



Spiritual walk. As this modern reenactment at a spiral geoglyph suggests, the Nasca culture used the desert lines in religious ceremonies.

ARCHAEOLOGY

Digging Into a Desert Mystery

A systematic campaign of aerial photography and archaeological digs has shed light on the enigmatic Nasca lines, massive designs created centuries ago on the desert floors of Peru

For almost a century, scientists have struggled to explain one of the best known and least understood ceremonial sites in the world. From 500 B.C.E. until approximately 650 C.E., the Nasca and Palpa valleys, 400 kilometers south of Lima, Peru, were home to a sophisticated culture that created massive designs by rearranging stones on the floor of the Atacama Desert. Ranging from spectacular animal and humanoid figures to trapezoids 2 kilometers across, the hundreds of so-called geoglyphs are easily viewed from the air. Some even suggested early on that the locals must have invented hot-air ballooning in order to create the intricate designs. And theories about their purpose have ranged from the somewhat scientific (astronomical charts, water maps) to the mystical (runways for alien spaceships).

Now, a decade-long effort by an international team of researchers is providing some answers. For archaeologists, the glyphs have been forbidding. So large they're nearly geographic features, the designs don't lend themselves to traditional archaeological methods. "Archaeologists are used to going somewhere, digging, and solving a specific historical problem," says Markus Reindel of the German Archaeological Institute (DAI), the project's co-director. "But the geoglyphs are huge objects. They're fascinating, but too much." To get a grip on them, the team employed a battery of high-tech equipment including laser scanners, carbon-dating technology, and even a 2-meter-long robotic helicopter.

At a meeting last month in Bonn, Germany, Reindel, DAI colleagues, and researchers from Peru, Germany, Switzerland, Austria, and elsewhere presented the results of their investigations. The geoglyphs, they reported, unquestionably served a ceremonial function; they were not simply massive pictures on the

desert floor. The team members also revealed unprecedented insights into the culture that created the famous Nasca lines—and the reason for its eventual decline. "It's an absolutely first-rate project. They're taking a smart approach to the lines," says University of California, Santa Barbara, anthropologist Katharina Schreiber. "It's the first time a section of the Nasca pampa has been subjected to that intensity of study."

Beyond the Chariots of the Gods

Although the Atacama region is extremely dry, with less than 0.5 millimeter of rainfall annually, between 1800 B.C.E. and 600 C.E., a progression of cultures culminating in the Nasca harnessed what little water there was to create agrarian societies. And beginning about 500 B.C.E., the region's people turned their artistic attention to the stony ground, which has a carpet of dark volcanic rocks atop a layer of lighter sand. Moving the top layer of rocks aside created high-contrast designs. It would have been a simple, if labor-intensive, project.

And the large designs wouldn't have required balloons or extraterrestrial assistance. Scientists over the years have come to the conclusion that a combination of tall posts, upright stones driven into the ground at regular intervals, string, and stakes were probably used to plot rough lines across the desert. The DAI team subscribes to this theory. "Making a geoglyph is easier than it seems," says DAI archaeologist Karsten Lambers.

The Nasca lines first attracted scrutiny from archaeologists in the late 1920s. About a decade later, American Paul Kosok began cataloging the lines while studying ancient irrigation systems. After his death, his German assistant, Maria Reiche, emerged as a charismatic advocate of the theory that the lines were ancient observatories that helped track the sun and stars.

The lines' fame brings with it unusual pressures. Call it the "Erich von Däniken effect," for the Swiss author of the 1968 book *Chariots of the Gods?* who made the lines a centerpiece of his theory that aliens influenced ancient cultures. Von Däniken's book made the Peruvian coast a focus of New Age theorists everywhere. "No archaeologist wanted to follow von Däniken. They'd just get their fingers burned," says Lambers. "When you work on the lines, everybody's watching you, everybody has their opinions."

Peruvian officials and academics have responded by cracking down on research in the area. "Anyone looking in or near the area of the Nasca lines is under extra scrutiny. They're very self-conscious about it," says University of Massachusetts, Amherst, archaeologist Donald Proulx. Archaeologists applying for permits to work in the country must go through a lengthy and expensive review of their credentials and publications.

Beginning in 1997, with funding from the Swiss-Liechtenstein Foundation for Archaeological Research Abroad, a team of archaeologists led by Reindel (then at the University of Bonn) and Johny Isla of the Andean Institute of Archaeological Research in Lima, Peru, overcame the red tape to begin a multipronged attempt to unravel the Nasca's secrets. "It was perfect for Germans; we really like to document things before we analyze. Data collection plays a big role for us," says Reindel.

Working in the Palpa Valley, which is not as well-documented as the Nasca Valley just to the south, the researchers set out to create a detailed survey of everything from settlement sites to geoglyphs. In addition to traditional ground surveys and test excavations, they used a small plane to take high-resolution black-and-white photographs of the designs

that cover the valley floor—photos good enough to make out individual stones pushed aside to make the geoglyphs.

The project's potential as a test bed for technology attracted the attention of the German Federal Ministry of Education and Research, which began funding the effort in 2002. Soon archaeologists, engineers, computer-imaging experts, and physicists from Germany, Peru, Austria, and Switzerland were visiting the Palpa Valley to test new methods on the desert plain. Experiments included attempts to date the stones based on their underside's last exposure to light and creating detailed aerial maps of specific sites using the robotic helicopter. All the equipment was a challenge to get through Peruvian customs, but the helicopter almost didn't make it at all—Lambers had to get permission from the country's suspicious aviation authority to bring the drone into Peru.

Working with Armin Gruen and his group of photogrammetrists from the Swiss Federal Institute of Technology (ETH) in Zurich, Reindel and Lambers turned the black-and-white photos into a three-dimensional digital model of the valley's topography. Lambers and ETH photogrammetrist Martin Sauerbier then used geographic information systems (GIS) to add layers of other information on elevation and topography to the digital model of the geoglyphs. "With the GIS model, we can calculate visibility index for every point in the terrain," Lambers says.

Far from the glyphs being invisible or incomprehensible to people on the ground, the model suggests that activity on the lines—people walking or conducting ceremonies, for instance—would have been visible far and wide. Spectators standing on neighboring glyphs or at nearby sites would have been able to observe or perhaps participate in valley-wide ceremonies.

Combining the digital efforts with traditional archaeological methods revealed even more. Excavations uncovered platforms and small buildings situated at the ends of large linear geoglyphs. Holes up to 60 centimeters deep situated near the platforms suggest masts or poles several meters tall that served as orientation points in the desert; other, shallower holes might have supported canopylike roofs. Broken pottery and ample evidence of offerings and sacrifices—including guinea pigs, corn, crayfish, and *Spondylus princeps* seashells from thousands of kilometers away—indicate that the sites had a religious function. "It's very clear; the geoglyphs were ritual terrain for water and fertility ceremonies," says Reindel. "They were locations, not pictures."

A royal surprise

The scientific team also devoted significant attention to the people who created the geoglyphs. Researchers had long assumed that Nasca culture lacked a strict hierarchy, because most of the graves found were fairly modest. Beginning in 1998, however, Reindel and Isla uncovered a royal necropolis while excavating a site called La Muña. Although long since looted, the elaborate grave chambers were as much as 6 meters deep and once filled with pottery and other grave goods. The necropolis was strong evidence that the Nasca had a much more organized class system than previously thought.



Lined up. In addition to massive geometric designs (above), Nasca geoglyphs often depicted animals such as birds and monkeys.

The comprehensive look at the Palpa Valley sites—more than 650 settlements were documented—revealed clues to another mystery: What happened to the complex culture that created the lines? Research by Bernard Eitel, a geographer at the University of Heidelberg in Germany, suggests it may have been doomed from the start. About 500 B.C.E., the region's climate began to grow steadily drier. Whereas pre-Nasca peoples lived in the valley basins, grazing their animals on grass and taking water from rivers that flowed down from the highlands, the dawn of the Nasca period around 200 C.E. marked a shift inland. As rivers dried up, the grasslands disappeared, and the desert crept east, people moved toward the mountains, following scarce freshwater supplies. "They moved [farther inland] little by little, because year by year water was difficult to find," Isla says.

In the end, the region's persistent droughts proved to be too much. Carbon dating shows that older settlements were regularly abandoned for new ones in the highlands. By 650 C.E., the culture had essentially dried up.

The German researchers plan to begin publishing their data next year, and they hope to conduct further studies on sites in the highlands to see what interactions the Nasca might have had with cultures on the other side of the Andes. Other archaeologists are already praising the project as a resource. The extensive documentation also "preserves the geoglyphs for future generations of scholars," says Kevin

Vaughn of Purdue University in West Lafayette, Indiana.

Preservation is badly needed. As the region's population grows, the centuries-old glyphs are under threat. In 1994, the United Nations Educational, Scientific and Cultural Organization chose the lines as a World Heritage site deserving protection. Modern copies of the ancient glyphs also contaminate the region more and more: Stones that were so easy for the ancients to rearrange are no less tempting for the area's current residents. "People go up to the hills and draw their names, or the name of their girlfriend," Lambers says. Local businesses and even political parties have begun using the slopes as free billboards. Not quite as mysterious as the Nasca lines, but perhaps less likely to be mistaken for alien runways in the future.

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