The crawl. Researchers hunt down every fossil at Aramis.

PALEOANTHROPOLOGY

The View From Afar

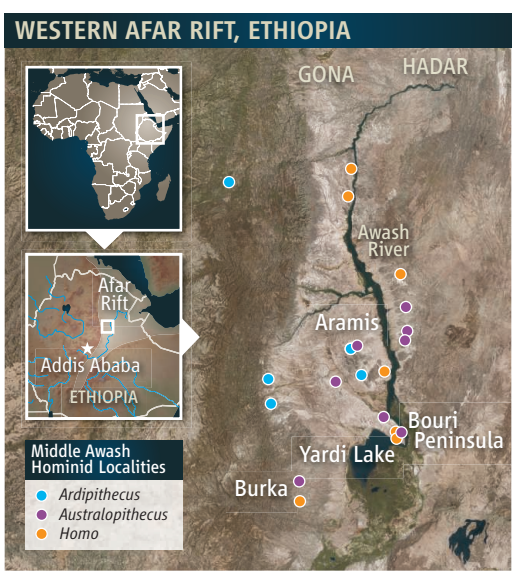
How do you find priceless hominin fossils in a hostile desert? Build a strong team and obsess over the details

MIDDLE AWASH VALLEY, THE AFAR DEPRESSION, ETHIOPIA—It's about 10 a.m. on a hot morning in December, and Tim White is watching a 30-year-old farmer inch his way up a slippery hill on his knees, picking through mouse-colored rubble for a bit of gray bone. The sun is already bleaching the scrubby badlands, making it difficult to distinguish a fragment of bone in the washed-out beige and gray terrain. The only shade in this parched gully is from a small, thorny acacia tree, so the fossil hunters have draped their heads with kerchiefs that hang out from under their "Cal" and "Obama for President" baseball caps, making them look like a strange tribe of Berkeley Bedouins. If there are fossils here, White is confident that the slender farmer, Kampiro Kayrento, will find them. "Kampiro is the best person in the world for finding little pieces of fossilized human bone," says White, 59, a paleoanthropologist at the University of California, Berkeley, who has collected fossils in this region since 1981.

Watching Kayrento is a sort of spectator sport, because he scores so often. Just minutes earlier, he had walked over the crest of a small hill, singing softly to himself, and had spotted the fossilized core of a horn from an ancient bovid, or antelope. Then he picked up a flat piece of gray bone nearby and showed the fossil to Ethiopian paleoanthropologist Berhane Asfaw, asking, "Bovid?" Asfaw, 55, who hired Kayrento when he was a boy hanging out at fossil sites in southern Ethiopia, looked over the slightly curved piece of bone the size of a silver dollar and suggested, "Monkey?" as he handed it to White. White turned it over gently in his hands, then said: "Check that, Berhane. We just found a hominid cranium. Niiiice."

As word spreads that Kayrento found a hominin, or a member of the taxon that includes humans and our ancestors, the other fossil hunters tease him: "*Homo* bovid! *Homo* bovid! Niiiice."

The Middle Awash project, which includes 70 scientists from 18 nations, is best known for its discovery of the 4.4-million-year-old partial skeleton of *Ardipithecus ramidus* at Aramis, about 34 kilometers north of here. That skeleton is now dramatically revising ideas of how upright walking evolved and how our earliest ancestors differed from chimpanzees (see overview, p. 60, and main Focus text, p. 36). But Aramis is just one of 300 localities in the Middle Awash, which is the only place in the world to yield fossils that span the entire saga of hominid evolution. At last count, this team had gathered 19,000 vertebrate fossils over the past 19 years. These include about 300 specimens from seven species of hominins, from some of the first members of the human family, such as 5.8-million-year-old *Ar. ramidus kadabba*, to the earliest members of our own species, *Homo sapiens*, which lived here about 160,000 years ago.



Ancestral territory. The area where Ardi was found is rich in hominin fossil sites, including these worked by the Middle Awash research team.

As they work in different places in the valley, the team members travel back and forth in time. Today, this core group is working in the western foothills near the Burka catchment, where an ancient river laid down sediments 3 million to 2 million years ago and where the team has found specimens of *Australopithecus garhi*, a species they suspect may have given rise to the first members of our genus, *Homo*.

This season, after a rough start, the 25 scientists, students, cooks, and Ethiopian and Afar officials and guards in camp are working well together. Their tented camp is hours from any town, graded road, or fresh water. (They dug their own well to get water.) "The 1st week, it's like an engine that's running but not running smoothly," says White, who, with Asfaw, runs a well-organized camp where every tool, map, and shower bag has its proper place. "By the 3rd week, people know their jobs."

The 1st week, White and a paleontologist were sick, and White is still fighting a harsh cough that keeps him awake at night. The 2nd week, some aggressive Alisera tribesmen who live near the *Ar. ramidus* site threatened to kill White and Asfaw, making it difficult to return there. (That's one reason the team travels with six Afar policemen armed with AK-47s and Obama caps, dubbed "The Obama Police.") The day before, a student had awakened with a high fever and abdominal pain and had to be driven 4 hours to the nearest clinic, where he was diagnosed with a urinary tract infection, probably from drinking too little water in

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Division of labor. Kampiro Kayrento (*top left*) homes in on fossils; he and others sweep the surface, and Giday WoldeGabriel dates sediments.

the 35°C heat. "The best laid plans change every day," says White, who has dealt with poisonous snakes, scorpions, malarial mosquitoes, lions, hyenas, flash floods, dust tornadoes, warring tribesmen, and contaminated food and water over the years. "Nothing in the field comes easy."

Calling the "A" team

Nothing in the Afar, for that matter, comes easy. We are reminded of that as we drive across the dusty Saragata plain to the target fossil site at 8 a.m., making giant circles in the dust with the Toyota Land Cruiser so we can find our tracks home at the end of the day. Men clad in plaid wraps, with AK-47s slung over their shoulders, flag us down seeking help. They bring over a woman who looks to be in her 70s but is probably much younger. Her finger is bleeding, and the men tell White and Asfaw, in Afar, that a puff adder bit her the night before while she was gathering wood. A quick-thinking boy had sliced her finger with a knife, releasing the venom and probably saving her life. White gets out a first-aid kit, removes a crude poultice, and cleans and bandages the wound, putting on an antibiotic cream. "It's good she survived the night," he says as we drive off. "The danger now is infection."

After inching down the sandy bank of a dry river, we reach the so-called Chairman's site. This is one of dozens of fossil localities discovered in the Burka area since 2005: exposed hillsides that were spotted in satellite and aerial photos, then laboriously explored on foot. The plan was to search for animal fossils to help date a hominid jawbone discovered last year. But in the 1st hour, with Kayrento's discovery, they're already on the trail of another individual instead.

As soon as White identifies the bit of skull bone, he swings into action. With his wiry frame and deep voice, he is a commanding presence, and it soon becomes clear how he earned his nickname, "The General." In his field uniform—a suede Australian army hat with a rattlesnake band, blue jeans, and driving gloves without fingers—he uses a fossil pick to delineate the zones in the sandstone

where he wants the crew deployed. "Get everybody out of the area," he calls to the 15 people already fanned out over the gully, scanning for fossils. "I want the 'A' team." He singles out Kayrento and three others and hands them yellow pin-flags, saying, "Go back to the bottom." As he watches them move up the slope, he warns: "Go slowly. You're moving too fast. … Don't squash the slope. Move like a cat, not a cow."

By looking at the relatively fresh fractured edge of the bone fragment, White knows that it comes from a larger piece of skull that broke after it was exposed, not while it was buried. As Kayrento and the others find other bits of bone, they place yellow pin-flags at those spots. "This process establishes the distributional cone," White explains. The top flag marks the highest point on the surface where the skull came out of the ground; the bottom boundary marks the farthest point where a fragment might finally have come to rest, following the fall line down the slope.

This discovery also illustrates one reason why the team comes to the field right after the rainy season. If they're lucky, rain and floods will cut into the ancient sediments, exposing fossils. But they have to get there before the fossils disintegrate as they are exposed to the elements or are trampled by the Afar's goats, sheep, and cattle. Timing is everything, and this season they're a bit late. "The ideal situation is to find a fossil just as it is eroding out of the bank," says White.

As they crawl the entire length of the gully, they turn over every rock, mud clod, and piece of carbonate rubble to make sure it doesn't contain a fossil fragment. "Not good," says Kayrento. "This is yucky," agrees Asfaw, co-director of the team and the first Ethiopian scientist to join it, in 1979 when he was invited to earn his Ph.D. at Berkeley (*Science*, 29 August 2003, p. 1178).

After 2 hours, the team has collected a few more pieces of skull around the temple, forehead, and ear. "It's getting bigger by the minute," White says. "If we're lucky, we'll find it buried right in here."

The team has to wait until the next day to find out just how lucky. At 9:45 a.m. Thursday, they return with reinforcements: Asfaw has hired two Afar men to help with the heavy lifting of buckets of dirt. With a button-down Oxford cloth shirt and a pistol stuck in the waistband of his khakis, Asfaw commands respect, and he is the best at negotiating with the Afar. In this case, he settles an argument by letting clan leaders select which men, among a large group, will get jobs.

At the site, White sets up a perimeter of blue pin-flags that look like a mini slalom course, outlining the gully that he calls the "Hot Zone" where fossil pieces are most likely to be buried. The plan is to excavate all the rock and dirt around those flags, down to the original layers of sediment. White explains that the ancient landscape would have been flatter and more verdant before tectonic movements of Earth's crust cracked and tilted the sediment layers. But the original soil is still there, a red-brown layer of clay beneath a gray veneer of sandstone. "Throw every piece of stone out of the channel," he orders. "If you see a hominid, I need to know right away!"

White and Kayrento literally sweep off the gray lag with a push broom and then scrape back the layers of time with a trowel to the ancient surface underneath. "Once we brush out the slopes, we'll be

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sure no fossil is left in place," says White. In case they miss a fragment, the loose sediment is carried to giant sieves where the crew sifts it for bits of bone or teeth. The sifted rubble is taken to a circle of workers who then empty it into small aluminum pans, in which they examine every single, tiny piece—a job that gives new meaning to the word tedium. "Sieving 101," observes Asfaw, who supervises sieving and picking today.

By 11:10 a.m., the pace of discovery has slowed. When the A team tells White it's "not good," he tries to infuse them with some of his energy, reminding everyone to stay focused, to keep going, to not step on fossils. But by midday, White is grumbling, too, because they've scoured the Hot Zone and it's clear the skull is not there. "We've eliminated every hope of finding it in situ."

Intensive care. Tim White uses dental tools and a gluelike adhesive to extract fragile fossils from matrix.

Time travel

It's a good time to take a walk with the four geologists, who are combing the terrain, hoping to find sediments with volcanic minerals to help them date the locality and its fossils precisely. While fossil hunters move slowly, stooped at the waist and focused on the ground, the geologists move fast, heads up, scanning the next horizon for a rock face with a layer cake of sediments, like those exposed in road cuts. The 6-million-year record of Middle Awash sediments is not stacked neatly in one place, with oldest rocks on the bottom and youngest on top. (If it were, the stack would be 1 kilometer thick.) Instead, the rocks are faulted and tilted into different ridges. By tracing a once-horizontal layer from ridge to ridge, sometimes for kilometers, the geologists can link the layers and place different snapshots of time into a sequence.

Today, Ethiopian geologist Giday WoldeGabriel of the Los Alamos National Laboratory in New Mexico, also a co-leader of the team (he joined in 1992), is searching for a familiar-looking motif—a distinct layer of volcanic tuff called the SHT (Sidiha Koma Tuff), previously dated to 3.4 million years ago by radiometric methods.

So far, the team has found just one species of hominin—*Au. garhi*—that lived at this time in the Middle Awash (*Science*, 23 April 1999, p. 629), although a more robust species, *Au. aethiopicus*, appears 2.6 million years ago in southern Ethiopia and Kenya. That's also when the earliest stone tools appear in Gona, Ethiopia, 100 kilometers north of here. The earliest fossils of our genus *Homo* come a bit later—at 2.3 million years ago at Hadar, near Gona, also with stone tools. That's why it is important to date *Au. garhi* precisely: Was it the maker of the stone tools left in the Afar? The team thinks *Au. garhi* is the direct descendant of the more primitive *Au. afarensis*, best known as the species that includes the famous 3.2-million-year-old skeleton of Lucy, also from Hadar. But did *Au. garhi* then evolve into early *Homo*? They need better dates—and more fossils—to find out.

> *"Nothing in the field comes easy."*
>
> –TIM WHITE, UNIVERSITY OF CALIFORNIA, BERKELEY

"Now that we have the SHT as a reference point here, we have to try to trace it to where the new fossils are," says WoldeGabriel. The only problem is that the SHT is several ridges and basins over from the excavation; linking the two will be difficult if not impossible. The team will also use other methods to date the new fossils.

Luckily, the fossil hunters have found a pig known to have lived about 2.6 million to 2.7 million years ago, which suggests that the sediments and the new discovery are also that old.

At 9 a.m. Friday, 12 December, we're back at the Chairman's site for a 3rd day, this time with a film crew from Sweden. After White and Kayrento jokingly reenact the discovery of the skull bone for the film crew, they resume sweeping and sifting, exactly where they left off. At first, there's little return. Berkeley postdoc Cesur Pehlevan from Ankara hands White a piece of bone: "Nope, tough luck. Right color, right thickness. Nope, sorry."

Finally, someone hands White something special. "Oh nice, frontal bone with frontal sinus. This is getting better. That's what we're after," says White. "If we can get that brow ridge, we can match it with the known species." He turns over the new piece of frontal bone in his hand, examining it like a diamond dealer assessing a gemstone.

By the end of 3 days, the team of 20 will have collected a dozen pieces of one skull, an average yield for this region. Taken together, says White, those pieces show that "It's an *Australopithecus* because it has a small braincase, small chewing apparatus." There's still not enough to identify the species, though White thinks it is *Au. garhi*. He notes that "it's a big boy, big for an australopithecine." If it is *Au. garhi*, that would be one more bit of evidence to suggest that *Au. afarensis* gave rise to *Au. garhi*; males are bigger than females in *Au. afarensis*—and so perhaps in *Au. garhi*, too.

For now, White and Asfaw are pleased with the new snapshot they're getting of *Au. garhi*. On our way back to camp, White stops so we can take a photo of the moon rising over Yardi Lake in front of us, the sun setting behind us. The landscape has changed since the australopithecines were here. But one thing's been constant in the Middle Awash, he notes: "Hominids have been right here looking at the moon rising over water for millions of years."

–ANN GIBBONS

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