Chronology of Pattanam: a multi-cultural port site on the Malabar coast

P. J. Cherian1*, G. V. Ravi Prasad2, Koushik Dutta2, Dinesh Kr. Ray2, V. Selvakumar3 and K. P. Shajan4

1Kerala Council for Historical Research, Thiruvananthapuram 695 001, India
2AMS Radiocarbon Laboratory, Institute of Physics, Bhubaneswar 751 005, India
3Department of Epigraphy and Archaeology, Tamil University, Thanjavur 613 010, India
41A Mottingham Road, Edmonton, London, UK N9 8DZ

Pattanam (10°09.434′N, 76°12.587′E; Ernakulam District, Kerala) has brought forth an early historic port town with archaeological evidence for mercantile contacts with the Mediterranean, Red Sea and Indian Ocean rims. Excavations by the Kerala Council for Historical Research in 2007 revealed maritime features, including a wharf with wooden posts/bollards of Tectona grandis, and a dugout canoe of Artocarpus hirsutus. The first-ever Iron Age habitation remains of Kerala were also unearthed. The AMS dating of charcoal samples from the Iron Age layer places the beginning of the Iron Age in the first half of the first millennium BC, and the wooden samples from the wharf context mark the maritime features of the site to the late first millennium BC to the early first millennium AD.

Keywords: Excavations, Iron Age, maritime archaeology, port.

The study of the early historic ‘Indo-Roman’ trade on the Malabar coast had been dependent almost exclusively on textual references; the archaeological barrenness of the region, but for a few coin hoards, till the beginning of the present century, left not too many options for researchers. The Sangam Tamil poems have graphic references to the maritime traditions of the Malabar coast. The Yavana (Roman and West Asian) trade links kindled the imagination of the poets and their references to the various port towns are of great relevance in understanding the early historic maritime activities. The Sangam text Akanamur 149, for example, refers to the flourishing port of Muziris, ‘...where the splendid ships of the Yavanas, bring gold and return with pepper, beating the foam on the Periyar’. The Greco-Roman classical accounts of Pliny, Ptolemy, the author of the Periphus Marei Erythrea and the Greek historian, Strabo, abound with references to the brisk trading activities between the Malabar coast and the Western world. The recently discovered Vienna papyrus has details of a contract between a merchant based at Muziris and a shipper from Alexandria inscribed on it.

Seafaring activity of ancient people is considered to date back to at least 45,000 years, as determined by radiocarbon (14C) dates of some Southeast Asian island archaeological sites. In the present study, based on accelerator mass spectrometry radio carbon (AMS 14C) analysis of three wood samples associated with the wharf area and two charcoal samples from the Iron Age-early historic context at Pattanam in Kerala, we propose to locate the maritime antiquity of Kerala to the 1st millennium BC.

The archaeological significance of Pattanam, 7 km south of Kodungallur (10°09.434′N, 76°12.587′E), Ernakulam District, Kerala (Figure 1), was identified by surface surveys and etymological inferences. The site covers an area of about 45 ha and parts of it were destroyed by quarrying activities.

The first ever interdisciplinary archaeological research in the history of Kerala archaeology, undertaken by the Kerala Council for Historical Research (KCHR) at Pattanam, has brought forth a wide variety of tangible evidence for the multi-cultural, urban and maritime features of the site. Besides the architectural and maritime features, the excavation yielded evidence for Mediterranean

*For correspondence. (e-mail: pischerian@gmail.com)
and West Asian contacts. The Mediterranean connections are explicit from the large quantity of amphora sherds, the few terra sigillata sherds, cameo blanks and Roman glassware fragments. The West Asian links are evident from the variety of ceramics such as the Yemenite, Mesopotamian and Turquoise Glazed Pottery (TGP) Parthian/Sassanian/Nebatean varieties. The other important finds include architectural features, a wharf structure, iron objects, semi-precious stones and glass beads, early Chera coins and late medieval Chinese sherds. In 2007, when about 120 m² of the site was excavated, remains of a warehouse-like structure, more than 200 sherds of amphora, a few hundreds of stone and glass beads, and some architectural features were recovered. This communication focuses primarily on the maritime features that are suggestive of a port and the corresponding AMS ¹⁴C dates from the context.

By the word 'port' we mean a riverine/estuarine town with facilities for loading and unloading goods transported through water. The classical literary sources and Greco-Roman accounts refer to an inland port town from where goods were transported to the large Roman vessels anchored in the sea. The port was referred as Muciri in the Indian accounts, whereas the Romans called it Muziris. The Periplus even specifies the exact distance from the mouth of the river, where the Roman ships berthed, to the riverine port. The geographical location of Pattanam and the structural remains, including the wharf and canoe, suggest the possibility that Pattanam could be Muciri or some part of it.

¹⁴C measurements in the samples were done by AMS method, using NEC 3MV 9SDH-1 pelletron accelerator, at the Institute of Physics (IOP), Bhubaneswar. The charcoal samples were first cleaned for removing adhering surface contaminants. The cleaned charcoal pieces were then subjected to acid–alkali–acid (AAA) treatment to remove contaminating extraneous carbonates and humic organic matter. About 5 mg of pre-treated charcoal samples was taken for combustion in pre-baked quartz tubes, containing wires of cupric oxide (CuO) and fine silver (Ag). The tubes were evacuated, flame-sealed and heated at 900°C for ~3 h. The CO₂ obtained by combustion of the samples was purified and converted into graphite by reducing with ultra-pure hydrogen (H₂) gas in the presence of iron (Fe) catalyst, and pressed into cathode targets for ¹⁴C analysis using AMS. NIST oxalic acids OxI and OxII (SRM 4990 and 4990C) were used as primary ¹⁴C standards. Ratios of ¹⁴C/¹²C were measured by sequential injection of ¹⁴C and ¹²C ions for standards as well as for unknowns. The sample changing was automated recently and about six independent measurements were made on each sample. The results of the ages of five samples collected are given in Table 1. The errors reported on the raw ages are external, which include instabilities of terminal voltage of the accelerator and other tuning parameters during measurement, over and above the statistical precision. All ¹⁴C ages were normalized with uniform δ¹⁴C of −25‰, and were calibrated with Calib5.1 (ref. 7) and OxCarb3.1 (ref. 8) calibration programs using INTCal04 atmospheric ¹⁴C dataset. In this communication we have only reported ±2σ (95.4%) probability ranges of the calibrated ages, which include both measurement and calibration errors.

It seems that the earliest settlement at Pattanam began in the Iron Age on a palaeo-beach ridge/dune. The 60+ cm thick Iron Age sand deposit (which was formed by aeolian reworking of palaeo-beach sand subsequent to the late mid-Holocene regression of the sea in this part of Kerala) is found up to a depth of ca. 3 m from the surface (the site is 3.32 m amsl). It yielded scanty iron objects, coarse red ware and other typical 'megaliithic' pottery – implying sparse occupation. The presence of imported artefacts, including terra sigillata, amphora and rouletted ware in the succeeding lower layers suggests that the Iron Age predated the 1st century BC; however, the beginning of the Iron Age could not be established through typological analysis of artefacts. In order to corroborate the assumption regarding chronology, two charcoal samples from the lower-most Iron Age layer in the Trenches PT 07-I and PT 07-II were sent for AMS ¹⁴C dating at the IOP, Bhubaneswar. The calibrated ¹⁴C date range for the charcoal from Trench I (Lab No. IP 724, PT07-I, 029a, 275–285 cm) is 1300–200 BC (average age 750 ± 550 cal. BC, with 95.4% probability; Figure 2b); and for the other sample from Trench II (Lab No. IP 741, PT07-II, 019, 250–260 cm), it is from 2500 BC to AD 100 (average age 1200 ± 1300 cal. BC, with 95.4% probability; Figure 2c).

Since the average age of the samples falls before 500 BC, the beginning of the Iron Age and hence the first settlement at the site could be placed in the first half of the

<table>
<thead>
<tr>
<th>Lab code</th>
<th>Sample name</th>
<th>Description</th>
<th>¹⁴C-age (BP)</th>
<th>Calibrated ¹⁴C-age range (BC/AD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP-728</td>
<td>W13 PT07-IV (3 m)</td>
<td>Wooden canoe made of Artocarpus hirsutus Lamk. wood</td>
<td>2528 ± 208</td>
<td>850 to 395 BC</td>
</tr>
<tr>
<td>IP-729</td>
<td>W14 PT07-IV (3 m)</td>
<td>Wooden post, away from brick lining of wharf</td>
<td>1826 ± 520</td>
<td>407 BC to AD 715</td>
</tr>
<tr>
<td>IP-730</td>
<td>W15 PT07-IV (3 m)</td>
<td>Wooden piece (bollard)</td>
<td>2372 ± 105</td>
<td>593 to 371 BC</td>
</tr>
<tr>
<td>IP-741</td>
<td>PT07-II (250–260 cm) 020</td>
<td>Charcoal fragments from Trench II</td>
<td>2918 ± 488</td>
<td>1693 to 509 BC</td>
</tr>
<tr>
<td>IP-724</td>
<td>PT07-I (275–285 cm) 029 a (Pit-fill)</td>
<td>Charcoal fragments from Trench I</td>
<td>2623 ± 180</td>
<td>945 to 510 BC</td>
</tr>
</tbody>
</table>
Figure 2. $^{14}$C ages of the archaeological samples excavated from Pattanam. a. Distribution of the calibrated (calendar) $^{14}$C ages. The spreads of the black and white bars signify the 1σ (68.2%) and 2σ (95.4%) probability ranges of the dates respectively. $^{14}$C ages of various samples are shown in (b)-(d), plotted using OxCal v3.10 radiocarbon calibration program. The red filled curves are the statistical (Gaussian) distribution of the measured $^{14}$C ages. The blue wiggly curve is the INTCa04 radiocarbon calibration curve from atmospheric $^{14}$C data. The filled black curve is the statistical distribution of the calibrated $^{14}$C ages obtained using Bayesian analysis. The horizontal lines signify the 1σ (68.2%, top) and 2σ (95.4%, bottom) probability ranges of the dates. The samples are: b. Trench PT 07-I 029 (275–285 cm); c. Trench PT 07-II 019 (250–260 cm); d. Canoe in Trench PT 07 IV; e. Wooden post in Trench PT 07 IV; f. Wooden post in Trench PT 07 IV.

The wharf built of a mixture of crushed laterite granules and some unknown materials (probably clay and lime) and with a lining of burnt bricks on its outer edge, adjacent to the waterfront is the most important maritime
feature at the site. The wharf complex featuring a dugout canoe made from a single log of wood (PT 07–IV, 011a) and several wooden posts/bollards, is the first-of-its-kind in India found in a hinterland context (Figure 3a). The waterlogged context underneath the canoe produced a well-laid layer of pottery, which included imported amphora and West Asian ceramics. The loci around and beneath the canoe produced a large amount of botanical remains such as pepper, cardamom, frankincense, grape seeds, etc.

The canoe, which measured 6+ m in length, was in a highly decayed condition and only the lowermost portions were preserved. Though initially it gave the impression of the keel portion of a possible plank-built watercraft, on closer examination it appeared more like a dugout canoe. The canoe has been identified by the Kerala Forest Research Institute (KFRI), Thrissur, as made of Anjili or aini (Artocarpus hirsutus Lamk.), a wood popular in Kerala for building canoes and plank boats.

The calibrated $^{14}$C age range for the canoe (Lab No. IP 728, W13, PT07-IV) is 1300–100 BC (average age 700 ± 600 cal. BC, with 95.4% probability; Figure 2d). Here we need to distinguish between the date of the canoe wood and the date of its context. The AMS date actually refers to the date when the canoe was cut. The sample for analysis was from the outermost portion of the canoe, which is the sapwood, i.e. the wood that formed just before cutting the tree. If we take the lowermost age suggested by the AMS, the tree used for making the canoe was cut in 100 BC. Assuming that the canoe was made soon after the cutting of the tree and also taking into consideration the ethnographic accounts that the average lifespan of such canoes is about 100 years, the date of abandonment or the context of the canoe can be suggested as the beginning of the 1st century AD. The archaeological deposit below the canoe had pottery such as amphora and rouletted ware. The rouletted ware is dated generally between 2nd century BC and 2nd century AD. Hence the average age of 700 BC as suggested by the AMS dating, does not corroborate with the archaeological evidence.

It needs to be mentioned that this date represents the lower range, and there is a possibility that the antiquity of the canoe is earlier than 100 BC. The dating of the amphora sherds excavated from the context (which is under way) could tell us conclusively whether the canoe is earlier than 100 BC. The AMS date proves that the canoe belongs at least to 1st century BC if not earlier, thus making it the earliest watercraft (excavated) from an archaeological context in India. The only other watercraft, discovered in Kerala from similar waterlogged archaeological deposit has been dated to 13th–14th century AD.

The canoe context can indirectly help us to date the wharf. The stratigraphic evidence crucial to study the relationship between the wharf and the canoe could not be fully explored, since the excavation of the area was done partly. Based on the available stratigraphic evidence, it could be assumed that the canoe postdates the construction of the wharf. However, the chronological relationship between the canoe and the wharf can be finalized only after further excavations in the area and more radiometric analysis.

Of the two rows of wooden posts found adjacent to the wharf, one row close to the wharf comprising ID nos. B1/E, B2/D, B3/C, B4/B, B5/A, B6 and P2/G, could have been bollards for securing boats (Figure 3b). Of these, B2/D, B3/C and B5/A were identified by KFRI as made of teak wood (Tectona grandis L.f.). The second row consisting of three bollards, P1/F, B7/H and P3/I, were planted near the canoe. Of these, P1/F was found planted through the canoe and hence could postdate the canoe. The post/bollard wood samples of P2/G and B7/H were $^{14}$C dated with AMS. The B7/H, a post/bollard (?) lying away from the brick lining of the wharf found near the southern section in the southeastern corner of the trench (Lab No. IP 729, W14 PT07-IV, 011a B7/H, 3 m) has calibrated $^{14}$C age range from 1100 BC–AD 1300 (average age cal. AD 100 ± 1200, with 95.4% probability; Figure 2e).

The bollard P2/G, lying close to the canoe (Lab No. IP 730, W15 PT07-IV, 011a P2/G, 3 m) has calibrated $^{14}$C age range 800–200 BC (average age $500 \pm 300$ cal. BC,
Estimation of contribution of southwest monsoon rain to Bhagirathi River near Gaumukh, western Himalayas, India, using oxygen-18 isotope

S. P. Rai1, Bhishm Kumar1,2* and Pratap Singh2

1National Institute of Hydrology, Roorkee 247 667, India
2Hydro Tasmania Consulting, 12th Floor, Eros Corporate Tower, Nehru Place, New Delhi 110 019, India

Gaumukh is the snout of the Gangotri glacier located at an altitude of 4000 m in the Himalayas from where the snow and glacier-fed Bhagirathi River emerges. Snow, ice, river discharge and rainfall samples were collected for stable isotope (δ18O) analysis along with other hydrometeorological data during the ablation period (May to October) in 2004 and 2005 at Bhogwasa, 3 km downstream of Gaumukh. The variation in river isotopic composition (δ18O) with time shows the varied percentage of snow, glacier and rain contribution in the flow of the Bhagirathi River during the ablation period. The discharge of the Bhagirathi River shows positive correlation with temperature and negative correlation with the rain event. The enriched δ18O values of river flow (−12 to −13.0‰) from May to June and its depletion afterwards reveal that snowmelt dominates the river discharge during May and June while ice/glacier melt dominates in the subsequent months of the ablation period. The contribution of rain was found maximum up to 40% of the total discharge of the river on the day of the rainfall. The complete hydrograph separated out for three rain events occurred in July and September 2005, revealed the rain contribution to the tune of 14–15% of the total river discharge. The contribution of the total rainfall which occurred during the ablation period was estimated to be only 3% of the total discharge. The results show that the melting rate of snow and glacier decreases due to decrease in temperature during the rainy period. This fact clearly explains the phenomenon of decrease in overall discharge of snow and glacier-fed rivers during the rainfall period at higher altitudes or near the snout.

Keywords: Glacier, ice, monsoon, snow, stable isotopes.

The snow and glacier melt run-off contributes significantly to all North Indian Himalayan rivers during summer, when demand for water increases for hydropower, drinking, irrigation, etc. Due to lack of information on hydrological processes of snow/glacier regime and assured availability of melt water, water resources management policies at the lower reaches of the glacier-fed rivers are


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*For correspondence. (e-mail: bk@nihernet.in)