

CHINA

Archaeologists Seek New Clues to the Riddle of Emperor Qin's Terra-Cotta Army

XI'AN, CHINA—In life, he subdued China's warring states and became the country's first emperor. In death, he brought an army to heaven to perpetuate his rule. Since the stunning discovery of Emperor Qin Shihuang's tombs 35 years ago, archaeologists have unearthed about 1300 life-size terra-cotta soldiers and horses and a wealth of other artifacts that illuminate the brief but world-changing Qin Dynasty 2200 years ago. Last month at the renowned site, archaeologists began the latest round of excavation in a pit untouched for 2 decades. They hope to penetrate lingering puzzles about the Qin Dynasty, and they will test a new method of preserving the terra-cotta warriors' exquisitely perishable hues.

Perhaps the biggest mystery is why Qin led an army into the afterlife. "We've never found anything like it in the tombs of earlier kings," says the excavation's executive director, archaeologist Xu Weihong of the Museum of the Terracotta Warriors and Horses of Emperor Qin Shihuang here. There are several theories, including a popular one that Qin believed his army would awaken and empower him in the spirit world. Supporting that idea, archaeologists have uncovered only real weapons—no facsimiles—interred with the soldiers. But the



evidence is not decisive. "The larger question of the significance and purpose of burying life-size replicas of Qin soldiers remains, in my opinion, largely unanswered," says Jeffrey Riegel, an East Asia scholar at the University of Sydney in Australia.

Contemporary accounts paint a broad-brush view of Qin Shihuang's life. Born in 259 B.C.E., the future emperor, Ying Zheng, ascended to the throne of Qin State when he was 13. Nine years later a regent ceded him power, and the young monarch was soon tested by internal revolt. Ying pacified Qin and then proceeded to conquer China's other six states. He proclaimed himself emperor and took the name Qin Shihuang in 221 B.C.E.

After unifying China, Qin Shihuang set out

to modernize it. Annals recount how he abolished the feudal system, built roads to China's far corners, and standardized weights, measures, and handwriting. During his reign, hundreds of thousands of laborers erected much of the Great Wall and scores of palaces. Legend has it that in his 40s, the emperor grew obsessed with death and searched for an elixir of immortality. But he failed to even attain old age: Qin died when he was 50. In the power vacuum that followed, rival armies vied for control of the empire. The victor was Liu Bang, founder of the Han Dynasty.

Soon after Qin took power, he began preparing for the afterlife. Construction of his mausoleum at Mount Li, 35 kilometers east of Xi'an, took 38 years. The mausoleum, once crowned with pavilions, was never a secret, and even today it is visible as a kilometer-long wooded mound that rises a gentle 75 meters above the surrounding land.

Nearby, one of archaeology's greatest surprises lay hidden for centuries. In March 1974, farmers digging a well discovered pottery fragments about 1.5 kilometers east of the mausoleum. Excavations revealed the smashed-up remains of Qin's terra-cotta army—8000 clay soldiers and horses, researchers estimate—arrayed in three vast pits.

Over the centuries, fire and floods bled many warriors of their original colors. Past excavations unearthed some figures with intact paint, but within minutes after exposure to air, the paint would peel off and reveal the dull-gray

PALEOANTHROPOLOGY

Still Seeking Peking Man

ZHOUKOUDIAN, CHINA—On a sweltering late June day, Zhang Xiaoling hunches under a makeshift canvas roof over one of Asia's most famous Stone Age sites. It's roasting in the shelter, but Zhang, a stone-tools specialist at the Institute of Vertebrate Paleontology and

Paleoanthropology (IVPP) in Beijing who just earned her Ph.D., is grinning from ear to ear. "I think we'll find something soon," she says. "I'm so excited."

Last week, work commenced on a new excavation here in the cave-riddled hills of Zhoukoudian, 50 kilometers southwest of Beijing, where early last century scientists discovered Peking Man: a trove of *Homo erectus* fossils as well as rudimentary tools and the bones of woolly rhinos and other Ice Age fauna. The new dig aims to both stabilize the iconic site and unearth evidence that could influence simmering debates, such as whether Peking Man was a hunter or a scavenger and whether the hominin tamed fire.



Perilous perch. The excavation will take place at the edge of an unstable 40-meter-high cliff.

"I strongly support new excavations," says paleoanthropologist Russell L. Ciochon of the University of Iowa in Iowa City. "For too many years, Zhoukoudian has been treated more as a shrine rather than a valuable paleoanthropological site."

Peking Man (now called Beijing Man in Chinese) has a storied history. European scientists discovered a few ancient teeth here at Dragon Bone Hill in the 1920s before archaeologist Pei Wenzhong made a stunning find in 1929: a nearly complete skull. Up until the Japanese invasion in 1937, Pei and others unearthed some 200 bones, including five more partial skulls—all of which vanished during World War II—and thousands of pieces of worked stone. In a paper last March in *Nature*, IVPP Vice-Director Gao Xing and colleagues used the ratio of aluminum-26 and beryllium-10 in quartz crystals to date the Peking Man strata to 680,000 to 780,000 years old, about 200,000 years older than previously thought.

The new excavation is in a 20-square-



Everlasting army. Pieced-together terra-cotta warriors on display at Pit 1.

fired clay. The loss was more than aesthetic. For example, one warrior's face was different from the rest: Instead of the usual cream-colored pigments, it was painted a garish green. "We think he was a kind of wizard meant to terrify the enemy," says Rong Bo, an analytical chemist and conservation scientist at the museum. Because such tantalizing clues flaked off before their eyes, archaeologists sharply limited further excavations.

In the meantime, Rong and others set out to crack the riddle of the brittle pigments. Working with experts from the Bavarian State Conservation Office in Germany, the museum researchers determined that Qin artisans ground up semiprecious stones, such as azurite

and malachite, for the pigments. The much-admired "Han purple," they found, is a mixture of barium copper silicate and a dash of cinnabar. Pigments were applied after fired figures were glazed with two layers of *qi* lacquer. The collaborators also figured out why the warriors have a bad case of peeling: Xi'an's bone-dry air shrinks the lacquer.

Hoping to prevent shrinkage, scientists tried every off-the-shelf adhesive they could lay their hands on. Nothing worked. "It was so frustrating," says Rong. Finally, they hit upon two solutions. One employs polyethylene glycol (PEG), used in everything from laxatives to skin creams. Short-chain PEGs penetrate the lacquer's tiny pores, replacing water that would

have evaporated out, and a poly-methacrylate dispersion helps keep the lacquer adhered to the clay. In a second technique, a compound called Plex 6801-3, a sealant for sewage pipes containing 2-hydroxy ethyl methacrylate, works its way into the lacquer and is hardened by electron beam irradiation. But preventing the terra-cotta warriors' colors from fading remains a major challenge, independent experts say.

After reviewing the new methodology, the State Adminis-

tration of Cultural Heritage certified the museum to resume excavations. The museum is going it alone, having ditched its earlier partner, the Shaanxi Institute of Archaeology. (A Qin expert formerly with the institute declined to speak with *Science*.) The new dig at the UNESCO World Heritage site is attracting intense scrutiny from authorities and the public. "We feel a heavy responsibility on our shoulders," says Xu.

Work is now under way at Pit 1, the biggest of the three and until last month undisturbed (apart from hosting millions of tourists) since 1986. By the end of the year, 200 square meters will be excavated; the plan is to complete 2000 square meters in 5 years. Workers frequently sprinkle water on the soil to protect relics. Xu's aim is not to raise the tally of disinterred warriors but to find artifacts that could help researchers understand Qin funerary practices. "Digging up more soldiers is not in the least bit interesting," she insists. "They really provide little information about that time."

Soon after the Qin Dynasty fell, annals say, the king of Chu State raided the tombs and torched their wooden rafters. His forces also razed the palaces and pavilions around the mausoleum but evidently failed to penetrate the mausoleum's inner sanctums. Annals tell of treasures there that would make King Tutankhamen look like a pauper, including a ceiling studded with jewels representing celestial bodies and flowing "rivers of mercury" representing China's great rivers. Archaeologists have peered inside with equipment such as ground-penetrating radar and have measured intriguingly high mercury levels in the soil. But the heritage administration forbids any digging at the mausoleum, and Xu insists she's not curious. "Not in 100 years will it be opened," she says. Rong, looking on, smiles. "I'm curious," he says. "But we have to leave something for future generations."

—RICHARD STONE

meter section of the western end of Site 1, where remains of some 40 *H. erectus* individuals have been unearthed. One objective is to stabilize the site, perched on the edge of a cliff and at risk of collapse, says Gao, the project leader. The first 2 months will be spent removing a hazardous outcropping. Team members will be roped like mountain climbers. "It's very dangerous to work here," Gao says.

Gao is downplaying expectations of what he describes as a salvage archaeology operation. The biggest prize, he says, would be a skull: It would be "sheer luck" to find one, he says. Only casts remain of the missing skulls. Gao says he would be happy with a jawbone, which could clarify evolutionary relationships with other hominin subspecies, or finger bones, which could shed light on Peking Man's dexterity for

fashioning tools. Researchers also hope to examine stone tools in situ. A better understanding of the timeline of hominin occupation "may be more important than the discovery of isolated fossils," Gao says.

Excavations will continue through October. Outside the glare of that spotlight, Gao and others are planning field surveys and excavations at localities across China under a 5-year, \$2 million project funded by the science ministry. Gao is eyeing one site in particular: a cave in Jianshi in central China's Hubei Province, dating to more 1 million years ago. "It has great potential" to yield *H. erectus* fossils, he says. Of course, they would have to be especially dazzling to nudge Zhoukoudian and Peking Man off center stage.

—RICHARD STONE



Under no illusions. Finding a skull would be sheer luck, says Gao Xing.