Heirs to Ancient Air

Scientists hope to study the delicate contents of a 4,600-year-old chamber without ever disturbing what rests inside

By RICHARD MONASTERSKY

Giovanni Battista Belzoni was not known for his light touch. He etched a space for himself in the annals of archaeology by being one of the first Westerners to begin excavating and collecting artifacts in Egypt. But he was more a heavy-handed plunderer than a scholar, and the scars of his work still mar the tombs of several pharoahs.

From such inauspicious beginnings, archaeology has evolved over the last century and a half into a rigorous science. And at the cutting edge, a project currently under way in Egypt is using a high-tech nondestructive approach to probe an ancient chamber.

Borrowing equipment from moon missions and nuclear power plants, the members of this project are seeking to probe a sealed pit that lies at the foot of the Great Pyramid of Khufu, known in the West by the Greek name Cheops. In 1954, archaeologists discovered this chamber and an identical neighbor, both of which were hewn from the limestone bedrock and capped with limestone blocks.

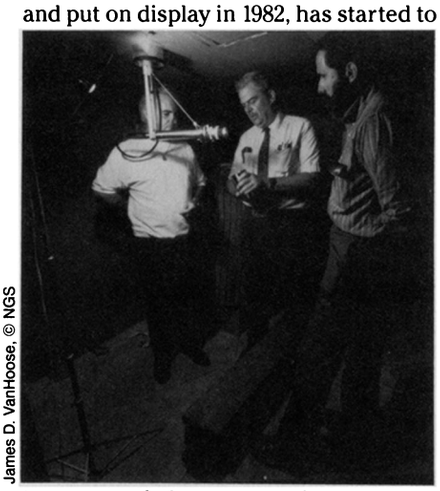
When they opened the first chamber, they found a dissasembled wooden boat in near-perfect condition. The ancient Egyptian workers had sealed off the chamber with a gypsum mortar that protected the wood from water, oxygen and bacteria — the principal elements of decay.

The other chamber of Cheops was left unopened.

Until this year, that is. In October, scientists finally plan to open the second chamber. However, instead of searching for a second boat, these scientists are primarily interested in finding another artifact preserved by the chamber — ancient Egyptian air.

The goal of the present project is to retrieve samples of the atmosphere from inside the chamber and at the same time avoid contaminating the chamber with anything from the outside world, says Zahi Hawass, who is working for the Egyptian Antiquities Organization, co-sponsor of the project with the National Geographic Society. "Once this atmosphere is analyzed," says Hawass, "its composition can be simulated in the museum environment to protect organic antiquities like wood [or] textiles, maybe mummies."

Organic decay is a central concern for archaeologists, who not only find artifacts but also seek to preserve them for future study. Scientists do not yet fully understand what qualities protected these ancient materials through the centuries, and museums often lack sufficient funds to adequately control the environment of displays and storage rooms. For these reasons, many organic artifacts begin to decay rapidly once they are removed from their resting spots. Indeed, the wooden boat, which was assembled and put on display in 1982, has started to show signs of deterioration. Several observers have noted with irony that while this boat survived more than 4,000 years, it is in danger of disintegrating within a few decades.



James D. VanHoose, © NGS

In a test of the system, the camera — designed for use in nuclear reactors — sticks down into a "mock" boat chamber through a hole in the ceiling.

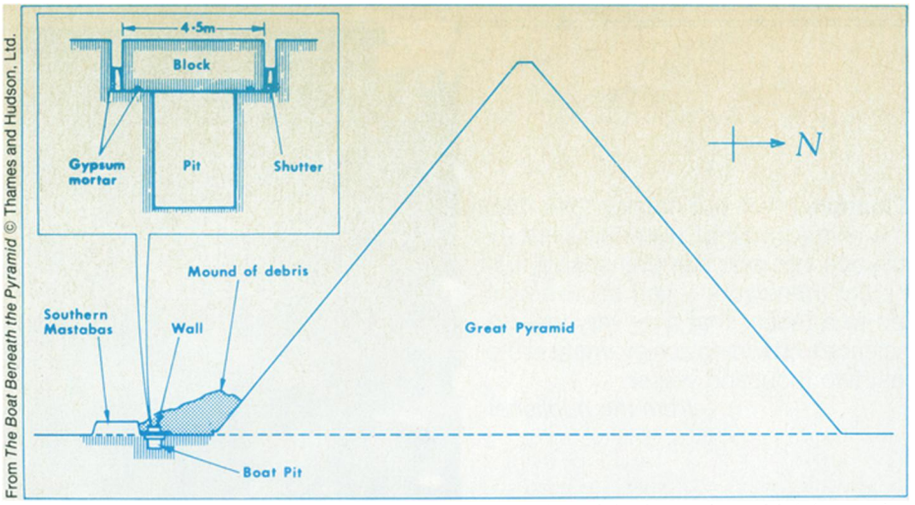
Aside from archaeologists, this project has also captured the interest of atmospheric scientists, because it offers them the almost unprecedented opportunity to analyze the atmosphere as it was 4,600 years ago — a time long before humans began to significantly alter the atmosphere by burning fossil fuels and deforesting lands. Measuring the concentrations of carbon dioxide, methane, chlorofluorocarbons and other trace gases in this ancient air will help scientists distinguish the natural cycles of the atmosphere from the possibly harmful effects generated by humans.

While bubbles in icecaps have yielded older samples of the atmosphere (SN: 9/29/84, p.205), they have been "minute amounts," says Lester Machta, director of the U.S. National Oceanic and Atmospheric Administration's Air Resources Laboratory in Silver Spring, Md. "Here we can get liters of air and more, so we can do a lot more scientific analyses."

The project plan is to drill a hole 3 1/2 inches in diameter through one of the 14-ton limestone blocks that roof the pit. The researchers will sample the air, take both video and still pictures and then insert devices to monitor the environment of the chamber. All the equipment, even the cameras, must fit through this small hole. And to further complicate matters, the researchers must protect the contents of the chamber from anything that will change the inner environment, which includes even the heat from the surrounding desert.

Because this project — the first of its kind — aims to be completely nondestructive, the planners have meticulously outlined every step, as if preparing for the launching of a moon probe. In fact, one of the central participants, Farouk El-Baz, worked extensively on the Apollo missions from 1967 to 1972 and now heads the Center for Remote Sensing at Boston University.

Last month, the team traveled to the site on the south side of the pyramid, where they used ground-penetrating radar to survey the insides of the chamber. The researchers are not expecting to be able to identify the contents of the chamber from enhanced radar images. Rather, says Hawass, "this will help us to select the site for drilling. Obviously, we

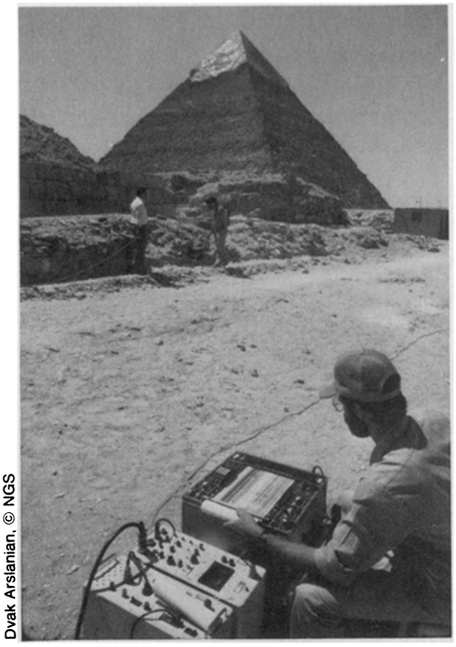


From The Boat Beneath the Pyramid © Thames and Hudson, Ltd.

Cross-section through pyramid illustrates the position of the boat pits, which lay under a pile of debris before their discovery in 1954. Inset shows how gypsum mortar created a seal between limestone ceiling blocks and the shelves on which the blocks rested.

don't want to drill [in a certain location] if there is something immediately adjacent to the top of the chamber."

The project has enlisted scientists from disparate sources, including private industry, academia and both the Egyptian and U.S. governments. During the choice of drilling equipment, the planners fortuitously found Robert Moores, an amateur Egyptologist who works with Black and Decker Inc. in Towson, Md. Moores, who joined the team, selected a drill similar to the one used on the Apollo missions that can cut through the 5-foot-thick chamber roof without a lubricant. In order to prevent the drill from producing microfractures in the surrounding limestone, the team will run it at a relatively slow 375 revolutions per minute.


Dvak Arslanian, © NGS

Using a ground-penetrating radar, scientist map the contours of the interior of a sealed pit near the Great Pyramid of Khufu, or Cheops.

Moore also designed a special air lock that will be bolted onto the limestone roof to prevent any exchange of gas between the chamber and the outside air. Throughout the drilling, the team will periodically stop to purge the dust and rock fragments from the hole. Then, when the drill is within a few inches of the chamber, Moores plans to change from a carbide-tipped drill bit to a diamond-tipped one. With this tip, the drill bit will clamp onto the remaining plug and prevent this piece from falling into the chamber when the drill reaches it.

After taking air samples from several different depths, the crew will lower the cameras into the chamber. The remote-controlled video camera, which measures 3 inches across, has been modified from those that are designed to check inside nuclear reactors for cracks. Since an ordinary light source would raise the temperature of the chamber, the project members have selected a fiber-optic system with a heat source that remains outside the chamber.

Finally, the scientists will insert environmental sensors that monitor the temperature, the humidity and the concentrations of certain gases in the chamber. At present, the team plans to remove these sensors before plugging the hole back up, but El-Baz thinks they might leave the sensors inside the chamber in order to test whether they are successful in resealing the pit.

Many archaeologists have long awaited the opening of this second chamber, as it may contain a second boat or at least some clues to help reveal the function of the boat that has already been recovered. This team, however, has no plans to excavate the chamber, and will reseal the hole according to their agreement with the Egyptian government. Future projects may open the entire pit, when archaeologists can ensure that they will preserve the contents, says Hawass.

Of course, the project rests on the belief that the airtight seal of the pit has survived until now – an assumption that can be tested only by opening the pit. Despite the millennia of heat, wind, floods and even earthquakes, "there is a very good chance that the air inside is pristine," says Elie Rogers, project coordinator for the National Geographic Society.

The gypsum mortar used by the ancient Egyptians to seal both chambers is a crack-filling agent that expands when wet, says Rogers. As proof that it works, researchers cite the exceptional preservation of Cheops's wooden boat. And according to many accounts, when archaeologists opened the first chamber, they could even smell the resinous Lebanese cedar from which the boat was fashioned.

To test whether the seal has held, Pieter Tans, who does research for the National Oceanic and Atmospheric Administration (NOAA), will measure the relative amounts of carbon isotopes, which will indicate the age of the air.

Tans, of the University of Colorado in Boulder, is also planning to assay the chamber air for chlorofluorocarbons (CFCs), the ozone-destroying chemicals that have attracted much scientific concern during recent years (SN: 5/9/87, p.295). While many scientists believe that CFCs originate solely from human manufacturing processes, others maintain that natural sources such as volcanoes also release them into the atmosphere. The presence of CFCs in an otherwise uncontaminated sample of 4,600-year-old air would support the latter possibility, says NOAA's Machta.

Machta notes, however, that even if the chamber has escaped contamination from the outside, any organic material that rests within must have decayed slightly during the time immediately after burial, which would cause problems for the atmospheric scientists. This decomposition would have altered the levels of certain gases such as carbon dioxide, thereby skewing the portrait of the ancient atmosphere, although it will not prevent scientists from using the NOAA results to help preserve artifacts, says Machta.

In the end, whether or not the chamber's seal has remained intact, the project will have accomplished one of its primary tasks simply by testing these nondestructive archaeological techniques. "Once we leave and seal it, it will be as if nothing had even intruded," says Rogers.

With time, the new techniques might redefine archaeology, says Rogers: "I think that's the way the archaeology of the future will be – look, don't touch." If so, then this research philosophy will bring new resonances to an old museum phrase. □