



PHOTOGRAPH BY MIKE GOLBY



FINDING AN OLD

FLAME

BY BEEBE BAHRAMI

Michael Chazan C'85 has been blazing a trail back in time from Biblical to Lower Paleolithic archaeology.

THE funny thing is, Michael Chazan C'85 wasn't even looking for fire that April day in 2011. Yet there it was: ancient, ashy sediment coming into focus through the lens of an Israeli microscope, a thin slice taken from an immensely deep cave in South Africa, some four thousand miles and a million years away. What the archaeologist and his international team of collaborators found throws some new light onto the stumbling journey of hominids through the ages. And it wasn't the only discovery they made.

TO get to Wonderwerk Cave, just south of the Kalahari Desert in South Africa's barren Northern Cape Province, you have to pass through the Kuruman Hills, northwest of the provincial capital of Kimberley. The hills are "low and rolling, but particularly in the late afternoon reflect the light beautifully," says Chazan, the 50-year-old professor of anthropology at the University of Toronto, director of its Archaeology Centre, and co-director of the Wonderwerk project. Chazan comes to South Africa at least twice a year and works with project co-director Liora Kolska Horwitz (curator of the Life Science Collection at Hebrew University), Francesco Berna (assistant professor of archaeology at Simon Fraser University in Vancouver), and Paul Goldberg (professor of geoarchaeology and archaeology at Boston University). He divides his time between two sites: Wonderwerk, a Lower to Upper Paleolithic cave on the eastern flank of the Kuruman Hills, and Kathu Pan, an open-air Lower Paleolithic site some 25 miles away.

Wonderwerk is a national heritage site, and for good reason. In the world of caves, it qualifies as a mansion: spacious (up to 79 feet wide), high-ceilinged (up to 17 feet), and more than 450 feet deep. A metal fence stretches across its wide maw, which looks like a grouper's mouth agape. About 130 feet into the dolomite cavity, a great, tonsil-like stalagmite rises up from the floor. Compared to the rest of the cave, that stalagmite is young, having only begun forming some 35,000 years ago.

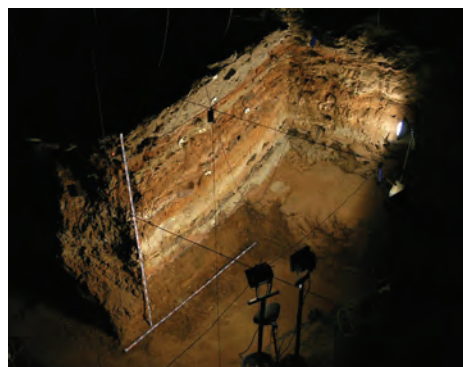
"In terms of early human occupation, Wonderwerk is an important archive," explains Zenobia Jacobs, a geological and archaeological dating specialist at the School of Earth & Environmental Sciences at the University of Wollongong in Australia. "You know," adds Jacobs, a native of South Africa, "*wonderwerk* is the Afrikaans word for miracle."

In the 1940s, dung diggers began pilfering the thick layers of bat guano that cover the Wonderwerk floor to sell as fertilizer in town. But as they poached dung, they disturbed something far older: ancient stone tools and old animal bones. Initial excavations at the time confirmed that the cave was a time capsule of early hominid occupations. From the 1970s to the 1990s, Peter Beaumont, an archaeologist at the McGregor Museum in nearby Kimberley, excavated both Wonderwerk

and Kathu Pan. Then, about a decade ago, Chazan's team revisited and reviewed Beaumont's work and collections, and began excavating the two sites.

The combined excavations have revealed signs of hominid occupation throughout the entire cave—including in the cave's deepest and darkest recesses, at Excavation 6. (The numbers honor the work of Beaumont, who carried out six excavations along the length of the cave.) Chazan and his team have focused on Excavation 1, about 100 feet in from the mouth of the cave, as well as Excavation 6.

For some 2 million years, various hominids have been coming to this protective lair. The most frequent inhabitants would have been *Homo erectus*, who lived roughly from 2 million to 140,000 years ago and are associated with a stone tool-making style called the Acheulean, which is the most common tool type found here.



Excavation 1, where evidence of the "first fire" was found; Michael Chazan in the field; gated entrance to Wonderwerk Cave.

There may have also been earlier bipedal relatives, such as *Australopithecus* (circa 4.5-1.5 million years ago) and *Homo habilis* (circa 2.5-1.5 million years ago), who are associated with the earliest human stone tool-making tradition, the Oldowan. (It appears that Neandertals and *Homo sapiens* branched off from *Homo erectus* somewhere around 500,000 years ago and then went their own ways, with perhaps a bit of comingling along the way.) Much, much later, starting around 10,500 years ago, early modern humans also occupied Wonderwerk. They left engraved stones and cave paintings.

Unlike the Neandertals, who had the "same brain size as modern humans and did the same things as modern humans for 100,000 years," notes Chazan, *Homo erectus* "had a smaller brain than any

population of living humans. It had very different adaptations. My general question is whether our mistake has been to say that *Homo erectus* is 'less' of something than modern humans. We inevitably have fallen into this kind of stages-on-a-ladder [thinking] as opposed to saying that *Homo erectus* may have just been very different, that there may be aspects to his adaptation and cognition that we just don't have any imagination to think of at this point."

IF YOU HAD TO SPEND A LOT OF TIME INSIDE WONDERWERK, you'd probably want to spend it at the spot identified as Excavation 1. Far enough inside for protection, it also offers light, warmth, and good air. That may explain why it contains the world's oldest and most continuous undisturbed sequence of occupation in any one place. Its oldest stratum, Stratum 12, appears to contain Oldowan material

and is estimated to be around 2 million years old. At present, the team is focused on Stratum 10, a layer dating to around 1 million years ago and holding a rich collection of undisturbed Acheulean tools.

Chazan is an expert in stone tools, or lithics, and his excavations have benefitted from approaches and techniques developed since the late 1980s. One is the greater practice of collaborative work with diverse specialists. Chazan teams with fire, fauna, flora, and micromorphology (microscopic soil) experts, among others. He also applies the best excavation and mapping methods in the field, which include the innovative software and site-mapping techniques of two Penn-connected men. One is Harold Dibble, a Paleolithic archaeologist whose titles include Penn professor of anthropology, curator-in-charge of the European archaeol-

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ogy section, and deputy director for curatorial affairs at the Penn Museum. The other is Shannon McPherron Gr'94, a Paleolithic archaeologist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany ["On Hearths, Ancient and Modern," Nov|Dec 2010].

"Every artifact you recover gets mapped in three-dimensions—so that you can look at the spatial organization of the sites," explains Chazan. "The two of them were real pioneers in that. We'll be using the methods that they developed to create very, very fine-grained maps" of the sites.

"The nice thing about the geoarchaeology stuff is you try to apply geological principles, which are fairly well known, to archaeological settings, which are totally unknown, from the sedimentological standpoint," Goldberg explains. "Geological principles are sort of standard. But when you start combining them with archaeology, then it



gets kind of dicey. At each site, you've got to go back to square one. You hope to get enough experience so that you can see some patterns. [But] you can't predict it. There are no two sites that look the same."

After taking sediment samples from Stratum 10, the team carefully packaged them and sent them off to be processed. It wasn't until months later that Chazan and his colleagues had a chance to get together and look at them.

A LITTLE-KNOWN TRUTH about archaeological research is that most great discoveries, especially on Paleolithic sites, occur in the lab, not in the field.

In April 2011, Chazan and his team gathered at the Weizmann Institute in Rehovot, Israel, just south of Tel Aviv, to analyze the Wonderwerk data. One was the sediment from Stratum 10, which had been impregnated with resin to render it permanent and easily viewable, then sliced into very thin

sections and studied under a microscope. They also used Fourier transform infrared microspectroscopy (mFTIR) to make sense of the forces that may have worked on the bone, stone, and soil in question.

"I was trying to get them [Berna and Goldberg] to systematically describe everything—like, 'Okay, let's get going,'" recalls Chazan.

Berna and Goldberg had other ideas.

"They were looking at the stuff and going, 'Wait a minute, this is really big, this is really important,'" Chazan adds. "Paul said, 'Wow, that looks like wood ash.'"

Though Chazan was impatient to finish the analysis, Goldberg and Berna took the slide down the hall to an expert in wood ash who had the "right kind of microscope," Chazan recalls. "She looked at it and said, 'Yes, that's what it is.'"

"We pulled up this thin section," recalls Goldberg, "and we looked at it and said, 'Holy shit, this is ashes.' It's not like we were looking for it. We weren't having a quest looking for the first [fire]. We were just trying to write a paper on the site formation, how the thing filled up, what happened to it. And then we came across this and we said, 'Wow, this is fire in here.' I didn't cry over the microscope, but we were pretty happy."

When Berna, Chazan, Goldberg, and Horwitz published their findings in the *Proceedings of the National Academy of Sciences* in April 2012, word spread like, well, wildfire, first through the profession, then through the non-archaeological press—from *Nature* to *The Atlantic*, from *The Guardian* to *Huffington Post*, from *The Daily Mail* to *ABC News*.

"The analysis pushes the timing for the human use of fire back by 300,000 years," Chazan said in a widely quoted release, "suggesting that human ancestors as early as *Homo erectus* may have begun using fire as part of their way of life."

The control of fire "would have been a major turning point in human evolution," he added. "The impact of cooking food is well documented, but the impact of control over fire would have touched all elements of human society." Furthermore, "socializing around a campfire might actually be an essential aspect of what makes us human."

After publishing their findings, the team kept reviewing the data. Goldberg talked extensively to other geoarchaeologists,

knowing well that new perspectives are always rolling in. He learned, for example, that while it was the presence of oxalates that had confirmed the presence of burnt wood ash, oxalates can also show up in the form of unburned calcinated plant roots. He and Berna have been reanalyzing the plant ash in light of this new perspective.

"[That] is a perfect example of why I like working with Paul," says Chazan, "and how I generally approach the process of archaeological research. Our argument for the presence of fire rested on several lines of evidence. Paul's question is pushing us towards renewed questions about the landscape outside the cave.

"I am very confident that the overall picture is robust," he adds. "But the key is that this claim is the starting point."

Chazan's team went the extra mile to eliminate any natural reasons for the presence of fire in that location—scrutinizing and analyzing the samples from multiple angles, even checking for evidence of self-combusting bat guano. Not only did they establish that the layer was stable and undisturbed from the time of its creation, but they had several lines of evidence indicating an intentional fire hearth, with a far higher concentration of burnt bone and stone than neighboring areas. It also showed burning at campfire temperatures—between 400 and 700 degrees Fahrenheit—not the higher temperatures associated with wildfires.

"Our evidence, although far from being conclusive, is probably the most compelling link between *Homo erectus* and the use of fire in some capacity," says Berna, adding that they are continuing their investigations at Wonderwerk to "better understand the nature of the fire and the human activities in the cave."

BEFORE THE DISCOVERY at Wonderwerk, all other evidence for early hominid fire use had come from open-air sites, making wildfires—sparked by nature, not humans—a hard possibility to eliminate. (One very early site, Gesher Benot Ya'akov, in northern Israel near the Dead Sea, has fire evidence that dates to around 800,000 years ago. But it is an open-air site.) The firmest evidence for hominid fire use comes much later—from Beeches Pit, England, and Schönningen, Germany—from around 400,000 years ago, and in the hands of Neandertals.

In his 2009 book *Catching Fire: How Cooking Made Us Human*, Harvard primatologist Richard Wrangham put forth a “Cooking Hypothesis,” a detailed case for how hominid use of fire may have altered the course of our evolution on many levels. Wrangham speculated that hominid fire use goes back further than our present archaeological evidence for it, and that it would have already been in the hands of *Homo erectus*. Using the evolving hominid brain as his trail of evidence, he argued that our relationship with fire may have helped select for the evolution of larger and larger brains—a trend that appears in the archaeological period beginning with *Homo erectus* around 1.8 million years ago. Big brains require a lot of calories to fuel, and cooking raw foods rendered them more efficiently digestible—not to mention more pleasant to eat, which meant that more of it could easily be consumed in a sitting. The invention of cooking would thus have relieved some of the energy requirements of our digestive tracts, enabling a higher proportion of calories to be sent to the brain. Plus, fire also offered our ancestors warmth, protection from predators, and may have even stimulated greater sociability among hominids. While more evidence is needed to promote the acceptance of this hypothesis, the discovery at Wonderwerk certainly thickens the mix.

Last February Chazan published the third edition of his *World Prehistory and Archaeology: Pathways Through Time*, whose first edition came out seven years ago. The textbook’s Amazon page describes it as “an integrated picture of prehistory as an active process of discovery,” and unlike other introductory texts, most of which organize material geographically, his focuses on discoveries and theories about each period of prehistory, from the Paleolithic through to the Neolithic, Bronze, and Iron Ages.

The goal was to show that “what’s exciting about archaeology is that the methods relate to our knowledge of the past,” he says. “It’s not just, ‘Here are a bunch of facts about the past,’ or ‘Here are a bunch of methods,’ which is the way other books are written. To me, the whole point is that there actually is no fixed past and that you’re continuously discovering new things using [new] methods—and so the two go together.”

Chazan, who is as passionate about education as he is about his research, was hooked on archaeology even before he arrived at Penn as a freshman in 1981, thanks to courses and fieldwork he had taken the prior year at Tel Aviv University. (Though he grew up in Columbus, Ohio, he had spent about four years of his childhood in Israel.) Then, during his first year at Penn, he met James A. Sauer, an archaeologist who invited him to take his graduate course in biblical archaeology.

“One thing that was really incredible that Sauer did at Penn was a program where you brought students from all over the Middle East—Yemen, Egypt, Jordan, Palestine, Israel—so it was really before any of the peace agreements,” says Chazan. “It was this new Middle East. It was before its time in seeing archaeology creating connections between people. It was very influential.”

(So, on a personal level, was a small poetry seminar at Penn, where he met his future wife, Michelle Fost C’85, who now teaches at the University of Toronto’s Victoria College Writing Centre.)

As he pursued his doctoral studies at Yale in Paleolithic archaeology, Chazan worked on an ancient Egyptian site at the Giza Plateau, then hooked up with a project in southern France at the Middle Paleolithic site of Les Canalettes. Next was Kebara, a Middle Paleolithic cave south of Haifa, where archaeologists had recently uncovered the most complete Neandertal skeleton found to date. These two projects officially kicked Chazan backwards in time, past Roman, Egyptian, and biblical into the Paleolithic. Indeed, he left the modern human species entirely behind, working on Neandertal-era occupations.

After earning his PhD at Yale, Chazan began a long-term project at Holon in Israel, where he collaborated on a monograph with Horwitz. That site is roughly 200,000 years old, with evidence of Acheulean stone-tool industries, and represents a transitional period of tool-making within this tradition, whose reign stretches from around 1.8 million to 150,000 years ago. By then Chazan was on his way to studying yet another human species, *Homo erectus*.

After the project at Holon wrapped up around 10 years ago, Chazan was looking for something new. Horwitz, a native of

South Africa, had been struck by the pre-history buzz on the ground when she visited family there. She told Chazan that he might want to check out the Northern Cape.

It turned out to be terrific advice, says Chazan. “We met Peter Beaumont, who took us around and showed us this whole series of sites that he had excavated.” They decided to reopen excavations at two, Kathu Pan and Wonderwerk.

EXCAVATION 6 is the quietest and deepest part of Wonderwerk Cave, Chazan and Horwitz say, a place where natural light does not penetrate. The senses shift away from vision—unless, of course, the visitor has fire. Here is where the team found remains that may illuminate our understanding of early symbolic behavior among hominids. At the strata dating to around 180,000 years ago, Chazan and his colleagues found an odd array of objects that could only have been carried in from the outside: quartz crystals, round chalcedony pebbles, and ironstone slabs with surface lines on them, some possibly etched by human hands.

This part of the cave produces a pleasing aural resonance that exists nowhere else in Wonderwerk. One possible ancient sound there would have been the drip from an ancient water source identified by Goldberg. From that, Chazan and Horwitz posit that there may have been unique aural sensations in that spot, not to mention the enigma of the non-native, non-utilitarian—but aesthetically pleasing—stones. They offer an elegant hypothesis: that maybe symbolic behavior began through a wedding of sensory and material experience—that a dawning appreciation of light, sound, and tactile beauty contributed to our cognitive development, just as fire and cooking may have helped select for a pathway toward bigger brains with complex things going on inside.

TWENTY-FIVE miles away from Wonderwerk lies the open-air site of Kathu Pan 1. While the two sites could hardly be more different, they overlap in *Homo erectus* occupations where similar tool traditions show up in both places at the same time periods. As such, they offer an invaluable comparative perspective.

The Pan “is like a dried lake bed, and there’s a series of sites within that. Pan 1 is one of them,” says Chazan, “It’s the one that so far has the oldest material.”

The site is rife with stone tools—hundreds, even thousands of them, the oldest dating to around half a million years ago, and possibly older than that.

Chazan and one of his Toronto doctoral students, Jayne Wilkins, have published a report on what looks to be the earliest evidence for hafted spear production and use among hominids. *Homo erectus* is the probable maker, and the spears come out of the 500,000-year-old layer.

It was Wilkins who noticed that there were a lot of regular triangular pieces in the collection that might have served as spears, or spear tips. She took these and carried out intensive analysis of the triangular points, in collaboration with others at the University of Arizona who were using microscopy to discern edge patterns and fractures. Wilkins also made 32 spears and repeatedly lanced them at a dead deer carcass, then put them to the same microscopic examination as the 500,000-year-old spears from Kathu Pan. The patterns matched up.

Kathu Pan is a landscape full of sinkholes. Underground springs pushed up water, creating vents that are lined with rich layers of vertically exposed artifacts. Because of this, Chazan's team is beginning the excavations at the lower, older layers. There they are finding a good quantity of hand axes and elephant teeth. As they excavate and map the site, they will begin to try to make sense of why there are so many tools and so many signs of *Homo erectus* here.

"There's a huge mystery around Kathu, which is we're finding sites everywhere," says Chazan. "There were a lot of people around this area half a million years ago and we don't know why. Ultimately, I think we're going to find that the environment was very, very different [from today]. What we know was that there were hippos in the area, and it's a dry, semi-arid, desert environment today." Half a million years ago, the attraction for *Homo erectus*, as well as hippos and elephants, would most likely have been water, and the green, fertile landscape it engendered.

Chazan has now firmly lodged himself in an area of Paleolithic archaeology that Shannon McPherron explains is often called the "muddle in the middle."

"For some time now," McPherron says, "two of the more intensely researched areas have been the origins of stone tool technology (the Oldowan) and the origins

of modern humans [and their] replacement of Neandertals. Between these two is a huge expanse of time that is covered by very few sites and relatively little research.

"One reason for this is that origins and replacements are more attractive topics than what happens in between," he adds. "There are also some basic logistical problems. It is hard to find old sites. Another logistical problem is dating.

"In this light, the work of Chazan is important," McPherron concludes. "He has been plugging away at that great middle trying to find new sites and re-evaluating the potential of known sites. In doing so, he is finding new things—for instance, the fire at Wonderwerk—that help fill this huge gap in our knowledge."

Despite its wealth of extraordinarily ancient materials, time is running out for Kathu Pan 1. The region in which it is located is loaded with valuable minerals, and the



Stone tools from Kathu Pan.

local mining industry is advancing. But to Chazan, archaeology can serve as an important bridge between today's *Homo sapiens*.

"We don't have a huge financial footprint," Chazan explains. "This is a mining region, so the mines have the [big impact]. We're not big players. But [by being here] the economy of information changes; the way that the place is represented changes. It's not like you can change the situation, but you can at least be aware of it and try to create spaces."

To accomplish that, Chazan works with locals to create an educational outreach program with science teachers and their students.

"It's more to listen to them about what *heritage* means to them and what the past means to them," he explains. "A lot of them will be very religious, so when I say,

'2 million years old,' that doesn't mean much. But we try to see how we can create a bridge between my view of heritage and what they think they connect to and what their kids would connect to."

One question that occupies Chazan concerns "the size and the nature of the groups that were living on this landscape." At Kathu Pan, there is a "phenomenal amount of stone tools across a large area," he notes. "The skeptic's approach is to say, 'Well, there's a long period of time, and if you were to average it out per year, they were just small groups of people who were producing all of that material. It just built up over time.' The problem with that is you don't find it everywhere, so either this is a unique area and there have been continuous occupations, [or] there's the possibility that you might have had very, very large groups of humans."

Chazan is now fully warmed to the subject: "We see baboons all the time. They're big creatures and they move around in all kinds of group sizes. You can have small groups of baboons—you know, five or 10. But we can get groups around the cave that are in the hundreds. That's not uncommon. I wonder if the area where we're working in, some times of the year, if there were hundreds of thousands of *Homo erectus* running around. Not in any kind of organized society, the way that large groups of modern humans live in organized societies, but with some other form of social organization that would look more like baboons. We tend to think of *Homo erectus* and early [modern] humans in terms of what modern hunters and gatherers do—which is, they live in small groups, they're highly mobile. Could it be that it was different for *Homo erectus*?"

Chazan pauses for a moment, then adds: "What we're looking at is very large groups around Kathu, probably because there was water in the area. And what we're seeing at Wonderwerk is an area [where smaller groups of] people would go for special activities. These two sites turn out to be very different, even though they are on two flanks of a hill. At some point, we'll be able to look [at the two sites] and we'll be able to link them. It's really exciting." ♦

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