

Angkor

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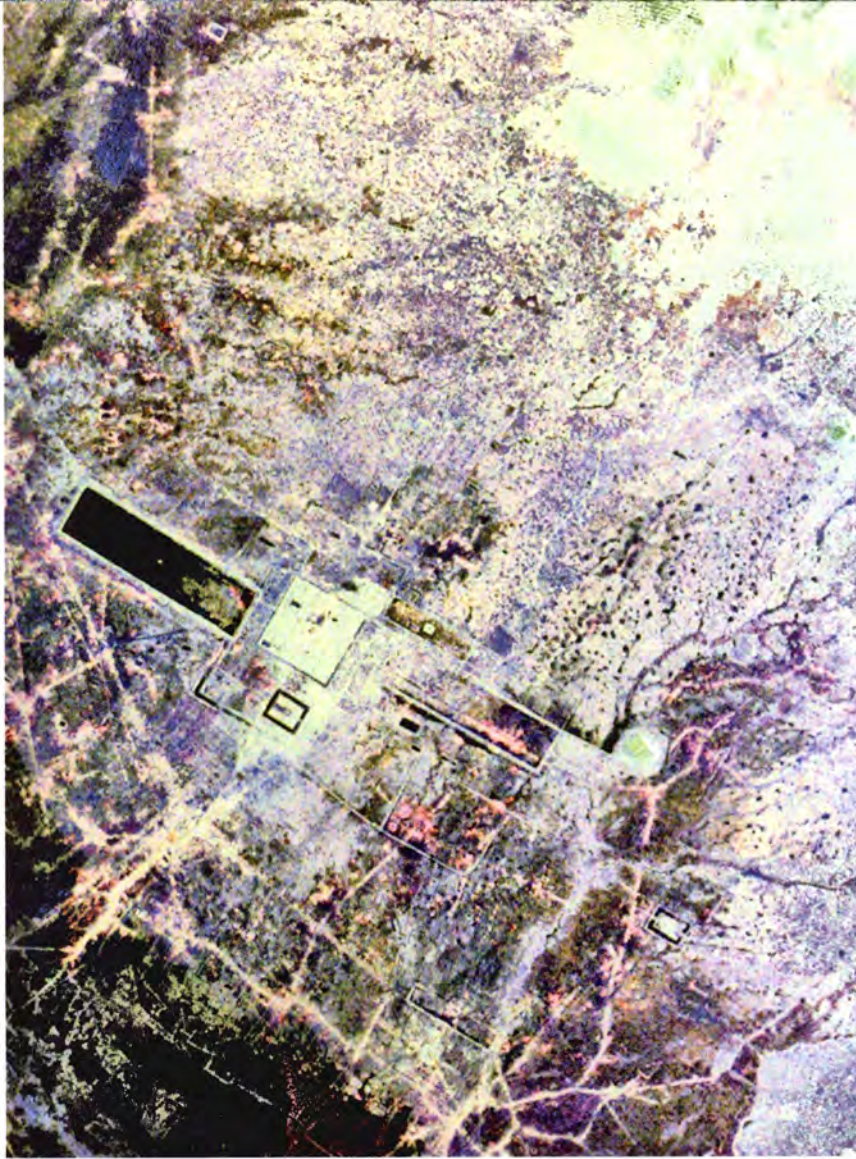
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This image, taken from the space shuttle Endeavor, shows an area of approximately 55km by 85km around the ancient city of Angkor. Angkor Wat is the light-coloured square to the left of centre.

Situated deep in the jungles of north-western Cambodia, it included a vast irrigation system which provided water supplies for rice farming, and thus allowed its people to prosper. Angkor's citizens travelled along roads complete with rest houses and hospitals, visiting giant temples built to celebrate Hindu gods. At its height, the rulers of Angkor dominated much of the south-east Asian mainland.

Angkor was originally built around the Phnom Bakeng temple which stood on a hill symbolising the mountain that stands, according to the Hindu cosmology, in the middle of the world. Phnom Bakeng was the first of several temples devoted to different Hindu deities. As the city grew, vast reservoirs were constructed which, as well as providing irrigation for rice farming, symbolised the ocean surrounding the central mountain.

Over the years, Angkor's people became wealthy enough to finance wars and the construction of the magnificent temples still standing today. The largest temple in Angkor is Angkor Wat, a huge structure built to mark King Suryavarman II who was believed to be the incarnation of the god Vishnu (see box). The temple is surrounded by concentric walled courtyards almost a kilometre square, flanked by eight-kilometre-long reservoirs. Within Angkor Wat's walls stands the main temple adorned with five graceful lotus-shaped towers. Inside, the gallery walls are decorated with sculptures showing the legends of Vishnu.

In the 12th century, cracks began to appear in the rigid social order as Angkor's rulers began making excessive demands on their people while

neglecting the maintenance of the all-important irrigation system. Rebellions were followed by the spread of disease.

One of the contributing factors to social unrest is thought to be the introduction of Theravada Buddhism which taught that everyone could achieve spiritual advancement, not just the rich or powerful.

Eventually the social order broke down, and Angkor's

From the viewpoint of the gods

The ancient Khmer city of Angkor Wat remained undisturbed in the jungle for centuries until it was uncovered about a hundred years ago. Now we are seeing it afresh, thanks to space technology.

STORY BY GEOFF MCNAMARA

A thousand years ago, King Jayavarman II, ruler of the Khmer empire from AD802 to 850, began the construction of what was destined to become one of the most important architectural monuments in the world: the city of Angkor. The sprawling metropolis covered a hundred square kilometres—at the time one of the largest cities in the world.



people finally fled the city in the 14th century fearing attacks from the neighbouring Siamese army. The Khmers established their capital farther south and, while Angkor Wat remained as a Buddhist pilgrimage centre for some time after, it, too, eventually fell to the Siam in 1431, and later to the relentless perseverance of the encroaching jungle.

The remains of Angkor were hidden for centuries until French archaeologists began to excavate the city in the 1860s. Since then its importance as an archaeological and

Imaging equipment was carried in the cargo bay of the space shuttle.

architectural site has been realised; the Royal Angkor Foundation has been established to study and preserve the area. Appreciating the full extent and history of Angkor and its temples has been difficult, however.

Now, in a unique form of archaeology, scientists have taken a fresh look at this historic city, not from the ground but from space.

To get a better view of Angkor and its surroundings, the

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Royal Angkor Foundation and the World Monument Fund approached NASA about the possibility of observing Angkor from space. The aim was to gather data to allow better documentation and monitoring of Angkor, as well as allowing a reinterpretation of the origins and prehistory of the ancient city. NASA responded by taking a unique look at Angkor from the space shuttle Endeavor in 1994.

To be able to see through the dense jungle that surrounds Angkor, astronauts used an Earth imaging system called the Space-borne Imaging Radar-C/X-Band Synthetic Aperture Radar (SIR-C/X-SAR).

The system is used to produce detailed images of the Earth's surface regardless of whether it is day or night, and is used for a wide variety of applications, from making detailed images of the Earth's surface to monitoring the movement of air, water, vegetation and human activity. Information like this is essential if scientists are to understand the Earth's ecosystem, and the impact humans are having on it.

During the September 1994 flight of Endeavor, SIR-C/

To get a better view of Angkor and its surroundings, the Royal Angkor Foundation and the World Monument Fund approached NASA about the possibility of observing Angkor from space.

X-SAR was used to study areas of cultural, natural and archaeological importance. The areas observed were mainly in Laos, Thailand, Vietnam and Cambodia, including the city of Angkor.

The SIR-C/X-SAR was carried in the payload bay of the space shuttle which flew upside down, aiming the instrument at Earth. As Endeavour passed overhead, SIR-C/X-SAR transmitted a wide beam of microwave radiation to the Earth. The microwave—harmless as a torch beam because of

the low power involved—penetrated cloud cover, vegetation, even sand, reflecting off more substantial structures such as rocks and buildings. The reflected microwave radiation was recorded by the system which built up an image of a wide strip of land during each orbit. After a number of orbits the SIR-C/X-SAR covered the entire site being observed.

The results of the 1994 flight were presented in April this year at a Radar Imaging and Cultural Resource Management symposium at the University of Florida.

The images of Angkor returned from Endeavor reveal

Vishnu's role in creating a new world

Vishnu is one of three gods believed to be three aspects of the one incomprehensible supreme being.

Vishnu is believed to be the personification of the preserving power of the divine spirit.

The other two manifestations are the gods Brahma, the creative energy who remains quiescent and to whom no temples are erected, and Siva, destroyer of evil doers, whose necklace is made of human skulls.

The Hindu Trinity, or Trimurti, is a relatively recent formation, and Vishnu was alleged to be the paramount god by the Vaishnavas, one of two great



Reclining Vishnu in Preah Khan temple.

Hindu sects (the other being Saivas).

Vishnu is represented as being blue in colour, and to have four hands.

In one hand he holds a chank (shell); in another a chakra (quoit); in the third he holds a club; and in the fourth he holds a lotus.

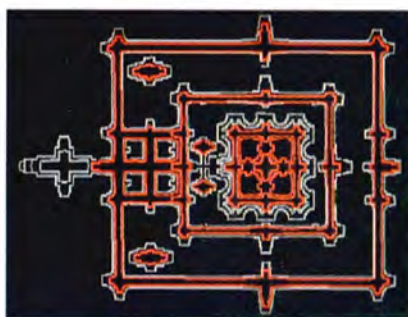
His wife is the goddess Lakshmi, and he rides on the back of Garuda, the winged half-man/half-bird, king of birds.

At the end of the Kali Yuga (present age of the world), Vishnu will sleep on Ananta, the serpent of eternity.

By then the entire world will be covered in water, but from Vishnu's navel will spring a lotus stalk which will rise above the water. At the top of the stalk, Brahma will appear to create a new world.—GM



Well-preserved thousand-year-old carvings showing scenes from everyday life have survived at Angkor temples; floor plan of the Angkor Wat temple complex



Another aspect of Angkor previously unknown was the existence of underground springs that flow under Angkor on their way to the Tonle Sap. Scientists believe the Angkor architects made use of them in designing the city.

aspects of the ancient city never before seen, and have sparked new theories about why and how it was constructed. One of the things that makes Angkor so special is its architecture. Unlike Western designers, the Cambodian architects refrained from clearing the land before building. Although the city is currently overgrown, it isn't due simply to the encroachment of an untamed jungle. Preferring to leave large trees standing, Angkor's builders simply worked around them. Considering the climate and latitude, the extra shade was welcome.

Another aspect of Angkor previously unknown was the existence of underground springs that flow under Angkor on their way to the Tonlé Sap, a large lake to the south of the city. Scientists believe the Angkor architects understood the flow of these springs and made use of them in designing the city.

Studies of tributaries that flow into the Tonlé Sap may lead to a better understanding of the life-cycle of the lake. This is especially important at a time when the Cambodian Government is considering damming the tributaries. Ultimately, Cambodia hopes to have the Tonlé Sap listed with UNESCO's World Heritage List as a bio-reserve.

To the east and west of Angkor Wat are two large structures measuring eight kilometres long and almost two

kilometres wide. Called the Eastern and Western Barays, they have long been considered to be reservoirs for irrigation. The radar observations have added to that theory, however. The Western Baray has an elevated area that has long been thought to be the result of sedimentation but, when combined with other data, the radar observations suggest that the walls were built to retain something more than simply water. One theory is that the barays were also used as animal pens to keep water buffalo or elephants.

The radar observations are allowing archaeologists to dig even deeper into the past than Angkor.

One of the mysteries surrounding the city is what was there before. Revealed in the data are 68 prehistoric mounds. There are at least four main areas of prehistoric settlement in Angkor: two in the central area, one to the west near an old river bed and a fourth to the east. Now that the radar observations have pinpointed the mounds, archaeologists on the ground will be able to find the mounds and

study them to try and understand Angkor's prehistory.

Although future shuttle flights to study the area are not planned, observations from aircraft could be combined with the SIR-C/X-SAR data to produce a 3-D map of the area. Thanks to modern technology, we have now glimpsed one of the most important cities in the world's history from a vantage point once reserved for the gods. □

Geoff McNamara is a freelance science writer based in Australia.