Dating resin coating on pottery: the Spirit Cave early ceramic dates revised

C.D. Lampert¹, I.C. Glover², R.E.M. Hedges³, C.P. Heron¹, T.E.G. Higham³, B. Stern¹, R. Shoocongdej⁴ and G.B. Thompson¹

Pottery found at Spirit Cave, Thailand, has been claimed as among the earliest ceramics in the world – a radiocarbon date of 7500 BP being obtained from associated charcoal. However radiocarbon dating of organic resin found on some of the sherds gave a date of around 3000 BP. This is another example of improved precision in dating by pin-pointing the context and using AMS. The authors describe how it was done and assess its validity.

Keywords: Spirit Cave, ceramics, resin, radiocarbon dating.

During the summer of 1966, Chester Gorman, then a Ph.D student at the University of Hawai’i carried out archaeological excavations at the rock-shelter of Spirit Cave in the karst uplands of Mae Hong Son Province, Northwest Thailand (Figure 1), and he revisited the site

---

¹ Department of Archaeological Sciences, University of Bradford, UK
² Institute of Archaeology, University College London, UK
³ Oxford Radiocarbon Accelerator Unit, Oxford University, UK
⁴ Department of Archaeology, Silpakorn University, Bangkok, Thailand

Received 29 January 2002; Revised 20 December 2002.
in 1971 to extend the excavations. Throughout all levels of the cultural deposits, lithic, faunal and botanical materials were found. The majority of the cultural remains recovered from the site were typically Hoabinhian, characterised by “Sumatra-type cores, ochre-covered grinding stones, unifacially worked quartzite pebbles and utilised flakes” (Gorman 1969:672), but objects recovered from the upper levels included some new find types. Amongst these were a small number of pottery fragments, perhaps representing no more than 20 vessels. Some of the sherds were burnished, with plain surfaces, and a few were decorated with incised lines but the majority had cord-marking or net impressions on their exterior surfaces. Some sherds were further described as having “been coated with an organic resinous material” (Gorman 1972:96) after they had been fired. One of these sherds can be seen in Figure 2, bearing patches of resin on both interior and exterior surfaces. Potsherds were only present in Layer 1 and compacted into the surface of Layer 2. This abrupt variation in material culture marks the boundary between the Hoabinhian deposits of Cultural Level I and a period of cultural contact, which Gorman termed Cultural Level II.

A series of radiocarbon dates, primarily obtained from bamboo-charcoal samples, taken from within distinct stratigraphic layers, indicated that the site dated to between 12 000 BP and 7500 BP, around a 5000 year time-span of continuous occupation and intermittent use (Gorman 1972).

Table 1 shows some of the published radiocarbon dates obtained for the upper layers of the site (Gorman 1972, Ehrich 1992). Based on these, the potsherds were originally considered to date to around 7500 BP. This small ceramic assemblage was therefore cited as amongst the earliest examples of pottery in the world (Solheim 1972). Solheim (1972) further speculated that the presence of pottery and the possibility that some of the plant remains may have come from

<table>
<thead>
<tr>
<th>Laboratory Ref.</th>
<th>General Layer</th>
<th>Date BP (5568 year half-life)</th>
<th>Date BP (5730 year half-life)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSU 317</td>
<td>1</td>
<td>7400 ± 300</td>
<td>7622 ± 300</td>
</tr>
<tr>
<td>FSU 314 *</td>
<td>2</td>
<td>7905 ± 390</td>
<td>8142 ± 390</td>
</tr>
<tr>
<td>GaK 1846 *</td>
<td>2</td>
<td>8550 ± 200</td>
<td>8806 ± 200</td>
</tr>
<tr>
<td>BM 501 *</td>
<td>2</td>
<td>7907 ± 198</td>
<td>8144 ± 198</td>
</tr>
</tbody>
</table>

*samples from the surface of Layer 2
deliberately cultivated plants might suggest a shift away from a purely hunter-gatherer economy, linking this with the early development of horticultural practices in Southeast Asia, although Yen (1977) considered the evidence for cultivation to be tentative.

However, reservations have since been expressed on the early date for the Spirit Cave ceramics. Higham (1989: 60) noted that there may have been a long hiatus between occupation of Spirit Cave during Cultural Level I and the emergence of the pottery fragments marking Cultural Level II. A single radiocarbon date, of 7622±300 BP (FSU 317), is associated with the bottom of the thin deposit forming Layer 1, the uppermost excavation layer. The three somewhat earlier dates, FSU 314, GaK 1846 and BM 501, are associated with the surface of Layer 2 and may also be considered relevant to the defence for an early date for the pottery. However, it is largely on the date obtained from the sample taken from within Layer 1 that the possible debate hinges.

That there was later use of the rockshelter is evident from the presence of a number of log coffin burials within the Spirit Cave complex. It is plausible that the ceramics, being confined to the upper part of the site, might have originated from disturbance of these burials and their associated grave goods. If this were the case, the pottery could be of a later date than first thought. Supporting this theory is the stylistic similarity noted between some of the Spirit Cave ceramic fragments, particularly the cord-marked sherds, and pottery recovered from other rock-shelter sites with log coffin burials in Mae Hong Son Province (Shooongdej, pers. com.). The log coffin burials are thought to be Iron Age or later in origin. Whilst the log coffins from Spirit Cave have not themselves been dated, radiocarbon dates from comparable log coffins found at other cave-sites in Mae Hong Son Province fall into a range between 2209 ± 97BP and 1323 ± 85 BP (Hotchkis et al 1994).

New work has clarified the Spirit Cave sequence, dating the pottery itself by targeting the resinous coating on a potsherd. Having first determined that the visible residues on potsherds from Spirit Cave were organic, i.e. carbon-based, and having identified the deposits as resinous, small samples of the material were sent to the Oxford Radiocarbon Accelerator Unit for AMS radiocarbon dating. Two samples were submitted which, coming from a single sherd, permitted the repeatability of dates using resin samples to be tested. One sample was collected from an exterior resin coating on the sherd, the other from an interior resin coating. The uncalibrated dates for the Spirit Cave resin samples (see Table 2) were reported as 3042 ± 37 BP and 2995 ± 40 BP.

Table 2. AMS radiocarbon dates from archaeological resins from Spirit Cave. Dates reported as BP were calibrated using version 3.5 of the ‘OxCal’ computer program (Bronk Ramsey 1995) and atmospheric data from ‘INTCAL 98’ (Stuiver et al. 1998). For the resin dates, isotopic fractionation was measured and corrected for by the radiocarbon laboratory.

<table>
<thead>
<tr>
<th>Oxford Ref</th>
<th>Date BP (uncalibrated)</th>
<th>62.8% prob.</th>
<th>Date (calibrated)</th>
<th>95.4% prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>OxA-10271</td>
<td>3042 ± 37</td>
<td>1380BC (26.4%)</td>
<td>1330BC</td>
<td>1410BC (90.9%)</td>
</tr>
<tr>
<td></td>
<td>1320BC (38.6%)</td>
<td>1250BC</td>
<td>1200BC (1.7%)</td>
<td>1190BC</td>
</tr>
<tr>
<td></td>
<td>1230BC (3.2%)</td>
<td>1220BC</td>
<td>1180BC (1.1%)</td>
<td>1160BC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1140BC (1.6%)</td>
<td>1130BC</td>
</tr>
<tr>
<td>OxA-10272</td>
<td>2995 ± 40</td>
<td>1370BC (1.0%)</td>
<td>1360BC</td>
<td>1390BC (94.2%)</td>
</tr>
<tr>
<td></td>
<td>1320BC (67.2%)</td>
<td>1120BC</td>
<td>1100BC (1.2%)</td>
<td>1080BC</td>
</tr>
</tbody>
</table>
The samples were specifically chosen to try to resolve uncertainties concerning the early date originally suggested for the pottery, as part of a project which aims to characterise resins from archaeological contexts in Southeast Asia and establish their potential for radiocarbon dating purposes. The resin is considered an integral part of the outer surface of the pot and is interpreted as a waterproof coating. In this case it is likely that the resin would be applied to pottery during its functional lifetime, and so should be comparable in date to the ceramic. The resin dates indicate that the ceramics may be significantly younger than originally suggested by the charcoal dates (Gorman 1972, Ehrich 1992). If this is so, the new dates may no longer serve to support an especially early agricultural element to the Spirit Cave site.

However, as shown in Figure 3, the resin dates are older than would be expected for artifacts from log coffins in the region, although the log coffin chronology cannot yet be considered secure. There have been relatively few reliable dates for material from these sites and future work may yet see the log coffin chronology extended. At present it does not appear that the potsherds were introduced to the site by disturbance from the burial of later log coffins. The presence of potsherds of around 3000 BP might suggest a continuation in the use, possibly intermittent, of the rockshelter during the Late Neolithic-Bronze Age. It would appear that the pottery was deposited during a phase between the period Gorman originally suggested for the occupation of the site and that when the log coffins were most probably put in place.

**Assessment**

One of the aims of this research is to assess the validity of radiocarbon dates obtained from resin. The two AMS dates from Spirit Cave (OxA–10271 and OxA–10272), which come from a single sherd, are in good agreement with one another, which indicates that dates from resins are repeatable. It would clearly be desirable to measure the date of resin on other samples of pottery from Spirit Cave, but regrettably this is not possible. Very little of the original ceramic assemblage can be located and there is insufficient resin for even one further AMS date on any of the small number of potsherds available for examination. Given the limited numbers of potsherds bearing traces of a resin coating (only four of the twenty two sherds available have obvious patches of resin) it has also proved impossible to show a clear correspondence between the resin from the surface sherd dated and resin coatings on sherds deeper in the stratigraphy. However, it would appear from analytical results that the resin used on each of the coated sherds stemmed from the same source.

AMS dates obtained from resins on potsherds recovered from excavations at Noen U-Loke, an Iron Age site on the Khorat Plateau in Northeast Thailand offer some support for the reliability and validity of the method. So far, three reliable radiocarbon dates have been obtained from resinous deposits of a similar type on potsherds from the site (see Table 3).
Once again, two of the samples, OxA-10268 and OxA-10269, come from a single sherd and show close correlation, confirming the repeatability of dates obtained from resin samples; and in this case the resin dates tie in well with radiocarbon dates on charcoal samples from the same site (Figure 4; Higham and Thosarat 1998a, 1998b). Further AMS dates on resin samples from this site are planned in the near future.

Given that natural plant resin is an unusual material to submit for radiocarbon dating, a few points are offered for discussion. Natural resins can be obtained from a wide variety of plant sources. Beck et al. (1994) suggest that diterpenoid conifer resins from the Pinaceae family may provide a reliable carbon source for dating. Dates from triterpenoid resinous material thought to be of birch origin, from the deciduous Betulaceae family, from three early Mesolithic British sites would also appear to provide credible radiocarbon dates (Roberts et al. 1998). It is likely that this is also the case for other resinous plant families. Additional substantiation for the validity of radiocarbon dates from natural plant resins can be found in a report by Beck et al. (1994) in which a black resinous substance of pine origin and a small piece of wood embedded in this substance both gave late fourth century dates for material from a late-Roman shipwreck. These dates were further confirmed by the presence of a Roman copper coin in the resinous mass.

In the case of Spirit Cave and Noen U-Loke, analysis of the archaeological resins from both sites using gas chromatography-mass spectrometry (GC–MS) shows that both exhibit

---

**Table 3. AMS radiocarbon dates from archaeological resins from Noen U-Loke.**

<table>
<thead>
<tr>
<th>Oxford Ref</th>
<th>Date BP (uncalibrated)</th>
<th>Date (calibrated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OxA-10268</td>
<td>1900 ± 37</td>
<td>30AD (2.7%) 40A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50AD (65.5%) 140AD</td>
</tr>
<tr>
<td>OxA-10269</td>
<td>1861 ± 35</td>
<td>80AD (8.3%) 110AD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>120AD (59.9%) 220AD</td>
</tr>
<tr>
<td>OxA-10270</td>
<td>2149 ± 35</td>
<td>350BC (17.4%) 310BC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>230BC (3.5%) 220BC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>210BC (47.2%) 110BC</td>
</tr>
<tr>
<td></td>
<td>20AD (95.4%) 230AD</td>
<td>70AD (95.4%) 250AD</td>
</tr>
<tr>
<td></td>
<td>20BC (95.4%) 230BC</td>
<td></td>
</tr>
</tbody>
</table>

---

**Figure 4. Radiocarbon dates (cal BC/AD) from Noen U-Loke**

---

130
characteristics in common with a sample of modern ‘dammar’, a triterpenoid resin produced by members of the Dipterocarpaceae family (Figure 5; for details of the analytical methodology, see Lampert et al. 2002).

However, although the potential for using a range of archaeological resinous deposits for radiocarbon dating appears to be promising, for archaeologists working in Southeast Asia at least, a further note of caution must be sounded. The practice of tapping trees for resin is well established within the region but documentary evidence exists for resin collected by digging in the soil at the foot of old trees or in areas where resinous trees are no longer found but were once common (Howes 1949). This appears to have been a more common practice in the case of resins such as Agathis, from the Araucariaceae family, which is widespread in Insular Southeast Asia, but may also have taken place with Dipterocarpaceae or ‘dammar’ type resins on the mainland (Burkill 1935).

Since radiocarbon techniques date the cessation of exchange of carbon with the biosphere, the so-called ‘fossil’ or ‘semi-fossil’ resins collected in this manner may have been exuded from the tree many years before their use on ceramics, unlike freshly-tapped contemporary resins. Radiocarbon results where ground-collected resin was used on pottery could considerably pre-date the ceramics to which it was applied. It would be prudent to identify the source of any resin samples considered for dating. If significant reservations are held as to the possible source of the resin, radiocarbon dates from resinous deposits on potsherds should be regarded only as a *terminus post quem* for the pottery to which it has been applied.

---

**Figure 5.** Partial chromatograms of resins from the Dipterocarpaceae family. 1 – Modern Dipterocarpaceae resin, 2 – Archaeological resin from Spirit Cave, 3 – Archaeological resin from Noen U-Lake.
For the dates obtained from resin samples from Noen U-Loke, this would not appear to be of concern as the resin dates are in good accord with conventional dates from the site. However, in the case of the resin dates obtained from Spirit Cave, there is no correspondence with the previous site chronology and the dates do not correlate with the proposed chronology of log coffin sites in the area. It may be that ‘semi-fossil’ resin was collected and used as a coating on ceramics found at the site. If this were so, the dates obtained from the resin would pre-date the pottery and this could support the theory that potsherds were present in the upper layers of the site due to disturbance of the log coffin burials. Without further research to clarify the chronology of log coffins in Mae Hong Son Province, this point cannot be fully resolved.

In summary, natural resins have potential for dating and may be considered a useful substance from which to obtain information on the chronology of individual artefacts and archaeological sites, as well as indicating the use of non-timber forest resources. The radiocarbon dates obtained from samples of resin adhering to the surfaces of potsherds from Spirit Cave appear reliable and would suggest a possibly intermittent continuation in the use of the rockshelter during the Late Neolithic-Bronze Age.

Acknowledgements
The authors would like to express their gratitude to the following people and organisations. The Natural Environment Research Council, UK for the award of a research studentship and a supplementary award for radiocarbon analysis to support this work. The Research Laboratory for Archaeology and the History of Art, Oxford, UK for undertaking AMS dating of resinosous samples. The Royal Botanic Gardens, Kew, UK for modern reference samples. Dr Joyce White, MASCA, University of Pennsylvania, U.S.A. and Prof. Charles Higham, University of Otago, New Zealand.

References


