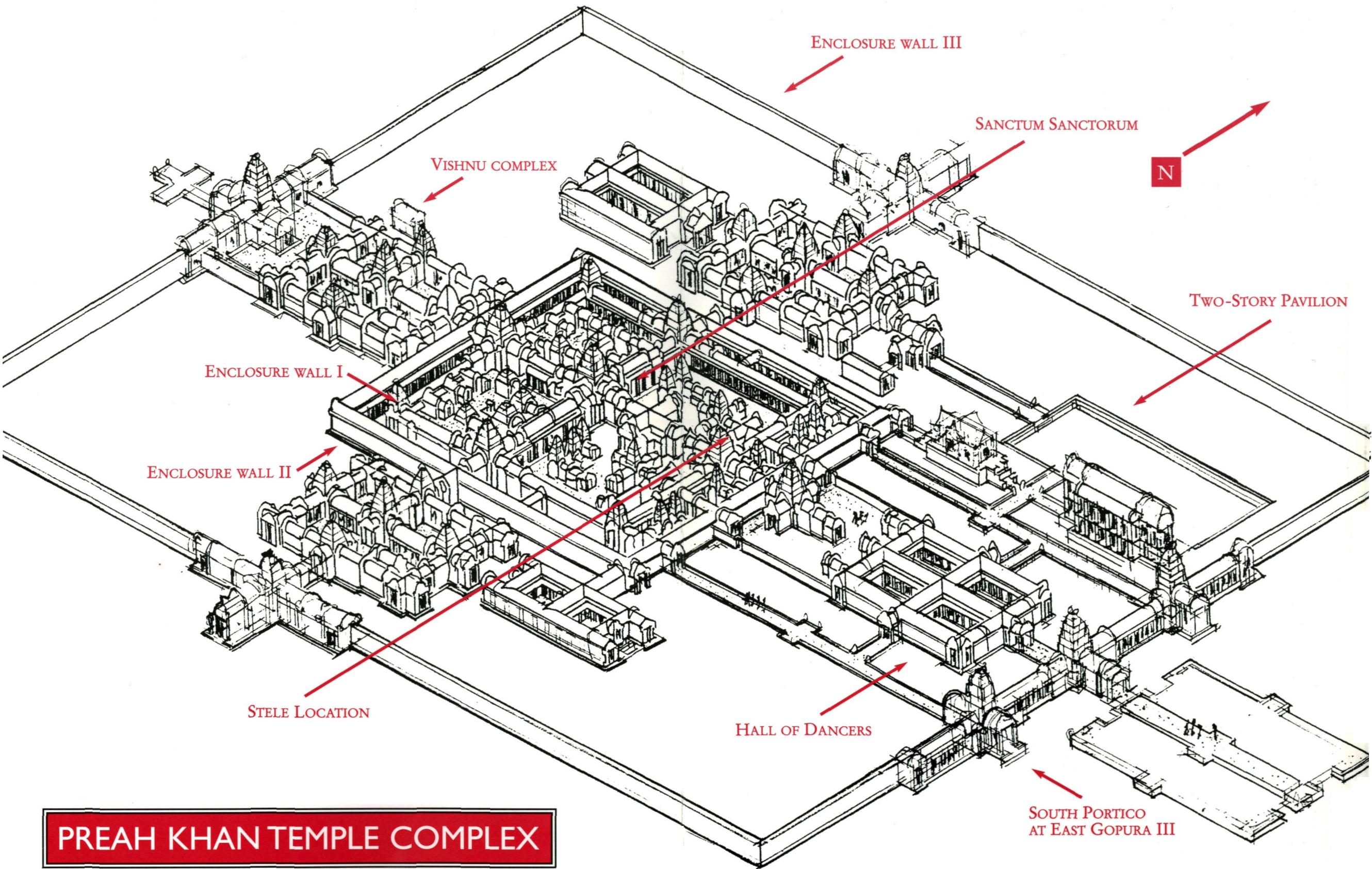


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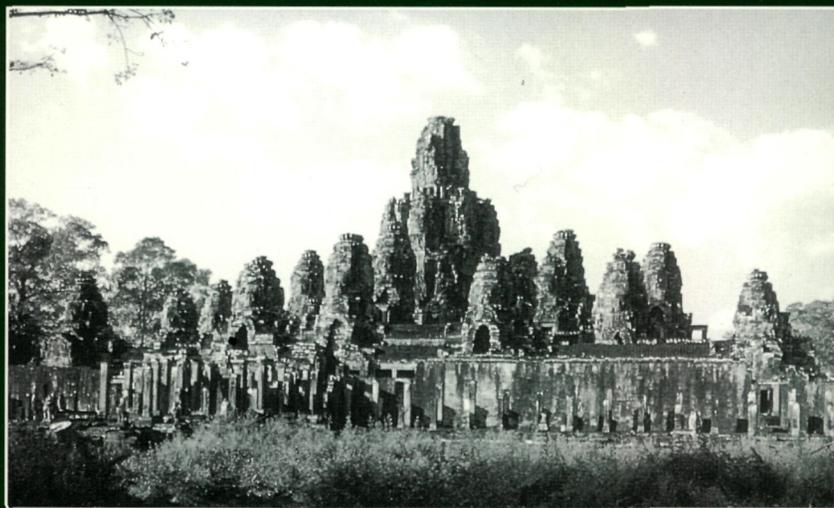
PRESERVATION PRIORITIES:
THE ANGKOR CHALLENGE





PREAH KHAN TEMPLE COMPLEX

WORLD MONUMENTS FUND



PRESERVATION PRIORITIES:
THE ANGKOR CHALLENGE

TEXT BY KEITH EIRINBERG

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PREAH KHAN FACTS



FOREWORD

In 1995 the World Monuments Fund reached the halfway point of a 10-year program at Angkor. WMF's initial field mission in 1989 was one of the first visits of western experts to Cambodia after almost two decades of civil war, genocide, and chaos. Our mission team surveyed Angkor and discovered that the magnificent temples there had been relatively unaffected by the war. Rather, it was the people of Cambodia who had suffered great deliberate destruction—almost the entire educated population eradicated, and the universities and libraries destroyed.

WMF's main priorities at Angkor are to train a new generation of Cambodians to care for and manage the complex, and to bring contemporary conservation methodologies and technologies to Cambodia in order to solve the unique problems of this vast site. Preah Khan has become a model project for developing conservation techniques that can be applied at other Khmer sites throughout Cambodia.

As this booklet goes to press in December 1995, we see our work paying off. The first of WMF's student trainees is en route to the Frank Lloyd Wright School of Architecture for a year of graduate work. By the time WMF's program at Angkor concludes, several more of our student protégés will have furthered their educations abroad and returned to their homeland. This new generation will then be ready to continue the work of preserving Angkor. For the Cambodian people this site has many levels of meaning—it is a symbol of identity, a touchstone of the past, and a basis on which to build a future. Restoring the Angkor monuments is therefore fundamental to the restoration of peace and prosperity to Cambodia and its people. Our vision at Angkor is being realized through the hard work of our international team consultants—the project manager at Preah Khan, John Sanday; conservation architect Kevin Lee Sarring; engineer and seismologist Predrag Gavrilovic; botanist Ronnie Yimsut; and stone chemist Frank Preusser—brought together under the steadfast coordination of WMF's director of programs John Stubbs and program administrator Felicia Mayro.

WMF gratefully acknowledges the support of its host, the Royal Cambodian Government, and in particular His Majesty King Norodom Sihanouk; H.E. Van Molyvann; H.E. Son Soubert; H.E. Nouth Narang; and the other members of the government. WMF also extends its gratitude to APSARA, the national authority established to manage and protect the Historic City of Angkor. To the local staff in Siem Reap, WMF extends its sincere appreciation. We congratulate and thank everyone warmly.

Marilyn Perry
Chairman

Bonnie Burnham
Executive Director

ANGKOR OVER TIME



ABOVE: ANGKOR WAT, west entrance inside first enclosure

BELOW: ANGKOR WAT, colomade

BOTTOM: THE BAYON, detail



Amidst the lush tropical jungle in northwest Cambodia near the great lake called the Tonle Sap lies Angkor, the ruins of a grand civilization that flourished between the 9th and 15th centuries A.D. Renowned in its time as a major religious center and the capital of the Khmer empire, Angkor is no less famous today. Cambodians view Angkor with pride as the site of the glorious reign of their forebears, while Cambodians and foreigners alike, impressed by the scale, scope, and artistry of the monuments, hail it as one of the

“wonders of the world.”

Since the 19th century, scholars have attempted to understand the rise and fall of the Khmer civilization at Angkor. Many mysteries remain.

What We Do Know

The monuments and the written record provide clues to the history and the nature of the Khmer civilization at Angkor. They provide a chronology and portrait of the rise of the Khmer empire from the monarch Jayavarman’s ascent in A.D. 802 to the great construction boom of Jayavarman VII (1181 – ca. 1220). The stelae (inscribed stone slabs), bas-reliefs, statues, and artifacts provide significant details of the reign of kings, as well as accounts of battles, religious beliefs and practices, governmental administrative matters, the lifestyle of inhabitants, and even fashions in dress and hairstyle.

What We Don’t Know

The abandonment of Angkor is not well documented. Few written records from the 14th to the 16th centuries exist that definitively



ANGKOR WAT, dancer

explain the movement of the capital from Angkor to Phnom Penh or the major shift in the nature of Cambodian society.

OTHER FUNDAMENTAL QUESTIONS REMAIN:

At the height of its glory, how did Angkor support over a million people?

Angkor's ruins reveal the existence of a vast, sophisticated hydrological system. How did it operate?

How long did it take to build the temples?

How was agricultural production organized?

What caused Jayavarman VII to engage in an expansive building program? What was the purpose and meaning of his various public works?

Misinformation about Angkor

Angkor's history has been clouded by misinformation:

FICTION: Angkor was discovered in 1860 by the French naturalist and explorer, Henri Mouhout.

FACT: Angkor was never lost. It was just unknown to most Europeans. While foreign travelers and missionaries had been aware of or had visited Angkor in the preceding centuries, it was not until Mouhout's account was posthumously published between 1863 and 1868 that "Angkor's magnificent ruins" sparked the imagination of the West. The ancient capital had not completely succumbed to the jungle when Mouhout arrived. Angkor Wat and some of the other temples had been used continuously for religious purposes after the capital was abandoned following the Thai invasion of 1431. Nevertheless, Mouhout was soon touted in Europe as Angkor's discoverer.

FICTION: Armed conflict around Angkor in the 1960s and 1970s seriously damaged the monuments.

FACT: Angkor was sometimes used as a sanctuary by warring parties. The few bullets and shells that did come into contact with the monuments had little impact, causing superficial damage to the surface of the stones. Generally, there was no willful destruction of the monuments during that time.

"Next Day I went to Angkor. At once I left the contemporary world and plunged a thousand years back into history,"

— From *Malcolm MacDonald, Angkor, London: Jonathan Cape, 1958*



BANTEAY SERI, sculpture relief

ANGKOR BUILDING TYPES

There are no visible remains of the Khmer civilization from the Angkor period except for temples and civic works, such as the embankments, *barays* (reservoirs), canals, bridges, and defensive walls.

Nevertheless, the stone legacy of that era provides valuable information about the evolution of Khmer architecture and building technologies, and reveals the variety and types of materials used in construction.

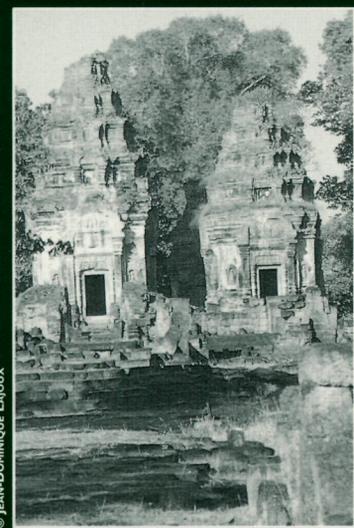
Architectural Evolution

Architecture at Angkor evolved over four distinct periods coinciding with the reigns of certain kings: Pre-Classical (802 – 921), Transitional (921 – 968), Classical (967 – 1181), and Late Classical (1181 – 1295). Throughout these years, the style used by the Khmers often borrowed elements from sacred Indian architecture.

Noteworthy developments during these periods include: the construction of plastered brick *prasats* with sandstone embellishments and simple Indian-inspired decorative motifs (Pre-Classical period); the switch to laterite as a prime building material and sandstone for decorative purposes; and the innovation of “library” designs and the triple form of the frontons positioned over the doorways at Banteay Srei (Transitional period); the creation of terraced pyramids and eastward-oriented, stone-vaulted galleries, with more refined decoration; and the use of inner enclosures, such as seen at Angkor Wat (Classical period); and the sophistication and aesthetic qualities of the many temples and structures built by Jayavarman VII, with the Bayon temple, Preah Khan, the gates of Angkor Thom, and Ta Prohm as striking examples (Late Classical period).

Construction Materials

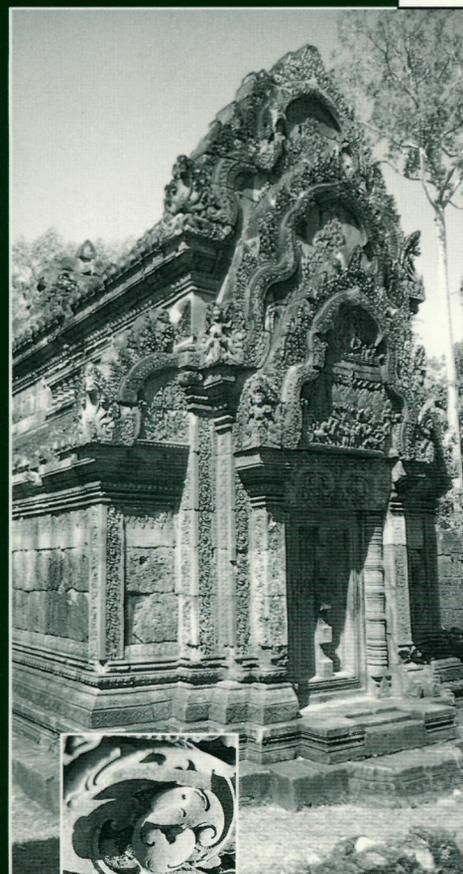
Few types of building materials were used at Angkor. The monuments that survived centuries of jungle growth and harsh tropical



ABOVE: PRAH KŌ

BELOW: BANTEAY SREI

BOTTOM: BANTEAY SREI, detail



climate consist of the most durable masonry materials—clay brick, laterite, and sandstone—while the dwellings and nonreligious buildings of the Angkor citizenry no longer exist, having been constructed of timber or other perishable materials.

Most of the larger temple complexes and the remaining foundations of the palace compounds are partly constructed of and faced in sandstone. Khmer workers quarried this material near the Kulen Hills, approximately 15 kilometers northeast of Angkor.

At Angkor the Khmers used laterite, a soft stone found throughout Cambodia, in the construction of foundations, building structures, and enclosure walls. Its source was probably the many moats and *barays*. Laterite did not prove as strong or durable as sandstone, but it was used as the substructure for most buildings throughout the history of Angkor.

Finely laid, high-quality clay brick was the prime building material in the early structures of Angkor and in Roluos. The brick was normally covered by an equally high-quality decorative or protective stucco finish. While few examples of this stucco work survive, the remains of some stucco decorative finishes can still be seen at Preah Khan.

Evidence exists of the limited application of metal in construction at Angkor. It was used to tie stone blocks together, and in embossed sheet form to decorate sanctuary walls.

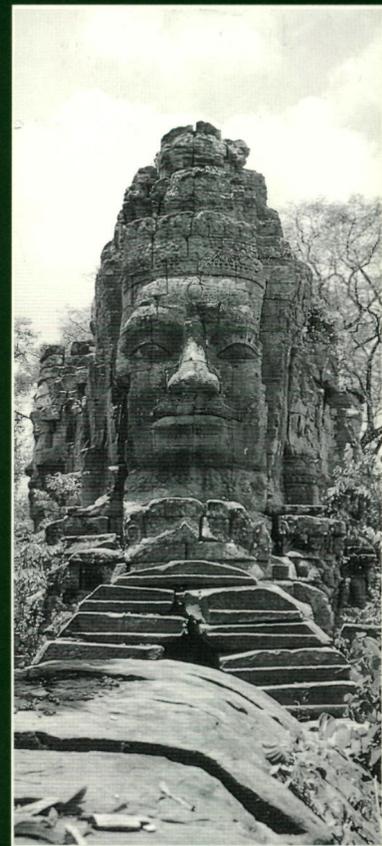
Building Technologies

The major temple sites at Angkor, such as Angkor Wat and the Bayon, were constructed using dressed stones laid without mortar. Weight and friction kept the stones—which could weigh over four tons apiece—in place, after careful and precise cutting and rubbing to form tight joints. A bonding agent may have been employed at times. Sandstone facing material was secured to the laterite substructure. Once the stones were properly positioned, they were then sculpted in elaborate sections.

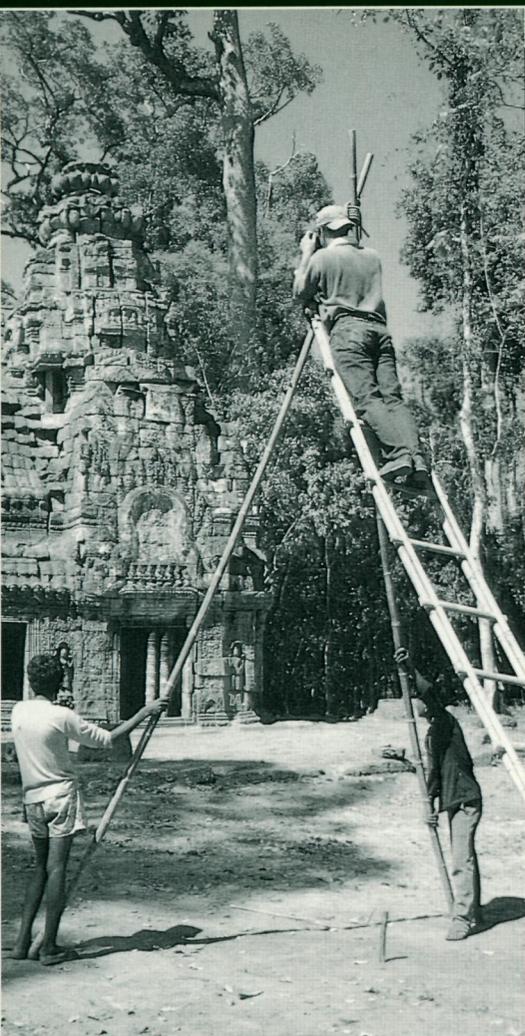
The architects formed domes and roofs using the “corbeled vault” structural system. A series of successive corbelled stone “drums” supported the superstructure. These load-bearing stone arches were typically hidden from view by a low ceiling formed of perishable material that has long since disappeared.



ABOVE: ANGKOR WAT
BELOW: THE BAYON



WORLD MONUMENTS FUND AT ANGKOR



ABOVE: PREAH KHAN, documentary photography

BELOW: Project Manager John Sanday at the Preah Khan Visitors' Center



The World Monuments Fund (WMF) sent its initial field mission to Cambodia in December 1989 to survey Angkor and evaluate the damage the site had suffered after 20 years of civil strife and isolation. The mission soon discovered that the temples were relatively unaffected by the upheavals that shook Cambodia. Angkor's caretakers, however, were not as fortunate. Among the educated Cambodians to die in the "killing fields" were those with specialized training in architectural conservation. By the time the Khmer Rouge were ousted from power in late 1978, only a handful of the former workers at Angkor had survived. While the country remained isolated for more than a decade after the overthrow of the Khmer Rouge, the site was virtually unattended and the French conservation facility was in shambles.

When WMF visited Angkor in 1989, the Cambodian government urged its team to organize a pilot project to address some of the key problems in preserving Angkor. The site selected by WMF for this undertaking was Preah Khan, a 12th-century temple city. WMF has since conducted regular field missions to the site, under the supervision of Project Manager John Sanday, a conservation architect with expertise in Asian structures who has worked for WMF since the late 1970s.

Philosophy and Approach

WMF's philosophy at Angkor is based on a unique challenge: to preserve a magnificent heritage site and to restore to its

Cambodian custodians the expertise needed for its care and management. Initial surveys of the site led WMF to construct a long-term program to repair and conserve the site as a partial ruin. Major reconstruction was not judged appropriate due to the lack of historical data, the magnitude of the task, and the questionable philosophical nature of such an approach.

WMF seeks to pass Preah Khan on to future generations in a state similar to that in which it was found, but with the added assurances that, by using modern conservation technology, the site will be rendered structurally sound and the natural environment will be sustained.

WMF also intends for its work at Angkor to help support the restoration of peace and prosperity in Cambodia. It strives not only to preserve Angkor, the country's most cherished symbol of identity and its touchstone to the past, but also to strengthen the sense of stability and security in the local population by providing jobs, new expertise, and contact with the outside world.

THE WORLD MONUMENTS FUND'S COMPREHENSIVE APPROACH TO CONSERVATION AT ANGKOR:

- *Establish conservation methodologies which are appropriate for use at Khmer monuments and analyze building materials to determine how to resolve problems related to their use and conservation.*
- *Stabilize and partially restore structures at locations within the Preah Khan complex.*
- *Recommend ways to protect and properly present the historic monuments and their environs.*
- *Emphasize formal on-site conservation training for Cambodian architecture students and for local craftsmen.*
- *Seek to ensure the protection of Angkor's movable cultural property by deterring theft and vandalism, using video imaging and site-specific computerized inventories to document the architectural sculpture at Preah Khan.*
- *Employ above-ground archaeological research at Angkor to learn more about the ancient Khmer empire and Angkor's prehistory.*



PREAH KHAN, detail
of relief sculpture

“Here in the dark depths of Pre[e]ah Kahn, with the jungle writhing about you, is the proper place to contemplate the vanished glory of Angkor.”

— From James A. Michener, *“The Mystery of Angkor,”* Holiday, November 1952

AN INTRODUCTION TO PREAH KHAN

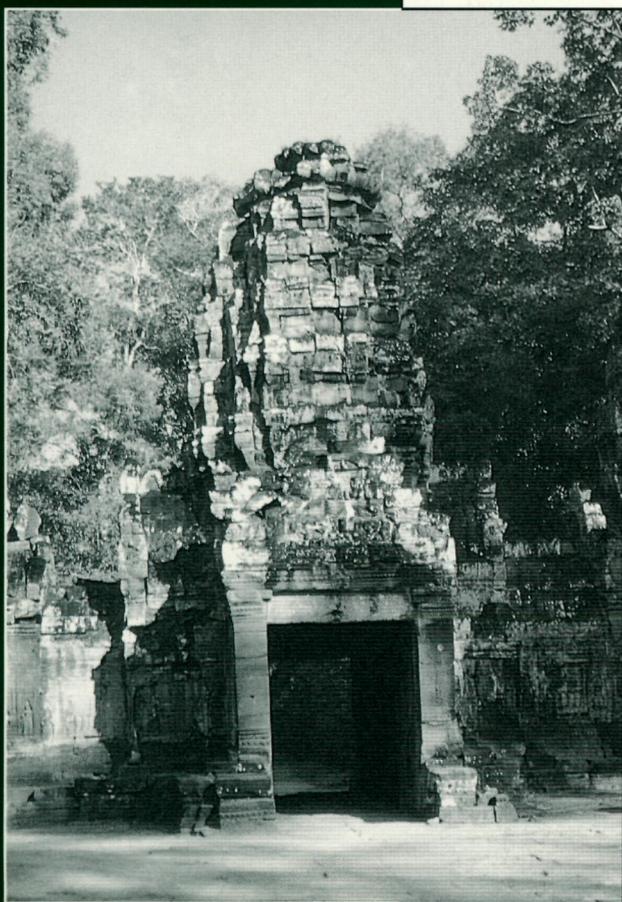


ABOVE: Bust of Jayavarman VII National Museum, Phnom Penh

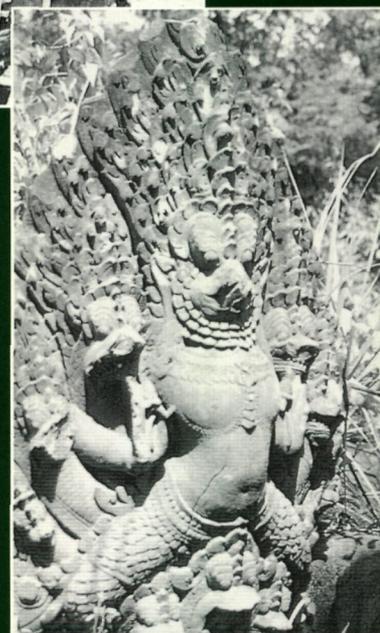
The history of Preah Khan, one of the largest and best-known monuments of the Angkor group, would have been difficult to reconstruct had not Jayavarman VII left a stele, or stone inscription. The inscription describes the origin of the temple city and the population dependent on it.

In modern times, the site has been known as Preah Khan, or “Sacred Sword,” a name given to other temples in Cambodia as well. At the time of its dedication in 1191, it was known as the city of Jayasri (Nagara Jayasri) or “City of Royal Victory.” It is thought that Jayavarman VII built the city on the site of a momentous victory over the Chams, a people from the area that is now central Vietnam. It may also have been erected by the monarch as a replacement for one of the royal palaces of his predecessors (Yasovarman II and Tribhuvanadityavarman).

The central temple was dedicated by Jayavarman VII to his father, King Dharanindravarman II, in the name of Lokesvara, a god who encompasses the compassionate qualities of the Buddha. Indeed, the sculptures of Lokesvara found at Preah Khan are believed to have been carved to resemble Jayavarman VII’s father. Inscriptions from the entrances to the Central Temple’s chapels reveal that hundreds of deities were assembled as a pantheon around the dominant image of Lokesvara.



PREAH KHAN, west entrance gopura



TOP: PREAH KHAN, *Hall of Dancers*

ABOVE: PREAH KHAN, *garuda*

BELOW: PREAH KHAN, *entrance lanterns*

Preah Khan is the second of two temple cities built by Jayavarman VII to honor his parents. In 1186, the monarch dedicated the temple complex now known as Ta Prohm (Ancestor Brahma) to his mother. At Ta Prohm, the king's mother is depicted as Prajnaparamita, the goddess of wisdom and "the mother of all Buddhas."

Preah Khan is unique among Khmer monuments. Its approach to religious practice reveals Jayavarman VII's tolerance of different faiths: individual chapels were constructed for Buddhist, Shaivist, Vaishnavist, and ancestor worship. The stele relates that thousands of Buddhist monks at Preah Khan coexisted with practitioners of Hinduism. The Buddhist king is believed to have employed Hindu thinkers and bureaucrats. Statues and sculptures at the site show this mixture of influences.

Preah Khan also served as a place of learning. The stele had a once-legendary listing of the names of students and teachers housed there.

It is the stele, rather than the ruins of Preah Khan, that provides the leading clues to the size of the temple city. It reveals that 97,840 taxpayers of both sexes were linked to Preah Khan under an obligation to provide food, clothing, and services to the temples. They came from 5,324 villages in the general area. The inscription describes an earlier time when more than 300,000 people from around 13,500 villages performed these services for the gods at Preah Khan.

The walled site occupies 56 hectares (approximately one-third the size of Central Park in New York City). It included living quarters, independent pavilions, and a central enclosure with a tower and surrounding porticoes containing a stupa. Preah Khan is historically linked with the nearby temples of Neak Pean and Ta Som, all positioned in relation to the northern *baray*.

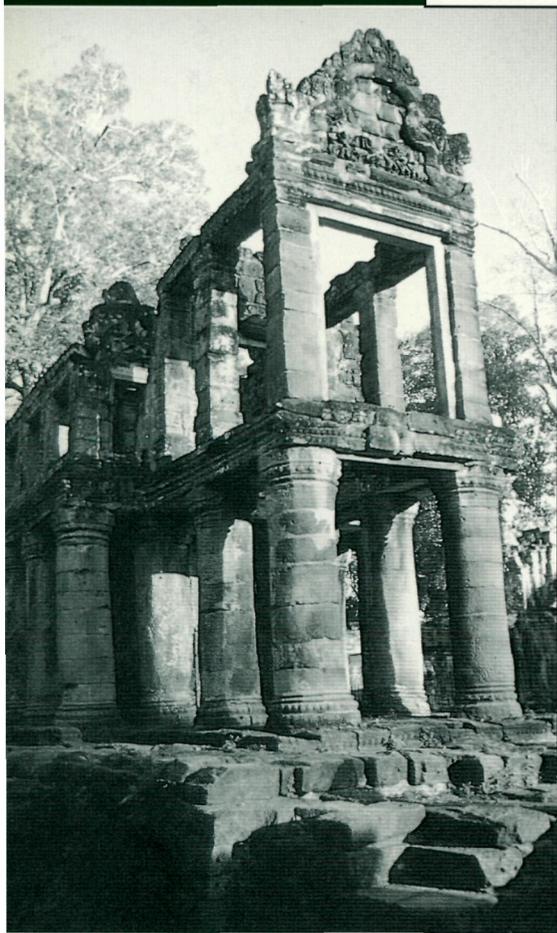


THE MONUMENTS OF PREAH KHAN



ABOVE: PREAH KHAN, *Dharmasala* with shoring

BELOW: PREAH KHAN, *the Two-Story Pavilion*



Visitors approaching the west entrance to Preah Khan may be surprised to learn that it is not

the original principal entrance to the temple city. The present western approach has long been used because of a decision early in this century to accommodate tourists along a nearby road.

The impressive monuments of Preah Khan lie within four concentric walls. The enclosures formed by these walls defined specific precincts of the city.

The outer wall (Enclosure Wall IV) measures approximately 700 by 880 meters. The wall is surrounded by a 40-meters-wide moat. Wide causeways lined by characteristic *naga* (snake motif) cross the moat and lead to the central entrance structures, recognizable by their cross-shaped domed towers and column-supported porches. The outer wall contains 72 *garudas*, which are carved-sandstone anthropomorphized birds that are the guardian protectors of the monastic complex.

Within Enclosure Wall IV were the living quarters of the monks, students, and other supporters of the Preah Khan holy district. Dense jungle now occupies this area. Little is known of the design and placement of structures in this enclosure because they were probably made largely of wood and perished over time.

From the four principal entrance *gopuras* (large processional gateways), a second series of *gopuras* is encountered at Enclosure Wall III. Within this enclosure, the principal reli-

gious zone of the site consisted of a rich concentration of temples and shrines.

The two inner enclosures contained a labyrinth of shrines, courts, halls, pavilions, and entrance porticoes. Enclosure Wall II was altered soon after its construction to become a walkway around Enclosure Wall I. The latter, which also included a circular passage, was formed from the perimeter wall of central Buddhist temples and shrines, and it also included a circular passage.

Visitors can easily tour the important monuments of Preah Khan, including:

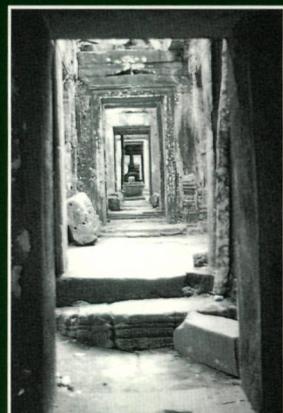
THE VISHNU COMPLEX: *This complex is located immediately within Enclosure Wall III at the western end of Preah Khan. Smaller in scale than most of the other monuments at the site, it consists of a square of shrines joined by low galleries, all surrounding a central shrine.*

THE PAVILION: *This unique two-story pavilion with circular columns is located in the eastern part of Enclosure III. Its original use is unknown.*

THE HALL OF DANCERS: *The Hall of Dancers is also situated in the eastern part of Enclosure III. The finely proportioned hall features lintels over the doorways decorated with finely sculpted and sophisticated depictions of dancing apsaras.*

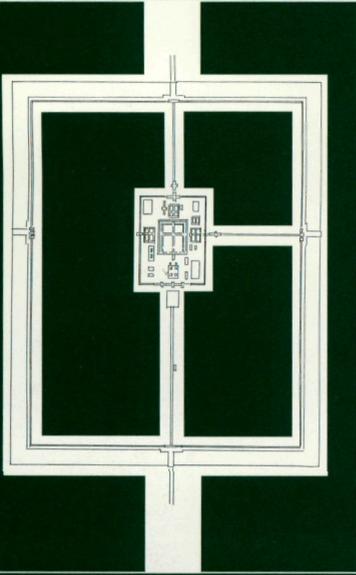
THE PREAH KHAN STELE: *This stele was rediscovered in 1939. One of the most important sculptural elements at Preah Khan, formerly located at the east gopura of Enclosure Wall I, it has been removed for safekeeping. Its Sanskrit inscriptions provide valuable information about the history and population of Preah Khan.*

THE DHARMASALA: *This “Pilgrim’s Resthouse” is located on the eastern side of Preah Khan, along the principal entrance route, roughly midway between the eastern gopuras of Enclosure Walls III and IV. It was only recently “rediscovered” by WMF workers who had cleared jungle growth. It has been identified as the rest-house for pilgrims visiting the temple site and may have been where the sacred flame of the temple was kept.*



TOP: PREAH KHAN, Hall of Dancers
ABOVE: PREAH KHAN
LEFT: PREAH KHAN, Stele
BELOW: PREAH KHAN, Stele detail

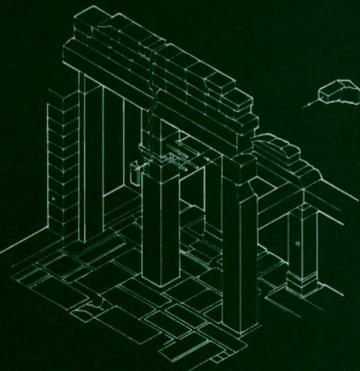




TOP: PREAH KHAN, Diagram showing vegetation clearance of major axis and enclosure walls

ABOVE: PREAH KHAN, site safety sign

BELOW: PREAH KHAN, Hall of Dancers column repair



PRESERVING THE SITE

The World Monuments Fund is preserving Preah Khan as a partial ruin. In keeping with this philosophy, minimum intervention is practiced, with an emphasis placed on site maintenance and protection.

Many of the structures at Preah Khan appear to be on the verge of collapse. A concerted effort is under way to stabilize and repair the numerous architectural remains that are threatened. WMF is also attempting to control vegetation that otherwise would severely disrupt the stability of walls and carved stonework.

Three of WMF's recent building conservation efforts at Preah Khan are:

Column Repairs in the Hall of Dancers

The sandstone columns in the Hall of Dancers are typical of sandstone columns at Preah Khan. They are monolithic, having been cut whole from the quarry. The geological characteristics of this type of stone are such that large elements, such as columns, may tend to split lengthwise when the stone is placed vertically and bears a significant weight load. This can eventually lead to complete structural failure.

WMF is repairing the split columns in the Hall of Dancers by using a simple but effective method. First, the column is relieved of its load by carefully raising the lintel or beam above it. The fracture is cleaned using compressed air. After that, the damaged stone is drawn together and bolted. The open section of the fracture is then filled with a mortar that matches the stonework. Finally, the column is cleaned of any residue and the bolt heads are concealed.

Clearance of the East Processional Way

Once WMF successfully reestablished a clear passage from the western entrance of Preah Khan, it turned to the challenge of

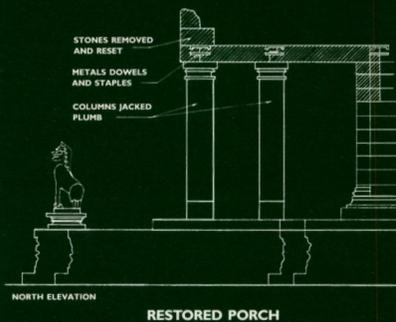
opening the East Processional Way in the area between the eastern causeway and Angkor's northernmost great reservoir known as the "Preah Khan Baray." As the principal entrance to the temple city was always from the east, clearance of this processional way was central to the interpretation of Preah Khan.

The work produced immediate and unexpected results. At the *baray's* embankment, WMF found the remains of an elaborate landing complete with stone steps and traces of sculpture, revealing that Preah Khan was accessible by boat. The clearance also exposed a paved surface along the processional way, upon which pedestrian and vehicular traffic traveled. The original disposition among Preah Khan, the exquisite Neak Pean temple at the center of the reservoir, and the Ta Som temple at the opposite end is now more intelligible as evidence of a vast planning concept.

East Gopura South Portico Stabilization

In 1989, WMF first noticed that a portico at the primary entrance to Preah Khan was in imminent danger of disintegration. The portico's collapse would have caused extensive damage to its monolithic columns and other carved details. The project team assessed the stability of the entire structure and developed a plan for consolidation, repair, and strengthening.

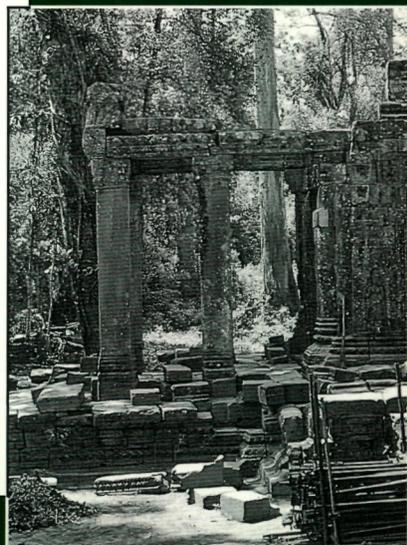
Prior to undertaking any stabilization work, all stones—including paving stones, lintels, vaults, and wall structure—were measured and drawn to scale as part of an "as-found" conditions survey. The stones were carefully referenced against the drawings and number-coded to facilitate removal and accurate replacement. Workers then removed the stones and laid them out in preparation for reconstruction. After inserting an emergency support system of raking shores, a steel scaffolding was built for support and to provide loading platforms. The stabilization plan included workers using chain hoists and hydraulic jacks to raise stone lintels and other elements up as close to the original locations, and refixing and consolidating elements with epoxide glues and stainless steel dowels.



TOP: PREAH KHAN, South Portico stabilization drawing

ABOVE: PREAH KHAN, South Portico before stabilization

BELOW: PREAH KHAN, South Portico after stabilization



PREAH KHAN IN CONTEXT

Preah Khan is more than the stone remains of a once-vibrant temple city.

A significant aspect of the site is the interaction among the complex ecosystem of vegetation and wildlife, hydrological systems, and the stone ruins.

Today, the local population is applying sustainable forestry practices at Preah Khan. Villagers have traditionally collected resin from the dipterocarpus trees, cut firewood, and collected fruits, plants, and fibers. These nonintrusive activities provide them with a source of income.

Some of the lush vegetation has directly affected the monuments: it has choked the moat, dominated the outer- and inner-enclosure walls, and destroyed structures within the complex. The giant ficus trees are a particular problem. Many of these trees are dead or dying and consequently threaten to fall on the fragile stonework.

While small trees are abundant, few medium-size trees exist to replace the large ones. This situation may have been caused by illegal logging practices. The loss of these trees could detrimentally affect site maintenance, wood-fiber production, and forest coverage.

As part of its overall preservation effort, the World Monuments Fund is engaged in, studying, presenting, and protecting the natural environment at Preah Khan. Its management plan takes into account how the environment affects the monuments and the needs of the local population. WMF is laying nature trails, removing hazardous trees, and opening new vistas of the ruins to provide fresh perspectives of the site.

WMF's environmental efforts at Preah Khan include a thorough survey of hydrological features, including water-collection



TA PROM, giant ficus tree

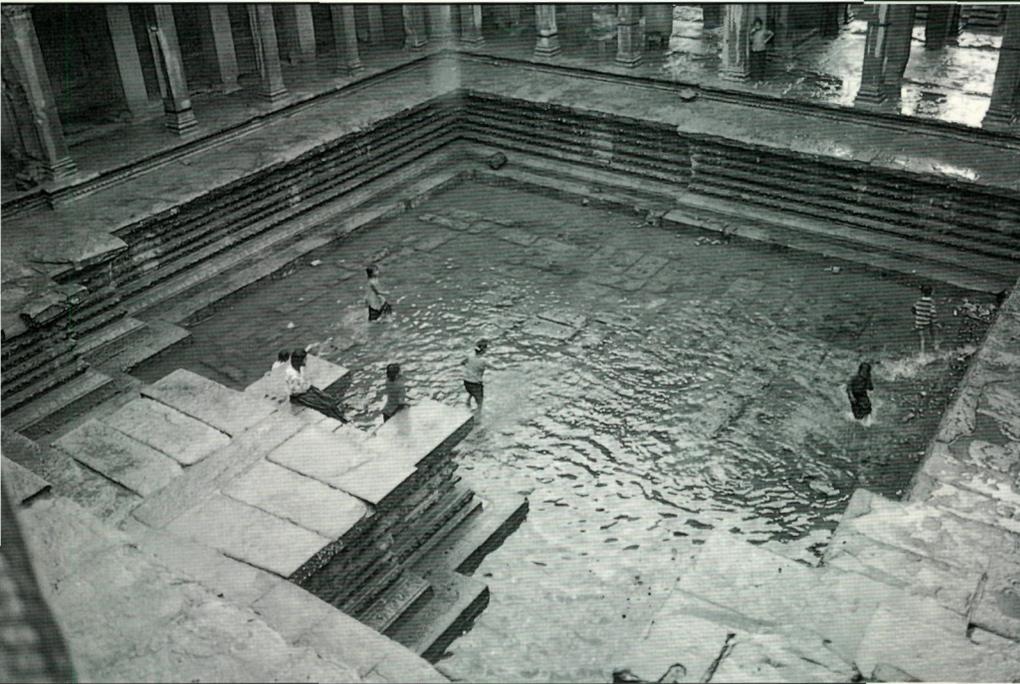
and irrigation systems. These early hydro-engineering works represent major accomplishments for their time. WMF intends to restore at least part of the system, such as the perimeter moat and smaller water features within the site. Preliminary research indicates that it is feasible to restore the great Preah Khan Baray and some of its associated canals. This would boost agricultural production for local farmers and permit the historic structures to be seen again in their former settings.

WMF is committed to maintaining the distinctive character of Preah Khan—especially its serene and spiritual nature—by protecting its magnificent jungle setting. The temple complex was built to honor the gods and is still used for worship and contemplation.

Because Preah Khan is part of the larger Angkor historical city, WMF has endeavored to share its knowledge and techniques with preservation organizations working at other Angkor sites. Collaboration and cooperation benefit not only the overall preservation effort, but also contribute to a better understanding of life at Angkor in its prehistory and its heyday. An example has been the partnership between WMF and the Budapest-based Royal Angkor Foundation to use space-borne radar-imaging data from the U.S. space shuttle *Endeavour* for investigations of Angkor's hydrological system and related urban development, and for archaeological research.

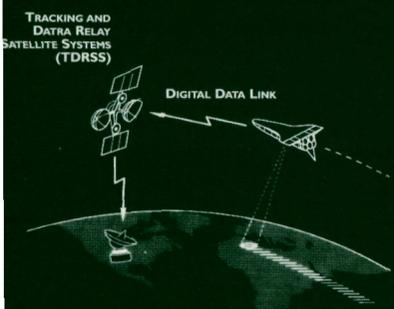
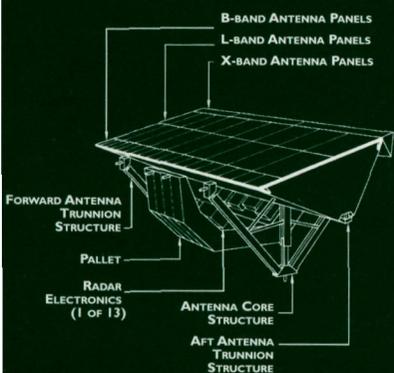
“For Pr[e]ah is a prisoner of the jungle; towering wild fig trees rise from the broken roofs, immense roots twist and crawl and thrust tiny fingers into crevices, embracing whole walls and ripping away enormous chunks of stone.”

—From James A. Michener,
“The Mystery of Angkor,”
Holiday, November 1952

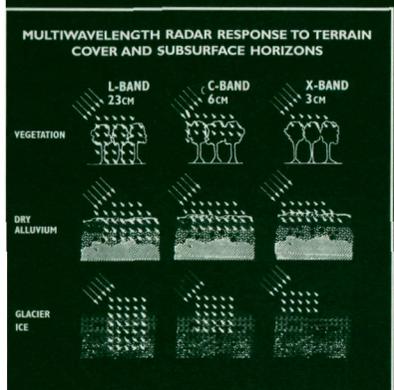


LEFT: ANGKOR WAT,
reflecting pool

SPACE-AGE TECHNOLOGY COMES TO ANGKOR



TOP: SIR-C/X-SAR antenna
ABOVE: SIR-C/X-SAR in operation
BELOW: SIR-C/X-SAR radar frequencies



On October 4, 1994, the astronauts of the U.S. space shuttle *Endeavour* (SRL-2) orbited their craft on a path that would take them across southern Thailand, above the Dangrek mountains of northern Cambodia, over the ruins of the Historic City of Angkor, past the Cambodian capital of Phnom Penh, and down the Mekong River to the Mekong Delta and the South China Sea. Housed in the payload bay of the space shuttle was a sophisticated space-borne radar-imaging laboratory which, as the shuttle passed silently over Cambodia, was activated to take pictures of the former capital of the Khmer Empire.

In two passes over Angkor, the *Endeavour* collected a wealth of radar data on its SIR-C/X-SAR Earth Imaging Radar system, a laboratory that is unique in that it uses three radar frequencies to penetrate different levels of the earth's atmospheric, biological, and surface covers. The *Endeavour* collected an enormous amount of data on archaeological and ecological sites at Angkor, including Preah Khan, to assist in the documentation and analysis of the ancient capital.

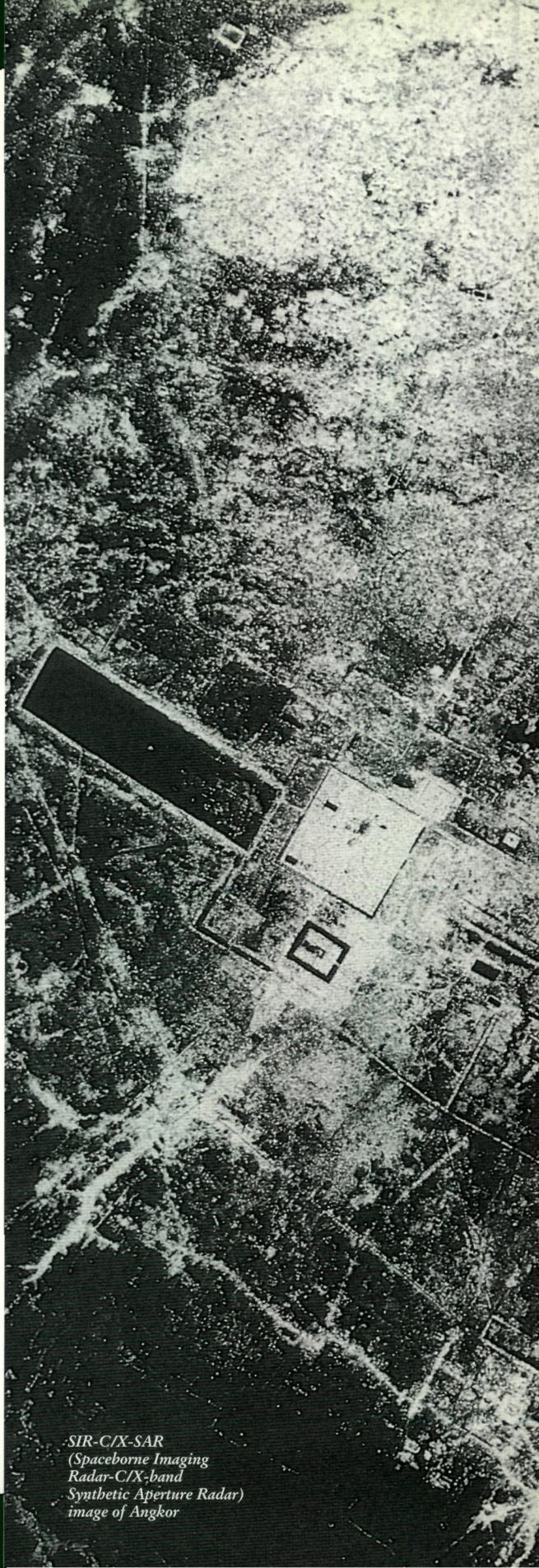
This unique initiative arose from a proposal submitted jointly by the World Monuments Fund and the Royal Angkor Foundation (RAF) to the Jet Propulsion Laboratory (JPL) of the U.S. National Aeronautics and Space Administration (NASA) in July 1994. Both preservation organizations saw the space-borne x-ray laboratory as having the potential to aid the archaeological and geographical programs in progress at Angkor and to facilitate, for the first time, a coherent and

comprehensive analysis of both surface and subsurface features, including an examination of environmental, archaeological, and hydrological irregularities. In addition, it was proposed that the radar data might offer a new methodology for the study of the site. JPL and NASA agreed, and Angkor radar imaging was added to the shuttle mission.

In February 1995, WMF and RAF organized a roundtable held at Princeton University to determine the criteria and establish a detailed program for analyzing the data provided by NASA. The meeting of the international project team offered a rare opportunity for specialists in archaeological and ecological fieldwork to join forces with scientists in outer-space-based radar-imaging research to learn how state-of-the-art technology might aid in the pursuit of the knowledge of man's past.

A WMF and RAF plan emerged for the new radar data to be interpreted by specialists in archaeology, ecology, and land use and to be integrated as imagery into geographic information systems (GIS). A GIS allows the analysis of different environmental and development data by layering that data so that linkages are revealed among normally diverse subjects. This strategy will allow different information inherent in images of Angkor (taken by ground-based, aircraft, satellite, and space-shuttle three-band x-ray sensors) to be compared.

A major goal of this WMF and RAF project is to provide the information gathered from the radar data to the Royal Cambodian Government, Cambodians with an interest in Angkor, the international research community, and the interested public. Computer users will be able to access the information on the World Wide Web.



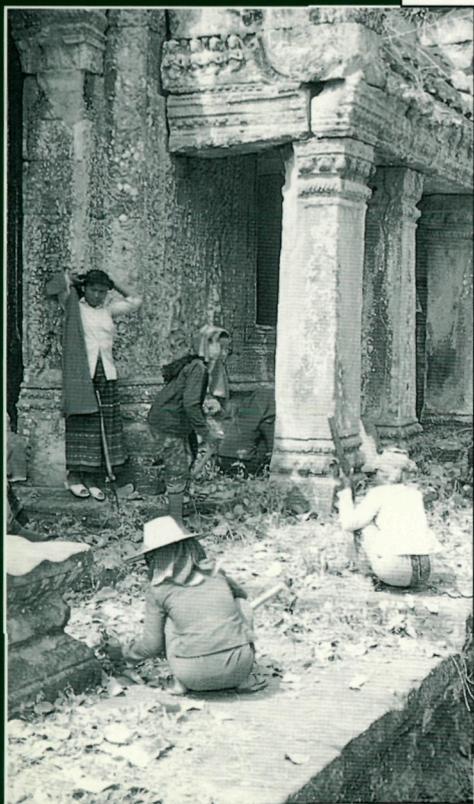
*SIR-C/X-SAR
(Spaceborne Imaging
Radar-C/X-band
Synthetic Aperture Radar)
image of Angkor*

CONSERVATION MANAGEMENT



ABOVE: WMF staff, architecture students
and workers

BELOW: PREAH KHAN, workers



The World Monuments Fund established the Preah Khan Conservation Project with the intent to preserve an important part of Cambodia's national heritage. From the start, WMF has worked closely with the country's government and its people to achieve this goal. At the same time, it has operated within the administrative framework of international organizations working at Angkor.

From training Cambodian architecture and archaeology students to providing space-shuttle radar data, WMF is committed to building mutual trust and cooperation with those who work to conserve Angkor. Since WMF arrived in Cambodia it has consulted on the broader issues with Cambodian government authorities. It continues to do so with APSARA, the Royal Government of Cambodia's new autonomous conservation and tourism authority established by royal decree in February 1995. APSARA has taken over the administration of Angkor from the Ministry of Culture and oversees the agencies responsible for the management of the site.

Examples of cooperation between WMF and the royal government include:

All WMF reports pertaining to Angkor and Preah Khan have been presented, with synopses in French, to the royal government. These include an annual program and work plan and field reports documenting the previous years work.

Since 1989 WMF, by putting forward proposals beyond those relating to Preah Khan, has assisted the royal government's efforts to develop a sustainable Conservation Management Plan for

the monuments of Angkor and its environment. The royal government provides in-kind support for WMF's work at Preah Khan through improvement of access to the site and through the provision of security and cooperation. This support is critical because WMF's work at Preah Khan is supported entirely through contributions.

WMF, with the Budapest-based Royal Angkor Foundation (RAF), sought and received royal government approval for the NASA space shuttle radar imaging of Angkor. After the shuttle mission, the two organizations and NASA provided radar data and images to Cambodia's minister of state, Mr. Van Molyvann.



Cambodian flag with image of Angkor Wat

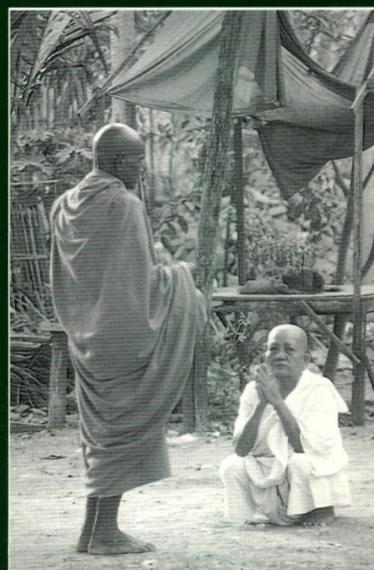
WMF is an active participant in the international cooperative efforts to conserve Angkor. Since March 1994, it has participated in the sessions of the technical committee of the International Coordinating Committee on the Safeguarding and Development of the Historic City of Angkor (ICC). This international group meets three times a year to review—with Cambodian officials, foreign diplomats, and invited

preservation organizations—ways to assist in the safeguarding of Angkor. As the Preah Khan program is part of the international campaign for Angkor organized under the auspices of UNESCO—which has listed the Historic City of Angkor as a World Heritage site—WMF maintains close contact with UNESCO's Cambodia office and its Paris headquarters.

WMF has participated in valuable collaborations with other organizations working at Angkor. During the first two years of on-site activity, WMF conducted several research efforts with Sophia University in Tokyo. Partnership with the RAF expanded from technical cooperation to organizing the unprecedented NASA radar imaging of Angkor. RAF is now working to interpret and make accessible the information gathered from the radar data. WMF has also benefited from the participation of researchers from the Ecole Française d'Extrême Orient (EFEO) in Paris, who contributed to WMF's efforts to identify the parameters of its Preah Khan Conservation Project and who generously shared with WMF information about its efforts to preserve Preah Khan through the mid-1970s.



*ABOVE: Cambodian student trainee
BELOW: Buddhist worshippers*



PREAH KHAN FACTS

IMPORTANT QUESTIONS ABOUT PREAH KHAN:

What are the main causes for the deterioration of the stone work at Preah Khan?

Structural damage from plant growth and erosion from running water are the main physical causes for stone deterioration at the site. The other debilitating factor is found within the stone: the climatic conditions of Preah Khan have over time created instability of some component minerals. Microbiological growth on the stone work appears to be an insignificant factor in its deterioration.

Has Preah Khan suffered from the recent spate of looting?

Angkor has been victimized in recent years by incessant thievery and vandalism. Looters have targeted *nagas*, guardian lions, and bas-relief sculpture pieces at the more remote temple sites. Even the main government storehouse for Angkor's artifacts, located at the Conservation d'Angkor in



Siem Reap, was pillaged in a raid in February 1993.

Preah Khan has not escaped these depredations. Five stone *nagas*, each weighing over one ton, have been stolen since WMF arrived at Preah Khan. Two were subsequently recovered from hiding places nearby.

WMF is fighting this threat by enacting security measures and thoroughly cataloguing the movable cultural property at the site. Standard international inventory methods are followed and augmented by computer and video documentation.



ABOVE: ANGKOR WAT, shrine

RIGHT: Vandalism

BELOW: Stone deterioration



What was the role of water at Angkor and Preah Khan?

The physical and spiritual importance of water to the Khmer people in the Angkor period is indisputable. The historical record, the stories told in Khmer stone work at Angkor, and the remains of the vast hydrological system show that the physical role of water encompassed irrigation, water storage, and transportation, while the water also served a spiritual or religious purpose. The details, however, are largely unknown.



Temple with reflection

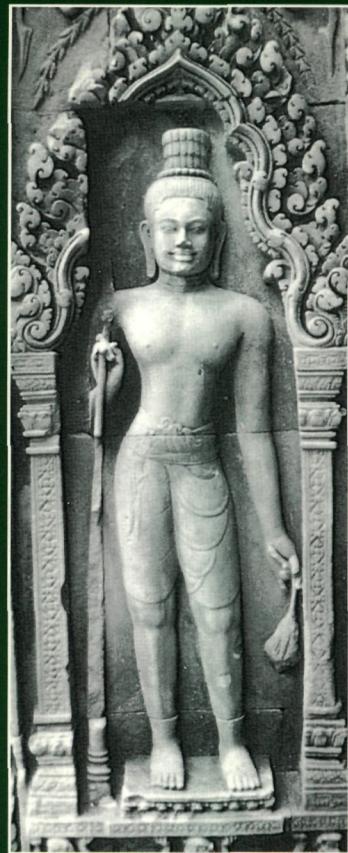
The role of water is key to understanding how the Khmer Empire thrived at Angkor in what was normally an arid savanna.

Like many of the other monuments at Angkor, Preah Khan's architectural design and religious iconography convey the importance of water. The buildings' reflections in still water are a vital part of experiencing Angkor. WMF and others are studying this aspect of Angkor with the expectation that the radar imagery taken from space may help unlock this mystery.

Having contributed to the discovery of Oman's "Lost City of Ubar," might the space shuttle Endeavour's radar imagery be similarly successful in revealing the existence of subsurface archaeological features around Preah Khan?

The limited archaeological work at Angkor has not yet succeeded in locating buried houses and palaces, built from perishable materials, that were situated near the stone monuments. Heavy sedimentary deposits in the alluvial fan near Siem Reap may have covered some of these ruins.

The possibility that radar imagery may identify these buried features is slim. Unlike the ease with which the L-band of radar can penetrate porous sand, it may not be possible for it to see into the moisture-laden soil at Angkor. However, the radar can detect clues, such as the subtle undulations of both the soil and the top tree canopy, that might lead to the discovery of underground features.



ABOVE: BANTEAY SREI, relief before vandalism

BELOW: BANTEAY SREI, relief after vandalism



TIMELINE

1860

Henri Mouhot "rediscovers" Angkor.

1864

Cambodia becomes a French Protectorate.

1866

John Thomson of Scotland is the first photographer to visit Angkor Wat.

1908

Conservation d'Angkor established by Ecole Française d'Extrême Orient (EFEO).

1927-32

Jungle clearance by Conservation d'Angkor at Preah Khan under supervision of Henri Marchal of EFEO.

1939

Restoration of small shrines inside Enclosure Wall I at Preah Khan by Maurice Glaize.

1952-54

Repair by anastylosis of Two-Story Pavilion by EFEO.

1975

Khmer Rouge take over Cambodia. Civil strife leads soon after to the removal of French presence at Conservation d'Angkor and elimination of Angkor's management and maintenance system.

1989

First WMF mission to Angkor. Missions were also undertaken in this year by Sophia University of Tokyo and the Association d'Amis d'Angkor in Paris.

1991

WMF returns to Angkor and Cambodian government assigns Preah Khan as WMF pilot project. An initial condition assessment is undertaken. In collaboration with Sophia University, WMF takes first group of 25 students to Angkor, 7 of whom are selected to work at Preah Khan.

1992

WMF prepares Conservation Management Plan for Preah Khan. UNESCO regional office is established in Phnom Penh. UNESCO commences Zoning & Environmental Management Plan (ZEMP) for Angkor.

1993

Historic City of Angkor inscribed as World Heritage Site. WMF conducts selective jungle clearance and site preparation at Preah Khan, as well as development of appropriate conservation technology and project mobilization.

1994

First year-round annual campaign of conservation work at Preah Khan commences.

First session of technical committee of the International Coordinating Committee on the Safeguarding and Development of the Historic City of Angkor.

Radar image of Angkor obtained by United States space shuttle *Endeavour*.

At Preah Khan: south portico east *gopura* structural stabilization completed; reopening of east entrance; removal and documentation of items for protection against looting.

1995

APSARA, a nongovernmental authority responsible for site protection and regional planning for the Historic City of Angkor, is inaugurated.

1996

Second roundtable on Radar Imaging at the Angkor Eco-Site planned.

2000

WMF project at Preah Khan is scheduled to end, with Cambodians to assume responsibility for site maintenance.

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BACK COVER IMAGE: PREAH KHAN, *GARUDA*
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