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A study of glass beads from Phum Snay Iron Age archaeological site and settlement, Cambodia Data from excavation in 2001 and 2003

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Abstract

The study of beads in Phum Snay Iron Age Site and Settlement which is in danger since 2000 because it was looted the site and sold out its artifacts. There are 349 beads were analysis received from the archaeological data in both years excavation in 2001 and 2003. All of beads were analyzed macroscopic but only 100 beads were brought from Cambodia to Paris for the chemical analysis. Among them 75 glass beads were done with the compositional analysis by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) because Carnelian beads (stone beads) do not work with LA-ICP-MS. The analysis reveals three groups of glass beads were recognized: 55 High Alumina glass beads (m-Na-Al), 16 Potash glass beads (K) and 4 Soda Lime glass beads (m-Na-Ca). As a result, it is clarifying that Phum Snay site belongs to Iron Age period which dated from 4th c. BC until 3rd c. AD. Because of Potash glass was only found in the early of 4th c. BC until 3rd c. AD. In the beginning of 4th c. BC there are much more Potash glass and it become rarely until it's exiting. There are no Potash glass found after that date.

Keywords: Iron Age Site, Phum Snay, compositional analysis glass beads.

Introduction

Iron Age Sites in Cambodia were discovered in the last decade. Most of the sites were being looted. Phum Snay is one amount the Iron Age site which is in danger by looting as well. This study carry out a combination study of the site, the technological, style and compositional analysis on glass beads for the expecting results of making it possible to reconstitute the exchange between Thailand, Cambodia and Vietnam and intend to understand the groups of beads can be classifying, the component of Phum Snay glass beads, the different technique of manufacture of beads and the date of the site is belongs to. The proposed project will fill gaps in prehistoric and early proto-historic understandings of ancient Cambodia. Thus so far, few studies have been conducted. Studies such as this will provide vital information for understanding the development of ancient mainland Southeast Asian societies and exchange networks.

Regional setting

During a road construction in 2000 was undertaken to link a village with National road, an archaeological site was discovered accidentally named Phum Snay site which fellow the name of the village Phum Snay. It is located along the National road number 6, Phreah Net Preah district, Banteay Mean Chey province, Northwest of Cambodia (48P UTM 0305983/1506856 N13˚37′26.3″ E103˚12′23.5″) (Douglad & Sytha, 2003) (Fig. 1). The village is one of the several hamlets located on the edge of a large mound that is about three kilometres in diameter and on the west of the site about a hundred meters, there is Preah Net Preah river. Since the burials were presented, the site has been looting by the villagers (Fig. 2). According to the investigation, the burials associated with the great deal of materials culture such as complete pottery, bronze and iron objects, glass and stone beads, human bones, and fauna remain. It assumed the burials to be prehistoric. Phum

Snay is an Iron Age Site dated about 200 BC to 200 AD (Christophe, 2000) which located near other Iron Age Site named Phum Korsang Thmie which dated about 1st BC to 4th AD (Sok, 2005). All kind of artifacts were found at Phum Snay site are similar to those sites in Thailand and Vietnam which belong to Iron Age period.

Fig.1. Phum Snay Site in large view. The shape as circular earthwork.

Fig.2. (a) Site looting, overview of many holes left behind because villagers looking for the beads for sell (b) Looting activities which made the lost of important archeological data (c, d) Glass /carnelian beads found from the site which were traded. (Phum Snay, Cambodia), Photos: O'Reilly/ Vuthy.

During the Iron Age period, there are the changing of social stress, population aggregation, labor organization and trade. Recently, Phum Snay site was found as one of the Iron Age site in Southeast Asia (Douglad, 2001). It was unclear how and when metal working was first discovery. Archaeologists had investigated only some Bronze and Iron sites in Ban Chieng, Thailand which dated from 4th c. BC to 4th c. AD, Dong Son in Vietnam dated from 7th c. BC to 2nd c. AD and rarely found in Cambodia. Only a few sites were consider as Iron Age sites: Angkor Borei dated from 200 c. BC – 200 c. AD (Stark, 2004), Krek 52/62 which were found 5 fragments of glass bangles (Haidle, 2002) Phum Krosang Thmei, Phnom Borei, Phum Sophy, Phum Bit

Meas and Phum Snay. Normally, the Iron Age cemetery were found a lot of artifacts in the burial such as iron objects, bronze objects, beads and some fauna but the most important thing is weapons. Those are the swords with decoration, arrowheads, spears, lances and knives, thought by the excavators it maybe had been used in warfare. No exactly evidence getting to know where the technique of iron production came from. It maybe came from India and China (Higham & Thosarat, 1998: 135). Iron was used in Xinjiang in China since 9th c. BC and in Mongol since 650 BC (Higham, 2002: 169). And according to Bernard-Philippe Groslier, the technique of making bronze maybe influenced from the North China (Udaya, 2000: 183).

Materials and methods

Generally glass is produced by melting a mixture of natural Silica (quartz sand about 80%) with the required calcium compounds (lime about 10%) and some metallic oxides are added as colouring agents. The primary materials necessary for making glass are silica, alkali and lime. Alkali acts as a flux and lowers the melting point of silica. Lime in certain proportions makes the glass stable (Frank, 1982: 72).

The chemical compound silicon dioxide, also known as *silica* (SiO_2) is most commonly found in nature as quartz or sand. Heated the crystallisation gets in an amorphous material called "glass". Because the melting point of pure silica was too high for ancient furnaces to achieve, a flux, generally an alkali (usually soda (NaO_2) or potash (KO_2)) was (and still is) added to lower the melting point. Lime (CaO_2) or some other stabilizer must also be added. The ancient may not have known this. The lime was nearly always present as an impurity in the sand (Turner, 1956a: 39T - 52T). The ingredients are heated for several days, forming a dark, hard substance called "frit". Glassmakers break it up, add some scrap glass (cullet) and perhaps colorants, and then heat the mixture again. It melts and flows and molten glass in results. When glass is first made, it is translucent green because of the universal impurity of iron in both the ferric and ferrous states. This colour is called "bottle green" because cheap bottle are made from this untreated glass (Francis, 2001).

Glass is a main material for this research. The study was made by 2 different methods. Firstly, the study focuses typological objects, using microscope to observe their shapes, drilling hole and colour. The electronic calliper was used to measure the length and width of the beads and the electronic balance was used for weigh (Fig. 3&4). It allow in some cases of allocation of objects in manufacturing places or to apprehend the technical work of glass beads. However the simple forms or widespread, this type of study has a limited scope, and it is not helpful when it comes to the question. Secondly, study is focus on composition. Indeed, the old glass is made from two main ingredients, which are sand and a compound alkali or alkali earth. They both contain impurities that are found various amounts depending on their nature. The composition can be classifying the beads into different groups.

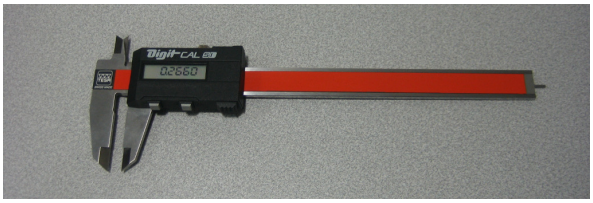

Fig.3. Electronic caliper in millimeter use to measure beads, Photo: Song S.

Fig.4. Electronic balance in gram use to weigh beads , Photo: Song S.

Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) offer several advantages over the other analytical methods (Fig. 5). It has tremendous potential for chemical characterizations of archaeological materials, permitting questions regarding prehistoric production, trade, interaction, and manufacturing technology to be addresses and it is a non-destructive method (Bernard, 2002). Glass reveals in different shape, components and colours. The late appearance of multi-colored beads is highlighted in the classification of beads in Southeast Asia, developed by Francis (Francis,

1986a). For natural material like agate (natural hydrothermal chalcedony) and carnelian (heated hydrothermal chalcedony), were the most precious beads widely manufactured in India from about third millennium BC. For long time agate and carnelian beads found in Southeast Asia originated from India, like in Cambay (Bellina, 2007).

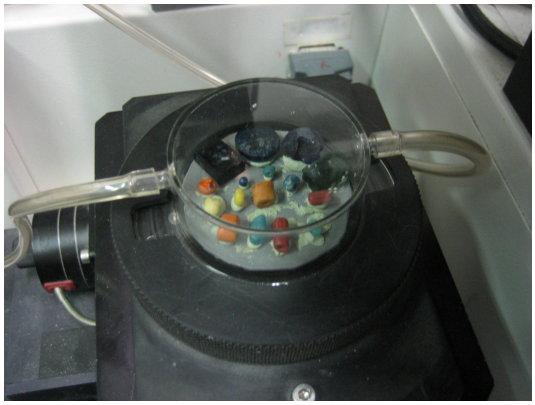

Fig.5. Glass beads on the quartz cell for analysis.

In Phum Snay there are 3 different kinds of glass were found (Fig. 8) (Bernard 2005, 2007):

High Alumina glass

The 55 High Alumina glass beads contain a large variety of different colours such as light blue, dark blue, green, orange, red and yellow. Using the colouring agents, high alumina were divided as copper high alumina glass, copper and lead stannate high alumina glass, copper and manganese high alumina glass, copper as cuprite (Cu_20) high alumina glass, copper as metal high alumina glass, lead stannate high alumina glass and copper as metal on the surface of bead but not inside the beads.

Potash glass

Among the 16 Potash beads, only 3 different colours appeared. Those are green, light blue and dark blue. There are the different percentages of potassium concentration (K_2O) around 15 up to 18%, CaO is between 1-6%, and Al2O3 is about 0.7-3%. Sometime, MnO and CuO concentration can be count as well because of the colour agents. Thus, there are 4 types of Potash beads depending on the colour agents. It is cobalt potash glass, copper potash glass, copper and manganese potash glass and no colorant potash glass.

Soda lime glass

The 4 Soda lime glass beads contain only light and dark blue colour which coloured by cobalt. It contains the concentration of Sodium (Na_2O) about 15-18%, CaO between 6-9%, Al_2O_3 is about 2-3%, K_2O is 1-3%, and Fe_2O_3 is around 1.2-2%. Iron oxide is one of the other colouring agents that can be found in these beads, it is generally an impurity of cobalt ores. In Soda lime glass beads, MgO concentration is a bit high compare to other two groups, potash glass and high alumina glass. It is around 1-3.5% and is provided by the plant ashes.

Refers to some researchers discussion, there are different method of manufacture by examination the ancient beads and analogies the modern craft practice, that glass beads are made by winding Francis (1983a: 194), dipping (Lugay, 1974:157, drawing (Francis 1986b: 55), mound-pressing, and cutting and grinding (Basa 1991). There are some external methods of cutting, drilling hole and decoration of beads. The beads may have preceded monochrome and multi-colored beads (Glover, 1990). Basa said that Thailand, Malaysia, Indonesia and Vietnam, the multi-colored beads are still unknown during the late prehistoric period (Basa, 1991). Moreover, the lead glasses are characterized by a high concentration of lead. They are found only in Southeast Asia Iron Age site and were probably imported from China (Karlström and Källen, 2002). Specific weight of the lead glass gets more important when proportions of lead are more important. Early Southeast Asia glass beads may be grouped in to two broad compositional types: mixed-alkali glass and potash glass (Bellina and Glover, 2004). The Indo-Pacific beads maybe imported from India. Those are in red, yellow, blue and orange colour. In Southeast Asia and China glass are rich in potassium and poor in sodium. Orange beads are distributed throughout all the Indian world and Southeast Asia, the red disc shape, opaque that look like clay disc-beads usually found in Dvaravati Period. It was found also in Thailand, Laos, Burma and Cambodia as well. According to Glover and Henderson, there are three regions have to be considered as early production center for Southeast Asian glass, these being India, China and Mediterranean (Glover and Henderson, 1995).

Results

The villagers gave a special name to the beads in order to recognize the different types of beads. There are three different kinds of beads:

1. Very small glass beads are always orange color (sometime, there are some strike line in brown color presented on the surface) was called "Sand bead" which is in Cambodian word called *Angkam Ksach,* because of very small beads you can find as sand seeds. The very small interested beads or sand beads which were mention above are weight about 0.63mg to 3mg. The smallest one is about 0.0006g = 0.63mg. It has length between 0.05mm to 0.03mm, the thickness around 0.05mm to 0.03mm and the diameter about 0.02mm. It maybe wound method. The hole is not drilling but it was blowing through the tube then makes it in segments. When it is finish, it was keeping in a container in water and washing.
2. The glass beads with big and medium sizes and various colors as yellow, red, black, blue, green, white and some in orange colors were called *Angkam Krab Pot* which is mean "Corn seed bead". This kind of beads was produced by wind method, dawn method and dipping method.
3. The carnelian beads were called "Honey beads". In Cambodian word is *Angkam Tek Kmom.* It is because of the color of beads similar to the color of honey.

According to microscopic analysis, glass beads in Phum Snay were made in 3 different methods.

a. Wound method: This method used the twisted rope. It is transversely elongated air bubble, almost horizontal lines and sometimes the presence of more than one colour in the bead. While taking it out, the bead maker twirls the strip of molten glass around the rope or wire.
b. Dawn method: Beads were made from the tube of glass which have been pulled or drawn, and subsequently cut into smaller segments. Dawn beads have lines parallel to the perforation and elongated air bubbles in the same axis.
c. Dipping method: This method involves dipping a solid rod into the glass melt and pulling out the melt. A bead is form by the glass attached to the rod after cooling. It has small diameter and perfect shape of drilling hole.

In the two types of beads, stone beads found in the different shape of round, square barrel, hexagonal bicone, pentagonal bicone, hexagonal barrel and octagonal Stone (Fig. 6) but glass beads were found as tube, annular, trapezoidal, cylinder, barrel, bicone and some special glass ornament as glass earring (Fig. 7).

Fig.6. Carnelian. Stone beads shapes in Phum Snay. (1) Round. (2) Square barrel. (3) Hexagonal bicone. (4) Pentagonal bicone. (5) Hexagonal barrel. (6) Octagonal (From left to right).

Amount 75 glass beads which are different shapes, colours, layers and units were analyzed by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) (Tab. 1). There are 3 group of glass were found: *55 High Alumina Glass* (light blue, dark blue, green, orange, red and yellow. Using the colouring agents, high alumina were divided as copper high alumina glass, copper and lead stannate high alumina glass, copper and manganese high alumina glass, copper as cuprite high alumina glass, copper as metal high alumina glass, lead stannate high alumina glass and copper as metal

on the surface of bead but not inside the beads.), *16 Potash Glass* but 5 of them are corroded. There are the different percentages of potassium concentration (K_2O) around 15% up to 18% and *4 Soda Lime Glass* which contains the concentration of Sodium (Na_2O) about 15 % - 18%).

Fig.7. Glass beads shapes in Phum Snay. (1) Tube. (2) Annular. (3) Trapezoidal. (4) Cylinder. (5) Barrel. (6) Bicone (7) Glass ornament. (8) Blue glass earring (From left to right).

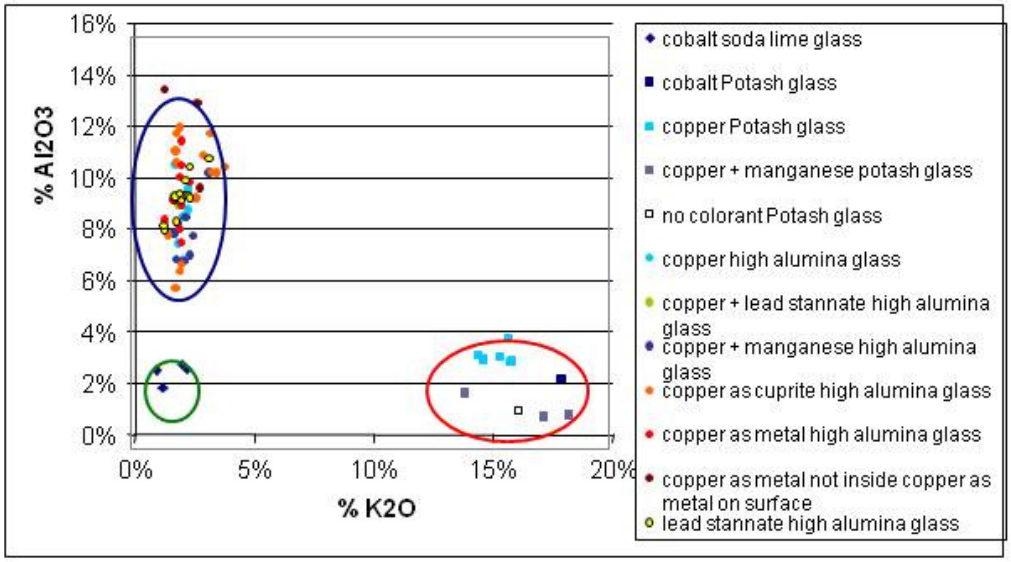

Fig.8. Three different types of glass beads in Phum Snay (Bernard, 2005&2007).

Phum Snay has an exchange network with other Iron Age sites in Thailand concerning to:

a. The Phimai Black ceramics and also there is an ancient road linking the Angkor Area to Phimai through the region.
b. Some iron and bronze artefacts' found the similar to some sites in Thailand as well.
c. The composition of potash glass in Phum Snay is similar to Ban Dong Ta Phet.
d. Even it is no marches of chemical composition with Khao Sam Kaeo, maybe it is not the same early exchange network.

According to Dussubieux (2001) who studied more than 550 glass beads in Southeast Asia, glass beads were divided into 5 groups (Fig. 9).

1. **High Alumina glass (m-Na-Al)** is the most current material for glass beads found in Southeast Asia, India, China and Sri

Lanka. It would actually be difficult to know where the exact origin of these beads came from. It is only know about the date started 4th c. BC until 10th c. AD.

2. **Potash glass (K)** was only found in the early of 4th c. BC until 3rd c. AD. In the beginning of 4th c AD there are not many Potash glass beads until its exiting. There was no Potash glass found after that date. Potash glass maybe imported from India and China.
3. **Soda lime glass (v-Na-Ca: Plant ash soda lime)** also found nearly every where and nearly every time the same as high alumina glass of lead and tin since the about 4th c. BC until 10th c. AD. It is present in Near East and Middle East.
4. **The mixed glass** can be found in the similar date to Potash glass started since 4th c. BC to 3rd c. AD. It maybe imported from China.
5. **The soda lime glass (m-Na-Ca)** was found from the beginning of Iron Age from third century BC until 7th c. AD. There is no m-Na-Ca type after 7th c. AD. It maybe came from the India Ocean and Mediterranean.

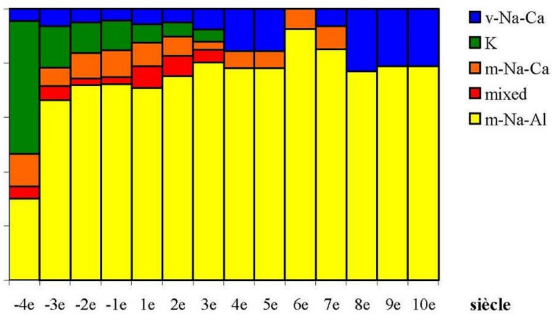

Fig.9. Appearance of all glass beads by time (Dussubieux 2001).

Potash glass found in Southeast Asia Iron Age sites only the period from 4th c. BC until 3rd c. AD. The compositional of beads which were analyzed is very importance to clarify the old information that we had before. Thus Phum Snay site is dated from 4th c. BC until 3rd c. AD and it maybe Phum Snay was occupied until Pre-Angkorian period refers to the ceramics evidences.

According to the comparison of composition, there is a similarity of chemical composition of Phum Snay beads and Indian, Sri Lanka beads (Giribawa, Ridiyagama in Sri Lanka and Alagankulam, Arekamidu in India). It can assume that maybe Phum Snay has long destination exchange network with India and Sri Lanka.

Discussion

Phnum Snay was suggested in the different date by the different researcher. According to the Potash glasses which were found, Phum Snay should be dated in the early of 4th c. BC until 3rd c. AD. Angkor Borie which was not found Potash glass should be younger. Thus only the further research can be providing more and clearer answers and information.

Conclusions

Phum Snay is not a manufacture place of glass beads because there is no evidence of waste glass left. All glass beads are not locally made. It maybe imported from Thailand or Vietnam. It also has an exchange network with Vietnam which we found the similar chemical composition of potash glass in Going Ca Vo and Dong Son, in addition of the similarity of glass bangle in Phum Snay and Sa Huynh site. It could be related to some Iron Age Sites in Thailand as well such as Ban Dong Ta Phet but there is no march of chemical composition with Khao Sam Kaeo, maybe it is not the same early exchange network. .

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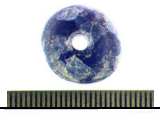
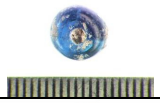
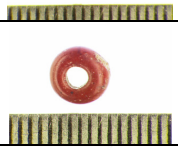
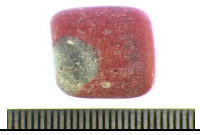
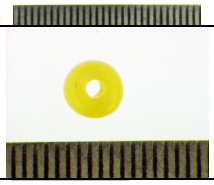
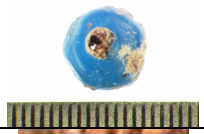
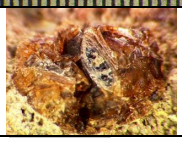
Reference	Burial n° or unit n° and layer	Photos	Glass type	Colorants
B10n122	Unit s3/e1 Layer 2 :3		Soda lime	Cobalt
N262	Unit a/e Layer 2 :3		High alumina	Copper as Cu2+
B4n16c	Unit c Layer 2 :1		High alumina	Copper as Cu2+ and lead stannate
B10n341	Unit s2e1 Layer 2 :4		High alumina	Copper as Cu2+ and manganese
B10n237d	Unit s2/e1 Layer 2 :4		High alumina	Copper as cuprite
B10n237a	Unit s2/e1 Layer 2 :4		High alumina	Copper as metal
B7n27gris	Unit s3/e1 Layer 1 :4		High alumina	Copper as metal difference between surface and interior
B13n67	Unit s1/e1 Layer 2 :1		High alumina	Lead stannate
B35n441b	Burial 7		Potash	Copper as Cu2+
B35n441f	Burial 7		Potash	Cobalt
B4n17	Unit b Layer 2 :1		Potash	Copper as Cu2+ and manganese
B42n473	Burial 13		Potash	No colorant just iron as impurity

Tab.1. Studied material, beads recovered in 2001 and 2003, Phum Snay, Cambodia.

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