BUKIT CHORAS ARCHAEOLOGICAL COMPLEX: GEOPHYSICAL AND GEO-ARCHAEOLOGICAL ANALYSIS

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by

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LIST OF SYMBOLS

C.E	Common Era
AD	Anno Domini
MHz	Megahertz
12C	Carbon-12
13C	Carbon-13
14C	Carbon-14
Si	Silica
Na	Natrium
K	Kalium
Ca	Calcium Carbonate
Fe	Ferum
Al	Alumina
Ti	Titanium
Mn	Manganese
As	Arsenic
Ba	Barium
La	Lanthanum
Co	Carbon monoxide
Cr	Chromium
Cu	Copper
Zn	Zinc
Zr	Zirconium
NE	North-East
EW	East-West

Ga	Gallium
Nb	Niobium
Ni	Nickel
Pb	Lead
Rb	Rubidium
Hf	Hydrogen Fluoride
V	Vanadium
±	Plus-minus sign
<	Less than Sign

LIST OF ABBREVIATIONS

GPR	Ground Penetrating Radar
XRD	X-ray Diffraction
XRF	X-ray Fluorescence
GPS	Chemical Mass Balance
GIS	Geographic Information System
VLM	Visible-light microscopy
SEM	Scanning Electron Microscope
EDXA	Energy-dispersive x-ray analysis
Ses	secondary electrons
MCA	Multichannel Analyser
EMCL	Earth Material Characterization Laboratory

LIST OF APPENDICES

KOMPLEKS ARKEOLOGI BUKIT CHORAS: ANALISIS GEOFIZIK DAN GEO-ARKEOLOGI

ABSTRAK

Kedah Tua merupakan sekumpulan penempatan-penempatan pesisir pantai dan pinggir sungai yang berfungsi sebagai pusat pelabuhan antarabangsa dan industri dari kurun ke-2 hingga ke-14 Masihi. Kompleks Arkeologi Bukit Choras merupakan salah sebuah tinggalan arkeologi yang masih terpelihara, yang memperlihatkan ciri kebudayaan dan perkembangan ekonomi Kedah tua. Kajian terdulu di tapak ini telah membawa kepada penemuan dua buah tinggalan struktur binaan laterit, dua buah kolam air purba, serta artifak-artifak seperti serpihan tembikar tanah, prasasti Buddha dan paku-paku besi. Kajian ini bertujuan untuk menjawab persoalan mengenai tatasusunan, bahan binaan serta persekitaran kuno tapak Bukit Choras. Pendekatan Geofizik telah diaplikasi dalam kajian ini untuk memetakan penemuan permukaan, serta mengkaji potensi keberadaan tinggalan struktur yang tertanam di bawah tanah. Kaedah pemetaan kontur, kaedah magnetik, keberintangan serta radar tusukan bumi telah dijalankan di kawasan sekitar struktur utama dan kolam purba. Kajian Geo-Arkeologi juga telah dijalankan di Bukit Choras dan kawasan sekitarnya untuk memahami komposisi geokimia bahan binaan candi tersebut, serta mengkaji ciri paleo-alam kawasan sekitar tapak tersebut. Bagi kajian ini, sampel-sampel bata laterit, tanah serta batuan dengan menggunakan kaedah teknik penggerudian tangan dan pengambilan sampel secara rambang. Sampel-sample ini, seterusnya dianalisis dengan penggunakan kaedah-kaedah saintifik seperti X-Ray Diffraction (XRD), *X-Ray Fluorescence (XRF)*, *Scanning Electron Microscope (SEM)* and *Digital Microscope*. Kajian ini membawa kepada 3 penemuan utama. Pertama, pemetaan permukaan dan

kajian geofizik menunjukkan bahawa tapak tersebut terdiri daripada sebuah struktur utama yang dikelilingi oleh sekurang-kurangnya 7 buah struktur yang lebih kecil, 6 masih tertanam di bawah permukaan tanah dan dapat dikesan menggunakan kaedah geofizik. Tatasusunan tersebut adalah hampir sama dengan kompleks agama Buddha di India dan Asia Tenggara. Kedua, analisis terhadap sampel bata dan mineral menunjukkan bahawa bahan binaan untuk membina struktur tersebut dilombong dari kawasan berdekatan. Laterit-laterit mentah tersebut kemungkinan besar dibawa dari kawasan Tenggara Bukit Choras, manakala sebahagian kecil bahan binaannya dibawa dari kolam purba dan utara. Akhir sekali, didapati bahawa pada kurun ke-6/7 Masihi, garis pantai terletak lebih dekat dengan kaki Bukit Choras, manakala Sungai Sala adalah lebih luas dan boleh dimudik oleh kapal-kapal besar. Penemuan ini menunjukkan bukit Choras merupakan sebuah kompleks yang terdiri daripada sebuah struktur utama yang dikelilingi struktur kecil yang lain serta terdapat dua buah kolam air purba di bahagian timur. Bahan mentah binaan struktur tapak ini pula telah diambil daripada kawasan tenggara Bukit Choras manakala persekitaran purba tapak merupakan persekitaran bakau serta lautan cetek.

BUKIT CHORAS ARCHAEOLOGICAL COMPLEX: GEOPHYSICAL AND GEO-ARCHAEOLOGICAL ANALYSIS

ABSTRACT

Ancient Kedah is a collection of several riverine and coastal settlements which flourished as the *foci* for international trade and industry between the 2nd to the 14th Century C.E. The Bukit Choras Archaeological Complex is one of the very few well-preserved archaeological findings related to the cultural and economic development of Ancient Kedah. Previous studies had revealed two structural remains made of laterite bricks, two ancient water tanks, as well as other artefacts such as potsherds, Buddhist inscription and corroded iron nails. This research attempts to answer questions regarding the layout, building material and palaeo-environment of the site. In this study, geophysical studies were carried out in Bukit Choras in order to map the surface remains and to determine the potential for buried remains. Detailed contour mapping as well as the magnetic, resistivity and ground penetrating radar methods were done around the main structure and the ancient water tank. Geo-archaeological survey was also carried out in Bukit Choras and its surrounding to understand the geochemical composition of the building materials used to construct the structural remains, as well as to get some insight into the palaeo-environment of the area. For this study, laterite brick samples, soil samples and rock samples were collected, either by using hand auger or hand-picked methods. These samples were later analysed by using the radiocarbon dating, X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF), Scanning Electron Microscope (SEM) and Digital Microscope methods. This research had led to three main discoveries. Firstly, the archaeological complex of Bukit Choras consisted of a main structure, possibly surrounded by at least 7 smaller structures, 6 of

which are still buried underground and could be detected by the geophysical methods. Such layout is like most Buddhist Stupa complex in India and Southeast Asia. Secondly, analysis of the laterite brick and mineral samples show the building materials used to construct the structures were mined from the nearby area. They were mostly brought from the southeastern outcrop of Bukit Choras, while materials extracted from the ancient water tanks and northern foothill to lesser extent were also probably used. Finally, in the $6^{th}/7^{th}$ Century C.E., the shoreline was located much closer to Bukit Choras while the Sala River was much more navigable by the big ship. These findings show that Bukit Choras is a complex consists of a main structure surrounded by other subsiadiry structure as well as there are two ancient water tank in the Eastern part of the site. The raw materials for the construction of the site were taken from the Southeastern area of Bukit Choras while the ancient environment of the site suggested to be mangrove and marine environment.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter begins with an introduction to the research on Bujang Valley, as well as Bukit Choras. Discussions regarding the position of Bujang Valley with Bukit Choras as the northernmost limit are included. Following the background of research, previous works on the subject is discussed, starting from overall research on the Bujang Valley, and then to specific research in Bukit Choras. Only three studied had been done, which is by James Low (Wales, 1940), Wales (1940) and Kamaruddin Zakaria (1989). From the research gaps in the previous works, the statements of problems are identified, which include matters regarding the unclear layout and palaeo-environment of the site as well as unknown origin of the building materials. The statements of problem are followed by the research objectives which to address the issues and ends with the scope of research and arrangement of chapters.

1.2 Background of research

Ancient Kedah was a collection of various coastal and riverine settlements functioning as a port industry from the 2nd to the 14th Century C.E. (Khaw, 2011; Khaw *et.al* 2019; Khaw *et.al* 2020). Most of the settlements and economic activities were centred in the area presently known as the Bujang Valley, which extended from Bukit Choras is the North, Gunung Jerai, the Merbok-Muda river, down to Cherok Tokkun in the South (Map 1.1; Plate 1.1). Excavation in Jeniang, Bukit Selambau and Kuala Ketil shows that settlements of Ancient Kedah might have also included those located upriver, connecting the polity to the eastcoast via the Muda-Pattani

transpeninsular route. Ancient Kedah have been mentioned in different names in various Chinese, Indian and Arab records, such as Kadaram, Kalah, Kataha and Chieh Cha (Zuraidah & Zuliskandar, 2016; Nasha 2011). These records had given important insights into the mercantile past of Ancient Kedah. Aside from foreign records, local sources such as Al Tarikh Salasilah Negeri Kedah and Hikayat Merong Mahawangsa also contributed to the historical narrative during the pre-15th Century period of the port-polity.

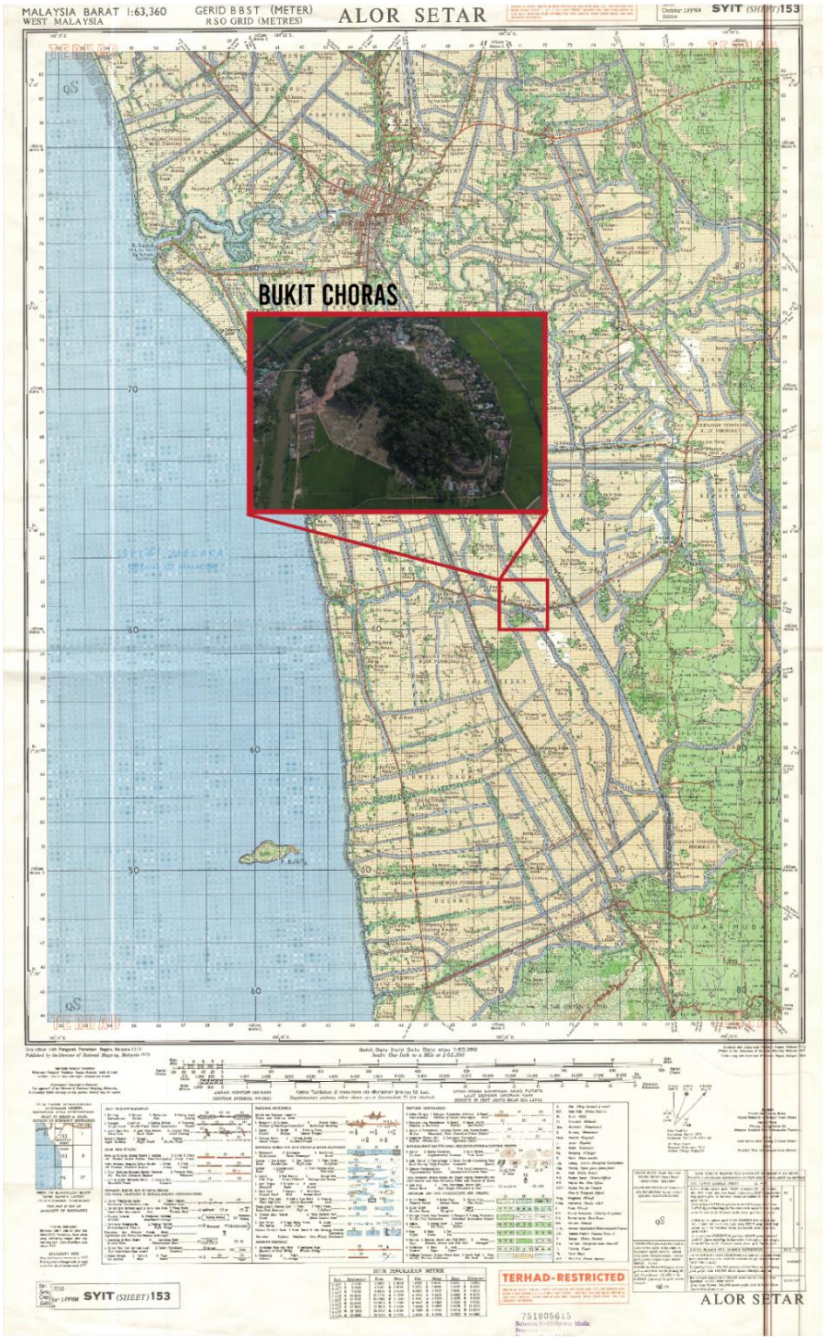
As important as the historical sources may be, most of what is known about Ancient Kedah was based on the archaeological discoveries in the Bujang Valley. Numerous archaeological finds have been reported in several areas, such as Kampung Sungai Mas, Kampung Pengkalan Bujang, Simpor Tambang and Kampung Sireh (Wales 1940; Lamb 1961; Allen 1988; Shuhaimi & Othman 1992; Khaw 2011, Saidin 2016). They include Hindu-Buddhist icons and inscriptions, tradewares, beads, potteries, as well as recently found iron smelting sites and brick jetty remains. Studies on these archaeological findings became the point of departure for several theories regarding the cultural and socio-economic make-up of societies in Ancient Kedah. One important aspect of study in the archaeology of Ancient Kedah is the structural remains, which generally consisted of Hindu-Buddhist shrines, and found mostly clustered at several localities almost exclusively within the Merbok-Muda river valley. However, there is one exception, which is in an isolated site located to the north of the Gunung Jerai: The Buddhist temple site of Bukit Choras.

The site is located at the southwestern tip of a crescent-shaped ridge known as the Bukit Choras (5º 57’52’’ N 100º 25’ 03’’ E), extending from north to south with the altitude of 57.6 meters. The ridge is surrounded by paddy fields, Chinese cemetery as well as madrasah and kampung houses, while rubber trees were planted at the

slopes. The visible remains at the peak of Bukit Choras currently consisted of 2 ruins of structures, reported to be Buddhist stupa and a shrine, as well as water tanks. The unique position of the site of Bukit Choras, located further away from other archaeological sites of Ancient Kedah raise much curiosity regarding its form of architecture and role in the history of Ancient Kedah.

1.3 Archaeological site of Bukit Choras

The rich archaeological remains in the Bujang Valley had attracted scholars and antiquarians alike. Earliest report regarding the findings in the Bujang Valley begin to surface in the first half of the 19th Century C.E, when Colonel James Low, a British government officer based in Penang came upon structural remains and inscriptions (Low, 1848). Other antiquarians such as Irby (1905) and Evans (1922) had reported more findings consisting of Hindu-Buddhist shrines and sculptures. Quaritch Wales pioneered a systematic research in the Bujang Valley, where he conducted a thorough survey in the Bujang Valley, excavated 30 sites and for the first time proposed historical and cultural interpretations regarding the ancient society (Wales, 1940). The location of Bukit Choras in Alor Setar map is shown in Map 1.1 and the Plate 1.1 shows Bukit Choras today.



Map 1.1 Bukit Choras location in Alor Setar, Kedah topography map
Sources: (Alor Setar map, L7010 series 1-PPNM sheet, Director of National Mapping, 1973)

Plate 1.1 Bukit Choras from South view.

Other scholars who did holistic studies in the site of Bujang Valley included Lamb (1961), Allen (1988), Leong (1973), Shuhaimi (1988), Sabtu (2002) and Khaw (2011). They carried out systematic studies of several sites and proposed new theories regarding the culture and chronology of Ancient Kedah. On the other hand, researchers such as Sullivan (1957), Wang Gungwu (1956), Peacock (1980), Adi Taha (1983, 1987, 1991), Michel Jacq-Hergoualc'h (1992, 2002) and Zuliskandar Ramli (Zuliskandar *et.al* 2012; Zuliskandar *et.al* 2018) published several sporadic researches on various materials remains of Ancient Kedah. The most recent study is done by Saidin (2016), who discovered a complex of iron smelting sites in Sungai Batu. The archaeological study in the Sungai Batu archaeological complex include survey and mapping, excavation as well as geo-archaeological study (Mokhtar, 2012; Zakaria, 2014; Aminuddin, 2015; Ahmad, 2016). Aside from archaeological research,

geomorphology study had also been conducted in the Bujang Valley to reconstruct the palaeo-environmnet of Ancient Kedah. These studies had been done by Intra-Asean (1980), Allen (1988), Khoo (1996) and Saidin (2011). However, their attempts to reconstruct the palaeo-environment only involved the area between the Muda river to the southern slope of Gunung Jerai.

Despite of the unique position of Bukit Choras, less attention had been given to the study of the site. The site had only been studied and reported by Low (Wales, 1940), Wales (1940) and Zakaria (1989). Bukit Choras was among the first archaeological site to be discovered in Kedah by James Low. According to Wales, Low approached the ridge from the west by using the Sala river route. Low reported the presence of a structural remains of a temple at the summit of the ridge, where he was believed to have dugged a trench in search of more antiquities (Wales, 1940). Bukit Choras was the first site to be studied by Wales during his archaeological campaign in 1937, and hence was named site No.1. During the study, Wales carried out trial excavations which partly exposed two structural remains, and several smaller artefacts (Plate 1.2).

Plate 1.2 Foundation of the Main Structure exposed by Wales
Source: (Wales, 1940)

Excavation of the main structure unveiled a laterite basement, with the measurement of 6.87 m long, 7.16 m wide and 0.91 m tall. To the south of the main structure, a flight of stairway was found, leading to another low laterite platform measuring at 6.4 m long and 6.7 m wide. A deep pit reported by Wales at the centre of this laterite platform was probably dug by the treasure hunter. For the main structure, Wales believed that a stupa had once stood on the basement, while the low laterite basement was probably the substructure of a wooden building. The structural remains of Bukit Choras are fully constructed of laterite bricks, which show similarities with the sites of P'ong Tuk, dated from the 6th Century C.E (Wales, 1940).

Aside from the structural remains, several artefacts had also been found. The most interesting discovery by Wales was an inscribed stone found at the roots of a tree located near to the low laterite platform, south of the main structure. This inscription was a small rectangular shaped slatestone measuring at 5.7 cm long, 2.4 cm wide, and 1.5 cm thick. It was engraved with 4 lines in Southern Indian script containing a Buddhist credo. This inscription is currently being preserved in the Asian Civilization Museum, Singapore. Other artefacts found in Bukit Choras include a roughly decorated potshard and 4 corroded iron nails (Wales, 1940). The scarce number of artefacts was probably due to the location of the site, at the peak of a steep ridge, where smaller cultural remains can be easily washed down by rainfall.

After the study by Wales in 1937, the site was left untouched until the year 1984 when Kamaruddin Zakaria, the then Curator of the Bujang Valley Archaeological Museum, conducted a survey at the site. He and his team cleared the area of 3200 square metres of bushes and undergrowth, exposing the structural and surface remains of the site (Kamaruddin, 1989). They have recorded two laterite basements previously reported by Wales (1940). According to Kamaruddin (1989), the main structure which

is still preserved is the base of the Stupa, while the square-shaped mound located 5 metres to the south of the stupa was believed to be a foundation of a building that functioned as vihara. In addition to the structural remains already mentioned by Wales, Kamaruddin also reported cultural remains not yet known prior to his survey. Thirteen metres to the east of the main structure, Kamaruddin (1989) recorded two large artificial trenches, believed by him to be remains of ancient water tanks. The first water tank is 20 meters long x 2.6 meters wide x 5 metres deep while the second one is 18 metres long x 14 metres wide x 8 metres deep. Kamaruddin Zakaria have also provided a pre-excavation plan of the structural remains visible on the surface and the water tanks situated to the east of the site (Figures 1.1 & 1.2). The pre-excavation plan by Kamaruddin only covered the visible part of the surface remains and have not provided clear description regarding the shape and dimension of the main structure.

The study in Bukit Choras by Low (Wales 1940), Wales (1940) and Kamaruddin (1989) consisted of trial excavations and surface survey to detect cultural remains at different locations within the site. However, these studies only focused at places where the surface remains can be easily observed though it is highly probably that more structures remained buried, hidden away from naked eye view. Despite of all these studies, questions regarding the layout of the site, origin of the building materials of the structures as well as the palaeo-environment of the area remained unanswered.

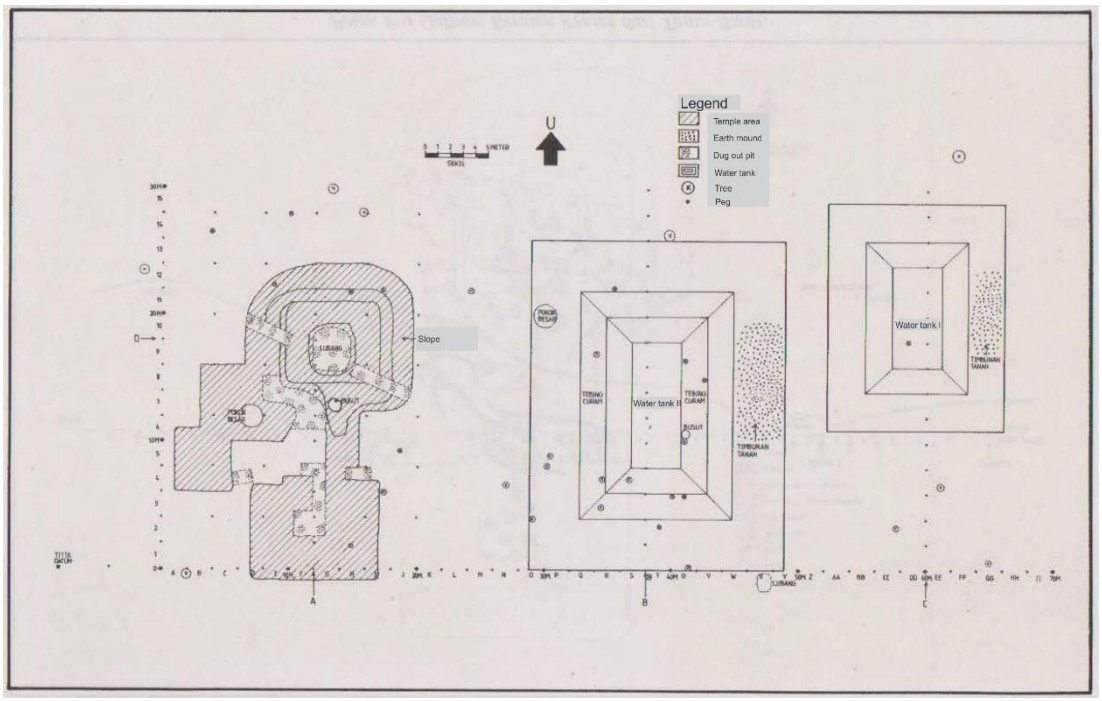


Figure 1.1 Pre-excavation plan of the temple and water tanks
Source: (Kamaruddin, 1989)

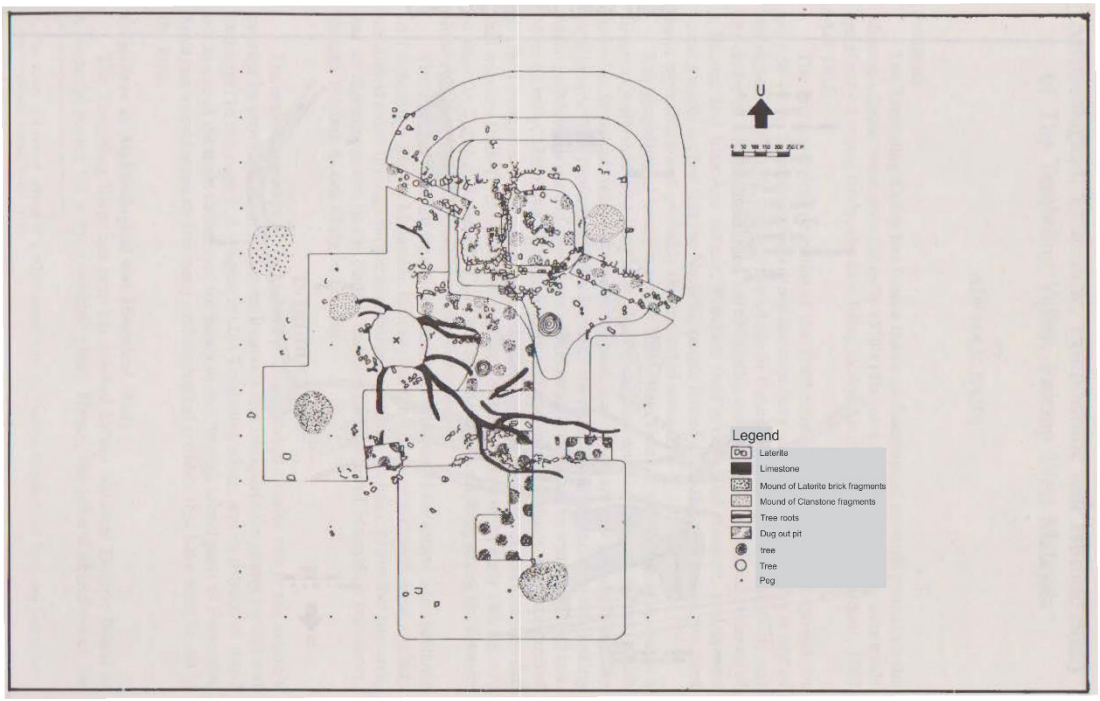


Figure 1.2 Pre-excavation plan of the temple
Source: (Kamaruddin, 1989)

1.4 Statement of problems

The layout of the site is unclear, Bukit Choras could have consisted of a main structure surrounded by subsidiary buildings. Previous works in Bukit Choras records a main structure, one low mound and two water tanks, without giving much attention to the traces of other cultural mounds. In addition to those observables on the surface, there could also have been sub-surface remains not visible to the naked eyes. Thus, the actual number of structural remains of Bukit Choras and the layout of the site is still unclear.

The origin of the building material has not yet been studied. The building material has not yet been studied, based on the surface remains, the site of Bukit Choras appears to have been fully constructed by laterite bricks, which mineral could be found around the area. However, question regarding the exact source from where the construction materials were mined or extracted, and how they were transported to the building site at the summit of the steep ridge has not yet been answered.

Paleo-environment of Bukit Choras is still unclear, During the development of Ancient Kedah from the 2nd to the 14th Century C.E., the geomorphological environment of the area is known to be extremely different, where the present days coastal dryland was submerged under the sea level. As for Bukit Choras, also it is presently located approximately 8 km from the coastline, during its period of development (6th to the 13th Century C.E), the environment could have been different. The paleo-environment of Bukit Choras has not yet been studied.

1.5 Research objective

To map the surface remains of Bukit Choras. In addition to the surface remains already reported by Low, Wales and Kamaruddin, there is a potential for more archaeological mounds possibly containing structural remains which have not yet been

detected. Thorough and more careful observation at the area topography and features of the soil surface can give important information regarding the presence of such finding's observable from surface.

To study the sub-surface remains. Based on the contour and distribution of scattered laterite bricks at the Bukit Choras site, there is possibility for more remains buried beneath the surface. The presence of such sub-surface findings can be detected by using various geophysical methods, which will in turn give useful information regarding the layout of the site, and potential locations for future excavations.

To identify source of the building material. The laterites used to construct the Bukit Choras structures were possibly extracted from the surrounding area. However, the exact location from where they were mined need to be studied, in order to understand how the material were transported and the manpower involved in constructing the site. The origin of the raw materials can be determined by comparing the trace elements of the bricks with the samples taken at various laterite-rich locations around the site. The mineral sample will be taken to the laboratory for scientific analysis and the data will be used for interpretation.

To study the paleo-environment in bukit Choras. In order to study the role and position of certain archaeological sites in the history of Ancient Kedah, it is important to interprete the data according to the environmental context, during which the sites were occupied. As for Bukit Choras which probably developed contemporary with other sites of Ancient Kedah, it is important to have some insights regarding the accessibility of the site from the river and coastline. Thus, a paleo-environmental study is important contextualize the findings according to its actual geomorphological setup during its period of occupation.

1.6 Scope of research

This thesis gives special focus on the geophysical survey and geo-archaeological study of Bukit Choras. For the geophysical survey, the magnetic, ground penetrating radar (GPR) and resistivity methods are applied. The geo-archaeological study, focus will be given to the paleo-environment study of the site, as well as the geochemical content of the structural remains. For the geophysical study, the survey covers 60 meter x 60 meter areas, corresponding to the areas where the surface finds such as structural remains, mounds, scattered bricks and the water tanks. There are two water tanks discovered by previous report, the water tank II is located only 13 meters from the main structure, while the smaller water tank I which is located further outside the research area is not covered in this study. As for the paleo-environment study, survey is conducted within the 5 kilometres radius of the site, covering the whole ridge of Bukit Choras, including Sungai Sala. This is to ensure the data obtained to be optimal and can be used to provide information on the paleo-environment of the area.

1.7 Arrangement of thesis

Chapter 1: Introduction, the first chapter introduces the Bukit Choras site, containing a review regarding location as well as previous works on the site. The statement of problems and objective of research presented in this topic become the main point of departure which justified this research, while the scope of research is being specified at the end.

Chapter 2: Previous research, contextualizes the study in Bukit Choras within the overall research of Ancient Kedah, as well as revising the previous works on geophysical survey and geo-archaeological study. The revision is done to demonstrate

the successful application of the geophysical and geo-archaeological research in other sites in the Bujang Valley, and the potential for such application in Bukit Choras.

Chapter 3: Methodology, discusses the research flow, as well as methodology adopted in this research. The methods and techniques used in the fieldworks, data collection and data analyses are described in detail, especially in terms of how they worked and how they contribute to achieve the research objectives.

Chapter 4: Fieldwork, this chapter describes the research process at the field, which is done to acquire data for this study, such as brick and mineral samples as well as geophysical data. The activities in the field involving site clearing, surface survey, contour and topographical mapping, as well as geophysical and geo-archeological are discussed in detail.

Chapter 5: Analysis and interpretation, discusses the analysis and interpretation on the data gathered from the fieldwork, consisting of mineral and brick samples, as well as readings from the geophysical survey. The analysis on the mineral and brick samples involving laboratory works such as XRD, XRF, SEM, radiocarbon dating and microscopic studies, and their results are discussed. As for the geophysical data, interpretation of the magnetic, resistivity and GPR reading are also presented. Finally, based on these analyses, conclusions are made regarding paleo-environment, origin of building materials, as well as the potentials for buried remains in Bukit Choras.

Chapter 6: Discussion and conclusion, this chapter summarizes the overall result of the research based on the fieldwork as well as scientific analysis and interpretation, involving the paleo-environment and position of the ancient coastline, the selection of raw material for the construction of the structure, as well as the potential areas for excavation at the site.

CHAPTER 2

PREVIOUS STUDIES

2.1 Introduction

The previous works chapter consist of discussion on previous study of geophysical and geo-archaeological that had been done in Bujang Valley. The geophysical study of Bujang Valley was mostly done in Sungai Batu complex from 2012 until 2016. These studies were done by Akma (2012), Izzati (2014), Muztaza (2015), Anwar (2015) and Nurashiken (2016). Geophysical methods that usually used in these archaeological sites were magnetic, resistivity and ground penetrating radar. Apart from geophysical studies, this chapter also discusses the geo-archaeological study of Bujang Valley. The geo-archaeological study in reconstructing Ancient Kedah paleo-environment had been carried out by the Intra-Asean (1985), Allen (1988), Khoo (1996) and Saidin & Komoo (2019). Studies on trace elements in bricks in order to discover the raw material of the ancient bricks used in Bujang Valley monument sites area also discussed. These studies were conducted in Pengkalan Bujang, Kampung Sungai Mas and Sungai Batu Archaeological sites.

2.2 Geophysical and Geo-archaeological study of Bujang Valley

The environmental settings of the Bujang Valley consisted of Gunung Jerai, the highest point of Kedah at 1217 metres in height. This imposing mountain was part of the Jerai and Mahang formation, consisting of igneous granite and quartz-porfyry rocks (Bradford, 1972; Almashoor, 1974). Gunung Jerai is surrounded by lowlands and small hills to the east and south, while being watered by the Merbok, Bujang and Muda rivers, forming fertile agricultural plains as well as mangrove swamps. Most of the archaeological sites of Bujang Valley are located at the banks of the Bujang and

Muda rivers, hilltops as well as near to the ancient beach ridges. Being positioned near to the coast and river valleys, the ancient settlement sites of Bujang Valley were subject to changes on the terrain from the presence of tidal plats, beach ridges and swales, natural levees and tributaries (Allen, 1988). As a result, the environment in which the sites of Bujang Valley flourished before the 14th Century C.E. was different than it is today. As for the building materials of the structural remains, they are usually obtained from the surrounding area in the Bujang Valley, mostly consisting of clay and laterite bricks, and in lesser extent granites and river pebbles.

Much research had been carried out to interpret the history and cultural features of Ancient Kedah based on the morphology, typology as well as the artistic attributes of the material remains which have already been acquired, either through excavation or random finds. However, another important aspect of archaeological study in the Bujang Valley, is to detect the presence of sub-surface structural remains, to trace the origin of the building materials, as well as to understand the paleo-environment of the area. To date, studies regarding the sub-surface remains, paleo-environment and origin of building materials have been carried out in the sites of Sungai Batu, Pengkalan Bujang, and Kampung Sungai Mas. These three areas are located near to the banks or tributary of the Muda, Merbok and Bujang rivers, and contained multiple sites clustered together as complexes. The application of geophysical and geo-archaeological methods had given important insights into the position of the structural remains within the contexts of the paleo-environment, as well as the usage of local resources to construct them.

2.3 Geophysical study

The Sungai Batu Archaeological Complex is strategically located at the banks of the Merbok river as well as near to the area which are rich in resources such as clay,

wood and iron ore. This has made Sungai Batu a thriving site for ancient iron industry as well as an important feeder point for Ancient Kedah's entrepot. Preliminary survey at the complex showed the presence of at least 97 potential archaeological mounds observable from the surface, where most of them have been excavated. Prior to excavation, geophysical study was first carried out to assess the potential of the sites regarding the presence and size of sub-surface structural remains. The geophysical survey had been adopted using the magnetic, resistivity and GPR methods by Mokhtar (2012), Zakaria (2014), Aminuddin (2015) and Ahmad (2016).

Naizatul Akma carried out detailed study in the site of SB2A for her Master's Thesis, which was previously recorded by Allen (1988) as site 71a. When first noticed, site SB2A was in the form of a small mound, with no surface remains. In order to study the terrain of the site and verify the presence of buried structural remains prior to excavation, the magnetic method of geophysical survey was carried out at the site, by using an instrument known as the magnetometer. The survey had given results, consisting of magnetic anomalies confined within the limits of the mound, consisting of five locations with low anomaly and three locations with high anomaly. The locations with high anomaly was suspected to be due to the presence of granite bedrocks (Dearing, 1994) while the locations with low anomalies probably resulted by the presence of remains for iron smelting activities which caused inverse magnetization (Mokhtar, 2012). Out of the eight locations, four locations had anomalies suggesting the presence of tuyere dumping chambers, iron waste disposal sites and iron smelting preparation sites (Mokhtar, 2012).

Based on the geophysical data, these four locations with high and low anomalies, suggesting buried remains were proposed for excavation (Mokhtar, 2012). The excavation had confirmed the geophysical results, unearthing iron slags, iron ores

and tuyeres underneath the mound (Mokhtar, 2012) and showed the role of the area as an iron smelting site.

Iklil Izzati (2014) studied the sites of SB2B and SB2D for her Masters Tesis. When the two sites were first documented, they consisted of low mounds and surface finds of broken bricks (Zakaria, 2014). Prior to excavation, magnetic method of the geophysical survey was carried out at the site SB2B and SB2D to detect buried cultural remains and determine the sites' potential for excavation. The study had resulted with low anomaly, probably showing that the structural remains only consisted of only several layers of bricks. Excavation on both sites is consistent with the geophysical result, unveiling the remains of brick pavements and ruins of low wall

The site of Kampung Perahu, Jeniang is located at the upper reaches of the Muda river, approximately 24 km from the Sungai Batu Archaeological Complex. Although the site is not part of the Sungai Batu Archaeological Complex, surface findings consisting of a mound, as well as the upper part of a furnace show that they could have also functioned as iron smelting sites. Prior the excavation, geophysical survey was carried out at the site, using the resistivity and GPR method to study the sub-surface remains and confirm their potentials for excavation (Muztaza, 2015). The resistivity study shows anomalies with low resistivity values at 1.5 m in depth. To confirm the resistivity survey data, the GPR with 250 MHz antenna frequency was used to identify the buried structure. Standard GPR antennas used in archaeology propagate radar energy that varies in bandwidth from about 10 MegaHertz (MHz) to 1200 MHz (Conyers, 2009: 247). The GPR method had also resulted with an anomaly also suggesting the presence of buried remains resembling a furnace. Comparison of the results of these two geophysical methods indicates that the two locations in Kampung Perahu contain buried archaeological remains. An excavation was

conducted and revealed the buried furnace, consistent with the resistivity and GPR data.

SB1M and SB1N are another two sites in the Sungai Batu Archaeological Complex, studied by Anwar (2015) for his Master's Thesis. The surface finds consisted of low mounds as well as brick fragments. The magnetic method was used to study the possibility for the presence of buried cultural remains. For the magnetic method, the survey area is divided into 2 anomaly area that is low and high magnetic anomaly area. Excavation had successfully exposed brick structural remains as well as other artefacts such as earthenwares, tiles and iron objects, and confirmed the magnetic survey data.

Nurashiken studied the sites SB1R, SB1S, SB1T, SB1U, SB1V and SB1Z of Sungai Batu for her Master's Thesis. The resistivity and magnetic method were used to study the potential for sub-surface remains. The resistivity method showed the low resistivity value, which implied the presence of ancient riverbed. As for the magnetic method, this site consists with both low and high magnetic anomaly. The high magnetic anomaly result was implicating by the presence of buried solid structures and it is corelated with the presence of surface remains, low mounds as well broken bricks on the area. Excavation at these two areas exposed brick structures consisting the remains of wall, pavements, stairs and pillar bases, which confirms the magnetic studies.

2.4 Geo-archaeological study

The geo-archaeological study covered two part of previous related study that is paleo-environment and the geochemical composition in building material. The paleo-environment study is discussed on the Bujang Valley southern area. Meanwhile,

the geochemical study of building material will be referred from previous study of Pengkalan Bujang, Kampung Sungai Mas and Sungai batu archaeological complex.

2.4.1 Paleo-environment study

Interpretations on the archaeological findings in the Bujang Valley should be done according to the pre-14th Century environmental context. This is due to the fact that geomorphological changes from the decline of Ancient Kedah until today had significantly changed the locations of the coastline and silted up the ancient rivers, to the extent that the once strategic location of certain sites rendered obsolete. Thus, it is important that the form of geomorphological and geological setup during the period of occupation of certain archaeological sites to be studied by using geo-archaeological approach, which is by assessing the locations of the sites and studying the soil samples. Attempts to reconstruct the paleo-environment by studying the geomorphology of the Bujang Valley and correlate them with the sites of Ancient Kedah had been done by the Intra Asean (1980), Allen (1988), Khoo (1996) and Saidin & Komoo (2019).

The first study regarding the geomorphology of the Bujang Valley was done by Intra-Asean Research group in the 1980s. Their research revolves around the preliminary survey around the Merbok and Muda river valley. The purpose of this study was to divide the area of Bujang Valley into several parts and determine the locations of the ancient coastline in correlation with the position of the archaeological sites. The research methods adopted for this study included the interpretations on the aerial photography and topography as well as the analysis on several archaeological site based on the contexts of their chronology and relationship with the geography of the study area (Intra-Asean, 1980). According to the research, Bujang Valley can be divided into three main units which are a. the uplands b. river sediments and c. marine geomorphic. The location of the ancient coastline and the archaeological sites in

Bujang valley can be correlated based on the observation on the marine geomorphic unit. This study resulted with the identification of locations of ancient coastlines with different dates, suggesting that the geomorphological changes happened gradually over a long period of time. In this study, the researchers only managed to determine the location of the ancient coastlines which corresponded with the locations of the sites. The geomorphological changes of Bujang Valley have not been demonstrated in chronological order as all the different coastlines are placed in a single map (Figure 2.1).

Despite of the weakness in this study, the preliminary data gathered from this research became important precedence for future works in this subject.

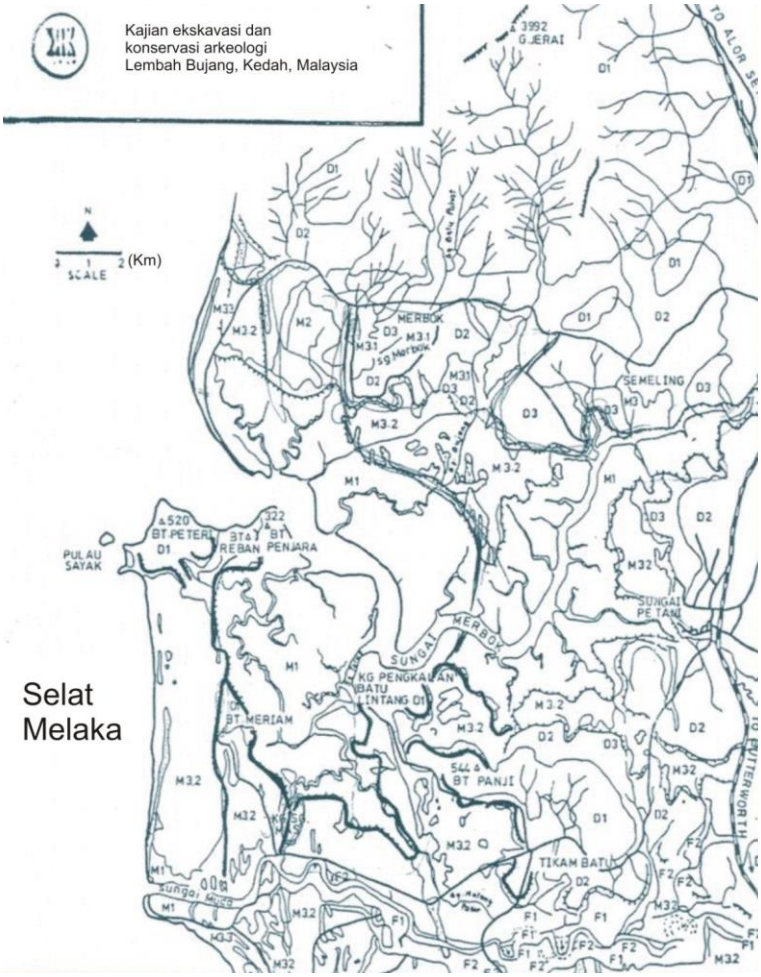


Figure 2.1 Intra-Asean Geomorphology Map.
Source: (Intra-Asean Archaeological Excavation and conversation Project, Bujang Valley, 4-27 October 1985)

Allen had carried out a geomorphological survey in the Bujang Valley, involving the study of sediment and soil samples as well as radiocarbon dating on various 14C samples. Allen (1988) proposed that the geomorphological changes in the Bujang Valley had less to do with changes of sea level, but was due to river sedimentation, accelerated by agricultural activities in the hinterland between the 11th to the 14th Century C.E (Figure 2.2). As the river deposited more sediments, this led to a rapid siltation process which eventually changed the coastline (Allen, 1988). After the 9th Century C.E., the coastline changed at the rate of 1 km per 100 years. She divided the chronology for the geomorphological changes in Bujang Valley into 6 phases, the final phase is in the 15th Century C.E., which coastline remains to this day. The study of Allen shows that in the 9th Century C.E., the Merbok River was a large bay, into which the Bujang, Muda, Simpor and Batu Pahat rivers flowed. As time progresses, the bay narrowed due to the siltation process, forming the Merbok river that we know today. However, the weakness in Allen's works lies in her assumption that the sedimentation process happens at a constant rate. In addition, her reconstruction should take into account factors of sea-level changes as it has influenced the geomorphology elsewhere.

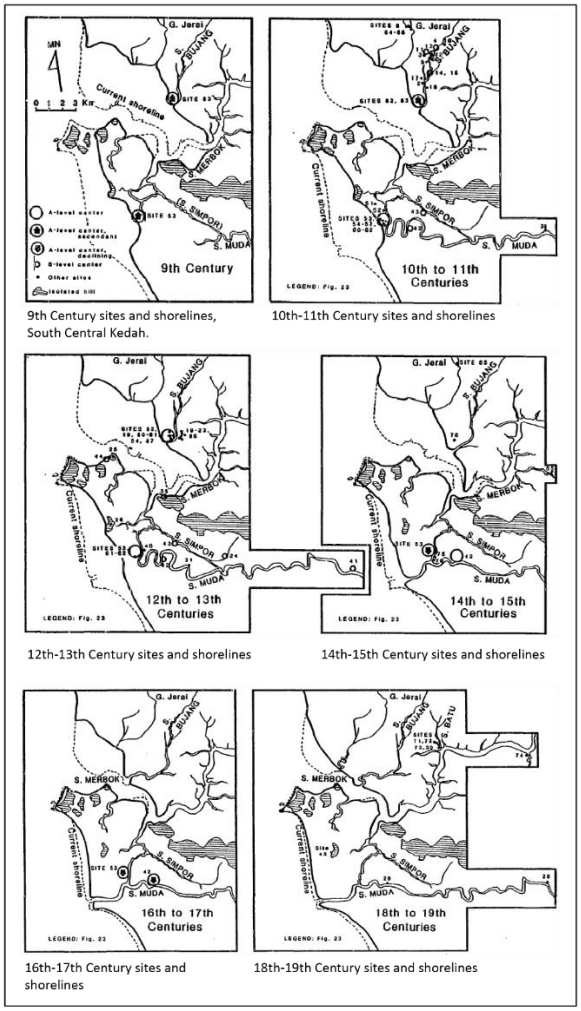


Figure 2.2 Geomorphology Map.
Source: (Allen, 1988)

Another geomorphological study in Bujang valley was conducted by Khoo which covers an area from the southern slope of Mount Jerai to the Muda river. The purpose of his study was to reconstruct the coastline of Bujang Valley during the development of Ancient Kedah before the 14th Century C.E. Khoo (1996) had taken into consideration the geomorphological formations resulting from changes of sea-levels since 4000 years ago in Langkawi, Perlis, Pulau Tioman, Pulau Redang and the coast of Kedah. His analysis on the distribution of soil types, location of coastal sediments dating of seashells as well as the correlation between the geomorphological features and locations of archaeological sites had given important insights into the

changes of coastline in the Bujang Valley. Unlike Allen, Khoo believed that the geomorphological changes in the Bujang Valley was due to the changes in sea-level and less influenced by river sedimentation. His study shows that between 600-640 BC to 1300 AD the coastline of the Bujang Valley remained the same, with no significant changes to the sea level (Figure 2.3). During this period, the Bujang Valley existed as a large bay protected by small islands and two sand ridges to the west, while Gunung Jerai was a promontary projecting into the Straits of Malacca. The Bujang river emptied into this bay while the Muda river emptied into the Straits of Malacca to the South.

Most of the archaeological sites were located either on this bay's shoreline, estuary and banks of the Bujang, Batu Pahat and Muda rivers or on the islands. After 1300 AD, the sea level dropped, and the bay started to silt up with marine sediments (Figure 2.4). In the period of less than 200 years, the bay narrowed, covered in mud and turned into mangroves. In the early 15th Century C.E., the bay finally transformed into the Merbok river that we see today. Although the geomorphological reconstruction was consistant with the locations of most archaeological sites at the Bujang and Batu Pahat rivers as well as most sites located at hilltops such as Bukit Meriam, Bukit Penjara and Bukit Batu Lintang. However, the sites in Kampung Sungai Mas, Simpor Tambang and Kampung Sireh had not been taken into consideration.

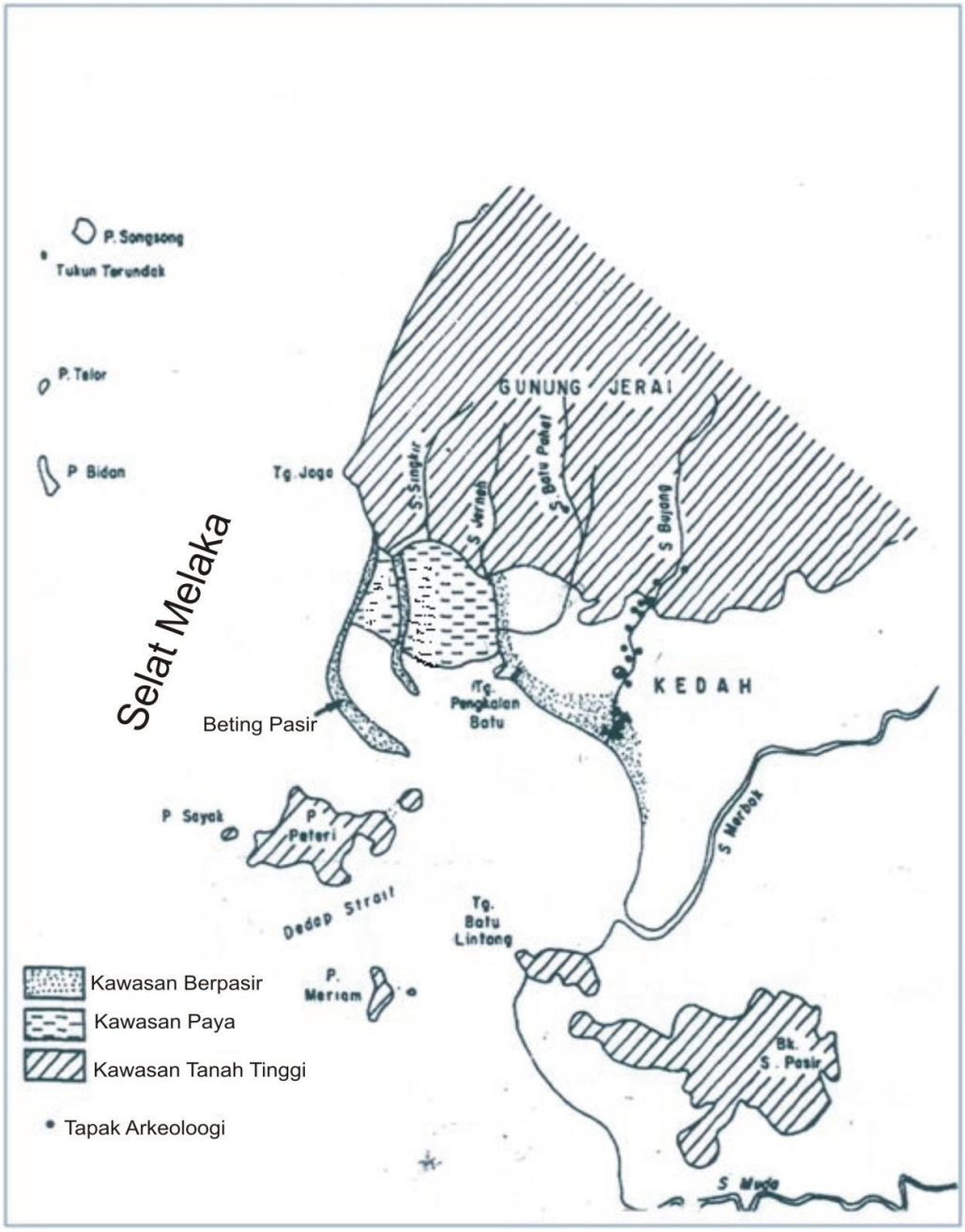


Figure 2.3 Early Coastline of Kedah Tua Map
Sources: (Khoo, 1994)