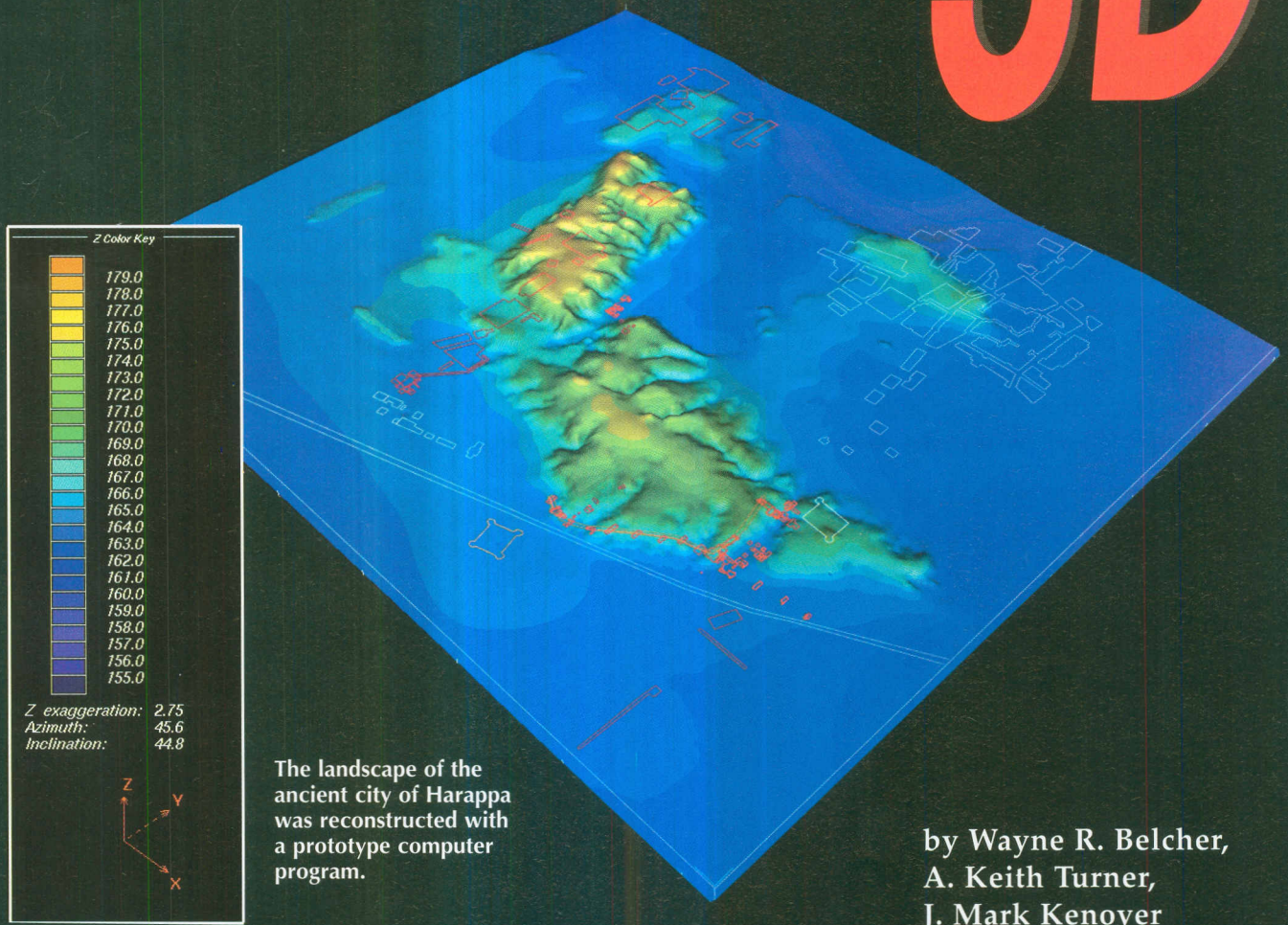
HARAPPA IN 3D

A Powerful New Tool Rebuilds the Past in the Indus Valley



The landscape of the ancient city of Harappa was reconstructed with a prototype computer program.

by Wayne R. Belcher, A. Keith Turner, J. Mark Kenoyer

The buried, ruined debris of a once-proud civilization rises for the first time in nearly four millennia – this time on a computer screen. The mud-brick city walls part at the towered gateway to Harappa, one of the earliest and grandest cities of the Indus Valley Civilization (2600-1900 B.C.). Sturdy rooms flanking the gate may once have held guards or city officials. A 3D image displays the gateway as it may have looked before the centuries hid it beneath the earth.

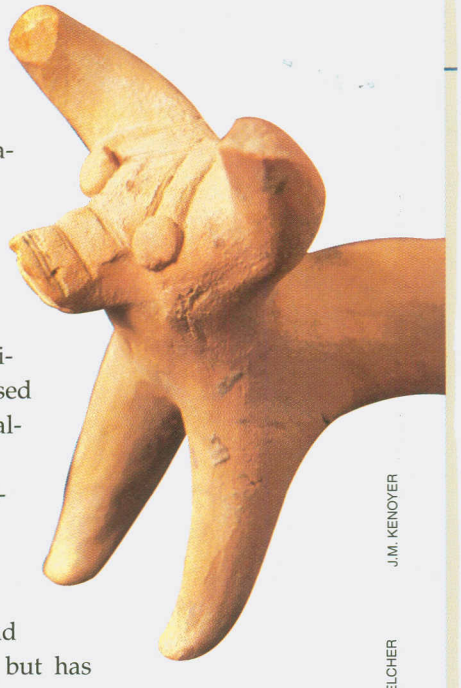
Another screen shows the ever-changing landscape before the city-builders arrived about 3300 B.C. in what is now the Punjab Province of northeastern Pakistan. The scene shifts and grows to reflect the restless river's changing paths and the digging, building, and mounding of people and nature. The images show the land as it was for each of the major phases of the Harappans' evolving culture – until it achieves the series of broad mounds that today punctuate the flatness of the Ravi River delta.

Overlain on the 3D topography are the trenches and excavations of archaeologists who have been probing and puzzling over the famous ruins since 1876. The image also displays the homes and buildings of the current town of Harappa. And all of it is linked – at measurement scales ranging from centimeters to kilometers – to a database that holds a representative amount of the accumulated archaeological knowledge of the site.

One of our team, Wayne Belcher, a federal-agency hydrologist, used technology derived from geoscience to develop new approaches and tools for reconstructing in three dimensions the chronological sequence of the site and the excavations made there. The result is a prototype "geoscientific information system" (GSIS) that offers new methods of data management for complex archaeological sites. Models and visualizations included a site-wide model of the topography (of today and of 5,000 years ago), 3D models of archaeological structures, and models of selected archaeological trenches.

Accurate 3D images give archaeologists an almost real-world view of their site, both the way it is now and how it might have been. Experience, intuition, and insight come into play with images in ways that they rarely can with streams of numbers or topographic lines. The visualizations also allow multiple data sets to be combined for hypothesis testing and interpretation, as well as for planning excavation strategies. And as new evidence is collected, it can be used to quickly update the visualizations and reconstructions.

Complex geologic modeling with three-dimension visualization has been used effectively for petroleum and mining exploration and for environmental research, but has rarely been applied to archaeology. We chose the Harappa site as a test case for this 3D-mapping and data-analysis software because of its long history of occupation and the wealth of new data collected by the Harappa



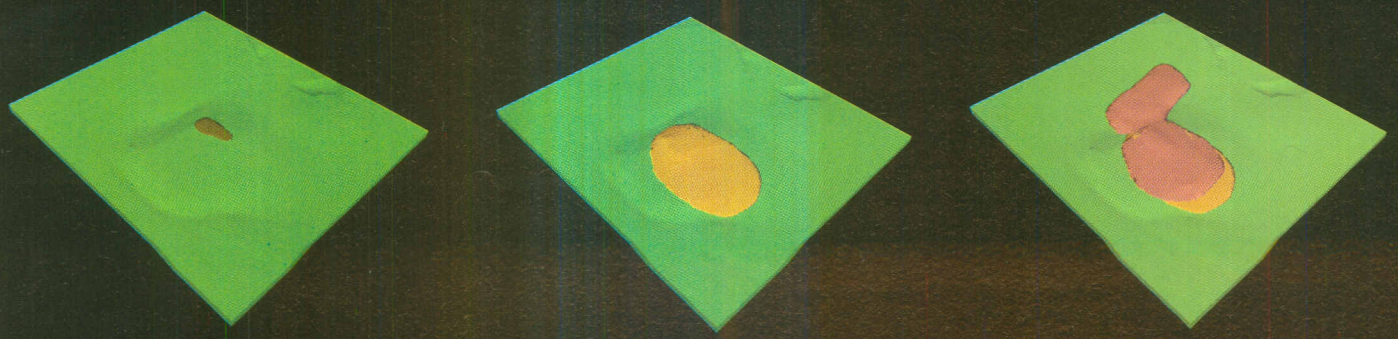
This terra cotta bull figurine was found at the Harappa excavation.

DIGITAL IMAGES BY WAYNE R. BELCHER J.M. KENOYER

Recreating the Landscape

Harappa's mostly flat modern landscape is punctuated by a series of mounds, built or exaggerated by generations of humans trying to protect their cities from floods of the Ravi River. Prominent gullies between the mounds apparently are remnants of roadways. Data from current and previous surveys were digitized and exported to the EarthVision program to create a digital model of the terrain.

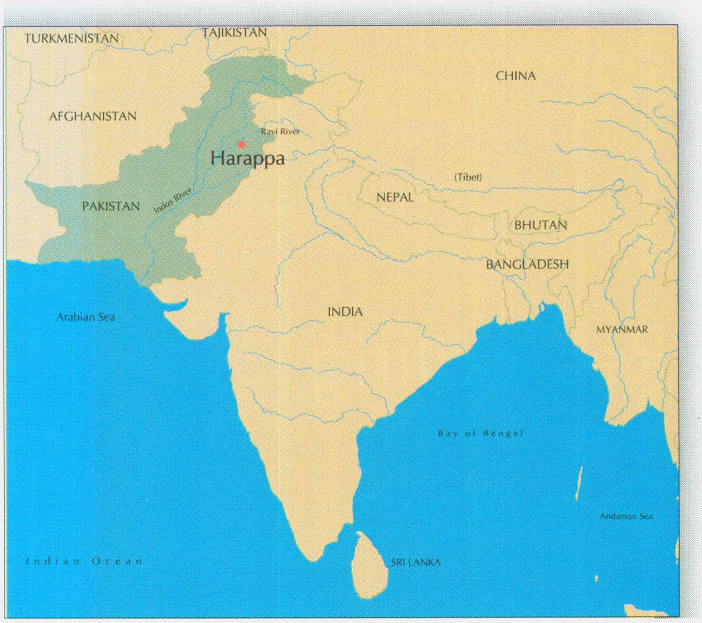
Modeling the stratigraphy – the subsurface layers of earth – began with the paleotopographic surface: the landscape as it may have existed 5,000 years ago. HARP provided natural soil elevations from excavations and borings, but only at a few locations. Our interpretation of the paleotopogra-



Archaeological Research Project (HARP).

Rising above the surrounding plain, the site of Harappa consists of several large mounds of cultural remains bordered by scatters of debris left by erosion and residents, who salvaged material for remodeling. Named after the modern town of Harappa, which occupies about a third of the ancient city, the site is on the south bank of the Ravi River, a tributary of the Indus. The Bronze Age Indus Valley culture evolved from earlier Neolithic communities in Pakistan and northwestern India as early as 6500 B.C.

The initial excavations at Harappa date back to the 1870s, but the first major work came during the 1920s and '30s. These excavations revealed the importance of this site for understanding the nature of early urban centers, but the full significance of Harappa was not appreciated until recently. In 1986, a long-term investigation was initiated by G.F. Dales at the University of California-Berkeley and J.M. Kenoyer of the University of Wisconsin-Madison. In 1992, this project became the Harappa Archaeological Research Project under the direction of Kenoyer, R.H. Meadow of Harvard University, and R.P. Wright of New York University. HARP excavations are



conducted in collaboration with Pakistan's Department of Archaeology and Museums.

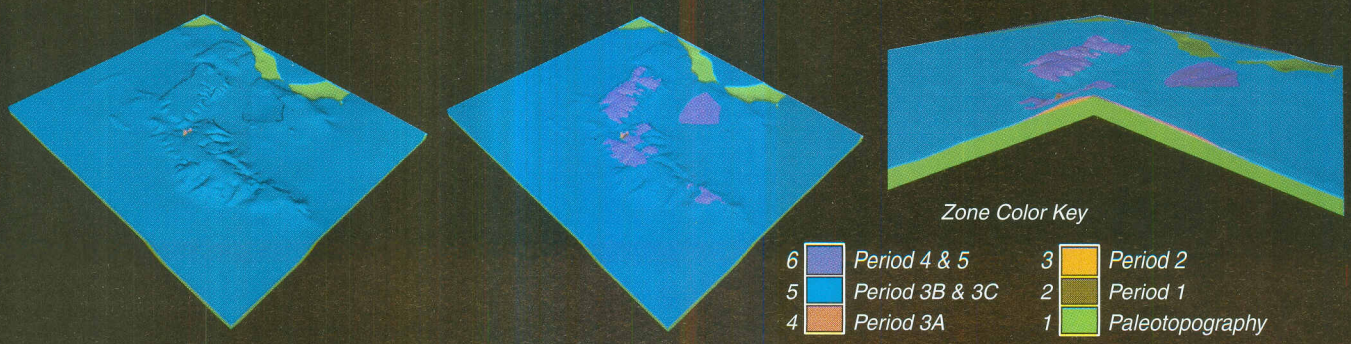
Based on HARP excavations and radiocarbon dating, the archaeological chronology for the site can be broken up into five major periods:

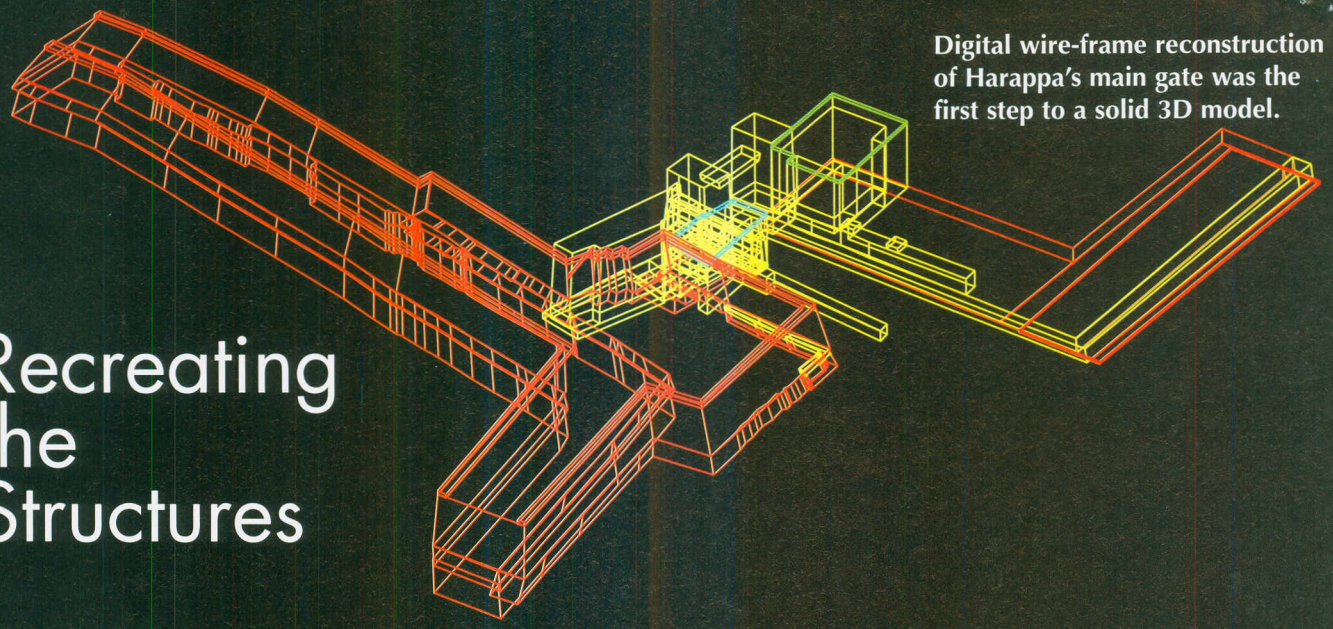
phy was built by combining "hard" numerical data on natural soil elevations with "soft" data – from geomorphic models, soil distributions, and professional judgment – which were needed to bridge the distance between the excavation points.

Ancient Harappa likely was built on a meander bend of the Ravi River, probably a point bar or natural levee. Two high areas were present on the original terrain: at the initial occupation site and beneath the modern town of Harappa. These apparently reflect actual paleotopography. Other, significantly lower soil levels resulted from excavation by the ancient Harappans, who used vast amounts of mud-brick for housing platforms and the massive walls that encircled all of the major mounds.

Most of the materials that form the mounds were deposited there, intentionally and unintentionally, by the site's inhabitants. The city literally was built upon the foundations of its ancestors.

Our stratigraphic layers comprise cultural deposits of each occupation stage: Periods 1, 2, 3A, 3B/3C, and 4/5. The elevations for each layer were digitized from excavation data. That was combined with information on the lateral extent of each deposit. EarthVision's "Geologic Structure Builder" allows users to model and image complex geology by using various geologic rules to specify how one surface interacts with others.





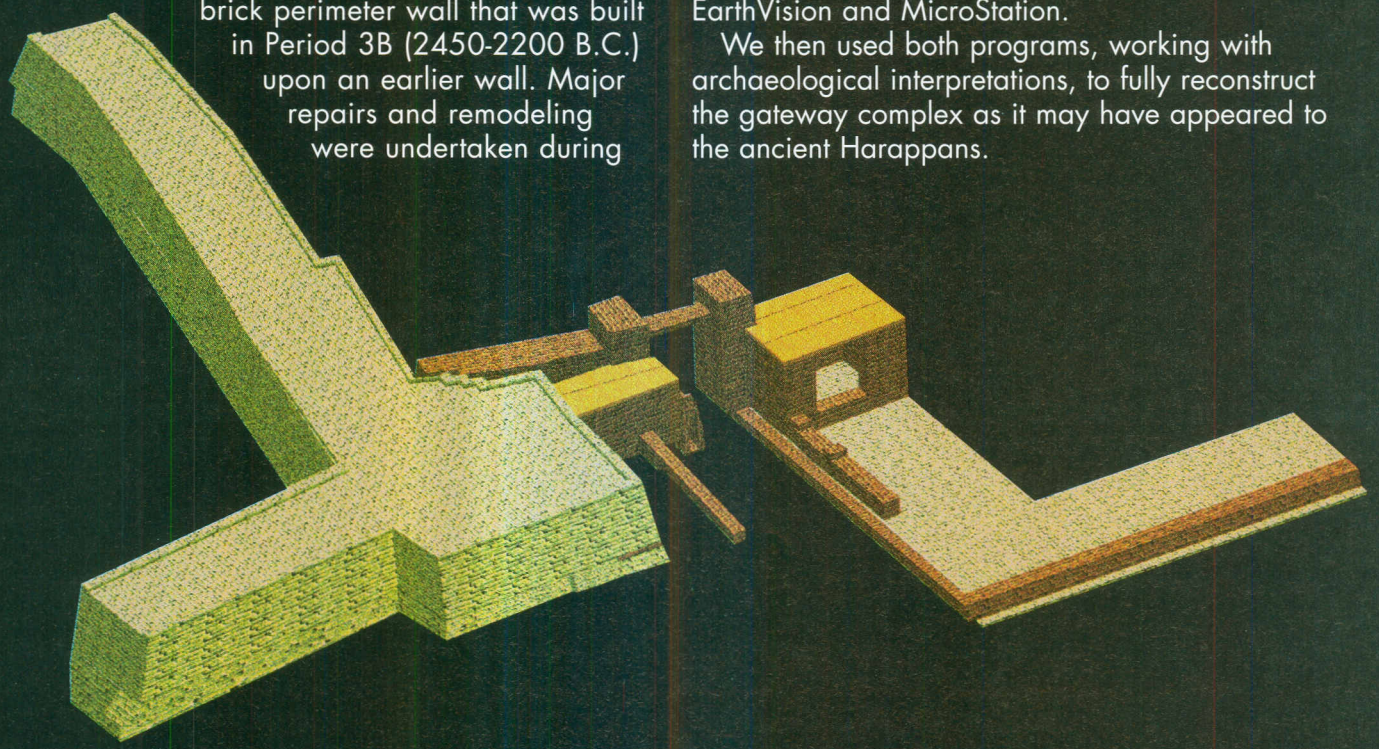
Digital wire-frame reconstruction of Harappa's main gate was the first step to a solid 3D model.

Recreating the Structures

Archaeologists attempt to recreate ancient sites as part of their interpretation process. Reconstructions force them to question the function of structures and provide visual clues to their use. To demonstrate the potential of our prototype system for digital reconstructions, we chose a gateway complex at the southeast corner of the largest of the mounds. The gateway is part of a mud-brick perimeter wall that was built in Period 3B (2450-2200 B.C.) upon an earlier wall. Major repairs and remodeling were undertaken during Period 3C (2200-1900 B.C.).

The gateway, with a main street 2.6 meters (8.5 feet) wide, probably was the main entrance to this part of the city. It is located between two baked-brick piers that connect to the massive perimeter walls. Side rooms flank the gate, and a culvert or drain runs through its center. Digital models of what currently remains of the structures were built in EarthVision and MicroStation.

We then used both programs, working with archaeological interpretations, to fully reconstruct the gateway complex as it may have appeared to the ancient Harappans.



This 3D image of the gateway is covered with scanned and scaled pictures of bricks used in building Harappa.

The main gateway into Harappa was envisioned as it probably looked about 4,300 years ago by artist Chris Sloan. A drainage ditch split the main roadway, which was 2.35 meters (7.7 feet) wide.

The archaeological excavation that exposed the various structures of the Harappa gateway provided much of the data used to digitally reconstruct the original edifice.

IMAGES COURTESY OF J.M. KENOYER

• Period 1: Around 3300 B.C., a small village was established on what appears to be an old, bypassed meander (or ox bow) of the river.

• Period 2: By 2800 B.C., this settlement had expanded to an area of more than 25 hectares (62 acres) with some portions of the settlement standing two to four meters (6.5 to 13 feet) above the plain.

• Period 3: From 2600 to 1900 B.C., the settlement grew rapidly, both horizontally and vertically. All major mounds were surrounded with massive mud-brick walls and were in some cases reinforced with baked brick. The highest portions of the mounds stood 16 meters (52 feet) high, and scattered occupations outside the walled areas extended the city to over 150 hectares (370 acres).

This ancient figurine was recovered from the Indus Valley.

• Periods 4 and 5: The site saw no additional expansion from 1900 to 1700 B.C., but more intense use of urban space and then the slow decline of the city.

Translating the wealth and complexity of archaeological data into databases, models, and images involved the use of Dynamic Graphics Inc.'s EarthVision software on a Silicon Graphics workstation and Bentley Systems' Microstation 95 software on an Intergraph workstation. The database was built in Microsoft's Access. □

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