



Chapter 17

Discovery and Interpretation of a Buried Temple in the Angkor Wat Enclosure

Till F. Sonnemann

Abstract

An extensive ground-penetrating radar (GPR) survey in the western part of the enclosure of Angkor Wat revealed the remains of a buried and demolished structure that consisted of six definite towers and potentially as many as nine towers. The structures were enclosed by a rectangular laterite wall and had probably been demolished before the western entrance gate was built. The symmetrical alignment of the foundations with the towers of the western *gopura* however implies a significant impact on the construction of the gate. Analysis of the GPR data in conjunction with the evaluation of results from preceding research was followed by excavations as part of the Greater Angkor Project. The combined results now allow a preliminary discussion of the successive construction and demolition phases on the western side of the Angkor Wat enclosure. The study indicates that the history of Angkor extends beyond its visible temples and that much of its history is buried beneath the ground. The survey demonstrates that there is a substantial need for research within temple enclosures and highlights the importance of archaeological prospection at Angkor.

Introduction

Extensive ground-penetrating radar (GPR) surveys in the western part of the enclosure of Angkor Wat [Fig. 17.1] have revealed the remains of dismantled and buried structures adjacent to Gopura 4 West (G4W), the principal entrance gate of Angkor Wat. The findings comprise six definite laterite bases of towers. These towers were in symmetrical alignment with the gate and the main temple of Angkor Wat and appear to be enclosed by a rectangular laterite wall, the remains of which are extant on the eastern side of the gate. There is evidence that they were constructed prior to the entrance gate of Angkor Wat, indicating the potential existence of three more towers that were demolished when G4W was built. The pattern is consistent with the form of an Angkorian period temple with a *quincunx* of towers enclosed by four additional towers.

Covering an area of nearly 4.3ha, mainly between the western moat and the main temple of Angkor Wat, the GPR survey was conducted to identify possible buried structures and preceding architectural configurations. In addition to the large range of subsurface structural features in symmetrical alignment, primarily east and west of Gopura 4 West, two linear masonry features were detected which indicate the original alignment of the southern road leading from the southern pavilion of Gopura 4 West (the southern “Elephant Gate”) straight to the southwest side of the main temple.

This paper focuses on the presentation of results and interpretation of the GPR survey undertaken at Angkor Wat. The discovery of the foundations demonstrates that the history of Angkor cannot be read solely from its visible temples and what is observable on the surface. There is a substantial need for research within temple enclosures and the survey demonstrates the importance of archaeological prospection at Angkor.

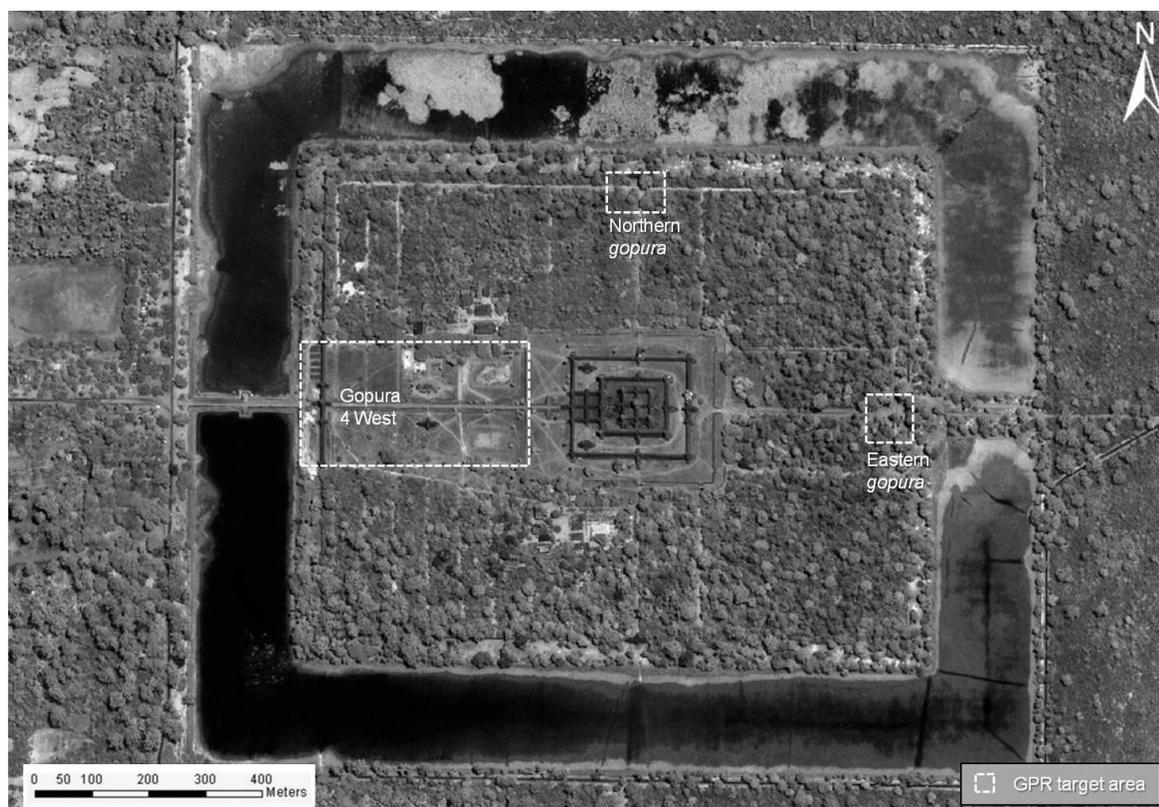


Fig. 17.1: The enclosure of Angkor Wat and the GPR survey areas in a white dotted line (Photo: IKONOS 2004, source: Greater Angkor Project).

Previous Work in the Study Area

The temple of Angkor Wat was constructed in the 12th century. Archaeological research at Angkor Wat started in the beginning of the 20th century. Since then it has been cleared of rubble, partly reconstructed, conserved and comprehensively analyzed. Archaeological campaigns by the École Française d'Extrême Orient (EFEO) led by Henri Parmentier in 1919 (Parmentier 1919) and Henri Marchal in 1920 and (Marchal 1920) concentrated on the area around Gopura 4 West [Fig. 17.2]. The initial work removed debris and two small mounds, which were interpreted as 19th century *stupa*, located east of the *gopura* to the north and south of the causeway. The excavation also revealed several laterite columns and platforms which were identified as post-Angkorian additions. Except for smaller excavations by EFEO archaeologist Jean Boisselier in 1951, who drew architectural plans of the earlier excavated platforms and unearthed additional laterite walls, most of the zone south of the main axial causeway has been left undisturbed. Today a small mound remains to the southeast of G4W and rises to about 1.5m above the base height at the bottom of the causeway. In the 1960s the area north of the main causeway was leveled and the columns removed by Bernard Philippe Groslier in an effort to reinstitute the “original” state of Angkor Wat. Hence today the area north of the central causeway is completely flat, with a few remaining laterite foundations and sandstone walls that are partly visible on the surface.

The area between the moat and G4W has recently been the focus of conservation work. North of the causeway, the sandstone enclosing the moat was repaired by a French-Cambodian mission. When part of the causeway was reconstructed by a Japanese-Cambodian team in the 1990s, an area alongside the gallery of G4W was covered with layers of rubble to store the stones from the causeway. The area south of the causeway was excavated close to the moat by an Italian-Cambodian mission in the year 2002 to reconstruct a collapsed element between the southern staircases (Santoro 2003). All campaigns were taken into consideration in the interpretation of the GPR survey results.

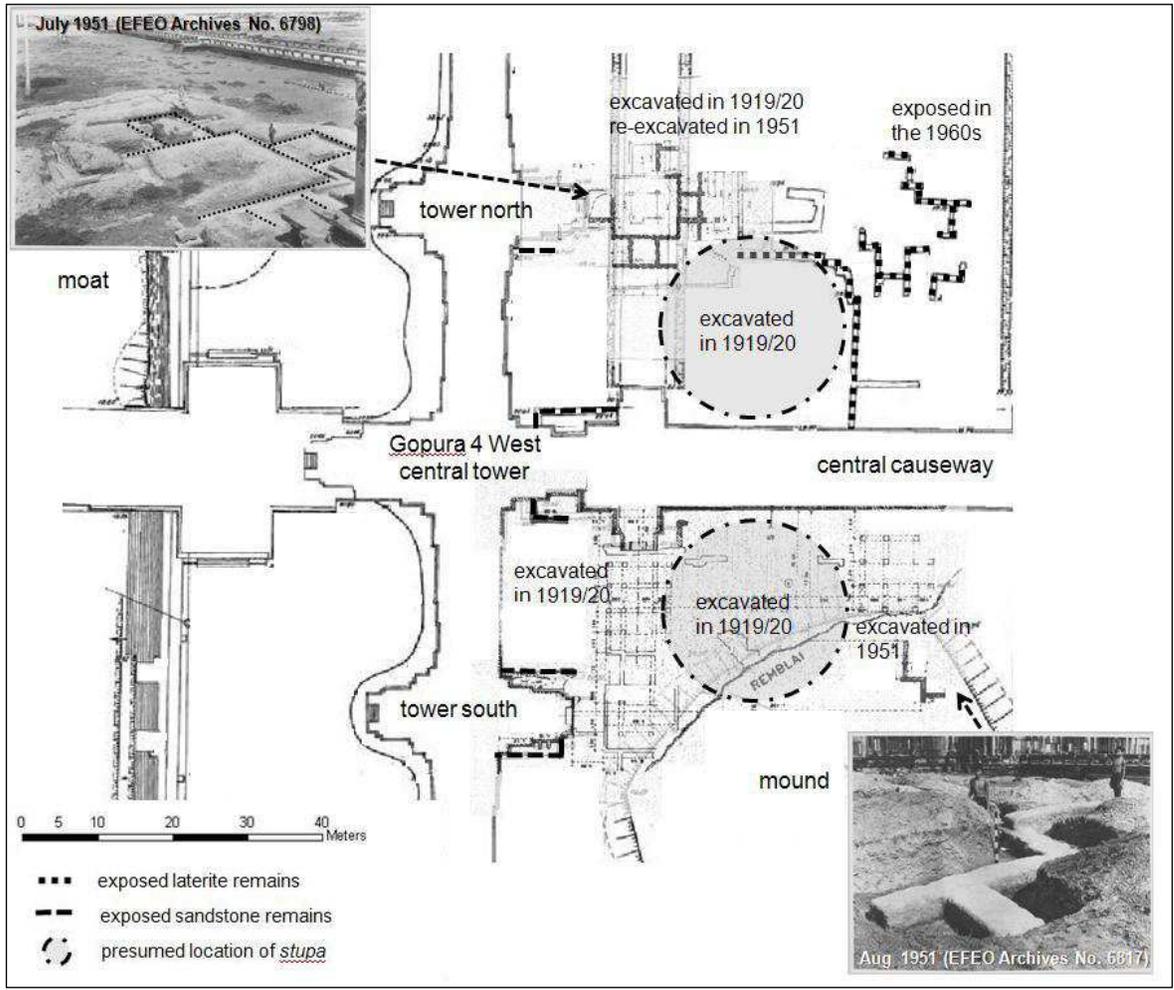


Fig. 17.2: Previous work around G4W by H. Parmentier (1919), H. Marchal (1920), J. Boisselier (1951) and B.P. Groslier (1966–68 revealed several masonry structures; some of them still in place (as highlighted). The circles show the approximate location of the two removed *stupa* (Base plan: Pottier 1993: pl. 39. Photos: EFEO Archives. Excavation plans: Boisselier 1951).

The Survey

The GPR survey at Angkor Wat was conducted over several weeks in December 2009, January and June 2010. The purpose was to investigate potential buried archaeological features, including evidence of occupation, inside the enclosure of Angkor Wat between the western entrance Gopura 4 West and the temple platform, to improve the understanding of the spatial configuration of enclosures.

The Method

GPR is a non-destructive geophysical survey method used to isolate soil changes in a vertical section of the near-surface underground. It is regarded as one of the most complex and versatile of the geophysical methods used in archaeology, providing three-dimensional information on the extent of an underground feature (Conyers 2004: 11). A transmitting radar antenna sends a signal into the ground. Part of the signal is reflected when it hits an area of measurable difference in electromagnetic characteristics to the top surface, e.g., a change from sand to masonry, or from soil to clay, and returns to the surface. With some knowledge about the ground velocity from, for example e.g., comparative excavations, the travel time of the signal provides information on the location and depth of the detected anomaly. GPR is widely used

in archaeological prospection to map subsurface features such as building foundations and other buried structures (e.g., Yasushi Nishimura and Goodman 2000: 101).

Major visible obstacles, such as structures or trees in the path of the GPR, were accounted for in the analysis. Using the travel time / depth information, GPR processing software (Goodman and Klein 2010) was applied to combine and process the data to produce a travel time and therefore depth-dependent three-dimensional image of the area. The resulting data is viewed as horizontal so-called time-slices, each slice displaying a certain travel time of each signal. For the presentation of results, depth slices showing the most prominent features were chosen. Strong reflections are displayed in red; blue indicates either no change in ground composition or shallow penetration depth. The first 40–50cm showed mainly reflections from the top surface.

The Survey Area and Equipment

For the Angkor Wat GPR survey, a total of 22 grids were laid out, covering an overall area of nearly 4.4ha, most of it inside the fourth enclosure of Angkor Wat between the western moat and the main temple platform [Fig. 17.3]. A Mala 250 MHz GPR system was used for most of the surveys. Additional surveys were conducted around the eastern and northern *gopura* using a Mala 500 MHz antenna. The study area was divided into rectangular grids which were surveyed with 0.5m spacing in parallel lines.

Description of Results

The GPR survey revealed several archaeologically important features within direct vicinity of G4W [Fig. 17.3]. To simplify the presentation of results, the features have been numbered, in addition to their location north (N) or South (S) of the central causeway.

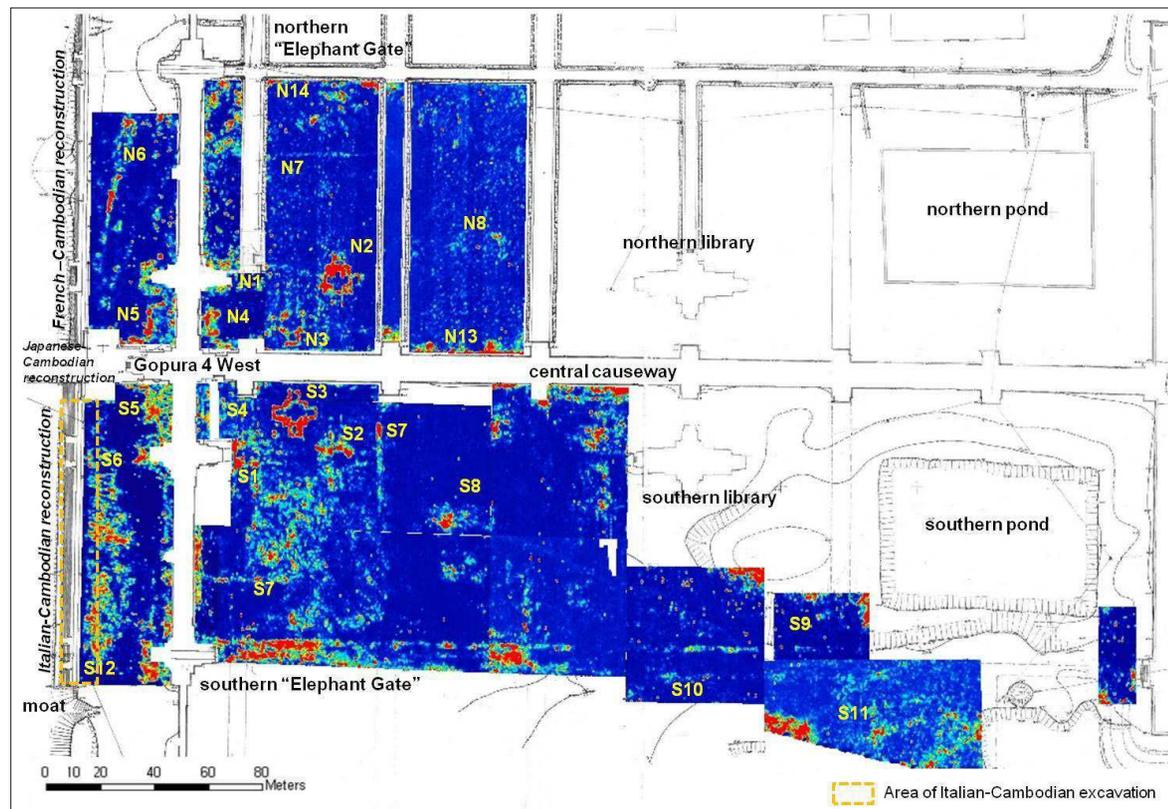


Fig. 17.3: GPR Survey overview (displaying only a time slice of ~150cm depth) over the base plan by C. Pottier (1993: pl. 39).

East of G4W: The Central Part

East of G4W, and inside the enclosure of Angkor Wat, the GPR survey mainly confirmed the results of the preceding excavations [Fig. 17.4]. Of the two laterite bases (N1, S1) that were unearthed in 1919 and 1920 directly east of the southern and northern side pavilions of G4W, the northern one is not clearly distinguishable in the survey and might have been subsequently destroyed. No column foundations were clearly identified during the GPR survey, either because they had been completely removed, or possibly as a result of the survey line spacing of 50cm.

The most apparent results of the survey are six stone foundations, each forming a square of about 10 x 10m, with remains of porticos on the sides in each axial direction. Among the six structures, the two outer ones (N2 — partly excavated, S2) are aligned with the northern and southern side pavilions of the G4W. They are also in alignment with the axes of the libraries and the outer border of the two ponds in front of the main temple [Fig. 17.5]. Within this rectangle, four structures — N3 (which had been excavated earlier and whose remains are still visible) S3, N4, and S4 — form a smaller square in its centre. Those structures formed a distinctive symmetrical configuration which can be interpreted as an inner and an outer set of cruciform features whose central point is covered by the axis of the central causeway.

A linear, approximately 1m wide, anomaly encloses all the structural foundations mentioned above. The feature begins 60m north and south from the axial causeway at the eastern side of the galleries of the *gopura*. It extends about 50m to the east and from there turns at a right angle to the causeway. The corresponding area to the north of the causeway was excavated in the 1960s, when a drainage channel was constructed perpendicular to the causeway (Groslier 1966–68). There was no trace of a corresponding anomaly on the western side of the gallery outside the enclosure wall of Angkor Wat, which indicates that linear feature did not completely enclose the proposed temple configuration, and could have been constructed subsequent to G4W.

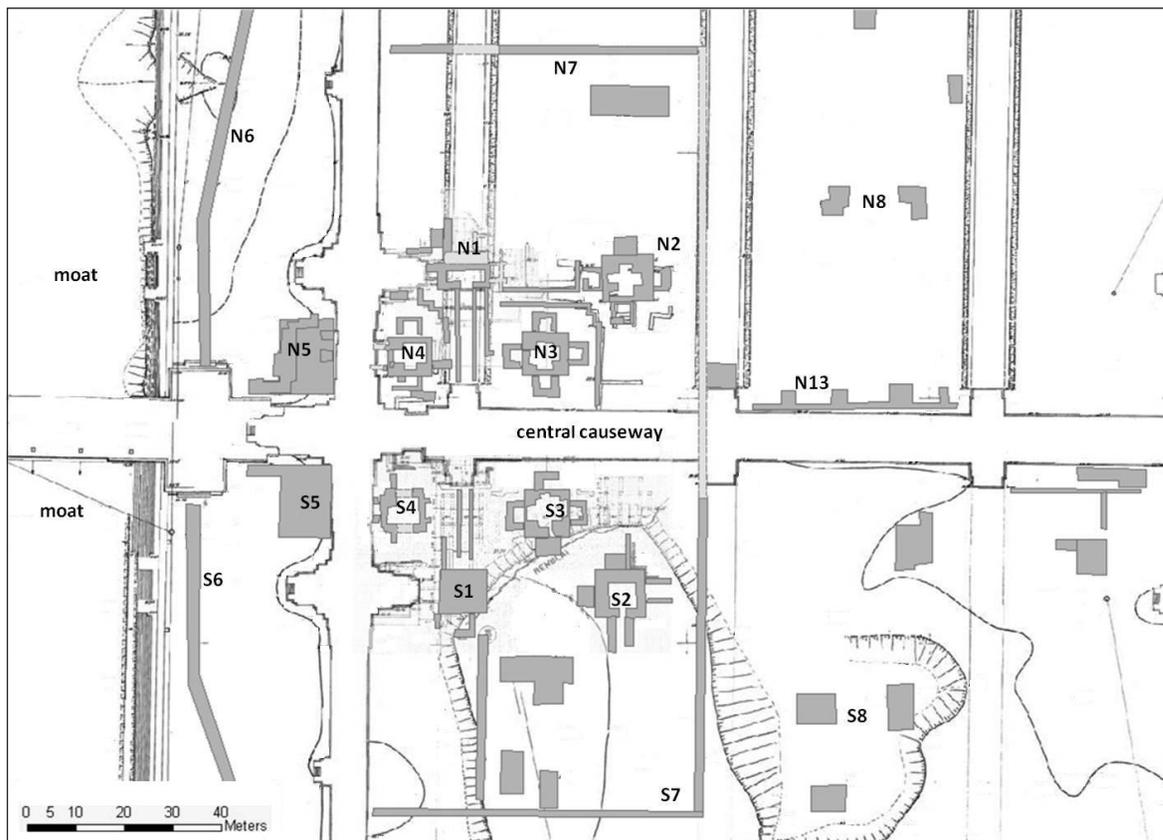


Fig. 17.4: GPR interpretation from all depths for the central area of Gopura 4 West (Base plans: Boisselier 1951; Pottier 1993: pl. 39).

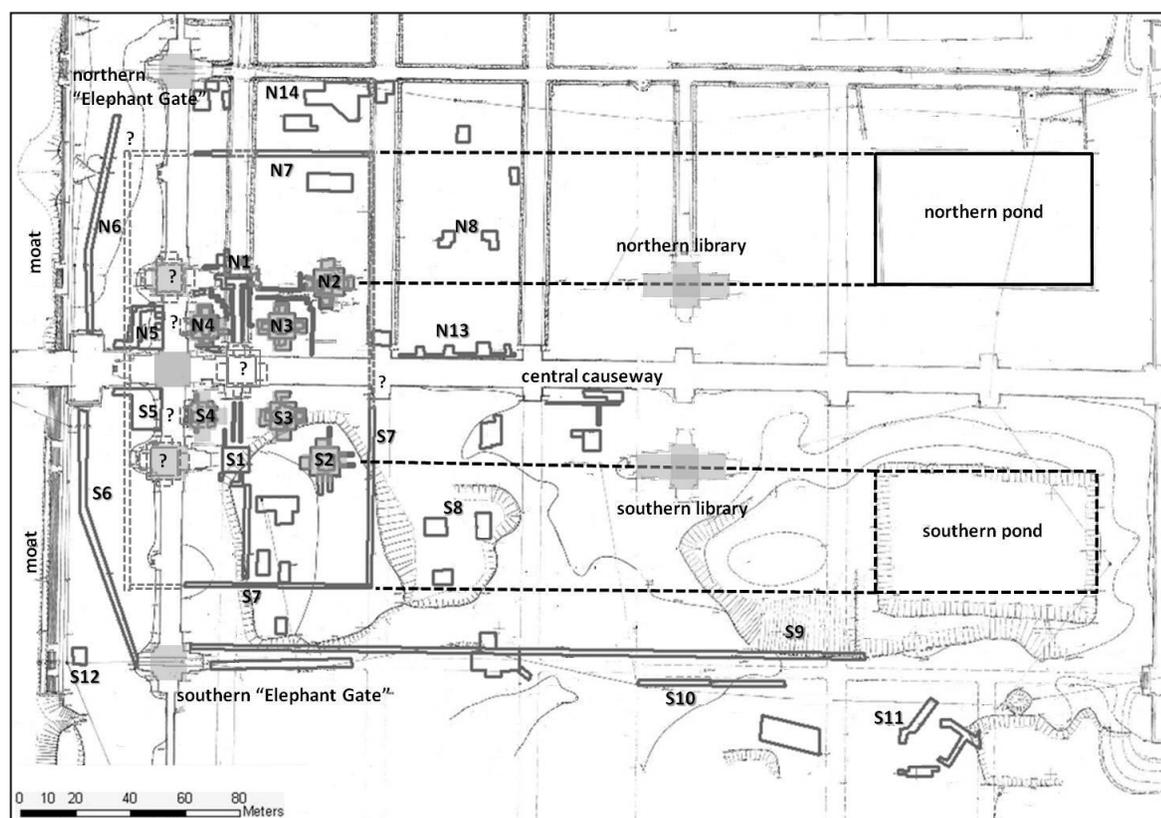


Fig. 17.5: Interpretation of underground features, alignment with visible structures (Base plan: Pottier 1993: pl. 39).

The GPR survey detected other potential structural remains to the east of this "enclosure" [Fig. 17.5]. There are four irregular anomalies (N13) directly adjacent to the northern side of the causeway that could indicate remains of an earlier, but now overbuilt, configuration of the causeway. Two additional anomalies were detected further north and south of the causeway. The northern (N8) is only barely visible in the GPR results, while the southern (S8) clearly represents a subsurface anomaly, possibly a lateritic structure. Although the features are not in direct geometrical alignment with each other, they could be related to the newly detected structures. Several other anomalies (e.g., N14) could not be related to any visible structures.

Features West of G4W

To the west of G4W, between the enclosure wall of Angkor Wat and the moat, the GPR survey detected another pair of symmetrical anomalies (N5, S5) located between the central and the two side pavilions of G4W. The western portico of the central pavilion is framed on each side by what was interpreted as a masonry wall or a foundation substructure corresponding, probably, to the remains of a platform. Nothing is presently visible on the surface and a potential connection to the tower bases on the other side is not clear.

Moreover, there is strong evidence for two linear features, almost symmetrical, running north (N6) and south (S6) from the main axial causeway. Each feature follows approximately 50m straight north and south and then inclines towards the "Elephant Gates" at the extremities of G4W. The strong reflection, its depth, as well as the symmetry of the features, indicates masonry structures of laterite or sandstone. Another smaller feature (S12) that showed very strong reflection to the GPR signal in about 200cm depth is in the far south, just east of the southern "Elephant Gate" in front of the staircase of the moat. None of these anomalies described seem to result from the excavations conducted previously on the edge of

the moat (Satoru Miwa, pers. comm., 13 Jan. 2010). The location of the excavations near the moat is, to some extent, visible in the GPR results (Santoro 2003).

Features in the East

A strong linear anomaly (S9) begins at the southern “Elephant Gate” and runs over 200m parallel to the main causeway towards the south-west corner of the temple platform. The strong reflection implies that it corresponds to masonry remains. 10m further south another linear feature (S10) parallel to the first is visible in part of the survey area, suggesting that these two linear anomalies could correspond to a road alignment. This “south road” was therefore as wide as the central causeway and matched the 1960s reconstructed road on the northern side (Groslier 1966–68). Additional evidence for a road is provided by several laterite blocks, on the slope near the southern side of the south pond. The architectural map of Angkor Wat by Pottier (1993) indicates its original outline [lower right Fig. 17.5]. To find out if the linear feature continued up to the main temple, to reach the southern staircase of the temple platform as its orientation indicates, an additional GPR survey was done in the precincts of the south-west corner of the temple platform of Angkor Wat [lower right of Fig. 17.3]. The results do not display any evidence that this was the case.

South of the pond, several nonlinear anomalies (S11) were detected which are oriented in a Northeast-Southwest direction. On their eastern side they border a small depression, probably the remains of a small pond. Strong signal reflection from those anomalies indicates masonry remains, while their orientation suggests that they are not in relation to the main temple. The redirection of the original southern road could have happened in connection with the construction of those irregular masonry remains, as the road is nowadays passing them on the southern side.

Additional surveys were conducted following the implication that the discovered enclosed features were mirrored by similar structures on either one of the other *gopura*. The GPR results from the northern and eastern *gopura* [Fig. 17.6] revealed the remains of small rectangular platforms in front of both entrances inside the enclosure, but nothing similar to the unique features was discovered next to G4W.

Discussion of the Configuration of Tower Complex near G4W

The symmetrical outline of each single feature identified by GPR, a central part with four porticos in all directions, indicates that they had been tower bases of a temple. Currently, only the laterite foundations remain, with no architectural superstructure. It is possible that there was either a masonry structure which has been removed atop the platforms or that the features on the platforms were made of a perishable material like, for example wood (Dumarçay 2005: 24).

The orientation and outline of the six features clearly indicate that they were constructed as part of a single complex. Their location also implies a relation to the construction history of G4W. There is no indication from the survey results that the structures were related to either the two *stupa* or the column bases, which had all been excavated and removed in the earlier archaeological and conservation work. The old EFEO excavations conducted in the area demonstrated on the other hand multiple and successive construction and destruction stages of G4W (Parmentier 1919; Marchal 1920; Boisselier 1951; Groslier 1966–8).

Several stages of construction and destruction regarding the towers were also interpreted from results of an excavation conducted by GAP in June 2010 following the GPR survey at the tower base S2 and the enclosure wall S7. The excavation revealed a 2m deep stratigraphy, showing that the features had substantial foundations that were cut through layers of fill and occupation. From the survey and excavation results, it was interpreted that the structure was built and removed during the period of the construction and use of Angkor Wat. Once the ceramic analysis and radiocarbon dating from the excavation has been completed, the stratigraphy will provide more precise information on the construction periods.

The GPR survey results of the two platforms N4 and S4 adjacent to G4W indicate that rectangular anomalies, identified as porticos in direction of the gallery, extend to the gallery wall. The proximity to

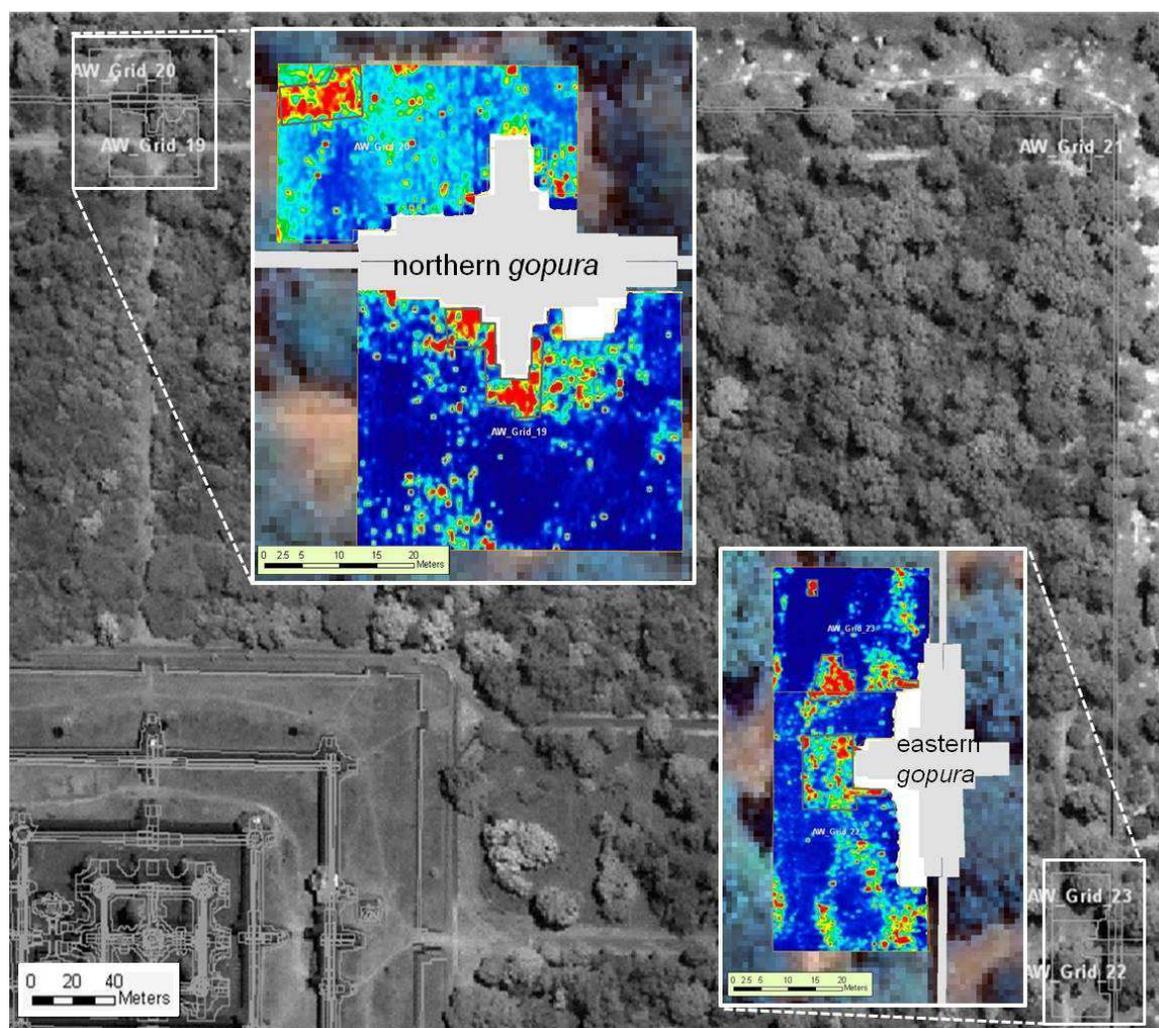


Fig. 17.6: GPR results from the northern and eastern *gopura* indicate small platforms in front of the structures. (Photo: IKONOS 2004, source: Greater Angkor Project superimposed photogrammetric model: Sonnemann *et al.* 2006).

the temple could indicate that they were either partly removed or overbuilt when the entrance gate was constructed. This implies that the foundations were built before the entrance gate of Angkor Wat.

A similar architectural arrangement of towers is known from pyramidal temples preceding Angkor Wat. A characteristic symmetrical outline, the so-called *quincunx* layout, consists of four towers in a square surrounding a central tower. This can be seen on architectural plans in the central area of Pre Rup or Ta Keo. The latter layout is displayed next to the interpretation of the GPR results at the same scale [Fig. 17.7]. A configuration of an inner and outer *quincunx* of a total of nine towers (plus one out of order) can be found at the East Mebon. A similar outline can be seen in the central tower of Angkor Wat. While constructed at a different scale, the Angkor Wat *quincunx* displays a consistent spatial relationship between the towers of the first and second enclosure. There is, however, no known symmetrical group of structures at Angkor without a central tower, suggesting that in the configuration identified near G4W, the central tower is under the causeway.

The construction history of Angkor supports the proposition that this was a temple structure which consisted of nine towers. The two mapped outer towers in the east of G4W were then matched by two in the west, located in the position of the northern and southern tower of G4W, and removed with its construction. The two western-most towers may have actually been further west than the symmetrical configuration suggests. This would be consistent with masonry remains observed in the GPR survey west of

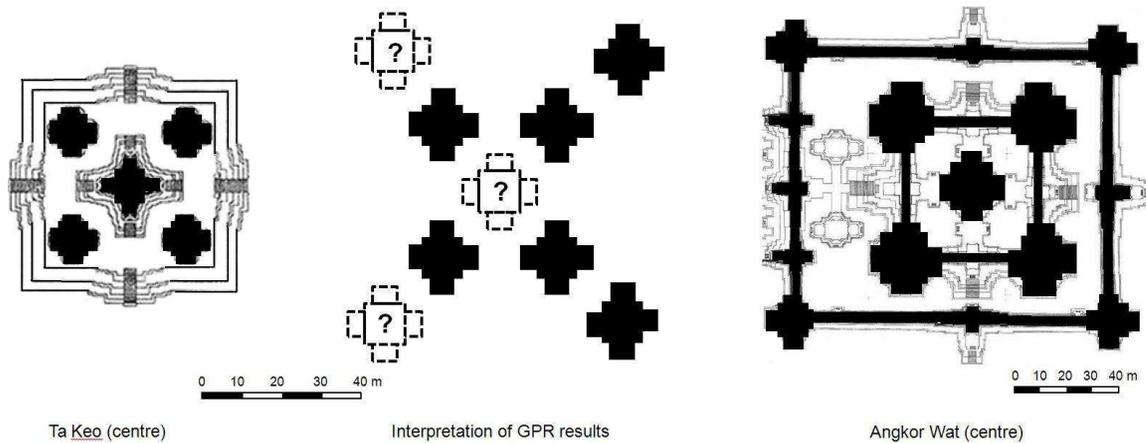


Fig. 17.7: *Quincunx* structures: architectural plan of the centre of Ta Keo temple (Glazé 1944), the outline of the detected towers in the same scale, and a smaller scaled Angkor Wat taken from an architectural base plan (Pottier 1993: pl. 40).

the gallery. The hypothetical remains of a central tower would now be buried under the central causeway. However, no evidence for its remains was detected by GPR alongside the masonry causeway, raising the question of the existence of a tower in the first place. A GPR survey on top of the causeway was not expected to show any interpretable results concerning subsurface features due to its height and structure.

Another unique characteristic of the temple complex near G4W is the equal surface height of the bases of the towers. All known examples of the *quincunx* configuration at Angkor are pyramidal, with the central tower placed higher than the surrounding four, and the inner *quincunx* configuration higher than the outer towers, as in the case of the East Mebon. The configuration at G4W appears to be entirely flat with all the tower bases at the same level.

Conclusion

The large number of complex subsurface features discovered in the temple enclosure shows the importance of underground survey in the interpretation of the architectural history of Angkor. The configuration of the tower bases at the western entrance gate of Angkor Wat is the only known *quincunx* layout built on a single terrace or non-stepped terrace platform at Angkor. A similar temple configuration has yet to be found, which makes it a unique example of Khmer architecture. The absence of similar subsurface features at the northern and eastern *gopura* suggests that this outline was exclusive to the western gate. Several stages of remodeling, including the architectural remains removed in preceding archaeological campaigns, indicate a complicated construction history near Gopura 4 West and highlight the long-term importance of the western entrance at Angkor Wat. A detailed ceramic analysis and radiocarbon dating of the excavated material will help to date the construction and dismantling of the towers and their relation to the existing temple configuration. Additional excavations will have to be conducted to understand the connection of the tower bases to G4W and the subsurface features detected on the western side. The survey demonstrates the great potential of GPR for this region. Similar studies in other enclosures would improve the knowledge on structural configurations within the enclosures of Angkor and offers the potential to greatly increase their histories.

Acknowledgements

The research was financially supported by the PhD Research Travel Grant Scheme, while the travel to the 13th EurASEAA in Berlin was supported by the Postgraduate Research Support Scheme (PRSS), both of the University of Sydney. Thanks to Martin Gibbs of the university's *Department of Archaeology* for providing the GPR equipment. Hen Chenda, Suy Pov, Long Chanta and Lam Touch were of great help in

the GPR survey. Many thanks to Roland Fletcher and the Greater Angkor Project (GAP) for supporting additional GPR surveys and excavations following the campaign, which were supervised by Dougald O'Reilly (formerly University of Sydney, now The Australian National University), Miriam Stark of the University of Hawaii at Manoa and Chhay Rachna of ASPARA Authority. Christophe Pottier of EFEO was of great help to find historical sources describing the preceding work at G4W in the EFEO archives. All involved in the excavations contributed to the discussion on the chronology of the structures. Thanks also to Valter Santoro (IGESSNC) and Satoru Miwa (Sophia University) for helping to explain the anomalies on the western side of G4W.

References

- Boisselier, J. Extract from *Rapports de la Conservation d'Angkor*. Siem Reap: EFEO Archives, 1951.
- Conyers, L.B. *Ground-penetrating Radar for Archaeology*. Walnut Creek, CA: Altamira Press, 2004.
- Dumarçay, J. *Construction Techniques in South and Southeast Asia — A History*. Leiden: Brill, 2005.
- Glaizé, M. *Les monuments du groupe d'Angkor*. Paris: A. Portail, 1944.
- Goodman, D. and Klein, J. *Processing Software GPR-SLICE Vers. 7*. Woodland Hills, CA: Geophysical Archaeometry Laboratory Inc, 1994–2011.
- Groslier, B.P. Unpublished extract from *Rapports de la Conservation d'Angkor*. Siem Reap: EFEO Archives, 1966–68.
- Marchal, H. Unpublished extract from *Rapports de la Conservation d'Angkor*. Siem Reap: EFEO Archives, 1920.
- Parmentier, H. Unpublished extract from *Rapports de la Conservation d'Angkor*. Siem Reap: EFEO Archives, 1919.
- Pottier, C. *Documents topographiques de la conservation des monuments d'Angkor*. Paris: École Française d'Extrême Orient, 1993.
- Nishimura, Yasushi and Goodman, D. Ground penetrating radar survey at Wroxeter. *Archaeological Prospection* 7 (2000): 101–5.
- Santoro, V. Historical City of Angkor — Angkor Wat — West-Embankment Restoration Project, 2003 [unpubl. talk, provided 18 May 2010 by Valter Santoro, project leader].
- Sonnemann, T., Sauerbier, M., Remondino, F. and Schrotter G. Reality-based 3D modeling of the Angkorian temples using aerial images. In *Proceedings of the 2nd International Conference for Remote Sensing in Archaeology*, 4–7 Dec. 2006, Rome, ed. S. Campana and M. Forte, pp. 573–9.