



**Manuscript Title:** The Sungai Batu Archaeological Complex: Re-Assessing the Emergence of Ancient Kedah

**Author(s):** Nasha Rodziadi Khaw, Gooi Liang Jun, Mokhtar Saidin, Naizatul Akma Mohd Mokhtar & Mohd Hasfarisham Abd Halim

**Accepted Date:** 05-September-2020

**Please cite this article as:** Nasha Rodziadi Khaw, Gooi Liang Jun, Mokhtar Saidin, Naizatul Akma Mohd Mokhtar and Mohd Hasfarisham Abd Halim. 2021. The Sungai Batu archaeological complex: Re-assessing the emergence of ancient Kedah. *Kajian Malaysia* (early view).

This is a provisional PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article.

## **THE SUNGAI BATU ARCHAEOLOGICAL COMPLEX: RE-ASSESSING THE EMERGENCE OF ANCIENT KEDAH**

**Nasha Rodziadi Khaw<sup>1\*</sup>, Gooi Liang Jun<sup>2</sup>, Mohd Mokhtar Saidin<sup>1</sup>, Naizatul Akma Mohd Mokhtar<sup>1</sup>, Mohd Hasfarisham Abd Halim<sup>1</sup>**

<sup>1</sup>Centre for Archaeological Research Malaysia, Universiti Sains Malaysia, Pulau Pinang, MALAYSIA

<sup>2</sup>Taylor's School of Architecture, Building and Design, Taylor's University, Selangor, MALAYSIA

\*Corresponding author: [masha@usm.my](mailto:masha@usm.my)

### **ABSTRACT**

*This paper proposes new historical perspectives arising from the findings in the Sungai Batu Archaeology Complex, Kedah, by the Centre for Global Archaeological Research, Universiti Sains Malaysia in 2009. Excavations in the complex unearthed the remains of iron smelting sites, wharves and other brick structures, dating back to the 2nd/3rd Century C.E. The discoveries of furnaces, tuyeres and iron slag attest Sungai Batu's role as the centre for primary iron production, employing the bloomery method. The study suggests that Ancient Kedah appeared as one of the hubs for the trans-Asiatic trade network with the rise of the iron industry, while its economic complexity grew steadily in successive centuries. The early emergence of Ancient Kedah was a development synchronous with the later phase of the Indian-Southeast Asian exchange network between the 2nd to the 4th Century C.E when inter and intra-regional trade intensified. Due to its favourable geological features, strategic location with a suitable ecozone, as well as being a thriving centre for primary iron production, Ancient Kedah emerged as an important harbour. It was this trading and industrial past, the paper will argue, that contributed to the rise of other economic hubs within Ancient Kedah, such as Pengkalan Bujang and Kampung Sungai Mas, which eventually developed into entrepôts after the 5th Century C.E.*

**Keywords:** Sungai Batu Archaeological Complex, Ancient Kedah, Iron Industry

© Penerbit Universiti Sains Malaysia, 2021. This work is licensed under the terms of the Creative Commons Attribution (CC BY) (<http://creativecommons.org/licenses/by/4.0/>).

## **INTRODUCTION**

Ancient Kedah was a group of various settlements and exchange sites located in the Bujang Valley. It was mentioned by Indian, Arab and Chinese records as *Kazhagam*, *Katāha*, *Kadaram*, *Kalah* and *Chieh-Cha* between the 2<sup>nd</sup> Century C.E. to the 14<sup>th</sup> Century C.E, suggesting its significance and importance to foreign traders and travellers (Takakusu 1896; Tibbets, 1978; Nasha, Nazarudin & Mokhtar, 2017). The rich archaeological deposits unearthed from the Bujang Valley consisting of trade wares, glass and beads, Hindu and Buddhist epigraphs, icons and shrines, as well as earthenwares imply the political, economic and cultural complexity of the societies there (Nasha, 2011). Although much has already been written about the chronology, culture, art and architecture of Ancient Kedah between the 5<sup>th</sup> to 14<sup>th</sup> Century C.E., less attention has been placed on development before that period. This is due to the scant number of pre-5<sup>th</sup> Century C.E. finds in the Bujang Valley. These remains have consisted mostly of a few precariously dated beads, icons and short epigraphs, while excavation in Kampung Sungai Mas by Zuliskandar Ramli (2012) yielded a cultural layer containing potsherds dated from the 2<sup>nd</sup>/3<sup>rd</sup> Century C.E.<sup>1</sup> Conclusions on how Ancient Kedah developed into a port-polity have mainly been drawn upon interpretations from various other megalithic and proto-historic sites on the Malay Peninsula, although these are not directly related to Ancient Kedah.

Different hypotheses on how Ancient Kedah emerged have been proposed by; H. G. Quaritch-Wales (1937, 1939, 1940, 1946, 1948, 1950), Alastair Lamb (1958, 1959a, 1959b, 1960, 1961, 1980), Nik Hassan Shuhaimi (1976, 1984, 1986, 1993), Jane S. Allen (1988, 1991, 1997, 2000) and Michel Jacq Hergoualc'h (1992, 2002). Alastair Lamb, Nik Hassan Shuhaimi and Michel Jacq Hergoualc'h each suggested that Ancient Kedah became a seaport after the 5<sup>th</sup> Century C.E.

This development was said to have been caused by the arrival of Buddhist traders from the Indo-Pakistan Subcontinent, whose religion influenced the locals. Their arguments have been strongly based on several sculptures and inscriptions found in the Muda River valley. However, these cultural remains could directly attest only to the presence of Buddhist communities during that period. Quaritch-Wales and Allen on the other hand placed the emergence of Ancient Kedah in the 2<sup>nd</sup>/3<sup>rd</sup> Century C.E. However, their arguments have not been supported by any direct archaeological evidence found in the Bujang Valley. Although the Tamil and Sanskrit literatures such as *Pattinappalai*, *Sillappadikaram* and the Jataka stories do give some hints about Ancient Kedah's economic significance before the 5<sup>th</sup> Century C.E, these records only made passing remarks and have not been taken very seriously, as their descriptions could not be attested to by direct archaeological evidence.

The archaeological mounds and surface finds in the Sungai Batu Archaeological Complex were first reported by J.S. Allen (1988) as sites no.71, 72 and 73. During a palaeo-environmental survey in 2007, the archaeological team of the Centre for Global Archaeological Research (CGAR) mapped at least 97 mounds in the same area. The first systematic excavation in 2009 uncovered religious and iron smelting sites, named SB1B and SB2A respectively. Iron smelting sites were considered a new discovery, as they had not been uncovered in areas previously studied in the Bujang Valley. Further excavations revealed brick structures as well as more remains of iron smelting activities. The discovery of furnace fragments, iron slag and *tuyeres* gave important insights into the iron smelting technology of Sungai Batu, showing similar assemblage with those found in South India, Myanmar and Thailand (Nitta, 1997; Sasisekaran, 2002; Hudson, 2012; Johansen, 2014). The types of iron ores used in the smelting process were mostly hematite and magnetite, minerals which could be found within a five-kilometre radius from the site. Among the areas abundant in iron ores which are

located near to Sungai Batu include Bukit Tupah, Semeling, the UiTM Campus and Kampung Besi (Nordianah, 2013). The rediscovery of the Sungai Batu Archaeological Complex by the Centre for Global Archaeological Research (CGAR), Universiti Sains Malaysia has given fresh insights into the economic role played by Ancient Kedah. By reviewing and re-analysing the archaeological finds at Sungai Batu, this paper proposes the synchronicity between the rise of iron smelting industry in the Sungai Batu Archaeological Complex with the emergence of Ancient Kedah as a port-industry

### **SUNGAI BATU ARCHAEOLOGICAL COMPLEX**

One important aspect of the study on Ancient Kedah involves the research concerning its chronology, cultural sequence and periodization. The archaeological findings at Sungai Batu suggest the position of the area as a polity or settlement specialising in primary iron production, which involved the activities of iron mining and smelting. The dating results from the sites of Sungai Batu, namely SB2A, SB2H, SB2F, SB1ZY and SB1G, can potentially give important clue regarding the emergence of Ancient Kedah, especially before the 5<sup>th</sup> Century C.E.

From these 5 sites, 73 radiocarbon and AMS dates were available for study. For sites such as SB2H, SB2A and SB2F, the Bayesian method for analysing the <sup>14</sup>C data could be applied as there was a large enough number of <sup>14</sup>C samples for radiocarbon and AMS dates. There were 17 samples from site SB2H, 19 samples from site SB2A, and 29 samples from site SB1F (Tables 1, 2 & 3). As for sites SB1G and SB1ZY, only 4 radiocarbon and AMS dates were available from each site (Table 4). Although some ideas regarding the age of sites SB1G and SB1ZY were available, the number of dates was far too small for meaningful Bayesian analysis. As opposed to Frequentist Statistics where large trials are required to

test the probability in archaeological analysis, the Bayesian Theorem can be applied to study the accuracy of the  $^{14}\text{C}$  dates even when only a relatively small number of samples are present. The Bayesian Method can coherently analyse absolute dates from different cultural layers. It helps in identifying underlying date-ranges via radiocarbon readings, pointing out outlier dates and performing the necessary calibrations (Buck & Juarez, 2017). In this paper, the AMS and radiocarbon dates were analysed by using the OxCal program version 4.3 which provided the calibration and analysis. This online chronological modelling software was developed based on Bayesian Theorem by Christopher Bronk Ramsey. The program can provide a simultaneous comparison of  $^{14}\text{C}$  datings from different stratigraphic layers as well as constructing an inclusive and contextual chronological model. This off-the-shelf Bayesian algorithm modelling software is commonly used in analysing  $^{14}\text{C}$  dates to deduce the ideal age range of archaeological sites (Ramsey, 2009).

Table 1: AMS dates of Site SB2H

Beta	Trench	Method/ Sample	Conventional Date	Calibrated Date	Artifact Association
SPIT 8					
516412	N3	AMS/Charcoal	1000±30 BP	AD 983 - 1152	Tuyere fragments and iron slag
SPIT 7					
516413	D4	AMS/Charcoal	2500±30 BP	BC 788 - 537	Tuyere fragments, iron ores and iron slag
516411	Y17	AMS/Charcoal	1740±30 BP	AD 236 – 386	Tuyere fragments, iron ores, laterite and iron slag
377031	Q11	AMS/Charcoal	1520±30 BP	AD 428 - 609	Tuyere fragments, iron slag and iron ores
410261	F12	AMS/Charcoal	1440±30 BP	AD 566 - 655	Tuyere fragments and iron slag

410260	M8	AMS/Charcoal	590±30 BP	AD 1299 - 1413	Tuyere fragments and iron slag
SPIT 6					
401263	W14	AMS/Charcoal	2420±30 BP	BC 748 - 402	Iron slag, laterite and tuyere fragments
517675	V14	AMS/Charcoal	1800±30 BP	AD 131 - 326	Tuyere fragments, laterite and iron slag
516410	Y17	AMS/Charcoal	1760±30 BP	AD 171 - 383	Tuyere fragments, iron ores, laterite, iron ingots and iron slag
517676	X14	AMS/Charcoal	870±30 BP	AD 1045 - 1250	Tuyere fragments, laterite and iron slag
SPIT 5					
377030	R9	AMS/Charcoal	1510±30 BP	AD 430 - 622	Tuyere fragments and iron slag
410264	F15	AMS/Charcoal	1420±30 BP	AD 582 - 661	Laterite and iron slag
410265	C14	AMS/Charcoal	1280±30 BP	AD 662 - 774	Iron slag, tuyere fragments, iron ores and laterite
517674	W14	AMS/Charcoal	1030±30 BP	AD 901 - 1116	Tuyere fragments, laterite and iron slag
SPIT 4					
377029	A13	AMS/Charcoal	1480±30 BP	AD 538 - 645	Laterite and tuyere fragments
410267	N8	AMS/Charcoal	1460±30 BP	AD 553 - 648	Iron slag, tuyere fragments, bricks and laterite
410266	A3	AMS/Charcoal	1250±30 BP	AD 676 - 870	bricks, iron slag, potsherds, tuyere fragments and laterite

Source: After (Naizatul 2019; OxCal 4.3)

Table 2: AMS and radiocarbon dates of Site SB2A

Beta	Trench	Method/ Sample	Conventional Date	Calibrated Date	Artifact Association
SPIT 17					
268002	M7	AMS/Charcoal	1570±40 BP	AD 402-572	Clay and charcoal
SPIT 16					
268001	M7	AMS/Organic material	860±40 BP	AD 1045- 1260	Clay and charcoal
293558	M7	AMS/Charcoal	1510±30 BP	AD 430-622	Clay and charcoal
SPIT 15					
276049	P15	AMS/Charcoal	1680±40 BP	AD 245-506	Tuyere
SPIT 13					
276048	P15	AMS/Charcoal	1490±40 BP	AD 430-648	Tuyere
SPIT 12					
268003	Q7	AMS/Charcoal	1670±40 BP	AD 252-530	Tuyere and iron slag
SPIT 11					
268009	S11	AMS/Charcoal	1640±40 BP	AD 266-538	Tuyere and iron slag
268000	O10	AMS/Charcoal	1630±40 BP	AD 338-539	Tuyere and iron slag
SPIT 10					
258295	Q7	AMS/Charcoal	1550±40 BP	AD 418-594	Tuyere and iron slag
276047	P15	AMS/Charcoal	1500±40 BP	AD 429-643	Tuyere and iron slag
SPIT 9					
258294	Q7	AMS/Charcoal	1550±40 BP	AD 418-594	Tuyere and iron slag
267999	O10	AMS/Charcoal	1490±40 BP	AD 430-648	Tuyere and iron slag
SPIT 8					
268007	L4	AMS/Charcoal	1570±40 BP	AD 402-572	Tuyere and iron slag
267998	O10	AMS/Charcoal	1570±40 BP	AD 402-572	Tuyere and iron slag
256964	O8	AMS/Charcoal	1460±40 BP	AD 478-659	Tuyere and iron slag
SPIT 7					



276046	P15	Radiocarbon/ Charcoal	1690±40 BP	AD 250-422	Tuyere and iron slag
268005	M11	AMS/Charcoal	1660±40 BP	AD 256-534	Tuyere and iron slag
268004	J6	AMS/Charcoal	1570± 40 BP	AD 402-572	Tuyere and iron slag
SPIT 6					
255955	D6	AMS/Charcoal	1700±40 BP	AD 246-416	Tuyere, potsherds and iron slag

Source: After (Naizatul 2012; OxCal 4.3)

Table 3: AMS and radiocarbon dates of Site SB2F

Beta	Trench/spit	Method/ Sample	Conventional Date	Calibrated Date	Associated artefacts
SPIT 9					
298598	G6/9	AMS/Charcoal	1470±30 BP	AD 545 – 645	Laterites
SPIT 7					
292870	J7/7	AMS/Charcoal	1510±30 BP	AD 430 - 622	Bricks, tuyere fragments and iron slag
292867	H8/7	AMS/Charcoal	1430±30 BP	AD 575 - 657	Bricks, tuyere fragments and iron slag
SPIT 6					
298591	M19/6	AMS/Charcoal	1990±30 BP	BC 49 – AD 72	Iron slag, stonetools and bricks
292868	H12/6	AMS/ Charcoal	1520±30 BP	AD 428 - 609	Laterite, tuyere fragments and iron slag
298590	G7/6	AMS/Charcoal	1580±30 BP	AD 410 -	Tuyere fragments

*The Sungai Batu Archaeological Complex*

				546	and iron slag
292871	G11/6	AMS/ Organik material	1540±30 BP	AD 426-588	Laterite, tuyere fragments, iron slags and iron ores
298596	H12/6	AMS/Charcoal	1500±30 BP	AD 432-639	Bricks, tuyere fragments, iron ores and iron slag
290613	H8/6	AMS/Charcoal	1500±30 BP	AD 432-639	Bricks, tuyere fragments, potsherds and iron slag
290614	H12/6	AMS/Charcoal	1480±30 BP	AD 538-645	Bricks, tuyere fragments, iron ores and iron slag
298579	K7/6	AMS/Charcoal	1480±30 BP	AD 538-645	Tuyere fragments and iron slag
292869	G7/6	AMS/Charcoal	1470±30 BP	AD 545-645	Tuyere fragments and iron slag
292872	H6/6	AMS/Charcoal	1470±30 BP	AD 545-645	Tuyere fragments and iron slag
298595	S14/6	Radiocarbon/ Charcoal	1120±40 BP	AD 777-1013	Tuyere fragments and iron slag
SPIT 5					
298580	K6/5	Radiocarbon/ Charcoal	1630±50 BP	AD 260-550	Bricks, tuyere fragments and iron slag
298584	G12/5	Radiocarbon/Charcoal	1600±40 BP	AD 383-557	Tuyere fragments and iron ores
298588	N9/5	AMS/ Charcoal	1570±30 BP	AD 416-557	Bricks, tuyere fragments,

					earthenwares and iron slag
290612	G9/5	AMS/Charcoal	1510±30 BP	AD 430-622	Tuyere fragments and iron slag
298594	K13/5	AMS/Charcoal	1510±30 BP	AD 430-622	Laterite and tuyere fragments
292866	G9/5	AMS/Charcoal	1490±30 BP	AD 436-644	Tuyere fragments and iron slag
298587	H7/5	AMS/Charcoal	1480±30 BP	AD 538-645	Bricks, tuyere fragments and iron slag
SPIT 4					
298597	K18/4	AMS/Charcoal	1490±30 BP	AD 436-644	Laterite, tuyere fragments, iron ores and iron slag
298589	V10/4	Radiocarbon/ Charcoal	1330±40 BP	AD 643-770	Bricks and tuyere fragments
298586	W10/4	Radiocarbon/ Charcoal	1140±40 BP	AD 775-985	Bricks, tuyere fragments and iron slag
290615	T12/4	AMS/ Charcoal	970±30 BP	AD 1016-1155	Pebbles, tuyere fragments, iron slag and iron ores
SPIT 3					
298592	K10/3	AMS/Charcoal	1720±30 BP	AD 248-391	Tuyere fragments, pebbles, iron slag and furnace remains
298585	M16/3	AMS/Charcoal	1510±30 BP	AD 430-622	Pebbles, tuyere fragments, iron

					slag and iron ores
298593	W11/3	Radiocarbon/ Charcoal	1210±40 BP	AD 687-940	Bricks, tuyere fragments and iron slag
298583	M4/3	AMS/ Charcoal	460±30 BP	AD 1412-1468	Laterite, tuyere fragments, ceramics, bricks and iron slag

Source: After (Naizatul 2019; OxCal 4.3)

Table 4: AMS and radiocarbon dates of Site SB1ZY and SB1G

Beta	Trench/Spit	Method / Sample	Conventional Date	Calibrated Date	Associated artefacts
SB1ZY					
344762	E6/4	AMS/Charcoal	1180 ± 30 BP	AD 700 – 900	Tuyere fragments, bricks and iron slag
344763	G6/5	Radiocarbon/Charcoal	2210 ± 30 BP	BC 380 – 200	Laterite and bricks
344765	F7/8	AMS/Charcoal	1700 ± 30 BP	AD 250 – 410	Laterite, bricks and tuyere fragments
344764	J12/7	AMS/Charcoal	1610 ±30 BP	AD 390 – 540	Tuyere fragments and bricks
SB1G					
516415	G14/8	AMS/Charcoal	1150 ± 30 BP	AD 776 - 971	Tuyere fragments, iron ores, laterite, bricks and iron slag
516416	E9/8	AMS/Charcoal	1620 ± 30 BP	AD 382 - 538	Tuyere fragments,

282384	K11/9	AMS/Charcoal	930 ± 40 BP	AD 1020 – 1210	iron ores, bricks and iron slag Laterite, iron slag Tuyere fragments,
516414	G15/10	AMS/Charcoal	1280 ± 30 BP	AD 662 - 774	iron ores, laterite, bricks and iron slag

Source: After (Naizatul, 2019)

The <sup>14</sup>C dating was carried out on various charcoal samples found through excavation at the iron smelting sites, namely SB2A, SB2H, SB2F, SB1ZY and SB1G. The radiocarbon and AMS dates had already been published in the masters and doctoral theses by Naizatul Akma Mohd Mokhtar (2012, 2019). The charcoal samples were reported to have been associated with the remains of iron smelting activities, such as *tuyeres*, iron slag, iron ores, and fragments of iron furnaces (See, Tables 1, 2, 3 & 4). For this paper, the attempt to establish detailed chronological phases and boundaries for sites SB2A, SB2H and SB2F were hindered by the quality of the available data. The lack of sufficient information regarding the context and nature of the samples was due to Bayesian chronological modelling not being considered before the collection of dating samples. The sampling strategy did not entirely follow Bayesian Chronological Modelling, which should have also involved constructing a simulation model for the chronology of the sites as well as determining the matrix and structural phasing of the sites (Bayliss, 2009). Furthermore, the stratigraphic relationships between most of the samples were unclear, where they could only be viewed as a relatively continuous phase of activity. Consequently, this study lacks a robust evaluation regarding the relationships between samples with contexts, as well as between samples with other samples. For the data sets available to us, the

application of the Bayesian method could suggest rough estimates regarding the beginning and end of the period of occupation as well as iron smelting activities at the sites. While acknowledging these limitations, three multiple plots were produced for each site, namely SB2H, SB2A and SB2F. Before analysing the data in the OxCal 4.3 program, all of the <sup>14</sup>C dates were arranged according to their respective spit levels.

For site SB2H, 17 AMS dates of charcoal samples taken from 5 spits were analysed (Table 1). The initial model had a poor overall agreement between the AMS dates and the archaeological sequence. Four dates of poor individual agreement in the model (516412, 410260, 401263 and 517676) were excluded from the analysis and the model was re-run (Figure 1). Aside from the 4 dates which were already excluded, the AMS date 516413 (B.C. 788-537) also appeared to have been an outlier, as samples dated between the 6<sup>th</sup> Century B.C.E. to the 2<sup>nd</sup> Century C.E. had not yet been reported. The significant gap raised some questions regarding the earlier period for the beginning of the site's activities. The low precision of the model outputs was due to the small number of dating results used in the analysis. Based on the multiple plots, the site SB2H could be assigned from the 2<sup>nd</sup> to 8<sup>th</sup> Century C.E. More <sup>14</sup>C samples, especially from the older stratigraphic layer, need to be studied to establish the earliest date for the occupation of site SB2H. For site SB2A, 18 AMS and 1 radiocarbon dates of charcoal samples taken from 11 spits were analysed (Table 2). An individual sample from Spit 16 (268001) was excluded from the analysis as it was far too young for its archaeological sequence (A.D 1160-1240), given the other dates and stratigraphy. Based on the revised model (Figure 2), site SB2A could be placed from the 3<sup>rd</sup> to the 7<sup>th</sup> Century C.E. Finally for site SB2F, 24 AMS and 5 radiocarbon dates of charcoal samples taken from 5 spits were analysed (Table 3), most of which came from Spit 6 (18 samples). Five dates had to be excluded from the analysis, as they showed poor individual agreement with other dates and

their chronological sequence. Samples 298591 (B.C 50- A.D 70) and 298595 (A.D 820-1010) were respectively too old and too recent as compared to the other dates coming from the same spit. As for samples 298592 (A.D 248-391), 298585 (A.D 430-622) and 598593 (A.D 687-940), they did not seem to have an agreement with the overall model. After the 5 samples were excluded, the model was re-run (Figure 3). The revised model showed that site SB2F could probably be placed between the 5<sup>th</sup> to 10<sup>th</sup> Century C.E.

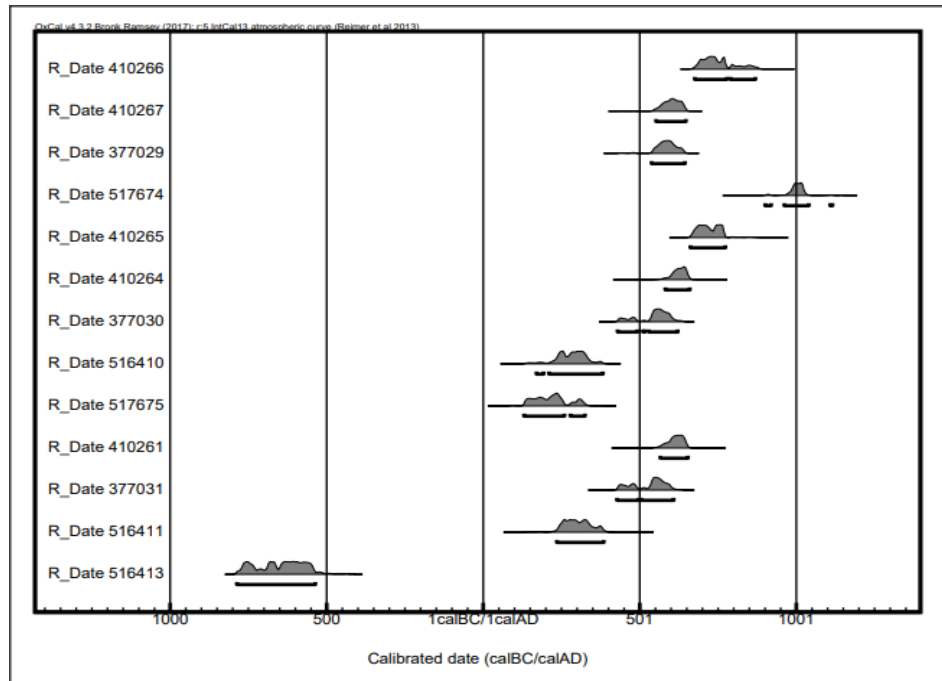


Figure 1: Chronological model of Site SB2H

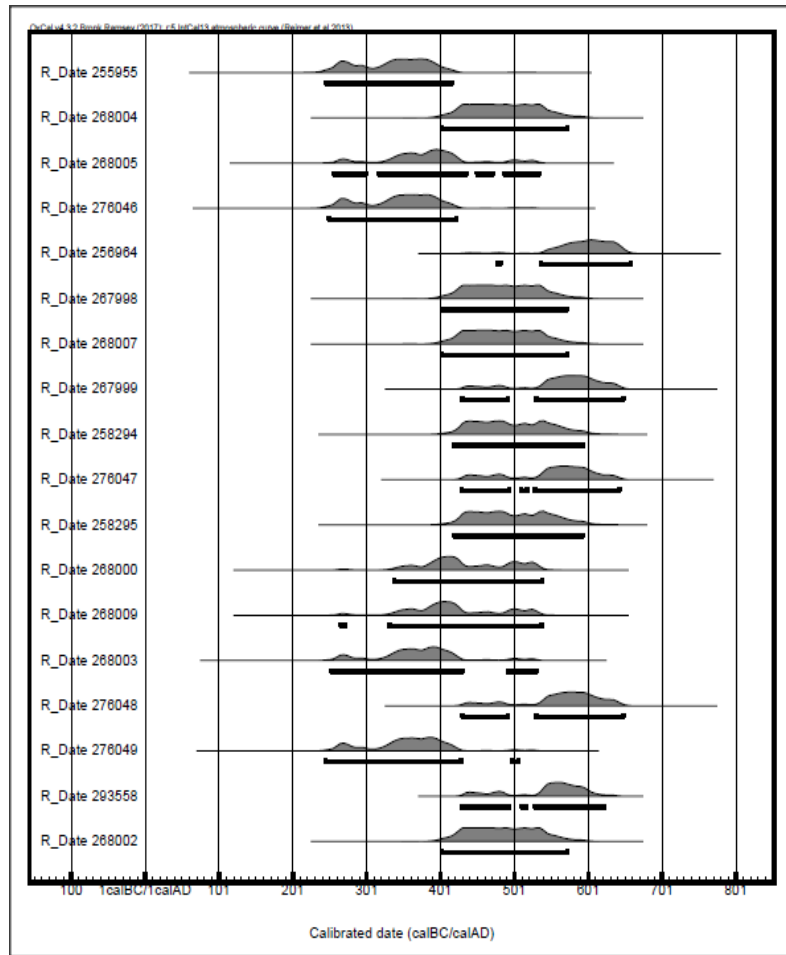


Figure 2: Chronological model of Site SB2A



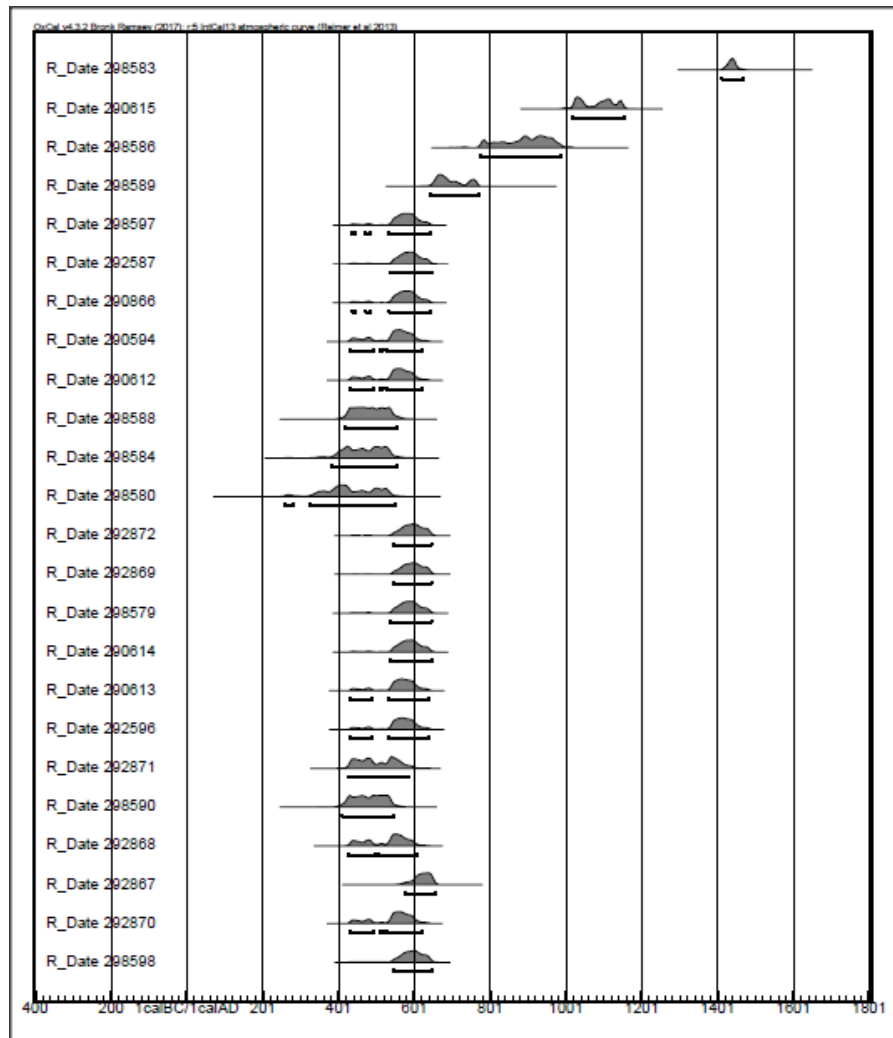


Figure 3: Chronological model of Site SB2F

The archaeological remains show that the smelting process at Sungai Batu was carried out using the bloomery method (Naizatun, 2012: 183; Johansen, 2014: 261; Nordianah, 2013: 199). The bloomery method begins with the preparation of iron ores and the construction of a furnace. The iron ores are smelted at high temperatures, producing solid spongy pieces of impure iron (also known as

blooms) and liquid iron slag which are composed of separated gangue (Johansen, 2014: 261). The melting point for iron smelting at Sungai Batu ranged from 1150°C to 1200°C, while in South India (6<sup>th</sup> Century B.C.E sites of Guttur and Kodumanai) the melting point was between 1140 °C to 1300°C (Sasisekaran, 2002: 22-23). At Sungai Batu, only the bases of the furnaces were found intact, while similar finds have been reported in Mel-Siruvalur and Ban Don Phlong (Nitta, 1997; Sasisekaran, 2002: 25). It is believed that when the furnaces were clogged during the smelting process, they were deliberately broken to retrieve the remaining blooms (Prakash, 2011: 388; Johansen, 2014: 261). The blooms which were produced during the first round of smelting contain a large percentage of slag. Thus, the impurities need to be removed through the process of primary smithing to produce iron billets. The iron billets are then shaped into a finished item during secondary smithing (Johansen, 2014: 261). Unfortunately, evidences for primary and secondary iron smithing have not yet been found at Sungai Batu.

The actual shapes and sizes of the furnaces of Sungai Batu can be deduced by comparing them with the discoveries of iron smelting sites in Jeniang, located in the upper reaches of the Muda River, 45 kilometres from the Sungai Batu site (Farahmasrine, Norhidahti, Zulfadilah, Mohd Zafri & Mokhtar, 2011) (Figure 4). Excavations in Kampung Chemara, Kampung Sungai Perahu and Kampung Kuala Gading have uncovered a few intact and well-preserved furnaces, alongside potsherds, iron remains and a *tuyere* (Farahmasrine *et al.*, 2011; Norhidahti, 2015). The dome-shaped furnaces were found clustered together. Clustered forms of furnaces have also been reported in the 6<sup>th</sup> Century B.C.E sites of Krishnagiri and Guttur in Tamil Nadu (Sasisekaran & Rao, 2001; Sasisekaran, 2002). The furnaces in Jeniang show similar characteristics with the remains found at Sungai Batu in terms of dating (1<sup>st</sup> Century B.C.E to 13<sup>th</sup> Century C.E), morphology and mineralogy (Norhidahti, 2015). Comparison with the sites SB2A and SB2C suggests that the furnaces at Sungai Batu could have also been

similarly dome-shaped (Naizatul, 2012; Nordianah, 2013). Similar forms of furnaces have also been reported in Naikund, Maharashtra (dated from 700 B.C.E), with conical/domed refractories attached with *tuyeres* which also produced semi-solid sponge iron (bloom) and liquid slag (Prakash, 2011). Excavations in Ban Don Phlong revealed oblong and oval-shaped furnaces (Nitta, 1997). Aside from the fragments of furnaces, a large number of artefacts directly linked to iron smelting activities, such as iron slag, iron blooms, iron ores, iron tools and *tuyeres* were found.



Figure 4: Intact Furnaces from Jeniang

At sites SB2A, SB2C, SB1G, SB2F, SB1ZY and SB2H, a total of 32,676 pieces of iron ores, 56 pieces of iron blooms and 275,591 pieces of iron slag were found (Naizatul & Mokhtar, 2019; Figure 5). This indicates the scale of iron production at Sungai Batu, which existed over a significant period (Naizatul, 2012, 2019). *Tuyeres*, or air conduits, used to regulate the temperature in the furnace, were found in large amounts at Sungai Batu. In Trench P15 of site SB2A, *tuyere*

remains can be dug up to 1.7 metres from the soil surface (Figure 6). At site SB2A, 968.22 kilograms of *tuyeres* have so far been excavated and removed. All of them are regularly shaped with diameters ranging from 2.25 to 2.75 cm (Naizatul, 2012). The *tuyeres* appear to have been made according to certain kinds of specifications meant for mass production. Aside from findings directly related to iron smelting activities, other artefacts such as iron tools and metal ornaments were reported. Several corroded iron objects have been found in most of the iron smelting sites such as SB2A, SB2C, SB1G, SB2F and SB2H (Naizatul & Mokhtar, 2019; Figure 7). Studies on the chemical composition of the iron tools discovered at site SB2A indicate a high percentage of CaO and SO<sub>3</sub>, elements which are not detected in the iron ores and iron slag found at the site (Naizatul, 2012). This finding could suggest that the iron tools were not locally smithed, but were brought to the site from elsewhere.

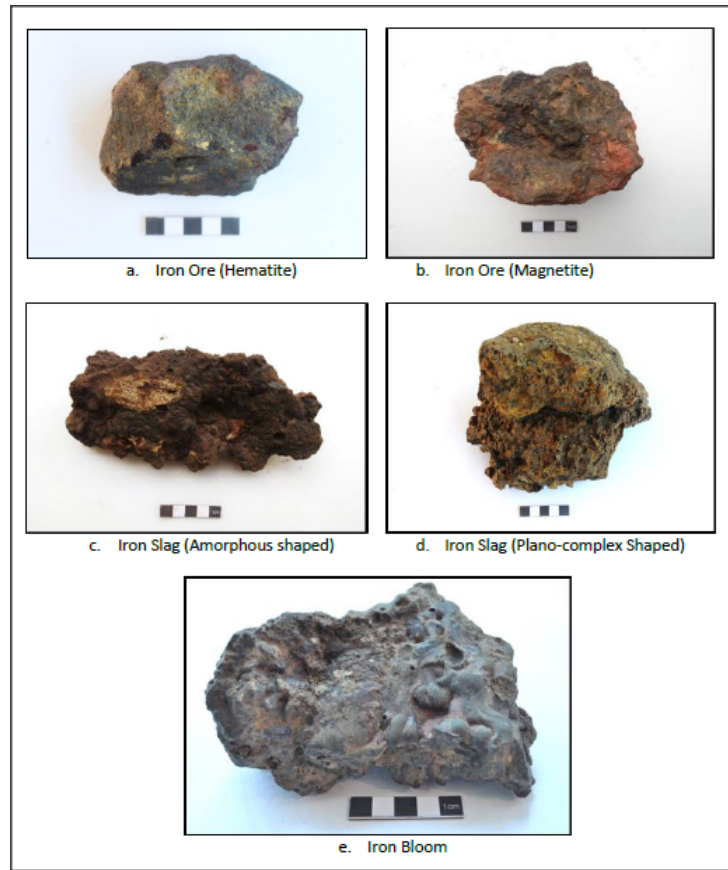


Figure 5: Iron Ores, Iron Slags and Iron Bloom (Naizatul & Mokhtar 2019)



Figure 6: Tuyere remains in site SB2A (Trench P15) (Naizatul 2012)

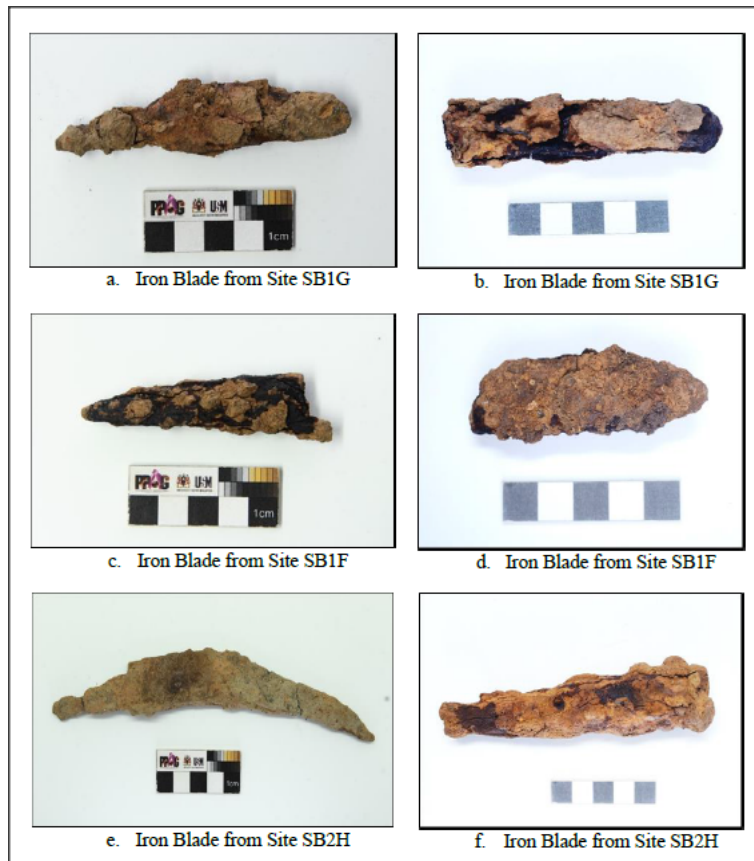


Figure 7: Iron Objects (Naizatul & Mokhtar 2019)

Ornaments made of other kinds of metals have also been found alongside the material remains of iron smelting activities. They consisted of a bronze bangle and a metal ring (Figure 8), both were found at site SB2A and were associated with iron slag and *tuyeres* (Naizatul, 2012). The bronze bangle, measuring 5.9 cm in diameter was found in Trench L8 at Spit 10, while the metal ring, measuring 2.52 cm in diameter was found in Trench L8 at Spit 6. However, the type of metal used to make the ring is still unclear as no chemical analysis has yet been carried out. The discovery of a bronze ornamental object at Sungai Batu reaffirms

the opinion of Pryce (2014), who stated that during the iron age, copper and bronze were used for decorative items while more durable iron and steel were used for utilitarian objects. Similar associations of iron and bronze artefacts have been observed in South Indian iron smelting sites such as Kodumanal and Adichchanallur (Sasisakaran, 2002). A large number of potsherds have been found in all of the archaeological sites excavated so far at Sungai Batu as well as in the Bujang Valley in general. Aside from the remains of iron smelting activities, they are among the most commonly found artefacts at Sungai Batu. In the iron smelting sites, they could have been used for domestic purposes such as for storing water and food (Naizatul, 2012; Nordianah, 2013). At site SB2A, out of the 765 shards found, 759 were undecorated, while the rest had cord-marked design. At site SB2C, out of the 1740 shards found, 1450 were undecorated, while the rest had cord-marked and checked designs (Naizatul, 2012; Nordianah, 2013; Figure 9).





Figure 8 : Metal Ornaments (Naizatul 2012; Nordinah 2013)

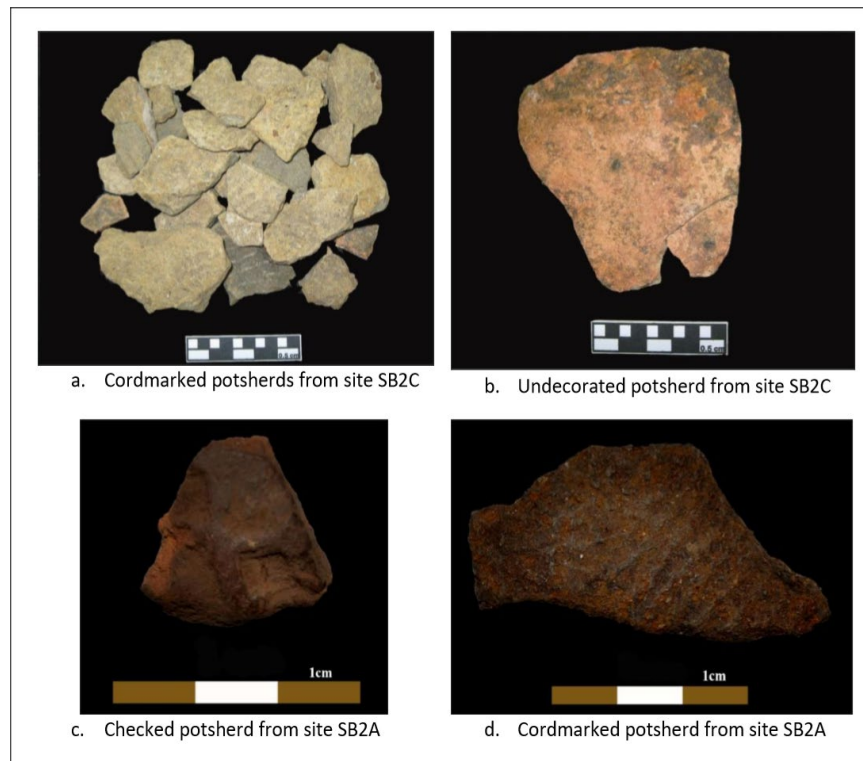


Figure 9: Potsherds (Naizatul 2012; Nordinah 2013)

Artefacts related to trade such as beads and foreign ceramics have also been found. A good number of beads and fragments of trade wares have been recorded in most of the archaeological sites of Sungai Batu. Findings of beads are well documented at sites SB2B, SB2D, SB1H and SB1J (Ikliil, 2014; Hasfarisham, 2014, 2019; Figure 10). A carnelian bead was found at site SB2B (Trench K24, Spit 5), while a monochrome glass bead was found at site SB2D (Trench A19, Spit 6). A terracotta bead was found at site SB1H (Trench S5, Spit 8) and a glass bead was found at site SB1J (Trench B7, Spit 3). All four of them were found just above the cultural layers. Being located near to the ancient shoreline, these materials could have easily been transported from other places and deposited onto the sites by natural elements, such as floodwater or high tide, rendering the

archaeological context uncertain. Foreign ceramics dated from the 10<sup>th</sup> to 14<sup>th</sup> Century C.E have also been found (Naizatul, 2012; Siha, 2014; Figure 11). Among those reported include the Yuan period celadon dan Sawankhalok stoneware from site SB1E (Trench C11, Spit 9) and Sung stoneware from site SB2A (Trench T14, Spit 6). All of these were found above the cultural layers (Naizatul, 2012; Siha, 2014). The role of these ceramics in the iron smelting activities is still unclear, as the dating of the ceramics at site SB2A is far too recent as compared to the date of the site. Although <sup>14</sup>C dates assign site SB2A from the 3<sup>rd</sup> to the 7<sup>th</sup> Century C.E, the Sung stonewares are dated at 10<sup>th</sup> to 13<sup>th</sup> Century C.E.

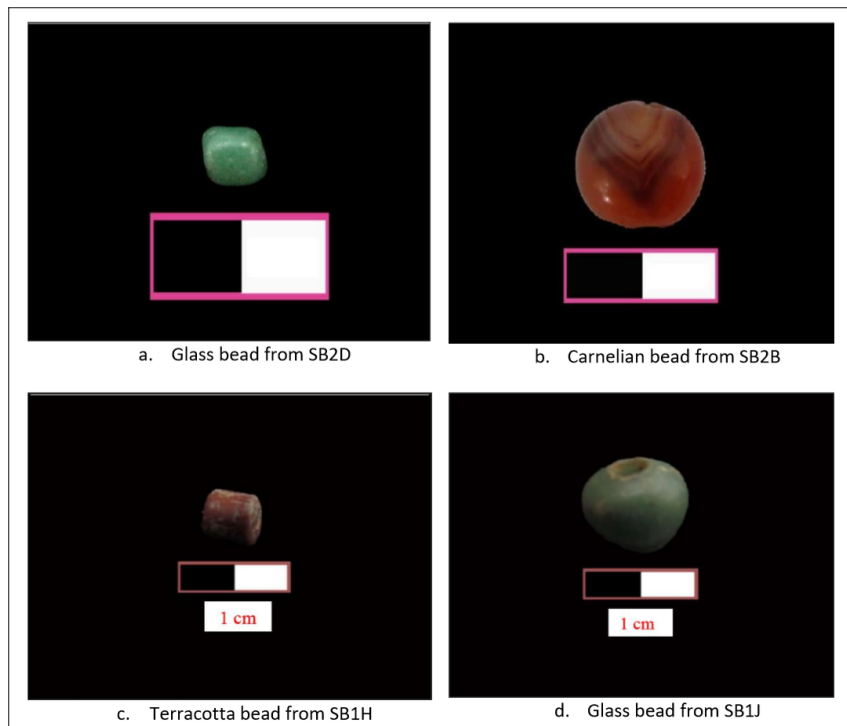


Figure 10: Beads (Iknil 2014; Hasfarisham 2014)

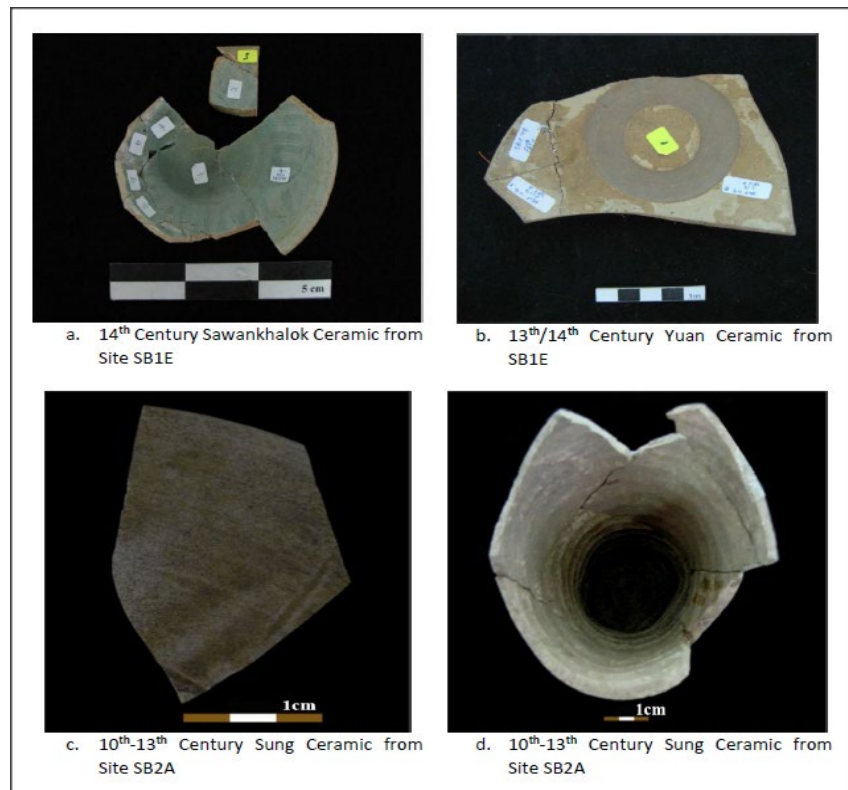


Figure 11: Foreign ceramics (Naizatul 2012; Siha 2014)

Aside from the iron smelting sites, excavation at Sungai Batu has also revealed extensive ruins made of bricks. These structural remains consisted of floorings, walls, stairs, corridors, as well as what appears to be cylindrical-shaped structures (possibly bollards), which are almost entirely made of bricks. Material remains such as iron tools, potsherds, beads, food remains, stone bobbins and even a fragment of a terracotta figurine have been reported at the sites (Ikhlil, 2014; Nurashiken, 2016; Hasfarisham, 2019). Parallel finds of jetties can be observed in several ancient ports, such as Dwarka and Porbandar (Gaur, Sundaresh & Odedra, 2004; Gaur, Sundaresh & Tripathi, 2004; Gaur, Sundaresh & Tripathi, 2006). Studies suggested that most of these brick structures could have functioned as wharves for the loading and unloading of vessels. The discoveries

of roof tiles (Figure 12) and traces of pillar bases (Figure 13) show that these structures were most probably roofed. Built on the ancient river banks, the floors had small channels between regular intervals of brick pavements, probably to drain out water during high tide (Hasfarisham, 2014; Iklil, 2014) (Figure 14). The walls which were possibly the outermost limit of the wharf were usually found between 4 to 10 layers of bricks (Figure 15). The presence of stairs (Iklil, 2014) and paved corridors (Hasfarisham, 2014) were suggested to have functioned as pathways leading from the riverbank to the land. To date, direct archaeological evidence which could confirm the relationship between the major iron smelting sites and the brick structures has not yet been found. However, the association can be suggested based on the sites' overall layout and orientations, observable from the site plans superimposed onto the reconstructed ancient coastline of the area (Figure 16).



Figure 12: Rooftiles (Iklil 2014)

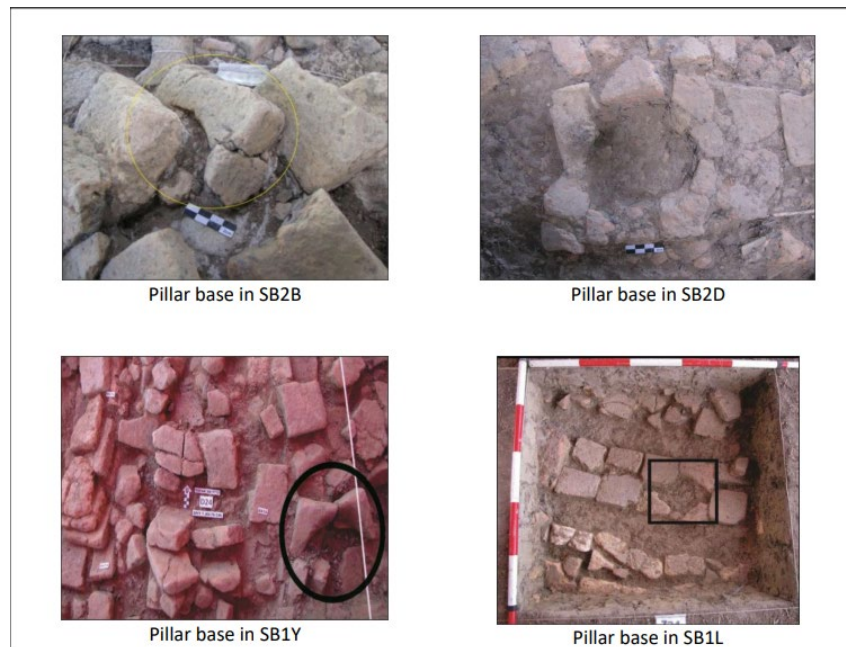


Figure 13: Pllar bases (Iklil 2014; Hasfarisham 2019)



Figure 14: Floor remains (Zolkarnian et.al2009; Iklil 2014)





Figure 15: Wall remains (Zolkarnian et.al 2009; Iklil 2014)



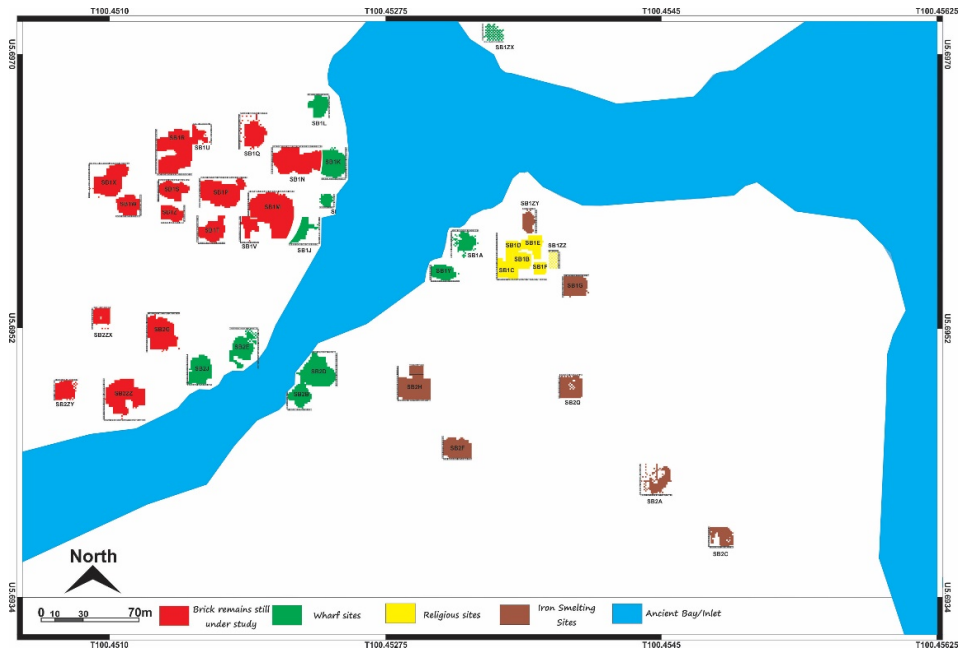


Figure 16: Sungai Batu Complex layout with reconstructed Ancient Coastline

Although the structural remains of these wharf sites are in an extremely ruined state, the palaeo-environmental study and 3-D conjectural reconstructions have provided some insights into their roles (Ikliil, 2014; Hasfarisham, 2019). Palaeo-environmental reconstruction has shown that Sungai Batu was located at the coastline of a sheltered bay, a suitable natural feature for the construction of wharves (Gaur & Vora, 2007). The brick structures appear to have possessed the structural characteristics outlined by De Kerchove (1948), which is “*the engineering structures projecting into the water of a nature of a pier, dike, embankment, constructed of timber, earth, stone or a combination thereof*”. The brick structures, such as at sites SB1B, SB1D, SB1Y and SB1A appear to have been located to the west of the iron-smelting sites of sites SB2H, SB1F, SB1G and SB1ZY (Figure 16). These brick structures were all built along the ancient shoreline, projecting into the inlet. They seem to be strategically positioned adjacent to the iron smelting sites, separated by no more than 150 metres in

distance. The detailed chronology for sites SB1B, SB1D, SB1Y and SB1A cannot yet be established due to the small number of <sup>14</sup>C and OSL dates available (Table 5). Nevertheless, the dates suggest that the periods of occupation of the wharf sites were at least partially contemporary with the iron smelting sites of SB2H, SB2A, SB1F, SB1G and SB1ZY. The presence of these non-religious structures in the Sungai Batu Archaeological Complex and not in other Ancient Kedah sites was probably due to necessity. The main produce of this complex appears to have been iron blooms which had been discovered at the wharf sites near to the ancient coastline, especially at site SB2D (Hasfarisham, 2019: 265). There was probably a need for strong wharf structures to bear the weight of the considerably heavy materials without collapsing.

Table 5: OSL and radiocarbon dates of Site SB1A, SB2B, SB2D and SB1Y

Sample Number /Code	Spit	Method	Sample	Conventional Date	Calibrated Date
SB1A					
90-250 µm	5	OSL	Brick	1.74±0.26 ka	A.D 269
SB2B					
Beta 290605	5	Radiocarbon	Charcoal	1450±30 B.P	A.D 560-650
-	5	OSL	Brick	1.3±0.1 ka	A.D 718
Beta 290607	8	Radiocarbon	Charcoal	1560±30 B.P	A.D 420-570
SB2D					
Beta 290608	4	Radiocarbon	Charcoal	950±30 B.P	A.D 1020-1160
Beta 277030	6	Radiocarbon	Charcoal	1110±40 B.P	A.D 870-1010
-	6	OSL	Brick	1.8±0.2 ka	A.D 218
Beta 277031	7	Radiocarbon	Charcoal	1330±40 B.P	A.D 640-770
Beta 277	8	Radiocarbon	Charcoal	1580±40 B.P	A.D 420-600

034					
SB1Y					
-	8	OSL	Brick	1.9±0.2 ka	A.D 119

Sources: After (Zolkarnian et.al 2011; Iklil 2014; Hasfarisham 2019)

Despite Sungai Batu’s role as a site for iron smelting activities, the area was not entirely devoid of spirituality as a religious site was also discovered, known as site SB1B (Zolkarnian *et al.*, 2011). The excavation unearthed big piles of broken bricks which appear to be the remains of the collapsed upper structure of a building. After the bricks were carefully recorded and removed, a structure with an interesting architectural design was unveiled. It consisted of three main elements which were a circular brick floor (diameter 10.17m), a square brick structure (5.91m x 5.91m) above the circular floor and a cylindrical void (3.12 m) in the middle of the square structure (Zolkarnian, Chia & Hamid, 2011). The total height of what remains of this monument is only 1.2 metre. The shape of this monument shows a close resemblance with other early Buddhist stupas. However, it is difficult to determine the date on an architectural basis, as only the substructure is preserved. Excavation on the surrounding area of site SB1B unveiled the ruins of the extension of the site, which could have functioned as living quarters or a worshipping hall (Siti, 2014). During the excavation at site SB1B and the surrounding area, broken potteries and inscriptions were also uncovered (Zolkarnian *et al.*, 2011). Two inscriptions were found, a stone inscribed epigraph containing *Sagaramatimariprccha* text<sup>2</sup> while the other was a fragmentary *Ye Te Mantra* inscribed on a gold leaf. Both were written in the Southern Indian Pallava script and palaeographically placed at 7<sup>th</sup>/8<sup>th</sup> Century C.E, which shows some similar characteristics with the 7<sup>th</sup>/8<sup>th</sup> Century inscriptions from Burma, Thailand and Southern India (Dani, 1986). Similar *Sagaramatimariprccha* inscriptions were also reported from Kampung Pendi

and Kampung Sungai Mas, which have also been associated with Buddhist stupas (Wales, 1940; Nasha, 2011).

## **DISCUSSIONS**

The Thai-Malay Peninsula was a natural crossroad situated between the South China Sea and the Bay of Bengal. This made the area an important stopover for merchants and sailors for extended periods while waiting for monsoonal changes (Bellina & Sillapanth, 2006; Bellina, 2016, 2018). Aside from its geostrategic location, the Thai-Malay Peninsula had favourable geomorphological and ecological setups for the transition of late Prehistoric coastal and riverine settlements into exchange sites. Even before the advent of inter-regional trade, there could have already been precedents of trading activities among the local polities within the region, which involved the exploitation and distribution of local resources (Bellina, 2018). The second half of the first Millennium B.C.E saw the consolidation of power to form unified and centralised governments in China and the Indo-Pakistan subcontinent, which ended the wars and conflicts between the different fragmented kingdoms and principalities. The rise of the Mauryan Dynasty and the Han Dynasty led to political stability in the two most highly populated regions. The prosperity that followed opened overland and maritime trade networks, which linked the ancient cultural and economic powerhouses with Southeast Asia, and the Thai-Malay Peninsula in particular (Bellina *et al.*, 2014; Bellina, 2016). The establishment of such networks initiated a trading boom, coined by Manguin (2000) as the “Pre-Modern Age of Commerce”. The maritime trade route in insular Southeast Asia passed through the Bay of Bengal, the Straits of Malacca and the South China Sea, while mineral resources as well as rainforest products which were abundant in the Southeast Asian region were often highly sought after. As a result, the middle of the first

Millennium B.C.E became a period of economic, social and cultural change in Southeast Asia (Bellina & Glover, 2004).

Consequently, the late prehistoric riverine and coastal settlements in the Thai-Malay Peninsula began transforming into a network of separate and independent polities, with different levels of size and complexity as well as the development of hierarchies and economic specialisations (Bellina *et al.*, 2014). These polities became hubs where the exchange of commodities and culture with other Southeast Asian polities and with traders and artisans from South Asia and China took place. By the final centuries B.C.E, they had already managed to establish ties with far-reaching ports as well as consolidating control over local resources (Bellina *et al.*, 2014). The archaeological finds in these sites attest trans-Asiatic encounters with locals since 500 B.C.E, such as Dong Son drums, Taiwanese Nephrites, Indo-Pacific beads, ornaments made of metal, stone and glass, bronze bowls, and ceramics (Bellina & Glover, 2004; Hsiao & Bellwood, 2010; Bellina *et al.*, 2014; Bellina, 2018). The foreigners had not only brought their products and cultural influences but also their technologies and industries. This is evident from the archaeological findings at Khao Sam Kaeo, where the earliest industries of very fine quality goods are found. They include workshops for making carnelian and agate ornaments, as well as rouletted wares, believed to have involved South Asian or South Asian trained craftsmen (Pryce *et al.*, 2010; Bellina *et al.*, 2014; Bellina, 2016). There is also evidence pointing out to the possibility of local industries involving artisans coming from the east of the South China Sea (Vietnam, Taiwan & China), with the discovery of Taiwanese nephrites ornaments, Western Han style potteries and Sa-Huyn Kalanay potteries (Bellina & Silapanth, 2006; Hsiao & Bellwood, 2010). These transfers of technology mostly involved the local production of ornaments and decorative items employing foreign techniques while adapting them to local taste (Bellina, 2018).

Another aspect of production which played an important role in the development of these polities was the metalworking industry. According to Higham *et al.*, (2011), the earliest evidence of copper-based metallurgy in mainland Southeast Asia can be dated from the end of the second Millennium B.C.E. The technology was believed to have been derived from contacts with the population of China (Pryce *et al.*, 2011). However, in the insular Southeast Asia, copper-based and other precious metal metallurgies appeared only after the mid-first Millennium B.C.E, synchronous with the appearance of iron metallurgy both in the mainland and insular zones (Bellwood, 2007). According to Biggs *et al.*, (2013), there were three possibilities for the origin of iron metallurgy in Southeast Asia which were (1) Indian origin of the bloomery and crucible steel technologies (2) Chinese origin of the bloomery and cast-iron technology, or (3) Local innovation from the established continental Southeast Asia copper-based technology. In the Thai-Malay Peninsula, iron smelting sites dated from the 4<sup>th</sup> to the 3<sup>rd</sup> Century B.C.E have been reported at the sites of Khao Sam Khaeo, Khao Sek and Phu Khao Thong (Bellina *et al.*, 2013; Bellina, 2016, 2018; Petchey, 2018). They almost exclusively used iron blooms which were produced elsewhere using the bloomery method, a smelting technique with strong links to South Asia (Biggs *et al.*, 2013; Bellina, 2018). As there is sharp synchronicity of the Southeast Asian iron age with the earliest Bay of Bengal exchange system in the mid-first millennium B.C.E., the bloomery techniques of iron smelting in Southeast Asia could have been derived from South Asia (Bellina & Glover, 2004; Biggs *et al.*, 2013; Bellina, 2018). Although one should not rule out the co-existence of South Asian bloomery smelting with Chinese cast iron making, South Asia appears to have been a likely candidate for the origin of most of the iron production techniques, at least in the context of Khao Sam Khaeo, Khao Sek and Phu Khao Thong (Yasuyuki, 2009; Biggs *et al.*, 2013; Bellina, 2018). To date, supporting evidence for iron smelting activities, such as *tuyeres* and furnaces have not yet been found

at these sites, while the iron slag excavated so far have been the results from primary and secondary smithing (Biggs *et al.*, 2013; Petchey, 2018).

The presence of iron smelting sites in Southeast Asia has not been well recorded. So far, only three have been reported, which are Sungai Batu (Kedah, Malaysia), Ban Don Phlong (Northeastern Thailand) and Sriksetra (Central Myanmar) (Petchey, 2018). Sungai Batu provides the first evidence of early historic primary iron production in insular Southeast Asia, which involved the activities of iron mining and smelting to produce raw iron blooms. The overall chronology of the Sungai Batu iron smelting complex has not yet been finalised as there are still many undated sites. The present Bayesian Model has given rough estimates of the chronology for site SB2H (2<sup>nd</sup> to 8<sup>th</sup> Century C.E), site SB2A (3<sup>rd</sup> to 7<sup>th</sup> Century C.E) and site SB2F (5<sup>th</sup> to 10<sup>th</sup> Century C.E). While many of the sites remain unexcavated, current data suggests an extensive complex of iron smelting industry using the bloomery method. Similar findings in Sriksetra and Ban Don Phlong have been dated earlier than Sungai Batu. Excavation of the Tabet-Ywa iron smelting site located in Sriksetra unveiled a mound of iron slag which was two metres deep and covered an area of fourteen thousand square metres, dated from the 1<sup>st</sup> to the 3<sup>rd</sup> Century C.E. (Hudson, 2012). The iron blooms were produced by burning a mixture of charcoal and haematite in furnaces, and they were probably forged into nails and other hardware (Hudson, 2012). In northeastern Thailand, the remains of iron smelting activities in Ban Don Phlong consisted of seventeen ellipsoidal and oval furnaces, *tuyeres*, as well as a large amount of iron slag and potsherds (Nitta, 1997). The twelve radiocarbon dates assign the site from the 3<sup>rd</sup> to the 1<sup>st</sup> Century B.C.E., mainly concentrated in the 2<sup>nd</sup> Century B.C.E (Nitta, 1997).

The preliminary dating has shown that the iron mining and smelting activities at Sungai Batu began in the 2<sup>nd</sup> Century A.D, after the decline of Khao Sam Kaeo,

Ban Don Phlong and Sriksetra (Nitta, 1997; Hudson, 2012; Bellina & Silapanth, 2006). Being located in the Bujang Valley, Sungai Batu was probably one of the polities within Ancient Kedah with its unique economic specialisation. Historical records suggest that Ancient Kedah was already a well-known harbour for inter-regional trade by the 2<sup>nd</sup> Century C.E, especially for the South Indians. The development of Ancient Kedah at the beginning of the first Millenium C.E is attested by Tamil literary accounts from the Sanggam age, a historical period of Southern India between 3<sup>rd</sup> Century B.C.E to the 4<sup>th</sup> Century C.E (Nilakantha, 1975: 30). The strategic location of Ancient Kedah which is conveniently situated across the Bay of Bengal from the Coromandel Coast had given the port easy access to South Indian trade. The earliest sources known to have mentioned Ancient Kedah are Pattinappalai and Sillappadikaram, two Tamil literary sources which can be dated around 2<sup>nd</sup> Century C.E. In one of the poems of Pattinappalai, a verse mentions that “*goods from Kazhagam*” were traded in the port of Kaveripattinam (Nilakantha, 1975: 82; Zwelebil, 1973: 57; Braddell, 1989: 346-347).<sup>3</sup> Another source is the 14<sup>th</sup> Century C.E. commentary of the Epic Sillappadikaram, mentioning that a variety of *agarwood* known as *Kidaravan* could be found in the city of Madurai. Kidaravan could have referred to Ancient Kedah (Braddell, 1989). These records suggest that, at least since the 2<sup>nd</sup> Century C.E., Ancient Kedah had already established close trade relations with the ports of South India. Aside from spices and rainforest products, the *goods from Kazhagam*, as mentioned in Pattinappalai, may have included raw iron produced at Sungai Batu.

Since the 4<sup>th</sup> Century B.C.E., there have been settlements of foreigners who lived in the sites of Khao Sam Kaeo, Khao Sek and Phu Khao Thong, consisting of traders, craftsmen and artisans coming from South Asia, China and Southeast Asia (Biggs *et al.*, 2013). The foreign craftsmen and artisans were actively involved in local industries, who adapted their production techniques to fulfil



Southeast Asian demands (Pryce *et al.*, 2010). Similar phenomenon may also have been possible in Ancient Kedah which possessed all of the natural advantages for its development as a port-industry. Ancient Kedah had protected bays and inlets suitable for trading vessels to harbour, an abundance of raw materials, such as tin and iron ore, supplies of fresh water, as well as rich hinterlands connected to the coastline by riverine networks (Nasha, 2011). Ancient Kedah's geostrategic location just across the Bay of Bengal from the Coromandel Coast made it a convenient stopover for mariners sailing to or from the Straits of Malacca. The beginning of the 2<sup>nd</sup> Century C.E. also marked a phase in the development of the Indian-Southeast Asian exchange link when inter and intra-regional trade intensified with the rise of local industries and manufacturing (Bellina & Glover, 2004). This period was also characterised by less diversity and a greater quantity of the items produced (Bellina & Glover, 2004). This can be observed from the comparison between the findings in Khao Sam Kaeo and the Bujang Valley. Between the 4<sup>th</sup> – 2<sup>nd</sup> Century B.C.E., local industries of diverse products flourished in Khao Sam Kaeo, such as glass, agate, carnelian and nephrite ornaments, copper-based items, iron tools, as well as Western Han, Sa Huynh Kalanay and Rouletted potteries (Bellina & Silapanth, 2006; Bellina *et al.*, 2014). However, for the post-2<sup>nd</sup>/3<sup>rd</sup> Century C.E. Bujang Valley, only the remains of iron smelting at Sungai Batu and a glass bead industry at Kampung Sungai Mas have been found, though in a considerably larger scale (Zuliskandar *et al.*, 2014; Naizatun, 2012, 2019).

## **CONCLUSION**

The excavation and chronometric dating of the Sungai Batu sites have so far uncovered several iron smelting workshops dated from the 2<sup>nd</sup>/3<sup>rd</sup> Century C.E, employing the direct/bloomery method. Similar finds of the direct method of iron smelting activities have been reported in other Southeast Asian sites, such as Ban

Don Phlong (3<sup>rd</sup> to 1<sup>st</sup> Century B.C.E) and Sriksetra (1<sup>st</sup> to 3<sup>rd</sup> Century C.E), while numerous more have been found in South India. Although circumstantial evidence has pointed out the likelihood of the South Asian origin of the smelting technique used at Sungai Batu, whether the smelting activity was done by South Asian smelters or South Asian trained local smelters has yet to be proven. The discoveries of brick structures along the ancient coastline and adjacent to the iron smelting sites can suggest their role as wharves to load the iron blooms into waterborne vessels. Findings at the Sungai Batu Archaeological Complex have positioned Ancient Kedah as another port-industry which flourished owing to its geostrategic position and natural resources, as well as the transfer of culture and technology resulting from trans-Asiatic trade which began in the late centuries B.C.E. In the 2<sup>nd</sup> Century C.E, Ancient Kedah was already well-known, at least among South Indian traders. As a port-industry, Ancient Kedah probably established trade relations with cities like Madurai and Kavetipattinam.

Aside from iron, other commodities which were in high demand such as beads, rainforest products and spices were also most likely traded in Ancient Kedah. The emergence of Ancient Kedah in the 2<sup>nd</sup>/3<sup>rd</sup> Century C.E. was probably the direct result of the intensifying Indian-Southeast Asian exchange link. From the 7<sup>th</sup> Century C.E. onwards, different economic hubs outside of Sungai Batu, such as Pengkalan Bujang and Kampung Sungai Mas continued to attract more traders from the Middle East, China and South Asia, leading to their growth as emporiums. Although Ancient Kedah is generally described in various historical accounts as a single political and port entity, its internal organisation possibly consisted of several confederated settlements with their economic specialisations. These settlements included Sungai Batu, Kampung Pengkalan Bujang and Kampung Sungai Mas. The presence of several nodes for exchange sites and industries in Ancient Kedah is comparable with the earlier network of industrial and exchange sites of Khao Sam Kaeo, Khao Sek, Phu Khao Tong and Bang

Kluay Nok. Despite the abundance of archaeological findings, the lack of epigraphic evidence poses some problems in getting a definitive answer on how the settlements of Ancient Kedah were organised and administered.

Interpretations regarding the culture and socio-technology of Sungai Batu are not yet conclusive because a large area of the archaeological complex has not yet been excavated, while evidence of primary and secondary smithing sites for the blooms have not yet been found. Systematic sampling for  $^{14}\text{C}$  dating using the Bayesian Chronological Model is still needed to establish detailed chronological phases and cultural sequence of the sites. Nevertheless, the present study suggests that the emergence of Ancient Kedah as a port-industry was the result of the trans-Asiatic trade. This had likely led to the gradual cultural exchange and the transfer of technology, and subsequently, the growth of the iron smelting industry at Sungai Batu. Other economic hubs, such as Kampung Sungai Mas and Kampung Pengkalan Bujang probably developed simultaneously with Sungai Batu in the successive centuries, which collectively transformed Ancient Kedah into a regional entrepôt.

#### **ACKNOWLEDGEMENTS**

We greatly acknowledge the Ministry of Higher Education Malaysia for granting the *Fundamental Research Grant Scheme (FRGS)* entitled “The Archaeological Monument of Bukit Choras: Geo-Archaeological Survey and Geophysical Mapping” (Tapak Monumen Arkeologi Bukit Choras, Kedah: Survei Arkeo-Geologi dan Pemetaan Geofizik) (INDUK/PARKEO/6711591) which funded and supported the research and writing for this paper. The *Research University Top Down Grant* entitled “Kajian Arkeologi Sungai Batu: Geran APEX” (1001/PARKEO/870007) had also contributed in this research. We would like to

thank Mr. Shaiful Idzwan Shahidan, Dr. Goh Hsiao Mei, Dr. Felice Noelle Rodriguez, Dr. Neil Khor Jin Keong, Ms. Nini Havela Dishong, Mrs. Iklil Izzati Zakaria, Mrs. Siti Nurul Siha Mohamad and Mr. Irfanullah for their assistance, constructive and valuable comments which have improved the manuscript quality. Finally, we would like to thank the National Heritage Department and the Malaysian Museums Department, for the all the assistance afforded to us throughout our research.

## NOTES

1. This date is based on the radiocarbon dating of a single sample collected from a stratigraphic layer where potsherds have been found, rendering the date of 1810±50 BP (Beta 229409) (Zuliskandar 2012).
2. Following are the translation and transliteration (Zolkarnian et.al 2011; Skilling 2018):

*balāni daśa catvāri vaiśāradīyāni yāni ca  
aṣṭādaśa ca buddhānāṃ dharmmā āveṇikā hi ye  
ye pratītyasamutpannā na te kecit svabhāvataḥ  
ye svabhāvā na vidyante na teṣāṃ sambhavaḥ kvacit  
jānīte ya imāṃ koṭīṃ akoṭīṃ jagatas samāṃ  
tasya koṭīṃ gataṃ jñānaṃ sarvadharmeṣu varttate*

The ten types of powers, The four kinds of confidence  
And the eighteen qualities, that are unique to Buddhas.  
Those things that have arisen in dependence  
[Have not arisen] from any own nature [of their own accord].  
Those that do not exist from [their] own nature [of their own accord]  
For them there is no arising. One who knows that this limit  
Of the world is equal to no limit: His wisdom has gone to the limit  
And functions with regard to all dharmas.

3. The text runs as following (Nilakantha, 1975:83):

Under the guardianship of the gods of enduring glory,  
horses with a noble gait had come by the sea; bagfuls  
of black pepper had been brought in carts; gems and  
gold born of the northern mountain, the sandal and agil  
from the western mountain, the pearl of the southern  
sea, the coral of the western sea, the products of the

Ganges (valley), the yield of the Kaveri, foodstuff from Ceylon, and **goods from Kāzhagam**, all these materials, precious and bulky alike, were heaped together in the broad streets overflowing with their riches [Pattinappalai]

## REFERENCES

- Allen, J. S. 1997. Inland Angkor, Coastal Kedah: Landscapes, Subsistence Systems, and State Development in Early Southeast Asia. *Indo-Pacific Prehistory Association Bulletin*, 16: 79-87.
- Allen, J. S. 2000. In Support of Trade: Coastal Site Location and Environmental Transformation in Early Historical Period Malaysia and Thailand. *Indo-Pacific Prehistory Association Bulletin*, 20: 62-76.
- Allen, J. S. 1991. Trade and Site Distribution in Early Historic Period Kedah: Geoarchaeological, Historic, and Locational Evidence. *Indo-Pacific Prehistory Association Bulletin*, 10: 307-319.
- Allen, J. S. 1988. *Trade Transportation and Tributaries: Exchange, Agriculture, and Settlement Distribution in Early Historic Period Kedah, Malaysia* (Doctoral Dissertation). University of Hawaii, Hawaii, United States of America.
- Bellina, B. 2018. "Development of Maritime Trade Polities and diffusion of the "South China Sea Sphere of Interaction pan-regional culture": The Khao Sek Excavations and Industries studies Contribution. *Archaeological Research in Asia*, 13: 1-12.
- Bellina, B. (2016). The Inception of the Trans-National Processes between the Indian Ocean and the South China Sea from an Early City-State on the Thai-Malay Peninsula (Fourth-Second Century Bce) In M. F. Boussac, J. F. Salles, J. B. Yon. *The Ports of the Ancient Indian Ocean* (pp.1761-1772), Primus Books.
- Bellina, B. & Glover, I.C. (2004). The archaeology of early contacts with India and the Mediterranean World from the fourth century BC to the fourth century AD In I.C Glover & P. Bellwood (eds). *Southeast Asia, from the Prehistory to History* (pp.68-89). London: Routledge/Curzon.

- Bellina, B. & Silapanth, P. (2006). Weaving cultural identities on trans-Asiatic networks: Upper Thai-Malay Peninsula – an early socio-political landscape. *Bulletin de l'Ecole française d'Extrême-Orient. Tome 93*: 257-293.
- Bellina, B, Silapanth, P, Boonyarit, C, Thongcharoenchaikit, C, Allen, J.A, Bernard, V, Borrel, B, Bouvet, P, Castillo, C, Dussubieux, L, Laclair, J, Peronnet, S. & Pryce, O. (2014). The development of coastal polities in the upper Thai Malay peninsula in the late first millennium bce and the inception of long lasting economic and social exchange between polities on the east side of the Indian Ocean and the South China Sea. *Before Siam. Essays in Art and Archaeology*: 69-89.
- Bellwood, P. (2007). *Prehistory of the Indo-Malaysian Archipelago*. Honolulu: University of Hawaii Press.
- Biggs, L. Bellina, B. Martín-Torres, M. Pryce, T. O. (2013). Prehistoric iron production technologies in the Upper Thai-Malay Peninsula: metallography and slag inclusion analyses of iron artefacts from Khao Sam Kaeo and Phu Khao Thong. *Archaeological and Anthropological Sciences*, 5: 311–329.
- Borell, B., Bellina, B., & Chaisuwan, B. 2014. Contacts between the Upper Thai-Malay Peninsula and the Mediterranean World. Revire, Nicolas. In N. Revire, & S. Murphy (Ed.), *Before Siam Was Born: New Insights on the Art and Archaeology of Pre-Modern Thailand and Its Neighbouring Regions* (pp.98-117). Bangkok, Thailand: Rivers book.
- Braddell, R. 1989. A Study of Ancient Times in the Malay Peninsula and the Straits of Malacca dan Notes of Ancient Time in Malaya, *Malaysian Branch of Royal Asiatic Society (Reprint No.7)*, Monograph.
- Briggs, L. P. 1950. The Khmer Empire and the Malay Peninsula. *The Far Eastern Quarterly*, 9(3): 256-305.
- Buck, C. E. and Juarez M. (2017). Bayesian radiocarbon modelling for beginners. University of Sheffield, England.
- Colles, B. (1980). Han and Shen-tu China's Ancient Relations with South Asia. *East and West*, 30(1/4): 157-177.
- Coedes, G. (1968). *The Indianized States of Southeast Asia*, Kuala Lumpur: University of Malaya Press.

- Dani, A. H. (1986). *Indian Palaeography*. Oxford: Clarendon Press.
- De Kerchove, R. (1948). *International Maritime Dictionary*, New Jersey: VanNostrand.
- Favereau, A., & Bellina, B. (2016). Thai-Malay Peninsula and South China Sea Networks (500 BC-AD 200), based on reappraisal of “Sa Huynh-Kalanay”-related ceramics. *Quaternary International xxx, Elsevier*: 1-9. Retrieved from <https://hal-univ-paris10.archives-ouvertes.fr/hal-01529068/document>
- Farahmasrine Mat Nawi, Norhidayati Mohd Mustaza, Zulfadilah Berhaudin, Mohd Zafri Mahmud & Mokhtar Saidin. (2011). *Bukti Industri Besi di Sungai Batu, Lembah Bujang, Kedah*. In Mokhtar Saidin & Suprayitno (Eds.), *Mengungkap Peradaban Asia Tenggara Melalui Tapak Padang Lawas, Sumatera dan Tapak Sungai Batu, Kedah*. Proceeding of International Archaeological Conference (pp.26-40). Medan, Indonesia.
- Gaur, A. S, Sundaresh, & Odedra, A. D. (2004). New light on the Maritime Archaeology of Porbandar, Saurashtra Coast, Gujarat. *Man and Environment*, 29(1):103-107.
- Gaur, A. S, Sundaresh & Sila Tripathi (2004). An ancient harbour at Dwarka: Study based on the recent underwater explorations. *Current Science*, 86(9): 1256-1260.
- Gaur, A. S, Sundaresh & Sila Tripathi (2006). Recent Marine Archaeological Investigations along the Saurashtra coast (pp.21-25), *West coast of India. Glimpses Of Marine Archaeology In India : Proceedings Of The Seventh Indian Conference On Marine Archaeology Of Indian Ocean Countries 6-7 October 2005*. Goa: National Institute of Oceanography.
- Gaur, A.S & Vora, K. H. (2007). Ancient technology of Jetties and Anchoring along the west coast of India. *Current Science*, 93(7): 987-991.
- Gooi L.J. (2018). The Development Of Monuments In Sungai Batu Archaeological Complex, Bujang Valley, Kedah From 500 B.C.E To 1200 C.E. *Masters Thesis*. Penang: Universiti Sains Malaysia.
- Hamilton, A. W. (1922). The Old Kedah-Patani Trade-route. *Journal of the Straits Branch of the Royal Asiatic Society*, 86: 389-393.
- Hergoualc’h, M. J. (2002), *The Malay Peninsula: Crossroad of The Maritime Silkroad (100BC-1300AD)*. Leiden: Koninklijke Brill N. V.
- Hergoualc’h, M. J. (1992). *La Civilisation De Ports-Entrepôts Du Sud Kedah, Malaysia*. Paris: L’Harmattan.

- Higham, G. Higham, C. & Kijngam, A. (2011). Cutting a Gordian Knot: the Bronze Age of Southeast Asia: Origins, timing and impact. *Antiquity* 85 (328):583-598.
- Higham, C & Higham, T. (2015). A new chronological framework for prehistoric Southeast Asia, based on a Bayesian model from Ban Non Wat. *Antiquity* 83(319):125-144.
- Hsiao, C. H. & Bellwood, P. (2010). Movement of Raw Materials and manufactured goods across the South China Sea after 500 BCE: from Taiwan to Thailand, and back. In B. Bellina, E. A. Bacus, T. O. Pryce, & J. Wisseman-Christie (eds.), *50 Years of Archaeology in Southeast Asia: Essays in Honour of Ian Glover* (pp.235-245), Canberra: Australian National University.
- Hudson, B. (2012). A Thousand Years Before Bagan: Radiocarbon Dates and Myanmar's Ancient Pyu cities In G. Y. Goh & J. N. Miksic (Eds). *Early Myanmar and its Global Connections* (pp.88-121). Singapore: ISEAS-Yusof Ishak Institute.
- Ikil Izzati Zakaria. (2014). *Kajian Arkeologi di Tapak Jeti SB2B dan SB2D, Kompleks Sungai Batu, Lembah Bujang* (Master's Thesis). Universiti Sains Malaysia, Penang, Malaysia.
- Johansen, P. G. (2014). Early ironworking in Iron Age South India: New evidence for the social organization of production from northern Karnataka. *Journal of Field Archaeology*, 39 (3):256-274.
- Källén, A. (2004). *Through Flows the River: archaeology and the pasts of Lao Pako* (Doctoral thesis). Uppsala: Uppsala University.
- Khoo, T. T. (1996). Geomorphological Evolution of the Merbok Estuary area and its impact on the early state of Kedah, Northwest Peninsular Malaysia. *Journal of Southeast Asian Earth Sciences*, 13: 247-368.
- Lamb, A. (1959a), Recent Archaeological Work in Kedah. *Journal of the Malayan Branch of the Royal Asiatic Society*, XXXII(1): 214-232.
- Lamb, A. (1959b). Restoring the Temple on the River Cut Stone. *Malay In History*, V(2): 5-21.
- Lamb, A. (1961). Miscellaneous Papers on Early Hindu and Buddhist Settlement in Northern Malaya and Southern Thailand. *Federated Museums Journal*, VI. (Monograph).
- Lamb, A. (1959). The Temple on the River Cut Stone. *Malaya In History*, IV(2): 2-9.



- Lamb, A. (1960). Report on the Excavation and Reconstruction of Chandi Bukit Batu Pahat, Central Kedah. *Federated Museums Journal*, V. (Monograph Republished in Kuala Lumpur: Jabatan Muzium dan Antikuiti).
- Leong Sau Heng. (1989). Satu Perbincangan mengenai peninggalan objek-objek gangsa kecil dari zaman Prasejarah Malaysia. *Jurnal Arkeologi Malaysia*, 2: 1-8.
- Linehan, W. (1951). Traces of the Bronze Age Culture Associated with Iron Age in the regions of Klang and the Tembeling. *Journal of the Malayan Branch of the Royal Asiatic Society*, XXVI(3): 1-59
- Low, J. (1849). On an Inscription from Keddah. *Journal of Asiatic Society of Bengal*. XVIII(1): 247.
- Lowenstein, P. J. (1956). The Origin of the Malayan Metal Age. *Journal of the Malayan Branch of the Royal Asiatic Society*, XXIX(2), 174: 5-78.
- Manguin, P. Y. (2000). City states and city state cultures in Pre-15th Century Southeast Asia. In M. H. Hansen (Ed). *A Comparative study of thirty city-state cultures: An Investigation conducted by Copenhagen Polis Centre* (pp.409-416). Copenhagen: C. A. Reitzel Forlag.
- Mohd Hasfarisham Bin Abd Halim. (2014). *Ekskavasi Tapak Senibina Jeti SB2E, SB1H, SB1J, SB1K, dan SB1L, Di Kompleks Sungai Batu, Lembah Bujang, Kedah* (Master's Thesis). Universiti Sains Malaysia, Penang, Malaysia.
- Mohd Hasfarisham Abd Halim. (2019). Sumbangan kajian di tapak SB1Y, SB2G, SB2J dan SB2ZZ kepada bukti seni bina pelabuhan di Kompleks Sungai Batu Lembah Bujang, Kedah. *Doctoral Thesis*. Penang: Universiti Sains Malaysia.
- Mokhtar Saidin (2016). Kedah Tua Kingdom: New Evidence from Sungai Batu Complex. Paper presented in *Kedah Tua International Conference*. Sungai Petani, Kedah, Malaysia.
- Naizatul Akma Mohd Mokhtar. (2012). *Ekskavasi Tapak Peleburan Besi SB2A, Sungai Batu, Lembah Bujang* (Master's Thesis). Universiti Sains Malaysia, Penang, Malaysia.
- Naizatul Akma Mohd Mokhtar (2019). Kajian kompleks peleburan besi di Kompleks Sungai Batu, Lembah Bujang daripada perspektif arkeometallurgi. *Doctoral Thesis*. Penang: Universiti Sains Malaysia.

- Naizatul Akma Mohd Mokhtar dan Mokhtar Saidin (2019). Artifak besi dalam industri besi Sungai Batu, Lembah Bujang. In Suresh Narayanan, Nasha Rodziadi Khaw dan Mokhtar Saidin (Eds). *Arkeologi Kedah Tua: Sumbangan data terkini dari perspektif warisan, seni & budaya* (pp.17- 32). Penang: Centre for Global Archaeological Research, Universiti Sains Malaysia.
- Nasha Rodziadi Khaw. (2011). *Pensejarahan Kedah Tua: Satu Analisis Sosioekonomi* (Master's Thesis). Universiti Sains Malaysia, Penang, Malaysia.
- Nasha Rodziadi Khaw, Nazarudin Zainun and Mokhtar Saidin (2017), "Kedah Tua: Satu Cerakinan Sumber India", *Jurnal Arkeologi Malaysia Vol.30, No.2*: 11-20.
- Nik Hassan Shuhaimi Nik Abdul Rahman. (1976). *Buddhist Sculpture from Sumatra, Peninsula Malaysia and Peninsula Thailand during the Srivijayan Period (7th-14th century AD)* (Master's Thesis). University of London, London.
- Nik Hassan Shuhaimi Nik Abdul Rahman. (1984). *Art, Archaeology and The Early Kingdoms in the Malay Peninsula and Sumatra: c. 400-1400 AD* (Doctoral Thesis). University of London, London.
- Nik Hassan Shuhaimi Nik Abdul Rahman. (1986). Arkeologi dan Kesenian Purba di Lembah Sungai Muda: Satu Kajian Tentang Pelabuhan –Negeri di Lembah Sungai Muda di Abad Ke-6 hingga Abad ke- 10 Masihi. Paper presented in *Pertemuan Ilmiah Arkeologi IV* (pp. 277-304). Pusat Penelitian Arkeologi Indonesia, Jakarta.
- Nik Hassan Shuhaimi Nik Abdul Rahman & Othman Mohd Yatim. (1992). *Warisan Lembah Bujang*, Bangi: Universiti Kebangsaan Malaysia.
- Nik Hassan Shuhaimi Nik Abdul Rahman & Kamarudin Zakaria (1993). Recent Archaeological Discoveries in Sungai Mas, Kuala Muda, Kedah. *Journal of the Malaysian Branch of the Royal Asiatic Society, LXVI(2)*:73-80.
- Nik Hassan Shuhaimi Nik Abdul Rahman. (1993). Pre-Modern Cities in the Malay Peninsula and Sumatera. *Jurnal Arkeologi Malaysia, 6*: 63-77.
- Nik Hassan Shuhaimi Nik Abdul Rahman. (2001). Loceng Gangsa Penuh Muar Johor dalam Konteks Zaman Gangsa Malaysia. *Jurnal Warisan Johor V*. Johor Bahru: Yayasan Warisan Johor: 165-173.
- Nilakantha Sastri, K. A. (1975). *The Colas*. Madras: The University of Madras.

Nasha Rodziadi Khaw et al.

- Nitta, E. (1997). Iron-Smelting and Salt-making industries in Northeast Thailand. *Bulletin of the Indo-Pacific Prehistory Association*, 16:153-160.
- Nordianah Binti Molinka. (2013). Teknologi Peleburan Besi di Tapak SB2C, Sungai Batu, Lembah Bujang, Kedah: Abad Ke-8 hingga ke-11 Masihi (*Master's Thesis*). Universiti Sains Malaysia, Penang, Malaysia.
- Norhidayahti Binti Mohd Muztaza. (2015). Kajian Arkeologi di Tapak Kampung Chemara dan Kampung Sungai Perahu, Jeniang, Kedah (*Master's Thesis*). Universiti Sains Malaysia, Penang, Malaysia.
- Nurashiken binti Ahmad. (2016). Kajian Arkeologi di Tapak SB1R, SB1S, SB1T, SB1U, SB1V, dan SB1Z di Kompleks Sungai Batu, Lembah Bujang, Kedah (*Master's Thesis*). Universiti Sains Malaysia, Penang, Malaysia.
- Quaritch-Wales, H. G. (1950). A Note on Takola, Langkasuka and Kataha. *Journal of the Malayan Branch of the Royal Asiatic* 23(1): 152.
- Quaritch-Wales, H. G. (1974). Langkasuka and Tambralinga: Some Archaeological Notes", *Journal of the Malaysian Branch of the Royal Asiatic Society*.47(1): 225.
- Quaritch-Wales, H. G. (1937). Further India. Archaeological Researches in Malaya. *Annual bibliography of Indian Archaeology*, XII: 38-41.
- Quaritch-Wales, H. G. (1939). New Light on the Expansion of Ancient India Culture and Mahayana Buddhism from sites in Kedah. *Illustrated London News* 24 Jun 1939: 1169-1171
- Quaritch-Wales, H. G. (1940). Archaeological Research on Ancient Indian Colonization in Malaya. *Journal of the Malayan Branch of the Royal Asiatic Studies* XVIII(1). (Monograph).
- Quaritch-Wales, H. G. (1946). Recent Malayan Excavation and Some Wider Implications. *Journal of the Royal Asiatic Society* XV-XVIII: 140-149.
- Quaritch-Wales, H. G. (1948). Culture Change in Greater India. *Journal of the Royal Asiatic Society* I: 2-32.
- Quaritch-Wales, H. G. (1950). A Note on The Four Main Waves", *Journal of the Malayan Branch of the Royal Asiatic Society*, XXIII(4): 153-155.
- Pillai, J. M. S. (1968). *A History of Tamil Literature with texts and translations from the Earliest times to 600 A.D.* Annamalainagar: J. M. Somasundaram Pillai.

- Petchey, P., Bellina, B., Pryce, T.O., & Innanchai, J. (2018). A Late Prehistoric Iron Smithing Workshop and Associated Iron Industry at the Port Settlement of Khao Sek, Thai-Malay Peninsula. *Archaeological Research in Asia*, 13: 59-73. Retrieved from <https://www.sciencedirect.com/journal/archaeological-research-in-asia/vol/13/suppl/C>
- Prakash, B. (2011). Ancient Indian Iron and Steel: An Archaeometallurgical Study. *Indian Journal of History of Science*, 46 (3):381-410.
- Pryce, T. O. Murillo-Barroso, M. Bellina, B. & Martínón-Torres, M. (2010). Khao Sam Kaeo—an archaeometallurgical crossroads for trans-Asiatic technological traditions. *Journal of Archaeological Science* 37(7):1761-1772.
- Pryce, T. O. Brauns, M. Chang, N. Pemicka, E. Pollard, M. Ramsery, C. Rehren, T. Souksavatdy, V. Sayavongkhamdy, T. (2011). Isotopic and Technological variation in prehistoric primary Southeast Asian copper production. *Journal of Archaeological Sciences* 38: 3309-3322.
- Pryce, T. O. (2014). Metallurgy in Southeast Asia. *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, 134: 1-17. Retrieved from [https://www.researchgate.net/publication/292340712\\_Metallurgy\\_in\\_Southeast\\_Asia](https://www.researchgate.net/publication/292340712_Metallurgy_in_Southeast_Asia)
- Pryce, T. O., Bellina, B., & Bennett, A. T. N. (2006). The development of metal technologies in the Upper Thai-Malay Peninsula: initial interpretation of the archaeometallurgical evidence from Khao Sam Kaeo. *Bulletin de l'École française d'Extrême-Orient*, 93: 295-315. Retrieved from [https://www.persee.fr/doc/befeo\\_03361519\\_2006\\_num\\_93\\_1\\_6040](https://www.persee.fr/doc/befeo_03361519_2006_num_93_1_6040)
- Ramsey B. C. (2009). Bayesian analysis of radiocarbon dates. *Radiocarbon*, 51(1), 337-360.
- Rostoker, W. & Bronson, B. (1990). Pre-Industrial Iron: Its Technology and Ethnology (*Monograph No. 1*). Philadelphia: Archeomaterials.
- Rao, K. P. (2018). Iron age culture in South India: Telangana and Andhra Pradesh. In Akinori Eusugi (Ed.), *Iron Age in South Asia* (pp.129-144). Osaka: Research Group for South Asian Archaeology.

Nasha Rodziadi Khaw et al.

- Rispoli, F., Ciarla, R., & Pigott, V. C. (2013). Establishing the prehistoric cultural sequence for the Lopburi region, central Thailand. *Journal of World Prehistory*, 26(2): 101-171
- Sasisekaran, B & Rao, R. (2001). Iron in Ancient Tamilnadu. In P. Ramachandra Rao and Nani Gopal Goswami. *Metallurgy in India: A Retrospective* (pp.92-102). New Delhi: India International Publisher.
- Sasisekaran, B. (2002). Metallurgy and Metal Industry in Ancient Tamilnadu- An Archaeological Study. *Indian Journal of History of Science* 37 (1): 17-29.
- Shamsul Anwar Aminuddin. (2016). Kajian Arkeologi di Tapak SB1M dan SB1N, Kompleks Sungai Batu, Lembah Bujang, Kedah, (*Master's Thesis*). Universiti Sains Malaysia, Penang, Malaysia.
- Shamsul Anwar Aminuddin, Akmahazila Ab Ghani & Mokhtar Saidin. (2011). *Senibina di Kedah Tua: Bukti daripada Tapak SB2G'10, SB1M'10 and SB1N'11*. In Mokhtar Saidin & Suprayitno (Eds.), *Mengungkap Peradaban Asia Tenggara Melalui Tapak Padang Lawas, Sumatera dan Tapak Sungai Batu, Kedah*. Proceeding of International Archaeological Conference (pp.82-105). Medan, Indonesia.
- Schlegel, G. (1899a). To-ho-lo 墮和國 or Tok-ho-lo 獨和羅, Takōla or Takkōla. *T'uong Pao*, 10(2): 155-158.
- Schlegel, G. (1899b). Tan-tan 丹丹 or Dan-dan 單單 Dondin?. *T'uong Pao*, 10(5): 159-163.
- Schlegel, G. (1899c). Tun-Sun 頓遜 or Tian-Sun 典遜 Tēnasserim or Tānah-Sāri. *T'uong Pao*, 10(1): 33-38.
- Sitthithaworn, E. (1990). *Metallogenic Map of Thailand*. Bangkok: Department of Mineral Resources.
- Siti Nurul Siha Mohamad. (2014). Ekskavasi Tapak SB1C, SB1D, SB1E, dan SB1F di Sungai Batu, Lembah Bujang, Kedah, (*Master's Thesis*). Universiti Sains Malaysia, Penang, Malaysia.
- Sieveking, de G. (1956). The Iron Age Collections of Malaya. *Journal of the Malayan Branch of the Royal Asiatic Society*, 29(2), 174: 79-138.

- Skilling, P. (2018). Sāgaramati-paripṛcchā Inscriptions from Kedah, Malaysia In Lutz Edzard, Jens W. Borgland & Ute Hüsken. *Reading Slowly: A Festschrift for Jens E. Braarvig* (pp.433-460). Wiesbaden: Harrassowitz Verlag.
- Sudyka, J. (2011). The “Megalithic” Iron Age Culture in South India-Some General Remarks. *Analecta Archaeologica Ressooviensia* 5: 359-389.
- Suhana binti Yusof. (2016). Ekskavasi Tapak Monumen SB1P, SB1Q, SB1W dan SB1X di Kompleks Sungai Batu, Lembah Bujang, Kedah, (*Master’s Thesis*). Universiti Sains Malaysia, Penang, Malaysia.
- Takakusu, J. (1896). *A record of the Buddhist religion as practised in India and the Malay Archipelago*. Oxford: Clarendon Press.
- Tibbetts, G. R. (1978). *A Study of the Arabic Texts Containing Materials on South East Asia*. Leiden: E. J. Brill.
- Wheatley, P. (1956). Tun-Sun (頓遜). *Journal of the Royal Asiatic Society of Great Britain and Ireland*, 1/2: 17-30.
- Wheatley, P. (1956). Langkasuka. *T’oung Pao, Second Series*, 44(4/5):387-412.
- Wheatley, P. (1966). *The Golden Khersonese*. Kuala Lumpur: University of Malaya Press.
- Wilkinson, R. J. (1939). The Bernam Slab-Graves. *Journal of the Malayan Branch of the Royal Asiatic Society*, 17(1), 133: 134-143.
- Wolters, O. W. (1989). *Perdagangan Awal Indonesia*. Kuala Lumpur: Dewan Bahasa dan Pustaka.
- Yasuyuki, M. (2009). *Iron Production in Han and Pre-Han periods in Sichuan Cheng Du Plain China. World of Iron Conference 16-20 February 2009, London*. London.
- Zolkarnian Hassan, S. Chia, & Hamid Mohd Isa. (2011). Survey and Excavation of an Ancient Monument in Sungai Batu, Bujang Valley, Kedah, Malaysia. In Chia S., & Andaya, B. W (Eds). *Bujang Valley and Early Civilisations in Southeast Asia* (pp.27-50). Kuala Lumpur: Department of Heritage Ministry of Information, Communications and Culture Malaysia.
- Zuliskandar Ramli. (2012). Proses akulturasi budaya india dan transformasi ilmu masyarakat melayu kedah tua berdasarkan data arkeologi dan kajian saintifik.

Nasha Rodziadi Khaw et al.

*Doctoral Thesis*. Bangi: Institut Alam dan Tamadun Melayu, Universiti Kebangsaan Malaysia.

Zuliskandar Ramli & Nik Hassan Shuhaimi Nik Abdul Rahman. (2010). Petempatan Masyarakat Zaman Logam di Selangor Berdasarkan Data Arkeologi. *International Journal of Malay World and Civilisation*, 28(1):41-55.

Zuliskandar Ramli, Nik Hassan Shuhaimi Nik Abdul Rahman, Sharifah Nur Izzati Syed Hassan, Ros Mahwati Ahmad Zakaria, Mohd Rohaizat Abdul Wahab, Norlelawaty Haron & Hasnira Hassan. (2014). Sungai Mas, Kuala Selinsing dan Santubong: Pusat Pengeluaran Manik Kaca Indo-pasifik di Asia Tenggara pada Zaman Protosejarah. In. Abdul Latif Samian & Nazri Muslim (Eds). *Isu-isu Sains & Teknologi di Alam Melayu* (pp.370-392). Bangi: Universiti Kebangsaan Malaysia.

Zuliskandar Ramli, Nik Hassan Shuhaimi Nik Abdul Rahman, Adnan Jusoh, & Muhammad Rizal Razman. (2014). Interpretasi Terkini Data Arkeologi di Kompleks Percandian Pengkalan Bujang, Kedah. *International Journal of the Malay World and Civilisation (IMAN)*, 2(2):81 – 90.

Zvelebil, K. (1975). *Tamil Literature*. E.J. Brill: Leiden.

Zvelebil K. (1973). *The Smile of Murugan on the Tamil Literature of South India*. Leiden: E.J. Brill.