by 23 degrees, each responding neuron retained its original connections from auditory neurons, but it gained a second set of connections from auditory neurons that responded to sounds from a location 23 degrees to the left. When the team removed the prisms, the young birds again adjusted their sound localization, apparently by reactivating the old connections that remained.

In the new experiment, Knudsen tested whether these previously trained birds can readjust their auditory maps to the prisms many months later, when they are well into adulthood. These birds were able to adapt, but adult birds that had never had prisms couldn't. "I put these prisms on birds that had been without prisms for half a year, which is a long time in bird life, and—*Voilà*!—3 weeks later, I saw this neural learning appear," says Knudsen. "In the normal adults, you'd never see it happen."

The prior prism exposure did not give the adults the same wide-open adaptability of young birds. Although they could relearn what they had mastered when they were young, they could not adjust to prism shifts of other directions or magnitudes. That suggested they were limited by the connections they had grown earlier to accommodate the 23-degree rightward shift. The birds seem to "go back and use the old anatomy," says Jon Kaas, a neuroscientist at Vanderbilt University in Nashville, Tennessee. "You can actually understand this in terms of altered anatomy of the system."

Although his data are entirely consistent with the reactivation of the old connections, Knudsen hasn't shown directly that the connections persist in older birds. But if tests he plans to do this year confirm that the connections remain, his system will allow researchers to ask new questions. Neurobiologist Michael Stryker of the University of California, San Francisco, proposes two: "What is it that causes these connections to be turned off after they are no longer useful, and yet to remain there? And what turns them back on again?"

Even if it turns out that the physical connections don't endure into adulthood, says Berkeley's Shatz, the owls' early experience must leave some relic that explains why they can relearn the prism shift. Knudsen's system, she says, "represents a fantastic opportunity to study what the enduring trace of that early experience is."

Many neuroscientists expect that what Knudsen has found in the brains of barn owls will generalize to learning in the brains of other animals, including humans. It all reinforces what Hillary Clinton and the news magazines have been telling us: that exposing our kids to more experiences at a young age may make them smarter adults. Indeed, it may physically lay down the pathways for achievement later in life.

–Marcia Barinaga

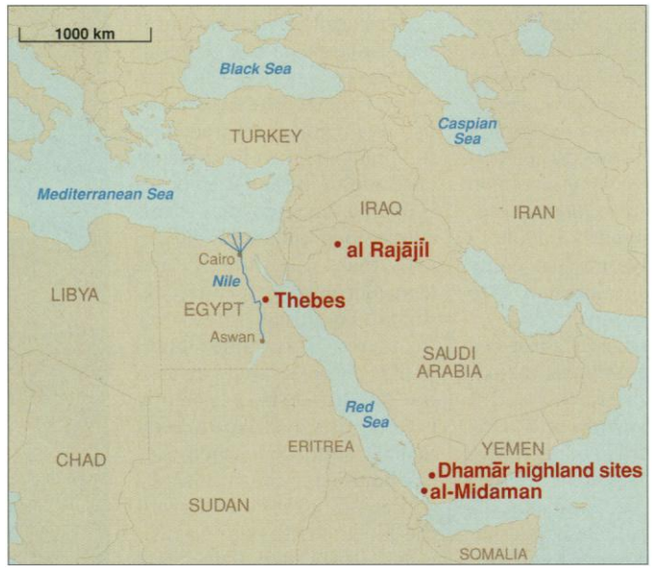
ARCHAEOLOGY

Yemen's Stonehenge Suggests Bronze Age Red Sea Culture

For decades, classical archaeologists focused much of their attention on the Mediterranean Sea, where Egyptian stelae, Minoan friezes, and Turkish shipwrecks reveal the rise and fall of empires and the skein of sea trade among them. Now, new excavations are offering the first, tantalizing glimpse of an ancient civilization that flourished 4000 years ago near another major Old World waterway: the Red Sea. Work by researchers from several different countries on the Red Sea's arid southeastern coast points to a complex culture whose people enacted costly rituals, possessed metal tools, and raised daunting megaliths at about the same time as Stonehenge appeared in Great Britain.

In research currently in press in the *Proceedings of the Seminar for Arabian Studies*, Edward Keall, head of the Department of Near Eastern and Asian Civilization at the Royal Ontario Museum in Toronto, presents preliminary evidence for a previously unstudied Bronze Age culture in coastal Yemen. His team members found the ruins of a circular prehistoric religious site, or henge, built of granite pillars weighing 20 tons. Buried at the foot of a fallen megalith, they discovered a cache of copper-alloy tools dated to between 2400 and 1900 B.C. And nearby, they unearthed fragments of children's skeletons from what appeared to be ceremonial burials. All this suggests a well-organized people living in an arid coastal plain once thought to have been almost empty at this time. "People had assumed that there was nothing there during the Bronze Age," says Keall.

Other experts say the finding should draw attention to the dozen or so similar stone pillar sites scattered across western Arabia. "These sites have been sort of looked at, but not very thoroughly," says Christopher Edens, a research associate in the Near Eastern section at the University of Pennsylvania Museum. "Now, someone has actually investigated these things and found this cache of bronzes, which is phenomenal for this area. I was floored." Moreover, the new excavation, which has yielded the first date for these mysterious megaliths, raises the possibility that an ancient and unsuspected trade network operated along this stretch of Red Sea coast.



Bronze Age networking. Discoveries at al-Midaman raise the possibility of trade between the famous Mediterranean cultures and those along the Red Sea coast.

Keall stumbled on the site, known today as al-Midaman, in March 1997, while transporting gear from work on a nearby medieval port. Taking a wrong turn along a local road, he encountered a date farmer, who led him to three granite pillars standing in roughly a straight line and towering nearly 3 meters above the desert sands. Other pillars, some granite and some of basalt, lay eroding on the ground or buried in the sand. "Stonehenge was the only thing I could think of," says Keall.

There are a dozen or so similar monuments in Saudi Arabia and Yemen, but until now only one—Rajājīl, in northwestern Saudi Arabia—had been excavated. Studied in the late 1970s, this dig was a disappointment, yielding no grave goods or bones and virtually no cultural material. And although relics of agricultural people from this time are known in the Yemen highlands, these sites yielded almost no metal, as might be expected of Bronze Age sites.

Keall, however, was fascinated by the standing stones. With the nearest granite

source in the Red Sea islands to the west or 50 kilometers east in the Surat Mountains, he realized that the henge represented a formidable labor. Either the builders had struggled for days to drag stones of 20 tons across the desert on rollers, or they had floated them to the site across water on a raft, then dragged them nearly 2 kilometers inland.

He decided to investigate. Preliminary reconnaissance turned up a dense litter of ceramic sherds, fragments of sheep and goat bones, flakes of obsidian, and pieces of copperlike metal and carnelian beads, all scattered by desert winds over an 8-square-kilometer area. Some of the sherds bore scored symbols and closely resembled a pottery type fashionable in Yemen between 1300 and 900 B.C. But other fragments seemed more crudely made and so were perhaps older.

Hoping to find ruins of what seemed to be a large settlement, Keall sunk a series of trenches around the henge. But the team found no trace of residential buildings, only firepits, broken cooking pots, and scorch marks in the sediments. There was so much domestic debris, however, that Keall suspects people did live there, in dwellings made of perishable materials such as reeds.

Undaunted, the team continued to excavate beneath two of the toppled 3-meter-long basalt columns. There, they discovered fragments of three poorly preserved skeletons of children who were about 8 years old at death. There were no grave goods or clues to how they died. But Keall speculates that they might have been buried during funerary ceremonies and might even have been human sacrifices, given that the immense amount of labor represented by the stones suggests some vital and dramatic ceremony.

A short distance away, team members unearthed part of the ruins of a huge public building more than 20 meters long. It was apparently built in a later phase of the culture, for its foundations included granite megaliths robbed from the henge and basalt columns uprooted from nearby children's burials. Seemingly empty of artifacts, the building is of unknown purpose and date.

At the foot of another fallen megalith, however, the team hit the jackpot: a cache of corroded copperlike tools—daggers, adzes, razors, and javelin points—arranged around a block of untrimmed obsidian. The tools were apparently buried deliberately, presumably as some sort of offering.

To date the unexpected trove, Keall enlisted the assistance of Alessandra Giumlia-Mair, an archaeometallurgist at the University of Udine in Italy. She analyzed the composition of 16 samples taken from the tools and their rivets. All the samples consisted of copper alloyed with small amounts of tin and arsenic, added to harden the metal. Some of the objects contained just 3% tin, others only 2% arsenic. The sparing use of these two alloying elements was a clue to the tools' age, because it is characteristic of Bronze Age objects made in Egypt, Syria, and Palestine some 4000 years ago. Objects made later contain more of these elements, but during this time some metalsmiths were still experimenting with adding tin, while others had scarce supplies, Giumlia-Mair explains.

The team also found that the al-Midaman daggers—made with a double rivet below the tang (the part of the tool that fits into the handle)—closely resembled daggers from the Red Sea and Levant regions between 2400 and 1900 B.C. Taken together, the evidence dates the weapons to "the last period of the Early Bronze Age or the early Middle Bronze Age, say, the end of the third millennium or the beginning of the second," says Giumlia-Mair. "You do find these sorts of shapes, these kinds of tools all around the Mediterranean at this time."

Romancing the stone. Researchers excavating a 4000-year-old megalith found a copper-alloy dagger *(top)* in ancient Yemen.

While Keall is expanding the fieldwork at al-Midaman and in the surrounding region, he and other archaeologists are trying to learn whether all the megalith sites of the Arabian peninsula were the work of a single culture—and why they were built. The outer stone circle of Stonehenge was raised at about this time—1800 B.C., at the beginning of the Bronze Age in Great Britain. "There seems to be a phase in the history of people where setting up a giant stone for some reason was their cultural expression," says Keall.

Like Stonehenge, the Arabian megaliths may have marked particular astronomical alignments such as the winter solstice, says Juris Zarins, a Near Eastern archaeologist from Southwest Missouri State University in Springfield and a member of the team that excavated the megalith site at Rajājīl. Some of the southern Arabian henges could have served as calendrical devices for the planting of sorghum, suggests Marcello Ranieri, an astrophysicist at the Istituto di Astrofisica Spaziale in Frascati, Italy. "Prehistoric people had to have an exact count or calendar to establish which were those 2, 3, 4 days during the year to plant sorghum," in order to benefit from monsoons, adds Geraldina Santini, a Near Eastern expert at Oriental University Institute in Naples. To check this theory, she and colleagues plan to map precisely the 900 or so stone pillars at Mohamdid al-Hamli, another as-yet undated megalith site on the Yemen coast.

Keall and others are also wondering how the people of al-Midaman acquired the wealth and leisure implied by the copper tools and the monuments while living in a desert of scorching heat and scant rainfall. One possibility is trade in a valuable good. Keall speculates that it might have been soap, as many of the dunes at al-Midaman today are covered with a shrub that can be dried and burned to produce natron, a form of sodium carbonate that is a key ingredient in soap. And Zarins has found evidence that the ancient Yemenite traded with the Egyptians, who at this time had already mastered the building of pyramids. He analyzed the trace element composition of obsidian, volcanic glass prized for use in knives and decorations. He found that obsidian pieces from 5000- to 3000-year-old Egyptian sites matched samples from highland Yemen and the Arabian Red Sea Coast.

The obsidian from al-Midaman itself has not yet been tested. But whether or not the megalith builders were trading all the way to Egypt, the new research clearly suggests that far more was going on along Yemen's western coast 4000 years ago than researchers once credited. "As archaeologists, we've been very Mediterranean-centric," says Keall. "We have Egypt, Anatolia, the Levant, and so on as the heart of the ancient world, and [we considered] everything else on the periphery of that as marginal. But we may find in fact that there were other civilizations—maybe not earth-shattering like the others, but viable in their own right—elsewhere. And that's the novelty."

–Heather Pringle

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