If this is, in fact, the way nature works, then it is possible—Stecker says inevitable—that the matter-antimatter asymmetry will itself depend on position. There would then be places where matter is even more predominant than it is locally, places that are empty because baryon had canceled antibaryon almost completely during the Big Bang, and, of course, places where antimatter is now dominant.

These regions would obviously have to be separated by vast distances if this scenario is to agree with the gamma-ray observations quoted by Steigman; critics wonder if this is possible even if the theory itself is true. They also contend—although Stecker disagrees—that the scenario predicts distortions in the 3 K microwave background much larger than are observed.

Still, Stecker claims that the diffuse gamma radiation seen in satellite data has a spectral distribution consistent with annihilation at very distant matter-antimatter boundaries. Moreover, the universe seems to have a lacy, cellular structure, with the vast superclusters separated by equally vast spaces that seem utterly empty. So it may just be that the local supercluster is matter, he says, but the next one over is antimatter.—M. MITCHELL WALDROP

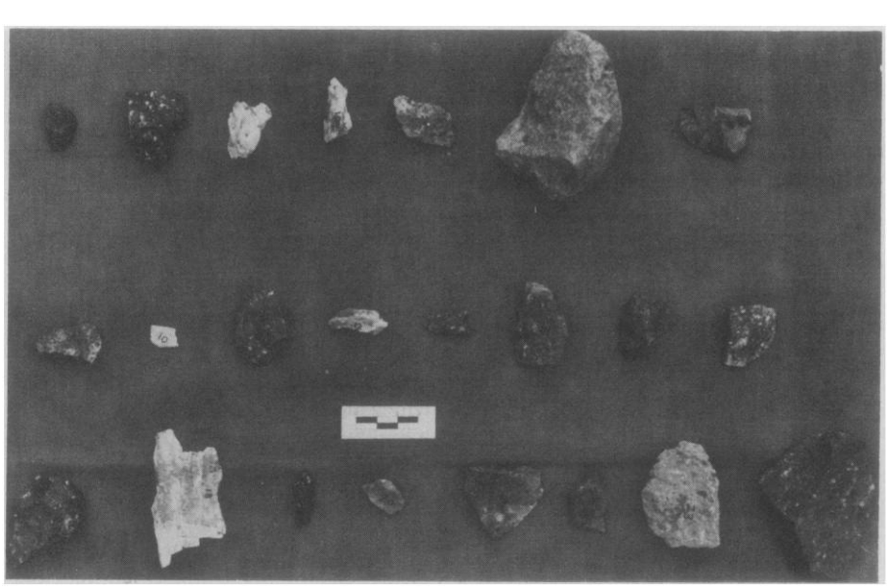
Ethiopian Stone Tools Are World's Oldest

Two-and-a-half-million-year-old artifacts pose new questions over relationship between toolmaking and brain expansion in human evolution

French archeologist Hélène Roche and New Zealander Jack Harris found putative stone tools from ancient deposits in the Hadar region of Ethiopia in 1976 and 1977. For 4 years the tools, pebble "choppers" and small stone flakes, seemed likely but unpublished candidates for being the oldest artifacts yet discovered. Recent analysis of volcanic material from the area confirms the claim, giving the tools a probable age of between 2.5 and 2.7 million years. The oldest securely dated artifacts known previously came from the Lower Omo region in southern Ethiopia: these are dated at 2.1 million years old.

"The tools come from that provocative 2 to 3 million year period," says Donald Johanson of the Cleveland Museum of Natural History and one of the leaders of the joint French-American expedition to the Hadar. "We believe that this is the time when early *Homo* first evolved from *Australopithecus afarensis* stock," he told *Science*. "It may be that the use of tools is intimately associated with that divergence between *Homo* and later species of *Australopithecus*."

The 1976–1977 field season in the Hadar was the fourth and last expedition to the area; political strife in Eritrea has so far prevented further work there. "Hélène found the first tools in November 1976," recalls Harris, "but very soon afterward she had to return to France. I went in January 1977 and stayed just 3 weeks, during which time I did some quick surface surveys of the area and one test excavation. I found 18 artifacts in situ from that excavation."



D. C. Johanson

Two-and-a-half-million-year-old bones and stone artifacts

Jack Harris recovered 18 artifacts and five fossil fragments (the white shaded objects) from a small test excavation. The artifacts are a core, flakes, and flake fragments. (Marker is 3 centimeters.)

Primitive stone artifacts can be found scattered over the ground surface of much of North and East Africa, but these are useless from an archeologist's standpoint. Unless the tools are firmly embedded in primary deposits there is no way of determining how old they are. The age of a stone tool is set by the date attributed to the deposits in which they are excavated, and this date may be established by one of several physicochemical techniques.

"I was surveying an area west of where most of the hominid fossils have been found," Harris told *Science*, "and I came across lots of surface occurrences of artifacts. The test excavation, covering about 7 to 10 square meters, was a kilometer from where Hélène had found the first artifacts." The total haul from the site was 50 stone artifacts: three 8-centimeter cobbles from which several flakes have been struck and a collection of flakes and flake fragments. These worked cobbles are traditionally known as choppers, though archeologists are beginning to believe that they serve primarily as cores from which sharp flakes are struck. The flakes would have provided a considerable technological breakthrough, their sharp edges being more than adequate for slicing through animal hide and meat. "Only one 'chopper' and 17 flakes and flake fragments came from the excavation," says Harris, "the remainder were on the surface. The excavated artifacts were in pristine condition, with cortex clearly visible on some of the flakes."

The nature of the deposits in the area suggests that the site was on or close to a bank of a river and several kilometers

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from a major lake that is known to have existed in the Hadar region. "Fine silt covers the artifacts," Harris reports, "and this was probably deposited fairly gently when the river overflowed its banks. The material was disturbed only minimally when it was covered, and there were some bone fragments associated with it too." Most of the fossil bone is unidentifiable, but two pieces were not: "There was part of an elephant tooth in the excavation," says Harris, "and a fragment of antelope jaw on the surface."

The sedimentation in the area is very complicated, and a complete analysis will have to await a further expedition, possibly this fall. "There was repeated flooding," says Robert Walter of Case Western Reserve University, "and some of it was quite severe. This inevitably makes interpretation a little difficult." The dating for the site comes from a layer of volcanic ash, a tuff, denoted as BKT-2. "The tuff has just been dated at 2.8 ± 0.2 million years using potassium-argon and fission-track techniques," says Walter. "The deposits containing the artifacts lie just above this tuff."

The question as far as dating the artifacts is concerned is, how much time elapsed between the deposition of the tuff and the accumulation of the sediments containing the tools? "It's difficult to be precise about this," admits Walter. "We know there was some flooding after the tuff was laid down, and theoretically this could have washed away a thick layer of deposits representing a long time period, after which the artifact layer was deposited," he conjectures. "This would mean that the tools would be very much less than 2.8 million years old. But we don't believe that because if there had been major removal of sediments at this site we would expect to see signs of the event elsewhere in the floodplain, and we don't." The age put on the artifacts, somewhere between 2.5 and 2.7 million years, is "an educated guess," concedes Walter, "and we hope to tie it down more precisely with paleomagnetic dating when we return to the site in October."

What do the tools mean in the context of prehuman activity? "It's not possible to be certain yet," says Harris, "as the excavation was limited. The site might be part of a large concentration of artifacts and bone fragments—a home base or camp site." A typical early hominid home base would have several thousand pieces of bone and stone scattered over an area some 15 meters in diameter. "Or it could be the result of a single individual knocking off a few flakes for some purpose, and then moving on within an hour or so," he adds. "Only by further excavation will we be able to answer this question.

D. C. Johanson

Excavation at the artifact site in the Hadar badlands

Hominid fossils have yet to be found in the floodplain sediments.

"What is interesting about the artifacts," comments Harris, "is that they are identical with the types that have been found at Koobi Fora in Kenya and Olduvai Gorge in Tanzania. These choppers and flakes were the basis of toolmaking until about 1.5 million years ago, when large bifaces, or hand axes, started to appear. And then the bifaces were the dominant theme for another million years, until people began using prepared cores, making more sophisticated and finer implements. The pace of evolution of stone tool technology was very slow," observes Harris.

Berkeley archeologist Glynn Isaac sees the Hadar artifacts as reviving discussion over the relation between brain expansion and tool use in human evolution. "If this date is secure, then we have toolmaking appearing in the record at least half a million years before the first specimen that shows undoubted brain expansion," comments Isaac. "This specimen is the cranium known as 1470, or *Homo habilis*, from Lake Turkana in Kenya, and it is dated at around 2 million years."

There are, however, virtually no good hominid fossils from the period 2 to 3 million years ago. Acknowledging this regrettable gap, Isaac says, "It is of course possible that brain expansion began 2.5 or 2.7 million years ago and that toolmaking was a behavioral manifestation of that advance." An alternative is that making and using tools was an important factor in the brain expansion seen later in the record. "With so few hominid fossils to go on from this period it is simply not possible to choose between these ideas," says Isaac. "But the new date for the Hadar artifacts certainly reopens this whole question."

An almost unresolvable puzzle of the earlier period of paleoanthropology, between 2 and 3 million years ago, is which of the several types of extant hominids made the tools? "Both *Homo* and *Australopithecus* existed at this time," says Johanson, "and although we always tend to associate toolmaking with *Homo*, you can't rule out the possibility that *Australopithecus* made and used crude tools."

The tools at the Hadar come from an area where so far no hominids have been found. "All the hominid fossils are from the older deposits to the east," says Johanson. These include "Lucy" and the famous "family group" from Afar Locality 333, all of which are dated at more than 3.5 million years old. "We haven't surveyed the artifact sites for hominids very much yet," says Johanson, "but you can be sure that we will just as soon as we get back to the Hadar. We want to know what creatures were living there when these tools were made."—ROGER LEWIN