Geo. Soc. Malaysia, Bulletin 29, July 1991; pp. 157 – 169

Natural and synthetic gem and rock artifacts, Pulau Kalumpang, Perak.

ABDUL RAHIM HJ. SAMSUDIN AND TAN TEONG HING

Department of Geology, Universiti Kebangsaan Malaysia, Bangi

Abstract: Natural and synthetic gem artifacts discovered at the Pulau Kalumpang archaeological site, are identified as beryl, sodalite, moldavite, plasma, aventurine, quartz cat's eye, analcime, jasper and glass beads with the latter predominating in quantity over the others. These gems were fashioned as facetted, cylindrical or spheroidal beads with each containing an axial string hole. The style of cutting, grinding and polishing seen in these gem artifacts are relatively inferior in terms of modern day lapidary practices, but nevertheless authenticate that these gems are relicts of past cultures. The glass beads which are allochromatic, commonly show annealing features as well as conchoidal fractures. From the geology of the Malay Peninsula, it can be inferred that the gem relicts were not locally mined, but had been imported from elsewhere such as India, Middle East and perhaps China. The glass beads were probably imported from elsewhere, with some being synthesized locally.

Besides the gem artifacts, several rock artifacts had also been unearthed. The rock artifacts which occur mainly as pebbles and cobbles of varying sizes, are identified as sandstone, siltstone, mudstone, chert, quartz, schist and basic igneous rock. Since rocks of similar lithology occur in abundance in the vicinity of the archaeological site, it can be inferred that these rock artifacts, unlike the gem artifacts, were derived from local sources.

Abstrak: Beberapa artifak batu permata tabii dan buatan yang ditemui di tapak arkeologi Universiti Kebangsaan Malaysia di Pulau Kalumpang telah dikenal pasti sebagai beril, sodalit, moldavit, plasma, aventurin, kuarza mata kuching, analsim, jasper dan paling banyak adalah manik kaca. Batu permata ini merupakan manik-manik yang berbentuk persegi, selinder atau sferoidal yang mempunyai lubang benang di tengah-tengahnya. Mutu bentuk rupa potongan, asahan dan gilapan pada artifak batu permata ini jauh lebih rendah berbanding dengan mutu pengukiran moden. Walau bagaimanapun batu permata ini amat penting kerana boleh menjadi bukti kepada kesan peninggalan kebudayaan lama. Manik kaca yang ditemui adalah bersifat alokromatik dan menunjukkan fitur sepuh lindap dan retakan lelokan. Daripada geologi Semenanjung Malaysia dapat disimpulkan bahawa artifak batu permata tabii ini tidak diperolehi secara lokal tetapi kemungkinan telah diimpot dari luar negeri seperti India, Timur Tengah dan kemungkinan China. Manik kaca yang ditemui juga diimpot daripada luar dan mungkin sebahagian daripadanya telah disintesiskan semula secara lokal.

Selain daripada artifak batu permata, beberapa artifak batuan juga telah ditemui. Batuan ini berbentuk pebel dan kobel dengan saiz yang berbagai-bagai, dan terdiri daripada batu pasir, batu lumpur, rijang, kuarza, skis dan batuan igneous basa. Oleh kerana batuan yang sama litologi banyak terdapat di sekitar kawasan kajian, maka dapat disimpulkan bahawa artifak batuan ini kemungkinan besar juga berasal dari kawasan yang sama.

Presented at GSM Annual Geological Conference 1990

INTRODUCTION

Application of geological knowledge need not necessarily be limited to exploring mineral, petroleum or water resources, to decipher sedimentary, metamorphic, igneous or plate tectonic event, to determine slope stability and other geologically related activities, but should also be extended to non-geological activities such as archaeological investigations. With this intention, the authors carried out geologic investigations on the some of the archaeological artifacts recovered from the Universiti Kebangsaan Malaysia archaeological site which is located at Pulau Kalumpang, near Kuala Sepetang (formerly Port Weld) (Figure 1). The artifacts which had been unearthed by researchers led by Encik Mohd Kamaruzaman Abdul Rahman consist of pieces of gemstones and rock specimens.

History has shown that eons ago, many lustrous and coloured minerals, and occasionally rocks, organic materials and fused glass beads had been used for personal decoration, as charms or amulets, or for the embellishment of objects of virtue or utility. The aim of this paper is not to use these artifacts for the interpretation of ancient cultures that had existed in this part of the Malay Peninsula, but rather to report objectively the gemmological and petrographical investigations that had been carried out on the gem and rock artifacts respectively. These findings are relevant to archaelogical interpretations.

METHODS OF INVESTIGATION

A total of 13 pieces of natural gem artifacts and 2 pieces of glass bead artifacts have been selected for gemmological investigation. Prior to any test, the weight and other parameters, viz. height, width, thickness or diameter of each of these artifacts were determined using an electronic balance and a precision Leveridge caliper gauge. The gemmological properties of each of the artifacts were subsequently determined using various appropriate methods, viz. hydrostatic weighing to determine specific gravity; polariscopy, dichroiscopy and spectroscopy to determine the various optical properties such as isotropism, pleochroism and spectral absorption; monochromatic light-refractometry to determine refractive indices of the gems; and a point hardness set to access their hardness. Finally, X-ray diffraction analyses were carried out as confirmatory tests. The results obtained from the above tests and together with other observed properties namely colour, cleavages, fractures and crystal symmetry facilitate the identification of these gems. In view of importance placed on these artifacts, no destructive tests were carried out.

The identified gem artifacts, and their corresponding weights, dimensions, morphologies, and gemmological properties are shown in Figure 2 and Tables 1, 2 and 3.

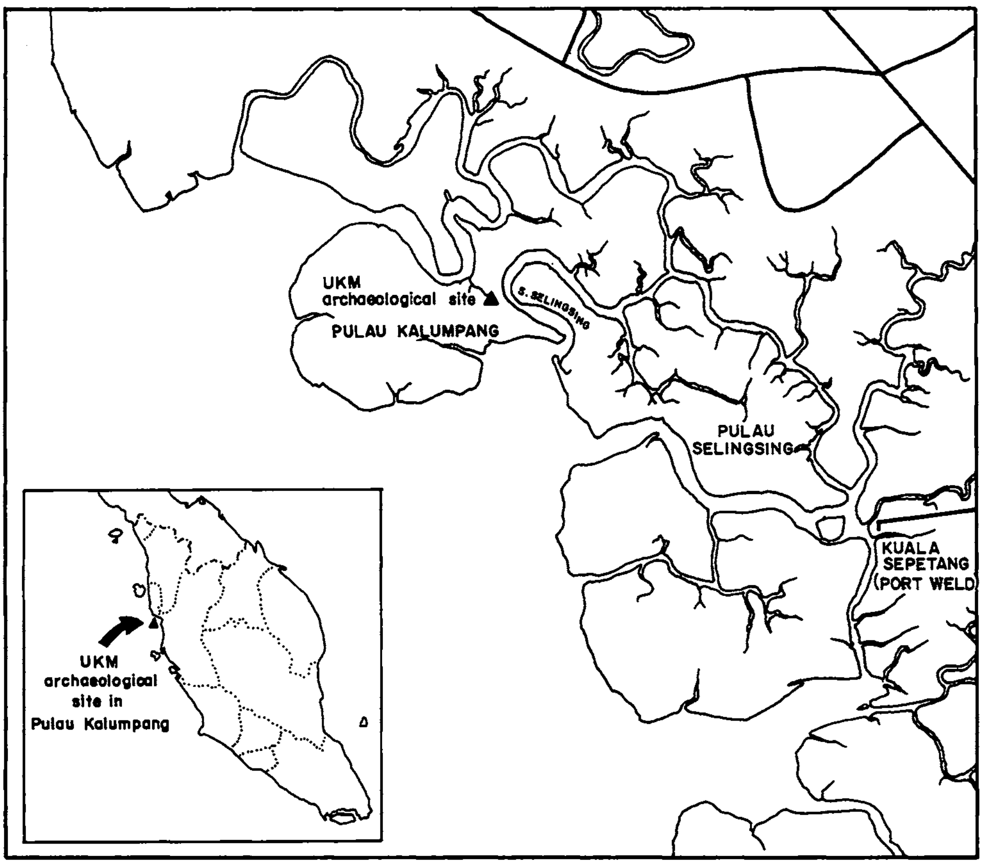

Figure 1: The location of UKM archaeological site in Pulau Kalumpang, Perak.

The rock artifacts were identified visually, and in some cases their mineral compositions were determined using hand lens and binocular. Though most of the rock artifacts show surficial weathering, their internal parts are still relatively fresh for identification. The results of the identification are shown in Table 4.

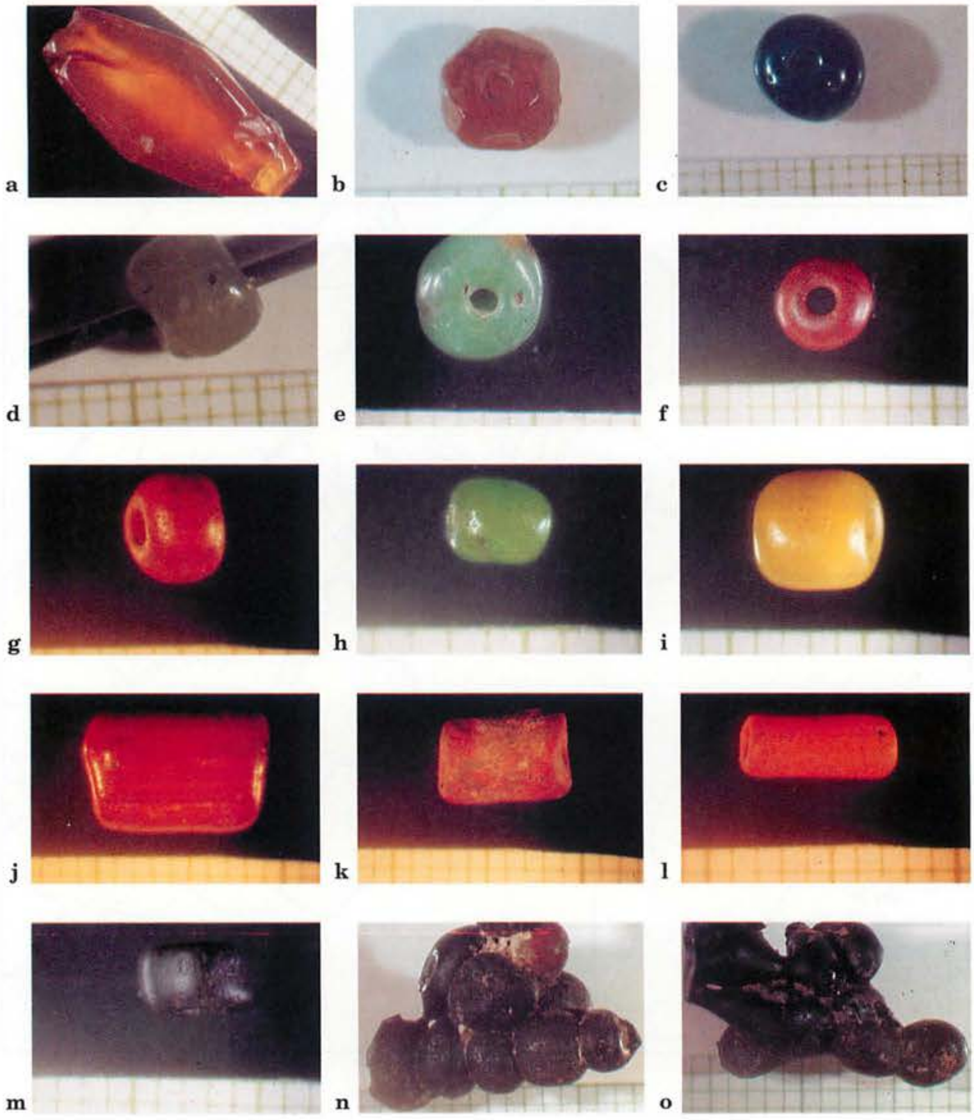

Figure 2: Gem artifacts from Pulau Kalumpang, Perak.
a = beryl, b = beryl, c = sodalite, d = moldavite, e = plasma, f = jasper, g = jasper, h = aventurine, i = quartz cat's eye, j = jasper, k = jasper, l = jasper, m = analcime, n and o = synthetic glass beads. (scale shown as millimeter graph paper)

Table 1 Gem artifacts and their morphologies

no. specimen	name of specimen	colour	shape cut	no. facets
a	beryl	golden brown	hexagonal spindle	6 above girdle 6 below girdle
b	beryl	golden brown	hexagonal bolt	6 above girdle 6 below girdle
c	sodalite	dark blue	spheroidal	-
d	moldavite	greenish yellow	spheroidal	-
e	plasma	dark green	spheroidal	-
f	jasper	dark brown	flattened spheroidal	-
g	jasper	light orange	flattened spheroidall	-
h	aventurine	grass green	cylindrical	-
i	quartz cat's eye	yellow	studdy cylindrical	-
j	jasper	brownish red	cylindricall	-
k	jasper	reddish brown	cylindricall	-
l	jasper	orangy brown	cylindricall	-
m	analcime	greyish black	stubby cylindrical	-

(number of specimen used in table is similar to those used in Figure 2)

IDENTIFICATION

From the results of the various gemmological tests, the gem artifacts are identified as beryl, sodalite, moldavite, plasma, jasper, aventurine, quartz cat's eye, analcime and glass. Among the natural gemstones, there are 5 jaspers, 2 beryls, 2 glass beads and the rest one each.

In terms of chemical composition, eight of the gem artifacts, namely jasper, plasma, aventurine and cat's eye belong to the cryptocrystalline quartz group. The differences among these gem members are mainly due to the presence of trace elements. Addition of ferric iron into the cryptocrystalline quartz gives the red, brown, and orange colouration commonly seen in jasper. Plasma and aventurine owe their green colouration to the presence of traces of chlorite and chrome mica respectively. The presence of orientated asbestos fibres gives a chatoyancy effect seen in the quartz cat's eye.

The facetted golden brown translucent beads are identified as beryl which has a chemical composition of $Be_3Al_2(SiO_3)_6$. It normally crystallizes with a hexagonal habit. This mineral together with their more precious equivalents, viz. aquamarine and emerald normally occur in pegmatites or in the derived alluvial deposits. The golden brown colour seen in these artifacts is due to the presence of traces of ferric iron in them.

The blue gem artifact is identified as sodalite which is a mineral component of lapis lazuli. It has compositions of sodium aluminium silicate

Table 2 Gem artifacts and their dimensional features

No. specimen	specimen	weight	mean height	mean width	string hole mean diameter
a	beryl	1.043 gram 5.214 carat	14.93 mm	i) 6.82 mm ii) 7.30 mm	1.45 mm
b	beryl	0.153 gram 0.767 carat	3.84 mm	i) 5.00 mm ii) 5.70 mm	1.20 mm
			mean diameter parallel to string hole	mean diameter perpendicular to string hole	
c	sodalite	0.221 gram 1.106 carat	4.41 mm	6.08 mm	1.40 mm
d	moldavite	0.151 gram 0.753 carat	4.14 mm	5.25 mm	1.23 mm
e	plasma	0.141 gram 0.703 carat	3.88 mm	8.98 mm	0.64 mm
f	jasper	0.077 gram 0.383 carat	3.23 mm	4.09 mm	0.78 mm
g	jasper	0.064 gram 0.320 carat	1.84 mm	4.45 mm	1.19 mm
			mean height parallel to string hole	mean diameter perpendicular to string hole	
h	aventurine	0.018 gram 0.088 carat	3.03 mm	2.25 mm	< 0.50 mm
i	quartz cat's eye	0.120 gram 0.600 carat	4.18 mm	4.82 mm	1.33 mm
j	jasper	0.659 gram 3.294 carat	9.27 mm	6.58 mm	1.26 mm
k	jasper	0.215 gram 1.074 carat	6.93 mm	4.99 mm	1.03 mm
l	jasper	0.061 gram 0.304 carat	5.84 mm	2.58 mm	0.80 mm
m	analcime	0.069 gram 0.343 carat	2.83 mm	4.14 mm	0.85 mm

(number of specimen used in table is similar to those used in Figure 2)

and sodium chloride ($3NaAlSiO_4.NaCl$). Sodalite which crystallizes as a cubic mineral with a dodecahedral habit, occurs only in feldspathoid-bearing rocks. The other gem artifact which resembles a glass bead, is identified as moldavite. The latter is probably of extraterrestial origin since it contains numerous large gas bubbles and swirl striations which are only observed in tektites and meteorites. The greyish black gem which is identified as analcime, belonging to the zeolite group, is commonly found in cavities present in volcanic rocks.

Table 3 Gem artifacts and their gemmological properties

No. speci-men	specimen	crystal system	form and habit	cleavage	hardness (Moh's scale)	specific gravity	opacity colour filter	Chelsea index	refractive character	optical	inclusion
a	beryl	hexagonal	bipyramidal {0001}	poor {0001}	7.5	2.75	translucent	-	1.57-1.69 160	uniaxial	ilmenite grains
b	beryl	hexagonal	bipyramidal {0001}	poor {0001}	7.5	2.73	translucent	-	1.57-1.60	uniaxial negative	-
c	sodalite	cubic	crypto-crystalline	-	8	2.22	translucent-	brownish-opaque	1.48 blue	isotropic	-
d	moldavite	-	"	-	5.5	2.35	translucent	-	1.50	isotropic	gas bubbles
e	plasma	trigonal	"	-	6.5	2.65	opaque	reddish-green	1.54-1.55	uniaxial positive	limonite grains
f	jasper	trigonal	"	-	7	2.68	opaque	-	-1.54	-	fine striae
g	jasper	trigonal	"	-	7	2.68	opaque	-	-1.54	-	fine striae
h	aventurine	trigonal	"	-	7	2.65	translucent-opaque	reddish-green	1.54-1.55	uniaxial positive	-
i	quartz cat's eye	trigonal	"	-	7	2.66	opaque	-	-1.54	-	fine fibers
j	jasper	trigonal	"	-	7	2.68	opaque	-	-1.54	-	fine striae
k	jasper	trigonal	"	-	7	2.69	opaque	-	-1.54	-	earthy encrustations
l	jasper	trigonal	"	-	7	2.68	opaque	-	-1.54	-	fine striae
m	analcime	cubic	prismatic	imperfect {010}	5	2.29	opaque	-	1.48	-	-

(number of specimen used is similar to those used in Figure 2)

Table 4 Rock artifacts and their lithology

no.	sample	lithology	no.	sample	lithology	no.	sample	lithology
1.	PB/KS C 40-60 (45 cm)	a. white quartz b. sandstone	8	PB/KS/88 Spit 120-140 Petak A 16.8.88	sandstone	15.	PB/KS/88 1 Spit 100-120 18.8.88	a. sandstone b. bone
2.	PB/KS Petak C Spit 40-60 (38 cm) 9.8.88	siltstone	9	PB/KS/88 Spit 100-120 Petak A 17.8.88	sandstone	16.	PB/KS/89 Petak B Spit 60-80 6.3.89	sandstone
3.	PB/KS Petak C Spit 60-80 (63 cm) 9.8.88	a. sandstone b. basic igneous rock c. weathered sandstone	10.	PB/KS/88 Petak A Spit 120-140 (dinding) 18.8.88	sandstone	17.	PB/KS/88 Petak B Spit 120-140 15.3.89	sandstone
4.	PB/KS Petak C Spit 120-140 (109 cm) 12.8.88	mudstone	11.	PB/KS/88 Petak A Spit 80-100 11.8.88	a. sandstone b. shell	18.	PB/KS/89 Petak B Spit 40-60 3.3.89	a. reddish black iron oxide
5.	PB/KS Petak C Spit 120-140 (122 cm) 12.8.88	sandstone	12.	PB/KS/88 Petak A Spit 100-120 17.8.88	sandstone	19.	PB/KS/89 Petak B Spit 60-80 6.3.89	sandstone
6.	PB/KS/88	sandstone	13.	PB/KS/88 Spit 80-100 Petak A 12.8.88	a. quartz b. shell	20.	PB/KS/89 Petak B Spit 120-140 14.3.89	glass
7.	PB/KS/88 Petak A Spit 80-100 12.8.88	sandstone	14.	PB/KS/88 Petak C Spit 40-60 8.8.88	a. slate b. sandstone pebble	21.	PB/KS/89 Petak B Spit 40-60 5.3.89	quartz

Table 4 Rock artifacts and their lithology

no.	sample	lithology	no.	sample	lithology	no.	sample	lithology
22.	PB/KS/89 Petak B Spit 60-80 5.3.89	quartz	29.	PB/KS/89 Petak C Spit 40-60 (50 cm) 9.8.89	schist	33.	PB/89(1) Petak 1 Spit 200-220 21.3.89	siltstone
23.	PB/KS/89 Batas BC Spit 80-100 18.3.89	sandstone	30.	PB/KS/89 Spit 140-160 16.8.89	sandstone	34.	PB/KS/89 Petak 1 Spit 40-60 15.3.89	siltstone
24.	PB/KS/89 Batas BC Spit 20-40	sandstone	31.	PB/KS/89 Petak 1 Spit 120-140 14.3.89 Batu D-136, U-65, B-91	sandstone	35.	PB/KS Petak C Spit 40-60 (50 cm) 9.8.88	schist
25.	PB/KS/89 Batas BC Spit 100-120 19.3.89	sandstone	32.	PB/89(2) Petak 1 Spit 200-220 21.3.89	schist	36.	PB/KS/89 Batas BC Spit 40-60 17.3.89	red mudstone
26.	PB/KS/89 Batas BC Spit 40-60 12.3.89	siltstone						
27.	PB/KS/89 Batas BC Spit 100-120 18.3.89	sandstone						
28.	PB/KS/89 Batas BC Dinding-timur kedalaman 26 cm	chert						

The glass beads unearthed together with natural gem stones are mainly brown and black in colour. These beads are characterized by conchoidal fractures, glassy surfaces and annealing features. Some of the glass beads are fused together indicating that they were still in a semi-manufacturing state.

A total of 36 rock artifacts of varying sizes had been presented for identification. From mineralogical compositions and rock textures, these artifacts are identified as sandstone, mudstone, quartz, chert, schist and basic igneous rock. Outcrops of rocks with similar mineralogy and texture, occur in abundance in the immediate vicinity of the archaeological site, particularly around the area north of Taiping.

MORPHOLOGICAL FEATURES

Six of the thirteen gem artifacts were fashioned as spheroidal beads, another five as cylindrical beads, and the remaining two as facetted beads. These beads were neither well cut nor ground, forming shapes and surfaces that are seldom seen in modern jewellery. Foreign inclusions (e.g. ilmenite grains in beryl, limonite grains in plasma, nodular markings and earthy encrustations on jaspers) were not removed during cutting and grinding. With the exception of a few beads (viz. the earthy-looking jaspers and analcime), most of the artifacts were however moderately well polished.

Observation through a binocular shows that the spheroidal beads (viz. sodalite, moldavite, plasma and jasper) generally have pits, grooves and minor protrusions over their surfaces, resulting in considerable variation in their diameter measurements. Generally, the shortest diameter occurs parallel to the string hole direction, giving these beads a non-spherical appearance. Prominent surface markings in the form of fine striations, running parallel and converging into the string hole, are ubiquitous in the spheroidal jasper beads, suggesting that the latter were cut from jasperized plant fossils containing plant fibers which had been preserved as fine striations.

The cylindrical beads (viz. aventurine, quartz cat's eye, jasper and analcime) are usually not terminated by planar surfaces at both ends. In addition, the diameter seldom remain constant along the entire length of these beads. The aventurine bead though rather small in size, appears almost perfect in terms of modern-day lapidary practices. The jasper beads are characterized by fine striations occurring parallel to their long axes. In one of the jasper beads, minute nodular swellings are also present. The presence of striations and nodular swellings suggests that these beads were cut from jasperized plant fossils.

The facetted beads (viz. beryls) are characterized by non-symmetrical dispositions of the facets along either their planes or axes of symmetries, as well as by inconsistency in the shape and size of the facets. One of the beryls was fashioned aping its original bipyramidal hexagonal crystalline outline, giving it a spindle shape; while the other which has a hexagonal bolt-shaped appearance, had been fashioned by truncating the apices of its pyramids. In addition, the surfaces of these facetted beads contain pits, holes, minute steps, and ilmenite inclusions; while the facet edges have crenulations and cracks. These lapidary flaws could be due to their hardness (7.5 on Moh's scale) which could have rendered cutting, grinding and polishing a very menial task in those days.

As all the artifacts were fashioned as beads, they were drilled with an axial string hole. The string holes in most of the gems are relatively coarse and large, with apertures of unequal sizes at both ends of a bead. However, one of the specimens (aventurine) has a relatively fine string hole with a diameter not exceeding 0.5 mm.

The glass beads are opaque and commonly show annealing and fusion features. These features are most prominent among the glass beads that have not been separated as individual beads. The beads are joint to one another, giving an earthworm appearance. These coloured glass beads were probably manufactured by rotating fused glass over a heat source. Broken fragments of these beads show concoidal fractures and glassy texture. The red glass beads owe their colour to iron oxides, whilst the black beads to manganese oxides. Both these elements were detected in the X-ray investigations.

It appears that even early civilization knew how to synthesize glass beads in an attempt to imitate the genuine ones particularly jaspers and analcime. The size and shape of the glass beads approximate those of the genuine gem relicts. Since these glass beads are opaque, their optical properties could not be determined. However specific gravity measurements give an average reading of 2.20. The high specific gravity could be due to addition of colouring agents into the molten glass prior to its manufacture.

The gemmological properties and other observed features present in these artifacts are summarized in Tables 1 to 3.

Unlike the gems, the rock artifacts were crudely sculptured without having any consistent shape or form. Most of these artifacts are characterized by variable combinations of subangular to subrounded surfaces which could have been shaped by knocking and abrading the original rocks, boulders, cobbles or pebbles available in the vicinity. In addition, the absence of scratch marks on these artifacts suggesting that they were not used as cutting or hunting tools.

CONCLUSION

Thirteen pieces of natural gem artifacts unearthed from the Pulau Kalumpang archaeological site are identified as beryl, sodalite, moldavite, plasma, jasper, aventurine, quartz cat's eye and analcime. Among these materials, five of them occur as jaspers, two as beryls, and the rest one each. In this collection, the biggest specimen is beryl, while the smallest is aventurine.

The synthetic beads are mainly glass beads which were manufactured by rotating glass over a heat source. The colour in these beads are mainly due to addition of iron oxides and manganese oxide, giving red and black colouration respectively.

Observation under a binocular shows that although the gem artifacts had been cut, ground and polished, the lapidary work afforded to most of them was rather crude and archaic as compared to gemstones fashioned by modern-day technology. The obvious designing flaws present in these artifacts, however reflect not only their true intrinsic values but also the level of lapidary skill and the knowledge to manufacture synthetic stones that had been practised in the early time.

Apparently, the gemstones preferred or perhaps affordable by the general populace in those days were those fashioned either as rounded or as cylindrical beads, since they predominate in quantity over the facetted beads. It can be inferred that they had been stringed together with other gemstones (similar or otherwise) and used as laces worn perhaps on necks, arms, wrists, fingers or even legs. The scarcity of the facetted beads could be that they were more difficult to fashion and hence more costly and perhaps limited to the elite populace.

The origin of the gem artifacts unearthed from the Pulau Kalumpang archaelogical site were not local but brought in from elsewhere since the rock types present in the Malay Peninsula do not contain such gem materials. Although jasper is relatively common in Malaysia, jasperized plant fossils had neither been reported nor observed locally. Similarly, the facetted gem beryls differ from those beryl present in pegmatites occurring in the vicinity of Kedah Peak; the latter beryl has a greenish blue colouration. The natural gem artifacts found at Pulau Kalumpang were probably introduced either as raw or as finished products, and could have originated from India, Middle East and perhaps China, all of which have suitable gem-bearing geological formations. Beryl, plasma, aventurine and sodalite had been mined for centuries in India, particularly from Mysore, Coimbatare, Rajasthan and Kashmir. Similarly, the Middle East countries, particularly Iran and Iraq are well known for producing sodalite and aventurine. The Chinese had for ages, used plasma and aventurine as jade substitutes. The synthetic glass beads were also imported from elsewhere since outcrops of silica glass have not been observed in the vicinity. The presence of unseparated and fused glass beads may suggest that local populace may be involved in the manufacture of these beads.

The crudely shaped rock artifacts unearthed from the Pulau Kalumpang archaeological site, unlike the gem artifacts, are not articles of attire. Most of the rock artifacts have characteristics of sedimentary rocks. From their mineralogy and texture, these rock artifacts resemble the sedimentary rocks of the Semanggol Formation. The latter consists of a sequence of fan-channel conglomerate, thick turbidite sandstone, thin turbidite sandstone interbedded with mudstone, thick black mudstone, red cherty mudstone, argillaceous chert, and chert (Ahmad Jantan *et al.*, 1989). These rocks which outcrop in great abundance in an area north of Taiping which is about 10 km east of Pulau Kalumpang, could be the major provenance for the rock artifacts. Three samples of the rock artifacts are identified as schist. These metamorphic rock samples are probably derived from Mahang formation which outcrops north of the Semanggol Formation. An artifact resembling basic igneous rock found at the site probably originated from basic dykes associated with a granite intrusion occurring nearby. The rock and gem artifacts together with other relicts may aid comprehensively the interpretation of ancient cultures that had existed some 2,000 years ago (personal comm., Encik Mohd Kamaruzaman Abdul Rahman) at Pulau Kalumpang.

ACKNOWLEDGEMENT

The specimens made available for this study were collected by the archaeological team headed by Encik Mohd Kamaruzaman Abdul Rahman from the Department of History, Universiti Kebangsaan Malaysia.

We thank Encik Mohd Ali Hassan, the Head of Department of Geology, University of Malaya for allowing us to use the photography facilities available in his department. We are also indebted to Puan Zohara Ghani in helping to take some of the photographs.

REFERENCES

AHMAD JANTAN, BASIR JASIN, IBRAHIM ABDULLAH, UYOP SAID AND ABDUL RAHIM SAMSUDIN, 1989. The Semanggol Formation – lithology, facies association and distribution, and probable basin setting. *Annual Geol. Conf., Geol. Soc. Malaysia*, 1989 (Abst.).

Manuscript received 6 September 1990