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Geochemical characterization of pottery shards unearthed from Kampung Baru Archaeological Site, Kedah, Malaysia

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Abstract: Candi Kampung Baru is situated in the Kampung Baru Archaeological Site, and it is one of the temple sites that used bricks as the main construction material. Based on the Global Positioning System, Candi Kampung Baru is located at N 05.58215°, E 100. 38004°. Apart from bricks, granite stones were also used as the pillar base of the construction's structure. This study is an analytical approach on the pottery properties of clays discovered at the Kampung Baru Archaeological Site. X-ray diffraction (XRD), X-ray fluorescence (XRF) and physical analysis have been performed on these potsherds. 15 pottery shard samples were analysed to determine the chemical and mineralogical characteristics of the pottery shards. The results indicate a local provenance of these samples. The mineral content in the pottery samples also indicate the presence of minerals, such as quartz, illite, datolite and microcline. Furthermore, the physical analysis conducted uncovered a variety of motifs that adorned the earthenware, such as lines, nets, square and floral motifs. The mineral content and physical observation of the pottery shards indicate that the open burning technique was used to produce these pottery shards due to the presence of illite mineral in the pottery shards. The mineral content (namely illite) also shows that the samples were baked at a temperature between 650°C and 750°C. The content of the major and trace elements also proves that these potteries were produced from the same source and it is proposed that local raw materials were used in the production of the potteries, from which the nearest source that could be detected is at the Muda River basin. Moreover, the involvement of the local community in producing the potteries should not be refuted, as this proves that the knowledge of producing pottery by the local community had already started since the evolution of the Neolithic culture at the Muda River basin since 4000 to 5000 years ago.

Keywords: Pottery, Kedah, Kampung Baru Archaeological Site, Muda River, Bujang Valley, X-ray diffraction (XRD), X-ray fluorescence (XRF)

INTRODUCTION

Archaeological study on artifacts (namely pottery, ceramic and beads) since the late 20th century in Malaysia has been employing interdisciplinary analysis by using chemical, geological and physical analytical techniques. By using the chemical and mineralogical analyses, the place of origin of the raw materials used for pottery or other type of artifacts should be given due attention. In order to identify if local raw materials have been used in pottery productions, the identification of specific chemical elements can help to distinguish locally made pottery from the imported ones. Compositional analysis of the ancient pottery found at the Kampung Baru Archaeological Site was carried out in order to determine the content of mineral, major and trace elements contained in the pottery sherds. Data obtained from the subsequent pottery analysis have been compared with the composition data of clay material around the Bujang Valley. It is important to conduct material composition analysis of the ancient pottery of this site, as it can help determine the provenance of raw materials used to produce the pottery, if it was locally made or otherwise.

The mineral content of pottery was determined through the use of the X-Ray diffraction (XRD) analysis, whereas the X-Ray fluorescence (XRF) analysis was used to determine the trace and major elements of the samples. The XRD and XRF analyses have also provided new data on the origin and technology of prehistoric pottery in Malaysia (Treloar, 1978; Mohd Kamaruzaman *et al*., 1991; Chia, 1997; Asyaari, 1998; Ramli *et al*., 2011, Moradi *et al*., 2013, Sarhaddi-Dadian *et al*., 2017), glass beads (Ramli *et al*., 2017), bronze drum (Jusoh *et al*., 2012), and ancient bricks (Ramli & Rahman, 2013; Ramli *et al*., 2013; Siti Norbaini *et al*., 2015).

Furthermore, the XRD and XRF analyses also have been conducted not only in Malaysia, but in other archaeological related researches throughout the Southeast Asian countries. The XRD and XRF analyses were conducted on ceramic (Ngun *et al.*, 2011), glass (Dararutuna *et al*., 2012), pottery (Malee & Thiansem, 2016), clay materials (Aidhia Rahmi & Helendra, 2018), and rock painting (Lebon *et al*., 2019; Nadya Nurdini *et al*., 2020).

The Kampung Baru Archaeological Site (N 05.58215°, E 100.38004°) was discovered during the Sungai Muda exploration work that was carried out from 2010 to 2011. It is one of the archaeological sites associated with the Ancient Kedah that thrived from the 9th century CE until 11th century CE (Ramli *et al*., 2018; Mohd Shamsul Bahari *et al*., 2018; Mori & Ramli, 2019a, 2019b). The site is located along the banks of the Muda River in the area of Kampung Baru, Kota Kuala Muda, Kedah (Figure 1). Based on the discovery of a Neolithic community settlement at Guar Kepah, it is a clear evidence that the Muda area, which comprises the states of Kedah and Penang, was inhabited since 4000 to 5000 years ago (Mokhtar, 2012; Shaiful *et al.*, 2018). The distance between Kota Kuala Muda with the nearest town, Sungai Petani, is 22 kilometres. The distance between this site and the Muda River is only about 100 metres. Mount Jerai can be seen from the front view (north) of this site. Before this site was discovered, it was used by the local community as a Muslim burial ground, and the impact of the Muda River flood mitigation project has uncovered a few bricks from a *candi* (temple) located at this site. This site is also located close to the Sungai Mas Archaeological Site, as well as the Permatang Pasir *Candi*. The position of this site, which is close to the Sungai Mas Archaeological Site, is an important point, as the Sungai Mas was once the administrative centre and entrepot for Ancient Kedah.

MATERIALS AND METHODS

The research methods used in this study includes physical analysis, as well as the XRD and XRF analyses of the pottery samples.

Physical analysis

The physical analysis has been performed on all 7595 potsherds discovered at this site, according to its excavation trench and spit (and later according to its respective cultural layer). This is to ensure that accurate data could be obtained. The first step in this analysis was to clean each of these artefacts before classifying them into several sections, based on their characteristics. During this process, the pottery was identified for any decorations on its surface. If there was any, its type, shape, and methods in which the decoration were made was documented. The measurement of each individual findings during the excavation was also recorded.

Clay samples

Data of the X-Ray diffraction (XRD) and X-Ray fluorescent (XRF) of clay samples were derived from Ramli (2012). The clay samples were taken from the area along the Muda River, the Baru River, the Bujang River and the Terus River. Samples were also taken from the vicinity of Mukim Kota, Mukim Bukit Meriam and Mukim Merbok.

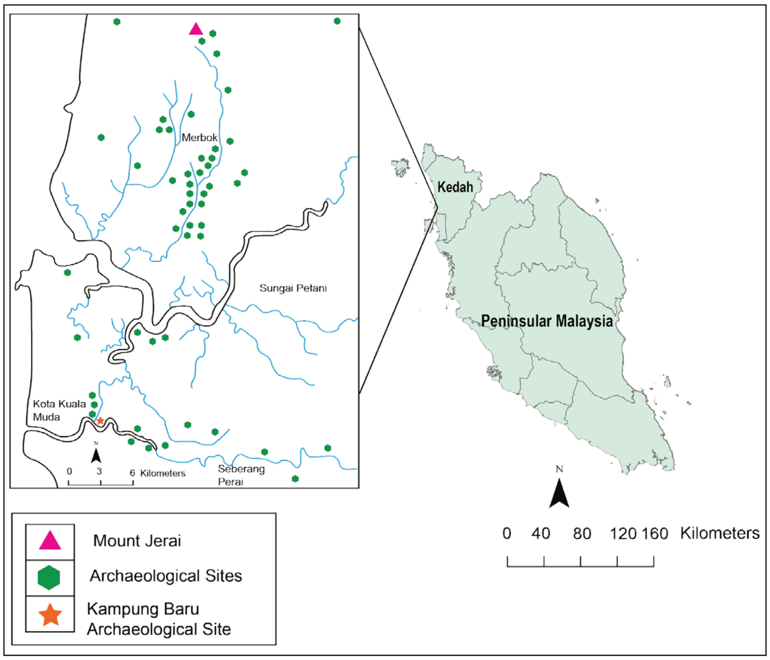

Figure 1: Location of Kampung Baru Archaeological Site.

XRD and XRF analysis

A total of 15 pottery samples from the Kampung Baru Archaeological Site were taken to the lab for cleaning, and were labelled with the names TTKB 1, TTKB 2, TTKB 3, TTKB 4, TTKB 5, TTKB 6, TTKB 7, TTKB 8, TTKB 9, TTKB 10, TTKB 11, TTKB 12, TTKB 13, TTKB 14, and TTKB 15 (refer to Figure 2 and Figure 3). The analysis was conducted to determine the mineral content in the ancient pottery samples. Samples weighing 0.4 g were refined and heated up for one hour at a temperature of 105 °C, and mixed until they turned homogenous with the flux powder, Spectroflux 110 (product of Johnson and Mathey). These mixtures were baked for one hour in a furnace with a temperature of 1100 °C. The homogenous molten was then moulded in a container and cooled gradually into pieces of fused glass with the thickness

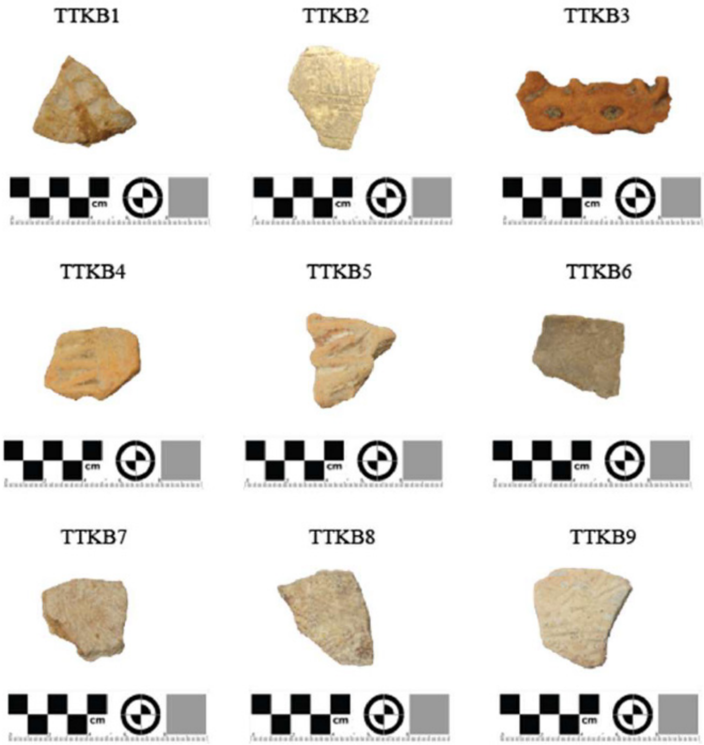

Figure 2: Pottery samples TTKB1 to TTKB9 from the Kampung Baru Archaeological Site.

Figure 3: Pottery samples TTKB10 to TTKB15 from the Kampung Baru Archaeological Site.

of 2 mm and diameter of 32 mm. In result, the samples were ensured to have a ratio of 1:10 dilution. Samples in the form of fused glass were prepared to analyse traces of major elements, such as Si, Na, K, Ca, Fe, Al, Ti, Mn, and Mg. This was then followed with the preparation of pressed pallet samples in order to analyse their trace elements, such as As, Ba, Ce, Cr, Cu, Ga, Ni, Pb, Rb, Sr, Th, V, Zn, and Zr.

These samples were prepared by mixing 1.0 g of samples with 6.0 g of boric acid powder and then the pressure of 20 psi was applied by using hydraulic pressure equipment. The samples of the fused pallet and pressed pallets were then analysed by using the Philips PW1480 equipment. Samples in the form of very fine powder were put into the pellets (sample holder) and then analysed by using the X-ray Diffraction instrument (D500 Diffractometer Siemens). A scatter plot diagram of MgO versus TiO_2 was then performed to demonstrate the differences among the group and was analysed using Microsoft Excel software. The main purpose was to discern the distribution of the samples in the group and to subsequently compare them with the elements in the clay samples. The applicability of the analytical methods for the multi-elemental analysis by XRF of the glass beads was evaluated by the analysis of certified reference material, 315 Fire Brick (Calibration: G-FBVac28 mm) for major elements and certified reference materials, SY-2 (Calibration: Trace Element P-20) for trace elements. The CRM was also used as the quality control material of the analytical procedure.

Table 1: Decorated pottery parts.

Parts	Quantity
Body	1688
Merged Parts	9
Lid	1
Total	1698

Table 2: Non-decorated pottery parts.

Parts	Quantity
Body	3971
Lip	1634
Neck	144
Lid	39
Merged Parts	64
Base	23
Handle	10
Kendi Spout	10
Total	5897

RESULTS

Physical analysis

There were 7595 sherds of pottery found at the Kampung Baru Archaeological Site during the excavation. However, the excavation did not discover any perfect pottery that were still intact, but only fragments of them in different sizes. Although the pottery was found to be imperfect, the results of typology and physical analyses conducted were able to identify different types of pottery found at this site, such as bowls, pots, jars, crocks, and *kendi* on some of the potsherds. The sherds of pottery found at the Kampung Baru Archaeological Site have also been divided into several identified parts, such as their body, lips, neck, foot, nozzle, handle, merged parts and lid.

The total number of decorated pottery found at this site were in 1698 pieces, while the classification of the decorated pottery sections is as shown in Table 1. In addition, the quantity of non-decorated pottery found in the Kampung Baru archaeological site are 5897 fragments, while the classification of the pieces of pottery is as shown in Table 2.

The analysis on the pottery also found that there were several types of decorative patterns used on the surface of the pottery. The most used decorative pattern type is the straight line motif, as well as the net motif. In addition, there were also decorative patterns that were modelled on the surrounding environment, such as flowers and grass. The floral decorations were clearly visible on the fragments of the pottery found at this site. Circular shapes were also found embedded on the pottery bodies and would be often adorned with other patterns, such as straight lines, flowers and even grass (Table 3). Some of the decorations on the pottery body can be seen in Figure 2 and Figure 3.

XRD and XRF analysis

The composition analysis on the potsherd samples from the Kampung Baru archaeological site was carried out to determine its geo-chemical and mineral contents. The composition analysis on the potsherds helped to determine if local raw material was used to produce these potteries. The mineral content in the pottery samples showed the presence of minerals, such as quartz, illite, datolite and microcline (see Figure 4). The mineral contents of each sample is shown in Table 4. From the table, it is clear that the quartz was present in each sample. Microcline was present in each sample, except for sample TTKB1, whilst datolite was present in sample TTKB1 only. The mineral content such as illite shows that the samples were baked at a temperature between 650 °C- 750 °C. Based on their mineral content, it indicated that the pottery sherds were made by the same raw material accepted for sample TTKB1.

The contents of the major elements in the pottery fragments can be referred to in Table 5. The analysis

Table 3: Motifs on the pottery.

Motif	Quantity
Straight line (cord marked)	1440
Net (Carved wood)	99
Straight line (incised)	66
Net (cord marked)	39
Flower (incised)	22
Triangle (incised)	6
Straight line and zigzag	3
Straight line and cross (incised)	3
Flower and circle (incised)	3
Square (impressed)	2
Line (Shell, impressed)	2
Zigzag (incised)	2
Line and Net (cord marked)	1
Line (Carved wood)	1
Line, zigzag, and triangle	1
U shape (incised)	1
Cross (incised)	1
Zigzag and square (incised)	1
Line and shell impressed	1
Zigzag, line, cross, and plant	1
Line and circle (incised)	1
Line and plant	1
Square (incised)	1

shows that the pottery fragments contained 54.59 per cent to 72.98 per cent dry weight silica. The percentage of dry weight for aluminium elements is between 13.59 per cent and 20.06 per cent. While iron elements contain a dry weight percentage of 3.31 per cent to 11.74 per cent. Further to this, the percentage of dry weight for potassium elements ranged from 1.58 per cent to 2.75 per cent, while dry weight calcium ranged from 0.07 per cent to 0.49 per cent. The percentage of dry weight for titanium elements ranged from 0.54 per cent to 0.95 per cent, while dry weight phosphorus ranged from 0.13 per cent to 1.54 per cent. The percentage of dry weight magnesium and sodium elements was 0.26 per cent to 1.27 per cent and 0.12 per cent to 0.66 per cent. Sulphur and manganese elements contain a percentage of dry weight 0.03 per cent to 0.42 per cent and 0.01 per cent to 0.14 per cent, respectively. Figure 5 shows the scatter plot graph for percentage of dry weight of Al_2O_3 and SiO_2 elements for the Kampung Baru archaeological site pottery samples and clay samples in the Bujang Valley.

Based on the scatter plot graph, it can be suggested that most of the pottery sherds had the same compositional content of Al_2O_3 and SiO_2 with clay samples taken from the surrounding area in Bujang Valley. Figure 6 shows the scatter plot graph for percentage of dry weight of MgO and TiO_2 elements for the Kampung Baru archaeological site pottery samples and clay samples in the Bujang Valley.

The contents of trace elements in the pottery samples from this site can be referred to in Table 6. The analysis showed only zirconium, zinc, rubidium and strontium were present in all samples. Copper was present in all samples except sample TTKB11, while chromium was present in all samples, except in samples TTKB5 and

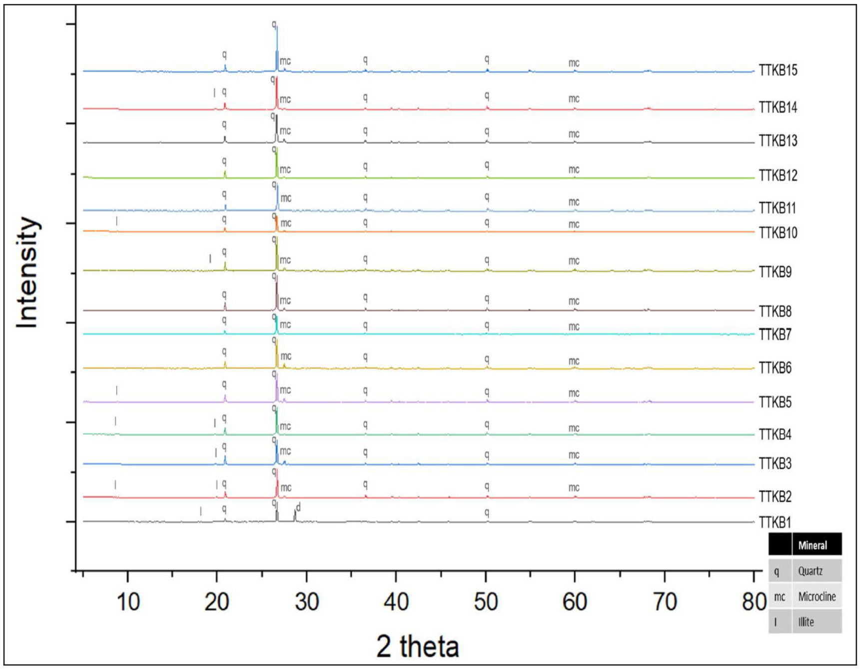

Figure 4: X-Ray diffraction pattern of the Kampung Baru Archaeological Site pottery sherd samples.

Table 4: Mineral content in pottery samples of the Kampung Baru Archaeological Site.

Sample	Mineral
TTKB1	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite SiO_5HCaB Datolite
TTKB2	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB3	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB4	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB5	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB6	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB7	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB8	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB9	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB10	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB11	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB12	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB13	SiO_2 Quartz $KAlSi_3O_8$ Microcline
TTKB14	SiO_2 Quartz $Si_2O_{12}KAl_4$ Illite $KAlSi_3O_8$ Microcline
TTKB15	SiO_2 Quartz $KAlSi_3O_8$ Microcline

TTKB11. Nickel was also present in all samples, except in samples TTKB11 and TTKB12. Zirconium content ranged from 200 to 300 ppm while zinc content ranged from 71 to 200 ppm. Rubidium and strontium content ranged from 100 to 200 ppm and 29 to 92 ppm. Copper content ranged from 31 to 300 ppm, while chromium content ranged from 79 to 200 ppm. Lead content is between 55

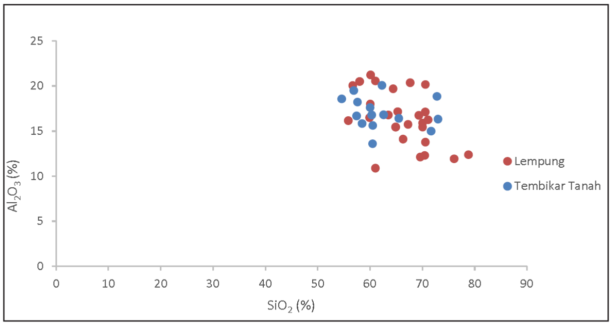

Figure 5: Percentage of dry weight (%) of Al_2O_3 and SiO_2 elements for the Kampung Baru Archaeological Site pottery samples (tembikar tanah) and clay samples (lempung) in the Bujang Valley.

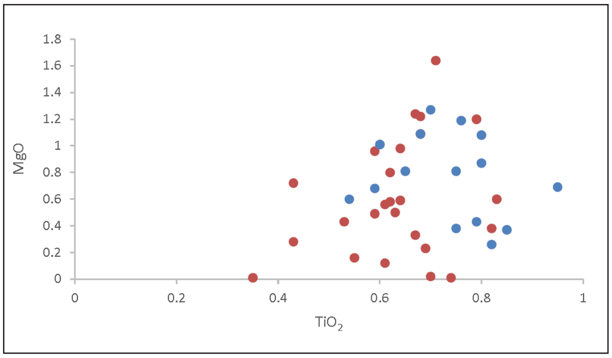

Figure 6: Percentage of dry weight (%) of MgO and TiO_2 elements for the Kampung Baru Archaeological Site pottery samples (red) and clay samples in the Bujang Valley (blue).

and 600 ppm, whereas nickel content is between 34 and 100 ppm. Figure 7 shows the scatter plot graph for the concentration of nickel and strontium elements for the Kampung Baru archaeological site pottery samples and clay samples in the Bujang Valley. Based on the scatter plot graph, it can be suggested that most of the pottery sherds have similarities with the contents of nickel and strontium in clay samples taken in the vicinity of the Muda, Bujang and Terus basins. It showed that the pottery from the Kampung Baru archaeological site were made by using local raw materials found in Kedah. However, there is also a pottery with a high lead content – the TTKB2 sample – with a reading of 600 ppm. It is proposed that, in addition to locally manufactured pottery, there were also pottery that were brought from outside of Ancient Kedah, as high lead content would often be found in pottery of Indian origin (Caleb, 1991).

DISCUSSION

According to the quantity of pottery sherds discovered here, it was clearly determined that the pottery was mostly used to serve domestic and religious purposes. Past excavations that were conducted in Kedah have discovered a lot of pottery; in fact, the pottery was the

Table 5: Major elements in the pottery samples of the Kampung Baru Archaeological Site.

Sample	Dry Weight (%)										
	SiO_2	Al_2O_3	Fe_2O_3	K_2O	CaO	TiO_2	P_2O_5	MgO	Na_2O	SO_3	MnO
TTKB1	60.33	16.79	8.14	1.65	0.21	0.65	0.41	0.81	0.15	0.12	0.05
TTKB2	58.50	15.84	9.99	1.82	0.43	0.60	1.16	1.01	0.16	B.D.L	0.05
TTKB3	54.59	18.57	8.10	2.42	0.40	0.76	0.32	1.19	0.66	0.09	0.03
TTKB4	57.42	16.69	11.74	1.62	0.49	0.68	0.88	1.09	0.15	B.D.L	0.14
TTKB5	71.68	15.00	4.28	1.88	0.21	0.70	0.13	1.27	0.23	B.D.L	0.03
TTKB6	62.59	16.81	6.45	1.70	0.18	0.75	0.39	0.38	0.13	0.08	0.02
TTKB7	60.01	17.60	5.61	1.76	0.20	0.82	1.12	0.26	0.12	0.10	0.04
TTKB8	72.79	18.84	3.31	1.87	0.13	0.80	0.28	0.87	0.16	0.04	0.01
TTKB9	60.52	15.63	7.30	1.58	0.10	0.79	0.91	0.43	0.17	0.36	0.01
TTKB10	56.88	19.49	5.67	1.97	0.07	0.85	1.54	0.37	0.17	0.42	0.01
TTKB11	60.50	13.59	3.36	2.21	0.10	0.54	0.23	0.60	0.17	0.03	B.D.L
TTKB12	72.98	16.32	3.64	2.75	0.18	0.59	0.43	0.68	0.28	0.15	0.03
TTKB13	57.59	18.22	7.80	2.59	0.08	0.95	0.95	0.69	0.12	0.25	0.04
TTKB14	65.51	16.40	4.95	2.07	0.37	0.75	0.68	0.81	0.22	0.03	0.01
TTKB15	62.29	20.06	4.44	1.95	0.25	0.80	0.17	1.08	0.18	0.05	0.01

B.D.L = Below Detection Limit

Table 6: Trace elements in the pottery samples of the Kampung Baru Archaeological Site.

Sample	Element (ppm)										
	BaO	ZrO_2	ZnO	Rb_2O	SrO	Cr_2O_3	CuO	NiO	As_2O_3	Nb_2O_5	PbO
TTKB1	300	200	200	100	38	100	56	69	B.D.L	24	100
TTKB2	600	200	200	100	57	100	200	84	3	B.D.L	600
TTKB3	700	200	100	100	92	200	200	97	15	12	100
TTKB4	800	200	200	100	57	97	100	100	25	B.D.L	400
TTKB5		300	89	100	42	B.D.L	41	45	22	18	B.D.L
TTKB6	700	300	100	100	29	100	81	77	B.D.L	26	100
TTKB7		300	100	100	38	100	64	39	B.D.L	B.D.L	100
TTKB8	300	300	200	100	39	92	300	66	9	19	70
TTKB9	400	300	100	100	32	100	100	60	B.D.L	21	100
TTKB10		300	100	100	32	94	45	56	42	38	67
TTKB11		200	71	100	29	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L	B.D.L
TTKB12	400	200	71	200	50	79	35	B.D.L	B.D.L	16	69
TTKB13	400	300	100	200	33	100	60	54	13	30	98
TTKB14	400	300	100	100	54	98	44	45	B.D.L	23	B.D.L
TTKB15		300	81	100	46	100	31	34	6	18	55

#B.D.L = Below Detection Limit

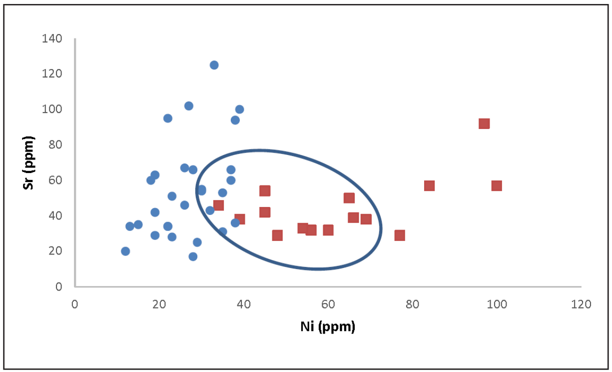

Figure 7: Concentration distribution graphs of strontium against nickel for the Kampung Baru Archaeological Site Pottery samples (red) and clay samples in the Bujang Valley (blue).

most discovered artefact that is associated with the Ancient Kedah. During the Protohistoric Time, the pottery was largely used because it was produced in mass, as proven by the number of pottery found in Kedah (Nik Hassan Shuhaimi & Asyaari, 2008). Besides that, the availability of local pottery also played its part, as in the Ancient Kedah, it would be easier to get the locally made pottery than the imported ceramics, especially the ones from China. Based on the pottery part discovered here, it is concluded that it was mostly used domestically as daily equipment and also in religious functions by the devotees who patronised the *candi* here. Furthermore, the devotees also used the pottery as a container – particularly water – as *kendi* spouts were also found at this site.

The analysis conducted on the decorations found that the pottery from this site also bore complex motifs. The adornment of complex motifs showcases the ability of local artisans in producing fine pottery. In order to produce complex decoration or motif, one would need high expertise to create it in minute details. The complex decoration of pottery from the Kampung Baru Archaeological Site were made using the incising technique, as only 100 of the sherds were made by using this technique, while there are another three sherds which combine incising and pressing techniques. There is no doubt that in the Ancient Kedah, the demand for complex motifs on decorated pottery had existed. It is also worth mentioning that, judging by the fine quality of the sherds discovered, it is suggested that the Malays of Ancient Kedah (including the devotees of the *candi* at this site) chose functionality more than the aesthetics of the ware. This suggestion was made based on two facts: 1) the quantity of undecorated pottery compared to the decorated ones, and 2) the comparison of quantity between the pottery with the imported ceramics that adorn with more complex decorations (Mori & Ramli, 2019a, 2019b).

Besides basic decorations that incorporated lines or nets as their main motif, there were also floral motifs that adorned the surface of the pottery. Although floral motif only comprised less than 1.6 per cent of the total of decorated pottery sherds found, this discovery strengthens the fact that functionality and practicality of pottery was not the only factor that was taken into account by the devotees in choosing their ware for the *candi*. Considering the existence of more complex decorations – especially the pottery that bore floral motifs – this is not deemed peculiar, as the Malays often used their surroundings and natural environment as an inspiration to their art. To a certain extent, the local and cultural philosophy was also a source of inspiration for their artwork. This can be seen not only on the decorations of the pottery, which used flowers and grass as adornment, but also in other aspects of the Malay lifestyle, such as the *pantun*. The usage of natural surroundings in the Malay *pantun* was a reflection of not only the Malay thought, but also to their philosophy, which was embodied in their aesthetic appreciation for art (Zarina & Anida, 2018).

The pottery found in the Kampung Baru Archaeological Site was a locally made product and had its own aesthetic value. The discovery of stone tools and *batu sondol* (an equipment used for pottery making, especially in the Malay Peninsular) makes up the evidences of pottery making activities that took place in the vicinity of this site. Archaeological data of past excavations also showed that pottery discovery in the area around Sungai Mas and Muda River were in large quantities. For example, the pottery discovery in Sungai Mas in the year 1981 found 4211 fragments of pottery, while in 2006, 1209 fragments of pottery were discovered (Nuratikah *et al.*, 2018). The discovery of pottery in large quantities at the Kampung Baru archaeological site and the Sungai Mas Archaeological Site indicated that there was a local pottery making industry in Ancient Kedah. This is because it is difficult to import large amounts of pottery from other regions, as it is more fragile than other ceramics; thus, the people of Ancient Kedah had a tendency to manufacture their own pottery, as it was discovered in the Kampung Baru archaeological site. Moreover, the XRD and XRF analyses conducted on the selected pottery samples also found that local raw materials were used to produce it.

CONCLUSION

A total of 7595 sherds of pottery were analysed in this study using physical analysis, and 15 samples were then analysed using the XRD and XRF analyses method. The chemical and mineralogical characteristics of these pottery sherds have indicated the source of the raw material. The mineral contents in the pottery samples showed the presence of minerals, such as quartz, illite, datolite and microcline; whereas the physical analysis conducted found that there were varieties of motifs involved in the adorations of the earthenware, such as lines, nets, square and floral motifs. The mineral contents and physical observation of the pottery sherds indicated that the open burning technique was used to produce these pottery sherds due to the presence of illite mineral in the pottery sherds. The mineral contents (namely ilite) also suggested that the samples were baked at a temperature between 650 °C and 750 °C. The contents of the major and trace elements indicated that these potteries were produced from the same source, and it is proposed that local raw materials were used in the production of the potteries, where the nearest source that could be detected was at the Muda River basin. The involvement of the local community in producing the potteries should not be refuted, and this proved that the knowledge of producing pottery by the local community had already started since the evolution of the Neolithic culture at the Muda River basins since 4000-5000 years ago.

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