Sari - International Journal of the Malay World and Civilisation 29(2) (2011): 3 - 20

Some Observations on Glass Beads Composition in Sarawak, Singapore and Peninsula Malaysia

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ABSTRACT

Since a great contribution by Beck in 1930's in studying beads especially in Southeast Asia region, a few other scholars have been encouraged to study the beauty of beads typologically and scientifically. Lamb for example has published several articles on beads in Southeast Asia and other parts of the world. Lamb also analyzed scientifically several beads from Kuala Selinsing, Pengkalan Bujang and Takuapa and demonstrated their compositional data. Tom Harrison, who has done a wonderful job on Sarawak beads also reported in his article, a research on Kuala Selinsing glass beads, Bukit Maras, Santubong associated with Tang and Song ceramics and a Buddha Gupta sculpture and also glass beads worn by Kelabit people. These beads have been analyzed scientifically and the result showed that Kuala Selinsing glass beads have a different compositional content with the Santubong glass beads and also Kelabit glass beads. Harrison suggested that glass beads from Kelabit have Chinese origin based on higher lead content in the beads. In this article, we would like to compare the compositional data of Sarawak glass beads with the data taken from Kuala Selinsing, Fort Canning, Singapore and Sungai Mas, Kedah glass beads. The compositional aspect of Santubong, Kelabit, Kuala Selinsing, Sungai Mas and Fort Canning will be analyzed and their differences and similarities will be discussed. According to our research, Bukit Maras, Santubong glass beads have a similar composition of elements with the Sungai Mas, Kedah glass beads and beads worn by Kelabit people are probably not of Chinese origin but have similar content of lead with the glass introduced in Europe in the seventeenth century AD.

Key words: beads, Kuala Selinsing, Bukit Maras, Santubong, Fort Canning, Sungai Mas

ABSTRAK

Sejak sumbangan besar yang dilakukan oleh Beck pada tahun 1930an terhadap penyelidikan manik terutamanya di kawasan Asia Tenggara, beberapa orang sarjana lain juga telah mempunyai galakan yang sama untuk menyelidiki keindahan manik secara tipologi dan juga secara saintifik.

Contohnya ialah Lamb yang telah menerbitkan beberapa artikel tentang manik yang terdapat di Asia Tenggara dan juga di kawasan lain. Lamb juga telah menjalankan analisis secara saintifik beberapa manik dari Kuala Selinsing, Pengkalan Bujang dan Takuapa dan telah memperoleh data saintifik mengenai manik tersebut. Tom Harrison, yang telah melakukan penyelidikan yang baik mengenai manik di Sarawak dan telah dilaporkan dalam artikelnya, penyelidikan tentang manik di Kuala Selinsing, manik di Bukit Maras, Santubong yang berasosiasi dengan jumpaan seramik Tang dan Song serta arca Buddha Gupta dan manik yang dipakai oleh masyarkat Kelabit. Manik-manik tersebut telah dianalisis secara saintifik dan keputusannya menunjukkan manik Kuala Selinsing mempunyai komposisi bahan yang berbeza dengan manik di Santubong dan manik Kelabit. Harrison mencadangkan yang manik kaca dari Kelabit mempunyai kandungan plumbum yang tinggi dan berasal dari China. Dalam artikel ini, kami akan cuba untuk membuat perbandingan komposisi bahan antara manik kaca yang terdapat di Sarawak dan juga manik kaca yang terdapat di Fort Canning, Singapura serta manik kaca dari Sungai Mas, Kedah. Aspek komposisi bahan manik kaca dari Santubong, Kelabit, Kuala Selinsing, Sungai Mas dan Fort Canning akan dibincangkan berdasarkan perbezaan dan persamaannya. Berdasarkan penelitian yang dibuat, manik kaca dari Bukit Maras, Santubong mempunyai persamaan komposisi unsur yang sama dengan manik kaca dari Sungai Mas dan manik kaca yang dipakai oleh masyarakat Kelabit barang kali bukan berasal dari China tetapi manik yang mempunyai kandungan plumbum yang sama dengan keluaran Eropah pada abad ke-17 Masihi.

Kata kunci: manik, Kuala Selinsing, Bukit Maras, Santubong, Fort Canning, Sungai Mas

INTRODUCTION

This study will focus on compositional aspect of Sarawak monochrome glass beads and comparing them with other data from Singapore and Peninsula Malaysia. Sarawak is a state located in Borneo Island has many important archaeological sites such as in Gua Niah and Santubong. Borneo lies in the centre of the South-east Asian archipelago, north of Java, east of Peninsula Malaysia, south-west of Philippines and west of Sulawesi. With a land surface area of about 750, 000 sq km, Borneo is larger than any of these more densely populated and historically more prominent places.

In the 3rd and 4th century AD, Kang Tai and Zhu Ying, Chinese envoys to Funan listed several locations in Borneo Island such as P'u-Io-chung, Chu'Po and Kutei. P'u-Io-chung was located in Sarawak, Chu'Po located in Sabah near Sandakan (Munoz 2006) while Kutei located in South Kalimantan. P'u-Io-chung is believed to be located near the estuary of Sungai Rajang and was known to early traders as a place that produced camphor. The location of Chu'Po however is still in debate by scholars which identified Chu'Po to be located in Sabah (Munoz 2006), Kedah (Moens 1940) and central Java (Wolters 1989). Chu'Po produced iron ore and exported it to Funan. Kutei a port-kingdom in southern Borneo is believed to have existed since 4th century AD. Based on Chinese document written by Fa Hsien, Kutei was ruled by King Devavarman, Asvavarman and Mulavarman.

Chinese seafarers of Sung Period (960 AD-1279 AD) knew Borneo and its produce, but the maritime trade, en route to the bigger markets of Peninsula Malaysia, Sumatera and Java mainly by passed the looming land mass. Several ancient ports that have Sung-Yuan ceramic and monochrome glass beads are Santubong in Sarawak, Bujang Valley, Kedah and Kuala Selinsing in Peninsula Malaysia and Singapore. Santubong in Sarawak is dated from 7th century AD, Bujang Valley, Kedah is dated from 4th century AD, Kuala Selinsing a coastal prehistoric and protohistoric settlement is dated from 200 BC and Singapore is dated from 10th or 11th century AD. Kuala Selinsing and Bujang Valley are known as Indo-Pacific beads centre (Francis 2002). Based on archaeological research in Pulau Kelumpang and Sungai Mas, it can be suggested that Kuala Selinsing produced monochrome glass beads since 2nd centrury AD while Sungai Mas in Bujang Valley produced their beads from 6th century AD.

Since the great works by Beck in 1930's in studying the beads from this part of the world (Beck 1930), it has encouraged other scholars to study the beautiful beads, typologically and scientifically. Lamb for example already published several articles on beads that have been found in Southeast Asia and other parts of the world (Lamb 1964, 1965). Lamb also analyzed scientifically several beads from Kuala Selinsing, Pengkalan Bujang and Takuapa and demonstrated their compositional data. Tom Harrisson, who has done important study on Sarawak beads reported in his article, a research on Kuala Selinsing glass beads, Bukit Maras, Santubong associated with Tang and Song ceramic and a Buddha Gupta sculpture and also glass beads worn by Kelabit people (Harrisson 1964). Kamaruzzaman (1989) also discussed further on beads found in Malaysia and made comments on works that have been done by Lamb and Harrison. Analysis on Sungai Mas drawn monochrome glass beads also have been done to distinguish the origin of the beads (Ramli et al. 2011; Rahman et al. 2008). Sungai Mas drawn monochrome glass beads also have been compared with the Oc-eo glass beads in compositional aspect and it can be suggested that Sungai Mas and Oc-eo produced their own beads since 2nd century AD. In Singapore, Miksic et al. (1996), in 1988 excavated at Fort Cannings, covering a surface area of 60 square meters (2 × 30 meter, including baulk), beginning from K2 and running west, up the slope of Fort Canning Hill. The trench produced more beads: 639 yellow, 335 black, 238 blue, 227 red, 133 white, 33 green and 2 orange. The lower sector of the trench (rectangles I and rectangle II) also yielded the first shards of glass vessels to be discovered in the 14th century stratum at the site (Miksic et al. 1996). Glass beads and glass fragments were taken to be analysed scientifically.

Several conclusions have been made on glass beads found in ancient sites in Malaysia and Singapore such as; the origin of the raw materials of the glass whether it was from Middle Eastern or Roman-Hellenistic-Byzantine (Lamb 1964, 1965). Several scholars assumed that Pengkalan Bujang and Kuala Selinsing beads centre have recycled glass scrap from Middle Eastern beads while beads that have been found in Singapore are winding beads and most probably originated from China.

INTERPRETING GLASS ANALYSES

Ancient and modern glasses are composed of many different elements. Glassmaking was traditionally an art, not a science, and early glassmakers did not have the ability to purify their ingredient completely. Some elements in glass are important in tracing the origin of the raw materials, but others are not considered significant. The constituents of glass may be grouped into six categories:

1. Glass formers. All glass considered here are silica-based. The silica contents vary from less than 55 percent to nearly 75 percent. The difference depends on the amount of other ingredient; it is rarely crucial to understanding glass samples. The other important glass former is lead, which by virtue of its high specific gravity can register up to 90 percent of the weight of ingredient. No Indo-Pacific beads were made of lead glass. However, the lack of lead in some of these glasses is important.
2. Alkalies. Silica melts at a very high temperature, too high for any ancient furnace to reach. A flux, employed to lower the melting point of silica, needed to be added to the batch. Lead can serve

as a flux, but more often alkalies were used, principally sodium (as soda) and potassium (as potash). They were derived from soil deposits, evaporated seawater or saline lakes, or the ashes of plants. Plant ash is usually a mixture of these two alkalies. In fact, most alkalies in ancient glasses are mixed to some degree. The ratio of alkalies in glass is often an important clue to their association and their sources.

3. Secondary ingredients. Calcium, aluminium, iron, manganese, and magnesium are usually present in older glass in concentrations from 1.0 to 10.0 percent; the higher concentration is rare. Lime (calcium) is necessary to stabilize glass, though ancient glassmakers may not have realized this (Turner 1956, 45T-46T). Manganese and iron maybe added as colorants (discussed next); otherwise along with aluminium and magnesium, they are impurities introduced with the sand, the alkalies, colorant, or the crucibles (especially in the case of aluminium).
4. Colorant. Metal salts are added to the batch to impart various hues. Upon firing they convert to oxides. All but the purest modern glasses have some colour. Iron and copper, both common by the time glass was invented, can impart a wide spectrum of colours, depending on their amounts and how the glass is worked. Manganese and cobalt are powerful colorants that have been known for a long time.
5. Opacifiers. Arsenic, antimony, and tin have been used as opacifiers, as have salt, bone, and fluorides. The elements in these ingredients are also commonly found in trace amounts. Purposeful addition is not usually assumed until concentration of 1.0 percent or so is reached.
6. Trace elements. Tiny amounts of other elements enter the glass batch inadvertently. Titanium, vanadium, gold, silver, and others are nearly always present in amounts of 0.1 percent, 0.01 percent, or even less. Combinations of trace elements may provide a "fingerprint" to help identify particular glasses. But the validity of that expectation has not yet been demonstrated. There are still not enough analyses revealing such "fingerprint" to be useful in comparing them. Differences in trace elements may be attributed to any of the primary or secondary constituents of glass, and the sources of these ingredients may vary widely, even at one glasshouse.

ANALYSIS OF GLASS BEADS AND GLASS FRAGMENTS

Tom Harrisson in his article has demonstrated compositional analysis on Bukit Maras, Santubong monochrome glass beads, beads worn by Kelabit people and also beads collected by J. McHugh at Kuala Selingsing, Perak. Kuala Selinsing glass beads was selected by J. McHugh and Tom Harrisson as a mainland 'control' for comparison and it is because of (i) Selinsing is readily accessible and more beads can be excavated there at any time, (ii) the beads selected are of type which look much the same as others found over much of South East Asia especially of beads from Bukit Maras, Santubong, (iii) there are already comparable series from Selinsing itself in a Beck Collection at Cambridge, at Hanoi, at Kuala Lumpur and in Sarawak Museum.

Seven glass beads from Kuala Selinsing (Table 1), ten monochrome beads excavated by a Sarawak Museum team at Bukit Maras, Santubong, Sarawak River delta (Table 2) and four slightly larger monochromes, all pale blue or green, taken to represent four main kinds of highly valued 'Let' bead from a Kelabit necklace (Table 3) which Tom Harrisson bought - for several buffalos - in 1946. These have been widely used in interior barter trade as far west as the lower Baram in Sarawak and as far east as the Kenyah-Kayan peoples of Bahau and Apo Kayan. Similar beads were valued by the Land Dayaks of south-west Borneo until recent times (Harrisson 1950).

Tables 1-3 give the basic information for the above three new sets of analyses. In addition to the above, traces of titanium (as TiO_2) were

Table 1. Series A beads, Kuala Selinsing (J. McHugh, excavator)

Sample	SiO_2	Na_2O	K_2O	CaO	Fe_2O_3	AI_2O_3	CuO	MnO	PbO	MgO
Terra-cotta red	67.0*	2.0	6.0	4.7	2.7	5.7	1.1	Trace	1.2	Trace
Orange	76.0	1.3	3.4	4.7	2.9	4.2	5.7	0.01	0.05	1.3
Dark blue	69.1^{T}	1.8	5.2	6.5	2.6	11.0	0.6	Trace	0.30	0.4
Light blue	69.5	2.9	3.2	6.3	1.5	11.5	1.6	0.04	Trace	Trace
Dark green	67.0	2.4	6.0	8.3	1.3	12.0	1.2	Trace	0.46	Trace
Light green	71.0	5.0	1.4	9.0	1.3	6.0	0.6	0.46	0.46	Trace
Yellow	64.0^{T}	5.0	Trace	7.3	3.0	10.0	0.2	Trace	2.7	0.6

* *A1 shows quartz crystals indicating incomplete fusion*
T A3 and A7 partly devitrified, attrition on external surface

Source: Harrisson 1964

Table 2. Series B beads, Bukit Maras, Santubong (T. Harrisson, excavator)

Sample	SiO_2	Na_2O	K_2O	CaO	Fe^*	AI_2O_3	Cu^*	Mn^*	PbO	Mg*
Standard red, long cylindrical	72.0	9.8	1.3	3.6	0.32	12.2	0.14	0.02	0.28	0.12
Standard red, oblate spheroidal	71.5	10.4	1.3	3.2	0.25	12.8	0.11	0.02	0.23	0.07
Green opaque, small	73.4	8.9	2.1	5.1	0.12	9.9	0.06	0.01	Nil	0.15
Green opaque, very small	74.0	7.9	2.4	4.9	0.19	10.1	0.05	0.01	Nil	0.11
Standard yellow, small	74.8	7.4	1.5	3.9	0.21	11.7	0.03	0.03	Nil	0.18
Standard dark blue	73.6	8.5	1.9	4.2	0.21	10.9	0.17	0.10	0.19	0.17
Standard black	72.5	8.7	1.9	4.3	0.23	11.4	0.19	0.12	0.17	0.19
Orange with black striœ, long cylinder	75.7	7.8	1.5	3.8	0.05	9.8	0.03	0.03	0.75	0.14
Orange with black striœ, small	76.5	7.2	1.3	3.9	0.04	9.8	0.03	0.03	0.61	0.15

* *Analysis is for element alone, not oxide (as in A and C); this slighty reduces the figure- compare Table IV*

Source: Harrisson 1964

Table 3. Series C beads, Kelabit uplands, necklace (T. Harrisson, collection)

Sample	SiO_2	Na_2O	K_2O	CaO	Fe_2O_3	AI_2O_3	CuO	MnO	PbO	MgO
Spherical, light blue	61.7	0.9	4.6	8.4	0.3	4.7	0.4	0.07	12..8	Trace
Barrel, light blue	62.9	0.6	3.6	7.9	0.4	8.0	0.8	0.04	13.6	Trace
Cylindrical, dark blue	60.3	0.9	3.4	8.5	0.3	9.0	0.2	0.3	16.9	Trace
Flat cylindrical, dark blue	61.1	0.8	3.2	8.4	0.3	8.7	0.2	0.3	16.0	Trace

Source: Harrisson 1964

found in A_3 Selinsing and C_2 Kelabit; and of zinc (as ZnO) in A_5 Selinsing and in K_1 and K_5 Kelabit; no phosphorus (Harrisson 1964). It will be seen that there are other variations in the three series. For instance A_7 is high in MgO (magnesium oxide) and A_2 in CuO (copper; often high in reddish or orange-coloured beads). Yet there is a close general consistency between the two excavated series, in West Malaya and Borneo, from sites 700 miles, a peninsula and a sea apart. In one major and several minor respects both series differ significantly and consistently from the valued 'ancient beads' off Kelabit necks in Borneo's far interior, series C. Whereas some of the excavated coastal beads in Malaysia have no PbO (lead oxide), none have over 3 per cent, of that compound (*cf.* A_7); but PbO is the second largest component of all the up-land beads, at 13 – 16 per cent. Na_2O (sodium) runs lower in the Kelabit series, not exceeding one per cent. –it is never below that figure for series A and B. The CaO (calcium) content also tends to be consistently high in the Kelabit lot.

Fort Canning, Singapore Glass Beads

Compositional analysis on glass beads in Singapore was done by Miksic and he selected five samples with different colour (Table 4). The excavation was done in 1988 at Fort Canning, Singapore by John Miksic and unearthed a lot of glass beads. The technique of making glass beads by twirling molten glass around a wire or mandrel is strongly identified with China. In the centre of ancient bead-making India, the glass was drawn out into a long tube or cane which was then cut into sections. Thus the technique of manufacture favours an origin for the beads somewhere in China.

The data (Table 4) showed that Fort Canning beads have high concentration of lead (Pb) and it can be suggested that the glass beads originated from China. However, the silica and aluminium content was not given. These two elements are very important when interpreting glass beads. The alkaline showed that sodium has a higher amount of concentration than potassium.

The high lead content of the beads also favours a Chinese origin. Documentary sources on Chinese glass-making from the 12th to 17th

Table 4. Compositional of glass bead samples from Fort Canning (in relative concentration)

Sample	SiO_2	Na	K	Ca	Fe	Al_2O_3	Cu	Mn	Pb	MgO
Blue	NA	30397	2074	2318	22337	NA	688	798	167857	NA
Yellow	NA	171490	8699	6441	59422	NA	5454	1285	1936263	NA
White	NA	88800	4742	4625	13507	NA	1543	1186	3070033	NA
Brown	NA	152940	8740	7298	464684	NA	21507	4214	2984335	NA
Dark	NA	154660	9171	7624	431114	NA	24912	3945	5352840	NA

Source: Miksic et al. 1996

centuries specifically require the addition of lead (Francis 1989: 11). According to Francis (1989: 14-15), such beads are found but rare at the sites of Hitam, Bukit Sandong, Kuala Selinsing, and Sungai Mas, whereas they are common at Bongkisam, Gedong, Pengkalan Bujang, Sungai Lumut, Kota Batu, and Calatagan. They appear in Southeast Asia around AD 900, and gradually came to replace the cane beads which probably came from India by about 1200. Dominant colours differ from site to site: red at Sungai Mas, white at Kuala Selinsing, blue at Kota Batu. A recent survey in the eastern Riau Archipelago (Pulau Tujuh group) also indicated their presence in association with burials containing *i.a*. Chinese ceramics of the 13th-14th century (Miksic et al. 1996).

Zhao Rukuo, harbourmaster of Canton in 1225, noted that Chinese merchants exported glass beads and bottles to *Poni* ("Borneo") and the Philippines (Hirth & Rockhill 1911). In the fourteenth-century account of Wang Dayuan. Chinese traders are reported to have vended beads at Xien, Cambodia (yellow and red beads; confirmed by the early fifteenth-century *Xing zha sheng lan* of Fei Xin), Malacca (*Xing zha sheng lan*), Kelantan (red and green beads), Jung (south end of Malay Peninsula?) (dark red beads), *Lung ya bo di* (Langkawi?) (red and green beads), Jambi (specifically red beads), Palembang ("small coloured *men-pang* beads"; the *Xing zha sheng lan* also mentions bead trade at Palembang), Java, Aru, the Moluccas, and Sulu (blue beads) (Rockhill 1915). Interestingly Wang does not mention beads among the items traded at Singapore (Miksic et al. 1996). In addition to glass beads, coral beads traded at Karimata (Rockhill 1915), and copper beads at San Tao (in the Philippines) (Rockhill 1915).

Glass Beads and Glass Fragment from Pengkalan Bujang, Kedah

Compositional analysis of glass beads from Pengkalan Bujang, Kedah (Table 5), shows that the beads contain higher amount of silica that is in range of 56.2 to 61.5%. Pengkalan Bujang glass beads also contain higher amount of aluminium (14.8 to 16.3%). Sodium content is much higher than potassium and it range from 14.0% to 16.8. Silica, sodium and aluminium content show that glass beads from Pengkalan Bujang not originated from India or Chinese origin but these beads were locally made and originated from Sungai Mas, Kedah. The glass fragment from Pengkalan Bujang also have a similar compositional content with the glass beads but the content of aluminium is in range of 7.1% to 8.2%.

Table 5. Analysis of glass beads and glass fragments (total of percentage) from Pengkalan Bujang, Kedah

Sample	SiO_2	Na_2O	K_2O	CaO	Fe_2O_3	AI_2O_3	CuO	MnO	PbO	MgO
Mutisalah	60.5	16.8	2.6	3.1	0.05	16.2	0.4	trace	NA	0.05
Yellow glass bead	56.2	14.0	1.9	2.6	0.02	14.8	0.03	trace	NA	0.07
Green glass bead	61.5	15.8	2.4	3.5	0.02	16.3	0.34	trace	NA	0.34
Dark brown glass	73.1	13.0	1.5	4.1	0.05	7.4	0.17	0.02	NA	0.15
Blue glass	73.2	13.0	1.6	4.2	0.06	7.1	0.17	0.02	NA	0.20
Green glass	73.2	13.0	1.5	4.1	0.05	7.2	0.16	0.02	NA	0.25
Amber glass	72.3	13.0	1.3	4.3	0.06	8.0	0.11	0.03	NA	0.25
Colourless transparent glass	72.3	13.0	1.3	4.3	0.05	8.2	0.11	0.02	NA	0.20

Source: Lamb 1965

A glass with a high silica content (50-70%), a high soda content (10-20%), and a virtual absence of lead. Such a glass is generally associated with old Mediterranean or Middle Eastern practise. It is the material of the mutisalah beads, of the glass fragment from Ahichchhatra and of the scrap glass from Pengkalan Bujang. Some beads manufactures in South East Asia from this kind of material may have used as one raw material scrap glass from the west (Lamb 1965).

Sungai Mas Drawn Monochrome Glass Beads

Table 6 shows the contents of major elements in Sungai Mas Indo-Pacific beads. The results indicate that beads and three samples suspect as raw material have relatively high amount of silica that is more than 60%. Content of sodium is also high that is in range of 14.08 to 18.53% whilst potassium in range of 1.54 to 2.12%. This signified that the Indo-Pacific beads are drawn beads and soda glass type. This data is in agreement to the previous report by Hancock et al. (1994) that most drawn beads are soda glass rather than potash glass type. The content of lead also confirms that Sungai Mas beads are Indo-Pacific beads not lead glass beads originated from China.

The aluminium content in Sungai Mas beads is also relatively high that is in range of 7.79 to 13.52 percent. The concentration of aluminium in Sungai Mas beads samples that have been done by Rahman et al. (Table 8) shown lower content of aluminium that is in range of 1.08 to

Table 6. Major elements content (percentage of total) in Sungai Mas Indo-Pacific beads

Bead Colour	SiO_2	Na_2O	K_2O	CaO	Fe_2O_3	AI_2O_3	TiO_2	MnO	MgO
Yellow	67.37	14.56	1.86	2.16	1.85	8.87	0.53	0.08	0.45
Green	63.09	15.40	1.93	3.27	2.00	9.46	0.56	0.08	1.05
Black	66.22	17.04	1.91	2.31	2.39	9.11	0.44	0.05	1.25
Translucent Blue	65.36	17.34	1.99	2.65	1.38	7.79	0.49	0.06	0.64
Orange	60.36	14.84	1.98	2.47	3.04	12.04	0.61	0.06	1.47
Translucent Blue	66.35	15.90	2.01	2.69	1.80	8.29	0.53	0.07	0.87
Translucent Blue	62.88	18.48	1.94	2.83	1.79	9.94	0.53	0.08	1.16
Light Green	63.90	16.36	1.76	2.54	1.96	9.83	0.52	0.08	1.15
Translucent Blue	66.25	18.17	1.50	3.07	1.63	8.21	0.30	0.05	0.82
Red (Opaque)	64.50	15.77	1.75	2.88	2.74	10.29	0.50	0.06	0.96
Light Yellow*	64.37	14.08	1.98	2.27	1.72	9.59	0.59	0.07	0.73
Yellow	64.82	16.87	1.97	2.08	1.70	9.84	0.52	0.07	0.92
Blue	68.81	16.64	1.72	2.09	1.67	8.08	0.49	0.06	0.95
Green	65.64	16.51	2.14	2.25	1.70	9.88	0.53	0.06	0.90
Light Yellow*	65.60	15.40	2.02	2.43	1.91	9.14	0.59	0.07	0.46
Red (Opaque)	62.16	17.70	2.12	2.86	2.03	11.05	0.53	0.07	0.85
Translucent Blue	62.66	17.78	1.87	2.73	1.87	9.95	0.52	0.07	1.25
Black	65.30	18.53	2.06	2.17	1.43	11.20	0.56	0.07	0.88
Green	67.60	16.33	1.90	3.13	2.06	9.70	0.54	0.07	0.92
Light Yellow*	58.46	18.31	1.54	3.10	1.38	11.99	0.60	0.05	0.82
Translucent Blue	64.21	17.72	1.85	3.03	1.36	9.20	0.45	0.05	0.67
Brown	61.48	14.64	1.96	3.12	3.83	13.52	0.60	0.08	1.69

* raw material

6.96%. The elevated amount of aluminium is also noticeable from samples of Sungai Mas, in which 17 out of 24 samples consist of aluminium higher than 5 percent (Rahman et al. 2008). No Arikamedu glass approaches these high levels of aluminium and it showed that Sungai Mas made their own glass beads. The relatively high aluminium has also shown in some of the glass beads from Kuala Selinsing, Khlong Thom of Thailand and Oc-eo of Vietnam (Francis 2002).

Table 7 shows contents of trace elements in the Sungai Mas Indo-Pacific beads. These elements known to be purposely added as colorants such as Fe, Mn, Pb, Cu, Mn, Zn, Co and Cr. Whilst As and Sb are elements added as opacifiers for the glass making process. The result

Table 7. Trace elements content (ppm) in Sungai Mas Indo-Pacific beads

Bead Colour	Cu (ppm)	Pb (ppm)	Zr (ppm)	Sr (ppm)	Ba (ppm)	La (ppm)	U (ppm)	Ni (ppm)	Cr (ppm)
Yellow	<10	5386	387	284	247	79	33	<10	64
Green	2529	6634	519	381	271	67	11	<10	85
Black	45	154	314	426	132	96	15	<10	111
Translucent Blue	5254	95	558	429	241	92	14	<10	53
Orange	13938	<10	348	446	327	96	11	48	79
Translucent Blue	4049	69	616	415	254	57	<10	19	60
Translucent Blue	3789	244	638	504	267	70	<10	<10	58
Light Green	2668	6454	527	404	267	80	12	<10	62
Translucent Blue	5295	104	522	611	152	77	<10	<10	88
Red (Opaque)	2661	<10	708	248	673	51	15	<10	85
Light Yellow*	17	<10	490	458	390	70	18	<10	86
Yellow	171	6533	490	467	303	74	29	<10	98
Blue	3976	111	584	398	240	70	18	<10	64
Green	2196	6424	510	360	283	64	30	<10	53
Light Yellow*	<10	<10	758	976	277	62	25	<10	84
Red (Opaque)	2240	<10	578	795	398	68	<10	<10	86
Translucent Blue	3264	64	649	481	275	82	11	<10	69
Black	<10	746	701	764	341	34	24	<10	65
Green	2368	4078	499	422	251	60	27	<10	64
Light Yellow*	<10	<10	779	1029	296	67	<10	<10	59
Translucent Blue	6187	18	343	361	247	80	12	<10	40
Brown	14587	268	337	240	318	75	20	50	92

*raw material

had shown that green glass beads contain higher amount of copper and lead. Usually the content of lead is much higher than copper. Blue glass beads contained higher copper whilst yellow glass beads have higher content of lead. The red glass beads contain higher amount of copper that is 2661 ppm and 2240 ppm and also high in ferum that is 2.74% and 2.03%. The orange and brown glass beads also have a very high content of cooper that is more than 1% and ferum that is more than 3%.

In Table 9, Rahman et al. (2008) stated that only one sample (331F) found to contain higher concentration of ferum, the rest of sample containing ferum of less than 2 %. The sample is also higher in manganese

Table 8. Major elements content of Indo-Pacific beads from Sg Mas, Bujang Valley

Sample ID	Colour	Ti%	Mg%	Al%	Ca%	Cl%	K%	Na%
1239 A	Black	<0.01	0.26	5.58	2.23	0.40	2.54	16.7
1239 B	Red (opq)	<0.01	0.49	5.70	2.33	0.29	2.15	16.2
1239 C	Green (opq)	<0.01	<0.01	5.11	1.83	0.32	2.30	16.3
1239 Da	Blue green	<0.01	1.18	5.13	2.42	0.25	1.86	18.2
1239 Db	Green	<0.01	<0.01	5.66	1.99	0.22	2.10	15.6
1239 E	Yellow (opq)	<0.01	0.15	5.18	2.04	0.34	2.09	16.7
1239 F	Green-blue	<0.01	0.07	5.73	4.40	0.21	1.99	20.7
331 A	Blue	<0.01	3.14	1.08	2.52	0.20	2.51	10.2
331 B	Red (opq)	0.83	0.34	5.45	2.46	0.25	1.53	14.3
331 C	Orange (opq)	<0.01	<0.01	6.21	2.24	0.23	1.56	11.1
331 D	Yellow (opq)	<0.01	3.11	2.36	4.24	0.23	3.22	11.3
331 E	Green (opq)	<0.01	0.80	3.22	3.25	0.26	1.40	9.84
331 F	Black	0.53	0.75	4.74	<0.01	1.05	2.05	13.1
331 G	Dark blue	<0.01	1.94	1.73	<0.01	0.83	2.29	11.0
331 Ha	Orange +Black (opq)	0.27	0.70	5.44	<0.01	1.24	1.64	12.3
331 Hb	Orange (opq)	0.36	0.64	5.62	<0.01	1.03	1.46	12.3
331 I	White	<0.01	2.07	2.19	<0.01	0.90	2.19	12.5
331 J	Blue (opq)	<0.01	1.11	2.61	<0.01	0.79	2.05	11.6
90 A	Green	0.33	<0.01	5.55	2.66	1.09	1.57	16.5
90 B	Red (opq)	0.35	0.92	6.96	<0.01	1.45	2.21	16.7
90 D	Brown	0.39	1.02	6.12	<0.01	1.57	1.65	11.3
90 E	Yellow (opq)	0.39	0.64	6.37	<0.01	1.18	2.13	13.8
90 F	Green-blue	0.35	0.89	5.27	2.83	0.49	1.64	16.1
90 G	Blue	0.36	0.94	5.01	<0.01	0.95	1.49	16.3

Sample labeling: opq = opaque

Source: Rahman et al. 2008

that is 3136 ppm or 0.3%. However other black sample, that is coded as 1239A does not show higher level of ferum. The content of its ferum and other elements in the sample are comparable and show no significant difference from other glass bead samples. This may be due to reason that apart from the chemical colorants the colour of glass beads also dependent on the presence of other ingredients, temperature change and the atmospheric oxidizing-reducing conditions.

Table 9. Elements content known to be used as colorant and opacifier of Indo-Pacific glass beads from Sg Mas, Bujang Valley

Sample ID	Colour	Fe %	*Mn* ppm	*Zn* ppm	Co ppm	Cr ppm	As ppm	Sb ppm
1239 A	Black	1.87	488	39.4	7.24	54.6	5.34	1.49
1239 B	Red (opq)	1.87	534	43.1	12.4	46.0	9.16	1.87
1239 C	Green (opq)	1.23	510	26.6	8.09	30.5	8.81	2.33
1239 Da	Green-blue	1.05	483	33.9	7.61	29.3	13.4	3.39
1239 Db	Green	1.47	571	33.7	9.33	32.5	9.86	2.22
1239 E	Yellow (opq)	1.24	482	27.1	5.87	34.1	10.3	3.56
1239 F	Blue green	0.94	675	18.1	4.40	25.2	12.6	5.00
331 A	Blue	0.97	789	6390	2210	60.0	<0.1	1.44
331 B	Red (opq)	1.77	442	37.5	9.93	49.8	21.1	7.05
331 C	Orange (opq)	1.72	393	282	37.7	49.5	64.2	84.0
331 D	Yellow (opq)	0.95	9600	27.8	6.87	37.2	85.8	3.65
331 E	Green (opq)	1.36	1060	1380	9.19	41.9	580	176
331 F	Black	15.2	3140	110	41.4	42.2	4.63	0.73
331 G	Dark blue	0.36	5430	101	394	37.6	24.0	3.91
331 Ha	Orange +Black (opq)	1.04	426	28.4	4.87	25.0	<0.1	0.24
331 Hb	Orange (opq)	1.42	406	43.1	33.5	24.6	19.2	5.88
331 I	White	0.19	1280	<0.1	5.70	21.4	11.6	<0.1
331 J	Blue (opq)	0.44	301	508	6.14	34.5	184	64.4
90 A	Green	2.40	517	40.5	23.7	41.0	24.4	8.05
90 B	Red (opq)	1.71	556	41.8	8.83	47.7	12.1	2.05
90 D	Brown	1.55	725	36.1	5.89	25.7	11.4	1.22
90 E	Yellow (opq)	1.06	474	35.4	4.30	18.1	6.97	1.05
90 F	Green-blue	1.24	528	31.0	4.71	28.3	13.9	6.59
90 G	Blue	1.18	2620	29.5	11.7	26.5	12.6	3.53

Source: Rahman et al. 2008

Only one bead shows high cobalt content that is 331A blue bead, however with relatively normal level of manganese content. Cobalt can produce blue colour to the bead either in oxidizing and reducing atmosphere. Other glass beads with white stripe dark blue color (331G) also shows high contents of cobalt (394 ppm) compared to other blue beads. The sample also has high content in Mn (5430 ppm). Other glass beads with dark blue color do not show elevated contents of Co or Mn. Cobalt is the strongest among coloring oxides. 0.5 percent of cobalt is enough to produce a strong blue color. Copper and cobalt are the earliest known blue coloring minerals. This signifies that the cobalt-manganese-potash dark blue glass of Arikamedu type is not found in Sungai Mas bead. It was believed that the blue color in glass was because of the mineral Bismuth. In fact early civilisations knew about combining cobalt and glass. Examples of cobalt glass jewellery were found in tombs of the Egyptian pharaohs. Cobalt glass pieces were found in ancient Minoan shipwrecks as early as 2700 B.C. A necklace made of cobalt glass was found in Persia dating back to 2250 B.C.

The opaque beads sample 331C, 331D, 331E and 331J were found to have elevated level of As and Sb, both elements known to be used as opacifier agent for the glass making. However other types of opaque glass beads such as 1239B, 1239C, 331H and 90B do not show elevated level of As or Sb. It is important to note that Sn, which is not analyzed in the study is also an element used as an opacifier agent by manufacturer of glass for bead making.

CONCLUSIONS

Glass beads at Bukit Maras, Santubong, Sarawak can be classified as Indo-Pacific or drawn monochrome glass beads. The content of high silica, aluminium and sodium can be suggested that these beads originated from South East Asia. There are three possibilities where the beads coming from and that is from (i) Oc-eo, Vietnam, an Indo-Pacific beads centre since 2^{nd} century AD to 6^{th} century AD, (ii) from Sungai Mas, Kedah, an Indo-Pasific beads centre since 6^{th} century AD to 13 century AD and other possibilities is from Sating Pra (7^{th} century AD to 10^{th} century AD). Francis (2002) suggested that bead-maker from Oc-eo settled in Sating Pra when Oc-eo was overrun by Khmers in the late 6^{th} century AD or early 7^{th} century AD. Sating Pra was related with Oc-eo because like Oc-eo, Sating Pra built canals for inland transportation, even linking the South China Sea and the Andaman Seas. It was a large city of perhaps 110, 000 people of Khmers, Tamils and Malays and an important link in the Srivijaya system (Bentley 1986). Bukit Maras also not similar with the Kuala Selinsing glass beads because of the differences of alkalis.

Glass with moderate lead content that is in range of 10%-20% and no significant barium content which as reported by Tom Harrisson are of this material, which in some ways, is similar to the crystal glasses which were introduced in Europe in the seventeenth century AD. A glass with very high lead content (40%-60%) is known for early Chinese beads, where sometimes part of the lead percentage is replaced by barium; and a bead of this kind of glass has been reported from Rhodes (Lamb 1965). Assuming that in the Southeast Asian context, glasses of this kind have a Chinese origin.

Based on compositional analysis that has been done on glass beads from Sungai Mas, Kedah showed that Sungai Mas, Kedah produced their own glass to make Indo-Pacific beads. Indo-pacific beads found in Sungai Mas are locally made and did not originate from Arikamedu, India. Sungai Mas beads contain higher amount of aluminium compared with western glasses that has amount of aluminium below 5 percent. Sungai Mas glass beads also contain higher amount of silica and used sodium as a flux. Compositional analyses on Sungai Mas glass beads have proven that Sungai Mas was one of the Indo-Pacific beads-making centres in Southeast Asia. The drawn monochrome glass beads are not from Arikamedu but locally made. Based on archaeological data, Sungai Mas established itself as the Indo-Pacific beads centre from the 6^{th} century CE to 13^{th} century CE and Sungai Mas glass beads also have a similar compositional content with Bukit Maras, Santubong, Sarawak glass beads but the content of sodium is much higher compared with Bukit Maras glass beads and it can be suggested also that glass beads from Pengkalan Bujang are locally made and originated from Sungai Mas, Kedah.

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