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THE GARDENS OF THE ROYAL PALACE AT AYUTTHAYA

This report describes archaeological investigations in the area of the gardens of the royal palace at Ayutthaya. The work was undertaken by the authors, accompanied by Dr H. Smith and Ms A. Badcock, at the invitation of Khun Bowornwet Rungrujee of the Ayutthaya Ancient City Project. Funding was provided by The British Council, the University of Sheffield, and the Fine Arts Department. Fieldwork took place in March 1997, when the team were assisted by Ms. S. Prakittipoom of the Fine Arts Department.

The project: objectives and methodology

The project was suggested by Khun Ronarit Dhankoses in the Division of Archaeology. He proposed that, as part of the Ancient City Project, a non-invasive investigation of the garden area of the royal palace should be undertaken, the objective of which would be to better understand the nature and the layout of this area prior to Ayutthaya's destruction in AD 1767.

The methodology adopted by the team comprised two principal elements. Geophysical survey would be used to identify buried structural remains and garden features, and palaeobotanical investigations (mainly pollen analysis) would be used to provide a general impression of vegetation in the garden area in the 18th century. In addition, a survey was undertaken of all visible structural remains, the present vegetation of the garden area was recorded, and relevant evidence from 17th and 18th century historical sources was collected and analysed.

A detailed technical report, complete with print-outs of all geophysical plots, was submitted to the Ayutthaya Ancient City Project in October 1997 (Branigan, Merrony and Smith 1997), whilst a report on the palaeobotanical investigations is in preparation and will be submitted to the JSS shortly. This report is concerned with the geophysical investigations, the historical evidence for the gardens, and the interpretation of the general layout of the garden areas.

The evidence of historical sources

Amongst the plethora of descriptions of Ayutthaya from the late 17th century, inspired by the French diplomatic initiative at that time,

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at least five sources make some brief reference to the palace gardens. These are the accounts of Chaumont (1686), Choisy (1687), Gervaise (1688), la Loubère (1693), and Tachard (1688); to these may, be added the description and simplistic sketch of the palace and its surroundings published by Kaempfer in 1727. These various sources together provide insights into three aspects of the gardens - their general layout, the plants that may have grown in them, and their water supply.

All the sources seem to agree that the area to the east of the king's apartments and the audience hall was occupied by various courtyards, with official buildings (e.g. stores, secretariat and the armoury). Tachard (1981,165) records that 100 paces south of the palace itself was a great walled park, and Kaempfer (1987, fig. 8) shows this area with rows of large trees. It is presumably here that Chaumont was "dined in the palace garden under great trees" (Chaumont and de Choisy 1997,53).

But there was clearly another area of gardens of a different nature. Choisy (1993,170) describes how he and his companions were taken into a secret area, normally closed to foreigners:

"It was a very pleasant garden divided by canals and fine walks". Gervaise (1989,39) is surely describing the same or a very similar area when lie speaks of "large well-tended gardens. The walks are intersected by little streams which make everything fresh". According to Gervaise, gardens of this sort were overlooked by both the King's and the Queen's apartments. Given that the womens quarters were in a separate walled enclosure on the west side of the palace precinct, it seems likely that there were two gardens with paths and water channels rather than one. Kaempfer's plan shows the womens enclosure but it is completely empty, because he, like all other male visitors, would never have been allowed to see inside it. Similarly, Gervaise and Choisy were presumably both describing what they had seen adjacent to the King's quarters.

None of the accounts describe the plants growing in the gardens of the palace, but several refer to trees, shrubs and flowers found growing in Thailand at this time. Gervaise (1989, 19) mentions roses, carnations and tuberoses, as well as "some flowers that are not found in Europe", the commonest of which are the *mungery* (jasmine?) and the *pousonne* (gardenia?). La Loubere (1986, 20-1) confirms that tuberoses, tricolours and ameranthi were plentiful, and gillyflowers and roses were also to be found, but says that the jasmine was so scarce "tis said there are none but at the king's house". Otherwise, says la Loubère "most of the plants which adorn our gardens are unknown to them". Gervaise, la Loubère and others note the abundance and variety of fruit trees available in Siam.

Apart from the mention of canals and streams in the gardens by Choisy and Gervaise, there are no direct references to water courses and water supply to the palace gardens at Ayutthaya, although Choisy (1993, 165) describes how the French ambassador's residence was being embellished with "a sparkling fountain; they are working night and day on a small reservoir to hold the water". Several fountains decorated the garden of the house provided for Chaumont at Lopburi (Chaumont and Choisy 1997,59) and Choisy (1993,194) mentions walks and canals in the King's gardens here. Gervaise's (1989, 44-7) description of King Narai's palace at Lopburi has much to say, about the use of water. A pavilion in the gardens is said to be surrounded by numerous fountains, and in the king's apartment is a further fountain which supplies water to four corner bathing tanks. In the outer court is "a large tank which supplies the whole palace with water. It is the work of a Frenchman and an Italian".

Gervaise describes further features of the gardens at Lopburi, which were of course contemporary with those of Ayutthaya. He mentions pavilions, groves of trees, evergreen shrubs, innumerable flowers, and a bed "filled with the rarest and most beautiful flowers in the Indies". Beyond these flower gardens and pavilions was a large garden filled with orange, lemon and other native trees, and walks bordered by low brick walls. At intervals along the walls were "spaces containing lanterns of gilded copper" and "in the space between the lanterns is a kind of hearth or altar" where aromatic woods were burned. Choisy (1993,194) specifically mentions fig trees as growing in the gardens here and says that the gardener at Lopburi was a Frenchman.

This brings us to the foreign influences which may have been at work in the design, embellishment and stocking of the royal gardens at both Lopburi and Ayutthaya. Given the intensity of the French diplomatic initiative in the 1680's Gervaise's mention of a French hydraulics expert and Choisy's of a French gardener may come as no surprise. On the other hand, the French involvement in Siam before the 1680s was low key (Hutchinson 1985, 42-67) and it is unlikely they would have been influential in the formative years of Narai's gardens.

The Dutch on the other hand were well established at Ayutthaya and we have contemporary evidence that Dutch traders, and the Dutch East India Company in particular, constructed gardens in their trading stations. On his journey to Siam, Tachard saw and admired the Dutch gardens at both the Cape of Good Hope and Batavia, present day Jakarta, (1989, 51, 110). Those at the Cape appear to have been not dissimilar to part of the gardens at Lopburi, with walks fringed by orange and lemon trees, and square plots containing fruit trees and flowers. Significantly, however, Tachard writes "the beauty of it consists not as in France, in compartments, beds of flowers, nor waterworks", even though a natural stream ran through the garden.

Other European influences are unlikely; the Portuguese were also well established at Ayutthaya but not a dominant force, and the English activities there were half-hearted and intermittent.

There is one further potential source of influence, however, and that was the Japanese. They had been the first foreign nation to establish a settlement at Ayutthaya soon after 1605, and it has been pointed out by Beckett (1909, 26) that in Narai's reign a small group remained at Ayutthaya and provided assistance to the King "in building, architecture and gardening".

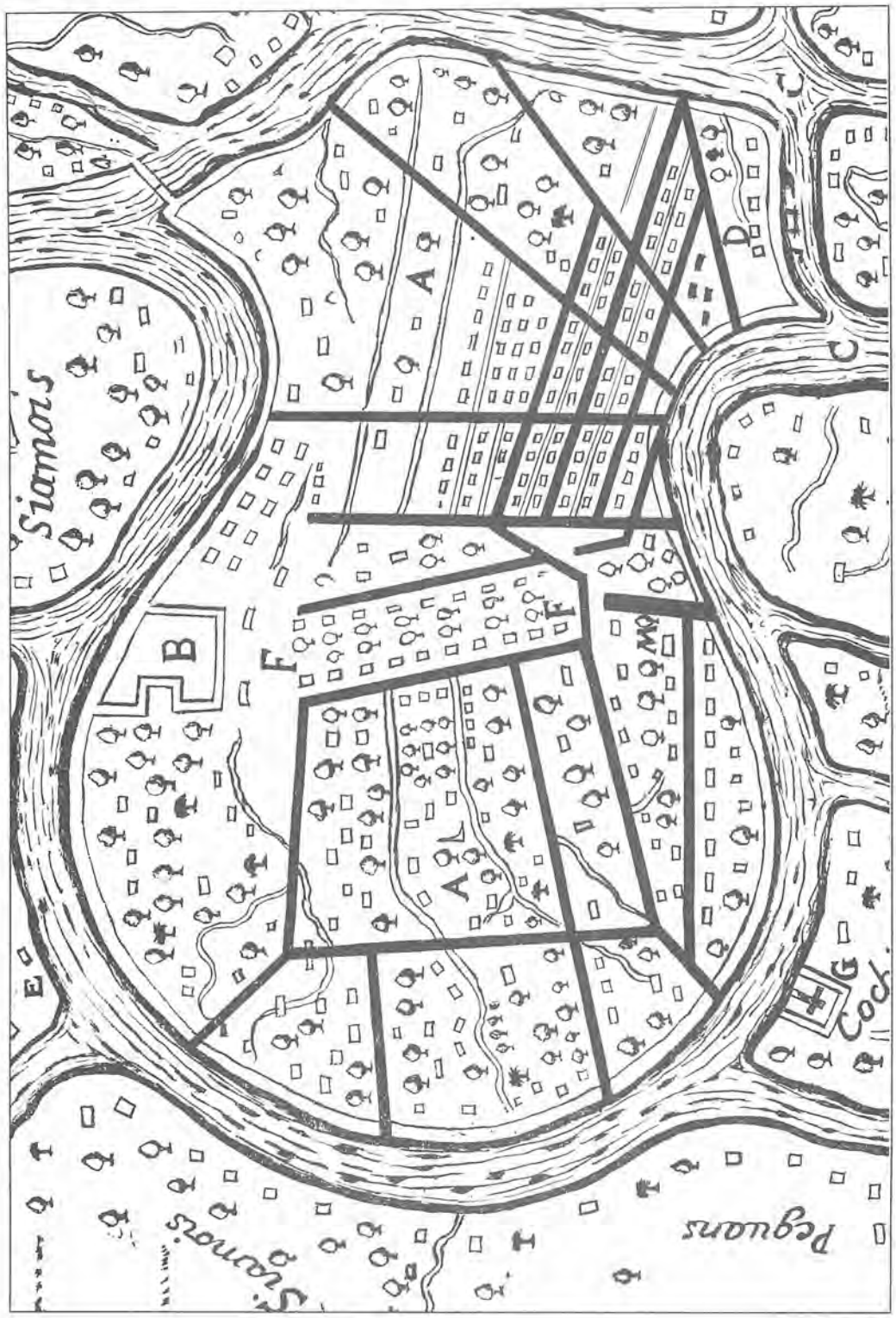
The evidence for the palace gardens provided by contemporary written sources may be summarised as follows. The area to the east of the king's apartments was occupied by courtyards given over to various official functions. To the south of the palace was an enclosed area of parkland planted with many large trees. Close to the palace and audience chamber, and also to the west in the womens quarters, were more formal gardens. Details of these are vague, probably because foreigners were able to see little or nothing of them. But it is probably legitimate to use the evidence from the contemporary gardens at Lopburi to fill out the picture. We should expect the pathways described by Gervaise and Choisy to run between miniature walls, flower plots, avenues of fruit trees, shrubs and small pavilions, and the water courses to feed fountains. The extent to which these gardens reflected foreign influence is open to question, but the most likely sources of inspiration were the Dutch, possibly the Japanese, and for hydrological engineering, the French.

The geophysical survey—background and method

Ayutthaya lies on an island, of approximately 7.5 square kilometres, formed from alluvial silts at the confluence of the Chao Praya, Lopburi and Pasak rivers. The survey area is virtually level except for several open ponds which are cut down below the current ground surface. At the time of this geophysical survey the water level in the ponds (and by assumption the water table under the survey area) was between 2 and 2.5 metres below the general level of the current ground surface.

The most substantial buildings (e.g. palace and temple buildings) within and around the City Island were built of a brick core with mortar rendering to produce ornate exteriors. A small amount of a conglomerate stone was also used. Other buildings in the city were largely constructed of wood. These buildings, along with associated features such as paths and roads, sit directly on the fine silts that make up the matrix of the city island and adjacent to the many canals that crossed through the city and lakes and ponds within its boundary.

A total of nine areas were surveyed comprising 37,600 square metres which sampled all the available areas of the Royal Palace Garden. The whole of this total was surveyed using Magnetometry, while 3,800 square metres was also surveyed using Resistivity. The current ground cover is short (generally mown) grass with mature trees. By using both magnetometry and resistivity it was hoped that not only would



Seventeenth century map, of Ayutthaya, la Loubère

the foundations of built structures be identifiable, but also that features clear of building material (such as planting beds and water channels) would become apparent.

There are two main mechanisms by which archaeological deposits become able to possess a magnetic field and therefore become detectable by magnetometer survey. The first of these is Thermoremanent Magnetisation. This results when a material containing iron oxide particles (i.e. virtually any soil or subsoil, as well as materials such as clays used for brick making) is heated up to above the Curie point of the iron oxide particles it contains (650 degrees Centigrade or more). On heating the iron oxide particles effectively demagnetise. When the material cools down again the iron oxide particles remagnetise preferentially aligned with the earth's magnetic field. This alignment of the magnetic fields of the iron oxide particles produces an effectively fixed permanent magnetic field for the material as a whole. This magnetic field can be detected by a magnetometer survey. The second mechanism is that of Magnetic Susceptibility, which is the ability of a material to become magnetised when placed in a magnetic field. Iron oxides are highly Magnetically Susceptible, although the precise level of this depends on the form of the oxide. A deposit may be made more Magnetically Susceptible by increasing the concentration of iron oxide within it or by changing the form of the iron oxide particles it contains (Fassbinder et al, 1990). The form of iron oxide particles can be changed in such a way as to make them more Magnetically Susceptible by heating them (any temperature above approximately 100 degrees Centigrade will have an effect) or if they are in an originally highly organic deposit where some or all of the organic material has been broken down by the action of bacteria and other soil organisms (for example a ditch fill which is not permanently waterlogged). If this deposit with enhanced Magnetic Susceptibility is placed within a magnetic field it will become more highly magnetised than it would originally have been. Provided the deposit is within a magnetic field at the time of the survey this increased magnetic field can be detected by a magnetometer survey. Fortunately all archaeological deposits, along with everything else on the Earth, are within the Earth's Magnetic Field at all times and the resulting magnetic fields of archaeological deposits can be detected by a magnetometer survey.

The instrument used to conduct this survey was a Geoscan FM18 which is a Flux-gate Gradiometer that utilises two sensors to measure external magnetic fields. The upper sensor is positioned to detect the earth's magnetic field, while the lower sensor detects the earth's magnetic field plus any other magnetic field resulting from below ground features. The two measurements are compared so that the component of the readings that represents the direct measurement of the earth's magnetic field can be removed. The strength of any other magnetic field present is then recorded.

During the Magnetometer survey readings were taken with a 1 metre spacing. The spacing was chosen in order to allow a reasonably fast coverage of the area, while still collecting data closely spaced enough to allow definition of most garden features (such as paths, beds, water channels, ponds, the bases of above ground structures and so on). Magnetometry was the obvious first choice in this situation as most features would have been constructed of fired bricks, a potentially good material for detection by its magnetic properties (Clark, 1996). In addition it was hoped that channels and ponds, now filled in, would produce magnetic responses as a result of their enhanced magnetic susceptibility.

What was not known, however, was how strongly magnetic the underlying silts were, how much brick and other burnt material was spread across the garden area either during the sacking of the city by the Burmese or subsequently during demolition, renovation and construction of the various buildings on the site and how much modern build up of material there has been (particularly strongly magnetic material such as discarded iron).

Inspection of recently excavated structures within the site revealed that there was very little build up of deposits over the level of the Ayutthaya period buildings. In some places there was as much as 1 metre, but in most places it appeared that the current ground surface was very close to the 18th century level. However, it

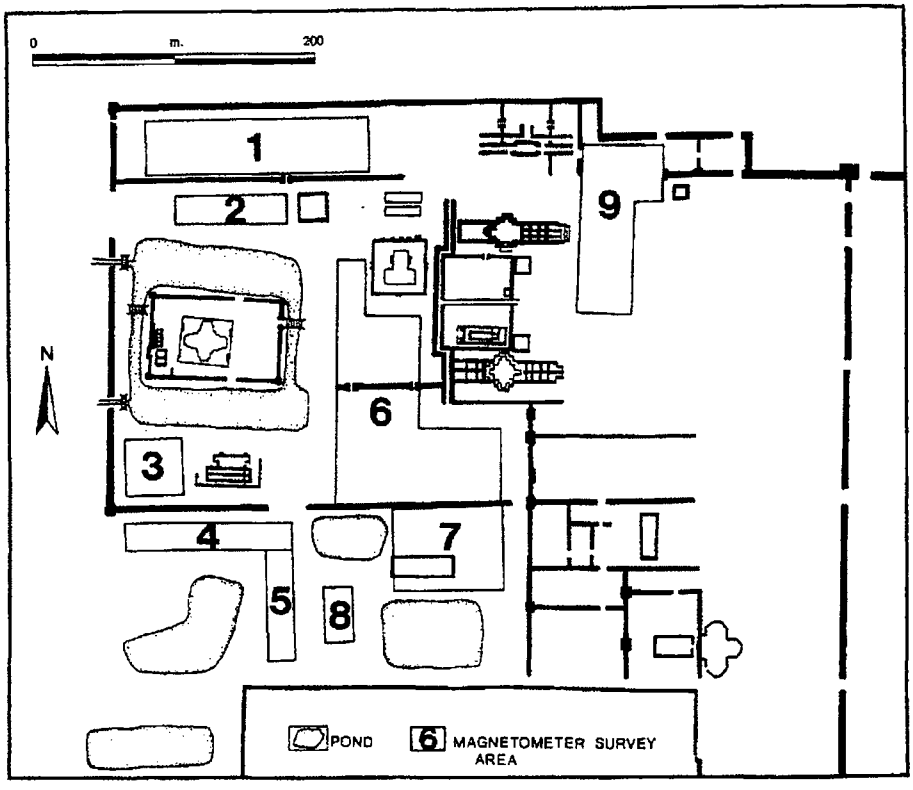


Fig. 1 The palace precincts at Ayutthaya showing areas of magnetometer survey

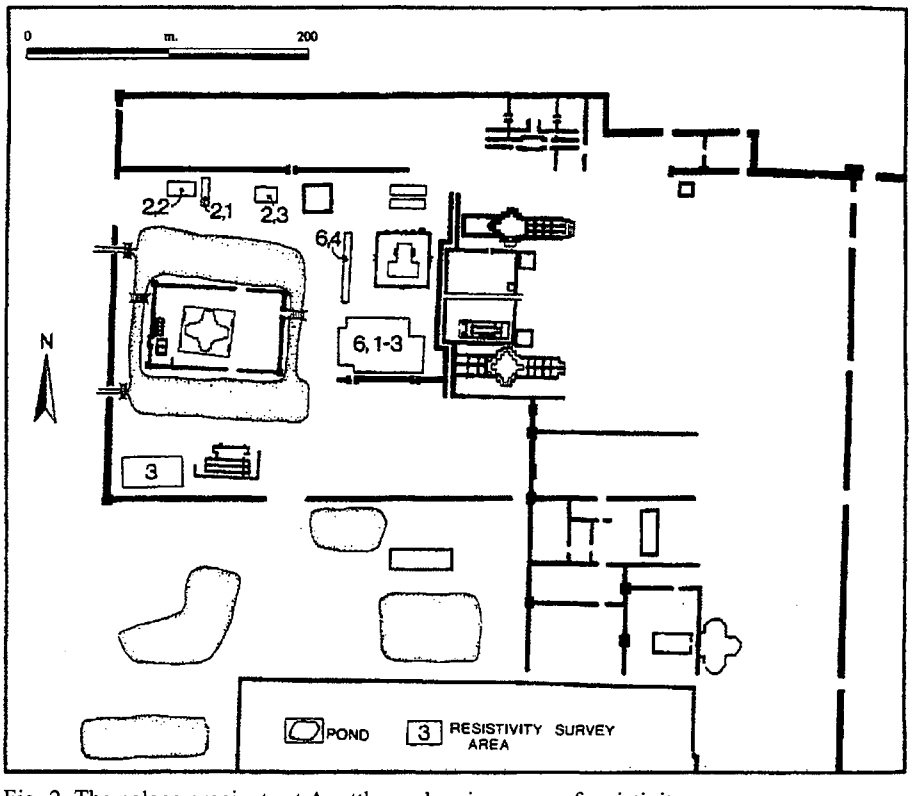


Fig. 2 The palace precincts at Ayutthaya showing areas of resistivity survey

did appear that substantial amounts of brick rubble were spread across the area. Surface inspection revealed some modern discarded metal on the ground surface, however, amounts of this did appear to be very low.

Unfortunately it would appear that the underlying silts making up the City Island have a significant iron content and are fairly magnetically susceptible. The genesis of this high level of magnetic susceptibility has not been investigated here (it may be natural soil processes, the inclusion of occupation material, or it may be the incorporation of burnt material during and subsequent to the sacking, or it may be a combination of all these). As is discussed below the Magnetometer survey was conducted with generally 'magnetically noisy' background conditions.

The only other potential problem for Magnetometry was the presence of overhead electricity cables. In fact experience showed that these did not make any significant difference to the results (except around the poles that support the cables due to supporting metal cables attached to ground anchorages). One must presume that these cables are conducting a fairly small current for a local supply, otherwise one would have expected them to create linear magnetic anomalies.

Many parts of the survey area were also surveyed using Resistivity. The spacing between readings was either 1 metre or 0.5 metres depending on time available. The use of closer spacing in some areas was intended to assist in the precise definition of small features in possible formal garden areas.

The resistance to the passage of an electric current through a soil, sediment or archaeological deposit is primarily related to moisture content. Electric current passes more easily through moist deposits than through dry. Consequently a resistivity survey is particularly suited to the definition of buried archaeological remains that are the result of past human actions that have altered the ability of those deposits to hold moisture. The foundations of a stone wall hold considerably less moisture than the organic-rich fill of a ditch or pit. Consequently the resistance values of a pit or ditch may be expected to be significantly lower than those of a stone wall. Complete waterlogging or desiccation of soils and sediments can cause these differences to become (temporarily) undetectable and so weather conditions and general soil moisture levels must be noted.

The instrument used to conduct this Resistivity Survey was a Geoscan. In order to pass the electric current through the ground and measure how easily it passes four electrodes are employed; two probes pass the electric current through the ground and two probes are used to measure the resistance to the passage of that current. In this survey these four electrodes were arranged in a Twin-Probe array. In the Twin-Probe array the electrodes are split into two pairs, each containing one of the probes passing the current and one of the probes measuring the resistance. One of the pairs remains in a fixed position whilst the other pair is moved across the survey grid. The Twin-Probe array as used in this survey has a depth penetration of approximately 0.75 metre, although the nature of the overburden, underlying geology and soil moisture levels will cause variations in this figure.

Initially it was uncertain as to how effective Resistivity surveying would be in the climatic conditions found here. There is a long history of the failure of Resistivity as a technique in areas with hot climates (Clark, 1996: 34). This is primarily due to the depth to which the soil dries out during dry periods or seasons. This survey was conducted during part of the dry period of the year in Thailand and temperatures were consistently above 35° Centigrade. However, as has already been mentioned the water table was as little as 2 metres below the current ground surface. In addition to this the soil and subsoil in the survey area are derived from very fine-grained alluvial silts, which it was thought may well act to draw water up from the water table through the soil profile. In fact the ground surface was extremely dry and it was not possible to get an adequate electrical contact between the survey probes and the soil. However it was found that by watering the surface of the ground the evening before surveying a good contact between probes and soil was easily obtained. It is possible that the results were further enhanced by the addition of water at the ground surface, which may have increased the Osmotic Potential in the soil profile overnight and allowed more moisture to be drawn up into the upper part of the soil. We had

no method of investigating the processes at work during this survey, however quite clearly as long as the Resistivity survey was conducted while adequate moisture was still at the ground surface very good results were obtained. Unfortunately the results in some areas are complicated by the presence of dry patches which probably either increased the Contact Resistance present or resulted in no contact being possible and so no reading taken. In future Resistivity survey will be very suitable at Ayutthaya as long as it is integrated with a systematic watering campaign. The problem is the slowness of Resistivity surveying combined with the drying out of the ground surface during the survey. However, this could potentially be overcome easily by covering the ground to be surveyed with some kind of sheeting each morning (after wetting it the evening before) and gradually exposing the ground surface as the survey progresses, thus ensuring as far as possible consistent surface moisture content across any one area.

The only other real difficulty that affected the results was the presence in some areas of mature trees. This was compounded in some areas by the local habit of piling up surface rubbish, spoilheaps from excavations and so on around the boles of mature trees thus creating large mounds around the trees which succeed in increasing the area masked and resulting in some gaps several metres across (or at least areas in which the readings are likely to be unrepresentative of buried features). Obviously a complicating factor that we cannot define is how the growth and removal of trees in the period since 1767 has disturbed the archaeological deposits.

Overall it was possible to apply both techniques at Ayutthaya and successfully obtain data, even though both techniques had some difficulties. Methods were quickly established that facilitated the collection of data. However, in future closer spacing between readings may allow some refinement of definition of Magnetometry data, and the use of automatic data logging and a more strict watering programme should allow Resistivity surveying to be speeded up. This would allow larger areas to be covered by Resistivity which would assist interpretation.

The geophysical survey—results

Area 1: Magnetometer Survey

This area is in the north-west corner of the Palace Garden and covers a total of 6,400m^2 which was surveyed by magnetometry. There are small to medium sized trees spread approximately evenly across area 1. However, readings were taken for all points as none of the trees had very large trunks, nor did they have the mounds of modern material common to so many of the larger trees within the Palace Garden area.

This survey was dominated by strong magnetic anomalies consistent with ferrous material on or near the ground surface. Apart from this there are no other significant anomalous readings that could be interpreted as relating to building structures or the layout of a formal garden. This does not prove that this area was not laid out as a formal geometric garden area as the features forming such a garden may result in very relatively slight changes in the magnetic properties of the deposits. As we have already noted this area is magnetically 'noisy' and this could mask slight features. However, the results are entirely, consistent with a relatively open area of lawn or parkland which had been simply levelled and then maintained.

Area 2: Magnetometer and Resistivity Survey

This area is to the south of Area I and north of the moat and the survey covered 1600m^2 with magnetometry. In addition to the magnetometry 3 parts of Area 2 were sampled with resistivity taking readings at 0.5m. intervals. Transect I was 100m^2, transect 2 was 200m^2 and transect 3 was 150m^2. There are many medium sized trees spread across the survey area. In addition previous excavation has revealed structural remains, in the form of walls and a broad path, which remain visible on the surface.

The magnetometer survey revealed a number of linear anomalies. Some, but not all, of these are related to features which are visible on the ground. However they are shown extending further to the east than is visible on the ground. There is, however, an additional major linear anomaly running from the eastern margin of the survey area (and by extrapolation perhaps from

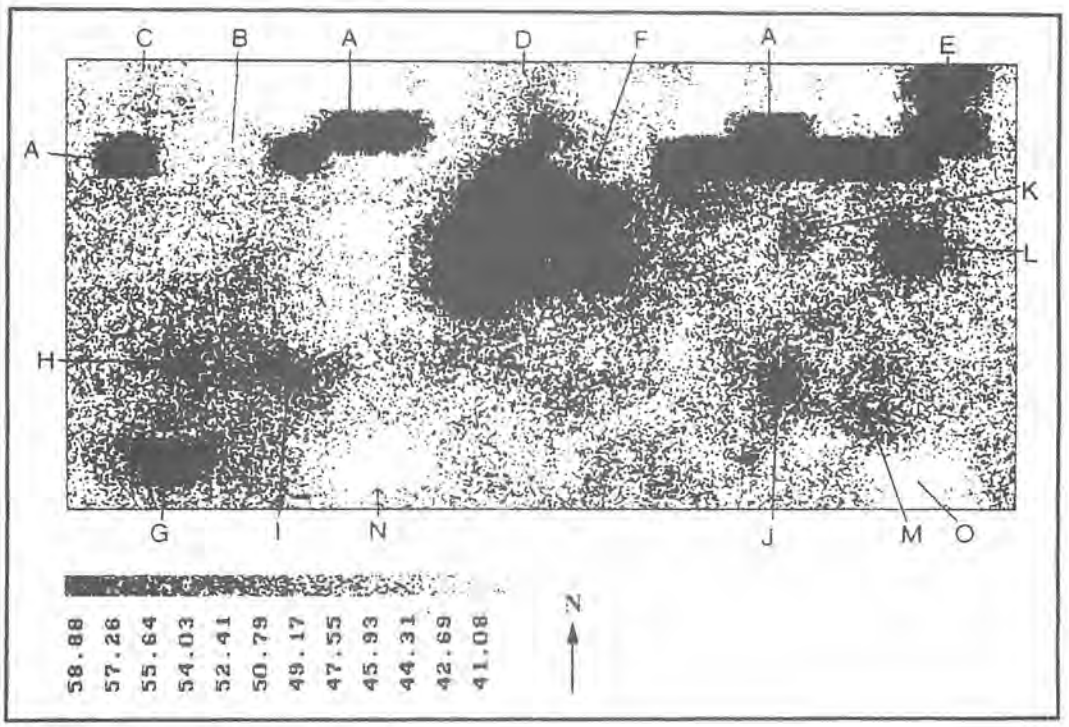


Fig. 3 Resistivity plot in area 2, transect 2

the reservoir) westwards for 40m. It may continue westwards from here towards the City Wall but if it does then it is as a much less clear feature. This feature appears to be a brick built feature, but whether a wall, water conduit or path cannot be determined.

The plot of the resistivity survey shows a number of features. Firstly to the north of the path (in transect 2,1) is an anomaly which could be the end of a small rectangular structure, but as this lies on the margin of the survey area this cannot be proven. Transect 2,2 was oriented so that its long axis was east west (i.e. approximately, parallel to the axis of the path and walls). This area revealed a number of anomalies (figure 3). The wall is clearly visible both as a high resistance anomaly A (where brickwork still survives) and as a low resistance anomaly B (where the brickwork has been removed). To the north of the wall are three small (c. 2m. square) high resistance anomalies C, D, E, apparently built between the wall and path. These are spaced approximately 7m. apart and may represent either regularly spaced brick pillars or perhaps platforms upon which some garden feature or structure stood. Near the centre of transect 2,2 is a large high resistance anomaly which must be either a dump of building material in a pit or other cut into the ground, or the base of a structure adjacent to this wall, perhaps a small building. To the west of this is a north-south linear low resistance anomaly. The most likely explanation for this is a ditch or slot filled with rubble-free, clean topsoil. Transect 3 lies towards the eastern margin of the survey area, beyond the visible end of the path and wall. This continues the suggestion of a series of regularly spaced high resistance anomalies running between the path and wall, however, here they are also mirrored to the south of the wall.

Area 3: Magnetometer and Resistivity Survey

Area 3 lies to the south of the moat and north of one of the main Palace walls—'Kamphaeng Kao'. 1,600m² were surveyed by magnetometry and the southern 800m² of this area was also surveyed using resistivity. Both of these methods employed a sampling frequency of 1 m. This area had a 'noisy' magnetic background. However, three weak linear anomalies were defined, although their insubstantial nature makes interpretation difficult. The strongest runs

almost north-south just east of the centre of the survey area. Comparison with areas 2 and 6 suggests that this feature may, be strong enough to represent a built structure (presumably of brick). The second anomaly runs from the centre of the eastern half of the southern margin of the survey area approximately north-north-east clearly for about 12m. possibly continuing beyond that. This is a weak feature and may be the result of a channel once filled with organic-rich debris rather than a built structure. Similarly weak is the third feature which meanders approximately north-westwards from close to the centre of the western half of the southern margin of the survey area.

These weak anomalies may well relate to garden features or infrastructure but do not allow firm interpretations. In an attempt to clarify this a resistivity survey was conducted. The resistivity plots are dominated by north-south linear anomalies. The strongest is a high resistance anomaly which runs from approximately the centre of the southern margin of the plot northwards. Close to the centre of the resistivity survey area there is a break in the anomaly, then it 'continues' northwards curving slightly to the east. It seems most likely this anomaly relates to a wall or path with a break/ entrance in it. However, it should be remembered that this survey area is quite small and we may be seeing parts of different features and falsely associating them together. East of this is an anomaly which appears as a double linear high resistance, the two lines of which merge to form a single linear high resistance anomaly approximately half way across the resistivity survey area. Again one assumes this is a built structure of some kind. This anomaly appears to be in the correct position to correspond with the strongest anomaly in the magnetometer survey. The difference between the resistivity plot and the magnetometer plot may be the result of the very 'noisy background' of the magnetometer survey. The resistivity survey has a much quieter, cleaner' background which allows subtle variations to be discerned.

Area 4: Magnetometer Survey

Area 4 lies immediately to the south of the wall 'Kamphaeng Kao' and comprised a 20m. wide strip running parallel to the wall and totalling 2,400m^2. This area was surveyed with the magnetometer using a sampling frequency, of 1m. The area includes a number of mature trees. These were less frequent towards the eastern end of the survey area. It should be noted that area 5 adjoins area 4 towards its eastern end. A number of significant anomalies were revealed in this survey, generally running parallel to the nearby wall although as the survey area is quite narrow the precise function of these features remains uncertain. If this area is on the edge of an area of parkland type garden then it is surprisingly large complex. However, the results could represent something like a pavilion and associated features on the edge of a parkland area, but this interpretation could only be proven by excavation

Area 5: Magnetometer Survey

Area 5 runs southwards from the eastern end of area 4 and covered a total area of 1,600m^2 and was surveyed by magnetometer. This area is virtually clear of trees. However many mature trees stand in the area around. This area runs between two of the existing ponds. The most interesting anomaly in this area is a linear anomaly that runs across the plot between the two ponds. This may represent a channel which once ran between the two ponds.

Area 6a and 6b: Magnetometer and Resistivity Survey

This is the largest single area covered in this survey totalling 12,800m^2 of magnetometry. In addition to the magnetometer survey 2,550m^2, in the northern part of this area, was also covered with a resistivity survey, (at 1m. spacing). The area is covered by, frequent trees many of which are fairly, large, mature specimens. This area lies south of the White Pavilion but north of the wall 'Kamphaeng Kao'.

The magnetometer survey revealed a number of features that may be related to the palace gardens. Two of these features are visible on the ground as excavated/reconstructed structures. The first of these is a broad path running approximately north-south through a gateway in the second anomaly, which is a substantial

wall. The path seems to have its southern terminus approximately half way between the wall and another substantial east-west anomaly which probably represents a wall, as it runs parallel to the first wall and the wall 'Kamphaeng Kao'. In fact this anomaly divides the area between the first wall 'Kamphaeng Kao' into two roughly equal halves (each approximately 40m. across north-south). The southernmost of these areas is split by a further linear anomaly (this running north-south) which most probably represents a path or wall. From this a further linear anomaly runs eastwards. Its eastern terminus may however be obscured by the strong anomaly which has been produced by metal debris from a recent bonfire.

The area to the north of the first wall and east of the path shows greater complexity then the areas to the south. There are suggestions of linear features and other small anomalies. This matches the complexity of the walls visible in the parts of this area that have been excavated. While it is not possible using this magnetometer data to reconstruct a precise plan of this part of area 6, there is a strong suggestion that this area has a series of walls, paths and other structures compatible with a complex (possibly geometric) formal garden area. The simplicity of the response of the area further to the south would suggest that these may well have been laid out in a less complex manner, perhaps compatible with a parkland, lawn or orchard area.

The resistivity survey focused on two sample areas within what may have been a complex formal garden. In the area to the south of the White Pavilion a path runs north-south but according to the recovered resistivity data it does not appear to continue as a buried feature to the north of its exposed length. It does appear to bounded, on its eastern side, by a linear high resistance anomaly, particularly clear at its southern end. While it is less clear in the northern part of this sample area it does still appear to be at present set approximately 1 metre away from the visible path. The results from these transects also suggest a number of rectangular features which are consistent with planting beds and other minor structures. The transect to the west of the White Pavilion revealed no anomalies that may have been related to earlier structures within the garden.

Area 7: Magnetometer Survey

This area lay south of the wall 'Kamphaeng Kao' and north of one of the extant ponds. Within the area lay what currently appears to be a brick wall containing a raised earth platform. This feature is variously described in the Ayutthaya Historic City Project records as a 'pond' or a 'pavilion'. A total area of 4,800m^2 was surveyed with the magnetometer. The area had only a few large, mature trees within it. However, it did overlap (on its southern side) with the beginning of the slope down to a large pond.

This area is quite 'noisy' magnetically and there are no strong, clear anomalies visible within the data. There are, however, some weak anomalies which are discernible against this background. One anomaly runs northwards out of the approximate centre of the raised platform In addition to this and running a little more towards the north-east out of the north-east corner of the raised platform is another weak linear anomaly. If the raised platform area had once been a pond then it might be suggested that these two linear anomalies were related to pipes or conduits taking water to or from this pond. There is nothing in the data recovered to suggest the survival of any remains of a complex or geometric formal garden laid out in this area. This may be because this was an informal parkland or orchard area.

Area 8: Magnetometer Survey

A small area of just 800m^2 between the two areas of recent machine excavated archaeological trenches which lie between the two ponds closest to Wat Phra Si Sanphet. It was hoped that this area may throw further light on any possible connecting channel between these two ponds. It is clear from data recovered that this area proved to have a generally high variability in its magnetic response. Unfortunately no clear magnetic features are visible against this background. Whether or not this is because the noisy background masks any archaeological features cannot be defined from this data.

Area 9: Magnetometer Survey

This is the easternmost area surveyed, totalling 5,600m^2 covered by magnetometer. This area

was covered by a large number of small to medium sized trees, although these were more common in the north of this area. Some of the anomalies defined are the result of modem activities The main east-west linear anomaly is the result of a wall now excavated and partly reconstructed. There are three linear anomalies which run north-west to south-east in the northern part of the survey area. At least one appears to cross the wall, which perhaps suggests that this (and perhaps the others) are relatively modern features, perhaps buried cables 'or pipes, although this is by no means certain.

In the southern part of this area there is the suggestion of a linear anomaly running eastwards from the western margin. This anomaly is aligned with some visible surface features which strongly suggest that this may be related to a path or wall that was part of the layout of gardens during the Ayutthaya period.

Summary of results of the fieldwork and their interpretation

To facilitate discussion of the results of the nine areas of magnetometer survey and eight resistivity transects we have divided the palace area into 6 zones, labelled A to F on figure 4. The correlation of zones, areas and transects is as follows:

Zone	Magnetometer Area	Resistivity Area/Transect
A	1	-
B	2 and 3	2,1-3; 3,1
C	6A	6,1-4
D	6B	-
E	4,5,7 and 8	
F	9	

Across the whole area occupied by the palace and its gardens there is a general spread of brick rubble debris. It apparently results from the deliberate levelling of the destruction debris of AD 1767. Together with the significant iron content of the silts which make up the 'natural' soils at Ayutthaya, this spread undoubtedly obscures much that would otherwise be revealed by magnetometer surveys. Only in some areas did the magnetometer survey clearly reveal buried features that were probably

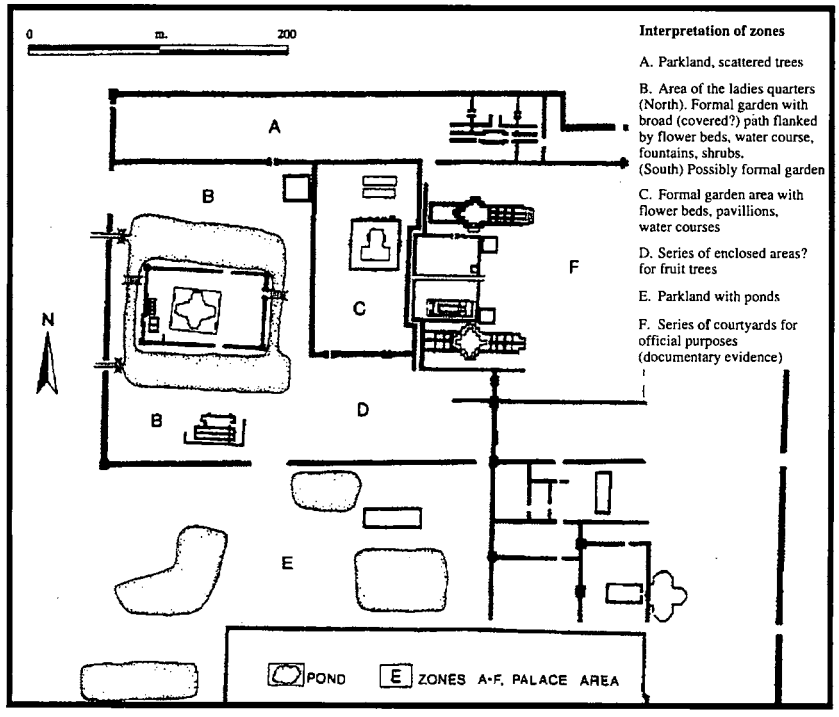


Fig. 4 The palace precincts at Ayutthaya showing interpretation zones used in this paper

contemporary with the later phases of the palace's occupation. In contrast the resistivity survey produced some excellent results, particularly in zone B, area 2.

From the comments made on the individual areas of magnetometer and resistivity survey we can make the following more general observations about the use of open spaces in the area of the palace. Due both to the scarcity of clear anomalies in the magnetometer survey and to the probable nature of the areas themselves, several zones need little comment.

Zone F is in the area of the forecourts to the palace. The geophysical survey revealed no significant features except for a brick path or wall foundation running east-west across the area towards its southern end. This confirms the impression of the historical accounts that the spaces and enclosures which stand to the east of the palace buildings were largely open courts and yards rather than garden areas.

Zone A appears to have remained an area without substantial structures but the high background 'noise' may have obscured some smaller magnetic anomalies associated with gardens. On present evidence we believe zone A was an open area without significant structures and most likely was planted with scattered trees rather than provided with a formal garden layout.

Zone D is separated from zone C by a wall with two gateways. The area is, however, further divided in two by an east-west wall which has been traced across the whole area by the magnetometer survey. From this wall a second can be seen on the magnetometer readings to run at right angles southwards to join the major wall known as Kamphaeng Kao, and there may be a further east-west wall returning eastwards from the north-south wall. In other words zone D appears to be divided up into a series of rectilinear enclosures. On present evidence there is no reason to think that these were areas of laid-out gardens, but the series of relatively small walled areas might have been planted with fruit trees like the lemon, orange and fig trees in the palace gardens at Lopburi.

Zone E, immediately south of zone D, currently contains three ponds and a built rectangular structure variously described as a pavilion and a pond. Magnetometer survey suggested the line of two possible water conduits running into this structure from the west. In area 4, close to the great enclosing wall Kamphaeng Kao, there were clear suggestions of a paved path running alongside the wall. A large anomaly immediately east of the path might indicate the location of a pavilion, perhaps with a water conduit leading into it from the north, but this is a speculative interpretation. The greater part of zone E shows no evidence of structures related to a laid out garden, and the historical evidence suggests that this area was parkland with ponds and probably a variety of mature tree cover.

Zone C, in which the modern pavilion stands, is enclosed by a wall on four sides and was entered by two gateways in the south wall and gates at the north end of the east and west walls. About half of the area south of the pavilion has been excavated down to the tops of brick structures at some time in the past, most probably between 20 and 30 years ago. We surveyed the patchy, visible and partly overgrown remains along with the magnetometer and resisitivity surveys in this area.

We believe that this was an area of garden which included pathed walks, small (probably timber) pavilions with brick floors, water conduits, and other features. The resistivity survey identified a rectangular structure 8m wide and probably about 15m long near the eastern edge of the area which might be a pavilion, artificial pond, or enclosed plant bed. A second squarer structure is identified by surface traces and resistivity anomalies, nearer the centre of the area. There are also anomalies suggestive of smaller brick platforms to the east and west of the western path, and traces both on the surface and in the resistivity survey of water conduits flanking this path, so that the platforms could have been the location of small fountains.

Zone B reveals interesting anomalies in both the magnetometer and resistivity survey in area 2 which we believe are elements in a formal garden layout. The area investigated runs parallel to the major wall which encloses the south side of zone A.

There appears to have been at least two water conduits running from the reservoir westwards through the area, and one or both of these seem likely to have been used to supply water to the gardens in this area. Taken together

with the traces of a path and walls visible on the surface the resistivity survey, particularly in transect 2, suggests an area of garden here which included the following elements:

1. A broad brick path running east-west parallel to the wall.
2. Between the wall and the path a cultivated soil - flower beds?
3. At least one (brick?) platform, about 1.5.m square, is situated in this cultivated area.
4. A similar cultivated soil south of the path - flower beds?
5. South of this bed runs a covered water conduit.
6. At intervals of c. 7m small (brick?) platforms c. 2m. square project from the north side of the conduit into the cultivated area.
7. At least one substantial brick platform, approx. 5 x 3m adjoins this conduit on the south side.
8. South of the conduit there may be bedding pits for shrubs.
9. At least one rectangular walled plot, probably about 2.5m square, stood in this area.

This evidence suggests an area of garden with features similar to those described at Lopburi. The small platforms to the north of the conduit (6) might be stands for ornamental vases or lanterns, whilst the bigger platform (3) might be an altar for burning aromatic wood. Platform 7 is clearly a far more substantial structure, and flanking the water conduit as it does it may well be a fountain. It is possible that the path and flanking flower beds, running parallel to the main enclosure wall, were partly protected from the sun by a wooden superstructure whose uprights rested on the enclosure wall and the covered conduit. It may have been a structure of this sort which Choisy had in mind when he referred (1993, 170) to the ambassador's attendants remaining "in the covered walks" of the garden.

Excavation would of course be needed to confirm these features, clarify their nature and purpose, and provide additional detail and evidence.

The evidence from area 3 is much more difficult to interpret, mainly due to the degree of background 'noise' in the magnetometer survey, although there are clearly some buried features here. There is certainly nothing to suggest the existence of substantial buildings in the area and on present evidence we think it likely that some formal garden features may exist here.

It is not surprising to find the areas of formal garden in zones B and C. These are the areas which either fell within the womens' quarters or within the private areas of the king's palace. Furthermore they are close to the great brick water tower which must have supplied water to the foundations and water courses in the gardens. This tower has been studied in some detail by Prateep Pengtako (1989). This reservoir was constructed under the direction of the Abbe d'Argolis and some French missionaries c-1682-1684 (Pengtako 1989, 21-22), and it was surely the same team that Gervaise (1989, 44) mentions as responsible for the palace reservoir at Lopburi. There, the reservoir supplied water to the palace, and presumably to the fountains and water courses in the gardens which according to Gervaise were only "30 paces" from it.

We carried out a brief examination of the structure, and also surveyed the levels of the course from the reservoir to the moat and the 'water-bridge' at the north-west corner of the palace enclave. The tower, approximately 20m square, appears to have been divided into two main tanks by a thick N-S partition, with their floor at a height of 5m above the surrounding area. The surviving height of the tank is 2.65m, although the wall plaster survives to only a height of 1.65m.

One can calculate the minimum volume of water that could be stored as approximately 500m^3. How much higher the tanks rose, and how much greater the original storage capacity was is uncertain. Pairs of vertical pipes are found embedded in the west, south and east sides of the tower. If one follows the proposition that water was pumped into the tower from the moat or river (Pengtako 1989) then the pipes on the south side would be bringing water into the tower from the direction of the 'water-bridge'. Because of the flat topography of Ayutthaya, if water was piped into the reservoir, then it would have to have been force pumped to raise it not

only 6-9m above its point of origin, but also 75m horizontally. We remain unconvinced that the tower was supplied from the moat or river. There is certainly no recorded trace of a pumping installation at or near the 'water-bridge'. The alternative would have been the collection and storage of monsoon rains and if necessary topping up by hand-carried water jars - an immense labour-intensive task, but labour was no doubt freely available to the king.

The location of the vertical pipes on the south, east and west sides of the tower supports our interpretation of the geophysical surveys in zones A, B and C. We have suggested that zone A, to the north of the tower, remained an area of parkland with scattered trees, and this would accord with the absence of any water supply from the tower to this zone. Zones B and C on the other hand we believe were areas with formal gardens including flower beds, water courses and fountains, and the pipes on the south and west sides of the tower could supply these directly. The pipes on the east side presumably were for supplying piped water to the palace itself, 200m away from the tower.

Summary

We believe we have identified two areas of the palace gardens where there were formal garden features in the late Ayutthaya period. These are in zones B and C. Zone B probably featured a paved walkway flanked by flower beds with a series of regular brick platforms to carry large vases or altars, and by a water conduit which may have led to one or more fountains or small built ponds. Beyond these were shrubs or small trees. Zone C had paved walkways too but also contained small pavilions and perhaps ponds, fed by a water conduit.

On present evidence zones A and D were enclosed areas with few if any built garden features, whilst zone E was parkland garden with ponds and free cover. Zone F was probably occupied with enclosed courtyards rather than gardens.

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