



Black pitch, carved histories: Radiocarbon dating, wood species identification and strontium isotope analysis of prehistoric wood carvings from Trinidad's Pitch Lake

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ABSTRACT

We report on the results of a multi-disciplinary project (including wood identification, radiocarbon dating and strontium isotope analysis) focused on a collection of pre-Columbian wooden carvings and human remains from Pitch Lake, Trinidad. While the lake's unusual conditions are conducive to the survival of organic artefacts, they also present particular challenges for analysis. There is a loss of any contextual association beyond that of the lake, and specific methodologies are required to deal with pitch contamination. A surprising taxonomic range of woods was employed for the various utilitarian and ceremonial items recovered. The 14C results range from ca. 3200 BCE to ca. 700 CE, and include the earliest known wooden carvings in the entire Caribbean. The strontium isotope results - interpreted with the aid of an isoscape developed for the project, based on extensive samples of modern trees across Trinidad and Tobago - indicate that most carvings are consistent with the site's immediate environs; however, a 'weaving tool' came from a more radiogenic region that is unlikely to be found on Trinidad, suggesting links with the South American mainland.

1. Trinidad's Pitch Lake: A unique source of prehistoric wood carvings

1.1. Introduction

Trinidad has been the gateway into the Caribbean for waves of South American migrants since 3500 BCE, thus forming the first stepping-stone in the long chain of islands that make up the archipelago. Its critical position to the settlement of the Caribbean is reflected in its

archaeological record, documenting the complex interactions between its diverse peoples over millennia (e.g., Boomert, 2000). Unique among its archaeological sites is Pitch Lake, one of the largest natural deposits of asphalt in the world, which over the years has yielded extremely rare wood carvings – to date the largest concentration of ancient wooden artefacts in the Lesser Antilles, an area stretching from the Virgin Islands in the north to Trinidad in the south: of the 18 carvings known from this region, 11 were recovered from Pitch Lake.¹ However, the

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¹ Previous research on prehistoric Caribbean wood sculpture has focused primarily on the Greater Antilles (Calvera Rosés et al., 2006; Conrad et al., 2001; Ostapkowicz, 1998; Ostapkowicz et al., 2012, 2013), since the majority of carvings have been recovered from this region. The Lesser Antillean corpus, which here includes the most southern islands of Trinidad and Tobago, is much less well known for a variety of factors. Unusually, only a handful of wooden artefacts from the Lesser Antilles have been securely identified in museum collections (Delpuech and Roux, 2015; Ostapkowicz et al., 2011; Roux, 2012). This is surprising given that these islands, much like the rest of the Caribbean, were of intense interest to European colonisers from the 16th century onwards. Indeed, a lively trade was sustained between the indigenous populations and passing European ships, though colonising efforts were largely resisted by the Island Carib/Kalinago (e.g., Hulme and Whitehead, 1992). The handful of references to early artefacts from these islands – such as the acquisition of a bow and five arrows from St Vincent donated to the Society of Antiquaries of Scotland in 1781 (Smellie, 1782:48) – are all that remains to document the presence of such pieces; they have long since disappeared.

lake's contribution to the archaeology of Trinidad – and to Caribbean prehistory in general – has been impeded by the nature of the site itself. Impossible to excavate using archaeological methods, only chance finds have been recovered as a consequence of commercial harvesting (Fig. 1). Any association between the carvings, or a possible connection between them and the skeletal remains that were also recovered, has been lost. Further, asphalt is a contaminant of geological age: two samples of pitch from the lake have been dated as part of this project to $41,300 \pm 800$ BP and $44,400 \pm 1300$ BP (Brock et al., in press), presenting a particular challenge to radiocarbon dating and a factor that, until now, has limited their interpretive potential. This research – the first systematic study of the organic artefacts from Trinidad's Pitch Lake – specifically addresses such contamination issues in order to more concretely explore the material culture of this complex region.

This article provides an overview of the AMS ^{14}C results from 10 carvings (Figs. 2–5) and a human cranium (Fig. 6) recovered from Pitch Lake and now in museum collections (Table 1; all bracketed numbers – e.g., [2] – in the text and figure captions cross-reference with Table 1, where more detailed information about the artefacts can be found).² Its aims are: 1/ to provide a chronological framework for the artefacts and human remains recovered from Pitch Lake, based on a methodology developed specifically for this project to address issues of pitch contamination (see also Brock et al., in press); 2/ to identify the wood used to carve the artefacts, and so be able to address local and/or regional timber utilisation as well as any potential for in-built wood age that could affect the dates; and 3/ to explore artefact provenance through strontium isotope analysis in order to establish which may be local and which, if any, are non-local. Results from the artefact wood identification directly informed the botanical field collecting for the comparative strontium dataset. By sampling the same woods as those used by indigenous carvers, the aim was to match as closely as possible the variables that could affect the strontium results: the expectation was that the same species would root to a similar depth, and hence more accurately reflect the isotope ranges obtained on the artefacts. The project has two further interrelated methodological objectives: 4/ to develop protocols for radiocarbon dating and strontium isotope analysis when working with pitch contaminated materials and 5/ to establish an isoscape of the biologically available strontium for the twin islands of Trinidad and Tobago, which will be of value to researchers investigating mobility and exchange in the wider Caribbean (cf. Laffoon et al., 2012).

1.2. Pitch Lake: context, history of pitch use and artefact finds

Pitch Lake, one of the largest natural deposits of asphalt in the world, is 47 ha (115 acres) in size, 87 m deep and contains an estimated 10 million tons of asphalt, which continues to churn below a thin layer of hardened surface (Attwooll and Broome, 1954:18–19). It formed millennia ago, when crustal movement resulted in faults reaching a large oil and gas reservoir, bringing these to the surface via channels to fill a large conical-shaped basin (Attwooll and Broome, 1954:15–16; Boopsingh and Toney, 1981; Keyes, n.d.v). The continuous influx of material into the lake creates a constant state of motion, likened to “waves, flows or currents” (Keyes n.d.:vii). This is best illustrated by the movement of large objects, such as fallen tree trunks (Fig. 7), within the lake, which have been known to rise from the depths, flow with the ‘current’ to the lake's edge, only to disappear again below the surface (e.g., Attwooll and Broome, 1954:19; Keyes, n.d.:vii-x; Nugent, 1811:64). Particularly relevant here is that this constant motion negates any association between artefacts that may have been deposited together, such that it is difficult to substantiate any connection between those recovered even in the same location.

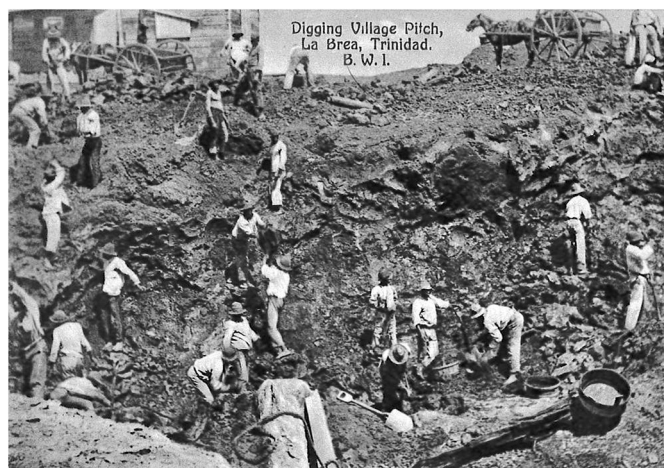


Fig. 1. ‘Digging Village Pitch, La Brea, Trinidad, B.W.I.’, late 19th-century postcard. This ‘land pitch’ originates from the overflow of Pitch Lake.



Fig. 2. Two seats recovered from Pitch Lake, Trinidad. Left: Three views of zoomorphic bench [3], *Andira* sp., 560 CE–648 (95.4%). L: 590 mm; W: 255 mm (max); H: 200 mm. Photos: Ostapkowicz, courtesy Peabody Museum of Natural History, ANT.145145. Right: Three views of high-backed seat [5], *Carapa* sp., 554 CE–635 (95.4%; two dates combined). L: 755 mm; W: 275 mm (max); H: 245 mm (with back oriented in correct position). Photos: Ostapkowicz, courtesy The National Museum and Art Gallery of Trinidad and Tobago, 80/A/550.



Fig. 3. Bowls and mortar recovered from Pitch Lake, Trinidad. Left: Small vessel [10], *Guaiacum* sp., 2906–2761 BCE (3 dates combined; NB pitch contamination detected, so dates are too old); NMAGTT, n/n. H: 70 mm (max); W: 102 mm; D: 94 mm. Centre: Platter [2], *Drinys* cf. *granadensis*, 573 CE–654 (95.4%); NMAGTT, 80/A/551. W: 325 mm; D: 300 mm; H: 75 mm; Right: Mortar [9], *Handroanthus chrysanthus*, 1606–1418 BCE (95.4%); NMAGTT, 80/A/549. H: 315 mm (max); W: 189 mm; D: 154 mm. Photos: Ostapkowicz, all courtesy The National Museum and Art Gallery of Trinidad and Tobago.

² Of the 11 known carvings from Pitch Lake, one (a wooden paddle) remains in a private collection, and so was not included in this study.



Fig. 4. Front and side views of two weaving tools recovered from Pitch Lake, Trinidad. Top two views: handled weaving tool [1], *Palmae/Arecaceae* (Monocot, Palm), 617 CE–690 (94.1%). L: 547 mm; W: 27 mm (max); Thickness: 24 mm (max). Bottom two views: handleless weaving tool [11], *Brosimum cf. guianense*, 3340–3204 BCE (95.4%; two dates). L: 555 mm; W: 42 mm (max); Thickness: 23 mm (max). Photos: Ostapkowicz, all courtesy Christopher Harris, the Peter Harris Collection, Pointe-a-Pierre Wildfowl Trust.



Fig. 5. Three paddles recovered from Pitch Lake, Trinidad. Left: Paddle [6], *Terminalia dichotoma*, 428 CE–598 (95.4%). L: 1440 mm; L of blade: 724 mm; W: 142 mm (max). Image courtesy, Peabody Museum of Natural History, ANT. 145144. Centre: paddle [7], *Platymiscium* sp., 411 CE–541 (95.4%). L: 1290 mm; W: 105 mm (max), courtesy, National Museum and Art Gallery of Trinidad and Tobago, n/n. Right: Paddle [4], *Terminalia dichotoma*, 547 CE–641 (95.4%). L: 1265 mm; L of blade: 640 mm; W: 101 mm (max). Images courtesy Christopher Harris, the Peter Harris Collection, Pointe-a-Pierre Wildfowl Trust. Photos: Ostapkowicz.

The handful of wooden artefacts that survive today in museum collections must comprise only a small fraction of what has been removed from the lake over centuries of commercial pitch exploitation. As early as 1595, Sir Walter Raleigh had expounded on the value of the Trinidad pitch, calling it “...most excellent good” for caulking ships (in Whitehead, 1997:131), and its economic potential was more fully recognised in the 18th century, though harvesting remained small scale and largely local (Boomert, 1984b:23–24; Boopsingh, 2014:1; Newson,

1976:211). Production greatly increased with the worldwide demand for road-surfacing material due to the rise of the automobile from the mid- to late-19th century, though even with this larger-scale commercial enterprise, pitch extraction continued to involve hard manual labour, with cutters using specially designed mattocks to excavate the asphalt – indeed, some of the artefacts [4; 7;10] feature damage from being dug out with mattocks or other equipment. It was not until 1956 that mechanical diggers were introduced, which increased yields exponentially. Over the years of working at the site, the lake level has dropped by some 12 m, accounting for an estimated 11 million tons of excavated asphalt (LATT: *Lake Asphalt of Trinidad and Tobago* (1978) Limited, n.d.; Boomert, 1984a:19). The fact that the site was being worked by hand for such a large part of its history means that artefacts were likely recognised as they emerged from the pitch. For example, in 1951 the director of Trinidad’s Brighton Terminal (whence much of the pitch was exported) wrote to Caribbean archaeologist Irving Rouse that “...there are many objects found in the Pitch Lake by the... diggers, who take them home or sell them to tourists” (Kallman, 1951); others, as will be seen below, were handed over to the company managers, either being sent to the head office as curios or entering private collections before being donated to museums. Given this, the potential of further additions to the corpus is quite likely, as is the possibility of future finds from the lake.

There is very limited information available in museum records concerning the histories of the Pitch Lake artefacts under discussion here. The earliest documented pieces were those acquired by the Royal Victoria Institute (now the National Museum and Art Gallery of Trinidad and Tobago) in ca. 1933 (Bather and Sheppard, 1934:61). The platter [2] (Fig. 3, centre), high-backed seat [5] (Fig. 2, right), and mortar [9] (Fig. 3, right) may have been part of this early collection (Boomert and Harris, 1984a:34). Other finds were also made at this time, but do not appear to have entered museum collections: Baker (in Boomert and Harris, 1984a:37; Boomert, 2000:297–300; 327) noted that one particular spot of the lake was known “...for producing in the diggings the bones of animals and even human [remains]”.³

Further finds were made in the 1940–50s. In 1951, R. Kallman (1951), the director of Brighton Terminal Ltd., wrote to Irving Rouse that the company had “...a wooden paddle ([6]; Fig. 5, left) about six feet long which must have been handled by a giant... even with the buoyancy of water is too heavy for any present day human to handle. We also have a four-legged bench with animal heads carved at each end” ([3]; Fig. 2, left). Kallman donated these two artefacts to the Peabody Museum of Natural History (henceforth PMNH) of Yale University, New Haven in 1952. By 1953, the artefacts were on loan to the Victoria Institute in Port of Spain and by 1955, the Pitch Lake material – including the PMNH loans – were on exhibit, together with a partial cranium ([8]; Fig. 6) recovered from the lake (Bullbrook, 1955:2) The cranium’s history is obscure, though its connection to Pitch Lake is clearly underscored by the fact that it is mounted within pitch on a wooden display board. Less is known about the subsequent Pitch Lake additions to the museum collections, including the small vessel ([10]; Fig. 3, left) and paddle ([7]; Fig. 5, centre), thought to have been donated in the late 1980s, and two human bones (a femur and rib) attributed to the lake in the museum records.⁴

Another organization, the Trinidad and Tobago Historical Society (South Section) headed by Peter O’Brien Harris, acquired three wooden artefacts in 1972 via donation from H. Costelloe, then managing director of the Asphalt Company. Two ‘sword-clubs’ – later identified as

³ Reportedly, fossil remains of various extinct Pleistocene mammals, such as mastodon tooth and bone fragments, have been recovered from the lake (Saunders 1960).

⁴ A human rib and femur attributed to Pitch Lake in the museum records of the National Museum and Art Gallery, Trinidad, despite lacking any visible evidence of pitch, were included on the basis of their documented history; however, the radiocarbon results clearly showed that they were recent: rib 171 ± 28 BP (1661 CE-modern; OxA-34979) and femur 132 ± 32 BP (1677 CE-1940; OxA-34845).



Fig. 6. Two views of the partial cranium from Pitch Lake. Photos: Ostapkowicz, courtesy, National Museum and Art Gallery of Trinidad and Tobago, 80/A/551.

loom weaving tools ('pressers/beaters') ([1]; [11]; Fig. 4] (Boomert and Harris, 1984a:35) – were found in the north part of the lake in 1965 within two months of each other (Assee, 1972:7), while a paddle ([4]; Fig. 5, right] was recovered from roughly the same area in 1971 (Boomert and Harris, 1984a:34). The fact that two such similar weaving tools were found in the same location, though not in association, initially suggested to Harris that they were contemporaneous (Assee 1972:7). A ceramic *adorno*, recovered from the same part of the lake, though some six weeks after the weaving tools, was considered to belong to the (late) Palo Seco (Saladoid) complex, dating to ca. 500 CE–650, potentially suggesting a similar chronological placement for the wooden pieces as well (ibid; Boomert and Harris, 1984a:37; Fig. 14).

2. Methods

Pitch contamination presents challenges for radiocarbon dating and strontium isotope analysis; the project developed methodologies specifically targeting this issue, as detailed in this section.

2.1. Radiocarbon dating

Samples for radiocarbon dating were taken from the outer edge of each carving, to ensure that a date closest to the felling period (and therefore likely time of carving) was obtained, while minimizing the visual impact to the artefact. Additionally, samples were taken from within the bole of several artefacts ([5, 7, 9, 10]) to investigate the age of the tree vs. its size. Wood samples (most ca. 30 mg) were taken with a clean scalpel, and bone powder (150 mg) was collected from the human cranium by drilling.

Extensive tests were undertaken to identify the most effective pretreatment protocol for removing pitch (Brock et al., *in press*), as any residual pitch would have resulted in an artificially old age. All samples initially underwent a sequential wash with methanol and toluene based on the method employed by Fuller et al. (2014) for pretreating tar-impregnated samples from the Rancho La Brea Tar Pits in California, USA: 2:1 toluene:methanol (30 min, with ultrasonication, $\times 4$); 2:1 toluene:methanol (30 min with ultrasonication, followed by soaking overnight for a minimum of 17 h); 2:1 toluene:methanol (30 min, with ultrasonication); methanol (30 min, with ultrasonication, $\times 2$); ultra-pure milli-Q water (30 min with ultrasonication, $\times 2$).

'Collagen' was extracted from the cranium for dating as described by Brock et al. (*in press*) via a modified Longin method with gelatinization, consisting of sequential washes at room temperature with HCl (0.5 M, 3 rinses over ~ 18 h), NaOH (0.1 M, 30 min) and HCl (0.5 M, 1 h) with

thorough rinsing with ultrapure water after each step, followed by gelatinization at pH 3 and 75 °C for 20 h. The resultant solution was then filtered using a cleaned 45–90 μ m Eze-filter™ (Elkay, UK; Brock et al., 2010) prior to freeze-drying.

The wood samples underwent a routine ABA-bleach pretreatment protocol, as described by Staff et al. (2014) and Brock et al. (2010; *in press*), consisting of sequential washes with HCl (1 M, 20 min, 80 °C), NaOH (0.2 M, 20 min, 80 °C), HCl (1 M, 60 min, 80 °C), 5.0% w/v NaOCl bleach (pH 3, up to 30 min, 80 °C) with ultrapure water rinses after each step, before freeze-drying. One sample from the NGTT paddle ([7]) also underwent an α -cellulose extraction prior to dating, as described by Brock et al. (*in press*): sequential washes with acidified NaOCl bleach (1.5% w/v, 70 °C, 4 rinses over 24 h), HCl (1.12 M, 20 min, 70 °C), NaOH (17.5% w/v, room temperature, 1 h with ultrasonication under a constant N₂ atmosphere), HCl (1.4 M, 10 min, 70 °C), rinsing with ultrapure water after each step.

The final products were freeze-dried, combusted and the resultant CO₂ cryogenically trapped, graphitized and AMS-radiocarbon dated (see Brock et al. 2010). As well as routine laboratory checks to verify the radiocarbon dates, additional analysis was undertaken using py-GC/MS and optical microscopy to determine the effectiveness of the pretreatment protocols for removing pitch from some of the samples, as described by Brock et al. (*in press*).

2.2. Wood identification and permeability to pitch

Wood identification samples were carefully trimmed with a razor blade to expose the transverse surface, then observed with a 14 $\times$ loupe. Thin sections were cut from the radial and tangential (and sometimes transverse) surfaces of the specimen when possible, and placed into a small pool of 1:1 glycerine: 95% ethanol mounting medium on a slide labelled with the specimen designator. A coverslip was placed atop the sections and mounting medium and the whole slide was transferred to a hot plate (105–150 °C) where it was heated until air bubbles ceased to exit the sections. The slide was then cooled on the lab bench and either stored horizontally in a covered slide case or observed immediately. Identifications were based on observation of cells and cell features, and comparison of those patterns and features to information in published keys, online databases (e.g. InsideWood – <http://insidewood.lib.ncsu.edu>), and ultimately to specimens in the MADw-SJRw xylarium housed in the Center for Wood Anatomy Research at the Forest Products Laboratory in Madison, WI, USA. Most of the specimens submitted for wood identification did not exhibit excessive contamination with asphalt, but when asphalt removal was necessary to improve visualization of wood anatomical features, sections were rinsed in a mixture (approx. 1:1) of toluene and acetone and heated gently on a hot plate to speed dissolution. The resulting dirty acetone-toluene was wicked from beneath the coverslip with tissue paper and clean mixture was added. When the sections ran clean, they were transferred to a new labelled slide and mounted as noted above.

There are two basic mechanisms by which pitch and its constituents can enter wood. One is the diffusion of compounds through the cell walls themselves. This route, while available in all woods regardless of species or differences in anatomy, is presumed to allow only small molecules with a molecular weight (MW) of less than roughly 6000 (Fournoy et al., 1991), thus if the isotopic signal of pitch differed according to the specific chemical constituent, diffusion of low MW compounds could influence the signal differently from the signal of the pitch at large. Also relevant is that the total mass of low MW pitch constituents that could enter the wood via the cell wall would be likely limited by cell wall volume, and so would be constrained at a low level. The second mechanism is the bulk flow of pitch into the open spaces in the wood, and because the flow is in bulk, the relative composition of the pitch accumulated in the wood should mirror that in the source at large. There are two basic domains of open space in wood, the lumina of the cells, and intercellular spaces. In the case of the former, access to the lumina of the cells is mediated by cell-to-cell connections called pits,

Table 1

Summary of ^{14}C and wood ID results for 11 Pitch Lake artefacts. 19 AMS radiocarbon results are reported excluding combined dates listed on lines 3.2, 5.2, 7.3 and 10.3. The Oxford Radiocarbon Accelerator Unit lab numbers (OxA) are provided alongside the material and sample site (e.g., *terminus*: sapwood or outer growth rings, to indicate when tree was felled and likely carved; *growth*: selected areas within the bole marking growth rates). Multiple dates are listed sequentially after the artefact number, with terminus dates listed first, followed by growth rates. Dates BP and calibrations at 95.4% confidence are listed, the most likely calibration ranges highlighted in bold. All dates are calibrated using the IntCal13 dataset (Reimer et al., 2013) and OxCal v4.2.4 (Bronk Ramsey, 2013).

Artefact	Institution/donor/Accession number	OxA-	Wood IDs, sampling location	$\delta^{13}\text{C}$	^{14}C BP	Calibration
1	Handled weaving tool	Harris Collection/Pointe-a-Pierre Wildfowl Trust, Pointe-a-Pierre, Trinidad; recovered 1965; n/n; Recovered together with [11] in the north part of the lake in 1965, donated by Mr. H. Costelloe, then managing director, to the TTHS-SS in 1972	31397	Palmae/Arecaceae (Monocot, Palm), terminus	– 24.4	1362 ± 28 617–690 CE (94.1%) 751–760 CE (1.3%)
2	Platter	National Museum and Art Gallery of Trinidad and Tobago, Port of Spain, Trinidad; donated ca.1933; 80/A/551	31969	<i>Drinys</i> cf. <i>granadensis</i> , terminus	– 24.2	1437 ± 27 573–654 CE (95.4%)
3	Zoomorphic bench	Peabody Museum of Natural History, New Haven, USA; 145,145; recovered between 1940 and 1950, donated to PMNH in 1952 by W. L. Kallman, director, Brighton Terminal Ltd.	19174 31965	<i>Andira</i> sp., terminus	– 25.1 – 25.3	1538 ± 29 427–587 CE (95.4%)^c 1457 ± 27 560–648 CE (95.4%)
4	Paddle	Harris Collection/Pointe-a-Pierre Wildfowl Trust, Pointe-a-Pierre, Trinidad; n/n; found in the north part of the lake in 1971, donated by Mr. H. Costelloe, then managing director, to the TTHS-SS in 1972	31971	<i>Terminalia dichotoma</i> , terminus	– 24.9	1475 ± 26 547–641 CE (95.4%)
5	High-backed seat	National Museum and Art Gallery of Trinidad and Tobago, Port of Spain, Trinidad; donated ca.1933; 80/A/550	31966	<i>Carapa</i> sp., terminus	– 25.0	1505 ± 26 432–490 CE (10.9%) 532–624 CE (84.5%)
5.1			31967	<i>Carapa</i> sp., growth	– 24.9	1447 ± 26 568–650 CE (95.4%)
5.2			Combined			
6	Paddle	Peabody Museum of Natural History, New Haven, USA; 145,144; recovered between 1940 and 1950, donated to PMNH in 1952 by W. L. Kallman, director, Brighton Terminal Ltd.	31964	<i>Terminalia dichotoma</i> , terminus	– 22.7	1476 ± 19 554–635 CE (95.4%) 1530 ± 26 428–598 CE (95.4%)
7	Paddle	National Museum and Art Gallery of Trinidad and Tobago, Port of Spain, Trinidad; found in the late 1980s; n/n	31968 31470 ^a 31396	<i>Platymiscium</i> sp., terminus	– 24.1 – 24.3 – 24.1	1588 ± 27 411–541 CE (95.4%) 1596 ± 25 408–538 CE (95.4%) 1559 ± 28 422–562 CE (95.4%)
7.1						
7.2						
7.3						
8	Cranium	National Museum and Art Gallery of Trinidad and Tobago, Port of Spain, Trinidad; found pre-1951; 80/A/551	X-2590-53 ^b	N/A	– 18.2	2222 ± 27 376–337 BCE (17.4%) 329–204 BCE (78%)
9	Mortar	National Museum and Art Gallery of Trinidad and Tobago, Port of Spain, Trinidad; donated ca.1933; 80/A/549	31344	<i>Handroanthus chrysanthus</i> , terminus	– 24.2	3216 ± 33 1606–1583 BCE (4.4%) 1559–1553 BCE (0.7%) 1546–1418 BCE (90.3%)
9.1					– 25.6	3260 ± 31 1617–1493 BCE (87.3%) 1482–1453 BCE (8.1%)
10	Small bowl	National Museum and Art Gallery of Trinidad and Tobago, Port of Spain, Trinidad; found in the 1980s; n/n	31395	<i>Handroanthus chrysanthus</i> , growth	– 24.7	4197 ± 32 2894–2838 BCE (26.3%) 2816–2673 BCE (69.1%)
10.1			31469	<i>Guaiacum</i> sp., terminus	– 24.3	4273 ± 29 2926–2872 BCE (95.4%)
10.2			31970	<i>Guaiacum</i> sp., terminus	– 24.1	4106 ± 30 2865–2805 BCE (23.4%) 2761–2573 BCE (72.2%)
10.3			Combined			4195 ± 18 2889–2856 BCE (25.3%) 2811–2748 BCE (57.8%) 2725–2698 BCE (12.3%) × 2-Test: df = 2 T = 16.0 (5% 6.0)
11	Handleless weaving tool	Harris Collection/Pointe-a-Pierre Wildfowl Trust, Pointe-a-Pierre, Trinidad; n/n; recovered together with [1] in the north part of the lake in 1965, donated by Mr. H. Costelloe, then managing director to the TTHS-SS in 1972	31972	<i>Brosimum</i> cf. <i>guianensis</i> , terminus; 2 dates on the same pretreated material	– 24.6	4472 ± 32 3340–3204 BCE (52.1%) 3198–3082 BCE (34.2%)
11.1			32980		– 24.7	4472 ± 32 3340–3204 BCE (52.1%) 3198–3082 BCE (34.2%) 3068–3027 BCE (9.1%) 3198–3082 BCE (34.2%) 3068–3027 BCE (9.1%)

^a This sample was treated twice, with two different pretreatments, to further check the pretreatment protocol. OxA-31,470 underwent alpha-cellulose extraction, while OxA-31,396 underwent routine ABA-pretreatment.

^b The sample was issued with an OxA-X due to the yield of collagen falling below routine laboratory requirements of 10 mg. However, the sample yield overall was 1.8 mg, exceeding the laboratory requirements of 1% yield.

^c Note that the date previously reported (431 CE–592) in Ostapkowicz et al. (2012) used an earlier version of the calibration curve (IntCal09); the updated version – IntCal13 – has resulted in the date range changing slightly, to 427 CE–587.



Fig. 7. Organics preserved in pitch. Leaves (left) and a large timber stump (right). Photos: Ostapkowicz.

which are in turn determined by the cell types themselves. Certain types of cells are likely to be more prone to bulk flow based on their function in living trees (e.g. vessels in hardwoods) whereas other cell types are structurally unlikely to be a realistic route for bulk flow (e.g. libriform fibers, ray parenchyma cells). It is thus plausible that different taxa could show quite different relative pitch infiltration into cell lumina under the same deposition scenarios. Intercellular spaces in wood are typically quite narrow, occurring in cell corners where three or more cells meet. Because they are narrow spaces, materials with high viscosity are less able to flow into them, but if wood sinks lower into Pitch Lake and pressure increases, flow could be possible. Even with such flow, the total volume of intercellular spaces is small compared to the volume of cell lumina.

2.3. Strontium isotopes

Strontium isotope analysis offers a novel approach to artefact provenance. $^{87}\text{Sr}/^{86}\text{Sr}$ values provide a 'signature' that is indicative of the region and environment from which the tree used to carve the object originated. To address the possible origins of the Pitch Lake artefacts it was necessary to characterise the local environment by creating a comparative baseline. Sampling focused on those wood species originally used for carving: 132 strontium wood samples (111 from Trinidad and 21 from Tobago) were collected from 116 locations (Fig. 8). Three samples were taken from each tree, one for the strontium isotope analysis and two for herbarium specimens for archiving in the respective collections of the National Herbarium of Trinidad and Tobago and the National Museums Liverpool.

For the modern reference material, ca. 1 g of wood sample was ashed in a muffle furnace at 650 °C. The acid digestion process and subsequent Sr purification were undertaken under a class 100 laminar flow hood in a class 1000 clean room (Université Libre de Bruxelles, Belgium, hereafter ULB). About fifty mg of sample were digested in a mixture of subboiled concentrated HNO_3 and HF at 120 °C for 24 h, before purification of the Sr analyte.

For the artefacts, due to pitch contamination and the very small amount of material available (< 50 mg prior to pre-treatment), it was necessary to develop a pre-treatment method as well as a digestion protocol as ashing would result in complete loss of the sample. The pre-treatment of the wooden artefacts was identical to radiocarbon dating pre-treatment except that the ABA was not carried out as it appears to remove large amounts of endogenous strontium leading to inaccurate and/or imprecise results. Once pre-treated, the samples were directly digested (without ashing) in successive steps using subboiled HNO_3 (14 M), HCl (6 M) and HF (23 M).

The purification of the Sr analyte used a chromatographic technique of ion-exchange resins (see Snoeck et al., 2015 for more details). The isotope ratios of the purified strontium samples were then measured on a Nu Plasma MC-ICP mass spectrometer (from Nu Instruments) at the Université Libre de Bruxelles, Belgium.

A geostatistical model of the spatial variation in biologically available strontium for Trinidad and Tobago was generated using Empirical Bayesian Kriging – a geostatistical interpolation technique that estimates values for non-sampled locations based on weighted averages of the values of nearby samples. In contrast to other methods of kriging which employ interactive variography (de Smith et al., 2015), Empirical Bayesian Kriging uses simulation to automatically calculate the parameters used to estimate values for non-sampled locations (Krivoruchko and Gribov, 2014). A semivariogram is estimated from the data and used to simulate the values at each of the sample locations. For each simulation, the simulated values are used to estimate a new semivariogram and Bayes' rule is used to calculate a weight that indicates the likelihood that the semivariogram can be used to correctly predict the observed values for the sampled locations. Predictions and standard errors for non-sampled locations are calculated from the resultant set of semivariograms and weights. Larger datasets are split into smaller sub-sets and semivariograms are estimated separately for each subset of the dataset. Empirical Bayesian Kriging was carried out using the Geostatistical Analyst Extension for ArcGIS 10.3.1.⁵

3. Results

The 10 Pitch Lake artefacts and cranium yielded 19 radiocarbon dates (Table 1; Fig. 9), and identification to nine wood species (Table 2); a total of 146 $^{87}\text{Sr}/^{86}\text{Sr}$ measurements are reported (Tables 3–5) from both artefacts (14) and field samples (132).

3.1. ^{14}C results

The human cranium produced 1.8% wt collagen of a pale golden colour. Although several small specks of black, insoluble residue were visible within the processed material, these were easily removed by hand prior to combustion and dating. The collagen gave a date of 2222 ± 27 BP, and a C:N ratio of 3.2, within the accepted range for

⁵ http://desktop.arcgis.com/en/arcmap/10.3/guide-books/extensions/geostatistical-analyst/what-is-empirical-bayesian-kriging-.htm#ESRI_SECTION1_3A9F416328A24CE18A0F9680E11720EF (visited on 05/06/2017)

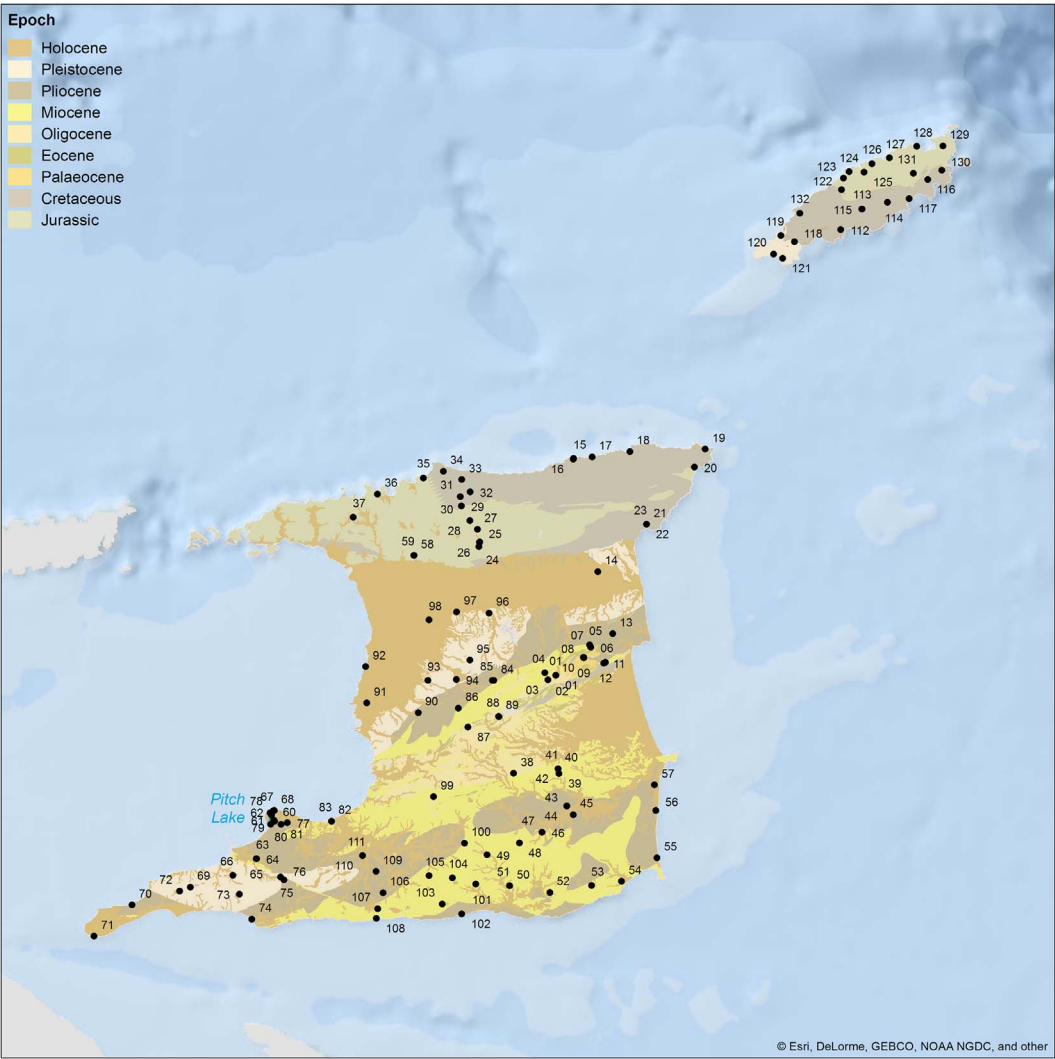


Fig. 8. Modern plant samples and solid geology of Trinidad and Tobago. The strontium isotope ratios for the sampled locations exhibit positive spatial autocorrelation (Moran's I test statistic: $I = 0.7031$, Expected $I = -0.0076$, Variance = 0.0047, z-score = 10.3177, p -value = 0.0000, conceptualisation of spatial relationships = inverse-distance, distance method = Euclidean, row standardisation = true, distance threshold = 17,719.5200 m). Image: Pouncett.

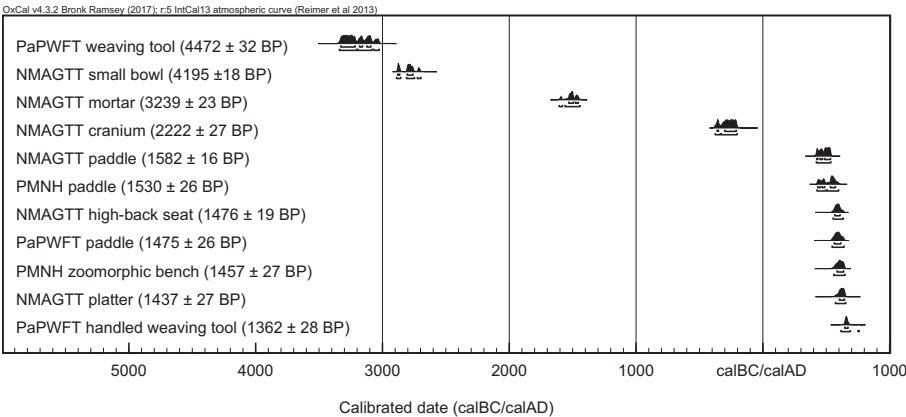


Fig. 9. Plot of radiocarbon results for the Pitch Lake artefacts and human cranium, calibrated in OxCal 4.2 using IntCal13.

collagen of 2.9–3.5 (Ambrose, 1990), and also within the range of 3.2–3.5 observed on bone collagen from tar seeps (Fuller et al., 2015). Unfortunately, due to the small amount of bone powder that could be sampled from the skull, there was insufficient material to produce a second date by single amino acid dating (which would not have been affected by any residual pitch). However, the yield, % C content of

collagen on combustion (41.7%), C:N ratio, and the colour of the collagen all suggest that no pitch remained after pretreatment and thus provide confidence in the date.

It had been hoped, prior to sampling the wooden artefacts, that some, if not all of the pieces, would have been suitable for α -cellulose extraction, rather than acid-base-acid (ABA)-bleach pretreatments, as

Table 2
Wood identifications with descriptions and current distributions within Trinidad and Tobago.

Artefact	Species [common name]	Previous wood ID ^a	Description and current distribution in T & T
[3] Zoomorphic bench, PMNH ^b 145.145	<i>Andira</i> sp., [Angelin, Bat Tonka Bean, Black Plum (Tobago), Cabbage Bark Tree, Laginette]	<i>Chlorophora tinctoria</i> [Fustic]	Common in the West Indies. <i>Andira</i> wood is hard and durable, moderately heavy and varies in colour from reddish-yellow to brown and is sometimes highly figured. It is an evergreen that prefers clay soils in poorly drained areas, is moderately deeply rooted, and has mauve flowers, with large, green fruit in June to late October, the latter consumed by bats. It is considered a slow growing tree (Marshall, 1930:29). Current distribution of <i>Andira</i> <i>hermis</i> : Trinidad : Arena-Cumuto; Arima Valley; Arima-Blanchisseuse Rd. N; Aripo Heights; Cumaca; Grande Riviere-Matlot; Guanapo-Chaguaramal; Matura-Salybia; Sangre Grande-Valencia-Oropouche. Mt. St. Benedict-Caura; NW Peninsular Corner; Tucker Valley-Mt. Catherine. Biche-Poole; Catshill-Basse Terre; Central Range; Longdenville-Talparo; Manzanilla-Fishing Pond; Nariva; North Central Coast; P.O.S.-Santa Cruz; Princes Town; Rampanalgas-Toco; Rio Claro-Mayaro; SW Erin-Guapo; SW Icacos-Cedros; San Fernando; Southern Watershed; Tabaquite-Brickfield; Trinity Hills. Tobago : E. Coast; Little Tobago St. Giles; NE Coast-Main Ridge F.R.; SW Coastal; Scarborough-Plymouth.
[11] Handleless weaving tool, Harris Col./ PaPWFT ^c n/n	<i>Brosimum</i> cf. <i>guianensis</i> [Moussara, Gatia or Leopard wood]	Fabaceae family	<i>B. guianense</i> ranges in height to ca. 25 m with a diameter between 15 and 30 cm. Its distribution ranges from southern Mexico and the eastern coast of Mesoamerica (Belize, Costa Rica, Guatemala, Nicaragua and Panama) to northeast South America (e.g., Guyana, Suriname, Venezuela), including many Caribbean islands in between (e.g., Jamaica, Antigua, Trinidad). It was apparently used to carve seats in the Lesser Antilles – as described by de la Borda (1674:18) who mentions one carved of a single piece of <i>bols de letre</i> ('letter wood'). <i>Brosimum guianense</i> (Ostapkowicz et al., 2011:158). The Carib of Guyana call it <i>palla</i> , and use it to make bows of 'extraordinary quality' (Grenand, 1989:327). Other common names in the Guianas (Guyana, Surinam, French Guiana) include Aberemou; Anap purubunnak; E-mo-yik; Pairea; Pleya; Pui-yik; Tibolkushi; Timeri; Tukwanru kamwi (DeFilippis et al., 2004). Current distribution of <i>Brosimum guianense</i> : Trinidad : Arena-Cumuto; Arima Valley; Arima-Blanchisseuse Rd. N; Aripo Heights; Biche-Poole; Catshill-Basse Terre; Central Range; Cumaca; Grande Riviere-Matlot; Guanapo-Chaguaramal; Longdenville-Talparo; Maracas-Tucuche; Mt. St. Benedict-Caura; Nariva; North Central Coast; P.O.S.-Santa Cruz; Princes Town; Rampanalgas-Toco; Rio Claro-Mayaro; SW Erin-Guapo; SW Icacos-Cedros; Southern Watershed; Tabaquite-Brickfield; Trinity Hills; Tucker-Mt. Catherine. Manzanilla-Fishing Pond; Sangre Grande-Valencia-Oropouche. Matura-Salybia. Arena. Siparia Quarry. Tobago : NE Coast-Main Ridge F.R.
[5] Long-backed seat, NMAGTT ^d 80/A/550	<i>Carapa</i> sp., [Carap. Carapa, Carapo, Crabwood]	Unidentified	<i>Carapa</i> sp., is categorised as a hardwood and is described as, on average, "70-90 ft. high, 1.5-2.5 ft. diameter above its large buttresses, wood reddish brown, belongs to the same family as mahogany, but is somewhat courser in grain, moderately hard, liable to split while felling and to warp in sawing especially when green, durable for interior work, weight 40-45lbs per cubic foot. Used for building construction and for furniture." (Trinidad Forest Department, 1923:5; see also Brooks, 1935:14). The seeds are also used as a medicinal oil (Chalmers and Cooper, 1981:92; Williams, 1973:11), and were in constant use by South American Amerindians for the oils hair and skin ointments, particularly for mixing with body paints (Roth, 1924:85). <i>Carapa</i> is widely distributed across the neotropics, from Mexico throughout Central America and tropical South America. The density, physical, and mechanical properties of <i>Carapa</i> vary somewhat across its range according to local environmental conditions, but in general the wood is medium density, brown to reddish brown, and medium textured. In modern trade its wood is often found as a lower value mahogany substitute, and has been known as crabwood in English. Current distribution of <i>Carapa guianensis</i> : Trinidad : Arena-Cumuto; Arima-Blanchisseuse Rd. N; Aripo Heights; Biche-Poole; Brasso Seco; Catshill-Basse Terre; Central Range; Cumaca; Grande Riviere-Matlot; Longdenville-Talparo; Manzanilla-Fishing Pond; Matura-Salybia; Mt. St. Benedict-Caura; Nariva; P.O.S.-Santa Cruz; Princes Town; Rampanalgas-Toco; Rio Claro-Mayaro; SW Erin-Guapo; SW Icacos-Cedros; Tabaquite-Brickfield; Trinity Hills Southern Watershed. North Central Coast; Sangre Grande-Valencia-Oropouche. Tobago : NE Coast-Main Ridge F.R.
[2] Shallow bowl, NMAGTT ^d 80/A/551	<i>Drimys</i> cf. <i>granadensis</i>	Unidentified	<i>Drimys granadensis</i> grows in northern South America, Mexico, and the Caribbean. In Colombia its bark has been valued as a cinnamon substitute, and to this day Colombian native people use the leaves and bark medicinally. Because the wood lacks vessels, its texture tends to be quite uniform, and in modern times is used in construction, carpentry, and some furniture, though it is quite a light wood. <i>Drimys</i> is a genus in the family Winteraceae, and one of the few lineages of so-called higher plants that show an interesting evolution reversal in their wood anatomy. Specific cells, vessel elements, arose fairly early in the evolution of the higher plants, and in most lineages have been retained, but in Winteraceae were lost, giving rise to the anomalous "vessel-less hardwood" wood anatomy.
[10] Small bowl, NMAGTT ^d n/n	<i>Guaiacum</i> sp., [Guayacan, lignum vitae]	Unidentified	Current distribution in T & T: Gardens.
[9] Mortar, NMAGTT ^d 80/A/549	<i>Handroanthus chrysanthus</i> [Guayacan]	Unidentified	The wood of <i>Handroanthus</i> is dark, hard, and heavy, and in that regard is similar to the wood of <i>Guaiacum</i> , and indeed both <i>Handroanthus</i> and <i>Guaiacum</i> are known by the common name guayacan
[1] Handled weaving tool, Harris Col./ PaPWFT ^c n/n	Palmae/ Areaceae (Monocot, Palm)	Areaceae family	Palms and other monocots do have the ability to form true wood, so the microscopic structure of the hard, heavy stem tissue produced in the tree palms is fundamentally distinct, composed solely of primary tissues. Current distribution: throughout T & T

(continued on next page)

Table 2 (continued)

Artefact	Species [common name]	Previous wood ID ^a	Description and current distribution in T & T
[4] Paddle, Harris Col./PaPWFT ^c n/n.	<i>Terminalia dichotoma</i> [Olivier; Olivier Mangue]	Harris Col./PaPWFT: <i>Gymnospermae</i> PMNH paddle; <i>Dipterix Adorata</i> [Tonka bean]	<i>Terminalia dichotoma</i> is a medium-small tree growing throughout the Caribbean and northern South America valued in modern times for its moderately dense, high-quality wood, although it is not a common commercial species. Its wood is used in fine furniture, and is superficially similar to a number of other species in the same genus. Some species of <i>Terminalia</i> produce edible nuts, essential oils, bark extracts of reputed pharmacological activity and other ethnobotanical uses. Current distribution of <i>Terminalia dichotoma</i> : Trinidad: Catshill-Basse Terre; Guanapo-Chaguararamal; Rio Claro-Mayaro; SW Erin-Guapo; Trinity Hills, Arena-Cumuto; Manzanilla-Fishing Pond; Rampanalgas-Toco. Southern Watershed Reserve, Guayaguayare, Guapo River
[7] Paddle, NMA GTT ^d n/n	<i>Platymiscium</i> sp., [Roble]		<i>Platymiscium</i> trees can reach up to 24 m in height with a trunk diameter of up to 110 cm, and their distribution spans northern Mexico to northern South America and Trinidad. The heartwood, which is a bright red to reddish brown with distinct stripes, is very heavy and dense, with an irregular and interlocked grain. Current distribution of <i>Platymiscium trinitatis</i> : Trinidad: Central Range; Princes Town; SW Erin-Guapo; San Fernando; Southern Watershed; Tabaquite-Brickfield; Port of Spain, St. Augustine, Claxton Bay, Main Road to Point Fortin.

^a In Boomert and Harris, 1984a, b:44.^b Peabody Museum of Natural History, New Haven, USA.^c The Peter Harris Collection at the Pointe-a-Pierre Wildfowl Trust, Pointe a Pierre, Trinidad.^d National Museum and Art Gallery of Trinidad and Tobago, Port of Spain, Trinidad.

the former is more rigorous and hence may have been more effective at removing pitch in addition to the preliminary organic solvent sequence. However, α -cellulose extraction is a very harsh treatment requiring a large (> 50 mg) starting weight, and very few of the artefacts provided sufficient well-preserved wood to survive this. To demonstrate that the routine ABA-bleach pretreatment applied was suitable for the samples, two sub-samples from the same region of the NGTT paddle [7] were taken, and each pretreatment applied to one of them. The α -cellulose extracted sub-sample [7.1] yielded a date of 1596 ± 25 BP, while the ABA-bleach treated sample [7.2] gave a date of 1559 ± 28 BP. These determinations successfully combine (χ^2 test (df = 1, $T = 1.0$ (5% 3.8)) to give a date of 1580 ± 19 BP (95.4%), providing confidence in the ABA-bleach pretreatment protocol.

In all wood samples, pretreatment yielded products that were pale yellow in colour, with no indication of residual pitch, except for occasional black specks of insoluble residue that could be removed by hand, as for the collagen sample.

The wooden artefacts recovered from Pitch Lake were previously tentatively attributed to the Palo Seco complex (1 CE-650) (Boomert and Harris, 1984a), but the mortar [9], small bowl [10], and handleless weaving tool [11] produced much older dates than expected (Table 1), which required further investigation. In particular the handleless weaving tool [11] was considerably older than the one with handle [1]. For the older weaving tool to date to the same period as the more recent one, it would need to contain around 40–50% pitch contamination. The pretreated material from all pieces appeared extremely clean visually, incongruous with the idea that they were composed of 40–50% 'dead' radiocarbon. There was insufficient untreated material to redetermine the handleless weaving tool or the mortar, but sufficient pretreated material remained from the weaving tool for a second aliquot to be combusted and dated. The second date of 4472 ± 32 BP was identical to the first, strongly indicating that the first date was reliable as it is highly unlikely that, even if the samples were heavily contaminated, both aliquots would have contained identical levels of residual pitch. In addition, optical microscopy and py-GC/MS of the pretreated material from this specimen found no evidence of any exogenous material that could have affected the date (Brock et al., in press).

Another way of investigating potential pitch contamination in the wooden artefacts is to compare their $\delta^{13}\text{C}$ values. The pitch is relatively low at -28.4‰ , while the artefacts range from -22.7‰ to -25.2‰ , averaging $-24.5 \pm 0.7\text{‰}$. To make a date 2000 years too old, for example, it would need to be contaminated with ca. 40% pitch. Given the ca. 4‰ difference between the measured $\delta^{13}\text{C}$ value of pitch and the average for the artefacts, this should deplete the latter by ca. 1.6‰. Some indication of a correlation between the ^{14}C determinations and $\delta^{13}\text{C}$ values for the artefacts would then be expected, i.e., artefacts with lower $\delta^{13}\text{C}$ values would tend to return older dates. This is not the case ($r^2 = 0.012$), and so supports the absence of any large effects from pitch contamination.

However, optical microscopy of the pre-treated material from the small bowl revealed the presence of residual pitch throughout the wood (Brock et al., in press), which was not removed by the radiocarbon pretreatment process; this is in contrast to the other samples, where microscopy clearly demonstrated that no pitch remained. The presence of pitch within the pre-treated material from the bowl indicates that the date is erroneously old, and as such can only be used as a terminus postquem. This highlights the fact that while, for many pieces, the pitch contamination appears confined to the outer surfaces of the artefacts and was effectively removed during the pretreatment process, in this instance the pitch had permeated the wood. Nevertheless, from the other artefacts in this study, we can be confident that the Archaic Age is well represented.

The zoomorphic bench [3] had previously been dated to 1538 ± 29 BP (OxA-19174; Ostapkowicz et al., 2012). Initial tests with a small piece of surface pitch indicated that the routine organic solvent sequence for removal of organic contaminants at the Oxford

Table 3
Strontium isotope ratios for the modern wood samples.

Sample	$^{87}\text{Sr}/^{86}\text{Sr}$	$2\sigma^a$	Sample	$^{87}\text{Sr}/^{86}\text{Sr}$	$2\sigma^a$	Sample	$^{87}\text{Sr}/^{86}\text{Sr}$	$2\sigma^a$
T01	0.711710	0.000009	T47	0.707780	0.000011	T90	0.712306	0.000010
T01bis	0.711708	0.000009	T48	0.707266	0.000015	T90bis	0.712319	0.000008
T02	0.711129	0.000008	T49	0.709026	0.000010	T91	0.710234	0.000010
T03	0.710772	0.000009	T50	0.710017	0.000007	T92	0.709869	0.000007
T04	0.708061	0.000009	T51	0.710000	0.000010	T93	0.710925	0.000009
T05	0.710196	0.000009	T52	0.707628	0.000013	T94	0.709605	0.000009
T06	0.710889	0.000009	T53	0.710915	0.000009	T95	0.710174	0.000012
T07	0.713970	0.000010	T54	0.708755	0.000012	T96	0.710089	0.000010
T08	0.709667	0.000008	T55	0.708691	0.000010	T97	0.709166	0.000010
T09	0.709755	0.000009	T56	0.709001	0.000011	T98	0.710919	0.000010
T10	0.711686	0.000009	T57	0.708283	0.000010	T99	0.708894	0.000013
T11	0.709245	0.000008	T58	0.710645	0.000011	T100	0.708069	0.000010
T12	0.709036	0.000007	T59	0.709473	0.000008	T100bis	0.708078	0.000009
T13	0.710768	0.000011	T60	0.711242	0.000009	T101	0.708437	0.000008
T14	0.712019	0.000009	T61	0.712445	0.000008	T102	0.708234	0.000010
T15	0.713033	0.000009	T62	0.710897	0.000014	T103	0.709708	0.000008
T16	0.712757	0.000012	T63	0.709569	0.000010	T104	0.709528	0.000013
T17	0.712666	0.000009	T64	0.709523	0.000008	T105	0.709108	0.000018
T18	0.708976	0.000008	T65	0.709776	0.000012	T106	0.708768	0.000011
T19	0.709830	0.000006	T66	0.710708	0.000016	T107	0.708824	0.000010
T20	0.712065	0.000009	T67	0.709042	0.000014	T108	0.707553	0.000011
T21	0.711898	0.000008	T68	0.709521	0.000008	T109	0.708121	0.000007
T22	0.711246	0.000009	T69	0.715371	0.000011	T110	0.708951	0.000008
T23	0.711246	0.000012	T69bis	0.715419	0.000009	T111	0.709007	0.000012
T24	0.710702	0.000009	T70	0.709071	0.000010	T112	0.705441	0.000012
T25	0.710905	0.000010	T71	0.709263	0.000011	T113	0.706963	0.000011
T26	0.710648	0.000011	T72	0.713228	0.000013	T114	0.704170	0.000011
T27	0.711808	0.000012	T73	0.710537	0.000011	T115	0.704840	0.000011
T28	0.710765	0.000011	T74	0.708394	0.000013	T116	0.706111	0.000008
T29	0.711925	0.000009	T75	0.710247	0.000012	T117	0.705025	0.000009
T30	0.710992	0.000011	T76	0.708615	0.000012	T118	0.710946	0.000009
T31	0.711163	0.000008	T77	0.709675	0.000008	T119	0.708872	0.000009
T32	0.711255	0.000010	T78	0.709602	0.000010	T120	0.708903	0.000013
T33	0.713242	0.000009	T79	0.711515	0.000010	T121	0.709194	0.000017
T34	0.712358	0.000009	T80	0.712524	0.000017	T122	0.705525	0.000013
T35	0.711904	0.000012	T81	0.713043	0.000009	T123	0.706003	0.000010
T36	0.709929	0.000008	T82	0.710529	0.000009	T124	0.706486	0.000010
T37	0.708993	0.000009	T83	0.709741	0.000012	T125	0.708381	0.000018
T38	0.710586	0.000012	T83bis	0.709666	0.000009	T126	0.705265	0.000009
T39	0.709104	0.000011	T84	0.709002	0.000009	T127	0.705649	0.000009
T40	0.709043	0.000008	T85	0.710835	0.000009	T128	0.706622	0.000009
T41	0.708996	0.000008	T86	0.709003	0.000008	T129	0.705202	0.000011
T42	0.709235	0.000006	T87	0.710011	0.000009	T130	0.707007	0.000011
T43	0.709265	0.000010	T88	0.713539	0.000009	T131	0.704844	0.000009
T44	0.709462	0.000008	T88bis	0.713606	0.00001	T132	0.704965	0.000011
T45	0.708553	0.000012	T89	0.713093	0.000012			
T46	0.707895	0.000012	T89bis	0.713314	0.000009			

^a 2σ error (absolute error value of the individual sample analysis – internal error).

Radiocarbon Accelerator Unit (consisting of washes with acetone, methanol and chloroform) was sufficient to remove any residual pitch, and the sample was treated accordingly and dated. However, extensive testing as part of the larger Pitch Lake dating project (Brock et al., in press) indicated that a more thorough pretreatment protocol was required, and hence the bench was redated with the same pretreatment protocol as applied to all other wooden artefacts from Pitch Lake. The new date of 1457 ± 27 BP (OxA-31965) is significantly more recent than the previous date (χ^2 test, $df = 1$, $T = 4.2$ (5% 3.8), though only by 81 ^{14}C years, indicating that a small amount of pitch may have remained after initial pretreatment. We therefore take the new determination of 1457 ± 27 BP to be more reliable.

3.2. Wood ID results

The woods used to carve the Pitch Lake artefacts are surprisingly varied, and include *Andira* sp., [3], *Brosimum* cf. *guianensis* [11], *Carapa* sp., [5], *Drimys* cf. *granadensis* [2], *Guaiacum* sp., [10], *Handroanthus chrysanthus* [9]; *Palmae/Arecaceae* [1], *Terminalia dichotoma* [4] and

Platymiscium sp., [7] (Table 2; Fig. 10). Some of these identifications differ from previous attributions (compare Table 2, columns 2 and 3), probably because these were made without the benefit of samples. These results guided the selection of modern herbarium specimens for the strontium study.

3.3. Strontium isotope results and isoscape

The strontium isotope measurements on the modern wood samples (Table 3) range from 0.7041 to 0.7154. To assess their reproducibility, two samples were measured twice after complete digestion and strontium extraction (Table 4); the difference falls within the 2σ internal measurement error, supporting the reliability of the results. Furthermore, for five samples, two fractions were ashed separately and underwent distinct digestions and strontium separations (Table 5). The results show that the variation within a single wood sample is limited (below 0.00025).

The artefacts were pre-treated to remove any pitch contamination and potential cleaning or conservation treatments. Three samples (from

Table 4

Strontium isotope results for duplicate measurements carried out (a) on the strontium extracted from of a single digestion or (b) on two different wood samples ashed separately.

Sample	$^{87}\text{Sr}/^{86}\text{Sr}$	$2\sigma^a$	Difference
(a) Same digestion			
T01	0.711710	0.000009	0.000002
T01bis	0.711708	0.000009	
T100	0.708069	0.000010	0.000009
T100bis	0.708078	0.000009	
(b) Different samples			
T69	0.715371	0.000011	0.000048
T69bis	0.715419	0.000009	
T88	0.713539	0.000009	0.000067
T88bis	0.713606	0.000010	
T89	0.713093	0.000012	0.000221
T89bis	0.713314	0.000009	
T90	0.712306	0.000010	0.000013
T90bis	0.712319	0.000008	
T83	0.709741	0.000012	0.000075
T83bis	0.709666	0.000009	

^a 2σ error (absolute error value of the individual sample analysis – internal error).

Table 5

– Strontium isotope results for the artefacts before and after pre-treatment with several toluene:methanol washes.

Sample	After treatment		Before treatment	
	$^{87}\text{Sr}/^{86}\text{Sr}$	$2\sigma^a$	$^{87}\text{Sr}/^{86}\text{Sr}$	$2\sigma^a$
[1] PaPWFT Handled weaving tool (n/n)	0.710480	0.000011	0.710639	0.000012
[2] NMAGTT Platter (80/A/551)	0.710212	0.000018		
[3] PMNH Bench (145145)			0.710233	0.00003 ^b
[4] PaPWFT Paddle (n/n)	0.710402	0.000011		
[5] NMAGTT High-backed seat (80/A/550)	0.710450	0.000009		
[6] PMNH Paddle (145144)			0.710494	0.00003 ^b
[7] NMAGTT Paddle (n/n)	0.710842	0.000012	0.717780	0.000011
[9] NMAGTT Mortar (80/A/549)	0.710324	0.000011	0.710967	0.000011
[10] NMAGTT Small bowl (n/n)	0.710448	0.000011		
	0.710417	0.000012		
[11] PaPWFT Handleless weaving tool (n/n)	0.716934	0.000010		

^a 2σ error (absolute error value of the individual sample analysis – internal error).

^b Machine precision.

[1, 7] and [9]; TA2, TA6 & TA8) were measured before and after pre-treatment. The pre-treatment results (Table 5) show a wide range of $^{87}\text{Sr}/^{86}\text{Sr}$ values from the 0.7106 (corresponding to the local signal of 0.7107 ± 0.0013 based on 13 plant measurements around Pitch lake) to 0.7178. After pre-treatment, however, all samples range between 0.7102 and 0.7108, except for the handleless weaving tool [11] which has a much higher value of 0.7169.

The modern plant data were used to create a geostatistical model of biologically available strontium for Trinidad and Tobago (Fig. 11). The resulting model explains over 95% ($r^2 = 0.957$) of the variability in the measured strontium isotope ratios (Fig. 12). Predicted $^{87}\text{Sr}/^{86}\text{Sr}$ ratios range between 0.7049 in central and eastern Tobago to 0.7137 in southwestern Trinidad, consistent with the ranges of both the modern samples included in this study (0.7041 to 0.7154) and those reported by Laffoon et al. (2016: 0.7045 to 0.71152). The geostatistical model reflects multiple sources of biologically available strontium, with differences in the weighting of bedrock weathering and atmospheric inputs evident in southern Trinidad where the predicted values reflect the underlying bedrock geology and northern Trinidad where they reflect mean annual evapotranspiration. Differences in the weighting of bedrock weathering and atmospheric inputs within the study are captured directly by the measurements of biologically available strontium for the

modern plant samples upon which the geostatistical model is based.

4. Discussion

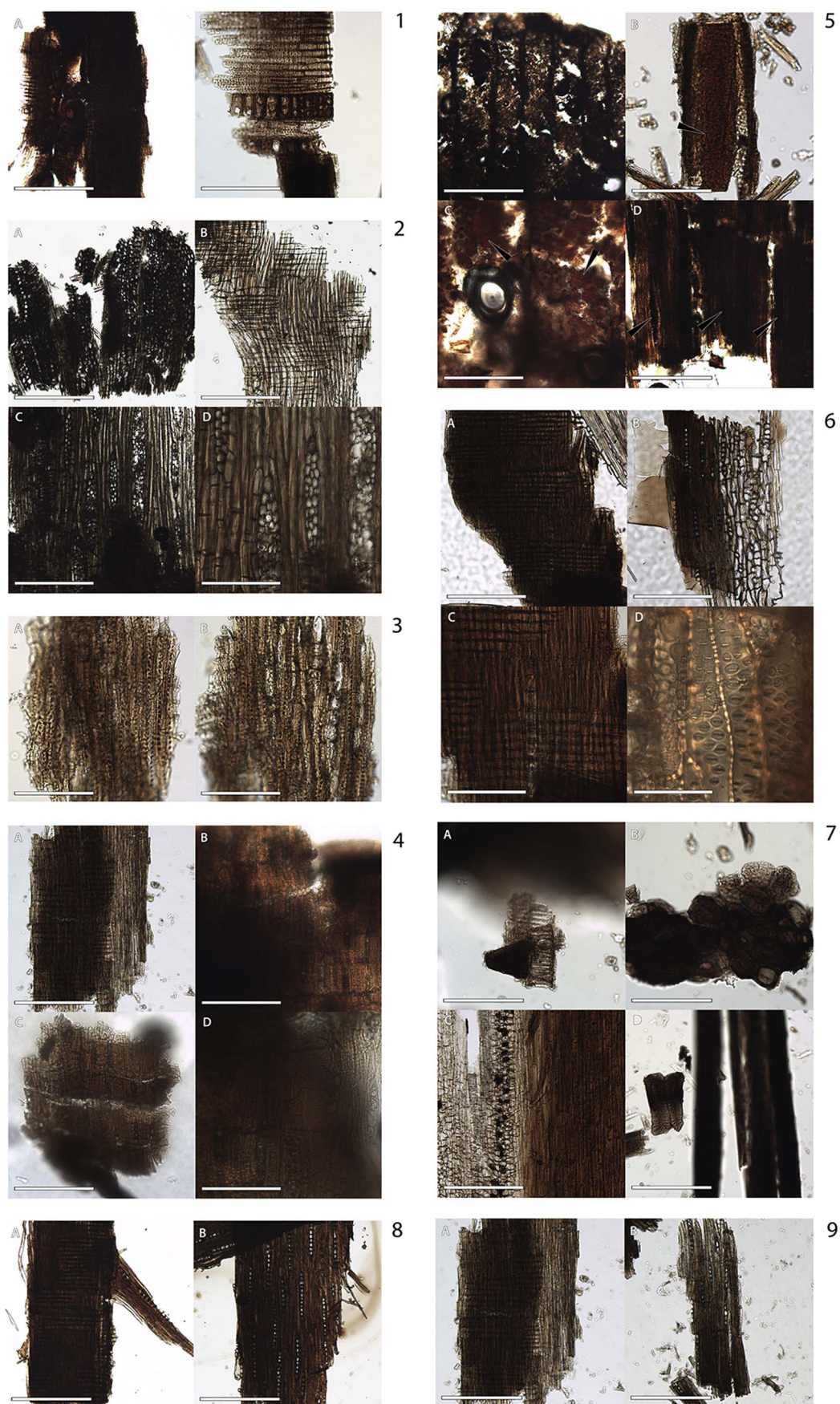
This study has identified the earliest woodcarvings in the Caribbean region. The organic artefacts recovered from Pitch Lake reveal a significant time-depth for this site, with the full chronological range represented, surprisingly, by two very similar weaving tools – the earliest dating to 3340–3027 BCE [11] and the latest to 617 CE–690 [1]. The artefacts and remains pre-dating 200 BCE were somewhat unexpected given that previous assessments tentatively placed the finds at 1 CE–650 (albeit based on unassociated Saladoid ceramic fragments recovered from the lake) (Boomert and Harris, 1984a:39). At the other end of the span, it is unusual that no artefacts later than ca. 700 CE have been identified. Both of these points are considered in the discussion below, which broadly follows their chronological placement.

4.1. The Archaic finds

Three carvings (the mortar [9], small bowl [10],⁶ and weaving tool [11]) and the cranium [8] are placed in the Archaic Age, 6000 BCE to 300 BCE. Relatively little is known about this period in Trinidad as few sites have been systematically studied, with the main concentration at Banwari Trace and St John in southeast Trinidad, not far from Pitch Lake. The Ortoiroid peoples of this time were hunters, fishers, foragers and incipient horticulturalists (Boomert, 2016:17). Archaic period flint scatters around Pitch Lake, such as sites SPA-27 and SPA-3, (Boomert and Harris, 1984a:38, 42–43), provide independent evidence for an early presence around the lake. Some sites (e.g., SPA-27) have yielded large assemblages of irregular chert and flint flakes that may have been used for processing plant fibers for basketry (Boomert, 2000:303–304), which is of relevance to discussions below. Further, a grooved stone axe blade, possibly dating to Archaic times, has been encountered as an individual find < 2 km northeast of Pitch Lake (Pointe d'Or 2 – SPA-4).

The earliest of the Archaic finds is the weaving tool (3340–3027 BCE) [11], which precedes current understanding of when cotton (*Gossypium* sp.) cultivation first appeared in Trinidad, assuming the tool was used specifically for cotton weaving (see below). Cotton weaving is thought to have developed during the Saladoid period (300 BCE – 800 CE), though this is based entirely on what survives in the archaeological record (stone, shell, ceramic) – such as the presence of ceramic spindle whorls in sites spanning South America north to the Greater Antilles (Boomert, 2000:300). Certainly, by the Ostionoid period (600 CE–1200), archaeobotanical remains confirm its presence at sites in the Virgin Islands and on Vieques (Newsom and Wing 2004:129), and judging from early Spanish accounts and some rare surviving cotton-based objects (Ostapkowicz and Newsom, 2012; Ostapkowicz et al., 2013), cotton is well represented in later periods across the Caribbean. However, not all weaving tools were made of non-perishable materials. Indeed, the oldest documented ethnographic object from Trinidad is a calabash spindle whorl attached to a wooden shank, collected in 1786 from the local Caribs/Kalinago (Boomert, 2000:300), and such implements – unlikely to survive in the archaeological record – were used well into the 20th century by indigenous South American groups (Roth, 1924:93–96). It seems reasonable to expect that such spindle whorls were also used in the processing of cotton and other fibers both pre- and post-Saladoid period, though of course they are not essential for spinning yarn, which can be done entirely by hand. Since modern studies suggest that wild forms of cotton were absent from Trinidad and Tobago (Coppens d'Eeckenbrugge and Lacape, 2014), an intriguing

⁶ As discussed above, the small bowl retained some pitch contamination even after extensive pretreatment, indicating that its date range can only be a *terminus post quem*. However, the contamination was unlikely to exceed 10%, which would still provide a date range within the Archaic period (ca. ~ 3400 BP) (for further discussion see Brock et al., in press).



(caption on next page)

Fig. 10. Light micrographs of wood anatomical features of Pitch Lake artefacts. 10.1 *Brosimum* sp., [11], PaPWFT handleless weaving tool. Scale bars: A = 400 μ m, B = 200 μ m. A. Partial radial section showing sclerotic tyloses in the vessel. B. Radial section fragment showing prismatic crystals in upright cells and highly pitted procumbent cells. 10.2 *Carapa* sp. [5], NMAGTT high-backed seat. Scale bars: A–C = 400 μ m, D = 200 μ m. A. Highly degraded transverse section. B. Highly degraded radial section showing procumbent and square marginal/upright cells. C. Tangential section showing rays 1–5 + seriate. D. Tangential section showing heterocellular rays, axial parenchyma strands. 10.3 *Drimys* cf. *granadensis* [2], NMAGTT platter. Scale bars: A–B = 200 μ m; wood highly degraded. A. Longitudinal section showing highly pitted fiber-tracheids and no vessels. B. Longitudinal section showing narrow portions of rays and highly pitted fiber-tracheids. 10.4 *Guaiacum* sp., [10], NMAGTT small bowl. Scale bars: A = 400 μ m, B,C = 200 μ m, D = 100 μ m. A. Radial section showing homocellular rays. B,C. Tangential sections showing storied, low, uniseriate rays. D. Tangential section showing storied uniseriate rays and degraded remnants of a vessel with minute intervessel pits. 10.5 *Handroanthus* cf. *chrysanthus*, [9], NMAGTT mortar. Scale bars: A,D = 200 μ m, B,C = 100 μ m. A. Heavily degraded transverse section. B. Single vessel element showing medium-sized intervessel pits (arrowhead). C. Transverse section showing extremely thick-walled fibers (arrowheads) and otherwise heavily degraded cells. Large air bubbles occupy spaces that likely were formerly vessels. D. tangential section showing storied 2–3-seriate rays (arrowheads). 10.6 *Platymiscium* sp. [7], NMAGTT paddle. Scale bars: A,B = 400 μ m, C = 200 μ m, D = 50 μ m. A. Radial section showing homocellular rays. B. Tangential section showing storied uniseriate rays. C. Radial section showing prismatic crystals in chambered axial parenchyma cells. D. Vestured large intervessel pits. 10.7 *Palmae/Arecaceae* [1], PaPWFT handled weaving tool. Scale bars: A = 100 μ m, B,D = 200 μ m, C = 50 μ m. A. Portion of a vessel element – note scalariform pitting common in monocot xylem. B. Group of sclereids – this cell type is extremely rare in wood, and in this abundance and distribution is absent in wood. C. Longitudinal section of reference material of *Ceroxylon* showing extremely thick-walled fibers (right side of image) and parenchyma cells and vessel elements on the left. D. thick-walled sclereids (left) and thick-walled fibers (center right). 10.8–9 *Terminalia* cf. *dichotoma* [6], PMNH paddle (left); PaPWFT paddle (right). Scale bars: A,B = 50 μ m. A. Radial section showing procumbent ray cells. B. Tangential section showing uniseriate rays. All images: Wiedenhoef.

possibility is that domestic cotton was one of the suite of plants transported to the islands from mainland South America (see below), where its presence is attested in Ecuador back to at least 3500–3000 BCE (Damp and Pearsall, 1994), with even earlier evidence in Peru (Dillehay et al., 2007).

Equally, cotton was not the only fiber used for weaving, and there is no reason to limit the use of the weaving tool to cotton processing alone, or indeed solely for loom work. Aside from cotton, Roth (1924:111–118; 382) notes a wide variety of materials used in hammock making in the Guianas, including the palms *Mauritia flexuosa* and *Astrocaryum* sp. and the silk grass *Bromelia* sp. Basketry materials include *Attalea maripa*, *Ischnosiphon* sp., *Astrocaryum vulgare* and *A. tucuma*, *Carludovica* sp., *Desmoncus* sp., *Merostachys* sp., *Anthurium macrophyllum* Sw., *Philodendron giganteum* and *Stromanthe thalia*, among others (Roth 1924:137; Boomert 2000:303; relevant species names have been changed to reflect current nomenclature). It is likely that these and similar species have a deep history of use in South America, where non-cotton twined textiles date back to 8600–8000 BCE (Bruhns, 1994:159, 161), millennia before fired ceramics appeared (Adler and Pouwels 2014:72). Within the Caribbean, Keegan and Rodríguez Ramos (2007) have argued that many Archaic traditions (including pottery,

previously considered solely a Saladoid introduction) forged later cultural and material identities, and weaving could well be one of these precursors. Indeed, weaving and sewing tools have been recovered from Trinidad's Archaic sites, such as the drilled bone needle found in direct association with the flexed burial from the site of Banwari Trace, southern Trinidad, dating to ca. 5000–4350/4000 BCE (Boomert, 2000:65; Boomert, 2016:21). The needle is very thin and drilled at its distal end (Fig. 13), suggesting that it may have been used for working with fine fiber cords. Roth (1924:105) documents the use of similar needles for the purposes of manufacturing crochet-style anklets and armlets among 20th-century Guiana groups. It is clear that tools that were 'fit for purpose' have a very long history of use spanning diverse South American and circum-Caribbean cultures, changing little over time. This can also be said for the weaving tool recovered from Pitch Lake [11], which could have been used for guiding fronds through the weave when making basketry containers, a practice that continues today by artists in Trinidad's Santa Rosa First Peoples community (Adonis, pers. comm., 2015). Within this context, it seems reasonable to suggest that weaving (whether palm fronds for basketry containers or plant fibers for bodily adornments, fishing nets, hammocks, etc.) extended to the Archaic in Trinidad.

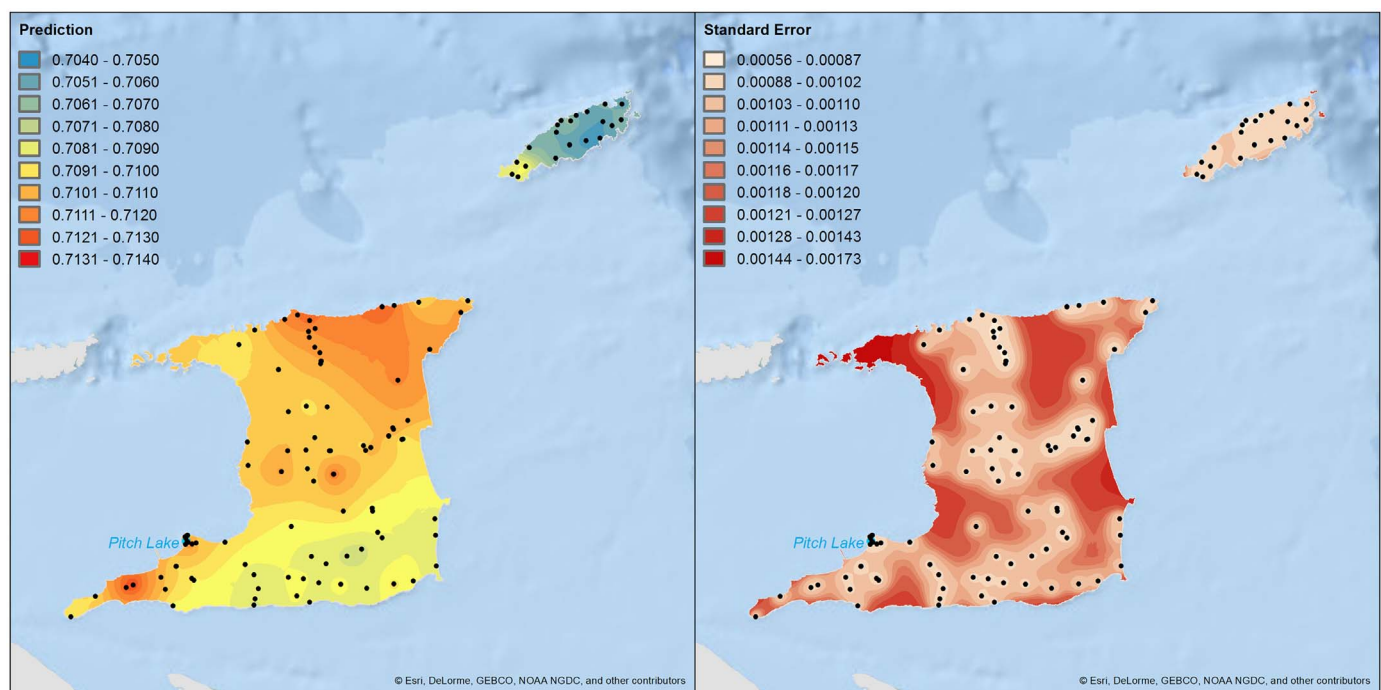


Fig. 11. Prediction surface (left) and standard error surface (right) of the spatial variation in biologically available strontium for Trinidad and Tobago calculated using Empirical Bayesian Kriging (parameters: subset size = 100, overlap factor = 1, number of simulations = 100, transformation = none, semivariogram type = power, neighbourhood type = smooth circular, smoothing factor = 0.2 and radius = 17,719.52). Images: Pouncett.

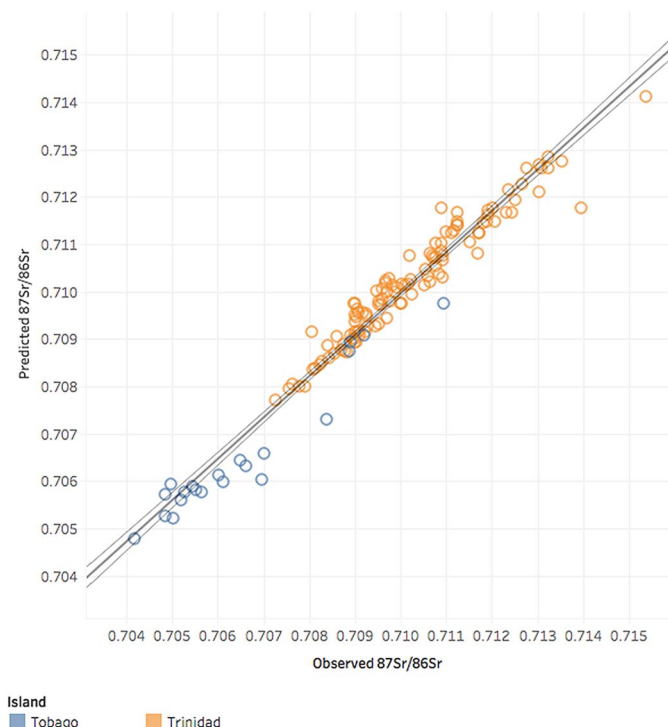


Fig. 12. Correlation between the predicted and observed strontium isotope ratios for the sampled locations on Trinidad and Tobago (prediction errors: mean = 0.000; RMS = 0.001; standardised mean = 0.021; standardised RMS = 0.995; average standard error = 0.001). Image: Pouncett.

At 1606–1418 BCE, the mortar [9] also documents the processing of organic resources in the Archaic. Mortar and pestle are one of the most common means of tuber processing in the circum-Caribbean region (Roth, 1924:299–301); examples in the Caribbean span the archipelago from the Bahamas in the north, where one was recovered in a water-logged environment and dated to 1290 CE–1465 (Winter and Pearsall 1991), to the southern Lesser Antilles, where they were still in use by the Kalinago in the 1940s (Taylor, 1949). While simple in design, such tools were well suited for their required function and hence changed little over millennia, extending to similar examples still in use today in the Americas – including Trinidad itself, leading Bullbrook (1960:22) to comment that the Pitch Lake mortar was ‘suspect’ (i.e., recent) in age. Fewkes (1907:210) describes examples used in Hispaniola in the early 20th century, but with an eye to their antiquity: “Wooden mortars... apparently closely resembling those of the ancients, are common in some parts of the island... They are probably direct survivals of the Indian implements having a similar form...[and] are widely distributed over the whole of tropical South America”. The mortar hints at the variety of other organic materials, including processed plants, that were utilised by Trinidad’s Archaic settlers, but that rarely survive in the archaeological record. A recent study analysing starch grain residues on Archaic pestles from the site of St John, near Pitch Lake, has revealed a wide range of cultigens such as maize (*Zea mays*), chilli peppers (*Capiscum* spp.), sweet potatoes (*Ipomoea batatas*) and wild resources such as *marunguey* (*Zamia* spp.) dating to 5840–3370 BCE (Pagán-Jiménez et al., 2015), far earlier than previously assumed. Indeed, *Zamia* spp. is not known from Trinidad and Tobago today, suggesting that either rare wild populations have not been recognised (cf. Pagán-Jiménez and Lazcano-Lara, 2013), or that it was brought from South America but at some subsequent point went extinct. Its use shows the sophistication of resource knowledge of Trinidad’s early inhabitants: these toxic tubers require lengthy processing to make them safe to consume (ibid.; Boomert 2016:17–18). That this botanical knowledge is in evidence during the Archaic Age underscores early settlers’ understanding and



Fig. 13. Two views of the bone needle associated with Banwari woman, est. ca 5000–4350/4000 BCE. L: 92 mm; W: 5 mm (max); D: 2 mm. Photos: Ostapkowicz, image courtesy Christopher Harris, the Peter Harris Collection, Pointe-a-Pierre Wildfowl Trust.

use of their environment, and further confirms their reliance on perishables for tools, ornaments and domestic items that were the core components of indigenous Caribbean and South American groups in later (pre-)history.

The cranium date (376–204 BCE) lies at what has been identified as the transition point between the late Archaic and the Cedrosan Saladoid period (Boomert, 2000; 2015:25). This pre-dates the currently known chronological range for the main settlement at Pitch Lake (SPA-15) at ca. 300 CE–650, based on the presence of Barrancoid-influenced Saladoid (Palo Seco) ceramic sherds (Boomert and Harris, 1984a:39, 41). However, as noted above, Archaic sites around the perimeter of the lake, and indeed the presence of Archaic wooden artefacts within the lake itself, clearly give a greater time depth to the presence of people in the area, so the date for the cranium is not out of keeping with this wider context. Previous interpretations have suggested that the cranium and other human remains found at the site were ‘burials’, accompanied by the wooden artefacts as funerary offerings (Boomert and Harris, 1984a:37, 43). In the case of the cranium, however, we can say with some certainty that none of the wooden artefacts in this study overlap chronologically, and so cannot be confirmed as burial offerings: over a millennium separates the cranium from the mortar found in the lake, and a minimum of 600 years from the later artefacts.

4.2. The Saladoid/Barrancoid finds

The majority of artefacts [1–7] date within the relatively short ~250 year period ca. 420 CE–690, in agreement with previous assessments of the Saladoid/Barrancoid (Palo Seco) occupation around the southeast bank of the lake (SPA-15) (Boomert and Harris, 1984a). These include the handled weaving tool [1], platter [2], two seats [3]; [5] and three paddles [4]; [6–7]. Indeed, Pitch Lake has yielded the single largest concentration of surviving pre-Columbian paddles known in the Caribbean – four from this single site (one of which is in a private collection, and hence not part of the current study); a further four individual paddles have been found in the Dominican Republic, Turks and Caicos, the Bahamas and Cuba – the latter two from caves (caves, like asphalt ‘lakes’, are unusual contexts for paddles) (Ostapkowicz, 1998:127–131). Two of the

Pitch Lake paddles are quite bulky, with unfinished cross-bars and surfaces [6; 7], perhaps suggesting that they were in the process of manufacture. A similar issue is noted with the seats: the zoomorphic bench [3] appears roughly hewn, with blocky carving and the coarse adzing clearly in evidence on the surface; this is in contrast to *cronista* references to 16–17th-century Lesser Antillean stools being ‘...polished like marble’, confirmed by the fine *duho* examples that survive from the wider Caribbean region (Ostapkowicz et al., 2011:160–161). The high-backed seat features breakages at the legs and a warping or twisting to the back, likely a direct result of carving unseasoned wood – it may have been abandoned part-way through construction due to problems with the material. While seats among later South American and Lesser Antillean societies were a common domestic item, used regularly both during work (such as weaving – e.g., basketry weaving by men: Guss 1989:83–84; hammock weaving by women: Roth 1924:Plate 128) and repose, they also in certain contexts came to function as potent conduits for connecting shamans or *piái*-men to the other world, or were used to position the body of a leader for burial (Ostapkowicz et al. 2011). These aspects, among others, have implications for interpreting the significance of their deposit into the lake.

4.3. Deposition in Pitch Lake

The Palo Seco settlement was positioned at the lake's shore, with refuse discarded along the slope down to the lake – indeed one possible scenario for the presence of the post-400 CE artefacts, as has been proposed by Boomert and Harris (1984a:42), was that a sudden landslide toppled several houses and their contents into the lake. The area surrounding the lake is notoriously unstable, with existing fault lines radiating from the lake in all directions (ibid.). A similar event apparently occurred in the 1720s (Gumilla, 1963:46). To the Amerindians living in the area disasters like these may have given support to already existing beliefs concerning the legendary origin of Pitch Lake, which actually appears to form part of an Arawak (Lokóno) mythological cycle, known from the mainland of South America (Boomert, 2000:454–457; Boomert, 2010). Indeed, such an event may have given birth to the famous ‘myth’ associated with Pitch Lake, which is relevant here in providing a potential context for the finds. The story, as romanticised by Joseph (1838:19), holds that the Chaima who once occupied the area where the lake is now, had offended the ‘Good Spirit’ by killing many hummingbirds – the incarnations of their deceased relatives – and were punished for this misconduct by the sinking of the entire village into the asphalt lake (Joseph, 1838:19; Boomert and Harris, 1984b). Possibly, then, an actual event became mythologised. Even today, houses within several miles of the lake may shift due to the instability of the ground upon which they are built.⁷

This scenario may account for the presence of domestic items in the lake – such as the platter [2] and handled weaving tool [1] – items that may have been left within structures that collapsed into the lake, during natural disasters such as discussed above. Equally, they may have been lost or thrown away. The presence of the larger items – the three paddles ([4]; [6–7]) and two seats ([3, 5]) – however, is somewhat more difficult to explain. One would expect paddles to be stored with canoes, rather than in a house; the mere presence of paddles ‘inland’ (albeit only ca. 500 m from the sea, and on the edge of an asphalt ‘lake’) is conspicuous. Given the unfinished condition of two of the paddles, it is possible that they were abandoned part way through their

manufacture at the village site; equally, given that they were some distance from navigable water, they may have been purposefully brought to the lake for deposition, perhaps as burial goods, to symbolically transport the deceased to the otherworld. This would be fitting given that Pitch Lake was considered by local inhabitants as a portal to the world of the ancestors: another version of the myth collected in 1893 by a Dominican priest recounts that through it, souls of the deceased could return in the shape of hummingbirds in order to visit their descendants (Bertrand in Boomert and Harris, 1984b:29).

The presence of two seats raises similar issues: what ‘purpose’ did they serve when deposited in the lake, if any at all? The idea of two seats being rather unceremonially disposed of in the lake due to manufacture issues seems incongruous given what is understood about the significance of seats in the circum-Caribbean, particularly those that have zoomorphic or anthropomorphic imagery (Ostapkowicz, 1998). Boomert and Harris (1984a:37, 43) suggest that the seats, as items associated closely with the *piái* role, may have accompanied them in death; positioned on his seat, the deceased would be placed close to one of the ‘mothers’ of the lake, where the remains would slowly disappear beneath the surface. Given this symbolically laden and dangerous environment – a solid ‘lake’ made of black, sticky, odiferous, liquid material that hardens with exposure, with undercurrents that drag objects (including bodies) down into its depths – the lake was undoubtedly a liminal, charged place. The recurring themes in the Pitch Lake legends, of death and the afterlife, give some support to the possibility that the area had a spiritual resonance, perhaps a conceptual parallel to caves, which were used across the Caribbean for burials and the deposition of ritual objects, and as such a fitting arena for ceremony and myth. As evocative and fitting as this possibility is, it is not possible – at least at this stage – to show a chronological overlap, let alone an association, between any of the artefacts and the single dated pre-Columbian human find. Alternatively, the seats may have been votive offerings, comparable to the wooden-handled stone axes that were apparently deposited as such into the rivers of the Guianas in late-prehistory (Migeon et al., 2010:80–83; Versteeg, 2003:206–214).

The key question here is whether the Pitch Lake finds represent debris on the periphery of a settlement (whether permanent or not), intentional deposition in a liminal place, or both? If some are votive offerings, a further consideration is why there were no further ceremonial or high-status artefacts recovered from the lake? This, unfortunately, is difficult to progress further because of the limited and rather random nature of the finds that have been recovered and deposited in museum collections.

4.4. Wood selection and its wider implications

One of the key questions of this study was how the organic artefacts recovered from Pitch Lake can inform on prehistoric adaptation to local environments and broaden our understandings of past material culture. Of the woods identified in the Pitch Lake corpus, only two – *Guaiaacum* sp. and *Carapa* sp. – are consistent with woods used for surviving carvings from the wider Caribbean archipelago, while *Andira* shows up infrequently in the paleoethnobotanical record (e.g., Newsom, 1993: Table 5.22; 7.2). *Guaiaacum* is the wood of choice for ceremonial carvings in the Greater Antilles: of the 62 sculptures provenanced to this region and previously studied as part of the *Pre-Columbian Caribbean Sculptural Arts* project, 46 were carved of *Guaiaacum*, while 5 were carved of *Carapa* (Ostapkowicz et al., 2012, 2013; see also Newsom and Wing's (2004) discussion of a *Guaiaacum* bowl from Major's Cave, Bahamas, and more detailed information on the use of *guaiaacum* as a fuelwood spanning much of the Caribbean region and its prehistory). The small bowl [10] carved of *Guaiaacum* appears misleadingly simple, though the fine, thin sides (averaging ca. 6 mm in thickness) hint at the artisan's skill and control (not to mention patience) in carving out this extremely hard wood, one that dulls metal tools today. Intriguingly, *Guaiaacum officinale* and *G. sanctum* are classified as exotic species in

⁷ Joseph (1838:13) noted this with interest in the 19th century: “This substrata affects in an extraordinary manner many of the light buildings of the village; the posts that support these occasionally sink perpendicularly into the earth and asphaltum, but more generally the layers of pitch affect the posts so as to make them lean in an oblong direction, apparently endangering the buildings; but this does not alarm the inhabitants of these dwellings, who of course build them of light materials, as often, when a house is on the point of falling, in consequence of the posts leaning to the right through some revolution of the action of the substrata, the posts not only resume their perpendicular but gradually commence leaning in the contrary direction.”

Trinidad and Tobago (Baksh-Comeau et al., 2016), introduced as an ornamental during the colonial period (e.g., TRIN 28357, TRIN 29337, Tropicos database; M. Bhorai B775, Missouri Botanical Gardens, MO-788867).⁸ Further, the seeds from these plantings have not established ‘wild’ populations, as other introduced species have done (e.g., mangoes, citrus, papaw), nor does *Guaiacum* (commonly known as lignum vitae) feature in Trinidad’s ethnobotanical, linguistic and cultural literature. If the trees were established on the island in prehistory, and harvested to extinction before being re-introduced, the expectation would be that they would re-establish new populations if the environment was suitable for their survival in the wild, but this is not the case. It would then follow that the small bowl or the wood from which it was carved was brought to the island; while the strontium isotope results are not inconsistent with a local source, it could equally reflect another region with similar values. On present evidence, *Guaiacum* appears not to be indigenous to Trinidad and Tobago, despite its presence on the South American mainland and the Lesser Antilles, but this has to be seen in the context of limited paleoenvironmental studies in the region (cf. Siegel et al., 2015; Pagán-Jiménez et al., 2015).

The high-backed seat [5] not only has stylistic parallels to a seat recovered from a cave near Juaco, Guantánamo, Cuba, but both are carved from *Carapa* (Ostapkowicz et al., 2012). This may be coincidence, given the intervening distance, though the two are also broadly contemporary (Pitch Lake high-backed seat: 554 CE–635; Juaco *duho*: 655 CE–771). This confirms that this style of chair was present across the Caribbean archipelago, from Trinidad in the south to Cuba in the northwest, a distance of over 2000 km. The Pitch Lake high-back is the earliest surviving example – a *duho* ‘prototype’ (Boomert 2000:297–300) that would eventually reach an artistic zenith in the Greater Antilles and Bahamas from about 1100 CE. From the wider corpus of Caribbean wood sculpture, *Carapa* was also used for two surviving *duhos* from the Turks and Caicos Islands, a *cohoba* stand from the Dominican Republic and a paddle from Cuba (Ostapkowicz et al., 2012, 2013), serving both practical and ceremonial purposes.

For the most part, the other woods featured in the Pitch Lake corpus – including *Platymiscium* sp., and *Brosimum* sp. – do not occur in the paleoethnobotanical record of the Greater Antilles despite their presence on the islands (Record and Hess, 1943:380–383; Grandtner and Chevette, 2014; Longwood, 1962:167; Baksh-Comeau et al., 2016; Sousa-Sánchez, 2005) though admittedly this is limited to surviving artefacts and a currently small comparative dataset from archaeological sites (see Newsom, 1993; Newsom and Wing, 2004). *Brosimum* was apparently used by indigenous groups to carve seats and clubs in the Lesser Antilles, though this is largely surmised from references to *bois de lettre* (‘letter wood’, *Brosimum guianense*) in 17th-century documents (de la Borde, 1674:18; du Tertre in Verrand, 2001:211). Recent studies on four ‘South American’ long clubs in the Ashmolean Museum collections, acquired by John Tradescant prior to 1638, and identical to those illustrated in publications pertaining to the Lesser Antilles (Dominica, St Vincent, Martinique and Guadeloupe), have confirmed the use of both *Platymiscium* sp., and *Brosimum* sp. (Ostapkowicz et al., in press). The point here is that the choices of wood for the Pitch Lake artefacts, and potentially the broader Lesser Antillean region, likely shared stronger parallels to mainland choices, given the cultural connections between the two (e.g., Boomert, 1986, 2000).

4.5. Strontium isotope results

The strontium isotope ratios obtained from nine out of ten wooden artefacts are consistent with the local signal, suggesting that they were likely carved from woods sourced in the general area of Pitch Lake. The handleless weaving tool [11], however, has a much higher ⁸⁷Sr/⁸⁶Sr value, suggesting that it was either imported or carved locally from

imported wood, though the latter seems very improbable. The nearest currently known location with values this radiogenic is northern Guyana, at least 300 km distant (Laffoon et al., 2016; Poszwa et al., 2002). This weaving tool is also the oldest artefact in this study, and a possible South American source is plausible given the greater antiquity of weaving on the mainland. While usually less visible in the archaeological record, it can be safely assumed that organic materials including wood artefacts were exchanged over the same distances as stone tools and pottery, and this may underscore indigenous values attributed to different materials and/or exotic objects (Helms, 1988).

The zoomorphic bench [3] appears highly influenced by the styles of South America, yet its ⁸⁷Sr/⁸⁶Sr value is consistent with the area around Pitch Lake. Intriguingly, both the zoomorphic bench and the high-backed seat are contemporaneous at ca. 550 CE–650, reflecting the escalating diversity of material culture entering Trinidad at a time of intensive contacts stretching to the vast expanse of the Orinoco Delta (Boomert, 2000; Ostapkowicz et al., 2011). While the directionality of influence from South America to the Caribbean cannot be taken for granted, in the case of ceremonial seats, there are clear antecedents in the form of modelled ceramic seats from Colombia and Ecuador going back to ca. 2000 BCE (McEwan, 2001:179). While proximity would suggest that those carvings consistent with a local origin were in fact made locally, this may underplay the amount of interaction with the mainland. Given the known inter-regional networks during the Saladoid period (300 BCE–800 CE), the seats underscore the connections between Trinidad and South America, maintaining these links stylistically and/or materially.

5. Conclusion

This study has not only yielded the earliest examples of woodcarving in the Caribbean, but considerably expanded on prehistoric wood technologies and resources. The results add to our understanding of the archaeology of Pitch Lake specifically, Trinidad generally, and more broadly, perishable organic material culture in the Lesser Antilles and the wider Caribbean region. Pitch Lake is the source of the oldest examples of Caribbean seats (in both low and extended styles), the largest concentration of paddles, and a variety of seemingly ‘utilitarian’ objects which are of significance because they inform on less recognised – but no less important – areas of craft production. For example, the early weaving tool sheds light on the antiquity of weaving in the circum-Caribbean area, an ephemeral material culture only because it disappears in the archaeological record, but one that was absolutely essential to daily life in the tropics (e.g., in the manufacture of hammocks, basketry containers, fishing nets, etc.). Mortars, a ubiquitous artefact essential for food processing from the Archaic Age well into the 21st century, offer a glimpse into the complexities of food processing, particularly as recent findings highlight the use of such genera as *Zamia* (Pagán-Jiménez et al., 2015), clearly underscoring the environmental knowledge of early Trinidadian settlers. Paddles hint at the importance of watercraft and the inter-regional connections they facilitate (e.g., Bérard et al., 2016), particularly in light of the fact that the cultures that flourished on the island maintained strong connections not only to the South American ‘motherland’ but also to the diaspora communities north along the island chain. And while questions of why paddles were deposited in an asphalt ‘lake’ remain unanswered, and we may never fully know whether the human remains were intentionally buried in the lake in association with artefacts, other aspects, such as the antiquity of deposition at the site, are coming into greater focus.

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⁸ This is under further investigation.

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