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THE RADIOCARBON DATING OF THIEN LONG UYEN AND CUC BO ARCHAEOLOGICAL SITES.

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ABSTRACT

One of the key factors of archeological research is to determine the age of a archaeological site and the excavated features and artifacts. Among various methods to identify ages, the one that deternines age based on radio carbon content (14C) in archeological samples tends to be used more widely and completely in terms of equipment and interpretation. Thien Long Uyen was excavated in a large scale and used modern methods and techniques. Results show that it is an important historical site, but complicated as the number of organic relics were well presereved. This is suitable for taking a collection of samples to determine accurate age. In this paper, we presents our findings after analysis of age from 15 samples. These samples were sent to the National University of Australia for analysis with strict principles, i.e., collecting, storing, sending and treating samples so that we could obtain reliable results of the existence time of the site. In order to make comparisions and confirm the potentials and accuracy of this method, the paper also mentions four samples of short-life plants in Cuc Bo, a little younger place than Thien Long Uyen.

Keywords: *Bayes Model, Cuc Bo, old wood effect, radio-carbon age, Thien Long Uyen*

XÁC ĐỊNH NIÊN ĐẠI CARBON PHÓNG XẠ CỦA DI TÍCH THIÊN LONG UYỂN VÀ CÚC BỒ

TÓM TẮT

Một trong những vấn đề then chốt trong nghiên cứu khảo cổ học là xác định niên đại của di tích hay di vật phát hiện được. Hiện có nhiều phương pháp xác định niên đại khác nhau trong đó phương pháp xác định niên đại qua tính toán hàm lượng các bon phóng xạ trong mẫu khảo cổ ngày càng được sử dụng rộng rãi và ngày càng được hoàn thiện về thiết bị cũng như cách diễn giải. Cuộc khai quật Thiên Long Uyển là cuộc khai quật có quy mô lớn, phương pháp và kỹ thuật khai quật hiện đại. Kết quả khai quật cho thấy, đây là di tích quan trọng, có tính chất phức tạp với một lượng di vật bằng chất liệu hữu cơ được bảo tồn khá tốt, thích hợp cho việc lấy một tập hợp mẫu xác định niên đại tuyệt đối. Trong bài viết này, chúng tôi giới thiệu kết quả phân tích niên đại của tập hợp 15 mẫu. Các mẫu gỗ gửi phân tích niên đại ở Đại học Quốc gia Úc theo một quy trình tuân thủ những nguyên tắc từ khâu lấy mẫu, bảo quản, gửi và xử lý cho những kết quả đáng tin cậy về thời gian tồn tại của địa điểm. Để có cơ sở so sánh và khẳng định tiềm năng và tính chính xác của phương pháp này, bài viết cũng đề cập đến bốn mẫu của những loài cây có vòng sinh trưởng ngắn từ Cúc Bồ, một địa điểm có thời gian muộn hơn một chút so với Thiên Long Uyển.

Từ khóa: *Cúc Bồ, hiệu ứng gỗ già, mô hình Bayes, niên đại các bon phóng xạ, Thiên Long Uyển*

1. INTRODUCTION

In this chapter we address the radiocarbon dating of the Thien Long Uyen and Cuc Bo archaeological sites. Nineteen archaeological samples, 14 fragments of wooden post, and a piece of wood from a layer from Thien Long Uyen, and two pieces of bamboo, a carbonized rice grain and fragment of wood charcoal from Cuc Bo were sent to the radiocarbon laboratory in the Research School Earth Sciences, Australian National University. The spe-cimens were sub-sampled, pre-treated and then dated using an NEC Accelerator Mass Spectrometer (AMS) following standard radiocarbon dating protocols. The chrono-metric dating demonstrates that the majority of samples from Thien Long Uyen, and all the specimens from Cuc Bo date to the Dong Son period.

2. METHODOLOGY

Twenty samples were dated (including one duplicate), 14 samples of wooden post and a fragment of wood from a layer from Thien Long Uyen, and two charred pieces of bamboo, one charred rice grain and one sample of wood charcoal (unidentified species) from Cuc Bo. Based on photographic evidence, the wood samples appear to have been taken from the outer few centimetres of posts. The dirty surface of all the samples was gently removed using a scalpel, and the wood was shaved into thin strips. Both wood and charcoal were crushed into samples with less than 2 mm particle sizes. All samples were treated with a series of acid (1 M HCl, 70°C, 30 minutes), base (1M NaOH/ 70°C / 1 hour, replaced until colourless) and acid washes (1 M HCl/ 70°C /30 minutes). Holocellulose was then extracted from uncharred wooden samples by treatment with chlorite bleach (1:1 mixture of 1 M HCl and 1M $NaClO_2$/ 70°C /1 hour). All treatments were followed with at least 3 rinses in ultrapure water, until the solution remained colourless.

The cleaned samples were freeze-dried and combusted in an evacuated sealed quartz tube in the presence of CuO wire and Ag foil (Wood et al. submitted). The resulting CO_2 was collected and purified cryogenically and converted to graphite over an Fe catalyst prior to measurement in a Single Stage NEC Accelerator Mass Spectrometer (AMS) at the Australian National University (Fallon et al. 2010). Dates are calculated according to Stuiver and Polach (1977) using an AMS derived δ13C.

As Vietnam falls within the Intertropical Convergence Zone where mixing of hemis-pheres occurs, dates have been calibrated in OxCal v.4.4 (Ramsey 2009) against a 50:50 mixture of the IntCal20 (Reimer et al. 2020) and SHCal20 (Hogg et al. 2020) calibration curves.

The unburnt wood and bamboo samples contained more than 35%C, whilst the charred rice contained more than 50 %C, as expected for cellulose and charcoal respec-tively – all within expected norms for these types of organic dating materials

2.1. Potential problems with dating wood and charcoal

Whilst radiocarbon dating of wooden artefacts and wood charcoal is a relatively straight forward process, the dates may have 'inbuilt age' and overestimate the age of the archaeological activity for two reasons.

1. As wood grows, the cellulose reflects the ^{14}C:^{12}C ratio of the atmosphere. This cellulose is not remodeled or altered later in the tree's life, and the radiocarbon clock starts. Thus, cellulose at the center of a tree is older than cellulose at the bark edge (or more specifically, the waney edge). So, the closer to the centre the tree trunk the older the wood is in terms of radiocarbon years. It is only possible to establish when a tree was felled if the outer ring is dated. Any other date will be older, leading to what is known as the 'old wood effect' (Schiffer 1986). Figure 1 presents a cross section of wood illustrating the growth rings and the difference between any potential dating sample (indicated by the black and white circle) taken from a post (within the dotted line) cut from a much larger piece of timber. The number of rings between final growth when the tree was cut down and the dating sample represents the inbuilt age (n-years) of the post (Illustration authors).

2. Wood, and in particular large timbers used for construction, may be seasoned and stored for several years prior to use, or they may be reused. This may add 10s to 100s of years of 'inbuilt age' to potential building material between felling and construction (Figure 2).

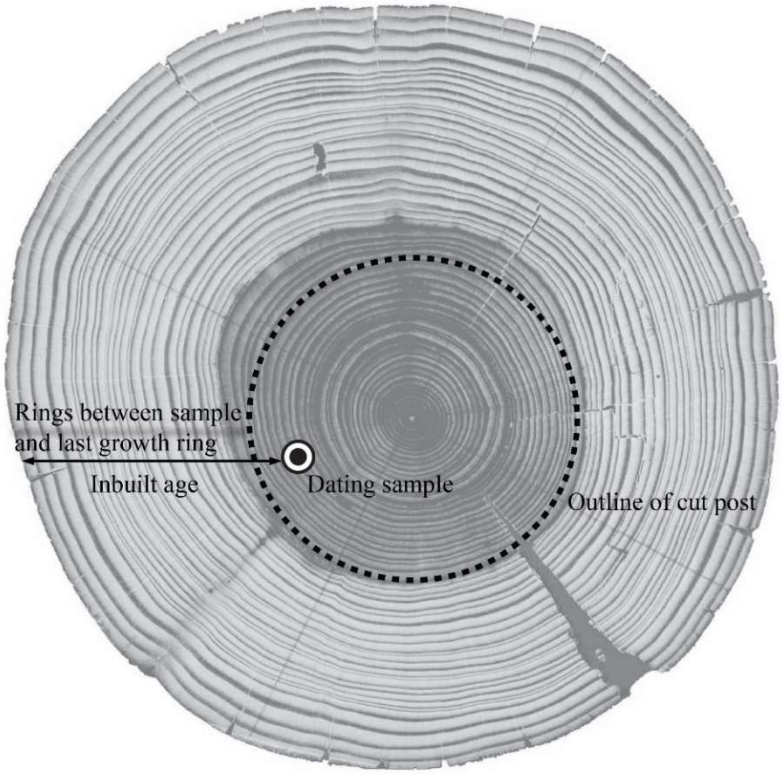

Figure 1. A cross section of wood illustrating the growth rings and the difference between any potential dating sample

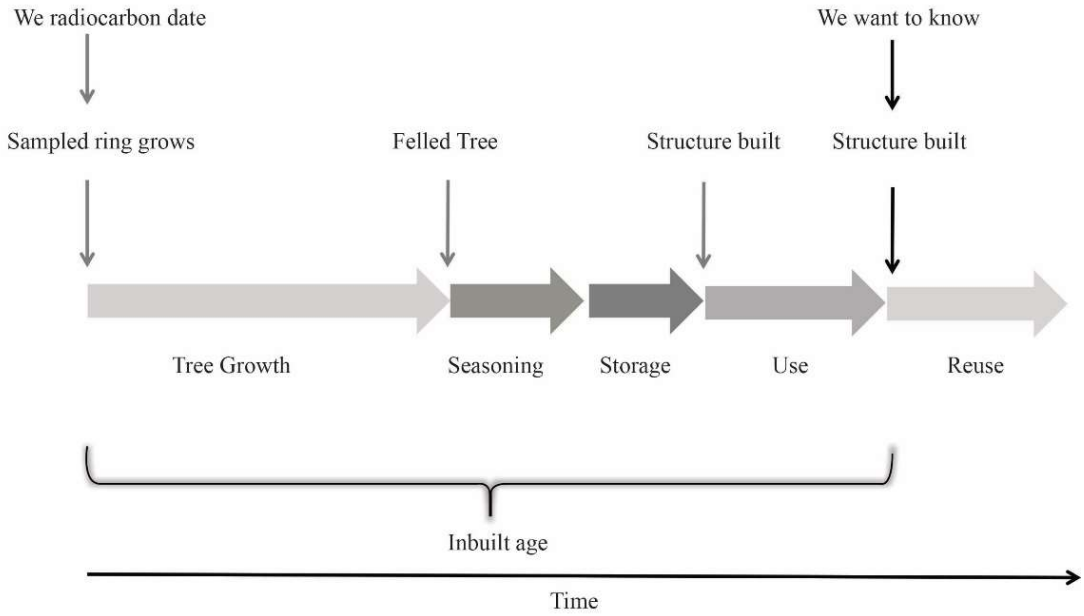

Figure 2. Illustration of the potential inbuilt age between a dated sample and the actual (final) use of a timber post (Illustration authors)

Several strategies can be applied to reduce and understand the inbuilt age in a sample of wood or charcoal submitted for radiocarbon dating. To reduce the old wood effect, samples of short-lived material such as seeds, which represent a single season of growth, or bamboo, which grows rapidly, can be dated. When dating large posts, a felling date can be established if the waney edge is present and the outer growth is dated. The inbuilt age resulting from storage and reuse of large timbers is more difficult to establish. However, it is possible that this inbuilt age is reduced within tropical areas due to abundant supply of large trees and extensive termite activity (e.g. Kim et al., 2019). It is always better to sample and date several posts, as this will always increase the confidence in the chronological age of an archaeological site, especially if there is consistency in the calibrated ages.

2.2. Bayesian Modelling

A Bayesian model was built in OxCal v.4.4 (Ramsey 2009a) to refine the chronology and assess the potential time-difference between TLU and Cuc Bo (Figures 3 & 4). TLU and Cuc Bo were modelled separately. Each model consisted of a single Phase of activity, with a start and end Boundary arranged within a Sequence. Within the Phase, radiocarbon dates are assumed to be uniformly distributed, and the Boundaries provide age estimates for the start and end of each site. The two obviously outlying Neolithic-aged samples (S-ANU68615 and 68618) were excluded from the model, but are represented in the image for completeness. All dates were assigned a 5% prior probability of being an outlier within the General t-type Outlier Model (Ramsey, 2009b), which assumes that dates are most likely to be accurate but that some may be either too old or too young. This is appropriate as inbuilt age is assumed minimal for the majority of samples.

3. RESULTS

3.1. Thien Long Uyen

One post, TLU.2020.H5.C11 returned a date of 3887±27 BP or 2461-2211 cal. BC (S-ANU68615). The post still retained the bark on the outer surface, and that the dating sample was taken from close to the final growth ring, and there is no evidence of working the wood in the vicinity of the sample. It is unlikely that there is any considerable inbuilt age with this sample. Another large post (TLU.2020.H7.C2) produced a date of 3228±25 BP or 1516-1425 cal. BC (S-ANU68618). The bark is not evident, but the sample was taken from close to the outer surface and there is no evidence of deterioration or working that would suggest the post is missing many outer rings that would result in an inbuilt age to the date. These two posts are more than 1000 years older than the rest of the samples, and reuse is unlikely. These posts were probably erected during the Neolithic period.

Photographic records suggest TLU.2020.H6.C10 was one of several posts/stakes from within a short alignment. The small diameter of 7 cm and the presence of bark suggests that this sample is unlikely to be affected by a substantial old wood effect. It dates to 2468±27 BP or 753-411 cal. BC (S-ANU68616). This date places it slightly earlier than the majority of other specimens from Thien Long Uyen. Whilst it could be a statistical artefact (noting that at 95% probability it overlaps with some of the other samples), it is possible that this piece of wood was reused in the structure, alternatively this feature is slightly older than the majority of the posts at Thien Long Uyen.

With the exception of the aforementioned very old posts (TLU.2020.H5.C11 and TLU.2020.H7.C2) and the small stake/post alignment that includes TLU.2020.H6.C10 there is good correspondence between the dated posts from Thien Long Uyen. Some posts might have an inbuilt age. For example, TLU.2020.H9.C2 was sampled in an area where the base of the post has been reduced to form a tapering end so that the post can be driven into the ground more easily, and this has probably resulted in an inbuilt age of unknown duration (Date: 2320 ±25 or 406-235 cal. BC, S-ANU68621). The reduction in post width related to shaving into a point at the base is reflected in the change in diameter at ground surface of 32.5 cm to just 20.5 cm

at the tapering end (worked base). Post TLU.2020.H9.C1 (Date: 2269±27 BP or 392-208 cal. BC, S-ANU68621) also appears to have a worked surface with residual evidence of cut/shaving marks around the sampling area, but this is much less extensive than that observed in TLU.2020.H9.C2. But, any potential 'old wood' effect has not impacted on the overall results, with all dated wooden artifacts falling between the outer limits of 516-205 cal. BC, and all within the Dong Son period (Table 1; Figure 3).

3.2. Cuc Bo

Cuc Bo has four radiocarbon dates on a carbonized rice grain, two pieces of bamboo, and a fragment of wood/charcoal. The rice grain and fragments of bamboo are plants/ plant parts with a short life span and, as long as they were identified in the correct archaeological contexts, provide accurate dates for the deposits from which they were recovered. The three samples produced consistent results of between 356-100 cal. BC (Table 1, Figure 3). Although, the fragment of wood charcoal (CB.2020.H1.L3.3) could potentially possess some inbuilt age, it produced a very similar date to the rice and bamboo of 2175±25 BP or 354-105 cal. BC (S-ANU68612). Although the dates Cuc Bo substantially overlap with those from Thien Long Uyen, they fall within the chronologically younger age range. This perhaps suggests activity at Cuc Bo was slightly later in the Dong Son period than the erection of the posts at Thien Long Uyen.

Table 1: Uncalibrated, calibrated and modelled radiocarbon dates using the General t-type model (5% prior probability) radiocarbon dates (95% probability range) from Thien Long Uyen and Cuc Bo (calibrated using Intcal20 Oxcal ver4.4)

Site/Sample No.	Material	Lab Code	Uncalibrated Dates (uncal. BP)	Calibrated Age (cal. BC)		Modelled calibrated age (cal. BC)		C
				from	to	from	to	
				95% prob. range		95% prob. range		
Cuc Bo								
Boundary End Cuc Bo						**345**	**17**	**98.2**
CB.2020.H1.L3.1	Wood charcoal	S-ANU68610	2176±27	356	100	351	135	99.2
CB.2020.H1.L3.2	Bamboo	S-ANU68611	2175±25	355	105	351	136	99.2
CB.2020.H1.L3.3	Bamboo	S-ANU68612	2175±25	354	105	351	136	99.2
CB.2020.H1.L3.4	Carbonised rice	S-ANU68613	2182±27	356	110	352	138	99.2
Boundary Cuc Bo Start						**426**	**154**	**98.5**
Thien Long Uyen								
Boundary End TLU						**394**	**352**	**96.8**
Trench H5								
TLU.2020.H5.C2	Wood	S-ANU68604	2361±30	511	365	412	377	99.1
TLU.2020.H5.C4	Wood, bark present	S-ANU68605	2303±25	402	232	401	366	99.4
TLU.2020.H5.C3	Wood	S-ANU68606	2325±25	408	239	404	371	99.7
TLU.2020.H5.C11	Wood, bark present	S-ANU68615	3887±27	2461	2210	2461	2211	99.8
TLU.2020.H5.C1	Wood, bark present	S-ANU68823	2247±22	380	205	399	365	99.1
Trench H6								
TLU.2020.H6.C10	Wood	S-ANU68616	2468±27	753	411	427	373	96.1
TLU.2020.H6.C12	Wood	S-ANU68607	2347±29	478	260	410	375	99.3
TLU.2020.H6.L2	Wood	S-ANU68824	2272±21	391	211	N/A		N/A

Trench H7								
TLU.2020.H7.C1	Wood	S-ANU68617	2385±25	516	388	417	382	98
TLU.2020.H7.C2	Wood	S-ANU68618	3228±25	1515	1425	1516	1425	99.8
TLU.2020.H7.C3	Wood	S-ANU68619	2314±26	408	236	404	370	99.7
Trench H8								
TLU.2020.H8.C1	Wood	S-ANU68609	2303±26	403	230	401	366	99.4
Trench H9								
TLU.2020.H9.C1	Wood - worked	S-ANU68620	2269±27	392	208	397	362	98.7
TLU.2020.H9.C2	Wood - worked	S-ANU68621	2320±25	406	236	403	370	99.6
Sample ST G3								
TLU.2019.ST.G3.2 (Duplicated)	Wood	S-ANU68625	2282±26, 2290±26	396	211	398	364	98.9
Boundary Start TLU						**343**	**386**	**95.4**

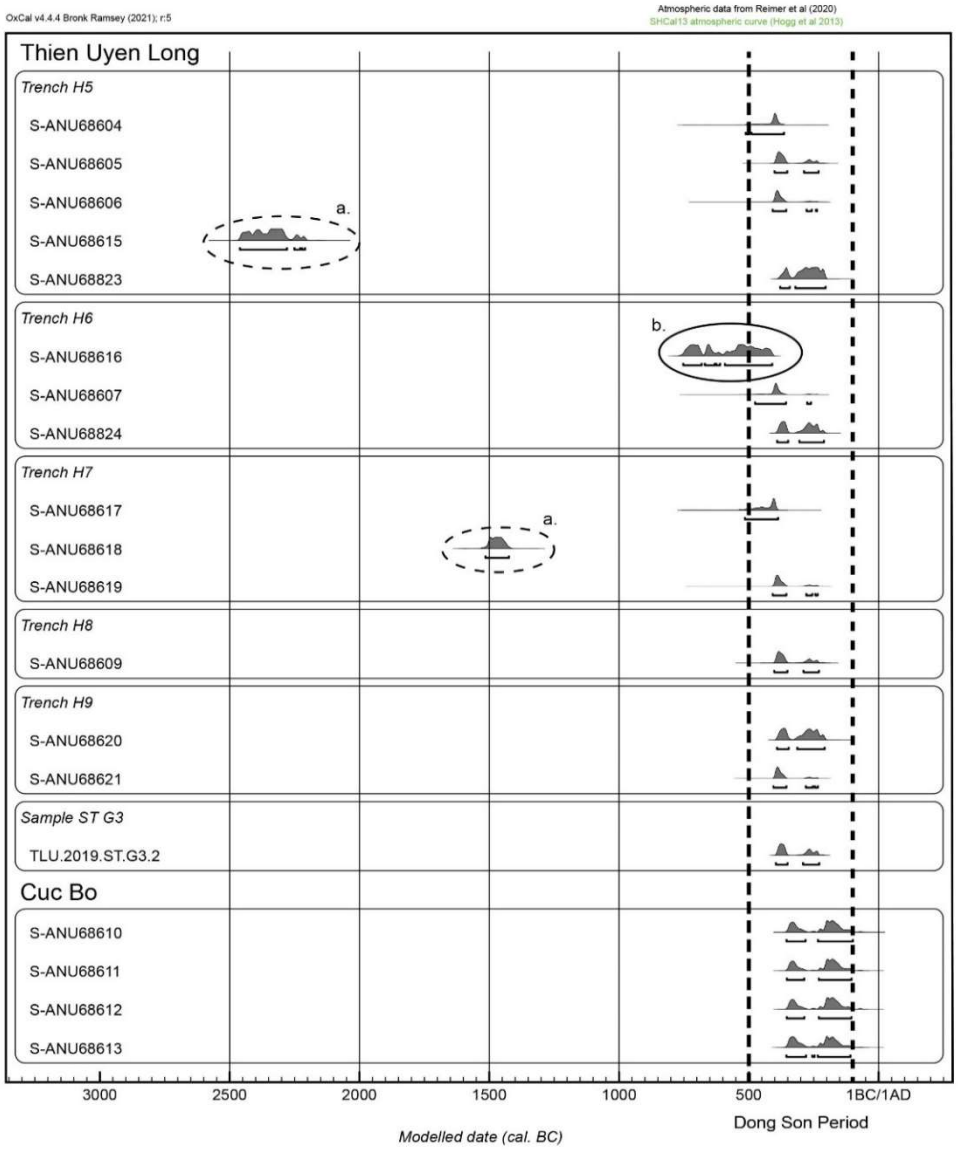

Figure 3. Calibrated radiocarbon dates from Thien Long Uyen and Cuc Bo archaeological sites; a. Neolithic posts, b. pre-Dong Son post feature

3.3. Bayesian Analysis and the potential ages of Thien Long Uyen and Cuc Bo

Each model is extremely consistent, with only one date (S-ANU68616, TLU.2020.H6.C10) identified as an outlier at more than 5% probability. This date has been automatically down weighted in the model, and has little impact on the modelled estimates for the start and end of TLU. Taken as a single group, the posts date between 434-386 cal. BC and 394-352 cal BC at 95% probability. Calibrated radiocarbon dates from Cu Bo have a double peak due to a wobble in the calibration curve, reducing precision. Within the model, Cuc Bo dates to between 426-154 and 345-17 cal BC, and may be up to 225 years younger than Thien Long Uyen (calculating the Difference between the end of Thien Long Uyen and start of Cuc Bo). However, further dating of Cuc Bo is required to increase the precision of the model, and to confirm whether Cuc Bo is indeed later than Thien Long Uyen.

Figure 4 presents the posts from Thien Long Uyen and the bamboo, rice and wood samples from Cuc Bo modelled using the General t-type Outlier Model (Ramsey 2009b) with an assigned 5% prior probability of being an outlier. For the purposes of the model, with the exception of S-ANU68615 (TLU.2020.H5.C11) and S-ANU68618 (TLU.2020.H7.C2) that are very clearly of Neolithic age (labelled a. in the diagram) all the posts from Thien Long Uyen are considered to be from a single phase.

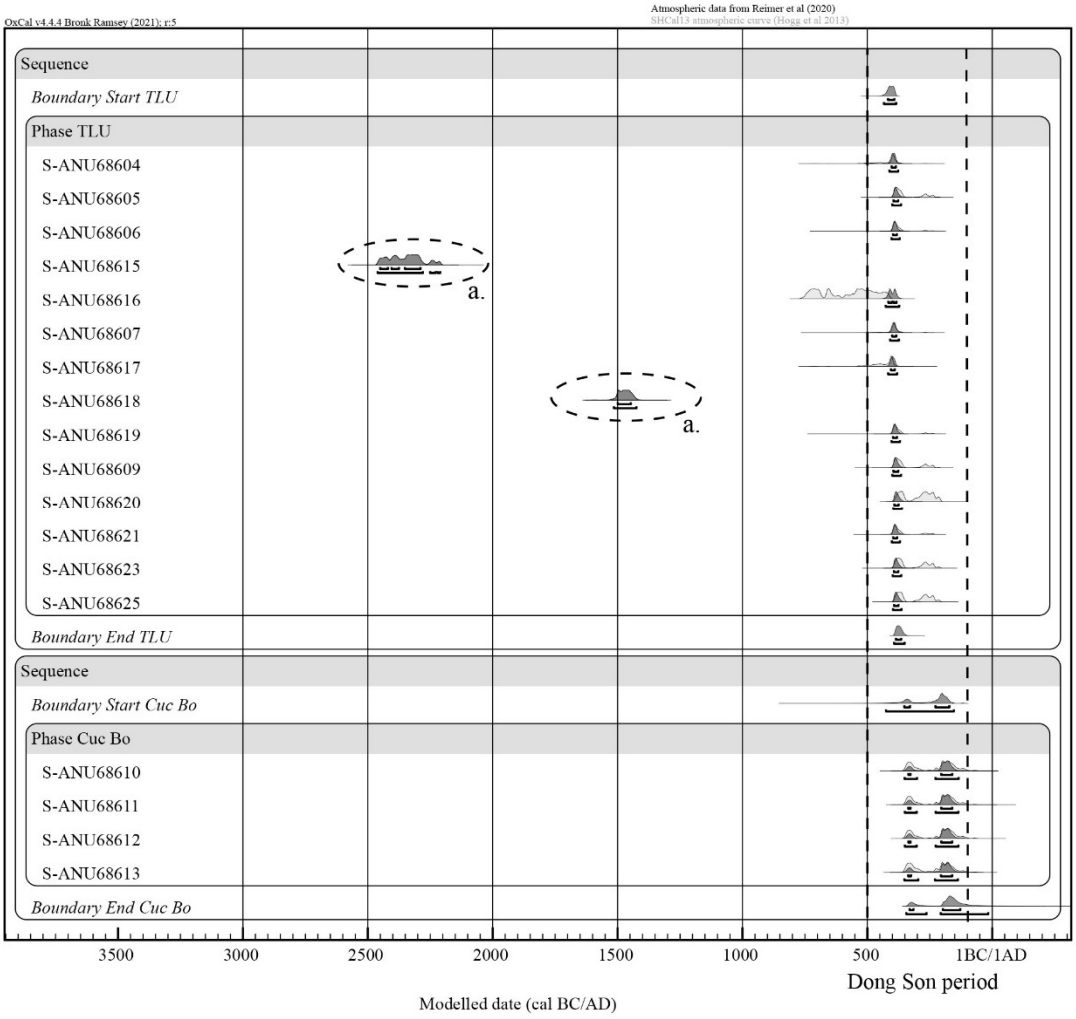

Figure 4. The posts from Thien Long Uyen and the bamboo, rice and wood samples from Cuc Bo modelled using the General t-type Outlier Model (Ramsey 2009b) with an assigned 5% prior probability of being an outlier

4. CONCLUSION

Nineteen archaeological samples, 15 from Thien Long Uyen and four from Cuc Bo were dated as part of the broader research project at the two sites. Two posts at Thien Long Uyen were probably erected during the Neolithic period, one more than 4000 years ago, the other around 3500 years ago. By far, the majority of wooden posts from Thien Long Uyen were constructed somewhere between a start date of 434-386 cal. BC and an end date of 394-352 cal. BC. The rice, bamboo and charcoal samples from Cuc Bo are all very consistent, and suggest occupation between 426-154 cal. BC and 345-17 cal. BC. It is possible that the posts at Thien Long Uyen are up to 225 years older than the occupation at Cuc Bo. Both archaeological sites are firmly dated to the Dong Son period.

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