Preliminary results of the Yodhawewa Archaeological Research in Sri Lanka - 2018: Exploration, Excavations, Findings, and Radiocarbon Datings

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Abstract

This archaeological research aimed to investigate the authentic metalworking activities of the Yodhawewa area and examine contemporary socio-economic movements based on discovered material culture. The entire research work was carried out in 2018 based on a surface survey and two excavations in an area of about 201600m² on the outskirts of Yodhawewa reservoir. The C14 chronology confirms the 1st-8th centuries activities, and in this research obtained a considerable artefacts collection related to metal extraction, copper metalwork, and crucible steel production. This research also discovered that half of a lower spherical (crucible-typed) metal furnace was used to produce crucible steel for the first time in Sri Lanka. Artefacts such as coins, BRW, RW, and some porcelain prove that the site maintained cultural relations with India and China in the c. 1st century and 8th century AD. Other artefacts of this site include ceramics, beads, faunal remains, minerals, and rocks that have been used for human needs for a considerable period. This article discusses at length the archaeological evidence that the Yodhawewa region is a metalworking site that has been active since the early historical period of Sri Lanka and a place that reflects national and international cultural relations.

Keywords: Copper, Crucibles, furnace, Metal Slags, Yodhawewa

Introduction

There is a copious amount of literature produced by the researchers who have focused on the South Indian Ocean port city of *Mannar* or '*Mantai*' as known and its archaeological value. The book "*Mantai: City by the Sea*" provides an extensive description of archaeological research centred on the port city of Mannar at various times since the 1880s (Carswell et al., 2013). Through such studies, it was shown that the Mantai ancient port in north-western Sri Lanka was one of the major ports in the route of East and West trade in the Indian Ocean. The archaeological record of the Mantai shows its wide range and diversified links with the local and international trade networks (Bohingamuwa, 2017; Prickett-Fernando, 2003). As the port-city of Mannar became an important economic centre in South Asia, researchers did not pay much attention to how it affected settlements in the surrounding suburbs.

Significant research has been done in ancient Sri Lanka in various fields such as regional metalwork, metal artefacts, raw materials for metal production, and technological parameters related to metalworking (Juleff, 1996, 2015; Seneviratne, 1985, 1995; Solangaraarachchi, 2011). The oldest evidence of metallurgical activities found at Anuradhapura citadel (c. 834-778 BC), Sigiriya-Aligala excavation, and the Pomparippu megalithic burial excavation (c. 998-848 BC) in Sri Lanka (Begley et al., 1981; Deraniyagala, 1992; Karunaratne & Adikari, 1994). They mainly focused on local iron smelting, iron production, and copper metallurgy. Then, two research related to two types of metal furnaces in ancient Sri Lanka stands out; (a) *Samanalawewa* research based on the seasonal monsoon wind power through the west-facing furnace technology in the 5th century BC to 12th century AD (Juleff, 1996), and (b) The magnetite iron ore extraction furnaces in the Sigiriya (Kiri Oya Basin - KOB) with the evidence of c. 3rd century BC to 10th century AD (Solangaraarachchi, 2011). Thantilage and Vithanage (2015) have also conducted significant research, including primary metal ore deposits, ancient smelting, and metal production sites, and some iron ore geochemical descriptions in Sri Lanka.

Furthermore, Seneviratne's studies (1995) on the quantitative factors, utility, and consumption of the Seruvila copper deposit near Trincomalee (East province in Sri Lanka) are particularly significant. Some researchers have explained that the utility of the Seruvila copper deposit was also crucial in coinciding with the demand for copper in South India (Juleff, 2013; Seneviratne, 1995; Srinivasan, 2016).

Ancient crucible steel production is a technological transformation of iron production in the world. The *Kodumanal* site in Tamil Nadu has uncovered a small circular furnace cluster (more than 12 furnaces) used for the production of crucible steel/wootz, and the earliest evidence (300 BC) of semi-solid crucible steel (Gullapalli 2009; Sasisekaran & Raghunatha Rao, 2001; Sasisekaran 2002; Srinivasan, 2013, 1997; Srinivasan & Ranganathan, 2004). Archaeological evidence for this type of circular (crucible-shaped) furnaces was not reported until the *Yodhawewa* was discovered. Ondaatje (1854) and Coomaraswamy (1908/1962) have provided eyewitness accounts of Sri Lankan crucible-steel production in recent history (Juleff 1996; Solangaraarachchi 2011), and most recently, a significant intervention has been carried out by Juleff (1996). Arab writers such as Al-Kindi report a tremendous demand for Sri Lankan (*Sarandibi*) steel from the Islamic world in the 6th-9th centuries AD (Juleff 1996). Analyzing the metal facts of Mannar (excavations 1980-84), Juleff (2013) pointed out that high-quality steel produced in *Sarandibi* may have been exported through the Mannar port.

Due to the central location on the South Asian silk road and the extensive port system around the country, Sri Lanka has maintained an excellent cultural network globally in ancient times (Carswell et al., 2013; Weisshaar, Roth, et al., 2001). Foreign artefacts such as pottery, coins, beads can form a broad discourse on cultural relations not recorded in the written literature. The quantities of foreign artefacts discovered in Sri Lanka help provide a quantitative and qualitative interpretation of these relationships. Here we intend to comment on some of such specific artefacts discovered by the *Yodhawewa* research.

The adverse effects of the civil war in the Northern and Eastern Provinces of Sri Lanka during 1983-2009 also significantly changed the geo-environmental conditions of the region, and archaeological sites were accidentally opened due to rapid irrigation projects initiated after 2009. The *Yodhawewa* archaeological site was discovered in October 2017 during a reconnaissance survey of ancient settlements around the *Yodhawewa* Reservoir (Giant's Tank). The Department of Archaeology and Heritage Management of the Rajarata University of Sri Lanka conducted a field investigation in 2018 with the Director-General of Archaeology's approval to further observe the material culture and settlements of the *Yodhawewa* area. This study aimed to provide a chronological description of the movements of the ancient settlement based on the material culture revealed by the archaeological observations. It will provide essential clues as to the impact of commercial activities centred on the port city of Mannar on the settlements in the periphery zone. Two specific objectives were expected to be achieved in this research: (a) Giving a chronological definition to the newly discovered *Yodhawewa* metalworking activities, and (b) Explaining the authentic technical parameters and resource utilization of the *Yodhawewa* area through the research findings of 2018.

(I) Study Area and the Geophysical environment of the region

The archaeological study was conducted near the Yodhawewa reservoir, located 12 km southeast of the Mannar ancient port city (Fig. 1) and in the 'Yodhawewa' village in the Mannar District North-Western coast and the Northern Province of Sri Lanka. The study area was bounded by the Yodhawewa Sanctuary - east, the Yodhawewa reservoir - South, and the canal and agricultural lands from the north and west. Archaeological investigations of the whole area were carried out beginning from the outer spill of the Yodhawewa reservoir to a length of 1600m area, especially on the right bank of the canal in the GPS location 08°89'14.0' N - 080°04'82.2' E (Fig. 1).

The study area was located in the North-Western plains of Sri Lanka, geologically on the Miocene limestone layer (Cooray & Katupotha, 1991). The region consists of three soil distributions. The undulating terrain spreads eastward from the *Yodhawewa*, comprising Reddish Brown Earth developed on the Red Yellow Latosol horizon. The flat coastal terrain mainly comprises alluvial soils, and eroded surfaces and grumusols noticed within the region (Alwis & Panabokke, 1972). Deposition of alluvial soil was reported from the river and flood basins. Climatically it falls into the North-Western Dry - semi-arid zone and, Grasslands, shrubs with thorny bushes are prominent as vegetation. Despite the prolonged drought, the region receives < 1,200 mm of rainfall annually, from June to August. The temperature remains high throughout the year causing higher evaporation and relatively low humidity. Droughts after August create a significant impact on the

soil and the vegetation. The dehydrating South-West monsoon winds prevail from April to August. Dry climatic conditions are frequent; however, floods are reported occasionally (Pemadasa, 1984).

Materials and methods

a) Surface Sampling

The exposed surfaces with artefacts were identified during the preliminary site visit at the end of 2017. A formal surface sampling was done through a water canal area of 201600 m² extended, and it was divided into 32 sampling units in an interval of 50m. In order to present a detailed and unbiased image of the premise's cultural and natural phenomena, artefacts scattered on the surface were collected to represent each sample unit following the Exploration Procedures (2015) declared by the Department of Archaeology Sri Lanka. Artefacts (pottery, Slags, furnace wall fragments, crucible fragments, beads, shells, coins) were collected and recorded by each sampling unit and were bagged in separate ziplock polythene bags. During the initial observation, several irregular vertical soil profile units were observed in the centre of the study area. Formal profiles (100cm / 150cm x 15cm) of such sites were observed to uncover further information in the study area. Profiles detail were also included in this research under exploration.

b) Excavations

In selecting the site for the first excavation LMBA/YW/2018/01 (Ex-01) of the *Yodhawewa* research (Fig. 1, 2a), the geophysical factors, minimal human impact, and the surface artefacts distribution density were considered. The primary purpose of that excavation was to identify the layer distribution pattern of the site and, the minimum to a maximum of 0.50m to 0.80m depth from the surface level was excavated in the 9m² area. The site for the second excavation, LMBA/YW/2018/02 (Ex-02), was selected based on the surface factors of the furnace structure discovered 700-750m sampling unit during the survey (Fig. 1, 2b). The Ex-02 was

carried out aiming at uncovering information on the technical parameters based on the furnace. The excavation was completed at the end of 0.60m to 0.75m depth from the surface level. The excavation process followed the established procedure (Standing Order No. 488) of the Department of Archaeology Sri Lanka and included detailed statements, illustrations, measurements, and photographs in contextual reporting.

c) Radiocarbon Datings

Five charcoal samples were collected from the Ex-02 excavation and dated using Accelerator Mass Spectrometry (AMS) from the Beta Analytic laboratory, USA. All radiocarbon dates were conventional Radiocarbon Ages, and sigmas are rounded to the nearest ten years as for the 1977 International Radiocarbon Conference conventions. When counting statistics when sigmas are lower than ± 30 years, a conservative ± 30 BP was cited for the result. For Beta Analytic, the reported results are accredited to ISO/IEC 17025:2005 testing accreditation PJLA #59423 standards.

Results and Discussion:

a) Stratification and Chronology

The six profiles reported in the surface survey revealed the study area's topography, confirmed that the entire region consisted of five main soil layers. All soil layers in the premises were certainly presented only in Ex-01, P1, and P2 areas and did not signify the same topography in other areas. The exposed facies' recorded depths vary between 120cm - 240cm. The Reddish Brown Earth was developed on the surface level or at 1-40 cm of depth whole study area. The lower horizons comprise reddish-brown soil (Dull Reddish Brown Layer).

Fig. 2. Two Archaeological excavations in the Yodhawewa site (2018) including specific contexts (a) First excavation pit (LMBA/YW/2018/01) and (b) Second excavation pit (LMBA/YW/2018/02) (Both Photo direction is west to east)

The anthropogenic provenances were noticed from two layers deposited between the upper (one or two) natural layer and characterized only in the Reddish Brown Earth. The Dull Reddish Brown soils in the lower horizon are devoid of any trace of anthropogenic evidence. The lowest horizon of all recorded profiles is a natural

deposit extending further beneath the exposed area. Based on that data, no attempt has been made to excavate the two main excavations beyond that level.

Area	Slags	Crucible Frag.	Furnace wall parts	Metal Frag.	Ceramics	Beads	Glass Frag.	Rocks/ Minerals	Flora/ Fauna	Total
Ex-01	32	26	1	27	2110	66	-	-	1	2263
Ex-02	6226	326	193	32	1217	18	5	-	1	8018
Survey	368	63	10	12	1634	70	30	73	18	2278
P.01	77	6	-	-	5	-	-	-	-	88
P.02	51	59	31	-	630	-	-	-	-	771
P.03	2	-	2	-	34	-	-	-	-	38
P.04	-	-	-	-	2	-	-	-	-	2
P.05	17	-	-	-	0	-	-	-	-	17
P.06	41	-	14	-	481	6	-	-	-	542
Total	6814	480	251	71	6113	160	35	73	20	14017

Table 1. Artefacts density of the entire *Yodhawewa* research in 2018

Fig. 3 Artefacts density of the *Yodhawewa* research in 2018 **(a)** Location-based percentage and **(b)** Artefacts type based percentage

The first excavation (Ex-01) reported five main layers and seven contexts. The stratigraphic composition is similar to the profiles registered during the exploration, where two anthropogenic layers (3rd and 4th layers) were sandwiched between the top and bottom natural layers. Several artefacts were reported from the top two layers of this premises and possibly mixed from the lower cultural deposit. Contexts

1, 2, 4, 5, 7 were the main soil layers in this area, and contexts 3 and 6 could be identified as two sub-soil layers. Accordingly, two natural layers (Contexts 1 and 2) of the surface could be identified, followed by two cultural layers (Contexts 4 and 5). The second culture layer was slightly wider (22–28 cm in height), followed by the natural layer (context 7). As mentioned above, after observing profiles 1 and 2, it was decided to stop probing beyond context 7 (Fig. 2a).

The second excavation (Ex-02) reported 24 contexts in four main layers, and the layers were assigned the numbers, which are the contexts numbers of 1, 2, 4, and 21. The top layer (context 1) is heavily disturbed through the recent canal expansion constructions and secondly by the monsoonal runoff. The second context was the first cultural layer of the premises, and the 4th context was the second cultural layer. Two circular furnace structures (fragmented) were exposed during the excavation and numbered as context 5 and 9. Layers 2 and 4 were the main cultural layers, including the furnace preparation remains, operational debris accumulation, post-production abandonment, and human-induced debris from later settlement phases. However, contexts 3 and 13 were the sub-soil layers that were not spread over the excavated area. It was decided to stop Ex-02 with the beginning of the bottom natural layer (context 21) based on prior understanding of the Ex-01 and the profiles. Contexts 8, 10, 11, 12, 14, 16, 17, 19, and 20 consisted of ceramics, slags, crucible fragments, and furnace wall fragments. Context 15 was an overturned pottery, and context 18 was an assemblage of potsherds. The contexts 7, 22, 23, 24 were fillings of the contexts 6, 5, 9, and 15, respectively (Fig. 2b). All the reported profiles and excavations revealed that the region's stratigraphic distribution is almost evenly deposited and has similar attributes, except that the thickness of the layers varies to some extent. Table 1 and Figure 3 show the density of the artefacts discovered from the entire *Yodhawewa* site.

In preparing a contextual note chronologically, it is essential to inquire about the context in which the samples were acquired. Five charcoal samples were dated from three different contexts; the S-159 sample from an accumulation dated back to the c.

1st century AD. Sample S-27 was collected near the main furnace, and results have been confirmed to belong to the c. 5th century AD. The samples of S-48, S-64, and S-78 were collected from the bottom of the fourth context belonging to the c. 8th century AD. Overall, the *Yodhawewa* site was confirmed by 60% of C14 datings as a c. 8th-century AD site. However, it cannot be ignored that the premises were still activated in the c. 1st and 5th centuries AD (Table 2).

Sample Reference No.	Sample Ref. (Beta analytic laboratory)	Locality			Radiocarbon age		Accuracy
		Context	MSL (m)	Location type	cal AD	cal BP	
S-159	Beta - 517842	12	11.45	Accumulation	70 ± 30	1880 ± 30	95.40%
S-27	Beta - 517342	4	11.61	Layer	430 ± 30	1520 ± 30	95.40%
S-48	Beta - 517843	4	11.41	Layer	760 ± 30	1190 ± 30	95.40%
S-64	Beta - 517844	4	11.36	Layer	730 ± 30	1220 ± 30	95.40%
S-78	Beta - 517343	4	11.32	Layer	730 ± 30	1220 ± 30	95.40%

Table 2. Conventional radiocarbon dating of selected contexts of the Excavation no. 2, *Yodhawewa* Archaeological Research in 2018

b) Metal Extraction evidence of the *Yodhawewa* site

Archaeological studies have uncovered much important information about metalworking in the *Yodhawewa* area. Slags, crucible fragments, metal fragments, and furnace wall fragments are the main material factors in the focus on metalworking in this site. It is noteworthy that the slag was found in both the high weight (metal type) and low weight (glass type). The exploration collected three hundred sixty-eight slags from the surface, and the Ex-01 produced fewer ($n=32$) slags (Table 1). A large number of slags ($n=6226$) were recovered from the Ex-02 premises (Table 1); in particular, the context of 8, 10, 11, 12, 14, and 16 shows the highest density. Slags were collected 48.61% of the total artefact density of the *Yodhawewa* research (Fig. 3b).

Fig. 4. Different types of two 'Tuyere' fragments were collected from the *Yodhawewa* survey 2018 (Drawn by N.R. Lankapriya)

Fig. 5. Slags collected from *Yodhawewa* site (A) Tap slag (B, C) Metal typed oxidized slags (D, E) Low weight Glass or Glassy typed slags with blue, green, and white-coloured bands, (F) Transparent or translucent green glass slags

Excavations in the Samanalawewa, Matale, and Sigiriya areas of Sri Lanka have uncovered essential facts about iron smelting furnaces (Juleff, 1996, 2013, 2015; Solangaraarachchi, 2011). Two fragments of unvitified air supplying tuyeres (into metal extraction furnaces) were discovered from the *Yodhawewa* exploration (Fig. 4). Tap-slag fragments, usually black, red, or reddish-brown, have also been

acquired from this research (Fig. 5A). The Colour of the slag functions in the 'metallurgical chain,' and the chemical composition usually hinders using slags to identify the initial metallurgical processes (Killick, 2014). Typical tap slags with their unique visual appearance are the best indicators for identifying the iron smelting locations (Eliyahu-Behar et al., 2013). The tap slags are recognized from the rosey texture on their upper surfaces, indicating they cooled from molten, flowing slag, most probably out of the furnace (Georgakopoulou, 2014). The oxidization process can be noticed on some slag surfaces (Fig. 5B-C). The metallic slag collection could be identified as having both high and low weight. Slags were largely discarded with the smelting process (Ettler et al., 2015), and they also usually act as an indicator of the amount of metal extracted. In total, 251 furnace wall fragments (1.79% of total artefacts) were discovered during the *Yodhawewa* research, and they are also more likely to have wall fragments of metal extraction furnaces. The 'Tuyere' fragments, furnace wall fragments, and the large-scale slags collection (including tap slag) were confirmed that the metal extraction took place at this site; however, the complete or fragmented smelting (metal ore) furnace structure could not be identified from the research area in 2018.

c) Crucible Steel Production and the copper metalworking

Two factors presented clues concerning crucible steel production at the *Yodhawewa* metalworking site; (a) A lower half of a crucible-shaped furnace and (b) a collection of crucibles and lid fragments. Thus, the most significant discovery of the research was a lower half-spherical (crucible) typed furnace half from the Ex-02 premises. The furnace (context 5) remains the lower spherical part, and the upper part is not visible (Fig. 2B). The remaining half of the inner furnace chamber could show a soil fill (context 22) with the depth of 29 cm, and in the region between 16–22 cm in-depth (11.59m to 11.53m MSL), 18 pieces of crucible fragments (>2cm) were detected. Observing how these crucible fragments existed as a cluster can be referred to as disposal to the furnace chamber by human intervention after the manufacturing process. Because debris of the furnace chamber (context 22) were

existed with crucible fragments ($n=32$), slags ($n=8$), ceramic fragments ($n=3$), furnace wall part ($n=1$), a metal fragment ($n=1$), and a fragment of a clay pipe ($n=1$) without interconnections. When considering the furnace structure, the wall shows the burned clay pieces, which nicely fit with the clay mortar into the wall to get the circular shape (Fig. 6 *top*). The wall thickness was 8-12 cm, and there was a bonded inner white colour plaster 1-1.5cm thick. It was also noticed that plaster (daub), which was weakened during prolonged use of the same furnace, was maintained by re-coating (Fig. 6 *bottom*). Such layers often act as thermal insulation coats (Parr & Boyd, 2002; Weisshaar, Schenk, et al., 2001). There was no 'tuyere' evidence related to the furnace, and In-out connected small "Tube hole" ($\varnothing = 2.5$ cm) through the furnace wall (west side) could be identified 16cm top to the furnace chamber base. Based on the lack of evidence of "tuyere" and the discovery of a small fragment of a clay pipe from the furnace filling (context 22), it can be assumed that the furnace was activated through the "bellow" method.

In this research, the *Yodhawewa* premises discovered a spherical metal furnace's lower half for the first time in Sri Lanka. Such crucible-shaped steel furnaces were discovered in the *Kodumanal* megalithic burial excavations (1986-1996) of South India, and they are believed to have been made to make crucible steel (Gullapalli, 2009; Sasisekaran & Raghunatha Rao, 2001).

These crucible fragments (crucibles and lids) were represented 3.42% ($n=480$) of the entire artefacts of the research, and the majority ($n=326$) were collected from Ex-02 (Table 1). However, a non-damaged (complete) crucible could not be found, and they have been uncovered as fragments of the rim, body, base, and lids (Fig. 7). The crucibles of Ex-2 represented an elongated tube-shaped and rounded base with an inner diameter of approximately 4cm - 6.5cm. Morphologically, the outer surface was completely dark green or blue (or mixed) with glazy vitrification or a waxy solution. The inner middle or lower part shows glass fins as a smelting line, and the bottom of that line shows a honeycomb pattern. The crucible lids in the Ex-02 area have a unique shape with a small hole connecting the inside and outside of them

(Fig. 7). Such small holes help balance the heat inside the crucible and expel the gas (Juleff, 1996). Traces of small metal particles were visible inside the crucible's upper parts and the lids. However, there were not found both types of crucibles in the same locations. Compared to Juleff's Samanlawewa (1996) and Hattota Amunne (2015) records, the crucibles found in the *Yodhawewa* Ex-02 were also used to make crucible steel.

Fig. 6. The crucible-typed furnace (context 5) was discovered from the *Yodhawewa* site. Outer west face of the furnace (*top*), detailed plan of the remained furnace top (*bottom left*), and Cross-sectional details A-B (*bottom*)

The crucibles' shape, size, and thickness in the first excavation area (Ex-01, P-1, and P2) displayed variations compared to the crucibles found in Ex-2. In the first excavation area, crucibles were shaped into round bowls with a flat base, and copper fragments were also deposited inside some crucibles fragments. However, crucible lids (or lid fragments) were not found in this area. However, the

metalworking process using copper and the crucibles are more likely to be an alloying process or a re-production than an extraction process. Juleff (2013) has presented a similar idea regarding the copper products discovered during excavations (1980-84) in the old port city of Mannar. Besides, researchers have pointed out that copper is sourced from the *Seruvila* copper deposit (in the eastern part of Sri Lanka) as a raw material for the Mannar port city and South Indian copper needs. (Juleff, 2013; Seneviratne, 1995; Srinivasan, 2016). There is no need to challenge that view as no copper deposits have been discovered so far near Mannar or *Yodhawewa*.

Fig. 7. Fragmented crucibles were collected from the Ex-02 area. The lid, body, and base were presented from inner and outer surfaces.

d) Glass produced at the *Yodhawewa* area?

Although various researchers have hinted that there may be an indigenous glass industry based on glass artefacts unearthed in various archaeological locations of Sri Lanka, no extensive archaeological study of such products has been conducted. However, in the Ex-02 area of the *Yodhawewa* site, there were many scattered

fragments of slags glass (semi-glass fragments or glass-ceramics). These were lighter than metal slag and were mainly blue, green, white, or subtle colour stripes (Fig. 5D-E). Some glass slags are either transparent or translucent (Fig. 5F). Their sizes are in the range of 1.1 – 1.5 cm³, and a higher quantity of samples ($n=163$) was recorded from the Ex-02 and the surrounding (These glass slags/semi-glass fragments/glass-ceramics included in the slags category in Table 1). The addition of silica during the extraction process separates the slag and iron well during the extraction process, creating a glass-ceramic volume in the slag bulk (Tong et al., 2021). The different colours of such glass-ceramic slags can be shown with the chemical reaction with the metal particles during the extraction process. Because some researchers suggest that the metal was used to make coloured glass; hence metal slags can be in the presence of glass manufacturing sites (Ettler et al., 2015; Henderson, 1985). According to Francis (1982), Indian beadmakers made glass beads of specific colours using different amounts of iron, copper, manganese, and antimony mixing with the batch. All three of the above examples show that mixing different metal compositions is inevitably a factor in the colour change of glass. Accordingly, the glass typed slag fragments found in the *Yodhawewa* site are more likely to be a by-product of the metal extraction, refining (iron or copper), or crucible steel production process.

e) **International Relations with *Yodhawewa***

The *Yodhawewa* production site near Mannar, the hub of South Asia on the Silk Road of the sea, cannot be defined as a place where only local needs were met. It was also confirmed that information on international relations was presented by investigating and comparing the morphological dynamics expressed by artefacts. Forty-one artefacts were used to substantiate this fact; 12 Rouletted Ware (RW) fragments, 23 Black and Red ware (BRW) fragments, six Porcelainware fragments, and one coin collected from exploration. Researchers confirm that imported BRW and RW pottery types were widely used in the Asian region, including historic settlements in Sri Lanka, from the 2nd century BC to the 2nd century AD (Magee,

2010; Schenk, 2001, 2006). One of the identified Changsha porcelain bowl fragments belongs to China's Tang Dynasty period (c. 610-907 AD). Various types of Chinese porcelain have been collected from excavations at the Ancient Mannar port-city, and the excavations 1980-84 have been given special attention to Changsha porcelainware (Carswell, 2013; Linrothe, 2013).

The coin's obverse depicts a lion standing in the middle of a beads circle, and a large flower pot on the reverse, this type of coin belongs to the Pallava dynasty of South India. The Pallava kingdom was established based on the South Indian Kanchipuram in the seventh and eighth centuries AD. In their short-lived kingdom period, the Pallava kings maintained significant political stability in the South Indian region and maintained a good relationship with Sri Lanka (Avari, 2016; Bohingamuwa, 2017; Dirks, 1976). Accordingly, it is not a coincidence that Pallava coins were found in the *Yodhawewa* research, and these types of coins have been found in Mannar and Anuradhapura in Sri Lanka before (Codrington, 1994).

f) Other Artefacts found from the *Yodhawewa* research

In this research paper, metal fragments, glass vessel fragments, beads, minerals, rocks, floral, and faunal factors were pointed out under the same category, and those are 2.56% of the total artefacts of *Yodhawewa* research (Fig. 3). Ceramics representing 43.61% of the total artefacts of this research also have been included in the same category (Fig. 3). Accordingly, this chapter provides a brief overview of those acquisitions and stimulates the need for future research.

Fig. 8. *Yodhawewa* Beads, (A) Carnelian/Agate short barrel circular bead (B) Glass long truncated bicone circular bead (C) Carnelian /Agate long truncated convex bicone circular bead (D) Semi-gloss/Terracotta barrel disc circular bead (E) Glass short barrel circular bead (F) Glass short barrel circular bead (G) Semi-gloss/ Terracotta short barrel circular bead (nomenclature sources; Beck, 2006) (Scale: 10mm)

Pottery and Porcelain Ware types	The development of pottery and porcelain in Sri Lanka			<i>Yodhawewa</i> Current Research
	Anuradhapura	Thissamaharama	Mannar	
Black and Redware	✓	✓	✓	✓
Fine Redware	✓	✓	✓	✓
Coarse Redware	✓	✓	✓	✓
Graphited ware	✓	✓	✓	✓
Mica-slipped ware	✓	✓	✓	NI
Blackware	✓	✓	✓	✓
Fine Grey ware	✓	✓	✓	✓
Red Polished ware	✓	✓	✓	✓
Red-on-White Painted ware	✓	✓	✓	✓
Glazed ware	✓	✓	✓	✓
Rouletted ware	✓	✓	✓	✓
White Stoneware	✓	✓	✓	✓
Islamic ware	✓	✓	✓	✓
Turquoise glazed ware	NR	✓	✓	✓
Unglazed ware	✓	NR	✓	✓
Yue ware	✓	NR	✓	✓

Table 3. Comparison of the ware types of foreign and local earthenware (pottery and porcelain) collected from Mannar (Graham, 2013), Anuradhapura (Coningham, 2006; Kuna, 1987), Thissamaharama (Schenk, 2001), and *Yodhawewa* current research in 2018 (NR: Not Reported, NI: Not Identified)

Pottery is of great value in the study of archaeology, and it belongs to the common artefacts category in most historic settlements (Shepard, 1985). Six thousand one hundred thirteen (43.61%) of pottery pieces and porcelain were collected from the entire research. The first excavation has uncovered the most significant number of pottery fragments ($n=2110$) here (Table 1). Some imported foreign ceramics were described above, and the ceramic diversity detected by the *Yodhawewa* site is summarized in Table 3. The dominant type of Plain/Coarse ware, clay disks, and a few types of unidentified earthenware (not related to furnaces) were identified from the site. The ceramics are typologically similar to the other significant sites in Sri Lanka as *Mannar* (Graham, 2013), *Anuradhapura* (Coningham, 2006; Kuna, 1987), and *Tissamaharama* (Schenk, 2001).

One hundred sixty beads of the types as glass beads and coloured glass beads (Fig. 8B, E, F), semi-gloss beads (Fig. 8D, G), and glass-stone beads like Carnelian/Agate (Fig. 8A, C) were collected during the study. The majority were disk beads, 52.2 percentage of all beads, and short beads, standard beads, and long beads were reported 29.9%, 8.9%, and 8.9%, respectively. The types of the beads were identical to the beads reported from the other archaeological sites of the *Anuradhapura* period of Sri Lanka (Beck, 2006; Francis, 2013; Hannibal-Deraniyagala, 2001). Among the coloured glass beads, a range of blue, yellow, red, green, black, white, and transparent beads have been identified. The beads' material, colour, shape, weight, and technology are identical to each type. Although the *Yodhawewa* research has collected a considerable number of beads signifying the economic and cultural activities and the relations of the ancient settlements, it is expected to present a detailed review in the future.

Through the exploration, gneiss rock artefacts and quartz pebbles were recorded with a smooth surface with one side or several sides. Some rocks and minerals might have been used as raw materials in metalworking activities or as grinding stones. Since the addition of silica in metal extraction helps to separate slag and iron better (Tong et al., 2021), these grinding stones may have been used to grind sand

for a better quality result. Other minerals and rocks such as green chert, which is not common in this region, and limestone of different varieties were reported.

A shell and a columella of *Turbinella pyrum* (Indian chank) were collected from the surface, and they should be transported to the region from the coastal area. *T. pyrum* played a significant role in the coastal economy of Sri Lanka as food as well as a raw material for ornament production (Ratnayake, 2003; Seneviratne, 1985; Siriwardana, 2014). However, the usefulness of the shells revealed by the *Yodhawewa* research is uncertain.

Conclusions and Future Directions

Most of the previous archaeological studies focused on the port-city of Mantai; this study ignored that approach and focused directly on understanding the habitats and industrial settlements of the hinterland of Mantai. However, the results of this research cannot be interpreted outside the socio-economic context of the Mannar port city. The radiocarbon (C14) datings of the present study show the use and functions of the region from 1st to the 8th century AD. Archaeological evidence suggests three significant types of metalwork in the study area: iron extraction, copper metalwork, and crucible steel production. The *Yodhawewa* iron ore extraction was mainly confirmed by factors in furnaces (including 'tuyere' parts) fragments and slags (including tap lags). However, this research did not provide an opportunity to find a complete iron extraction furnace. Archaeological evidence suggests that copper metalwork was carried out in the *Yodhawewa* area in the blue, green, and white range of glass slags, slags with small copper particles, and copper fragments found in crucibles.

The unique discovery from the *Yodhawewa* research was a crucible furnace with a lower half-spherical shape (crucible-shaped) for the first time in Sri Lanka. Several such crucible-shaped furnaces have been reported at the *Kodumanal* Archaeological research (1986-1996) in Tamil Nadu, and it has been confirmed that they were also used to make crucible steel. It has been pointed out that the 'glass typed slags' found

in the research area are more likely to be a by-product of the metal extraction, refining (iron or copper), or crucible steel manufacturing process, and not the result of glass production. In addition to Juleff's (2013) statement that Sri Lankan (*Sarandibi*) high-quality steel, which received tremendous demand in the Arab world, may have been exported from the Mannar port, it can be speculated that *Yodhawewa* crucible steel may have been among them.

The Indian BRW and RW ceramics and Chinese Changsha porcelain discovered in this research reveal direct or indirect relationships with those countries with the research area. Coins belonging to the Pallava kings of southern India have been found at this place, indicating that cultural ties may have existed with that kingdom as well. In addition, imported RW and BRW (c. 1st - 2nd century AD), Chinese porcelain and South Indian Pallava coins (c. 7th - 8th century AD), and carbon-14 dating from *Yodhawewa* research (c. 1st, 5th, and 8th century AD) confirms that the site was active at the time. Further research is needed on pottery, beads, minerals, rocks, and faunal remains found in the site. It is expected to provide a comprehensive explanation of the cultural and natural functioning of the premises in future research through extensive geochemical and geo-archaeological studies.

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