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Review Article

Traces of ancient Sungai Batu flow and trading complex from geophysical surveys and archaeological excavations

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Abstract

Excavations in Sungai Batu have revealed numerous archaeological artifacts that link Sungai Batu to a life heavily associated with trading. The discovered artifacts originated back to the 1st century; therefore, was established as one of the oldest known civilization in Southeast Asia. This encouraged researchers to dig deeper on Sungai Batu's archaeological events; however, many of the studies were relatively superficial and did not portray the dynamics between Sungai Batu trading complex and its ancient river as a whole but explained in localized sections. This paper seeks to provide a conclusion of the past events in the area based on geological, geophysical and geotechnical studies. The discussions include tracing the ancient Sungai Batu flows and the trading complex for better illustration of their associations so that future archaeological endeavors could discover more trade and religious artifacts aside from jetty structural remains, iron smelting sites, potteries and stupa at Sungai Batu.

Keywords: Sungai Batu, ancient river, trading complex, entrepot

1. Introduction

As the richest archaeological zone in Malaysia, Lembah (Valley) Bujang covers an extensive area of roughly 224 km^2. The region consists of three archaeological complexes; Sungai Batu, Sungai Mas and Pengkalan Bujang. Sungai Batu was named after a tributary river that flows into the area. Civilizations at Sungai Mas and Pengkalan Bujang emerged only after Sungai Batu complex started to decline economically; hence, are chronologically younger (Murphy, 2018). Sungai Batu complex possessed abundant archaeological structures and artifacts that could unravel the history of human activities (primarily trading activities), the geographical changes of Sungai Batu ancient river and ancient coastline.

With numerous studies that began more than a century ago, this brought about mismatched and unorganized interpretations on the matter. Seeking for strong legitimacy, this paper summarized a great number of studies regarding Sungai Batu trading complex and its ancient river in order to align the archaeological events accordingly for future references. 2D resistivity method was employed as the initial step in understanding Sungai Batu's geology with the assistance of physical samplings from borehole data and auguring. Traces of ancient Sungai Batu flow was also investigated using magnetic and 3D resistivity method in conjunction with physical samplings (Nordiana *et al.*, 2013; Saad, Saidin, Fauzi & Tarmizi, 2015; Yusoh *et al.*, 2018).

2. Location of Lembah Bujang

Lembah Bujang is situated in Kuala Muda, Merbok (Southern Kedah) and covers an area bordered by Mount Jerai in the north, Muda River in the south, Sungai Petani in the east and Straits of Malacca in the west (Roslan, Noor, Abdul lah & Ali, 2016; Saad *et al.*, 2015). The 1217 m high Mount Jerai, the highest point in the area, was particularly useful

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during active trading period in Lembah Bujang as it served as a landmark for traders and mariners (Zakaria, Saidin & Abdul lah, 2011). Principal rivers that flow into the valley include Sungai Merbok, Sungai Muda and Sungai Bujang which drains into the straits (Figure 1a); therefore, were prime areas for archaeological investigations as they held attractive features for living settlement due to close proximity to food sources and fertile land (Haughey, 2009; Washburn & Lan caster, 1968; Yesner, 1987). It is clear that most of the archaeological sites were found at very close distances to the rivers and coastal line, as supported by the 86 sites found in Lembah Bujang (Allen, 1991). However, changes in physical environment (river course or sea level rise) at some point of the history caused some sites to be located further inland as seen at Sungai Batu, Gunung Jerai and Tikam Batu sites.

Key interests in Lembah Bujang archaeological sites include Sungai Batu, Pengkalan Bujang and Sungai Mas archaeological complexes. However, this paper focuses on Sungai Batu archaeological site where a tributary river (Sungai Batu) that branches off from Sungai Merbok played an important role in archaeological perspective (Figure 1b).

3. Geography and Sea Level Changes around Sungai Batu

Geographically speaking, surface observations at Sungai Batu (Figure 1b) depict that the region is largely covered by palm and rubber trees with localized swamps. Two rivers; Sungai Merbok and Sungai Bujang flank each side of the archaeological complex. The elevation surrounding the complex is relatively flat with less than 25 m height (Figure 2); hence, could be considered as a flood plain zone due to close proximity to rivers.

In terms of shoreline, a large part of Lembah Bujang was engulfed by the sea during the 1st and 2nd centuries due to high sea level at the time (Saidin, 2011). This explains the interior localities of archaeological sites depicted by Figure 1A as a result of limited land at the time. In the 9th–13th centuries, the shorelines were more or less similar during the high-water level except for the changed in Sungai Muda flow course (Figure 3). Drastic changed of shoreline could only be seen in the 14th–15th centuries where the receding sea level caused an abundant of sediments brought by sea and river to be deposited onto the shore. This event encouraged coastal land development and subsequently contributed to the prominent sandy-clay soil deposited in the area (Wheatley, 1961; Allen, 1990).

4. Geology of Sungai Batu

A large part of Lembah Bujang overlies a broad band of Quaternary beach ridges (Matang Gelugor Member) that extends up to 8 km inland (Bosch, 1988). On the contrary, older Mahang Formation dated from Middle Ordovician to Early Devonian underlies the eastern and southern flanks of Sungai Merbok (Habibah, Wan Fuad & Mohamad, 2004). The formation composes of shale, red slate, grey slate and black slate. However, the shallow subsurface of Sungai Batu complex is primarily made of fluvial sandy clay soil.

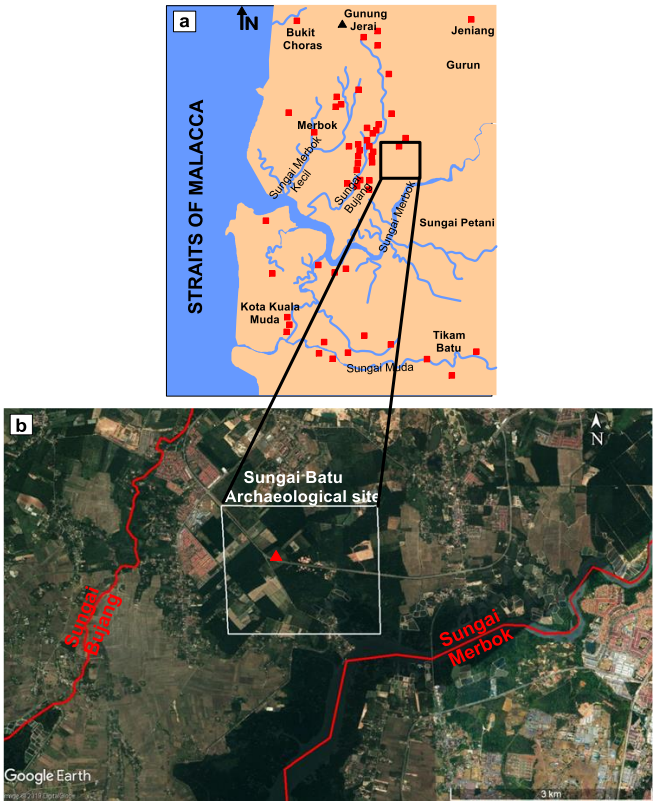

Figure 1. Known archaeological sites in Kedah where a) depicts the sites' locations relative to neighboring rivers while b) shows Sungai Batu archaeological site relative to Sungai Bujang on the west and Sungai Merbok on the east.

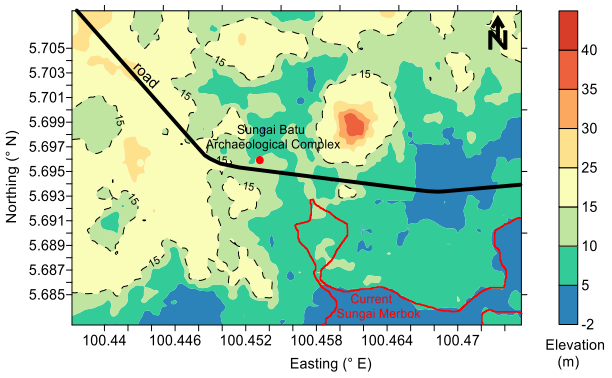

Figure 2. Topography surrounding Sungai Batu Archaeological Complex and Sungai Merbok which illustrates that the majority of the area is a flood plain zone.

A detail mapping of Sungai Batu's shallow subsurface was conducted in the last 15 years using not only archaeological methods, but also utilized geophysical methods such as 2-Dimensional (2-D) Resistivity Imaging, magnetic and remote sensing methods. The location of several studies conducted in the Sungai Batu complex are depicted in Figure 4. Alashloo *et al.* (2011) investigated the type of soil in Sungai Batu site by implementing 2D resistivity imaging with maximum penetration depth of 31 m. The results depicted that the subsurface could be categorized into three layers; unsaturated alluvial soil (sand and clay with occasional boulders) upper layer that have maximum thickness of 10 m, followed by saturated alluvial soil with thickness of up to 20 m and lastly underlain by hard bedrock. The first layer has relatively higher resistivity values (50–1,000 Ωm) compared to the second layer (<50 Ωm) due to difference in moisture content. The bedrock could be easily recognized due to its high resistivity values (>1,000 Ωm).

Samuel, Saad, Muztaza, Ismail and Saidin (2016) had further divided the upper layer into two more layers based on resistivity, magnetic and auguring methods at Sungai Batu (Figure 5) in the 14 m penetrated depth. Conducted just opposite of Alashloo's study area, this study shows that the topsoil (0–3 m depth) in the first layer has lower resistivity values of <200 Ωm due to sticky clayey material with decayed organic materials in the shallow subsurface. Muscovite was also found in the soil sample, suggesting a close proximity to sediments source considering that muscovite is a soft mineral; thus, is easily weathered**.** Going further down until 5 m depth, the upper layers change in grain size with the presence of sandy clay having values ranging from 73 to 152 Ωm. Furthermore, Ismail, Nordiana, Saidin, Masnan and Abir (2018) selected SB1 and SB2 sites in Sungai Batu to run resistivity survey on top a mound with exposed baked-clay bricks. Within the 10 m depth from ground surface, two distinct layers could be distinguished; top brick layer with high resistivity values (≥3,000 Ωm) and lower alluvial soil layer with low resistivity values (50–100 Ωm). The bricks, which were identified to be a floor structure, are highly resistive to current flow due to the intense ceramic bonds form at high temperatures (500–800 °C). A schematic diagram of the subsurface is demonstrated in Figure 5 based on these data.

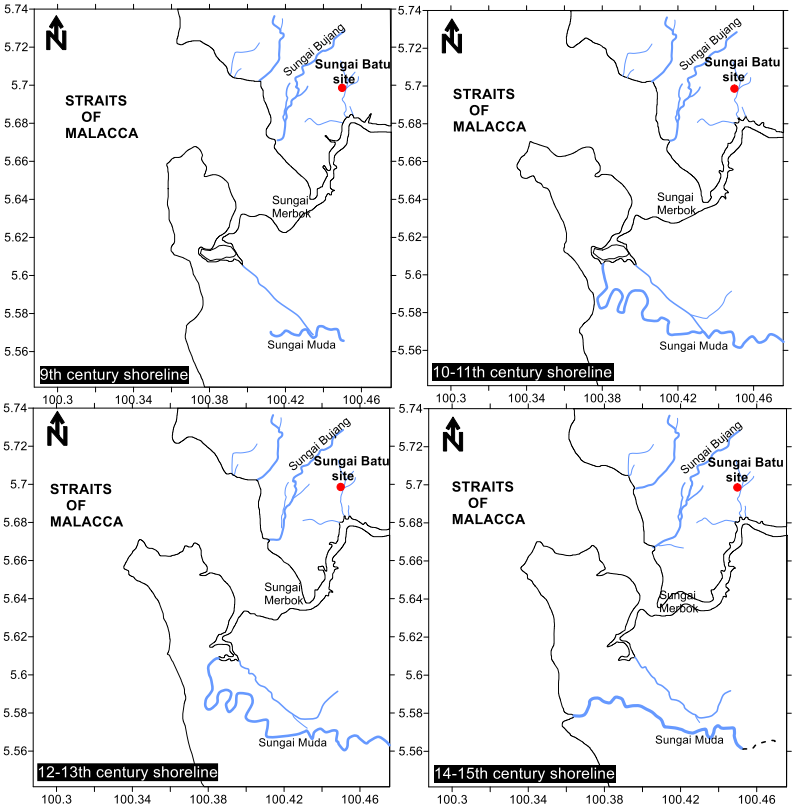

Figure 3. Shoreline regression throughout the 9th until 15th centuries relative to Sungai Batu site that caused the exposure of landmass (modified from Allen, 2000).

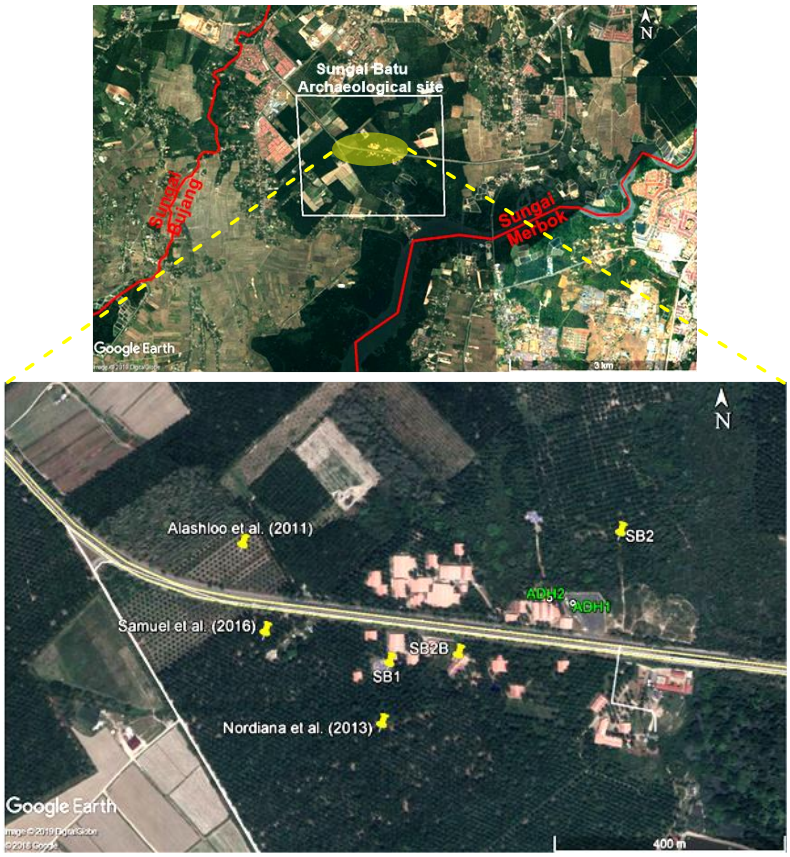

Figure 4. Location of Sungai Batu sites done by several researches which were all within 500 m radius.

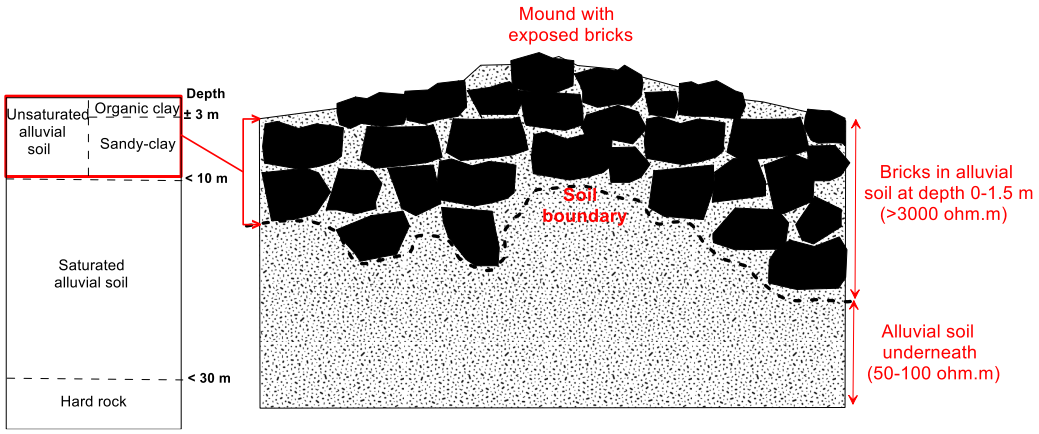

Figure 5. Schematic diagram of Sungai Batu's lithology and the relative position of the archaeological floor structure in the form of a brick mound.

5. Ancient River Flow at Sungai Batu

Believing that Sungai Batu used to flow in a more extensive area, Nordiana *et al.* (2013) conducted a comprehensive study to predict the ancient river flow in the archaeological complex through physical samplings (two boreholes) in the area (Figure 4). In less than 2 m depth, a hard layer of iron pans was detected in boreholes ADH1 and ADH2. This signifies an occurrence of iron-rich fluid oxidation and silica loss that typically transpired due to surface exposure or at very shallow subsurface (Saidin, 2009). At depths of <5 m, the boreholes exhibit stiff silty clay-soil layers in the area with SPT N-values of more than 30. Muscovite was also found in the alluvial deposits here**.** Presence of iron pan and muscovite at these sites suggests the possibility that they were previously situated on a river bank.

Based on magnetic residual results in Sungai Batu by Saad *et al.* (2015), two zones were categorized where low magnetic residual values of <0 nT is believed to be an ancient river (alluvium) whereas the high magnetic values of >0 nT is

unlikely to be one. While most of magnetic surveys used in archaeology were used in mapping fire-related artifacts (burning causes soil susceptibility to increase), occurrence of naturally high susceptibility soil in the absence of burning does exist due to the presence of fine-grained soil such as clay and silt which contain a large amount of iron (Crowther, 2003). Using the produced magnetic residual map, the ancient river and present Sungai Merbok were mapped onto the present elevation map (Figure 6). The existing Sungai Batu has an average width of only 35 m as it is a tributary river from Sungai Merbok. However, the suspected ancient tributary river used to have a longer route and flowed further into the land from the primary Sungai Merbok. Traces of the ancient river extend up to 1 km in width which flowed roughly from northwest to southeast direction.

Another detail survey was done by Yusoh *et al.* (2018) which covered almost the entire Sungai Batu archaeological complex in an attempt to map the ancient river using 3-Dimensional Resistivity method. 11 resistivity lines were conducted to generate a dense data for good subsurface visualization. In contrast to the location suggested by Saad *et al.* (2015), the ancient river identified from resistivity method was at the eastern zone of the complex. Figure 7 depicts the suspected ancient Sungai Batu with resistivity values of 0–45 Ωm where the 3-D models were sliced at two different depths; 0–6 m and 12 m. The shallow depth slice (Figure 7a) has similar resistivity values up to 6 m depth that extends up to ± 600 m in width. This indicates that the area composes of both the ancient river and its floodplains. The shallow depth slice also shows two paths of river flows; western and eastern flow-paths that were separated by roughly 200 m distance but became interconnected down-stream. In the 12 m depth slice (Figure 7b), traces of the eastern ancient river start to diminish whereas the western river's traces are still clear until 21 m depth, thus indicating that the western river was not only flowing deeper, but is older too. Any traces of the ancient river courses throughout the centuries completely diminished at 33 m depth.

With regards to previous studies discussed beforehand, the ancient rivers mapped by Saad (2015) and Yusoh *et al.* (2018) tallied with borehole results by Nordiana *et al.* (2013), seeing that both ADH1 and ADH2 were situated on the riverbanks of the proposed ancient river (Figure 8).

6. Trades in Sungai Batu, Lembah Bujang

Lembah Bujang is situated at the northern part of Straits of Malacca which was one of the key factors that boost the region into life, subsequently became a strategic port for trading and industry due to its prime location. With close

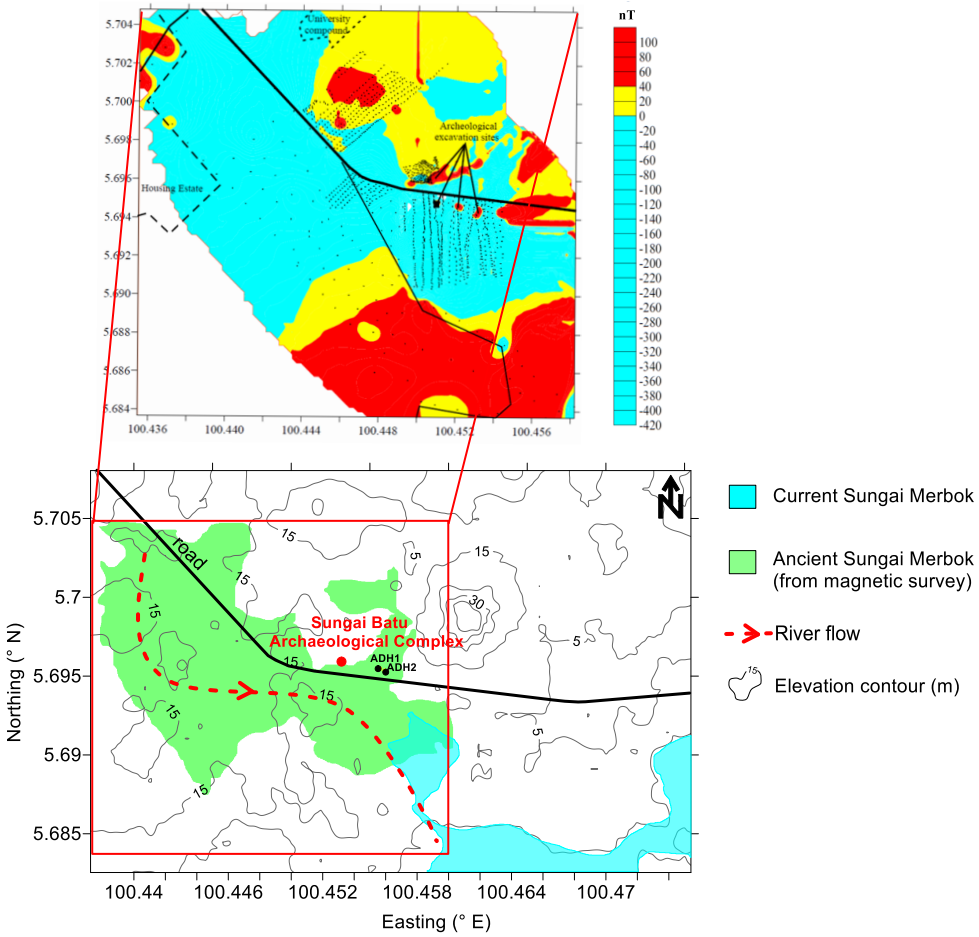

Figure 6. Ancient and present Sungai Batu flows based on magnetic data overlaid on top of elevation map of Sungai Batu archaeological complex.

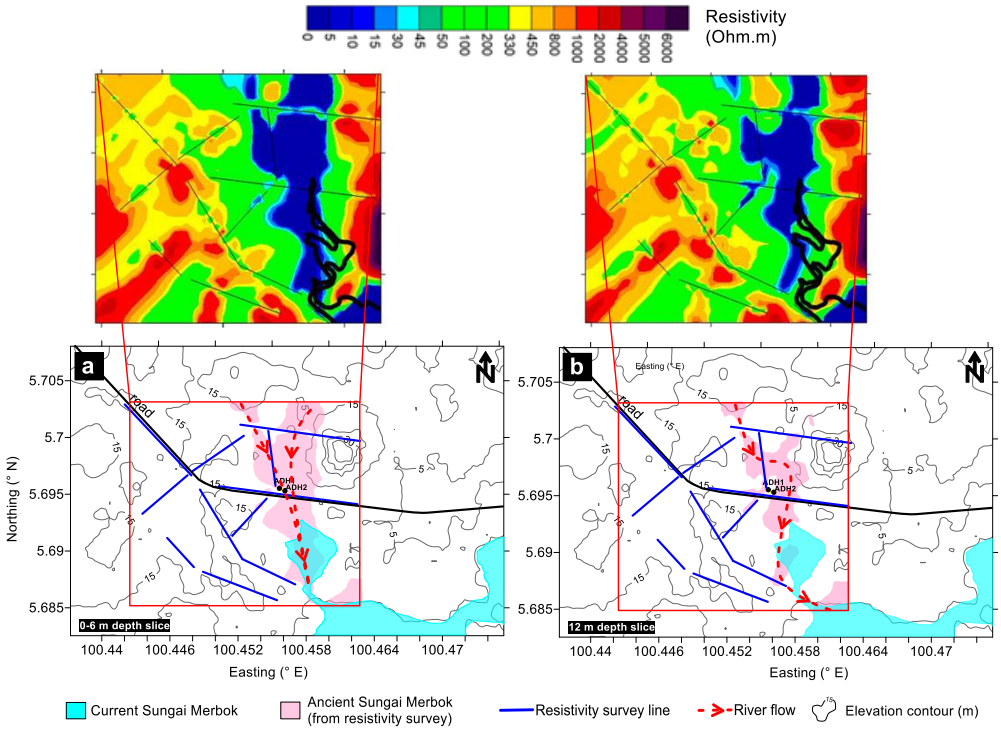

Figure 7. Ancient and present Sungai Batu flows based on resistivity data where a) is depth slice of 3D resistivity model at 6 m while b) at 12 m depth.

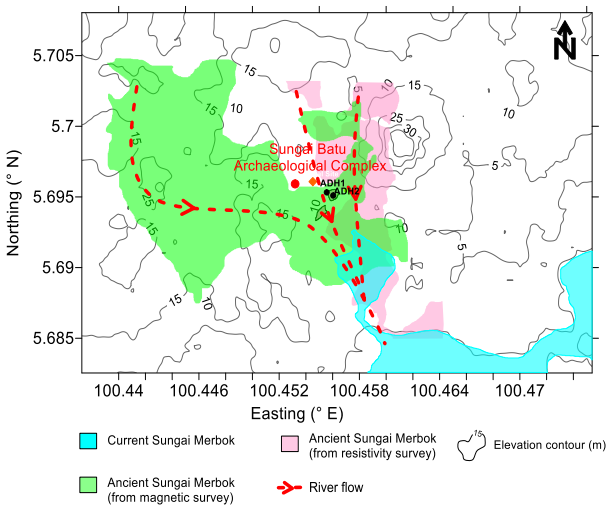

Figure 8. Integration of suspected ancient river flows mapped by Saad *et al.* (2015) and Yusoh *et al.* (2018) using resistivity and magnetic surveys.

proximity to the straits, Lembah Bujang was the pioneer of Kedah Tua Kingdom's civilization (Bellwood 1997; Jacq-Hergoualc'h, 1992). Up to present, abundance of relics, ancient structures and iron foundries were discovered in Sungai Batu archaeological complex. These brought to light that the complex was founded around 110 AD (2nd century) based on laboratories results of these artifacts such as jetty remains, iron smelting sites and a clay brick monument (Nordiana *et al.*, 2013). Two structures that have come to light, a possible stupa and a jetty, may date as early as the 1st–2nd centuries CE, while an iron smelting site has been dated to the 3rd–6th centuries CE. These results now indicate that Sungai Batu is chronologically older than it was previously thought (Nordiana, 2014).

Accommodated with fertile land and nearby water resource, the land flourished around the 4th century and continued to expand economically via trading surge. Lembah Bujang is believed to be not only the earliest entrepot but also a religious center in Kedah based on the discoveries of Hindu-Buddhist temple, statues, porcelain, beads and many other artifacts (Rahman, 2008; Wales, 1970). Presence of traders brought about a variety of artifacts in Lembah Bujang such as seen by the discovery of a brick structure in Sungai Batu that appears to be associated to either Buddhist or Hindu (Allen, 1991). On top of that, a Buddhist stone inscription was also recovered that was dated to be from the 5th – 6th centuries (Zakaria *et al.*, 2011). With more than 90 archaeological mounds recognized in Sungai Batu with high artifacts potential, SB2B and SB2D (Figure 4) are among those that have been excavated to reveal an ancient river connected to the Sungai Batu fluvial system (Zakaria *et al.*, 2011). Structures made of brick, roof tiles and timber-log pillar highly suggest that they were previously a river jetty, in conjunction with their strategized location and the structures' condition (water-damaged) as depicted in Figure 9. Jetty is an important means to facilitate water and landmass' related activities such as trading (Giri, 2004). Along with the structures came the relics such as potsherds, beads, stone tools and iron slags. Charcoal sample taken here indicated that it was from the 5th century via radiocarbon dating. Together with previously dated artifacts, these results illustrate that the jetties were associated with iron smelting activities not just during the 5th

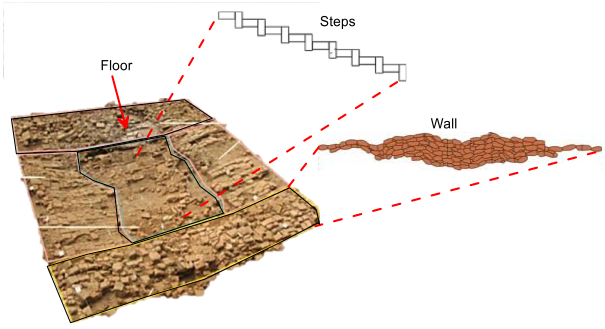

Figure 9. Jetty remains consist of floor, steps and lens-like wall structures found near ancient Sungai Batu channel (modified from Zakaria *et al.*, 2011).

century but even back in the 1st century. Jetties were primarily useful for loading and unloading of trade commodities that were also inclusive of iron ores, hence indirectly endorsing the existence of an upriver-downriver economical interaction and the occurrence of iron-based trading in Sungai Batu while concurrently acted as a religious center. Gradually, Lembah Bujang evolved to a collecting center for trading goods from all over Malay Peninsula before it was established as an entrepot in the 7th century AD (Omar, Mohammed, Nordin, Johari & Ibrahim, 2010).

A turn of events transpired when Lembah Bujang fell under the influence of Srivijaya in 670 AD, resulting that the influential region to be under Srivijaya's control for more than 400 years before Lembah Bujang regained its power at the end of the 11th century due to the crippling of the Srivijaya Empire**.** In the 14th century, Merbok Estuary continued to evolve as an influential port and trading center that catered both local and international traders including China, India and the Middle East as it became an extensive entrepot on the west coast of Thai-Malay peninsula (Khoo, 1996). Carnelian beads and Guangdong ceramic were among the discovered trading products in Sungai Batu site that proved the international relationship between Lembah Bujang and foreign countries (Zakaria *et al.*, 2011). Although Sungai Batu was blessed with favorable bay and estuary, changes of monsoonal seasons were among the favorable factors that force ships to layover for months to wait for the winds to change direction (Murphy, 2018).

Sungai Batu ancient river's headstream came from Mount Jerai, known as the landmark of the Bujang Valley. Allen (1988) did not characterized Sungai Batu Complex as one of the trading sites, although its river played a vital role in connecting remote areas to Sungai Merbok that flows into the Strait of Malacca due to its strategized location; on the banks of ancient rivers. Despite that, iron smelting site discovered in Sungai Batu (SB2B and SB2D sites) suggested otherwise as this discovery proved that Sungai Batu was once a site for iron accumulation before being exported (Mohd, 2009). Sungai Batu port was used in transporting trading commodities to areas along the river as iron ores were found at both Sungai Batu and Mount Jerai neighborhood (Almashoor, 1974; Bean & Hill, 1969; Bradford, 1972). Other than iron, forest products were also one of the traded commodities here as the area was rich in forest resources (Dunn, 1975; Kathirithamby-Wells & Villiers, 1990).

Sea level and river course changes also have significant impact on the location of the Lembah Bujang's entrepot. During the 1st – 6th centuries, Sungai Batu was among the few places on Lembah Bujang's limited land that was not submerged during high sea level (Saidin, 2011). Considering the close proximity of Sungai Batu to the shoreline connecting to Straits of Malacca combined in conjunction with the presence of Sungai Batu tributary channel for trading pathway, trading initially began here. As shoreline shifted with time (sea level receded), new passageways opened which provided better paths for traders and mariners into Lembah Bujang, thus promoted other entrepots to took over Sungai Batu such as Pengkalan Bujang and Sungai Mas as illustrated in Figure 10 (Murphy, 2018; Saidin, Abdullah, Osman & Abdullah, 2011). Sungai Mas and Sungai Bujang were either submerged or were too swampy to be inhabited in the 1st–3rd centuries, but they later were more viable for access from Straits of Malacca compared to Sungai Batu as sea level and river courses changed over time. These eventuated the rivers and streams to become clogged with silt and clay as the coastal plain continued to grow before finally succumbed to permanent landlocked and ceased as a viable location for maritime trade.

7. Conclusions

A wide range of studies were executed at Sungai Batu archaeological complex, yet most provided little satisfaction to literate on. This paper presented the overall review in an organized manner based on the studies conducted. Geological, geophysical and geotechnical results complimented each other which gave rise to the discovery of potential locations of ancient river flow in Sungai Batu. Series of studies, excavation and dating tests done revealed that Sungai Batu was a popular trading complex based on remaining jetty structures, iron smelting site and clay brick monuments. Bricks, roof tiles and timber-log pillars attest to the existence of jetty that was once situated here. Trade-related artifacts excavated

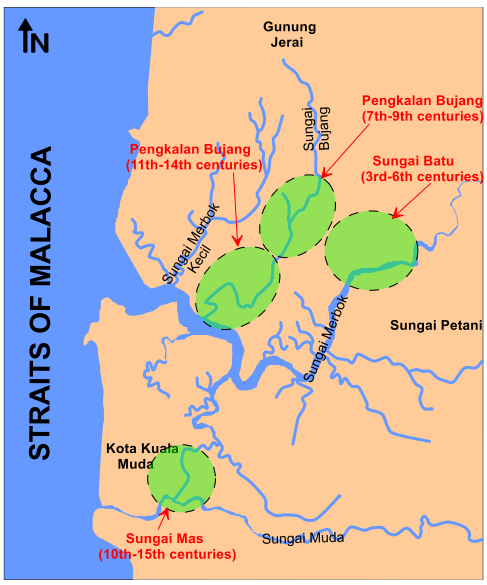

Figure 10. Shifting of trading ports throughout the centuries as an impact from sea level and river course changes.

were situated on the river banks of the predicted ancient Sungai Batu, therefore provided a strong support on the matter**.** Sungai Batu complex was not only a trading center but also served as a religious center. All these attributes were due to the strategic location of Sungai Batu during the long period of high sea level which was above sea level and near the straits, thus permitting the complex to hold its stature as an entrepot for several centuries.

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