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Chemical Composition of Clays for Pottery in Malaysia: A Review

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Abstract

Pottery in Malaysia is been known for its utilized functions and unique properties. Clays as the pottery's raw materials are a major factor that affecting the quality and reliability of some pottery products. Observations on clays' elements and phases are very helpful for productions of the good pottery. Hence, in this review, chemical compositions of clays in terms of elements and phases structures are discussed. Basically, the most elements found in clays are Si, Al, Fe, Ti, K and Ca. Depends on location, the concentrations for those clays elements in Malaysia are at range of 24.8 – 32.4 for Si, 10.8 – 19.0 for Al, 0.09 – 2.12 for Fe, 0.08 – 1.13 for Ti and 0.45 – 3.39 for K. Several studies reported, they exist in form of oxide compound which are SiO_2, Al_2O_3, Fe_2O_3, TiO_2, MgO, CaO, Na_2O, K_2O and P_2O_5. The percentages of elements in clays do not only determine the clays characteristics, but also influence the physical, mechanical and chemical properties of the end product. Increase of major element like silica arises the melting point, lowers the fluidity, and enhances the hardness and tensile strength. Meanwhile, increase alumina content enables the green body to withstand the sintering temperature and also increase the hardness of the pottery.

1. Introduction

Malaysia is a country that is consists of twelve states in Peninsular and other two states are located at Malaysia Borneo. In Malaysia, there are three types of famous pottery namely Mambong, Labu Tanah (clay pitcher) and Terenang. The first pottery which usually use for cooking and mostly produced in Mambong, Kelantan. This pottery produced by hand forming technique. The second pottery so called as Sayong which was inspired by a gourd or pumpkin and developed to various forms of clay pitchers produced in Sayong and Pulau Tiga, Perak. Lastly, the third pottery is Terenang from Tembeling, Pahang which similar to metal form.

Pottery can be referred as clay body formed into any objects of a desired shape and heated to high temperatures in a kiln to sinter the green body and become a solid strengthened object. Green body is a ceramic compound, usually clay or powder before firing process [1]. This form of ceramic is very soft and unable to withstand external force otherwise it will be broken. Pottery also can be refers to the potter art and craft or the manufacturer of pottery wares [2].The earthenware, stoneware and porcelain can be includes as pottery [3].

In pottery production, there are several things to be concern and one of them is chemical composition of clay. These crucial factors will affect the pottery products in term of characteristics of structure and performance of pottery. Clay chemical composition does include the elements that giving a significant influence on the processing and also the quality of clay. Therefore, small changes in major elements concentration in clay may result in the processing and the quality of pottery [4].

Nowadays, pottery has been commercialized and be one of iconic national heritages for Malaysia. Since pre-historic period, pottery activities are basically for daily needs. Labu Sayong is one of the

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most popular kitchen utensils until now but today it becomes an iconic souvenir of Malaysia.

2. Malaysia Clay

2.1. Chemical Composition

In identifying the composition, morphology and more importantly the origin of potteries, scientific analysis of pottery is important [5,6]. This shown that different area having different clay elements and not all clay types are able to produce a good pottery. Undeniable Sayong Perak is more popular with pottery production with the best quality offered.

There are several study have been done in Malaysia for chemical composition of clay. Some of the study is carried out to analyses the clay used in pottery production. Besides, it also studies on prehistoric pottery to determine whether the pottery found in the archaeological sites was locally made or trading items. Usually X-ray Diffraction and X-ray Fluorescent was used to obtain the mineralogical and elemental composition of clay.

According to Saat et al. the major elemental content of clay for North Peninsular Malaysia are Si, Al, Fe, Ti, and Ca. Fig. 1 shows the concentration percentage for those elements ranged between 24.8 – 32.4 for Si, 10.8 – 19.0 for Al, 0.09 – 2.12 for Fe, 0.08 – 1.13 for Ti and 0.45 – 3.39 for K. The North Peninsular Malaysia included Sungai Petani Alor Star, Sungai Dua, Bagan Serai, Sungai Sayong, Ipoh, Sungai Sipot, Bidor, Teluk Kumbar, Teluk Bahang, and Kampung Bercham. For all samples studied the Si/Al ratio is stable at 1.9 [7].

The result showing that iron is the dominant element for sample Bagan Serai, Sayong and Kampung Bercham. Those three are iron-rich clay samples that are collected from states of Perak. This iron domination explains the brownish colour of those samples. In another hands, in north peninsular Malaysia three sample of that showing high K/Ti ratio go along with that typical illite. Those samples are Sungai Sayong Perak, Teluk Kumbar Penang and Teluk Bahang Penang.

The area that popular in producing pottery in Malaysia is Sayong, Perak. According to, Haron et al., 2014, the best clay to produce a pottery is clay from the Sayong river bank [8]. Some study has been done to find out the element content on Sayong clay. The major elemental content on Sayong clay in percentage(%) are 27.7 % of Si, 12.6 % of Al, 0.57 % of Fe, 0.08 % of Ti and 2.32% of K [7].

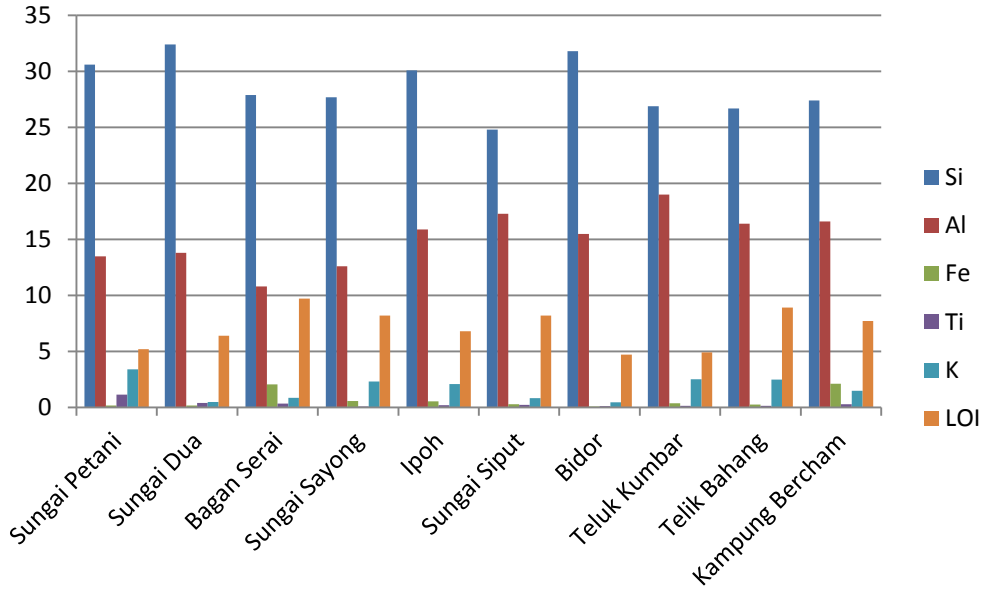

Figure 1: Chemical Composition of clay for North Peninsular.

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Another area that study about clay content in Malaysia is Ulu Kelantan, Kelantan. Samples taken from Perias River, Nenggiri River, Betis River, Peralon River, Chai River and Jenera River. Refer to fig. 2, the elemental content for Hulu Kelantan clay are ranged between 60.35 – 69.20 for Si, 21.52 - 28.87 for Al, 1.99 – 4.35 for Fe, 0.81 – 1.01 for Ti and 2.33 – 3.52 for K. The elemental content of clay taken around Hulu Kelantan has shown slightly different result. However, there are biggest different especially for Si content between both study for Kelantan and Peninsular Malaysia.

It was found that the raw material has high iron content which is between 2.00 to 6.41% in Pengkalan Bujang [9]. Zuliskandar stated that, major elements of clay from Bujang River, Baru River and the clay taken from the surrounding areas of Mukim Bujang and Mukim Merbok consists of different composition of Si, Fe, Al, Ca and K [10]. The percentages of Fe and Ti which is more than 2% will result in dark colour of clay after firing process. Based on fig. 3, the elemental content for study area ranged between 44.97 – 84.85 for Si, 7.29 – 32.95 for Al, 1.21 – 12.32 for Fe, 0.27 – 1.04 for Ti and 0.70 – 4.63 for K.

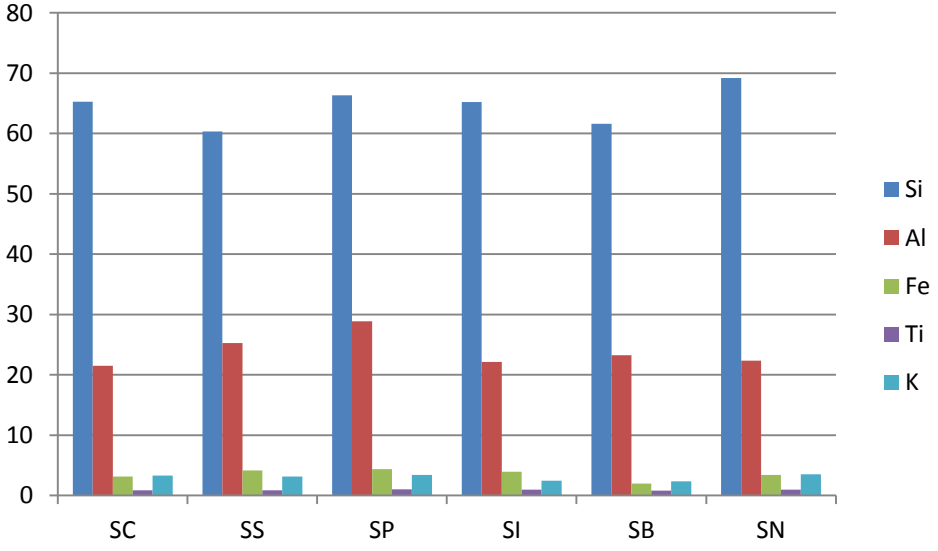

Figure 2: Chemical Composition of of clay for Ulu Kelantan.

Bujang River contain of 56.69 – 71.08 for Si, 16.25 – 20.35 for Al, 2.90 – 12.32 for Fe, 0.61 – 0.82 for Ti and 0.72 – 2.79 for K. Meanwhile Baru River chemical composition range between 44.97 – 84.85 for Si, 7.29 – 32.95 for Al, 1.67 – 6.47 for Fe, 0.27 – 1.04 for Ti and 1.60 – 4.63 for K. In another hand, Mukim Merbok Area is contain of 55.84 – 78.81 of Si, 10.88 – 20.56 for Al, 1.21 – 8.33 for Fe, 0.35 – 0.61 for Ti and 0.70 – 2.63 for K. Mukim Bujang area show that the elements for clay is ranged between 62.48 – 74.02 for Si, 13.33 – 16.17 for Al, 3.74 – 10.17 for Fe, 0.56 – 0.66 for Ti and 1.02 – 1.34 for K. Merbok Kecil elements percentage are 77.56 – 79.44 for Si, 9.49 – 10.80 for Al, 1.86 – 2.06 for Fe, 0.48 – 0.55 for Ti and 1.44 – 1.54 for K. Fe and Ti percentage which more than 2% will result in dark colour after firing at high temperature [10].

2.2. Grain Size

Ahmed et al. [11] reported that the chemical properties of clay effected by grain size. Grain size can be control using screen sieving which is necessary to significantly reduce Fe_2 O_3, Al_2 O_3 and SiO_2 which are undesirable constituent in raw clays. This screen sieving process is held after grinding dry clay.

The organic substances such carbon associates well with relatively finer clay particles. Therefore, clay particles with sizes 20 and 25 µm had higher contents LOI and total C than those of 63 µm. However, it is not obvious because the particle sizes are relatively close. It is differ from K, Na, Ca and Mg

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whose contents were not significantly affected by grain size. However, it is opposite for finer particles which are known to effectively retain Fe, Al and Si compared with relatively coarse clay particles.

Significant reduction in the contents of Fe_2 O_3, Al_2 O_3 significantly improved the strength of white clays. As a result, clay with particles 63 µm had the best working quality and this was so because the clay particles had the lowest amounts of Fe, Al and Si [11]. As a conclusion, the quality of Malaysian pottery can be improved upon proper grading of the clay particles.

Except for pottery from Gua Kecil which has a very fine paste texture, with an average grain size of 0.11 mm, a majority of the samples from Lenggong, Gua Harimau, Bukit Tengku Lembu, Kodiang, Gua Cha, Gua Kecil, Gua Sagu, and Jenderam Hilir showed medium paste texture with quartz grain sizes measuring between 0.50 mm and O.25mm [12].

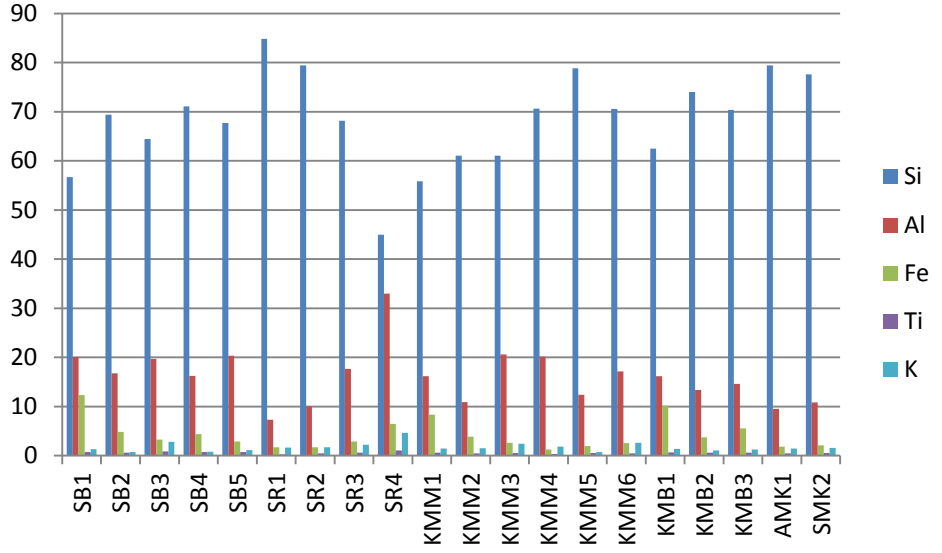

Figure 3: Chemical Composition of of clay for Sg Bujang, Sg. Baru, Mukim Merbok Area, Mukim Bujang Area and Sg. Merbok Kechil.

2.3. Effect of Certain Minerals on Clay

2.3.1. Silica

The mineral found in clay is Silica. However it is used commonly in pottery production. These minerals can be added by combine free grains quartz with other minerals to form clay substance. In tend to prevent shrinkage in clay and lessen its plasticity the free quartz and the silicates is added. It is a reason why powdered flint is added in the manufacture of pottery in order to produce good pottery product.

2.3.2. Iron Oxides

These mineral usually present in clay. Iron oxide may present in the yellow, red, black, and pale brass-like. But, stable sulphide is brown in colour. However, the colour does not reflect the amount of iron present. Besides being the colouring agent of the clay, it is believed but not proven yet that iron compounds also act as a flux and also effect in the absorption and the shrinkage of the brick.

2.3.3. Lime

Mostly clay contain small amount of lime which act as flux. These mineral are able to absorb moisture from the atmosphere. The quicklime will combine with other minerals and form iron and aluminium silicates when the kiln has been sufficiently heated. Ricke [13] concluded from his researches that marble decreases the shrinkage and also make it uniform. Besides, he also stated increase in percentage of lime will increase the porosity of burnt sample. However, it is opposite at the lowest temperatures at which the carbon dioxide has not been entirely expelled.

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2.3.4. Magnesia

The percentages for magnesia that usually found in clay in most cases are less than one percent. Macler [14] proved that effects of magnesia to be different from that of lime because magnesia has no bleaching effect like lime. It a1so separate the points of incipient fusion and viscosity. According to Hottinger [15], Magnesia clay can be made into wares of extreme length and very thin walls which may be nearly vitrified without warping.

2.3.5. Alkalies

Alkalies are needed to form a dense hard body and they are the more powerful fluxes in clay. Alkali are present in feldspar which is important flux in the manufacture of porcelain, encaustic tiles, and ware which are made from white clays and need to be impervious. The finer the grain of the feldspar the lower the temperature required to makes it vitrify.

2.3.6. Carbonaceous Matter

Rich in carbonaceous matter will result in dark colour of clay which can be found in the coastal areas. This dark-coloured clay may burn red or even white because the carbon is oxidised in the burning all passes off as carbonic acid gas.

3. Pottery

3.1. Pottery Manufacturing

3.1.1. Clay Preparation

Raw clays need to be prepared in order to improve its workability before it can be used to form pottery product. Normally the preparation is done by removing coarse particles of rocks and organic materials. The process of clay preparation is started when the clay is collected and dried out. Then dry clay is grind into small size and sieve to removes impurities such as stones, sand and small twigs.

Clay preparation can be divided into traditional and modern. Nowadays, in order to save time and energy and also to run an easier process, manufacturer decided to use modern equipment for the clay preparation. Plunger machine is used to grind clay and produce slip or liquid clay. Sodium silicate is added into mixture little by little to add plasticity. Then the slip is sieved and soaked for a day.

Traditionally they prepared the raw clay for labu sayong, Mambong and Terenang are quite similar. Clay will be grind by using traditional mortar and pestle after drying process. Two people are needed to grind the clay where one will handle pestle and another one to flip the clay inside the mortar. Grinded clay then sieved to remove impurities and become clay powder. This powder mixed with adequate amount of water and leave for a day until it became slurry.

However Mambong is a bit different, fine sand from the river is added to the grinded clay before being pounded again to make it even finer. Meanwhile Terenang production is special with ‘melepa’ where clay slip is poured onto a porous bat called ‘lepa’ which able to absorb water from the clay for easier kneading process [16].

3.1.2. Forming Process

Pottery forming process included pottery technique. There are several pottery techniques to form a pottery product[16]. Traditionally they used coiling and pinching to form a pottery. This method is the best method to produce Labu Sayong (clay pitcher), Terenang and Mambong.

Slip casting is a pottery product making using mould and slip [17]. The mould will be made by using plaster of Paris (POP). Slip is pour until it fills the mold up to the brink. Then it will be left for a few minutes. The slip will sink because the plaster wall is able to absorb the liquid to form the thickness of the clay pitcher body.

Jolly-Jigger Machine and throwing machine is other techniques that can be used to form a pottery [16]. Throwing machine has same function as plate used in coiling and pinching. However, this machine is not easy to handle with because it spins faster. Therefore in pottery manufacturing they prefer to use slip casting which is easy and fastened the drying process.

3.1.3. Decoration

Decoration is defined here as any form of surface patterning such incising, stamping and carving for Malay’s traditional technique. The best choice to create pattern on all three types of traditional pottery is stamping technique. The leather-hard clay surface stamped using a small wooden block. The pressure from the stamp will give an indentation marks on the body and the clay will stuck to the wood stamp if the

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surface body is soft but if the body is too dry, decorating process will cause cracks.

Incising is one of decoration technique that produced straight lines, horizontal, 'tulang ikan', 'pucuk rebung', 'potong wajik', triangle and oval on the surface of pottery product [18]. In additions, carving is not the popular technique used in traditional pottery decoration because it is usually owned by aristocracy and royals because the design pattern produced portrays the great skill and wisdom of the craftsmen [16]. Flora motif produced by carving technique during the leather-hard stage and free-hand drawing technique. Carved motif looks a bit complicated because is done repetitively and sometimes overlapping.

There is a new decoration technique called slip trailing which is used to create flora motifs on pottery product by using engobe. Engobe is coloured slip that can be applied on pottery by using a slip trailing bag or rubber syringe and drawing on the pottery surface using brush [16]. The other technique used in decorating pottery is Gold or silver marker pen which is becoming more popular to design or coloring the pattern on pottery surface. In order to produce a diversity of lines and motifs, different kinds of pen are used.

On the other hand, spraying technique is applied by using a spray gun with brown oil paint for the main layer of the clay body. In order to thin the oil paint and to avoid the paint from clogging the spray nozzle, the oil paint is blended with a small amount of turpentine or kerosene. Before starting the process, the bisque pottery is cleaned using wet sponge to remove dust that good for paint absorption [19].

3.1.4. Surface Finish

Surface finishing in pottery can be divided into three which are unslipped & unpolished, unslipped & polished and lastly slipped. Polished and unslipped surface finish also known as burnished, involves polishing or smoothing the drying surface of the pottery with a hard smooth tool before the pottery is fired. Slipped surfaces are usually applied before the pottery is fired by brushing a liquid of fine clay suspension over the leather-hard pottery.

Surface finishes and decoration in the form of cord-marking, burnishing, and slipping were noted in the pottery samples collected from from Lenggong, Gua Harimau, Bukit Tengku Lembu, Kodiang, Gua Cha, Gua Kecil, Gua Sagu, and Jenderam Hilir [12].

3.1.5. Firing

Firing is a process to harden the pottery body. The two basic regimes for firing earthenware are an open firing with no permanent structure, such as a bonfire, and firing in a closed and more permanent structure, such as a kiln [20]. In Malaysia, the open firing is done by placing the clay pitcher on a rack built with wood or bamboo for 3 hours for smoking process. Firing process in open trenches is similar for clay pitcher, Terenang and Mambong which a hole is made on the ground and lined with coconut tree leaves, twigs or small bamboos alternately.

When taken out from the cinder, the dark brown in colour is a result for well cooked body. The blackened surface can be acquired by immediately placed the cooked body on a pile of paddy husks. After that, in tend to render it waterproof, the base of the pot is brushed with liquid resin or wax. However, Mambong goes through a slightly different process where the cooked body was left to cool before being lathered with sap from banana heart in order to extend the lifespan of the pot.

Open firings typically reach their maximum temperatures in 20–30 min, and this temperature is maintained only for a few minutes. In contrast, kiln firings, as a result of the much greater thermal mass and the separation of fuel from the pottery, typically take an hour or more to reach maximum temperature, and in the firing of earthenware, this temperature is typically maintained for some 30 min. The range of temperatures reached in open and kiln firings (typically 600–950 ° C) tend to overlap, the heat input for kilns will be greater due to the longer firing time and, therefore, the estimated firing temperatures will tend to be higher.

The best firing technique is by using gas kiln which is safer, cleaner and time saving. Besides, the risk of level and broken body can be avoided because the heat can be controlled and constantly monitor [8]. This should be counted in concern because in firing process if the heat is increased drastically, the water inside the body will quickly vapourized and will caused the pottery to crack or misshape. By using a kiln, the

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wastage of time and raw material can be prevented effectively.

3.2. Pottery Product

Nowadays, pottery has been commercialized and be one of iconic national heritages for Malaysia [21]. Some of pottery products that can be found in Malaysia are Mambong, Terenang and Labu Sayong. Those pottery products have been used for their special function until now but today it becomes an iconic souvenir of Malaysia.

In 1903, Leonard Wray has recorded in writing and photography about the development of Malay pottery [18]. He had success described about the pottery production well known as Labu Sayong in Kuala Kangsar district of Perak. The Malayan Pottery of Perak is the tittle for the journal documented by him. The Royal Anthropological institute has published his work.

Subsequently, handicraft industry is famous in Kuala Kangsar, Perak. The most selected craft is Labu Sayong. It is named that way because the clay used to make the pottery is taken from the vicinity of the Perak River in a village called Sayong. In Perak, the pottery is different from Kelantan and Pahang pottery. This because of the formation is adaptation from gourd or pumpkin. The pottery is so called as "labu tanah" or "labu ayor".

Both pottery from Sayong and Pulau Tiga produced from same materials and function the same. However, the color of the clay pitcher from these two district are different. The clay pitcher from Sayong is black in color and large in size. The black color is result from oxidation reaction of the paddy husks during firing process or reduction. Besides, the surface of clay pitcher from Sayong is smooth compare to Pulau Tiga. Meanwhile, the clay pitcher from Pulau Tiga is yellowish in color and a little smaller than Sayong clay pitcher.

If Perak is well known for their Labu Sayong, in Pahang there are several pottery types which are Terenang, clay pot (belanga Tembeling), censer (bekas perasap), and large jar (tempayan). The famous one is Terenang. According to Rahman (1997), the pottery has existed in Pahang since the end of Mesolithic age. This discovered at archeological sites such as in Gua Kecil, Bukit Chinatamani and Kota Tongkat [22].

The main production of Pahang pottery is at Kuala Tembeling which situated in the middle of the junction three rivers which are Sungai Tembeling, Sungai Pahang and Sungai Jelai. Sungai Tembeling is an important settlement for human during Neolithic age. According to archaelogical study that has been conduct by Evan, (1931), along the Sungai Tembeling from Kuala Nyong to Hulu Sepia is the trade area [23]. There are similar characteristics for the technique and decoration for prehistoric pottery in Lembah Tembeling and traditional pottery Produce in Kampung Pasir Durian located at Kuala Tembeling.

According to Tajul et al., (2011), the tradition of Mambong village pottery is traceable to 1868 [24]. This village is situated on the banks of the Galas River, Kelantan, Kampung Mambung with its two hundred and thirty eight years pottery tradition is a rather unique phenomenon. It has produced pieces such as smoke container, round bottom water jar, squat water vessel, vessels with handles, earthenware pot and steam pot. Mambong pottery expresses the knowledge of forms and their functions but something of the sense of beauty.

3.3. Pottery Design

The aspect of design and pattern of the primitive pottery is starting evolved time to time. The transformation on pattern of pottery changes can be shown by the decoration on the primitive pottery. Previously the decoration was made by adding layer of clay on the surface of the pot and then it was tapped with wooden bats to give texture on pottery surface which marked with dots or lines pattern. This evolution of pottery decoration gives some impact on the society's value of life and for sure it gives some value to the pottery.

In Perak,they discovered of ancient pottery shards found at Gua Badak, Lenggong and Tanjung Rawa, Kuala Selising. The pottery found was amazingly creative because the surface produced was patterned. There is various patterned applied in pottery production during that time. Several examples for the pottery pattern applied on that time are striped line, zig-zag pattern, messy lines, round lines and points. There are similarities between pattern of ancient pottery and current Malay traditional pottery [8].

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Indeed, at archaeological sites all over Peninsular Malaysia has found a great numbers of cord-marked pottery. The beater or paddle wrapped with a cord is a decorative technique that believes to be used for cord-marking pottery. However, other decorations such as the carved-paddle impression, incision, and comb-impression, which can also be found in Peninsular Malaysia, were not noted in the pottery samples [12].

4. Prehistoric

In Malaysia, Malay primitive pottery is discovered in Neolithic age such as in Gua Cha and Gua Musang in Ulu Kelantan, Jenderam Hilir in Selangor and Bukit Tengku Lembu in Perlis. Most prehistoric potteries discovered have shown certain characteristics, forms, decoration and size. Neolithic pottery surface mostly decorated with lines pattern and archaeologies. This decoration is believed that was made by using stractched wooden bats [25]. According to Ham et al., (2005), traditionally in Malay communities, pottery was typically a woman's work which she would do once her chores were over [26].

The primitive pottery is starting evolved time to time based from the aspect of design and pattern. The pattern on the surface of the primitive pottery is undergoes transformation. The pattern of pottery changes can be shown by the decoration on the primitive pottery was made by adding layer of clay on the surface of the pot and then it was tapped with wooden bats to give texture on pottery surface which marked with dots or lines pattern. The evolution of pottery decorations are impact on the society's value of life and also give some value to the pottery.

The study of pottery has been held for certain purposes. In identifying pottery sources distinctive trace elements and minerals in the pottery composition are used. The compositional approach can be used to derive the pottery example the choice and preparation of raw materials is often reflected directly by the pottery composition. Besides, based on thermal changes in certain minerals, the range of firing temperatures used can also be known. In pottery manufacture, identifying such technology traits is a useful way of recognizing cultural connections and provide stronger evidence of tradition and culture than shape and decoration [27].

In addition, some study of the chemical composition of prehistoric pottery in Malaysia has shown that some of these potteries and also other clay products are not locally but are trading item. For example pottery shard from Hulu Kelantan has been analyzed and the result showed that most of the shard do not locally make and probably originated from the coastel area [9,12]. However, analyses for ancient bricks from Candi Sungai Mas, Candi Bukit Kechil, Candi Bukit Pendiat and Candi Pangkalan Bujang showed that those brick are using locally clay [9].

Recently Chawas cave, Hulu Kelantan shown that all votive tablet are not locally made because the chemical composition of votive tablets were not similar to the samples taken from several Hulu Kelantan rivers [28]. The result showed that all votive tablets have the minerals called clinochlore that do not found in samples taken from several Hulu Kelantan rivers.

4.1. Chemical Composition of Prehistoric Clay Products

The chemical composition of prehistoric clay product is being observed recently. Most of the study is carried out to ensure either the product produce from local or as a trade item. All sample collected from Gua Kecil contain high percentage in iron and barium content ranging from 7.34% to 10.25% . But, Jenderam Hilir percentage is1.23 to 2.22% means lower in iron and also calcium. As stated before Jenderam Hilir is lower in iron and calcium, however this factor support the localized clay used in pottery production [12].

The chemical composition of Ulu Kelantan prehistoric shards that collected from Gua Peraling and Gua cha is contain of high Si and Al. The average chemical composition percentage of Gua Peraling pottery shards is 54.34 - 63.44 for Si, 17.69 – 20.50 for Al, 4.51 – 7.49 for Fe, 0.69 – 1.27 for Ti, 4.43 – 5.51 for K. Meanwhile, Gua Cha consist of 52.49 – 69.12 for Si, 17.00 – 20.97 for Al, 4.30 – 8.01 for Fe, 0.59 – 1.21 for Ti and 2.31 – 3.08 for K [29]. The chemical composition of clay collected at nearer river is different from several sample pottery shard collected around Ulu Kelantan. This may suggest, some trading activity held on Ulu Kelantan.

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Other than pottery, there is another clay product which studied in Malaysia. The chemical composition of the ancient bricks at Pengkalan Bujang range between 65.49 – 78.95 for Si, 11.88 – 28.01 for Al, 2.00 – 6.49 for Fe, 0.35 – 0.97 for Ti and 0.85 – 1.88 for K [30]. Based on the chemical composition shows that the ancient bricks is locally produced. Besides, the physical and size of the bricks that is smaller and almost similar indicated developments in terms of brick making technology and temple architecture.

In addition, the percentage of votive tablets that found in Chawas Cave contain of chemical composition that range between 66.61 – 75.42 of Si, 13.04 – 17.46 of Al, 5.18 – 6.94 of Fe, 1.23 – 1.51 of Ti and 1.19 – 1.60 of K. Based on the chemical composition ,the votive tablets founds in Chawas Cave were not produce locally because its contain of clinochlore which commonly found in igneous rock[28].

5. Conclusion

Malaysia pottery product can be improved by concern on their chemical composition of clay. For example, in tend to producing durable pottery products, the clay should be low in term of Fe, Al and Si amount. Besides, the dry weight of Fe and Ti that more than 2% will result in dark colour after firing process. In addition, study of prehistoric clay product also necessary to observe the technology and also raw materials used on that time.

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