Dating the City Wall, Fortifications, and the Palace Site at Pagan

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FOR HISTORICAL SOUTHEAST ASIA little attempt has been made to absolutely date archaeological material from the last thousand years relative to earlier phases (see Bronson and White 1992). In this paper we use the dating of archaeological features at Pagan to outline the strengths and limitations of radiocarbon dating for this period. Pagan (21°N, 95°E; Map 1) is a city spread over 80 sq km, dense with more than 2,300 monuments that appear largely to have been built between the eleventh and thirteenth centuries A.D. (Fig. 1). Mythological accounts that push the date of local settlement back to the second century A.D. (Pe Maung Tin and Luce 1923) are unsubstantiated. The foundation date of the city is also obscure due to the scarcity of epigraphic and historical records before the commencement of large-scale construction in the eleventh century (Pichard 1992).

The city wall (Fig. 1) was reconstructed in the early 1990s by the Public Works Department. This work provided the opportunity to collect samples of charcoal in an attempt to establish an absolute date for the structure. A second set of charcoal samples was collected in 1997 from sections exposed after a large-scale excavation within the city walls of a building complex (Inventory No. 1590) known as the palace (Fig. 2). We use the dates obtained for these two structures (Table 1) to explore both general issues affecting the absolute dating of historical monuments in mainland Southeast Asia and the significance of these dates, or more properly calendar age ranges, for our understanding of the development of the city.

METHODOLOGICAL ISSUES

Radiocarbon is continually being produced in the atmosphere by cosmic radiation, which has its origin outside the solar system. Radiocarbon forms carbon dioxide and exists in trace levels in the atmosphere, where it is mixed with ordinary carbon dioxide. Plants take up carbon dioxide from the atmosphere through photosynthesis, and incorporate radiocarbon as well as ordinary carbon in their tissues. After the tissues are formed, the radiocarbon level decreases from the initial level through radioactive decay. The decay process is constant, regardless of the physical or chemical environment. If there is no exchange with the sur-

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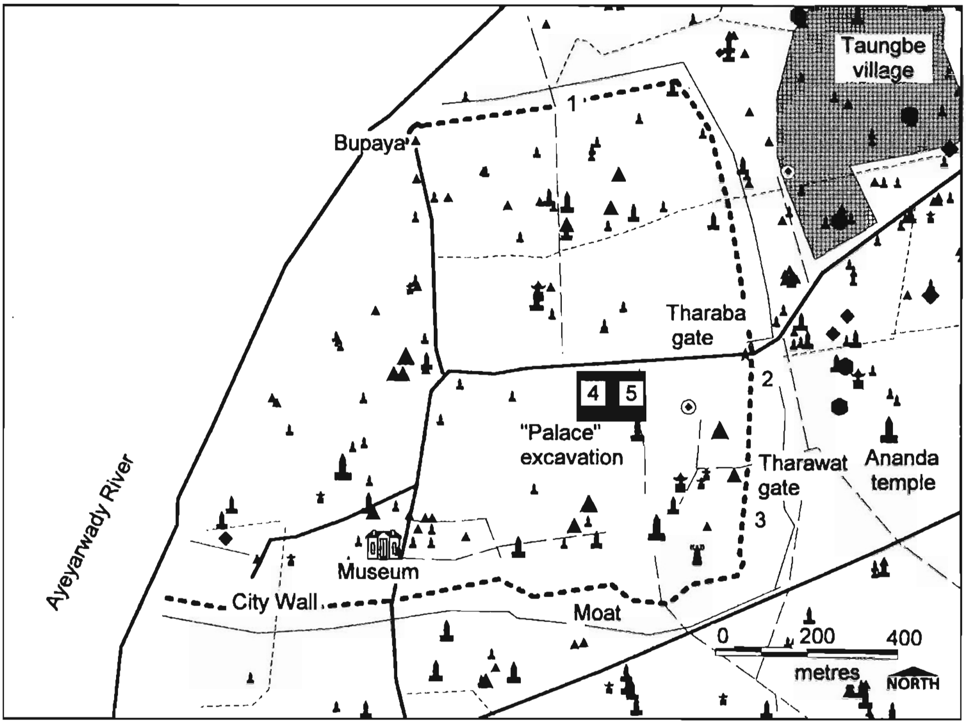

Fig. 1. Locations of the city wall and buildings at Pagan, showing locations of samples for radiocarbon dating, 1 = OZA202; 2 = OZA203; 3 = OZA204, SUA2949; 4 = OZD335; 5 = Beta-106247, Beta-106248.

roundings, half of the radiocarbon will disappear in 5,730 years. Thus, if the level of radiocarbon is measured in old materials, the time since they formed can be estimated. Radiocarbon dates assume a fixed level of radiocarbon in the atmosphere, and are expressed in years before present, where the present is defined as A.D. 1950. They have uncertainties typically about ±50 years at the one-sigma (or 68 percent confidence) level.

Radiocarbon dates estimate the time of formation of the material. In a tree, wood tissues are formed under the bark, so the most recently formed cells are on the under-bark surface. The innermost wood, near the center of the tree, was formed early in the life-span of the tree; it may be already tens or even hundreds of years old by the time the tree dies or is cut down. Charring or burning of the wood to form charcoal generally does not change the radiocarbon level; a radiocarbon date on charcoal estimates the time those particular wood cells formed, not when the wood was used or charred. Short-lived materials such as leaves, seeds, and grasses are preferable for dating, but they are rarely available.

Addition of foreign substances can happen during the archaeological time-span. Wood or charcoal, bones, or any other organic material, can be contaminated by physical or chemical means, such as the transport of materials through sediments by disturbance or insect activity, the percolation of carbonates or soil organic acids by water movement, or the penetration and decay of root material. Contamination (or the potential for it) can often be recognized and removed; a wide range of techniques are customarily used for this purpose.

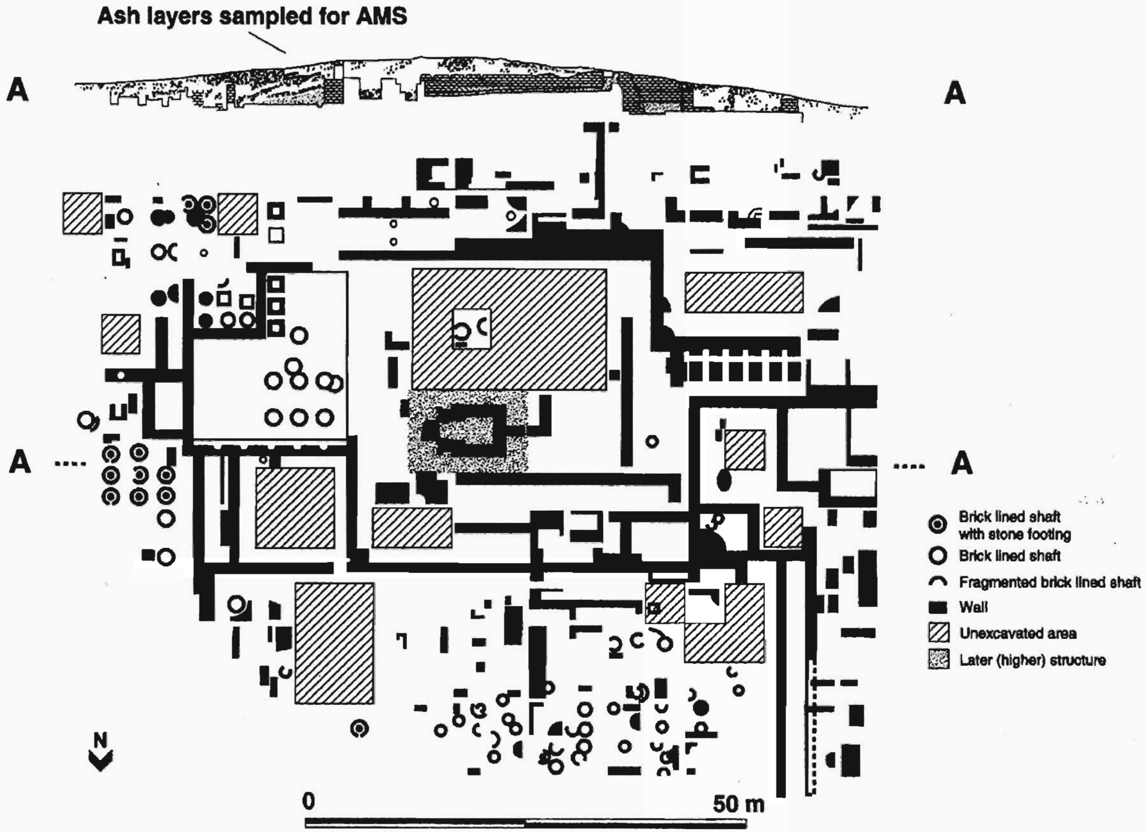

Fig. 2. Plan of the palace (Inventory No. 1590). Transect (A-A) with location of sampled ash layers indicated.

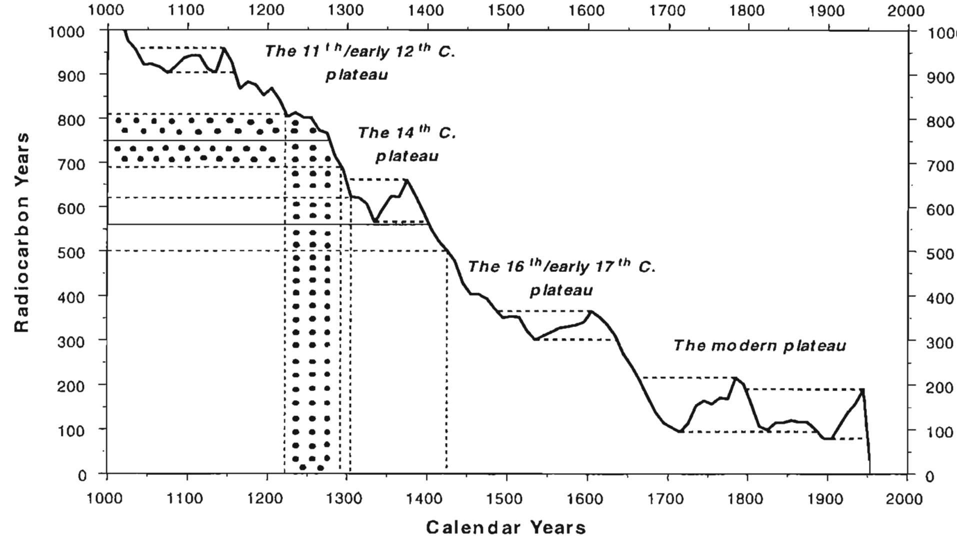

Fig. 3. A calibration curve showing the relationship between radiocarbon dates and calendar years A.D. (the INTCAL98 curve of Stuiver et al. 1998). There is a general downward slope from older to younger ages, but for certain periods the trend is reversed and radiocarbon ages become older rather than younger with time; these periods are indicated by dashed horizontal lines and are generally referred to as plateaux. The calibration of two high-precision radiocarbon dates is illustrated. An older radiocarbon date of 750 yr B.P. with two-sigma uncertainty of ±60 years (stippled region) is shown; it intercepts a steep part of the calibration curve, and vertical lines indicate the corresponding calendar age range at 95 percent confidence. A younger radiocarbon age of 560 yr B.P. with two-sigma uncertainty of ±60 years is also shown; it falls partly within a plateau region of the calibration curve, the effect of which is to markedly broaden the calendar age range.

The level of radiocarbon in the atmosphere has not been constant in the past, and this is a particular problem for all radiocarbon dates. A calibration curve (the INTCAL98 calibration curve [Stuiver et al. 1998]), showing the relationship between radiocarbon dates and calendar years, is illustrated in Figure 3. The curve is far from being an ideal straight line; it has an irregular shape, with a general trend from older to younger dates, on which are superimposed many "wiggles." Some parts of the curve are steep, and some are flat; a radiocarbon date which sits on a steep part of the curve will have a narrow calendar age range, whereas a radiocarbon age on a flat part will translate to a broader range of calendar ages. Several times during the last millennium, the general downwards trend of the curve reverses for about a century or more, and radiocarbon ages falling in these so-called plateau regions will always correspond to very broad calendar age ranges. Calibrated age ranges are usually quoted at two-sigma (95 percent confidence) levels. Radiocarbon dating is applicable to the dating of buildings and furniture, but it is not without problems of interpretation which arise mainly because the dates are for the formation of materials, which always precedes their emplacement in an archaeological context. These problems are more common with radiocarbon than with methods such as thermoluminescence dating, which measures time elapsed since the firing of bricks or pottery. Without on-site background radiation measurements, however, thermoluminescence has uncertainties in the order of 10% of age. Consequently, for most periods older than 500 years, it is less suitable than radiocarbon for dating archaeological features where high-precision determinations are desirable.

Because radiocarbon age determination and the calibration process produces date ranges of varying chronological significance, we adopt a Bayesian probabilistic approach, rather than the intercept method (Ramsay 2000) as an optimal way to interpret the archaeological significance of calibrated ranges and intervals (Bowman and Leese 1995; Buck et al. 1996; Ziedler et al. 1998). Calibration of the dates presented and discussed below was done with the online BCal Bayesian radiocarbon calibration and probability tool (James 2000).

DATING THE CITY WALL

In this section we outline the sampling strategy employed to date the city wall. The four wall dates (Table 1) fall on two of the radiocarbon plateaux discussed above, and illustrate the effect of the plateau on the resolution of calibrated age ranges.

Samples for dating the wall were collected in 1990, when the Burmese government was carrying out a program of restoration and rebuilding of the structure. Extensive sections of the wall were cleared of debris that had accumulated since the fortifications fell into disrepair, and the stratigraphy was clearly exposed in many places. The sections were sketched and recorded in photographs. The samples were collected from freshly exposed and secure stratigraphic contexts where no previous disturbance had occurred. Many of these features are now covered by new masonry built as part of the restoration program, and the samples collected in 1990 are therefore uniquely valuable in documenting the history of the city wall.

Pretreatment of the four samples, to remove rootlets, carbonates, and soil organic acids, was undertaken at the NWG Macintosh Centre, University of Sydney, following established methods ranging from physical separation with tweezers to treatment with a sequence of acid and alkali solutions (Table 1).

The most recent date in this group is from OZA202, a sample recovered from the east cutting of a foot track from the walled city to the Aye Yar Hotel. It came from near the top of the wall. The date may be indicative of continuing occupation between the fifteenth and seventeenth centuries.

The other three dates relate more directly to the construction or reconstruction of the wall itself. OZA203 was yellow fill from within a vertical earthenware tube (Fig. 4) that was located on a raised platform between the main wall and the moat. A number of these tubes, which are up to 90 cm long and 45 cm in diameter, have been excavated intact (or nearly so) within the walled city area, and in fragmentary form from Otein Taung (a possible pottery production site east of the Sulamani pagoda—see Hudson et al. 2001). They have a rolled rim at each end, and are undecorated. The tubes are identified by the archaeologists at Pagan as latrines. The sample of yellow fill was found to contain abundant rice phytoliths (L. K. Kealhofer, pers. comm.). These derive from an abundance of rice bran. If accepted as a latrine the abundant presence of bran suggests an attempt to sanitize the use of this installation. The calibrated age range spans the eleventh and twelfth centuries at 95 percent confidence.

The two samples OZA204 and SUA-2949 were about 1 m horizontally apart, in a gray, ashy layer, 400 to 800 mm beneath the lowermost bricks of the main wall. A thin band of rubble lay above the ashy layer and below the brick wall.

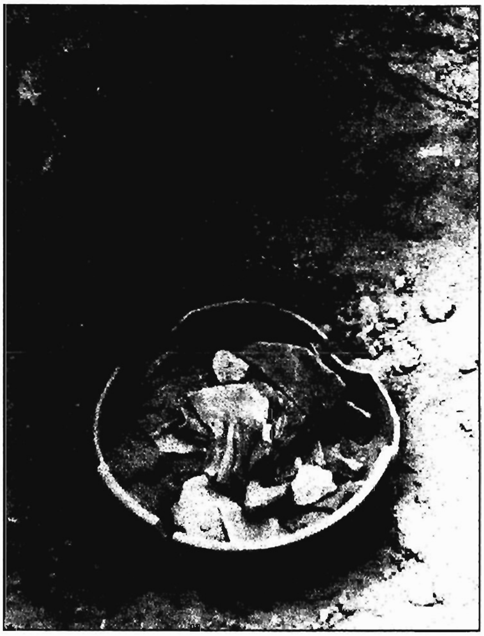

Fig. 4. Latrine tube with fill, on a raised platform between the main city wall and the moat.

The ash layer continued at least 700 mm back underneath the brick wall, and therefore predates its construction. While the two dates are statistically similar (with measurement uncertainties of 50 and 80 years), calibration of the weighted average produced a much wider calendar age range (Table 1, Fig. 5). The calibrated age range from the eleventh to the mid-thirteenth centuries reflects the broadening effect that the plateau in this region of the calibration curve has on the initial precision of the uncalibrated dates.

DATING THE PALACE

In this section we outline the strengths and weaknesses of radiocarbon dating as applied to resolving the historical significance of a secular structure within the city walls. The large area excavated in the early 1990s by the Archaeology Department is now known as the palace (Inventory No. 1590). It was initially thought by the excavators to have been a candidate for construction by King Kyanzittha (A.D. 1084–1111) (Kyaw Nyein 1989). Inscriptions by this king found around the Tharaba Gate date the building of a new palace somewhere within the city precincts to A.D. 1102 (*Epigraphia Burmanica* 1923). While consistent with a large palatial building, there were no inscriptions recovered during the excavation to historically date site 1590.

Notable characteristics of the excavated site include a complex arrangement of foundations and circular brick-lined pits evidently used as the basal supports for numerous timber columns of around 1 m in diameter. The pits provide indirect evidence of the massive wooden superstructure that once comprised the upper levels of this complex. In a central area of the structure a large brick wall running east-west provides evidence of the destructive intensity of the fire that was fueled

Table 1. Radiocarbon Determinations (± One-Sigma) in Years Before Present (b.p.), and Calibrated Age Ranges at the 95 Percent Confidence (Two-Sigma) Level

LABORATORY[a] NUMBER	SOURCE OF SAMPLE	RADIOCARBON AGE (UNCAL B.P.)	CALIBRATED RANGE, YEARS A.D. (OXCAL[b]: 95.4% PROB.)
OZA202	Near top of wall, eastern side of track to Aye Yar Hotel	440 ± 75	1390–1650
OZA203	Fill from abandoned latrine, 60 m south from Tharaba Gate, on platform between wall and moat	960 ± 50	990–1210
OZA204	Foundations, main wall, 130 m south of Tharawat gate	820 ± 80	1030–1300
SUA-2949	Foundations, main wall, 130 m south of Tharawat gate	920 ± 50	1020–1220
	Average for foundations	891 ± 42	1024–1252
Beta-106247	Palace excavation, southeast corner, lower ash layer	560 ± 30	1320–1440
Beta-106248	Palace excavation, southeast corner, upper ash layer	750 ± 30	1220–1300
OZD335	Palace excavation, charred teak fragment from base of column pit at western extremity of site	990 ± 125	980–1250

[a] Laboratories and techniques used: OZ = Australian Nuclear Science and Technology Organisation, Lucas Heights, Australia (Accelerator Mass Spectrometry); SUA = NWG Macintosh Centre, University of Sydney, Australia (radiometric); Beta = Beta Analytic Inc., Florida, USA (Accelerator Mass Spectrometry).

[b] OxCal is a comprehensive computer program for the calibration of radiocarbon dates (Ramsay 2000).

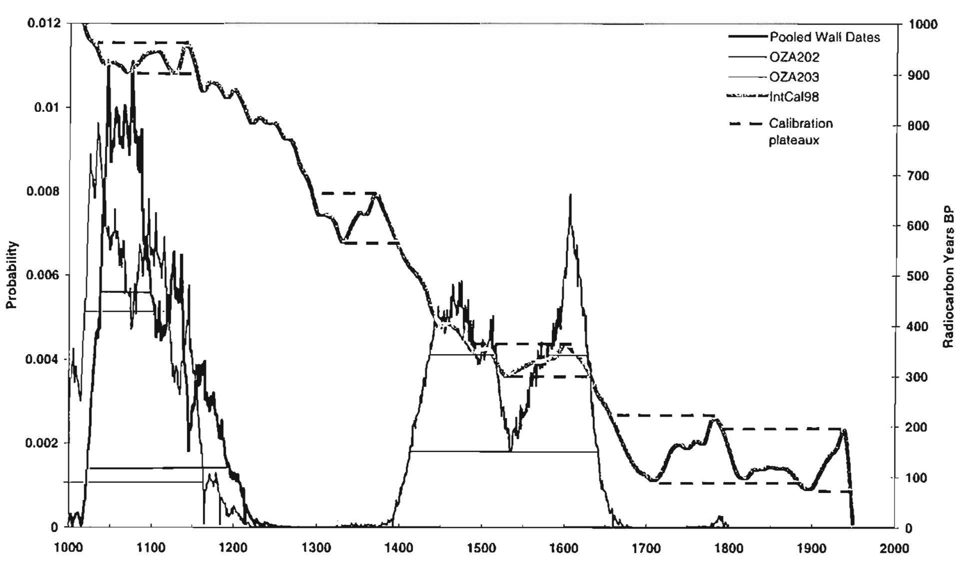

Fig. 5. Bayesian probability plot of calibrated AMS determinations in calendar years AD (X-axis) for the wall and latrine samples (Table 1) with the 68 percent and 95 percent confidence limits indicated. Probability distributions (left-hand Y-axis) are superimposed on the INTCAL98 calibration curve (right-hand Y-axis). Calibration plateaux are indicated by dashed lines.

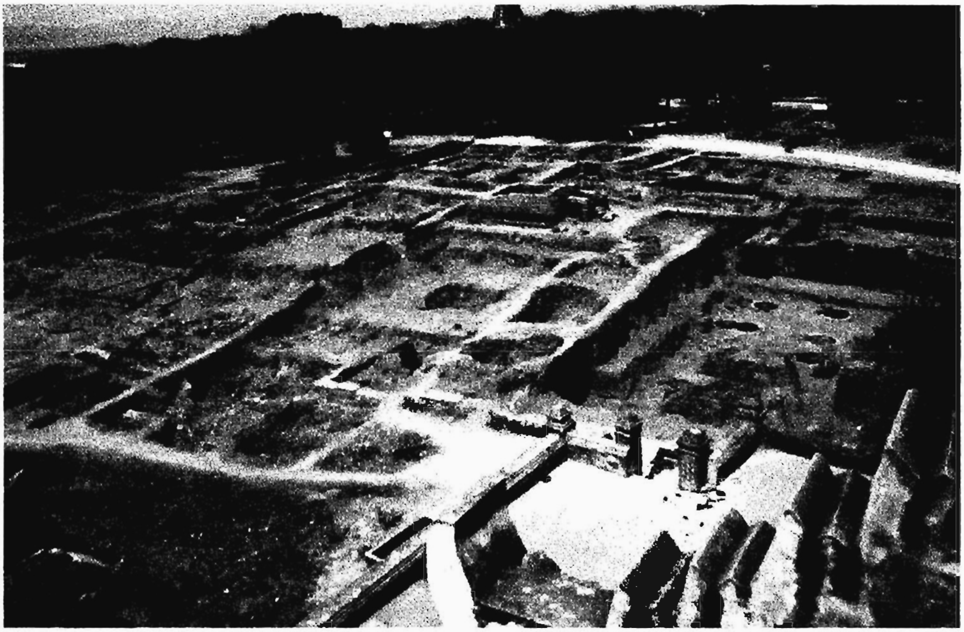

Fig. 6. Palace excavation, looking northwest.

by the timber superstructure and fanned by southerly winds (Figs. 2, 6). The brick surface of the south face of this wall was extensively vitrified with whole sections melted and slumped. Evidence of this event is also preserved in large quantities of stratified ash and rubble, visible in the side of an excavated section of the southeast corner of the excavation. The ash beds consist of (a) an irregular upper layer of ash and charcoal, up to 50 cm thick in places and (b) a lower even layer of fine powdery ash around 2 cm deep separated from the upper ash deposit by a band of brick rubble. In order to estimate the time of the destruction a charcoal sample was removed from each of the ash layers and submitted for AMS dating (Fig. 7).

Calibration of the dates indicates that the upper ash layer (Beta-106248: A.D. 1220–1300 at 95 percent probability) is earlier than the lower layer (Beta-106247: A.D. 1320–1440 at 95 percent probability) (Table 1 and Fig. 8). Calculation of the interval between the two determinations results in a range of 30–190 years at 95 percent probability (Fig. 9). This date inversion underscores a difference between the likely time of the conflagration that destroyed the palace and the date for the construction materials used.

To deal with the timing of the destruction first, while there is older charcoal in the upper layer the presence of a younger date below the older date means that *the period of the fire must be set no earlier than the youngest radiocarbon determination.* In view of the very different appearance of the two ash layers we propose that the inversion can be interpreted as a result of the older structural components of the palace collapsing on top of the burned remains of furnishings made from more short-lived materials contemporary with the last occupation of the structure. The extensive structural damage to the brick walls of site 1590 resulting from this fire also means that the structure was unlikely to have been rebuilt following its de-

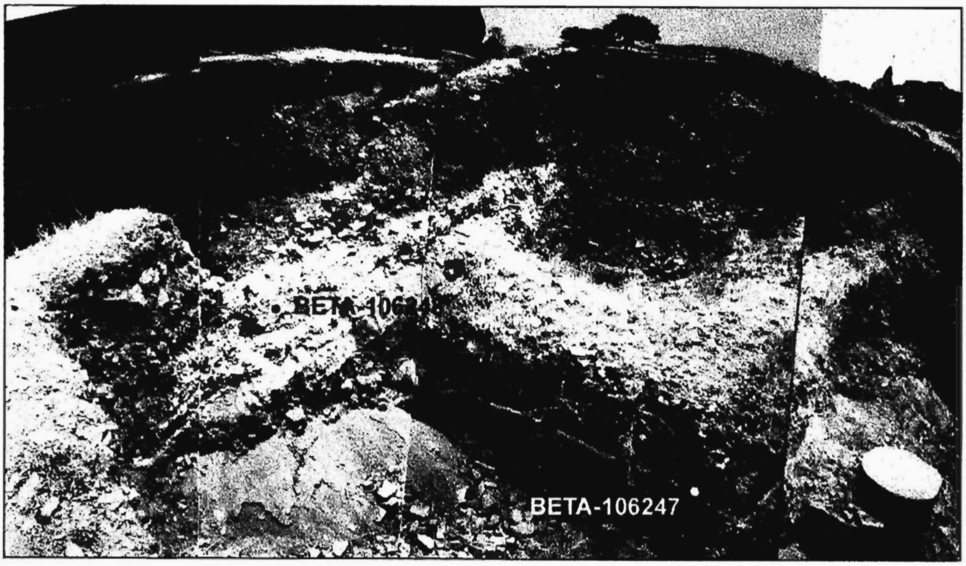

Fig. 7. Photomosaic showing appearance and structure of ash layers (digitally enhanced) and location of samples for AMS dating.

struction sometime in the fourteenth to mid-fifteenth centuries. Turning to the likely time of construction and the initial attribution of site 1590 as the original palace of King Kyanzittha, the older date from the upper ash layer appears to exclude this possibility. There is at least a 100-year difference between the historical date for the foundation of Kyanzittha's palace in the early twelfth century and the earliest date of the upper ash layer in the early thirteenth century. If the upper ash layer represents the period of construction as proposed, this gap may be even greater because of the complication of dating old wood discussed above. However, with only two dates from one area of a large complex the possibility that some parts of the site may date to different periods needs to be considered. A preliminary estimate of another section of the structure was undertaken through AMS dating of a sample from the west of the site. During the excavation of the bottom of a column pit in a western room of site 1590, a small charred fragment of the original timber column was found in situ. The dimensions of the pit suggest that the column must have been fashioned from a mature tree trunk of about 1 m in diameter dressed. Positively identified as teak *(Tectona grandis)*, the calibrated date range for this sample (OZD335) brackets a wide time range including the eleventh and twelfth centuries, allowing the possibility that the western section of the palace complex is older than the southeast corner.

However, two issues undermine interpretation of the date from this sample as unambiguous evidence for construction during the twelfth century. The first is again the old wood issue. The OZD335 determination is for a sample from a tree species that can be extremely long-lived (up to several hundred years). With no way of establishing from where in the trunk the charcoal fragment belonged, the date range merely brackets a period when the tree had been alive and is necessarily earlier than the time when it died, was cut down, or seasoned and fash-

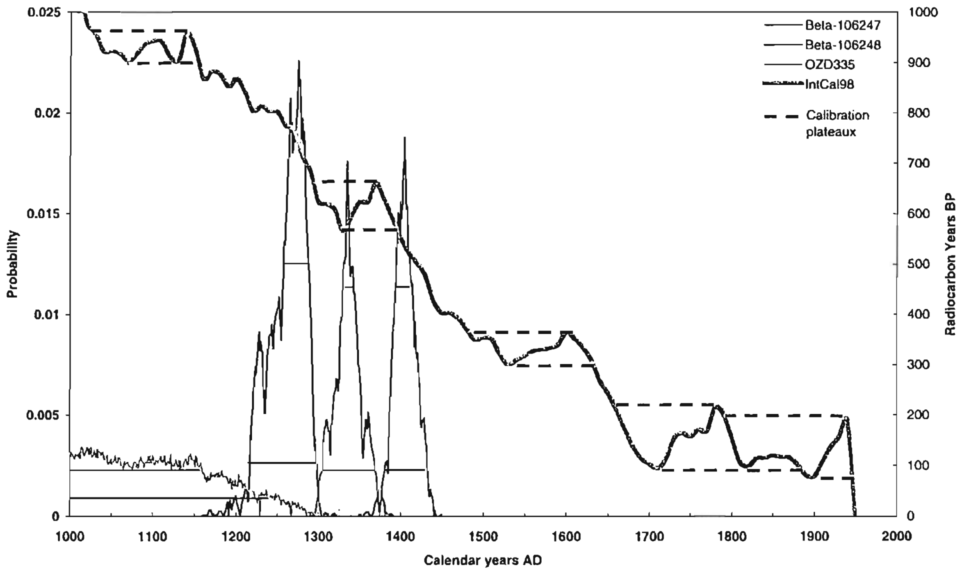

Fig. 8. Bayesian probability plot of calibrated AMS determinations in calendar years A.D. (X-axis) for the site 1590 samples (Table 1) with the 68 percent and 95 percent confidence limits indicated. Probability distributions (left-hand Y-axis) are superimposed on the INTCAL98 calibration curve (right-hand Y-axis). Calibration plateaux indicated by dashed lines.

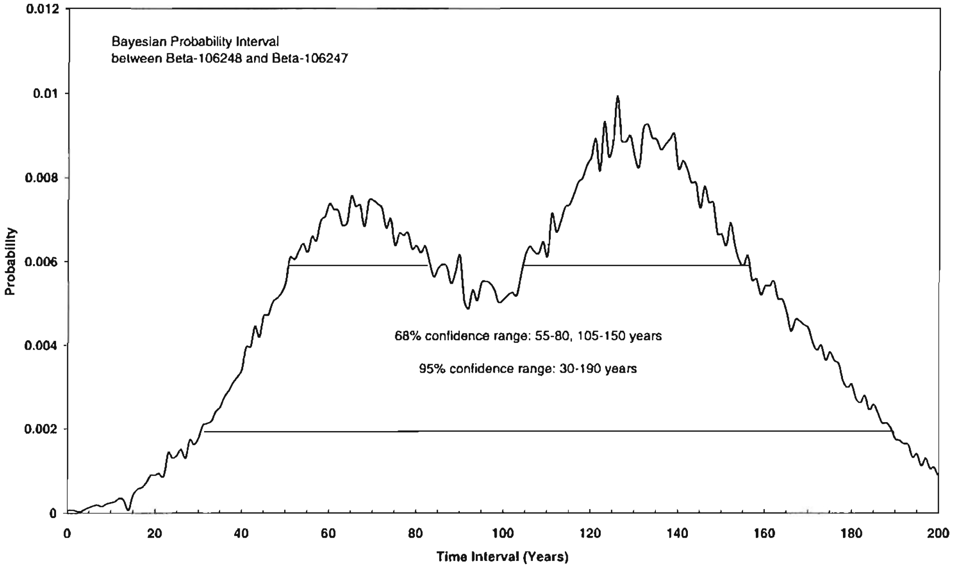

Fig. 9. Bayesian probability plot for the interval in years between the two ash layer samples from the southeast corner of site 1590. Confidence ranges as labeled.

ioned into a column and erected. A second undermining factor is the wide laboratory uncertainty for this determination ($\pm$125 years) that, when coupled with a plateau in the calibration curve for the eleventh to twelfth centuries, results in an extremely broad calibrated age range. As a result, while OZD335 could date from as early as the tenth century, the calibrated ranges for the teak sample and the upper ash layer sample overlap at the 95 percent confidence level (Fig. 8). This overlap means that OZD335 cannot be used to negate a period of construction for site 1590 (in both the southeast and western sections) from the thirteenth century.

DISCUSSION AND CONCLUSIONS

Methodologically, several issues arise from this analysis. First, radiocarbon determinations with small instrumental uncertainties have less chance of encountering calibration plateaux than determinations with large uncertainties (as clearly shown in Figures 3, 5, and 8). High-precision determinations are not only less likely to be affected by the plateaus but, when occurring on unambiguous sections of the calibration curve, they can produce narrow probability distributions that may justify the use of the one-sigma (68 percent) confidence estimate to refine the absolute date estimate. Conversely, when falling within a calibration plateau the resolution of high-precision determinations and confidence estimates is significantly diminished. This is graphically shown in Figures 3 and 8 where the two palace determinations, both with one-sigma uncertainties of ± 30 years, are widely divergent in their final calibrated age ranges. However, high-precision determinations are still preferable, because in the worst-case scenario low-precision determinations could combine with a calibration plateau to produce error ranges extending over hundreds of years (as exemplified by the calibrated range for the west palace sample in Figure 8).

Turning to the significance of these results for the absolute dating of the archaeological features at Pagan, we note that calibration of the pooled dates for the city wall and the single latrine determination produces a wide time range from the eleventh to the thirteenth centuries. Relatively poor resolution for this period is due to a wide plateau in the calibration curve as noted earlier. A similar problem exists for the calibrated range of the Aye Yar sample falling on the sixteenth/early seventeenth-century plateau. Further work to determine possible earlier foundation dates, or later phases of construction, with radiocarbon determinations would require more systematic sampling to attempt to date contexts on either side of these plateaus, thereby bracketing them.

The evidence from the radiocarbon dating of the palace structure provides independent support for the ongoing development of post thirteenth-century Pagan (Bennet 1971). Radiocarbon dating of site 1590 indicates *construction no earlier than the thirteenth and possibly during the fourteenth century* followed by occupation of the site as late as the fifteenth century. Temple construction occupied the resources and interests of the people of Pagan between the eleventh and thirteenth centuries. The end of this period saw a decline in acts of conspicuous individual merit-making, as far as temple building and dedications were concerned, in what has been characterized as increasingly out-moded structures in the relationship among rulers, sangha, and wealthy elites (see Aung-Thwin 1985, 1998). While the major phase of temple construction may have ended by the thirteenth century, large monumental building appears to have continued at Pagan albeit in palatial complexes. Through the careful selection of material for dating, this study indicates how a chronometric approach to historical Southeast Asia can provide an independent verification of historical interpretation. It also highlights the technical limitations inherent in radiocarbon dating particularly relevant for a period where high resolution is desirable. The vagaries introduced by possible old wood requires, at a minimum, accurate identification of the species to establish the possible life-span. Even with high-precision radiocarbon determinations, the plateaux of the calibration curve for the last thousand years will continue to inhibit the resolution of determinations that fall within their ranges. However, the impact of the calibration plateaux can be significantly reduced through strategies that combine absolute, relative, and historical dating techniques.

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ABSTRACT

The strengths and limitations of radiocarbon dating as applied to samples taken in and around the walled city center of Pagan, in Burma, are addressed. The last thousand years in mainland Southeast Asia remains a difficult period to date absolutely because of two critical issues. The first is the use of wood from long-lived species, such as teak, in archaeological contexts. The archaeologist dating such material must be aware of the significance of a date range that relates to the period when a tree was alive rather than to when the wood was actually used in the construction or reconstruction. The second issue stems from the character of the radiocarbon calibration curve for this time period. Several plateaux exist in the curve that seriously broaden the calendar age ranges deriving from uncalibrated high-precision dates. These effects are outlined using two areas sampled for radiocarbon dating at Pagan: the fortifications near the Tharaba Gate and a site within the old city walls, Inventory No. 1590, known as the palace. Keywords: Pagan, Bagan, Burma, Myanmar, radiocarbon, fire, fortifications, absolute chronology, calibration.