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The Production and Exchange of Glass and Stone Beads in Southeast Asia from 500 BCE to the early second millennium CE: An assessment of the work of Peter Francis in light of recent research

Alison Kyra Carter

University of Illinois Urbana-Champaign, 109 Davenport Hall, 607 S. Mathews, Urbana, IL 61801, United States

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ABSTRACT

Stone and glass beads are important artifacts in Southeast Asia as they are amongst the earliest objects from South Asia found in the region, and frequently seen as symbols of Indian influence and increasing socio-political complexity. Peter Francis Jr.'s writings regarding the production and exchange of beads in Southeast Asia have been influential to archaeologists who have viewed beads as prestige objects that were traded widely and produced at important urban centers in Southeast Asia. However, the field of beads studies in Southeast Asia has greatly expanded in the past 15 years and benefitted from new excavations and scientific techniques. In this article, I review Peter Francis' hypotheses regarding the production and exchange of beads in Southeast Asia from 500 BCE to the early second millennium CE. I then synthesize recent work by scholars that has transformed our understanding of the manufacture and trade of beads. I argue that this work has largely disproven Francis' model of bead production and interaction between South and Southeast Asia. Instead, there appear to have been multiple phases of bead production and exchange between the two regions, which reflect complex interaction networks between South and Southeast Asia and within Southeast Asia.

1. Introduction

Peter Francis Jr.'s interest in beads in Southeast Asia spanned from the archaeological to the ethnographic (e.g. Francis, 1992). Much of his work on beads in Southeast Asia focused specifically on the manufacture and trade of Indo-Pacific beads, or the small, drawn, monochromatic, round or doughnut shaped beads that are ubiquitous across the ancient world (Francis, 1990). In his 2002 volume on *Asia's Maritime Bead Trade*, as well as in earlier works (e.g. Francis, 1990, 1991a, 1991b, 1996) Francis built a hypothesis regarding the development of Indo-Pacific bead production at the site of Arikamedu in southern India, and the export of finished beads, the bead manufacturing technology, and the movement of craftsmen to various locations in Southeast Asia. Francis (2002: 141) also argued that stone beads were produced at many of the same Indo-Pacific beadmaking sites. In this model, glass and stone beads were a marker for Indian influence in Southeast Asia.

Francis' model has been influential amongst archaeologists of Southeast Asia as are his assessments of sites that were supposedly producing stone and glass beads. However, in the years since *Asia's Maritime Bead Trade* was published, there has been an expansion in the study of beads in Southeast Asia, and especially in the use of compositional analysis techniques and detailed studies of semiprecious stone beads (e.g. Bellina, 2014; Carter, 2015; Lankton and Dussubieux, 2013; Theunissen, 2003). While much of this new work has expanded on Francis' ideas, it has also disproved his assertion that Arikamedu was the cradle of Indo-Pacific bead production and that it was connected to many other beadmaking sites in Southeast Asia.

In this article, I use Francis' work as a springboard to bring together recent research on the exchange and manufacture of stone and glass beads in Southeast Asia. This article will focus primarily from 500 BCE–500 CE, a time frequently known as the Iron Age period in Southeast Asia, although I will briefly consider data on bead manufacture and exchange into the second millennium CE. I begin by summarizing Francis' hypothesis regarding the "Arikamedu League" and the manufacture of glass and stone beads in Southeast Asia. This will then be followed by a brief discussion on the evidence for stone and glass bead production in Southeast Asia, which is reviewed in more detail in Appendix 1. As bead manufacturing can take place in many steps over a large geographic area, I argue that scholars must evaluate evidence for bead production more critically. Bead manufacturing waste and by-products should be assessed carefully to identify which manufacturing stages were being undertaken within a site and to determine if manufacturing by-products may have been transported to the site with finished objects.

E-mail address: alisonkyra@gmail.com.

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In the third part of the paper, I present new research on stone and glass bead production, which I argue has largely invalidated Francis' Arikamedu model. Instead of a viewing Arikamedu as the source for Indo-Pacific bead manufacture in Southeast Asia, more recent work has identified three phases of glass bead production and exchange in Southeast Asia, with initial small-scale local production being followed by importation of high quantities of beads from South Asia. In contrast to Francis' model, early glass bead production sites were not necessarily in contact with one another, may have had a limited exchange of their finished products, and few seemed to have connections to the site of Arikamedu.

Francis' model for stone bead production in Southeast Asia is not as comprehensive as that for Indo-Pacific bead production. Nevertheless, the examination of stone beads in Southeast Asia has also shown evidence for technological traditions that changed over time (Bellina, 2014; Carter, 2015). Additionally, several scholars have used studies of stone and glass beads to shed light on socio-political and ideological developments taking place in Southeast Asia during this period (e.g. Bellina, 2014; Bellina, 2007; Carter, 2015; Gupta, 2003; Theunissen, 2003). Lastly, I conclude with a brief discussion of future avenues of research that are needed in order to better understand the production and consumption of beads in Southeast Asia.

2. Francis and the Indo-Pacific beadmakers

In Francis' study of the connections between South and Southeast Asia, it was the unassuming Indo-Pacific bead that was a key link between these regions. In his early work, Francis (1990) initially noticed connections between four sites, which had evidence for various waste products that were related to Indo-Pacific bead production. These four sites were Arikamedu in southern India, Mantai in Sri Lanka, Oc Eo in southern Vietnam, and Khlong Thom in peninsular Thailand (Figs. 1 and 2). As Indo-Pacific glass bead production was a technologically advanced skill and protected knowledge, Francis did not believe that this technology had been transmitted to local craftsmen. Instead, he argued that that Tamil beadmakers had traveled to each of these locations (Francis, 1990:18) and were connected to one another in a network he dubbed the Arikamedu League (Francis, 1990: 16). As is discussed below, there is little archaeological evidence to support this hypothesis (see also Kelly, 2016, for further challenges to the ethnic identity of the stone beadmakers).

A few years later, Francis (1996) had a more detailed proposal for the nature of Indo-Pacific bead production in South and Southeast Asia. In this model, summarized in Table 1, Indo-Pacific bead makers traveled from site to site as power at one urban center declined and

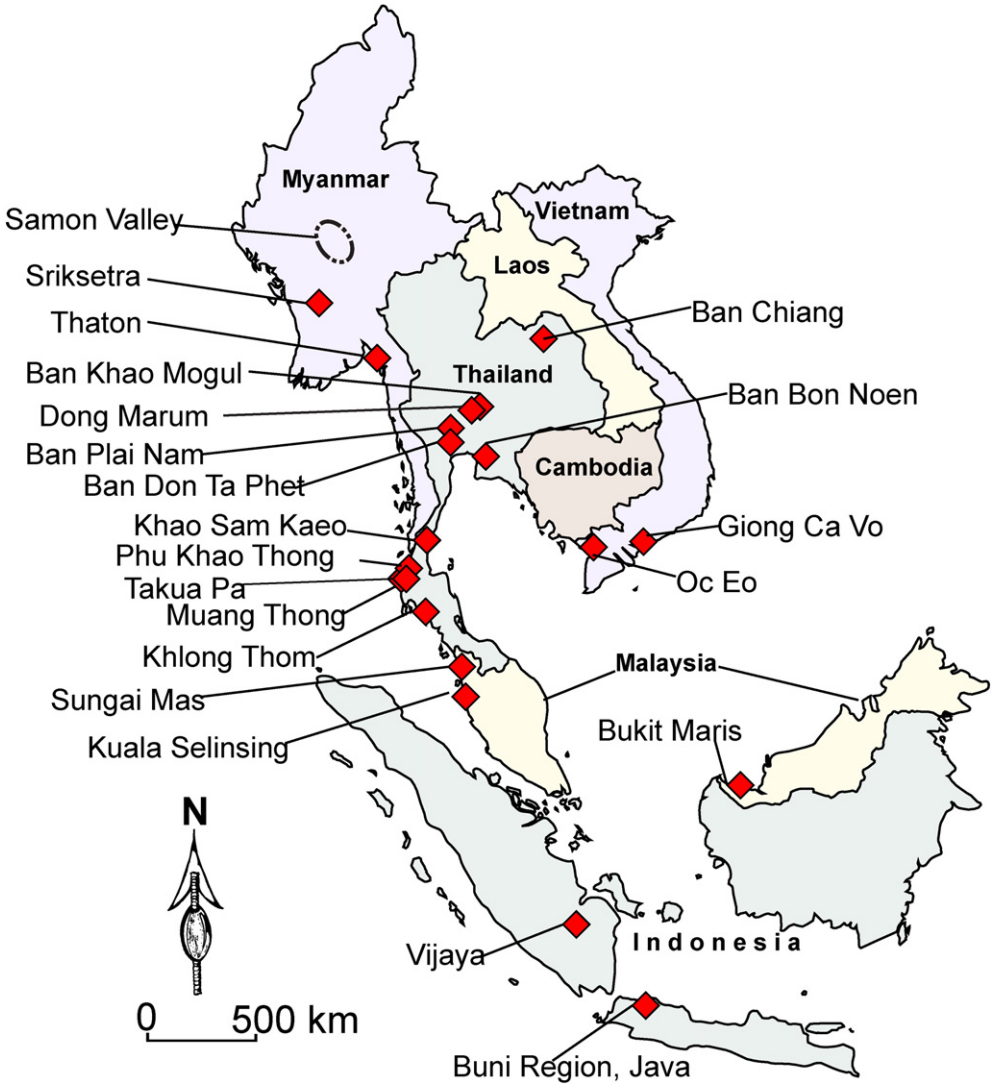

Fig. 1. Map of bead production sites in Southeast Asia mentioned in the text and Appendix 1.

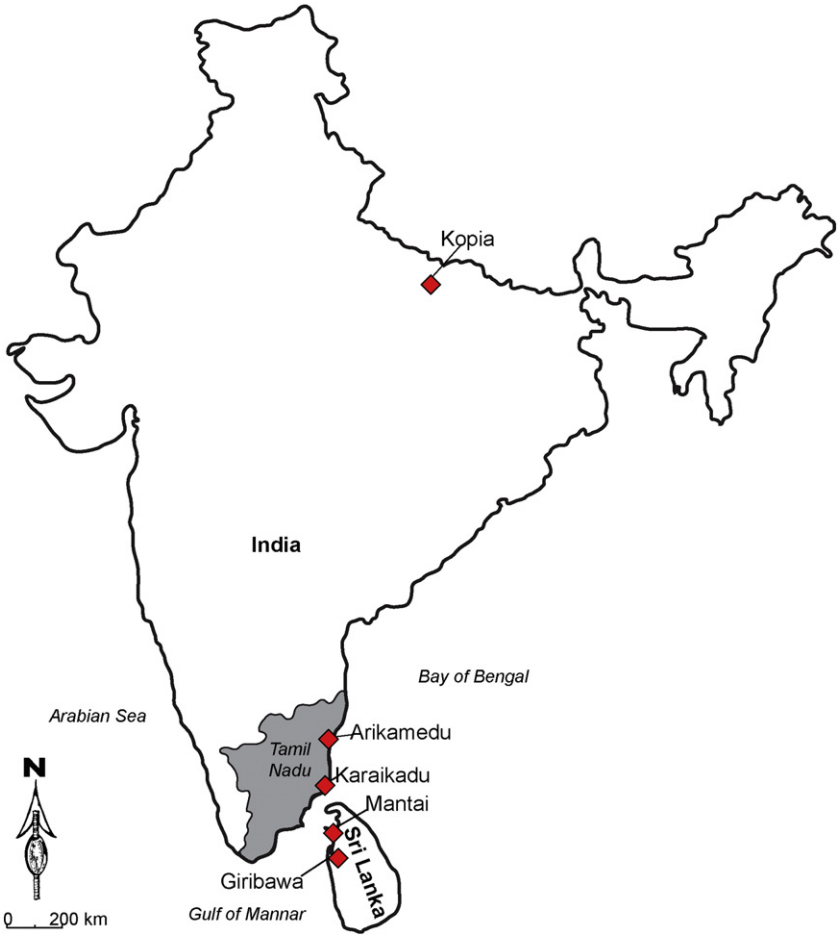

Fig. 2. Map of bead production sites in South Asia mentioned in the text.

another rose. Francis (1996: 141) also proposed additional potential production centers including Kuala Selinsing and Sungai Mas, Malaysia, and Takua Pa in Thailand (Fig. 1). Francis argued that products from the bead production sites might be distinguished from one another by the colors produced and the amount of re-heating after beads were cut from the tubes (Francis, 1990: 18–19).

By the time Francis published *Asia's Maritime Bead Trade* (2002) he no longer referred to a potential coalition of sites as the Arikamedu league. However, he did continue to see connections between the sites of Arikamedu, Khlong Thom, and Oc Eo, and argued that as these sites declined, the Indo-Pacific beadmakers moved on to other locales and especially the newly emerging state of Srivijaya in Sumatra (Francis, 2002: 36). Francis also began to report on the results of compositional analyses (2002: 37–38, 210-220) noting similarities between glass beads from Oc Eo and Khlong Thom, Arikamedu and the south Indian site of Karaikadu, as well as Vijaya, Sungai Mas, and Takua Pa. Although, glass bead production was the focus of Francis' model, he also argues that stone beads were produced at many of the same sites that were manufacturing glass trade beads (Francis, 2002:141).[1]

An important theme throughout Francis' work on Indo-Pacific beads was the socio-political context in which beadmakers would have been living and working. As a complex technology requiring a long training period, Francis argues that the techniques to make Indo-Pacific beads would have been a well-guarded secret. However, he does suggest that beadmakers were likely in contact with one another. Ethnographic and historic evidence suggests that beadmakers were low status, and not in control of all aspects of the manufacturing and trading of their products (Francis, 2002: 36). Therefore, Francis asserts that beadmakers would have needed contacts and transport to move from India to new locales in Southeast Asia (Francis, 2002).

Evidence for some kind of formalized network that would have facilitated the movement of beadmakers does not exist for the early first millennium CE. However, there is evidence for the presence of a guild system during the later historic period (Francis, 2002: 38–39). A ninth century inscription from the peninsular Thai site of Takua Pa describes the presence of an international trading guild called Manikgraman

Table 1
Proposed movement of Indo-Pacific beadmakers around South and Southeast Asia from Francis, 1996: 141 and Francis, 2002. In earlier discussions, Francis speculated that Sathing Phra, Thailand was also an Indo-Pacific beadmaking site but corrects himself later (2002: 226, note 25) saying that he could not find evidence supporting this assertion.

Beadmakers started at	And then went to
Arikamedu, India	Mantai, Sri Lanka
3rd century BCE–3rd century CE	Khuan Luk Pat, Thailand Oc Eo, Vietnam
Mantai, Sri Lanka	Returned to India, perhaps to
1st–10th century CE	Nagapattinam and then Papanaidupet
Khuan Luk Pat	Kuala Selinsing, Malaysia
(Khlong Thom), Thailand	6–10th centuries CE
2nd–6/7th centuries CE	Sungai Mas, Malaysia
	9–13th centuries CE
Oc Eo, Vietnam	Takua Pa, Thailand
2nd–6th centuries CE	9–10th centuries CE
	Vijaya, Sumatra
	11th–12th centuries CE

[1] The organization of Southeast Asian stone bead production workshops was not considered in as much detail by Francis, however he does discuss the much larger Western Indian (2002: 103–111) and South Indian (2002: 112–125) stone beadmaking industries, which likely exported a large amount of finished material to Southeast Asia.

(Francis, 1989, 2002). Although it is not clear that beadmakers were included in this guild, Francis (2002: 39) observes that they would have had the finances to assist beadmakers with migration between sites, the contacts with local elites to assist them with setting up workshops, and a network to assist with the distribution of beads. There is no material evidence for such a network existing during the prehistoric period, however the later guild system provides a model that can be tested and has indeed been discussed by archaeologists studying early stone bead production in Southeast Asia (Bellina, 2014).

As Indo-Pacific beadmakers would have been settling in urban centers that would provide elite oversight and a market for beads, Francis (1996: 149) has argued that Indo-Pacific beadmaking sites were "markers…of emerging core areas or states." Beadmakers would not be setting up shop in areas that did not have a market for their finished products. Furthermore, as it is unlikely that the technology for glass production was being transmitted to the local population, the presence of Indo-Pacific beadmakers also identified the spread of Indian influence in Southeast Asia (Francis, 1996).

Francis (2002: 35) has especially focused on the importance of Oc Eo as a trading entrepôt for the Mekong Delta state of Funan, suggesting that the other beadmaking centers in Southeast Asia might have been associated with Funan. Furthermore, he suggests that Oc Eo might not only have been a key manufacturing center for the Southeast Asian market, but also producing beads for the East Asian market (Francis, 1990: 5–6, 1996: 141). After the decline of Funan in the 7th century, Francis (2002:36) hypothesized that the Indo-Pacific beadmakers moved to the growing Srivijaya state. By the twelfth century, it appears that the quantity of Indo-Pacific beads in Southeast Asia greatly declined, being replaced by Chinese-made beads, which were primarily coiled instead of drawn (Francis, 2002: 71). Francis (2002: 40–41, 48–50) does not see evidence for continued production of Indo-Pacific beads in Southeast Asia and only limited production in South Asia, primarily for trade with Africa.

In reality, as will be discussed below, the Southeast Asian bead production industry was not as coherent and organized as Francis believed. Francis situated many of the early glass production centers as part of the Funan civilization, the Chinese name for a polity located in the Mekong Delta region of Cambodia and Vietnam (Stark, 2004). Francis (2002: 35) extended Funan's influence to the Thai-Malay peninsula and the sites of Khlong Thom and Kuala Selinsing. However, there is little historical and archaeological evidence demonstrating that Funan was a "unified kingdom" let alone had rulers and an infrastructure that could control or incorporate cities located across the Gulf of Thailand (Stark, 2006). Once Funan declined during the mid-first millennium CE, Francis (2002:36–37) argued that the beadmakers shifted to the state of Srijivaya, however compositional analysis suggest that most of the glass beads found in Southeast Asia during this period were likely imported from south India or Sri Lanka (discussed below).

In fact, compositional analysis of glass beads in Southeast Asia has identified several glass compositional types with influences from both north and south India, of which beads from Arikamedu were only a minor component. Due to the diversity in glass recipes, it is not clear that beadmakers at different sites were in contact with one another or a part of a larger guild or league, as Francis has hypothesized. However, compositional analysis has begun to clarify the trade networks for specific types of glass beads and artifacts and illuminating sites that may have been in contact with one another. In many cases, different glass types were likely circulating in pre-existing Southeast Asian exchange networks.

3. The evidence for stone and glass bead production in Southeast Asia

The process for producing stone and glass beads was complex and involved many stages. Ethnographic research suggests that in many cases, the steps needed to produce a stone or glass bead could be separated, and not carried out by the same people or even in the same location (for stone beads see: Kenoyer, 2003; Kenoyer et al., 1991, 1994; Vidale et al., 1992 and for glass beads see: Francis, 1982, 1990, 2002: 19–26; Kanungo, 2000, Kanungo, 2004). If the stages of bead production were dispersed, then identifying bead manufacturing in the archaeological record can be difficult. For example, glass beads were frequently strung in different locations from their manufacture, however beads that were unable to be strung and by-products from the manufacturing of the beads, such as dripped glass and cut segments of glass tubes with knots in them, were frequently transported with the unstrung beads. These objects would then be discarded by the consumer or bead stringer, and would then enter the archaeological record, but are not an accurate indicator of glass bead production at that site (Francis, 1990: 15–16). Kanungo (2000: 25) has argued that identifying a glassmaking or glass bead production workshop in the archaeological record requires finding waste by-products, tools, and a furnace, not just large quantities of finished beads, unperforated or semi-perforated beads, and small quantities of waste.

Ethnographic studies of contemporary stone bead production workshops have highlighted the large quantity of waste material produced during bead manufacturing, which often results in multiple dumps of lithic debitage (Vidale et al., 1993). Ethnoarchaeological work has identified patterns in the dumps from agate and carnelian bead production that can be used to distinguish between different types of workshops (Kenoyer et al., 1991; Vidale et al., 1993). Some sites have been classified as possible bead production centers simply due to the presence of unfinished beads. It is possible that if stone beads were being exported and sold by weight, some unfinished or broken beads may have been included as a means of increasing the price. As the production stages for both glass and stone beads can be spatially dispersed, researchers must be explicit in describing their finds so that the different stages of manufacturing taking place at the site can be determined.

Our understanding of glass bead production in Southeast Asia is also complicated by the fact that many sites Francis argued were production centers have been only studied by him, and their complete finds have not been properly published. In many cases, we must rely on Francis' word or limited notes regarding the nature of evidence for glass bead production, without associated information regarding the context of the finds or photographs of the manufacturing by-products.

Further complicating the study of bead production in Southeast Asia is the rampant looting that has taken place. With the exception of Khao Sam Kaeo, no bead production site has been well studied archaeologically and excavators at Khao Sam Kaeo still had to contend with considerable looting (Bellina, 2014). For this reason, it is important to critically approach the evidence for glass and stone bead production in Southeast Asia. Table 2 and Appendix 1 present a review of stone and glass bead production sites proposed by Francis and others.[2] Fig. 1 shows the locations of the sites discussed in this text.

4. Recent research on stone and glass beads in Southeast Asia

Recent research on stone and glass beads has emphasized the complex interaction networks between South and Southeast Asia, presenting a different picture than that hypothesized by Francis. Compositional analysis of glass beads and artifacts has been especially informative in understanding the influences and interaction networks within Southeast Asia and between South and Southeast Asia. These compositions are summarized in Table 3. Recent work by Dussubieux et al. (2012) has identified three distinct phases of glass bead production and exchange in Southeast Asia.

[2] For a similar assessment of glass beads in southern India see Abraham, 2013.

Table 2
Summary of possible stone and glass bead production sites in Southeast Asia. For further discussion of these sites see Appendix 1.

Site name	Evidence for primary glass production	Secondary glass working	Other glass production evidence	Stone bead production
Ban Bon Noen, Thailand (500 BCE–700 CE)			Large quantities of finished beads in non-mortuary context suggest possible bead trading area?	
Ban Chiang Culture, Thailand (500 BCE–300 CE)			Bead production speculated based on unique type of wound, truncated bicone bead and long, tubular glass beads.	
Ban Don Ta Phet, Thailand (Approx. 4th century–2nd century BCE)			Bead production speculated based on unique type of lapidary worked beads made from high lime potash glass.	
Giong Ca Vo, Vietnam (Approx. 400 BCE)	Pits with sand that might have been used in primary glass production.		Glass versions of typically Sa Huynh artifacts suggest local or nearby production. Also imported m-Na-Al lapidary worked glass beads and bangles from Khao Sam Kaeo.	Local production of nephrite ornaments? Knapping flakes. Local lingling-o ornament style made in carnelian
Java		Production of Jatim beads in East Java during mid-late first millennium CE (see Appendix 1)		Unfinished beads associated with Buni cultural complex. Possible bead roughouts found in Central Java dating to 2nd millennium CE.
Khao Sam Kaeo, Thailand (4th–2nd centuries BCE)		Glass waste and cullet, hot-working debris and flakes, fragments with impressions from glass working tools.	Bangles, lapidary worked beads, and drawn beads produced out of m-Na-Al 3, m-K-Ca-Al, m-K-Al, and mixed alkali glass. Best evidence for drawn glass bead production found in mixed alkali glass.	Evidence for all stages of bead production: shaping, polishing, perforation. Multiple technological traditions represented.
Khlong Thom/Khuan Lukpad, Thailand (1st/2nd–7th century CE)	Raw glass cullet in m-Na-Ca-Al composition and many finished products at site. Unworked chunks of glass and semi-finished glass, ceramics with glass on surface.	Debris from hot-working of glass and flakes. Melted glass beads, glass droplets, and glass slag. Also evidence for production of mosaic glass beads.		Undrilled stone beads, possible raw material.
Kuala Selinsing, Malaysia (3rd–8th century CE)		Chunks of raw glass, glass scrap, twisted glass tubes, knots in tubes, cut segments, and bead clumps.	Production of pinched beads in addition to traditional Indo-Pacific drawn beads	Unfinished beads that were polished with no perforation and vice versa. Waste material and possible grinding stones for polishing.
Myanmar (Late first millennium BCE)			Possible local production of unique bead shapes from m-Na-Al 3 glass	Availability of raw material resources. Roughouts and unfinished beads found in Samon Valley and at Pyu sites.
Oc Eo, Vietnam (Approx. 500 BCE–1st millennium CE)	Ceramic with glass on surface.	Teardrop shaped droplets, glass fragments, chunks, and rods, melted beads, and cut ends of tubes.	Malleret believed polychrome beads were produced at site, but Francis argued Indo-Pacific beads were also produced.	Unfinished and undrilled beads, possible flakes from bead production.
Phu Khao Thong, Thailand (2nd century BCE–4th century CE)		Chunks of raw glass, unfinished and melted beads.	Possible working of m-Na-Ca-Al/Arika glass and potash glass. Similarities in glass composition show connections with the site of Arikamedu, India	
Sungai Mas, Malaysia (10–11th centuries CE)		Glass chunks, glass drips, cut tub segments and knots in tubes, bead clumps, and discarded beads	Production of Middle Eastern style mosaic beads, in addition to Indo-Pacific beads.	
Takua Pa, Thailand (9th century CE)		Glass chunks, glass drips, cut tub segments and knots in tubes, bead clumps, and discarded beads	Indo-pacific bead production as well as drawn beads with stripes and Middle Eastern style wound eye beads	
Vijaya, Sumatra (7–12th centuries CE)		Colored glass chunks, glass drips, twisted glass tubes produced during the drawing of glass, cut segments, bead clumps, and discarded beads	Indo-pacific bead production as well as Middle Eastern style folded bead production	No direct evidence for bead production, however specific types of low-quality carnelian beads found in this location and Francis speculated they were produced locally.

Table 3
Table of different glass types discussed in the text.

Glass Type	Details	Artifacts	Colors	Time period	Produced at	Also found at
High alumina mineral soda glass (m-Na-Al 1)	Similar to m-Na-Al 2, but with low U, high Ba, Sr, and Zr	Drawn beads and bracelets	Opaque red, orange, yellow, green, black, white and translucent light blue.	1st millennium CE (Early and Late periods)	Known production center at Giribawa, Sri Lanka	Widespread across Southeast Asia (Dussubieux et al., 2010; Lankton and Dussubieux, 2006, 2013)
High alumina mineral soda glass (m-Na-Al 2)	Similar to m-Na-Al 1 but with higher U, lower Ba, Sr, and Zr	Drawn beads	Opaque red, yellow, green, black, white, and translucent blue colors.	Late Period Found at sites from late 1st millennium CE–2nd millennium CE	Unknown, possibly on west coast of India	Found in western India, parts of Africa (Dussubieux et al., 2008; Dussubieux et al., 2010), and the Cardamom Mountains, Cambodia (Carter et al., in press)
High alumina mineral soda glass (m-Na-Al 3)	Similar to m-Na-Al 2, but higher concentrations of Cs.	Lapidary worked beads and bangles	Red, black, and transparent emerald green.	Very Early Period	May have been worked at Khao Sam Kaeo, with red glass beads possibly produced in the Samon Valley, Myanmar. Similar to (imported from?) glass found in northern India at Kopia	Giong Ca Vo, Vietnam; Krek 52/62, Cambodia; possibly sites on Borneo and Palawan (Lankton et al., 2008); Samon Valley sites (Dussubieux and Pryce, 2016). Similar glass found in North India (Dussubieux and Kanungo, 2013).
High alumina mineral soda glass (m-Na-Al 4)	Lower lime concentrations than other m-Na-Al types	Drawn beads, bracelets, and vessels	Opaque yellow, green, brown, black, dark blue, translucent turquoise blue, red, and white	2nd millennium CE	Unknown, possibly northeast India	Sumatra (Dussubieux, 2009); northeast India and eastern Africa (Dussubieux et al., 2008, 2010); Wrecked Junk of Brunei (Gratuze, 2001); Cardamom Mountains Cambodia (Carter et al., in press)
High alumina mineral soda glass (m-Na-Al Mg>)	Higher magnesia concentrations (2–3 weight percent)	Drawn beads	Opaque black, opaque light green, translucent purple	2nd millennium CE	Unknown	Thus far only found in jar burials from Cambodia's Cardamom Mountains (Carter et al., in press)
Mineral soda glass with varying amounts of alumina and lime (m-Na-Ca-Al)	Compositions vary, but can be distinguished from m-Na-Al 1 glass through a PCA with Na_2O, Al_2O_3, Zr, Rb, La, Hf, and Th (Dussubieux and Gratuze, 2010)	Drawn beads, mosaic beads, and bangles	Cobalt blue, opaque green, opaque yellow, opaque red, transparent purple	Early Period to Late Period 4th century BCE–5th century CE (Dussubieux and Gratuze, 2013)	May have been produced at Khlong Thom, also worked at Phu Khao Thong.	Sa Huynh and Dongson sites, Vietnam; Khao Sam Kaeo; central and northeast Thailand; Oc Eo, Vietnam; Sri Ksetra, Myanmar; sites in Laos (Lankton and Dussubieux, 2013); Angkor Borei, Cambodia; Prohear, Cambodia; Phum Snay, Cambodia; Promtin Tai, Thailand; Ban Non Wat, Thailand; Noen U-Loke, Thailand (Carter, 2013)
Arikamedu (Arika)	Similar to m-Na-Ca-Al glass but with additional potash, magnesia, and phosphorous	Drawn beads	Green, red, and black	Early Period 4th century BCE–5th century CE (Dussubieux and Gratuze, 2013)	Worked at Phu Khao Thong? Primary glass production center is unknown	Arika glass beads may have been identified at Prohear (Carter, 2013) Also found at some sites in South Asia (see Dussubieux and Gratuze, 2013: 407–408)
Mixed Alkali glass from Khao Sam Kaeo KSK	May be mix of m-Na-Al 3 and m-K-Ca-Al from Khao Sam Kaeo	Drawn beads	Copper blue and red	Very Early Period	Worked at Khao Sam Kaeo? Or perhaps imported to site?	Red beads also found at Ban Don Ta Phet (Lankton et al., 2008; Lankton and Dussubieux, 2013)
Mixed Alkali from northeast Thailand	Over 5% of both soda and potash. May be related to high alumina mineral soda glass (Lankton and Dussubieux, 2006)	Wrapped glass beads	Opaque orange	Early and Late periods (most frequently found in burials from 200 BCE – 200 CE at Ban Non Wat and Noen U-Loke (Carter and Lankton, 2012).	Production site unknown	Compositional similarity with beads found at Ta Chana in peninsular Thailand, Chombeung, central Thailand, Don Klang, northeast Thailand, and sites in India (Carter and Lankton, 2012). Morphological similarities with beads from Non Muang Khao (Saitowitz

(continued on next page)

Table 3 (*continued*)

Glass Type	Details	Artifacts	Colors	Time period	Produced at	Also found at
						and Reid, 2001) and Ban Bon Noen (Pilditch, 1992)
Mixed Alkali from the Samon Valley	Similar amounts of potash and soda, ranging from 5–11 weight percent (Dussubieux and Pryce, 2016).	Unknown	Opaque orange Opaque red	Sites date from the mid-late first millennium BCE.	Production site unknown	N/A
Mineral source low alumina – high lime potash glass m-K-Ca	Less than 1 weight percent alumina and 3–6 weight percent lime (Lankton and Dussubieux, 2013)	Lapidary worked glass beads, earrings, in the Samon Valley these were translucent turquoise blue disk or oblate shaped beads (Dussubieux and Pryce, 2016).	Translucent blue-green	Early Period	Production site unknown, but perhaps near Ban Don Ta Phet (Lankton and Dussubieux, 2013). Strontium and neodymium isotope signatures suggest similarities between Ban Don Ta Phet and Samon Valley beads (Dussubieux and Pryce, 2016).	Samon Valley, Myanmar (Dussubieux and Pryce, 2016), Giong Ca Vo and Lang Vac, Vietnam (Lankton and Dussubieux, 2006), possible ring/earring fragment from Prohear, Cambodia (Carter, 2013); earring from Phum Snay (Gratuze, 2013).
Mineral source low lime–high alumina potash glass m-K-Al	Less than 1 weight percent lime	Drawn beads and bangles, Han period molded cups	Copper blue, greenish blue, translucent dark blue, and purple	Very Early Period and Early Period	Secondary glass working at Khao Sam Kaeo. Possible glass production in southern China or northern Vietnam (Dussubieux and Gratuze, 2010:252)	Ban Don Ta Phet, Thailand; Sa Huynh and Dongson sites in Vietnam; Samon Valley, Myanmar; Phu Khao Thong (Lankton and Dussubieux, 2013); Prohear, Cambodia; Village 10.8 Cambodia; Bit Meas, Cambodia; Phnom Borei, Cambodia (Carter, 2010, 2013)
Mineral source potash glass with varying amounts of alumina m-K-Ca-Al and lime	Lime and alumina between 1–4 weight percent	Drawn beads and bracelets, ring/earring fragments.	Translucent copper and cobalt blues, opaque red, translucent black, and purple	Very Early Period and Early Period (declines during early centuries CE)	Unknown, but most commonly found in South and Southeast Asia (Dussubieux and Gratuze, 2010:250)	Ban Don Ta Phet, Thailand; Khao Sam Kaeo, Thailand; Sa Huynh and Dongson sites in Vietnam; Samon Valley, Myanmar; Phu Khao Thong (Lankton and Dussubieux, 2013); Village 10.8, Cambodia; Prohear, Cambodia; Bit Meas, Cambodia; Phum Snay, Cambodia; Phnom Borei, Cambodia; Promtin Tai, Thailand; Ban Non Wat, Thailand; Noen U-Loke, Thailand (Carter, 2010, 2013)
Vegetable source soda lime glass v-Na-Ca	Magnesia over 1.5 weight percent and lime higher than alumina	Drawn beads and vessels	Lightly colored/colorless and translucent dark blue. One black and red bead found at Prei Khmeng, Cambodia (Carter, 2010, 2013)	Early Period and Late Period (after third century CE and throughout first millennium CE	Likely produced at Sasanian sites in Middle East, but may have been locally worked in Southeast Asia (Lankton and Dussubieux, 2013: 438)	Angkor Borei, Cambodia; Phum Snay, Cambodia; Prei Khmeng, Cambodia; Ban Non Wat, Thailand (Carter, 2013); Khlong Thom, Thailand (Lankton and Dussubieux, 2013)
Lead-Potash glass	Between 5–14 weight percent potash and 25–61 weight percent lead. Trace element compositions vary (see Carter et al., in press)	Wound glass beads	Opaque blue, white, yellow and some polychrome beads, translucent red/purple	2nd millennium CE	Likely produced in China	Fort Canning Singapore (Borell, 2010; Dussubieux, 2010); Philippines, Cardamom Mountains, Cambodia; Krang Kor, Cambodia (Carter et al., in press). Likely more widespread throughout Southeast Asia but more compositional analysis needed.

4.1. The Very Early Period

The Very Early Period of glass trade and production in Southeast Asia spans from the 5th century BCE to approximately the 2nd or 1st centuries BCE. Thus far, this early stage of glass production is centered on the site of Khao Sam Kaeo, Thailand with exchange of finished products to other sites elsewhere in Southeast Asia (Table 3). Glass objects are primarily found in two compositions during this period: potash glasses and a sub-type of high alumina mineral soda glass, called m-Na-Al 3 (Table 3)(see Dussubieux et al., 2010, 2012; Lankton and Dussubieux, 2013; Lankton et al., 2008). Opaque red glass beads made from m-Na-Al 3 glass have also been found at sites in the Samon Valley, Myanmar (Dussubieux and Pryce, 2016). The raw glass may have been imported from the north Indian site of Kopia in Uttar Pradesh, India for production into ornaments (Dussubieux and Kanungo, 2013).

Both the high alumina mineral soda glass and potash glass types appear to have been worked into artifacts at Khao Sam Kaeo (Lankton et al., 2008). The high alumina mineral soda glass was used primarily to make bracelets and beads that were shaped and drilled in a fashion similar to stone beads (i.e. lapidary worked beads). These objects were exchanged within a South China Sea network and have been found at the site of Krek 52/62 in southern Cambodia (Haidle and Neumann, 2004), Giong Ca Vo, Vietnam, peninsular and central Thailand, and the islands of Borneo and Palawan (Lankton et al., 2008).

Bracelets as well as drawn Indo-Pacific style beads were also produced out of a mineral source potash glass found at Khao Sam Kaeo. Two varieties of potash glass were identified, one with moderate amounts of alumina and lime (m-K-Ca-Al), which was the second most common glass type found at the site and a low lime potash glass (m-K-Al) (Lankton and Dussubieux, 2013; Lankton et al., 2008). The multiple sub-types of potash glass suggest that there were likely multiple production areas (Lankton and Dussubieux, 2013). The m-K-Ca-Al glass is fairly widespread in Southeast Asia, especially in the next period (discussed below).

The second type of potash glass with low lime (m-K-Al) was apparently also used to produce a small number of drawn beads and a bracelet fragment at Khao Sam Kaeo, but this particular glass type is not widespread in Southeast Asia and has primarily been found in mortuary contexts in southern China, where it was used to make molded glass cups dating to the Han period (Borell, 2012; Lankton and Dussubieux, 2013: 431). It is not clear what the relationship is between these glass objects and likely production of this glass type in southern China.

A third type of mixed alkali glass, a mixture of m-Na-Al 3 and the m-K-Ca-Al potash glass, was used to produce drawn beads in blues and reds found at Khao Sam Kaeo. Similar beads have also been found at the site of Ban Don Ta Phet in west-central Thailand (Lankton and Dussubieux, 2013; Lankton et al., 2008). In general, there is limited evidence for drawn bead production at Khao Sam Kaeo, however possible tools used in the production of drawn glass beads have been identified and researchers suggest that further evidence for Indo-Pacific bead production may be located in an as of yet unexcavated part of the site (Lankton and Dussubieux, 2013; Lankton et al., 2008). It should be noted that there is an additional glass type found at Ban Don Ta Phet that has not been found at Khao Sam Kaeo, suggesting that the presence of the mixed alkali glass at both sites is not necessarily evidence for direct contact between the two communities (Lankton and Dussubieux, 2013: 433).

4.2. The Early Period

The Early Period of glass production and exchange overlaps with the Very Early Period, beginning around the 3rd–2nd centuries BCE and extending into the 4th centuries CE (Dussubieux et al., 2012). During this period, glass production at Khao Sam Kaeo, specifically the production of objects from m-Na-Al 3 glass, declines for reasons that are currently unknown. However, the manufacture and circulation of potash glass expands and it became the dominant glass type at many sites in Southeast Asia (see Carter, 2010; Lankton and Dussubieux, 2013). The different sub-types of potash glass appear to have circulated in somewhat different networks (Table 3) and the location of potash glass production sites for all three sub-types is still unknown. High alumina, low lime potash glass was used to make molded glass cups found primarily in southern China and northern Vietnam, although some vessel fragments have also been found in peninsular Thailand (Lankton et al., 2009). This glass type was also used to make drawn beads found at sites in East Asia, Dongson and Sa Huynh sites in Vietnam, and at sites in southeast Cambodia (Carter, 2010, 2013). Scholars have proposed that the high alumina/low lime potash glass may have been produced in southern China or northern Vietnam (Dussubieux and Gratuze, 2010).

Potash glass with moderate amounts of alumina and lime (m-K-Ca-Al) is frequently found in both South and Southeast Asia and was used to produce bangles and drawn glass beads at Khao Sam Kaeo and has also been found at many sites across Southeast Asia as beads, bangles, rings, and earrings (Table 3). Interestingly, some of the earliest glass objects at Ban Non Wat, Thailand were not beads but potash glass earrings (Carter and Lankton, 2012; Higham and Kijngam, 2009). These rings, earrings, and bangles are also found at early Iron Age sites found in southeast Cambodia (Carter, 2010, 2013).

High lime potash glass (m-K-Ca) is rarer, having been found primarily at Ban Don Ta Phet, as well as at sites in the Samon Valley, Myanmar (Dussubieux and Pryce, 2016; Lankton and Dussubieux, 2013). An object made from this glass type has also been found in a stupa deposit from Deliwala, Sri Lanka and is believed to have been imported from Southeast Asia (Brigitte Borrell, personal communication, 2015). The beads from Ban Don Ta Phet are unusual in that some were lapidary worked beads, different from those found at Khao Sam Kaeo. Due to their uniqueness and limited distribution, it is possible that this glass type was manufactured near the site (Lankton and Dussubieux, 2013).

One of the new glass types being produced during this period is a type of mineral soda glass with moderate amounts of both alumina and lime (m-Na-Ca-Al), which shares a compositional similarity to a type of glass produced at Arikamedu, South India, called Arika glass (see Dussubieux and Gratuze, 2013; Dussubieux et al., 2012; Lankton and Dussubieux, 2013). This particular glass type has been found at numerous sites dating from the late centuries BCE to the mid-first millennium CE, suggesting that its production was long-lived (Lankton and Dussubieux, 2013). Many m-Na-Ca-Al glasses were dark blue colored with cobalt, or purple colored with manganese. Dussubieux et al. (2012:326) have suggested that the production and exchange of this glass type was likely due to the fact that these colors were not found in the high alumina mineral soda glasses that were pervasive in the Early to Late Periods. The popularity of this glass then, may have been related to a demand for these particular colors.

Arika glass is found only in green, red, or black and, appears to have been produced by adding an ingredient with potash, magnesia, and phosphorous to m-Na-Ca-Al glass (see Dussubieux and Gratuze, 2013: 406–408; Dussubieux et al., 2012: 320–321). This particular glass type has been found in large quantities at two sites in Thailand, Phu Khao Thong and Khlong Thom, but in smaller quantities at other sites in Southeast Asia (see Table 3).

At Phu Khao Thong, many of the m-Na-Ca-Al/Arika glass objects were found as clumps of melted glass beads, although their purpose is not clear (Dussubieux et al., 2012). Dussubieux et al. (2012: 325–326) have suggested that there was a relationship between Phu Khao Thong and Arikamedu based on the high quantities of this glass type and proportions of other glass types found at both sites. While raw glass does not appear to have been produced at either site, archaeological evidence suggests that an unknown source sent raw m-Na-Ca-Al/Arika glass to both sites for production into beads (Dussubieux et al.,

2012: 326). One possible production center for m-Na-Ca-Al glass is Khlong Thom, where it was also found in high quantities (Lankton and Dussubieux, 2013).

Mixed alkali glass, or glass with over five per cent of both potash and soda, is also frequently found at sites in Southeast Asia. As noted above, blue or red mixed alkali glass beads were produced at Khao Sam Kaeo during the Very Early Period. However other types of opaque red and orange mixed alkali glass beads have also been found at sites in both South and Southeast Asia (Dussubieux and Gratuze, 2013; Dussubieux and Pryce, 2016; Dussubieux et al., 2011). Recent studies of the orange mixed alkali type have identified a wide range of compositions that likely reflect multiple manufacturing locations (Carter and Lankton, 2012). A specific type of mixed alkali glass bead has been found at sites in northeast Thailand and especially at Ban Non Wat and Noen U-Loke, primarily in burials and layers dated from 200 BCE–400 CE (Carter and Lankton, 2012). The orange opaque mixed alkali glass beads were not drawn, as with Indo-Pacific glass beads, but instead wrapped around a metal rod to produce long thin tubes or sliced into disk beads with a large hole (see Saitowitz and Reid, 2001). Similar beads have been found at other sites in northeast Thailand (Carter and Lankton, 2012; Saitowitz and Reid, 2001; Pilditch, 1992). Compositional analyses of the beads from Ban Non Wat and Noen U-Loke shows some similarities with beads found in other sites in central and northeast Thailand, and sites in India (Carter and Lankton, 2012; Carter, 2013). The production area of these beads is currently unknown, however their unusual manufacturing method and restricted distribution in northeast Thailand suggest a manufacturing location in this region.

4.2.1. High alumina mineral soda glass

During the first few centuries CE a new glass type emerged, high alumina mineral soda glass, and began to dominate bead assemblages across Southeast Asia, eventually replacing potash glass. This shift was occurring regionally (Lankton and Dussubieux, 2013), and may have been related to intensified exchange networks with South Asia, which appears to have expanded and transformed regional trade in Southeast Asia during the mid-late Iron Age (Carter, 2015 see also Bellina and Glover, 2004). This high alumina mineral soda glass was slightly different in composition from the earlier sub-type found at Khao Sam Kaeo. Instead, this new glass was distinguished by low concentrations of uranium and high concentrations of barium; a sub-type known as m-Na-Al 1 (Dussubieux et al., 2010). Drawn Indo-Pacific beads were made in a wide variety of colors, opaque red, orange, yellow, green, black, and white, and translucent copper blues, and were produced at the site of Giribawa, Sri Lanka (Dussubieux, 2001; Lankton and Dussubieux, 2006, 2013). With this shift we see a decline in the small-scale production of many of the earlier glass types and a shift to the importation of high quantities of finished beads. As an example of the large numbers of beads now in circulation, two burials at Noen U-Loke, Thailand and Prei Khmeng, Cambodia contained over 1000 beads each.

4.3. The Late Period

The Late Period encompasses the first millennium CE. Drawn m-Na-Al 1 beads continued to be widely exchanged throughout Southeast Asia during this period. However, Francis (2002: 48, 71) has observed that by the 12th century CE the quantity of Indo-Pacific beads declines, which he attributed to the fall of Srivijaya and the "abandonment" of bead production sites. As noted earlier, the evidence for a network of Indo-Pacific beadmakers in Srivijaya is not clear, and the current evidence points toward a South Asian manufacturing center for m-Na-Al 1 glass. The reason for the decline of Indo-Pacific beads is unknown. Additionally, there are several factors that have impacted our ability to study the production and consumption of beads during this period. Firstly, little archaeological work has been done on mid-late first millennium and second millennium sites, with the majority of research focusing on temple and architectural sites belonging to pre-Angkorian, Angkorian, Dvaravati, and Cham cultures. Secondly, mortuary rituals appear to have changed during this period, influenced by Hindu and Buddhist practices, and fewer and fewer people appear to have been interred in graves in which beads would also be deposited.

As the presence of Indo-Pacific beads declined in the early second millennium CE, they were replaced by increased quantities of Chinese-made beads that were wound or coiled around a mandrel (Francis, 2002: 76–78). These small (3 mm or less) coiled beads were made from a lead-potash glass. However, during the 16th century, or possibly a few centuries earlier, a different type of larger coiled bead, often with multiple coils, became predominant (Francis, 2002:82). Recent analyses of Chinese lead glass beads from 14–17th century sites in the Cardamom Mountains of Cambodia, Fort Canning Singapore, and the Philippines have identified slight changes in their glass recipes with the earlier 14th century Fort Canning beads having higher concentrations of Rb and Li and the later Philippine and Cambodian beads containing the reverse (see Carter et al., in press). Francis (2002) has noted numerous types of Chinese beads that appear in Southeast Asia during the second millennium CE, however more work is needed to determine the different compositions and their exchange networks (see Fuxi, 2009, for a review). This is certainly one avenue of future research that will shed much light on interaction networks during this period of widespread maritime exchange.

It should be noted that drawn glass beads did not disappear entirely from Southeast Asia, as Francis believed. Recent research on beads found in 15–17th century jar burials in Cambodia's Cardamom Mountains have identified several types of drawn glass beads made from different glass compositions (see Carter and Beavan, 2014; Carter et al., in press). Many of the beads in the jars belonged to two additional subtypes of high alumina mineral soda (Dussubieux et al., 2010). The largest group belonged to the m-Na-Al 2 type, which have been previously identified at the site of Chaul, in western India (Dussubieux et al., 2008) and southern Africa (Robertshaw et al., 2010). A small sub-set of beads was found to belong to the m-Na-Al 4 group, which has been found in only a handful of sites, including in the Wrecked Junk of Brunei (Gratuze, 2001), at 12–16th century sites in Sumatra (Dussubieux, 2009), 15–16th century CE sites in northeastern India and Bangladesh, and at a 17–19th century site in Kenya (Dussubieux et al., 2008, 2010). It is not clear where either of these two sub-types of m-Na-Al glass was manufactured. The m-Na-Al 4 glass shares some similarities to the m-Na-Al 3 glass produced in northeast India and may have also been manufactured in this region (Carter et al., in press; Dussubieux and Kanungo, 2013), while the m-Na-Al 2 glass may have been produced on the west coast of India (Dussubieux et al., 2010: 1650).

A new type of high alumina mineral soda glass was identified in the Cardamom Mountain jars (see Carter et al., in press). These were drawn glass beads found in opaque black, light green, translucent purple, and a greasy yellow color This glass type, called m-Na-Al Mg>, is distinguished from the other high alumina mineral soda glasses by having lower concentrations of alumina, and higher concentrations of magnesia. Its manufacturing location is currently unknown, as the beads have thus far only been identified in these jars. The presence of this new glass type highlights how little we know about glass bead production and exchange during the second millennium CE.

Lastly, beads and glass objects, especially vessels, from the Mediterranean and Middle East have been a small but persistent component of the corpus of glass artifacts in Southeast Asia since the Iron Age. This long-distance glass exchange continued into the Early and Late Periods, but is outside the scope of this review.

4.4. Agate and carnelian beads

Francis (2002:141) observed that there was evidence for stone bead making at sites that were also producing Indo-Pacific glass beads, although he conceded that there was not enough evidence to determine

if stone bead production was organized in the same way as glass production. China was not a source of agate and carnelian beads in Southeast Asia until the late Ming Dynasty (Francis, 2002:145). Therefore, most of the beads in Southeast Asia were related, in some fashion, to either the western or southern Indian bead production industries (Francis, 2002). As discussed above and in Appendix 1, the evidence for stone bead production at many of these sites is problematic.

Like the glass beads, research on agate and carnelian stone beads also shows change over the late first millennium BCE and the early first millennium CE. In her work examining bead collections from sites across mainland and island Southeast Asia, Bellina (2007, 2014) identified differences in beads found at earlier and later period sites. Beads from sites that date to the late centuries BCE sites were generally found in more complex shapes, such as faceted shapes, in smaller sizes, had smaller perforation sizes, were polished using a rotary grinding technique, and had higher standards of workmanship. Beads from later Iron Age sites were generally found in simpler shapes, with larger perforation holes, and polished using drum polishing technique, a mass production technique that produces a low luster polish (Bellina, 2007: 32). Work by Carter (2013, 2015) has identified similar patterns in beads from Iron Age sites in Cambodia and Thailand. The higher quality of beads found at earlier sites appear to represent production by highly skilled craftsmen, made on a smaller scale using time intensive techniques.

Bellina (2003, 2007) has argued that in some cases the lower quality beads found at later Southeast Asian Iron Age sites may be due to local production of beads in Southeast Asia. Southeast Asian elites may have been commissioning the production of lower quality beads for use as part of alliance building strategies with other elites (Bellina, 2007: 72–74). However, Carter (2013, 2015) has also proposed that these lower quality beads may instead be related to intensified trade with South Asia and the importation of mass-produced beads from this location. The widespread importation of high alumina mineral soda glass beads from South Asia during the Early Period could also have included increased importation of mass-produced agate and carnelian beads from South Asia.

In depth research at Khao Sam Kaeo has shed light on the organization of hard stone bead production during the Very Early Period. The identification of several different technological traditions practicing hard stone bead production at the site indicates a diverse group of craftsmen may have lived and worked there (Bellina, 2014). Many of the bead production locations appear to have been within walled areas, suggesting that the craftsmen at the site may have been attached specialists working for Southeast Asian elites. Bellina (2003, 3007) has argued that some of the beads produced using South Asian techniques but in a local style were indicative of the agency of Southeast Asian elites in requesting objects in shapes that are culturally significant. Overall, it appears that elites at Khao Sam Kaeo used the production and exchange of beads as a means of maintaining and increasing their social status (Bellina, 2014: 370–371).

Compositional studies of agate and carnelian beads have thus far been few, but show promise for delineating exchange and interaction networks. An early study by Theunissen et al. (2000) used a non-destructive technique, PIXE/PIGME, to analyze beads from the sites of Noen U-Loke, northeast Thailand and Ban Don Ta Phet in west-central Thailand. These artifacts were compared with a small number of source samples from north, northeast, and south India, as well as Sri Lanka, and a source located in central Thailand. They concluded that the beads from the Thai archaeological sites were distinct from one another and from the Indian geologic source samples, and instead there appeared to be more similarity with the Thai and Sri Lankan sources. The use of a Thai source would point toward local manufacture of beads, presumably under the control of a local elite. However, the sample size for this study was small and additional studies have not found other beads made from the central Thai source (see Law et al., 2013; Carter and Dussubieux, 2016). More recent work on a larger set of samples and sources has shown that raw material to produce the beads found in Southeast Asia was largely derived from the Deccan Traps in northwest India. However, other potential sources have not yet been ruled out and this work is ongoing (Carter, 2013; Carter and Dussubieux, 2016).

4.5. Local production of stone beads and ornaments in Southeast Asia

The indigenous production of stone beads and ornaments was only mentioned in passing by Francis (e.g. 2002: 130). However, more recent work has shed light on these industries and the local production of ornaments more broadly, including beads and bangles made from shell, and bangles made from marble (e.g. Chang, 2001). Continued studies of these local industries would be fruitful avenues for research in the future. Of special interest are understanding how these local industries were organized, the avenues for the exchange for both raw material and finished products, and their meaning and use by local populations, especially in contrast to the import of "exotic" foreign objects like agate/carnelian and glass ornaments.

Of the local ornament industries, perhaps the best studied are the production and exchange of nephrite ear ornaments. Two forms are frequently found at sites across mainland and island Southeast Asia: the lingling-o and the double-headed or bi-cephalous earring (Loofs-Wissowa, 1983; Solheim, 1984). The lingling-o in particular has been described as one of the most common forms of ornament made from nephrite or jade-like green stones in Southeast Asia (Hung et al., 2007). Scholars have noted that despite being found across all regions of Southeast Asia, the earrings appear to be fairly standardized in their size, style, and manufacturing methods (Hung and Bellwood, 2010). Scholars have suggested that these earrings were important prestige objects for Southeast Asian communities (Bellina, 2007; Reinecke, 1996).

Compositional studies have indicated raw materials for many of these objects were coming from Taiwan, specifically from the Fengtian nephrite source, which may have been exploited and exchanged to the Philippines as far back as the 3000 BCE (Hung et al., 2007). It is interesting to note that there is no evidence for the manufacture of these items in Taiwan, leading the researchers to suggest raw material blanks were exported to regions "where artisans manufactured artifacts to local taste," (Hung et al., 2007: 19,746). While other local nephrite sources in Vietnam and the Philippines may have been used to make similar objects, the overwhelming majority appears to derive from this Taiwanese source.

Craft production workshops for the nephrite ear ornaments have been found on islands off the coast of Taiwan, the Philippines, Vietnam, and possibly peninsular Thailand (Hung et al., 2007: 19,749). It appears that blanks were being exported from the nephrite source in Taiwan to these manufacturing centers. Hung et al. (2007: 19,749) have proposed that these earrings were being produced by "itinerant jade craftsmen" who acquired jade from the source either directly or indirectly, and then circulated within the South China Sea network producing these objects for elites. The predominant use of jade from a single source as well as the standardization of the products indicates a high-level of specialization. The itinerant nature of the craftsmen also indicates that they were not attached to an elite patron who controlled the production of these objects. However, their association with high-status individuals points toward some amount of control over their distribution. It appears that there were more formalized trade networks connecting the coastal manufacturing centers with the raw material source, while the distribution of finished products, especially to sites further inland may have been through down-the-line exchange networks.

Another clue in the quest to understand the organization of local stone bead production lies in the excavation of a prehistoric Bronze Age jewelry workshop in northern Vietnam dating to the late second millennium BCE (Nguyen, 1996). Researchers have identified several possible types of drilling methods used to produce nephrite jewelry

including stone drills, a bronze drill, and jasper drills (Nguyen, 1996). Archaeologists have also noted the use of bamboo drills with abrasive to perforate objects made of nephrite at both East and Southeast Asian sites (Hansford, 1950; Nguyen, 1996).

Lastly, recent works on garnet beads from sites in southeast Cambodia have identified evidence for local production of these objects and their exchange at sites in southeast Cambodia and southern Vietnam (see Carter, 2012; Carter, in press). Garnet beads found at these sites appear to be small pebbles that were not shaped or polished and were drilled using a variety of drilling methods, including a stone drill and copper drills with abrasive (see Carter, 2012). Compositional analysis also sets them apart from garnet beads found at Angkor Borei produced using South Asian techniques (Carter, in press). The garnet beads were frequently found in burials and often co-occurred with imported stone and glass beads. However, their local manufacture and restricted distribution likely set them apart, and they may have had local meanings distinct from the foreign stone and glass beads.

5. Discussion: the socio-political implications of bead production and consumption in Southeast Asia

In Francis' "Arikamedu league" model, glass beadmakers at different sites in Southeast Asia were linked to one another, and belonged to an overarching organization that facilitated their movement between sites. These beadmakers would only establish workshops in urban centers, thereby becoming markers of emerging complexity and Indian influence in these regions. They present an impression of sophisticated and complex set of polities, with established elites and cosmopolitan urban centers.

In reality, the evidence from both glass and stone beads produces a more complex picture, with localized production and exchange networks during the earliest periods of contact, including diverse glass recipes and manufacturing methods. During the later Iron Age period trade networks expanded with larger quantities of mass-produced stone and glass beads dominating sites as trade networks with South Asia were intensifying (Bellina and Glover, 2004; Carter, 2015). The diverse glass recipes indicate that glass beadmakers at different sites were likely not closely linked to one another, as proposed by Francis. Furthermore, the circulation of these different glass types, especially during the Very Early Period, was limited.

Hung et al. (2007, 2013) has proposed that indigenous production of nephrite ornaments was undertaken by itinerant craftsmen that circulated around the South China Sea. Based on her work at Khao Sam Kaeo, Bellina (2014: 368-369) notes that production during the early Iron Age appears to have been at the household level, but that craftsmen appear to have been attached specialists working on commission for local elites. In some cases, hard stone beads produced by these craftsmen were in a local, culturally significant style. However, other beads produced at the site were made in the form of Indian religious symbols, which Bellina (2014: 371) has argued may be have been for elites who were in the process of becoming "Indianized" and "over-emphasizing the attributes of otherness." While Khao Sam Kaeo was an important cosmopolitan trading center, the products from this site were exchanged in only limited sphere, and elites in this community appear to have little impact on socio-political developments outside the immediate area.

Bellina's observation regarding the production of beads in the form of Indian religious symbols echoes earlier work by Gupta (2003:395), who has argued that these types of beads were objects of proto-Indianization. In his model, the etched and animal-shaped beads were specifically related to an aniconic religious tradition that was present several centuries prior to the appearance of Indian religious sculptural traditions, and were reflections of adoption of this ideology by Southeast Asian people. Complicating this hypothesis, however is that many of these beads have been found in non-Indianized mortuary contexts (i.e. those reflecting Southeast Asian ritual practices) (Bellina and Glover, 2004). Gupta acknowledges that many Southeast Asian people most likely projected their own beliefs and ideologies on agate and carnelian beads as well, therefore interpreting how Southeast Asian people may have perceived these objects is difficult.

Determining how Southeast Asian communities perceived beads is likely best undertaken on a site-by-site basis and work by Theunissen (1997, 1998, 2003, 2007) at the northeast Thai site of Noen U-Loke provides a model for appraising the value of ancient beads. In order to assess the impact of the introduction of agate and carnelian beads on the Noen U-Loke community, Theunissen first had to identify the value of the beads in relation to other grave goods; evaluating them based on their physical traits, rarity of material, exoticness, the labor used to produce the object, and the skill/technology needed to produce the artifact. In his evaluation, agate and carnelian beads were the highest valued objects placed in graves, even more valuable than gold beads (Theunissen, 2003: 199–203). A specific bead type, notched agate pendants, may have been especially valued, as several were repaired after having been broken and continued to be used as ornaments prior to inclusion in the burial (Theunissen, 1998).

Theunissen (2003: 211) also found that burials with agate and carnelian beads had other high-value grave goods, making them amongst the wealthiest at the site. However, these beads were not restricted to only the most elite members of the community, as nearly one third of the burials contained agate and carnelian beads. Instead, Theunissen argues the inclusion of beads signaled a shift in mortuary ritual at Noen U-Loke. During the earlier phases of the site communal feasting appears to have been a part of activities related to social status, but with the appearance of agate and carnelian beads, there is a transition to the use of personal ornaments to display status, wealth, and prestige (Theunissen, 2003: 220).

Work on the bead collections from other Iron Age mortuary sites in Cambodia and Thailand have shown considerable diversity in how beads were incorporated into burials over time and space (Carter, 2013, 2015). Therefore, future scholars would benefit from Theunissen's approach of looking at the impact of beads within a single community. As increasing numbers of sites are considered, we may begin to understand regional patterns in the exchange, use, and deposition of beads by different communities during the Iron Age. This in turn will assist with an understanding of exchange networks and socio-political transformations happening in these communities.

Studies of beads from multiple sites can also shed light on larger scale changes. As noted earlier, previous studies of glass and stone beads have indicated a shift in the type of beads being imported to Southeast Asia, which appears to coincide with intensifying trade with South Asia (Bellina and Glover, 2004; Carter, 2015; Lankton and Dussubieux, 2013). Recent work by the author (Carter, 2015) has argued that exchange networks were transformed and expanded by this intensified exchange, and especially the availability of greater quantities of mass-produced stone and glass beads. These transformations may have contributed to the development of the Funan state in the Mekong Delta region of Cambodia and Vietnam.

6. Conclusion

Many of the studies discussed above have highlighted the importance of examining stone and glass beads at multiple scales and from multiple perspectives. While Francis' model presented the production and exchange of beads as part of a well-organized group, the actual archaeological evidence is more complex, with both localized and regional responses, which changed over time. Many of the aforementioned studies have benefitted from new analytical techniques that can be used to identify compositional differences in beads that may not be clear to the naked eye.

Thus far, the research presented suggests that during the Very Early Period, interactions between South and Southeast Asia were limited primarily to coastal sites in Southeast Asia. The multiple different glass

recipes and different types of glass production show a diversity in the influences from South Asia in Southeast Asia. Some sites, such as Khao Sam Kaeo, show stronger links with northern India, while others, like Phu Khao Thong, show connections with southern India. During the early Iron Age, glass and stone beads were primarily circulating in pre-existing networks, especially the South China Sea network, which exchanged high-status goods between communities in mainland and island Southeast Asia, such as nephrite ear ornaments (e.g. Bellina, 2014; Carter, 2015; Hung et al., 2013; Lam, 2011).

High quality stone beads were produced at Khao Sam Kaeo during the Very Early period. Stone beads may have been produced elsewhere in Southeast Asia over different periods, although clear evidence for this is still problematic. Finished agate and carnelian beads, imported from South Asia, were also widely exchanged (Carter, 2013; Carter and Dussubieux, 2016). During the Very Early and Early Periods, high quality agate and carnelian beads appear to have been the norm and these beads appear to have been circulating in the same pre-existing exchange networks that also circulated potash glass beads (Carter, 2013, 2015).

Archaeological evidence shows an intensification of exchange with South Asia during the first few centuries CE (Bellina and Glover, 2004; Carter, 2015). It is during this period that larger quantities of mass-produced stone beads and high alumina mineral soda glass (m-Na-Al 1) beads enter Southeast Asia and are disseminated on expanding exchange networks (Carter, 2015). Additionally, glass beads from the Mediterranean, Middle East, and China were exchanged alongside beads from South Asia.

By the late first millennium and early second millennium CE, Indo-Pacific bead production declines, and a large number of Chinese produced beads enter into Southeast Asian networks. However, this time period is still under-studied and preliminary studies indicate that small quantities of drawn glass beads were still present alongside wound Chinese glass (e.g. Carter and Beavan, 2014; Carter et al., in press).

There is still much work to be done to fill in the gaps in this narrative. We know little about glass production and exchange in the historic period and second millennium CE. Materials from shipwrecks may prove to be a fruitful line of research as well as exploring interactions between upland and lowland communities. Also of importance is the identification and excavation of bead production workshops, a task that may be nearly impossible due to the widespread looting of sites with evidence for large numbers of beads. However, careful recording of disturbed sites, especially in terms of identifying debris and production by-products, can be useful in more confidently asserting that a site was the location and stages of bead production in the past.

Continued compositional analysis of stone and glass beads, especially from regions in Laos, Myanmar, Vietnam and Island Southeast Asia would also greatly expand our understanding of bead types in these areas. Future studies may also wish to incorporate isotopic analysis of artifacts (e.g. Henderson et al., 2005). In addition to understanding how communities in these areas might tie into broader regional developments, they may also identify additional locally exchanged bead types. I also argue that looking at both stone and glass bead collections together can be informative (Carter, 2015) and that future studies may wish to expand to the entire suite of personal ornaments at a site, including metal objects and locally produced beads made of shell and other natural materials in order to better understand the use of personal ornaments in ancient cultures and gain a more complete understanding of the range of external contacts and exchange networks within these communities.

Site-level investigations on the use and value of beads can assist with our understanding of the processes of socio-political and ideological changes happening during the Iron Age. These studies may also help identify both elite controlled and non-elite controlled production and exchange networks. As imported stone and glass beads have long been considered valuable objects, the focus on their study has been in terms of elites. However, some scholars have argued that social organization in some Southeast Asian communities was heterarchical (e.g. O'Reilly, 2000, 2003; White, 1995).

In short, despite the great advances in the study of beads in Southeast Asia since the publication of *Asia's Maritime Bead Trade* there is still plenty of room for continued study of beads. While recent studies have refuted Francis earlier model, which was based on limited data, these current studies owe much to his considerable contributions on the study of beads in Southeast Asia and his assertion that beads are worthy of in depth study. "Beads are common things…[w]hen they are studied, however, they begin to assume considerable importance," (Francis, 2002: 198). As demonstrated above, studies of beads in Southeast Asia have contributed to understandings of mortuary ritual, status, exchange, craft production, and emerging complexity. The continuation and growth of bead studies in Southeast Asia can serve as a model to archaeologists in other regions.

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Appendix 1. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ara.2016.02.004.

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