

Ancient Alexandria Emerges, By Land and By Sea

Excavators are finding surprisingly late signs of intellectual life in the ancient capital of Hellenistic Egypt and discovering that geology played a dramatic role in the city's fall

OXFORD, U.K.—For centuries the massive Pharos lighthouse, one of the seven wonders of the ancient world, guided sailors to the busy wharves that made Alexandria a prosperous center of Mediterranean culture and home to the greatest library of ancient times. Yet while rivals Rome and Constantinople survived the chaotic period following the collapse of the Roman Empire, Alexandria faded from the historical record. By the 8th century C.E. the famed metropolis had fallen into oblivion.

Today the city of Alexandria, site of Alexander the Great's tomb and Cleopatra's death, attracts scholars the way it once drew merchants and philosophers, as shown by a recent conference at Oxford University.* Rescue archaeology amid rapid urban growth combined with new underwater mapping technologies are yielding new insight into the old city's role and history. Archaeologists have uncovered tantalizing hints of surprisingly early



An ancient wonder. Excavators seek the remains of the Pharos lighthouse, shown here in a Renaissance artist's view.

beginnings as well as signs that the city's vibrant intellectual life lasted far longer than anyone had expected. "Now we can imagine the functioning of a university in antiquity," says historian Manfred Clauss of Germany's University of Frankfurt.

New data also suggest that environmental disaster played an important role in ancient Alexandria's downfall, which has long been attributed primarily to religious and political turmoil; the fate of Alexandria could provide a warning for today's fast-growing cities built on deltas, researchers say.

* "City and Harbour: The Archaeology of Ancient Alexandria" at the Oxford Centre for Maritime Archaeology, 18–19 December 2004.

An ancient think tank

Most of the new data comes from digs that began in the 1990s, when the Egyptian government lifted a ban on underwater archaeology and began to encourage salvage work on land as the city of 6 million expanded over its ancient foundations. Those foundations were officially laid in 332 B.C.E., when legend has it that the Greek bard Homer appeared to Alexander the Great in a dream and urged him to found a city along the narrow strip of land separating Lake Mareotis from the Mediterranean Sea. It seemed an unlikely choice; the mouth of the Nile was far to the east, where the major Egyptian ports were well established, and only small villages existed on the spot.

The city grew to prominence after Alexander died in 323 B.C.E., and his general Ptolemy made it the capital and largest port of Egypt. The vast wealth of Ptolemy and his Greek and Macedonian successors built a Greek-style city of temples, lavish palaces, and the famous library, says historian Gunther Grimm of Germany's University of Trier; scholarship in philosophy, physics, mathematics, and astronomy thrived. Under the Roman rule that followed Cleopatra's death in 30 B.C.E., Alexandria served as the nexus for grain exports for the vast empire. But within a few centuries, the city largely vanishes from the historical record.

Now nearly a dozen teams of excavators are sifting through what remains both in the city and in the harbor. Archaeologist Jean-Yves Empereur of the Center for Scientific Research in Paris is working fast to salvage remains of the ancient city as the new one expands. "Ten to 12 meters beneath the modern city, the old one is very well-preserved," says Empereur, who was one of

Oxford Center Raises Controversy

Ancient Alexandria was famed for its philosophical disputes, and that tradition is very much alive in excavations now under way in the Egyptian port. Scholars are hotly debating a controversial agreement that gives a nonscientist, French businessman Franck Goddio, control over underwater archaeological data collection for Oxford University. At a conference held in December—a coming-out party for Oxford's new Center for Maritime Archaeology—dozens of scholars discussed new finds (see main text). But others avoided the event, arguing that contracting out the leadership of maritime digs to non-scientists sets a poor precedent.

Under the deal signed 18 months ago, Goddio will oversee under-sea excavations; Oxford graduate students, under the guidance of professors, will analyze the data. The Hilti Foundation of Lichtenstein, which has supported Goddio's work for a decade and is funded by a tool company of the same name, will provide at least \$300,000 to fuel the center, which for now will focus on Goddio's work in Alexandria and nearby Abukir Bay.

Goddio, who has worked for 20 years on more than 50 underwater sites, is a Jacques Cousteau of archaeology, often featured on European television. Although he lacks a degree in archaeology—he studied statistics—Goddio says his experience speaks for itself. But he also seeks academic respectability. The Oxford agreement "is a chance for us to get closer to a university which could back our work and take advantage of our discoveries," says Goddio. "We were looking for a scientific base or 'harbor' for the findings and results from Franck Goddio's excavations," adds Michael Hilti, who heads the Hilti Foundation. "With Oxford, I think we have found a perfect partner."

The arrangement makes sense to university officials, who are eager to enter the burgeoning and expensive field of maritime archaeology. "We were blown over by the quality of Franck's underwater fieldwork," recalls Barry Cunliffe, the Oxford classical archaeologist who helped broker the deal. "It was an extremely smart piece of archaeology, well-ordered and observed."

But Goddio's deal with Oxford raises concerns among many maritime archaeologists uncomfortable with turning over part of the scientific process to those who lack formal training. "I'd be wary of

several scholars who declined to attend the conference because of their concerns about Oxford's ties to a private underwater archaeologist, Franck Goddio (see sidebar). Empereur adds that the houses, streets, and mosaics that have been uncovered represent "just 1% of what could be rescued."

Even that small percentage is rewriting the city's history. Most historians assume that intellectual life in the city withered with the destruction of the library—which likely occurred over hundreds of years—and the rise of Christianity. But among the most intriguing recent finds is a complex of lecture halls that appear to be "the center of [the city's] intellectual and social life in late antiquity," says Warsaw University's Grzegorz Majcherek of the Polish-Egyptian Archaeology Mission. Each hall includes a single central seat for a notable—likely the teacher—and often a smaller seat on the floor, perhaps for student recitations. The complex is part of the old city's most extensive area of urban architecture. Majcherek estimates that the halls were built in the late 5th and early 6th centuries C.E. and notes that a Roman theater was even converted into a lecture hall at this time. He speculates that what he calls "the Oxford of antiquity" could have survived into the era of Arab control—"surprisingly late."

The find intrigues historians, who say there has been little evidence that intellectual life in the city flourished for so long. "This is the most exciting find in years in Alexandria," says Clauss. "The buildings Professor Majcherek has found demonstrate the existence of a think tank" long after the fall of Rome. "It is surprising that it seems to function in a modern way," he adds.



Modern mariner. Former businessman Franck Goddio leads spectacular underwater digs.

considered one of the founders of maritime archaeology.

Robert Grenier, head of Ottawa's Parks Canada maritime archaeology unit, adds that Goddio's record is big on coffee-table books but small on scholarly publications. For example, he says, Goddio excavated the 35-meter-long Spanish galleon *San Diego* off the coast of



Facing the past. Divers have found artifacts such as this sphinx representing Cleopatra's father.

Down under

Just a few hundred meters away, an important part of ancient Alexandria lies undisturbed underwater, meters from the modern breakwater lining the harbor. In the 1990s, Empereur uncovered statuary and blocks that may be portions of the Pharos lighthouse, which survived in ruins until an earthquake in the 14th century. Goddio found a sunken palace from the Ptolemaic era and brought up statues and other artifacts that he hailed as remnants of Cleopatra's palace. That claim, as well as the exact location of the Pharos, remains in dispute.

More recent finds are less spectacular, but they shed important light on the evolution of the harbor that was Alexandria's heart. For example, Goddio's team now has found evidence of a dock that dates to about 400 B.C.E., predating Alexander. "We were surprised, took new samples, and got the

same answer—this was most probably a pre-Ptolemaic structure [and is now] 7.5 m below sea level," says Goddio. Geologist and team member Jean-Daniel Stanley of Washington, D.C.'s Smithsonian Institution told meeting participants he has found tantalizing hints that inhabitants smelted lead on the site as early as 2000 B.C.E.

The discoveries are part of an ambitious effort by Goddio to map the entire harbor bottom—one data point for every 25 centimeters—and conduct extensive radiocarbon dating of planks and pilings brought up by divers. The survey of the 2.5-kilometer-by-15-kilometer area will give researchers "quite a precise idea" of the location of docks and buildings that lined the harbor, says Goddio: "A ghost from the past is being brought back to life."

Meanwhile, geologist Stanley has examined dozens of cores from the harbor and

parceling out one of the links in the chain of science," says maritime archaeologist Jon Adams of the University of Southampton, U.K. "Archaeology should be conducted by proven and trained archaeologists," adds George Bass, a professor emeritus at Texas A&M University in College Station who is

the Philippines and produced a glossy catalog but limited scientific data. Grenier worries about data that may not be collected, such as apparently inconsequential fragments that might provide a clue to a ship's identity or place of construction.

Goddio defends his record, noting that the second *San Diego* mission lasted more than 4 months and was devoted to understanding the ship's hull construction; he adds that he still hopes to publish more details.

Cunliffe insists that skilled nonscientists can make an enormous contribution because retrieving information from underwater digs is so technologically intensive and expensive. The choice he sees is to ignore nonscientists' expertise and funding, or to find a creative way to work with it. "The cost of doing this work is almost prohibitive unless you have the backing of a large foundation," he says.

A large maritime excavation can cost upward of \$1 million a month, forcing many underwater archaeologists to seek foundations or television producers to help fund their work. "We've all done a bit of whoring to get the money we need," admits one respected maritime archaeologist. And when it comes to Goddio's bountiful financial support, he adds, "I'm jealous."

—A.L.

uncovered evidence of the centuries-long battle that ancient engineers waged against both gradual and sudden subsidence. He says the subsidence was brought on by a lethal combination of earthquakes, tsunamis, and the slow but relentless sinking of heavy foundations into unstable soil, which defeated even savvy Roman engineers. Although several wharves appear to have been reconstructed over centuries, no amount of piling could long hold up heavy stone foundations and buildings, he says. “[Adding] on all that material was asking for trouble,” Stanley says. “The additional weight of a wave surge could be powerful enough” to submerge part of Alexandria’s shore.

The historical record also shows an unusually active period of tremors from the 4th to the 6th centuries C.E. Quakes and tsunamis could have transformed sediment into a more fluid state, says Stanley. Sixty-five cores taken from the western harbor show signs of ancient liquefaction, he said, and numerous pieces of red coral not native to the harbor suggest that a tsunami washed them into the basin. But he says it is too early to reconstruct details of ancient collapse and rebuilding. “We need better 3D images of harbor substrate” to understand what repairs were done and when, he said.

The impact of these geological forces extended beyond Alexandria—and with even more dramatic consequences. Stanley



and Goddio also are excavating three submerged cities in nearby Aboukir Bay: Herakleion, Canopus, and Menouthis. The first was an important entrance point to the mouth of the Nile, and the others were well-known pilgrimage sites. The area received huge amounts of sediment from the Nile, which compacted and sank over time. This process, combined with a slow rise in world sea levels, pushed the water at least 2 meters higher between the 6th century B.C.E. and the 7th century C.E. “Arabic texts show a huge Nile flood in 741 and 742 A.D.,” notes Clauss. And by the 8th century—the same time Alexandria slips into obscurity—the historical record on these sites goes silent.

Stanley’s research supports a theory that combines catastrophe and gradual sinking to explain the disappearance. Submergence alone cannot explain why much of the area is now a full 6 meters under water, and Stanley posits that sudden shifts in the flow of Nile branches on the delta—perhaps brought on by the pace of earthquakes—may have triggered more dramatic changes. Unstable sediment would have been laterally displaced, causing sudden destruction as the Nile moved into a new bed. Goddio’s team has found

evidence of human remains underneath toppled walls at the three sunken cities, backing up this theory.

In an era of climate change and fast urban growth along coasts, this research may have implications today. Stanley notes that modern cities such as Venice, Bangkok, and New Orleans sit on unstable delta soils. “This is becoming a world problem,” he says. “Understanding the subsidence threat might help such cities avoid the fate of Herakleion, Canopus, and Menouthis.” Alexandria, at least, escaped with only a flooded harbor—a sign that Homer perhaps was as canny a geologist as he was a storyteller.

—ANDREW LAWLER

Radio Astronomy

Bristling With Promise

By substituting software for massive signal-gathering dishes, arrays of simple FM antennas offer astronomers a cheap, versatile alternative to traditional radio telescopes

In a remote Chinese valley sit 25 neat clusters of antennas, each tipped slightly askew. They are testing the airwaves, listening for interference from TV signals. If reception is clear enough and other things go well, within the next year or two the fields of the Ulastai Valley will fill with tilted antennas, like a Christmas tree farm pummeled by wind.

The valley will become a huge array of 2-meter-long antennas, 10,000 strong, covering 30,000 square meters. The array, dubbed the Primeval Structure Telescope (PaST), is the brainchild of a group of Canadian, Chinese, and American scientists pursuing a low-frequency portrait of the early universe. And they hope to find it out in the vast, quiet stretches of western China, one of the last places on Earth out of the reach of jabbering TV and FM radio broadcasts.

Though just 25 pods of 127 antennas each right now, PaST is a herald of what’s to come.

Thanks to recent advances in theory and computing power, radio astronomers can now build telescopes consisting of huge arrays of antennas capable of viewing the universe in a novel palette of low frequencies hitherto rarely used for astronomical observations. “What’s most exciting to me [is] that we don’t know what we’re going to see,” says PaST collaborator Jeffrey Peterson of Carnegie Mellon University in Pittsburgh, Pennsylvania.

Peterson isn’t alone in his enthusiasm. Several other array telescope projects are under way in the Netherlands, Western Australia, and the American Southwest. Their scientific goals include finding radio equivalents of gamma ray bursts and detecting the faint traces of the first stars.

The arrays will take radio astronomy back to its roots in the 1930s, when Karl Jansky, an engineer at Bell Telephone Laboratories in Holmdel, New Jersey, noticed

radio waves emanating from the center of the Milky Way galaxy at 20 MHz. The field took off after radar operators during World War II discovered a technique called interferometry, which enabled astronomers to string together several small antennas to get the same resolution as that of one huge antenna. But researchers soon realized that low frequencies were wrinkled and warped into indecipherability by Earth’s ionosphere. Frustrated, they switched their attention toward frequencies above 1 GHz. And that’s where radio astronomy stayed until recently, when new calibration techniques opened a window into the low-frequency range.

The breakthrough came in 1991, when astronomers using computer algorithms to correct for the effects of ionospheric interference jiggered the Very Large Array (VLA), a Y-shaped assemblage of 27 dish antennas in western New Mexico, into receiving at a record low frequency of 74 MHz. Their success blasted open opportunities for large low-frequency arrays. “The old low-frequency telescopes were like a nearsighted person trying to read from far away without his glasses,” says Namir Kassim, a radio astronomer at the Naval Research Laboratory in Washington,

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