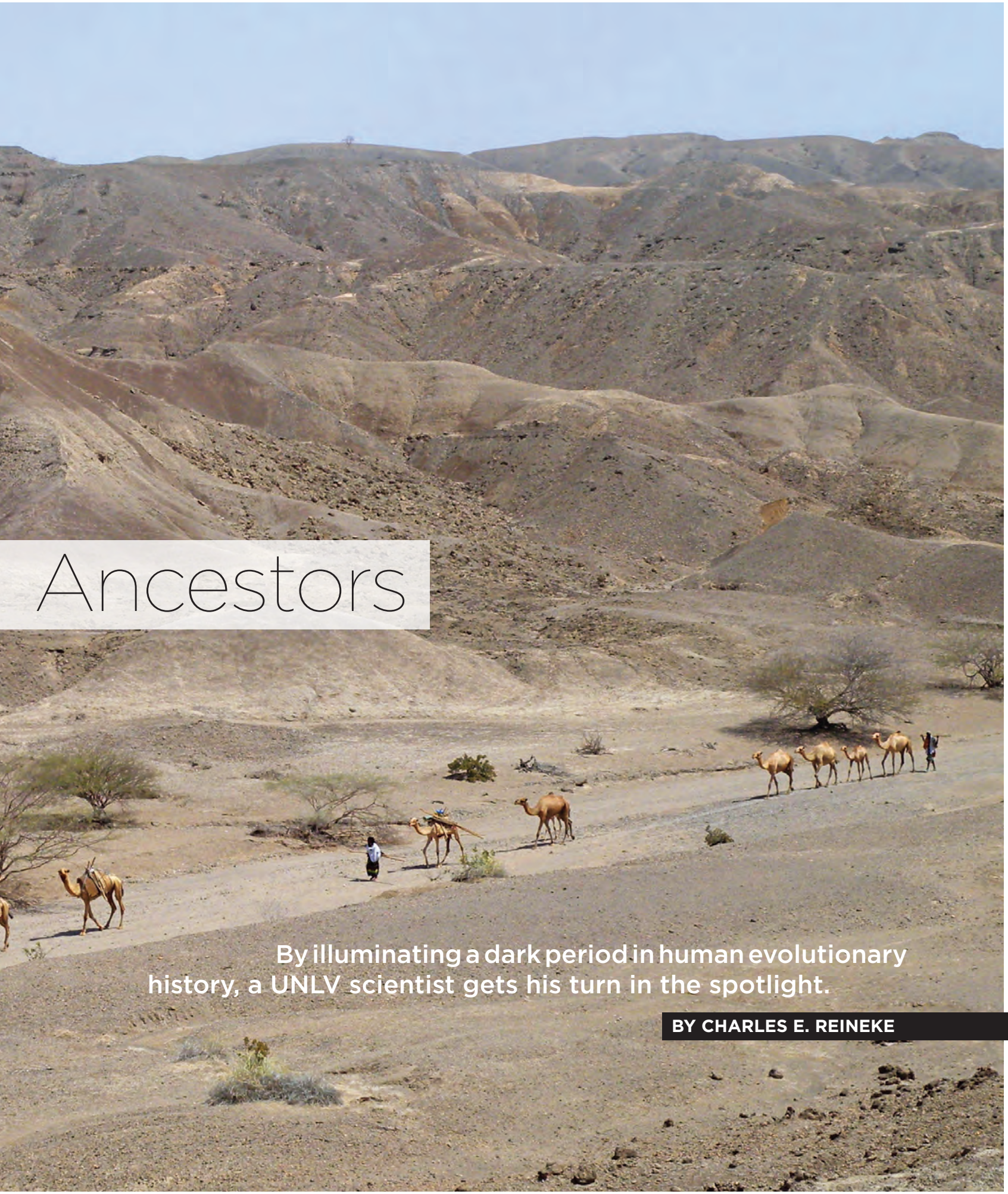
# A Quest for Our Earliest Ancestors

Charles E. Reineke

# A Quest for Our Earliest

**WHERE THE FOSSILS ARE** A camel caravan winds its way through the sun-blasted hills of Ethiopia's Ledi-Geraru region.



# Ancestors

**By illuminating a dark period in human evolutionary history, a UNLV scientist gets his turn in the spotlight.**

BY CHARLES E. REINEKE

Brian Villmoare had only recently returned to Las Vegas after another long stretch in the African desert. Then his cellphone started ringing. And ringing.

CNN, *The New York Times*, Fox News, Agence France-Presse, National Public Radio, *The Guardian*: Reporters and producers from across the globe all seemed to have Villmoare on speed dial, scrambling to get his take on the stunning anthropological find that had, just hours before, appeared under his name in the journal *Science*.

The discovery, a 2.8 million-year-old fossilized lower jawbone and teeth, represents the oldest vestige of the genus *Homo* ever uncovered. Its age suggests our earliest human ancestors — that "branch of the human family tree that leads to us," as Villmoare puts it — were living in eastern Africa almost half-a-million years earlier than scientists had previously supposed.

For Villmoare, a charismatic but low-key assistant professor at UNLV, the media onslaught was something of a whirlwind.

"Especially the first two weeks after the *Science* article was released, I was really overwhelmed," Villmoare says. "I had just gotten back from Ethiopia a couple of days before, so I was still on Ethiopian time. I was doing interviews at five in the morning, 1 a.m., noon. I never got any sleep; I was just in a haze the whole time."

Sleep deprivation and the occasional over-the-top antics of television news crews notwithstanding, Villmoare didn't begrudge reporters their interest. He had, after all, spent years working alongside Kaye Reed, William Kimbel, and other prominent researchers from Arizona State University's Institute of Human Origins (IHO) to unearth exactly this sort of fossil. When the breakthrough finally happened — on a late January morning two years ago in Ethiopia's sun-blasted Ledi-Geraru region — everyone on hand knew they had accomplished something special.

It took a while, but soon enough the whole world would know too. A headline in the online edition of the journal *Nature* was typical of the breathless international coverage: "Ethiopian jawbone may mark dawn of humankind," it read.

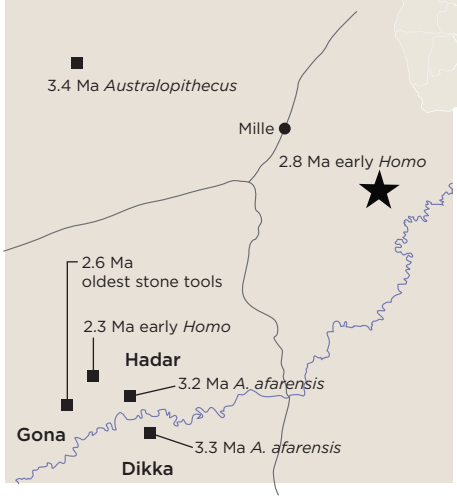
## SITE AND STRATA

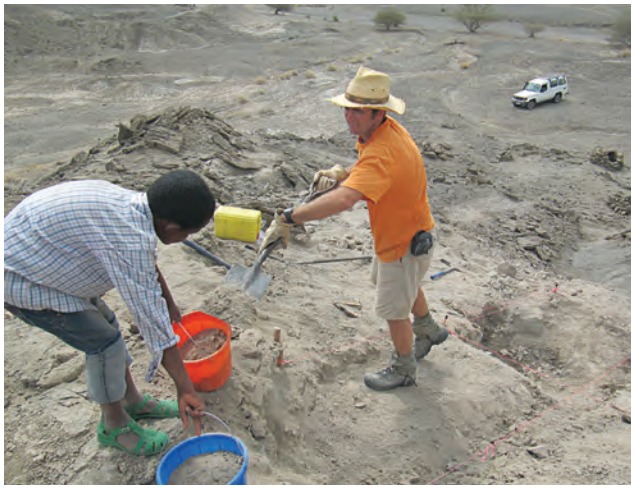
The desolate site of "humankind's dawn" hadn't been chosen by accident. Ledi-Geraru is located less than 20 miles northeast of Hadar, the fossil-hunting ground made famous by Donald Johanson's 1974 discovery of "Lucy," the famous 3.2 million-year-old skeleton of *Australopithecus afarensis*. The Hadar region has produced many other important finds, but all older than the 3-million-year horizon predating the appearance of our genus, *Homo*.

Ledi-Geraru, on the other hand, showed great potential for yielding up very old fossils of *Homo*. Adding to the site's luster were data provided from radiometric dating, a technology that allowed geologists to peg fossilized flora and fauna from the area at 2- to 3-million-years-old. This period is a critical time in human evolutionary history, one that had previously yielded precious few finds shedding light on *Homo's* origins.

Discovering early human fossils within this million-year gap had always been the team's chief objective. The availability of radiometric dating, Villmoare says, was crucial to making it happen. For millions of years, he explains, the Ledi-Geraru region has been rife with volcanic activity. During eruptions, lava and huge clouds of ash coat the landscape with crystals containing small amounts of naturally occurring radiation. As it cools, this igneous material hardens into layers of ash and rock, trapping its radioactive crystals inside. Because these decay at a predictable rate, geologists can use radiometrics to pinpoint when these layers, or stratigraphic

**Fertile Ground for Fossils**





**UNEARTHING EVOLUTION**
Clockwise from left: Villmoare cleaning fossils; Ali Muhammed helps to excavate a juvenile elephant skull; on "hominin hill," Villmoare and Humut Hussein excavate a test trench; an image by John Rowan captures Chelachew Seyoum holding the mandible moments after he found it; three images of team members at work on hominin hill; discovery of a fossilized hippo jaw indicates a once very different climate in the area.

sections, were formed.

Fossils are seldom found in the igneous strata formed by these volcanoes but are common in the sedimentary deposits that slowly built up between eruptions. It's thus a relatively straightforward exercise to date fossils found sandwiched in sediments between igneous layers; scientists simply "bracket" them from stratigraphic section to section. "The idea is that you have a geologist who can say, 'Ok, it looks like this time frame is between x and y,'" says Villmoare.

Finding the right strata, however, can be more of a challenge.

"The problem is that the [2- to 3-million-year-old] sediments don't preserve very frequently in eastern Africa. It took us a long time to find the right ones," he says. "This, incidentally, is why you have to do this sort of thing in a desert environment like Ledi-Geraru. There can't be a lot of foliage on the ground because you have to be able to see all the stratigraphy."

Ledi-Geraru is named for two rivers, often dry, that define the research area. It's good for dating fossils but difficult in other ways. It's hot. It's remote. Mounting a field camp for 50 to 60 researchers, students, drivers, kitchen staff, and others is a major logistical headache.

"Yes, it's quite a production getting the whole thing organized," Villmoare says. "In the early days we would just put all the gear on the top of a couple of Land Cruisers. But now we rely on a big, military-style six-wheel truck to come out and drop it off."

## BUILDING A CAREER

Villmoare, a self-described "late bloomer," says he took a circuitous route to anthropology. But it's a path that has left him with the breadth of skills necessary to deal with pretty much any situation that might arise in the desert.

He was raised in Baltimore, the son of lawyers. As a kid, oddly enough, he had only a passing interest in fossils, dinosaurs, and other things paleontological.

"I grew up wanting to be a novelist, actually," says Villmoare. "I didn't take a single hard science course as an undergrad [at the University of Virginia]. I had always had a problem with the math. I had a couple of bad math teachers, and I grew to dread it. It's kind

of ironic because much of my work is highly quantitative, and now I teach statistics to graduate students."

After graduating from UVA with bachelor degrees in English literature and philosophy, Villmoare, like a lot of liberal-arts majors, set aside his literary ambitions in favor of a more practical path to prosperity — in his case, work in the building trades.

"I really wanted to learn how to build a house from start to finish," Villmoare recalls. "So I found work in construction. Every six months I would switch trades: framing, sheetrock, trim, tile ... all these different skills."

Success followed, and he eventually headed up his own historic renovation firm in Phoenix, where he'd moved to be with his wife, Amy, who was there training to become a chef. Villmoare's firm prospered, earning contracts to work on some of Phoenix's most prized historical properties, among them the city's iconic Luhrs Building, its old Grace Court School, and many of the houses on Phoenix's famed Heritage Square.

But even as he built his business, Villmoare found himself yearning for something more than "just working." In part because he recalled enjoying family camping trips near Anasazi ruins, he signed up for a couple of anthropology courses at nearby Arizona State University. "It was just on a lark," Villmoare says. "But a couple of the professors liked my work enough to recommend me for admission to the anthropology program. I got in at the same time that the Institute of Human Origins arrived."

He had found his calling. "I'm not one of these people who was driven, someone who knew what he wanted and pursued it from day one. I almost just fell into it. IHO didn't have to appear at ASU at the same time that I did. But when it did, I could see that this was an amazing opportunity, and that paleontology was something I could see spending my life doing. Needless to say, I pursued it vigorously from that point."

Villmoare kept the construction firm going, using proceeds from the business to help sustain his family — he has two daughters, Margo, born in 2003, and Ava, born in 2004 — while he pursued a master's, then a doctoral degree. His academic work focused on the evolution of the human and primate skulls. After graduation, his first faculty position took him and his family to University College in London.

Villmoare says he and his wife loved London, and he was eventually offered tenure at University College. But making ends meet in England's capital was tough. Nearly all of his salary was going to pay rent on a modest home 45 minutes from the college, while his wife's income had to pay for everything else. "It was just too stressful financially," says Villmoare.

England's loss was America's gain. Villmoare returned to the U.S. in 2011, becoming a research professor at George Washington University's prestigious human paleontology program. He joined the UNLV faculty in 2014 and, with the university's blessing, soon found himself again collaborating with his former Institute of Human Origins colleagues, this time on one of the institute's most prominent projects: the hunt for 2- to 3-million-year-old remains at Ledi-Geraru.

## EVOLUTIONARY UNCERTAINTY

In their *Science* article, Villmoare and his co-authors begin by describing why finding a jawbone and teeth from the period was so exciting. The origin of *Homo* remains clouded, they wrote, an "uncertainty [that] stems in large part from a limited fossil record between 2 and 3 million years ago, especially in eastern Africa." Their specimen, they continue, "securely dated to 2.80 to 2.75 million years ago, combines derived morphology observed in later *Homo* with primitive traits seen in early *Australopithecus*. The discovery has implications for hypotheses concerning the timing and place of *Homo* origins."

Villmoare, by way of analogy, likes to describe what all this means in terms of an evolutionary "tunnel." Roughly three million years ago, he says, our early ancestors entered a million-year-long passageway. They emerged very different animals.

"At 3 million years we were essentially ape-like creatures," Villmoare says. "We lived in wooded environments eating fruits the way apes do. And even though we were walking on two legs, we were still long armed and still

**"It's quite a production getting the whole thing organized. In the early days we would just put all the gear on the top of a couple of Land Cruisers. But now we rely on a big, military-style six-wheel truck to come out and drop it off."**

**LATE NIGHT RESEARCH** Bare bulbs illuminate Institute for Human Origins researchers at their Ledi-Geraru command center.

adapted to living in trees, at least occasionally.

"At 2 million years, on the other side of the tunnel, we appear with larger brains, using stone tools, and starting to eat meat. We also have acquired more modern body proportions: longer legs and relatively shorter arms. It was a huge, huge adaptive transition."

Determining how and why this happened depends, in large part, on expanding the fossil record, that is, systematically searching through period-appropriate strata to find bits of fossilized plants and animals that might provide a fuller account of our ancestor's evolutionary environment. Enter the Ledi-Geraru jawbone.

Villmoare vividly recalls its discovery.

"We were all on this hill that produces a lot of fossils — a place where we found a lot of non-human stuff as well — circling around it," he says. "Chalachew Seyoum, an ASU graduate student who is from Ethiopia, was working his way toward the top, and he saw the thing poking out of the sand."

As soon as he realized the "thing" was a mandible, Seyoum excitedly summoned Kaye Reed, an expert in mammalian fossils who, with Villmoare, co-directs the Ledi-Geraru project. Reed took one look and whooped with joy. Villmoare arrived moments later. He and Reed quickly confirmed that the fossil belonged to a hominin, a member of that lineage of animals, including humans, that split from the common ancestor we shared with chimpanzees and bonobos some 6 million years ago.

After carefully unearthing Seyoum's find and methodically sifting through buckets of sand and mudstone collected from the surrounding slope, the researchers eventually emerged with approximately four inches of lower jaw and five well-preserved teeth. They packed the specimen — soon to be officially known as the LD 350-1 mandible — into a Land Cruiser and transported it to the National Museum of Ethiopia in Addis Ababa, that nation's capital. There, highly skilled museum staff helped reassemble the jaw and teeth. They also created detailed casts of the fossil to aid in further investigations.

**SINGULAR SPECIMEN** LD 350-1's distinctive features, among them the size and shape of its molars and premolar teeth and the relative narrowness of the rear part of the jaw, helped establish that the creature it came from was a representative of the evolutionary line leading to *Homo sapiens*.

At a laboratory in the museum, Villmoare teamed up with Kimbel, director of the Institute of Human Origins, to begin the painstaking analysis that would lead to the *Science* publication more than two years later.

"Bill and I met in Addis, and we spent eight or nine days just comparing the fossil to every specimen that they have at the museum," Villmoare says. They started with *Australopithecus afarensis,* the hominin species that lived in Ethiopia's Afar region between 3.8 and 2.95 million years ago.

"We compared it to every single one of those to make sure that it was truly different," Villmoare says. They then moved on to other specimens, working their "way outward from there," he adds, "toward other species of *Australopithecus* and early *Homo*."

This process of finding LD 350's evolutionary fit — an investigation conducted both at the Addis Ababa museum and with the fossil's cast at Arizona State — was anything but straightforward, recalls Kimbel. "You sit with a jaw and make these observations — lists, measurements, comparative annotations — to develop a sense of the jaw's affinities: what lineage it is most likely affiliated with, what species it differs from, *et cetera*. The hard part comes in trying to sort out the alternatives."

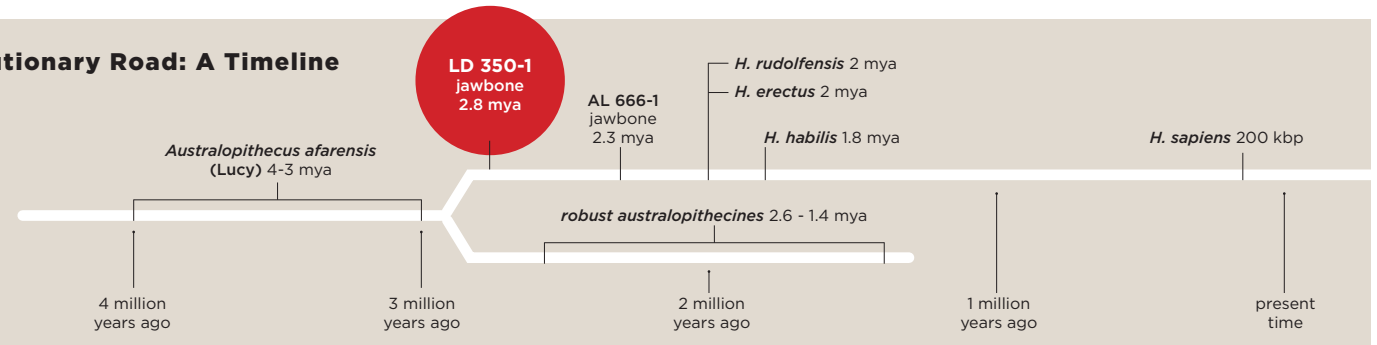
Kimbel and Villmoare knew right away that the jaw did not belong to Lucy's species, *A. afarensis*. This is because its bone structure and teeth were more "derived" than Lucy's; in other words, they had evolved to reflect the specialized needs of a hominin from a later period. But because all hominins following *A. afarensis* show at least some of these changes, the determination did little to settle whether LD 350 was, in fact, part of the early *Homo* lineage.

"The degree of difference between the LD 350 jaw and other species in Southern and Eastern Africa that are younger than 3 million years old is less obvious than the differences between LD 350 and its putative ancestor, Lucy. So, as you refine your hypotheses as to where it might fit on the evolutionary tree, the distinctions, potentially, become subtler. And when you have half a jaw with five teeth, well, you know" — here Kimbel pauses and laughs — "it gets a little touch-and-go sometimes."

"I, for one, was a little more skeptical at the outset as to where this thing was going to fit on the tree" he says. "I knew instantly that it was *not* going to fit with *afarensis*. That was easy. The question was, 'If not there, then where?'

"Brian and I haggled back and forth; we looked and thought. Ultimately, I asked myself ... 'What would we expect the jaw of one of the earliest representatives of our lineage to look

## An Evolutionary Road: A Timeline



like if it were, in fact, on the line leading to later *Homo*?' When I turned the question that way — thinking about its teeth, bone structure, *et cetera* — it began to bubble up to me that the representative jaw I was imagining was there on the table in front of us.

"That's hypothesis testing, and that's what we do. Paleoanthropologists sometimes project — though not consciously — that identifying these fossils is the outcome of some mystical process: We find them in the ground, we pull them out, and then, 'Voilà!' — like they have labels attached to them. In fact, just as in any other science, what we do involves a long, scholarly process of testing, questioning, forming hypothesis statements, and so on. And, frankly, this is the most interesting part."

In this case, of course, the consensus opinion pointed to LD 350-1 as the oldest *Homo* specimen ever unearthed. Villmoare adds the essential evolutionary context.

"In your mind picture a capital 'Y,' he says. "The stem of the 'Y' is *Australopithecus*. Then you have this split: the right branch goes to what is called the robust group, or *Paranthropus*, and the left branch goes toward us."

The LD 350-1 mandible, he continues, has some features that it shares with the *Australopithecine* stem — it is primitive in some respects, especially in the front, around the chin. "But it also has a lot of other features that you don't see until you are fairly far up the *Homo* branch of the 'Y.' In other words, they are not features that could be misidentified or misaligned with another group."

Among these are the size and shape of those molars and premolar teeth, along with the relative narrowness of the rear part of the jaw. These and other defining characteristics of the Ledi-Geraru mandible, he says, are still with us humans today.

"The fact that those features are present at 2.8 million years means that it's at that point on the 'Y' that's right above the split, on the base of the line leading to modern humans."

## MORE TO EXPLORE

All fossil finds, no matter how consequential, tend to raise as many questions as they answer. LD 350-1 is no exception. How did regional climate change affect this hominin's living conditions? What about physical and behavioral development? How did it move? Was the creature capable of using tools? And, perhaps most critically, did the jaw's owner have a brain size approaching that of modern humans?

R. MARSH STARKS

**MAN AND MANDIBLE** Brian Villmoare poses with LD 350-1, the fossilized jaw that pushed back the timeline on human origins.

Answers will depend on more research and further discoveries.

"Did we want to find more? Yeah, most definitely," Villmoare says. "A lot of the hypotheses that relate to early *Homo* center around brain expansion. And so one of the big questions is whether our specimen had a bigger brain than *Australopithecus*. The only way to know if it has a larger brain is, obviously, to find a piece of brain case. So next year we're going to go back over that hill."

The Ledi-Geraru Project is supported by funding from the National Science Foundation and the Institute of Human Origins. Villmoare says he's also impressed by UNLV's support, which goes beyond just providing a nice laboratory in Las Vegas.

"I'm a research guy, and so the fact that the university takes research seriously really does matter to me. The fact that UNLV has stepped up its game and is intent on supporting research going forward makes this place a great fit for me."