REPORT ON THE STONE BEADS, DEBITAGE AND RAW MATERIALS FROM THE 2007 AND 2008 EXCAVATION SEASONS AT PATTANAM, KERALA

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This article examines stone beads and production debris from the 2007-2008 excavations at the site of Pattanam in South India. An analysis of finished beads and debitage indicates that the bead assemblage at Pattanam is distinct from other bead production sites in southern India, namely Arikamedu and Kodumanal. Bead producers at Pattanam focused largely on agate, carnelian, and chalcedony materials, with beads having been manufactured using the "pecking" method. Scholar Peter Francis, Jr., had previously argued that there were two technological traditions of stone bead production in South India, which were associated with two different cultural/ethnic groups. Evidence from Pattanam challenges this assertion, arguing that different ethnic groups did not exclusively work with particular raw materials or manufacturing methods.

INTRODUCTION

Stone ornament production and trade were important aspects of economic life during the Early Historic period in South India (300 BCE – 400 CE). Stone beads and many other varieties of ornaments were important as expressions of social status and cultural identity during this period (e.g., Selvakumar 2021). Pattanam, identified with the literary and historical site of Muziris, was one of the most important port sites of the Indian Ocean trade, and as such, it most likely played a role both in bringing together various products from South India for trade and export, as well as in importing goods from around the Indian Ocean (Cherian et al. 2009a; Cherian et al. 2007, 2009b; Cherian et al. 2010, 2011; Shajan et al. 2005) (Figure 1).

Pattanam was not only a center for trade, but also for production of stone beads and other ornaments (Abraham 2021; Cherian and Menon 2014). Analysis of the stone beads, bead roughouts and blanks, as well as some of the stone raw material and debitage that was recovered during the 2007 and 2008 excavation seasons at Pattanam, indicates bead production at this site was distinct from that found elsewhere in South Asia. In contrast to workshops at Arikamedu and Kodumanal, the craftspeople of Pattanam primarily focused on the production of carnelian and agate beads as opposed to locally available semi-precious stones such as quartz, citrine, and garnet, which were found in lesser quantities.

The bead scholar Peter Francis, Jr., had previously argued that South Indian bead production was divided into two different bead-making communities that used different technological traditions: the pecking, polishing, drilling school associated with the local "Pandukal" people who worked local materials, and the grinding, drilling, polishing technique linked to migrants from Gujarat who used non-local carnelian and agate (Francis 2004: 490-1).

I argue that evidence from Pattanam, as well as Kodumanal and Arikamedu does not support Francis' hypothesis. Different bead manufacturing techniques were not exclusive to specific raw material types nor different cultural traditions or ethnic groups. In this article, I first present a background on this topic and discuss the importance of the gem trade at Pattanam based on literary sources. I then examine previous work by Peter Francis, Jr., on bead production in South India at the site of Arikamedu and my own work at the site of Kodumanal. Following this, I present my analysis of the *chaîne opératoire*, or operational sequence, of bead production at Pattanam.

Non-local influence at Pattanam

The connection between Rome and ancient India has been of longstanding interest to both archaeologists and historians (c.f. Aiyappan 1941; Begley 1983; Begley and DePuma 1991; Begley et al. 1996, Begley et al. 2004; Casson 1989; Ray 1986, 1987, 1989, 1994, 1996a, 1996b; Wheeler 1948, 1951, 1954; Wheeler et al. 1946). The debate has mainly centered on the question of exactly how much

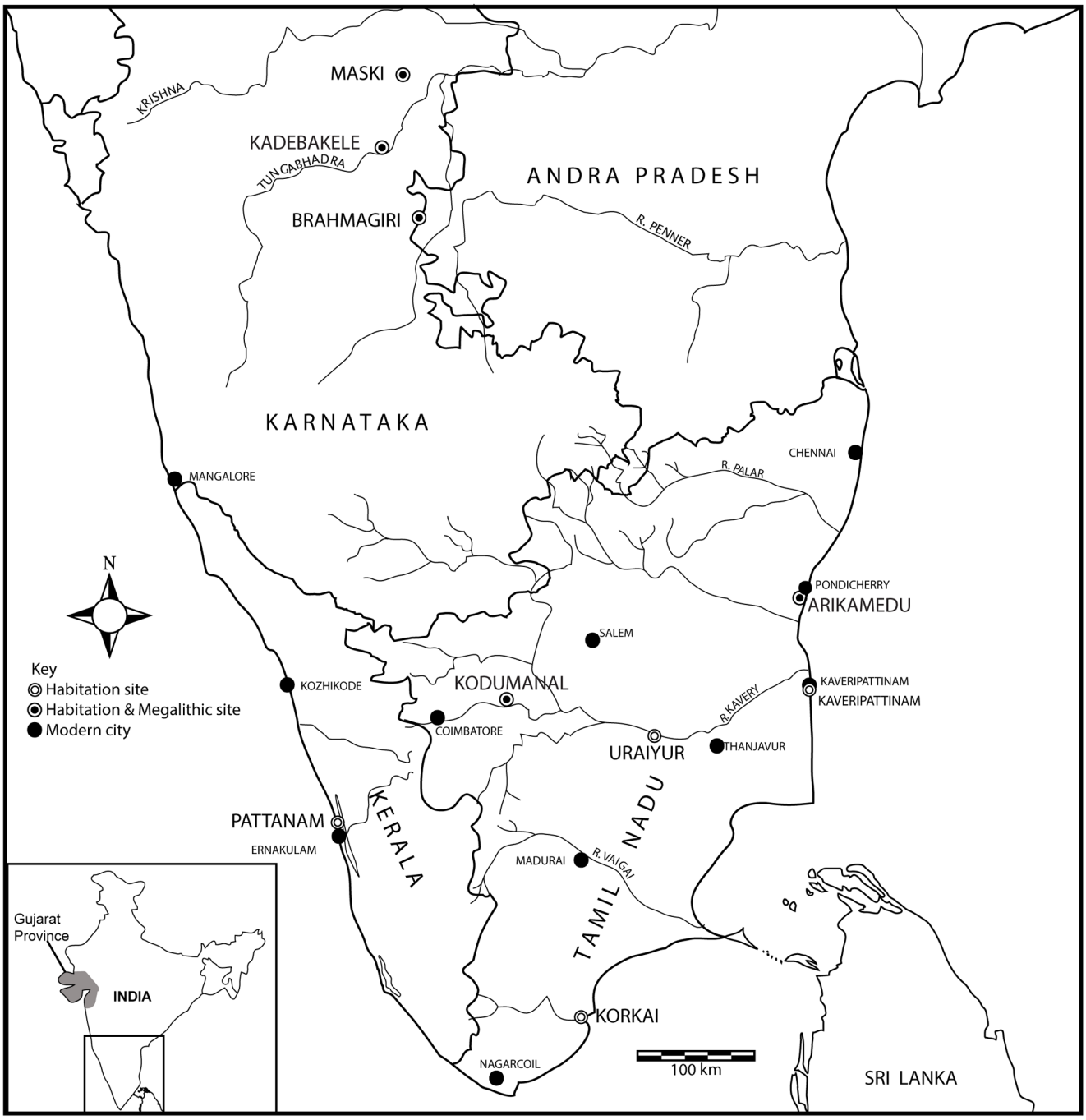

Figure 1. Map of Key Early Historic Sites in South India. Inset map shows location of Gujarat Province.

Roman or foreign presence and influence there was in South India during this period. Beyond the question of presence is the complex question of the impacts of such a presence and influence on the economy, trade, and political developments in South India during this period. Early scholars such as Wheeler argued, for instance, that Arikamedu was a Roman settlement in India (Wheeler 1948, 1951, 1954).

Recently the pendulum has swung significantly in the other direction, with scholars arguing that there was likely very little settlement or long-term presence of foreigners, but rather emphasizing the importance of Indian traders and ships, and the movement of Roman and Mediterranean goods through numerous hands, to finally reach South Indian ports (Ray 1986, 1994).

Exactly how many "Romans" ever set foot on the shores at Muziris or Arikamedu is impossible to know, but it is clear that Mediterranean goods were consumed there, and that Indian goods were consumed in the Roman world. In terms of actual connections of trade, chemical analysis of beads, cameos and other ornaments from Pattanam and sites in the Roman world could help to demonstrate actual connections between specific sites in both regions.

There are also questions of trade, social connections and potential migrations within South Asia. South Asia was clearly connected; there are no major geographic boundaries, and cultural areas, to the extent to which such areas are defined, blend into one another. As coastal ports of trade, Arikamedu and Pattanam likely received finished goods and raw materials via overland and sea routes (see Abraham 2002; Verma 2022).

Scholars have wondered whether all the carnelian in India came from the region of Gujarat (there are no known sources of carnelian or agate in South India) (Figure 1), and if stone bead makers from Gujarat may have migrated south and settled at sites like Arikamedu (Francis 1991, 2004). Francis argued that the *chaînes opératoires* of bead production evident at Arikamedu supported his migration hypothesis, while craftspeople also maintained trade contacts with Gujarat for agate and carnelian raw materials (Francis 1991, 2004).

Notably, the patterns Francis found at Arikamedu are not borne out by the material at Pattanam. There are several possible conclusions that may be drawn from this. First, it is possible that Francis was correct that beadmakers from Gujarat settled at Arikamedu, but that the same was not true at Pattanam. Second, it's possible that the different techniques and *chaînes opératoires* of bead production belonged to different technological traditions, perhaps originally of different regional affiliation, but which came to be shared and transmitted by other means (such as imitation and/or apprenticeship and training) across these geographic and cultural boundaries. Thirdly, it is possible that the material found at Pattanam derives from multiple sources. Being an active port of trade, it is possible that some of both the finished and partially worked bead roughouts and blanks could have arrived at the site in the state in which they were found, having been made or partially worked elsewhere. This article examines some of the questions related to the techniques of production. Further research will be necessary to clarify the picture with regards to the nature and impact of long-distance trade connections around the Indian Ocean and Mediterranean worlds.

Literary References to Muziris and Trade in Semi-Precious Stones

The ancient port of Muziris, with which Pattanam is identified, has been mentioned numerous times in both ancient Tamil Sangam literature and foreign sources such as the *Periplus Maris Erythræi*[1] and Ptolemy's *Geography*. The *Periplus Maris Erythræi* mentions the export of numerous varieties of semi- precious stones from India in general and Tamilakam[2] or the Tamil region, although only the stones and other materials are listed, not their forms. From Muziris in particular, the *Periplus* mentions *lithia diaphanes*, meaning diaphanous or translucent stones, which may include a wide variety of colors and gems. Diamonds, (*adamas*) are listed separately from other translucent stones. Other varieties of stone of dubious identification are also mentioned, such as *yakinthos* meaning perhaps either ruby or amethyst, according to McCrindle (1879:33-37), or possibly sapphire or lapis, since the color it refers to is interpreted as blue in most translations. Pliny, in his 'Natural History', mentioned a large variety of stones, including beryl, rock crystal, amethyst, garnets, prase, onyx and sardonyx. But only in the case of beryl, does he describe the forms in which it was worn, used and presumably traded:

> The people of India are marvelously fond of beryls of an elongated form, and say that these are the only precious stones they prefer wearing without the addition of gold: hence it is that, after piercing them, they string them upon the bristles of the elephant. It is generally agreed, however, that those stones should not be perforated which are of the finest quality; and in this case they only enclose the extremities of them in studs of gold. They prefer, too, cutting the beryls in a cylindrical form, instead of setting them as precious stones; an elongated shape being the one that is most highly esteemed. Some are of opinion that beryls are naturally angular, and that when pierced they become improved in colour; the white substance being thus removed that lies within, and their brilliancy heightened by the reflection of the gold in which they are set; or, at all events, their transparency being increased by this diminution in their thickness. … In our own part of the world it is thought that they are sometimes found in the vicinity of Pontus. The people of India, by coulouring crystal, have found a method of imitating various precious stones, beryls in particular (Pliny translated by Bostock and Riley 1857:415).

Excepting the above description, the fact that most such stones seem to primarily have been categorized by the authors as "semi-precious stones" without further

enumeration of their forms (such as beads, ornaments, cut gems, etc.) can be taken to mean several things. First, it could be that the forms these items took, whether raw materials or finished beads and ornaments, were irrelevant to the traders and others reading such documents. It could also mean that the category included multiple forms of finished and unfinished beads and ornaments as well as raw materials. Such vagueness in the literature suggests that trade may not have taken place only in finished products, but also in items and materials at various stages in their processing and manufacture.

The Sangam literature also refers to Muziris (as Muciṟi), and it is similarly described as an important port of trade. According to these sources, the most important items of export were paddy (rice), pepper, and fish. The passage below is likely representative of the kinds of items that were traded in the largest volumes and presents a vibrant and evocative picture of this port site:

> In Muciṟi with its drums, where the ocean roars, where the paddy traded for fish and stacked high on the boats makes the boats and houses look the same and the sacks of pepper raised up beside them make the houses look the same as the tumultuous shore and the golden wares brought by the ships are carried to land in the servicing boats,
>
> Kuṭṭuvaṉ its king to whom toddy [a type of fermented palm sap or palm wine] is no more valuable than water, who wears a shining garland, gives out gifts of goods from the mountains along with goods from the sea to those who have come to him. (from *Puranāṉūṟū* 343 Translated by Hart and Heifetz 1999:195-6).

This account of the loading and unloading of ships using smaller boats accords well with that of Pliny, who also mentions that the ships were moored out from the coastline:

> For from thence, and with the West Wind called Hypalus, they have a passage of forty Days' Sailing to the first Town of Merchandise in India, called Muziris. However, this port is not to be ventured in, because of the neighboring pirates, which keep ordinarily about a place called Hydrae; and it is not richly stored with Merchandise. And moreover, the Station of the Ships is far from the Land, so that they must convey their Wares in little boats which they use for the purpose. At the time in which this Account was written, the King that reigned there was named Celebothras [Keralaputras](Pliny the elder, translated by Holland 1849: 135).

Stone beads were not mentioned with regard to Muziris, or, in fact, any other place in the Sangam literary corpus. The lack of mention of beads and semi-precious stones in these sources suggests that the trade or production of beads and semi-precious stone ornaments was not considered particularly noteworthy, or perhaps not sufficiently poetic to Sangam authors. Considering their repeated mention in foreign sources, we might infer that such products had more significance to the foreigners importing them than the Indians who produced and exported them. Though "diaphanous stones" may not have been the prime economic force driving trade, it is certainly likely that the growing trade in grain, pepper, spices and textiles created economic opportunities for bead and ornament production.

PREVIOUS RESEARCH ON STONE BEADS, TECHNIQUES, AND TECHNOLOGIES IN SOUTH INDIA

Stone beads were produced at many sites in South India during the late Iron Age and Early Historic periods. Arikamedu and Kodumanal have been studied in the greatest detail, while excavation reports from other sites note the presence of stone beads and bead production without detailed information (Francis 1991, 2002a, 2002b, 2004; Kelly 2009; Rajan 1998). The beads and production debris from the site of Arikamedu (identified with the emporia of Podukê mentioned in the *Periplus Maris Erythræi*), were studied in detail by Peter Francis, Jr., (1991, 2002a, 2002b, 2004). Gwinett and Gorelick (1986, 1987, 1988) examined the drilling technology of stone beads in India and Sri Lanka. Additionally, I have examined the stone beads and manufacturing techniques of bead production from Kodumanal, Erode district, Tamil Nadu (Kelly 2009, 2016).

Bead production at Arikamedu

Francis' (1991, 2002a, 2002b, 2004) investigations of the Arikamedu collection produced several important conclusions about the techniques of lapidary production. There was a roughly 2:1 proportion of quartz and macrocrystalline materials to agate and carnelian and other microcrystalline varieties of bead blanks and unfinished beads in various stages of the production process. From the beads he examined, which had been excavated at different times by different excavators, he found that there were two predominant and distinctive *chaînes opératoires* of bead manufacture. One sequence of steps is:

0) procurement of raw materials;
1) chipping the stone to produce a roughout of the bead shape and removing cortex;

2) heating to intensify color and facilitate further chipping;
3) chipping to rough out a shape;
4) grinding the roughout into a bead blank;
5) drilling of the perforation; and
6) polishing the surface.

This sequence or *chaîne opératoire* is associated more strongly with agate and carnelian bead manufacture at Arikamedu (Francis 2004:479-491) and at Khambhat in Gujarat (Kenoyer, Vidale and Bhan 1991). The alternative *chaîne opératoire* was associated with quartz and other macrocrystalline materials at Arikamedu and involved:

0) procurement of raw materials;
1) chipping the stone into a roughout of the bead shape;
2) pecking the roughout into a bead blank;
3) polishing the surface; and
4) drilling of the perforation.

Francis argued that these two different *chaînes opératoires* were strongly associated with two different categories of raw material at Arikamedu. The grinding technique and associated sequence of drilling before polishing is mostly found with the agate, carnelian and chalcedony materials that were not locally available, and thus with non-local or migrant bead makers. In contrast, he argues that the pecking technique and alternative sequence of polishing, then drilling, was associated with the macrocrystalline stones such as quartz, and thus associated with the "Pandukal people," a "people" or culture identified with the construction of megalithic burials in South India (Francis 2004:490-491; Leshnik 1974). Francis also mentions that this pecking technique is known from Kodumanal in Tamil Nadu (citing Rajan 1990), and Mahurjhari in Maharashtra, (citing Deo 1973, and Mohanty 1999).

Though Francis argues that these two *chaînes opératoires* are associated with two different categories of material and therefore two different groups of producers, there is not an exact correlation between material and technique of manufacture. His own data from Arikamedu, (including both the Pondicherry Museum collections and materials excavated in the 1989-1992 excavations) show that both techniques were used for both categories of raw material – what he calls "crystalline", (meaning macrocrystalline varieties such as quartz, amethyst, citrine, etc.) and what he calls "chalcedonic" (meaning microcrystalline varieties of agate, carnelian, chalcedony, jasper, etc.). (Table 1). One might say that the correlation is strongest for the microcrystalline varieties, shown in both the Pondicherry Museum collections and excavated materials. The association for the local, and more readily available macrocrystalline stone varieties is weaker in both assemblages. Using a chi-square test, we can see that the proportions of pecked versus ground blanks in the Arikamedu sample are not random ($x2 = 60.758$, $p < .01$).

Though we can say with statistical certainty that the proportions of pecked and ground bead blanks are the result of patterned human action, we must still explain why it is that the assemblage of local macrocrystalline materials is split roughly in half, while a much larger proportion of microcrystalline agate, carnelian, jasper, etc., was predominantly made by the "grinding" method.

Francis examined three possible hypotheses to explain the differential use of "pecking" with crystalline raw materials (quartz, amethyst, etc.), and grinding with microcrystalline raw materials (agate, carnelian, chalcedony, etc.). He considered whether the techniques were related to the materials, that is whether pecking might be easier with crystalline materials and grinding with microcrystalline materials. He rejected this hypothesis on the basis that it does not explain why these techniques also reverse the steps of drilling and polishing. He then examined whether there was any chronological trend to the use of these different techniques and *chaînes opératoires*, and found none, at least within the Arikamedu data set.

Table 1: Pecked Versus Ground Bead Making Techniques at Arikamedu (Francis 2004:488).

Material Type	Pondicherry Museum Pecked v. Ground		Total from Pondicherry Museum	1989-1992 Excavations Pecked v. Ground		Total from 1989-1992 Excavations
Macrocrystalline varieties	172 (50.4%)	169 (49.6%)	341 (100%)	21 (65.5%)	11 (34.4%)	32 (100%)
Microcrystalline varieties	61 (20.2%)	241 (79.8%)	302 (100%)	13 (81.2%)	3 (18.8%)	16 (100%)
Total	233 (36%)	410 (64%)	643 (100%)	34 (71%)	14 (29%)	48 (100%)

He concluded that two different schools or traditions of technology were practiced by two different bead making communities: the pecking, polishing, drilling school associated with the local "Pandukal" people, and the grinding, drilling, polishing technique linked to migrants from Gujarat (Francis 2004: 490-1).

Bead Production at Kodumanal

My analysis of bead production at Kodumanal shows that both pecking and grinding were techniques used, though in both cases the order of the *chaîne opératoire* appears to have been the same as that which Francis associates with the 'pecking' complex (either pecked or ground, and then polished, prior to drilling). There is only one example of a bead that was pecked and then drilled before polishing. This assemblage is also almost entirely made up of clear, colorless crystalline quartz, with a ratio of approximately 2000:1 (including debitage), for quartz and macrocrystalline raw materials versus agate and other microcrystalline stones. The proportion of pecked and ground materials at Kodumanal is also about 1:1 (28 pecked: 29 ground), a ratio similar to that at Arikamedu for quartz and related materials (Kelly 2009, 2016.).

Gwinnett and Gorelick (1986, 1987, 1988) have examined the impressions of drill holes from Arikamedu and sites in Sri Lanka, demonstrating the predominance of double-diamond drill bits at these sites. Francis (2004:482) notes that all the beads he examined appeared to have been drilled by the double-diamond drill bit. However, analysis of the material from Kodumanal suggests that there were a wider variety of drill types in use at the time, or the continuing circulation and trade of beads that had been drilled with a wide variety of drill types (Kelly 2009, 2016.). These drill types include stone drills (possible materials include chert, jasper or ernestite c.f., Kenoyer 2005), single-diamond tipped, double-diamond tipped, copper/bronze rod with abrasive, and copper tube with abrasive. At Kodumanal the methods of drilling seem to have predominantly been both double-diamond drills, and copper/bronze rod with abrasive for beads, and copper tube drills with abrasive for rings (Kelly 2009). Considering the myriad ways in which the Pattanam stone bead material defies expectations, a study of the drilling techniques would be a useful and productive line of inquiry for future research.

PATTANAM LAPIDARY PRODUCTION

Pattanam bead making techniques appear to be exceptional, especially when compared with Arikamedu and Kodumanal. First, it is significant that Pattanam lapidary workers seem to have focused primarily on agate, carnelian, and chalcedony materials, producing beads, and cameos (or perhaps more likely, cameo blanks), inlays and pendants. Further, at Pattanam, and in contrast to Francis' conclusions from Arikamedu, it appears that the carnelian and agate beads were primarily being manufactured using the 'pecking' method.

The sample from these two seasons is small compared with Kodumanal and Arikamedu, and therefore some of the differences between these assemblages may result from the effect of sampling. Even so, the Pattanam assemblage is composed of different proportions of both stone raw materials and production techniques. In terms of production, microcrystalline materials (agate, carnelian and onyx) were the most common (n=50, 71%), with a ratio of 6:1 carnelian/microcrystalline materials to quartz/macrocrystalline materials. The macrocrystalline materials (quartz and citrine) made up only 23% of the assemblage (n=16, 23%), and garnet only 6% of the assemblage (n=4) (Figure 2 and 3 and Tables 2 and 3).

Figure 2. Agate and carnelian roughouts and pecked bead blank (lower left) from the 2007-'08 excavations at Pattanam.

Figure 3. Agate and carnelian beads from the 2007-'08 excavations at Pattanam.

With regard to the question of pecking versus grinding, there is only one roughout in this assemblage, and it is pecked (Table 4). The rest of the unfinished and waste material comes from stages prior to either the pecking or grinding stage. Of the finished beads I examined, a large proportion (74%) still show the marks of their methods of manufacture, despite polishing. The remainder (26%) is so highly polished as to have obliterated any marks of pecking or grinding.

The assemblage at Pattanam seems therefore to be the opposite of that from Arikamedu in that it contains predominantly microcrystalline material (agates of various colors including carnelian) and it is also largely pecked, rather than ground: 79% of the microcrystalline beads are pecked and 14% ground; the remaining 7% were indeterminate. In contrast, at Arikamedu 80% of the microcrystalline material was made by grinding (Francis 2002).

The Pattanam material is also noteworthy regarding the order of the stages in production. According to Francis (2002:479-491), beads made by grinding would be drilled before polishing, and beads made by pecking would be drilled after polishing. To determine the order of drilling and polishing, I examined the drill holes from the finished Pattanam beads to note whether the area around the perforation was polished or not. From this analysis, I determined that 67% of the finished beads were drilled before polishing, and 25% were

Table 2: Proportion of Finished and Unfinished Beads and Worked Material by Material, from Pattanam 2007-08 Excavations.

Pattanam 2007-'08 Excavations			
Material Type (% of Assemblage)	**Finished Bead (Row%)**	**Total Unfinished/Worked (Row%)**	**Total**
Garnet	2	**4**	6
(6%)	(33%)	(67%)	(100%)
Macrocrystalline	7	16	23
(21%)	(30%)	(70%)	(100%)
Microcrystalline	13	50	63
(58%)	(21%)	(79%)	(100%)
Serpentine	9	0	9
(8%)	(100%)		(100%)
Steatite	3	0	3
(3%)	(100%)		(100%)
Other/Unknown	3	1	4
(4%)	(75%)	(25%)	(100%)
Total (100%)	37 (34%)	71 (66%)	108 (100%)

Table 3: Sample of Stone Beads and Production Materials from Pattanam 2007-'08 Excavations.

Pattanam 2007-'08 Excavations						
Material Type	**Bead (Row%)**	**Blade (Row%)**	**Flake (Row%)**	**Raw material (Row%)**	**Roughout (Row%)**	**Bead blank (Row%)**
Garnet	2			4		
	(33%)			(66%)		
Macrocrystalline	7		2	13	1	
	(30%)		(9%)	(57%)	(4%)	
Microcrystalline	13	1	18	12	18	1
	(21%)	(2%)	(29%)	(19%)	(29%)	(2%)
Serpentine	9					
	(100%)					
Steatite	3					
	(100%)					
Other/Unknown	3			1		
	(75%)			(25%)		
Total	37	1	20	30	19	1
	(34%)	(1%)	(19%)	(28%)	(18%)	(1%)

drilled after (Table 5). All eight of the microcrystalline beads that were drilled before polishing, were also pecked. This contradicts not only the idea that pecking should be associated with macrocrystalline materials, but also that pecked materials should be drilled after polishing.

In addition, the range of colors in the microcrystalline materials suggest that heat treating of raw material was a possible, but not necessary, step in the *chaîne opératoire* for these materials as Francis suggested. Microcrystalline materials naturally vary quite significantly in their color from white, tan, brown, gray, light orange to dark orange, to dark red-orange, where heating or heat-treating the stone tends to darken and intensify the color. It would appear from the blanks and roughouts that only a small fraction (approximately 25%) of the microcrystalline materials were likely to have been heated. It is much more difficult to say with any certainty whether the orange, perhaps best described as "Fanta orange," was heated or not. The evidence here is not conclusive, but it does suggest that heating was perhaps an optional step in production when using microcrystalline materials.

Table 4: Proportion of Pecked Versus Ground Materials from Pattanam 2007-'08 Excavations.

Pattanam 2007-'08 Excavations			
Material Type	**Pecked (Row%)**	**Ground (Row%)**	**Finished (Indeterminate) (Row%)**
Garnet	1	0	1
	(50%)		(50%)
Macrocrystalline	3	0	4
	(43%)		(57%)
Microcrystalline	11*	2	1
	(79%)	(14%)	(7%)
Total	15	2	6
	(65%)	(9%)	(26%)
*Includes one unfinished pecked blank, the rest are finished.			

Table 5: Beads Drilled Before and After Polishing from the 2007-'08 Excavations at Pattanam.

Pattanam 2007-'08 Excavations			
Material	**Drilled After**	**Drilled Before**	**Indeterminate**
Macrocrystalline	2	1	4
	(29%)	(14%)	(57%)
Microcrystalline	3	8	1
	(25%)	(67%)	(8%)
Total	5	9	5
	(26%)	(47%)	(26%)

The *chaînes opératoires* for both micro- and macrocrystalline materials at this point are difficult to untangle, but can be summed up as:

0) procurement of raw materials;
1) chipping/flaking the stone to remove cortex and produce a rudimentary roughout;
2) —> OPTIONAL for microcrystalline materials—> heating to intensify color;
3) chipping to rough out a shape nearer the dimensions of the finished object;
4) shaping from roughout to blank, either by
    a) pecking to shape a "blank,"
    OR
    b) grinding to shape a "blank,"
    OR
    c) pecking then grinding to shape a blank; and
5) finishing by
    a) drilling the perforation THEN polishing the surface,
    OR
    b) polishing the surface and THEN drilling the performation.

Such variation in both the techniques of manufacture and in the order of steps in the *chaînes opératoires* suggests that the picture of distinct techniques and cultural traditions is far more complicated than Francis supposed.

Based on depths and stratigraphic associations, most of this material may belong to the latter part of the Early Historic or Early Medieval period, approximately from 2nd century CE to the 5th century CE or later (Table 6). Of the sample I have examined here, four finished beads and six roughouts can be dated with some confidence to the Early Historic (approximately 2nd century BCE – 2nd century CE). However, this dating is tentative, and a larger sample would be needed to establish any significant chronological trends. Instead, this assemblage can be treated as a palimpsest of the occupation at Pattanam and can be assumed to represent the composite of its history of bead production. Considering the overall consistency in the techniques of manufacture in the sample examined here, the technological traditions remained more or less constant over the course of the occupation. A more complete analysis would be necessary to look at the variation between different areas of the site, and over time.

There is little evidence for bead production from macrocrystalline material (quartz), which is in evidence in finished beads (shown in Figure 4). There are a total of 16 pieces of a worked macrocrystalline yellow-tinged stone that appears to be citrine (14.8% of the total sample) from the two seasons of excavation. None of these pieces are roughouts or bead blanks, and instead appear likely to have been waste material, though they are mostly pieces of shatter, rather than flakes. This contrasts with the debitage of microcrystalline production, which is a mixture of roughouts, cortex removal and core-reduction flakes. Likely these finished quartz beads were not made at Pattanam. However, the semi-opaque material does not match that of Kodumanal either. Only the smaller clear and colorless faceted crystal beads match the kinds of beads produced at Kodumanal (Kelly 2009, 2016.).

There appear to be two distinct categories of quartz beads. The beads in the top row of Figure 4 are made from a pure and transparent colorless quartz, similar to the quality and material found and produced at Kodumanal. Those in the second row are made of milky quartz, significantly less translucent, and almost white rather than clear. This quartz occurs under somewhat different geological conditions, resulting from the occurrence of gas bubbles that are trapped during the formation of the crystal, which increase the opacity of the stone. These bead forms (Figure 5), and perhaps also the material, are like those found at other coastal sites, such as Arikamedu, and Tissamaharama in Sri Lanka (Hannibal-Deriyanagala 2001:220)

In addition to the macrocrystalline and microcrystalline beads and debitage, there was a distinctive set of several

Table 6: Finished and Unfinished Beads and Production Evidence from 2007-'08 Excavations at Pattanam.

Pattanam 2007-'08 Excavations									
Excavation Unit	**Finished**			**Unfinished & Production Evidence**			**Grand Total**		
	Col%		**Row%**	**Col%**		**Row%**	**Col%**		**Row%**
Near Trial Trench 1	3%	1	100%	0%	0	0%	1%	1	100%
PT07-I	22%	8	73%	4%	3	27%	10%	11	100%
PT07-II	43%	16	89%	3%	2	11%	17%	18	100%
PT07-III	14%	5	20%	28%	20	80%	23%	25	100%
PT07-IV	3%	1	50%	1%	1	50%	2%	2	100%
PT08-IV	5%	2	25%	8%	6	75%	7%	8	100%
PT08-VII	5%	2	15%	15%	11	85%	12%	13	100%
PT08-VIII	0%	0	0%	17%	12	100%	11%	12	100%
PT08-IX	0%	0	0%	1%	1	100%	1%	1	100%
PT08-X	5%	2	20%	11%	8	80%	9%	10	100%
PT08-XI	0%	0	0%	10%	7	100%	6%	7	100%
Total	100%	37	34%	100%	71	66%	100%	108	100%

Figure 4. Quartz beads from 2007-'08 excavations at Pattanam.

varieties of green stone (Figure 6). The beads in the bottom row are all made of serpentine, a relatively soft stone. The four on the bottom right are all decorated with sawn incised marks around the surface. Of these, the three on the right are scored in a rough, spiraling pattern around the circumference of the beads. The fourth from the right is decorated with sawn collar marks and the middle is decorated by a cross-hatching pattern. These lines might have been filled with a paste or other colorant, without which the lines are not particularly visible. Though the serpentine beads on the bottom row are all relatively rough in shape, they can generally be identified

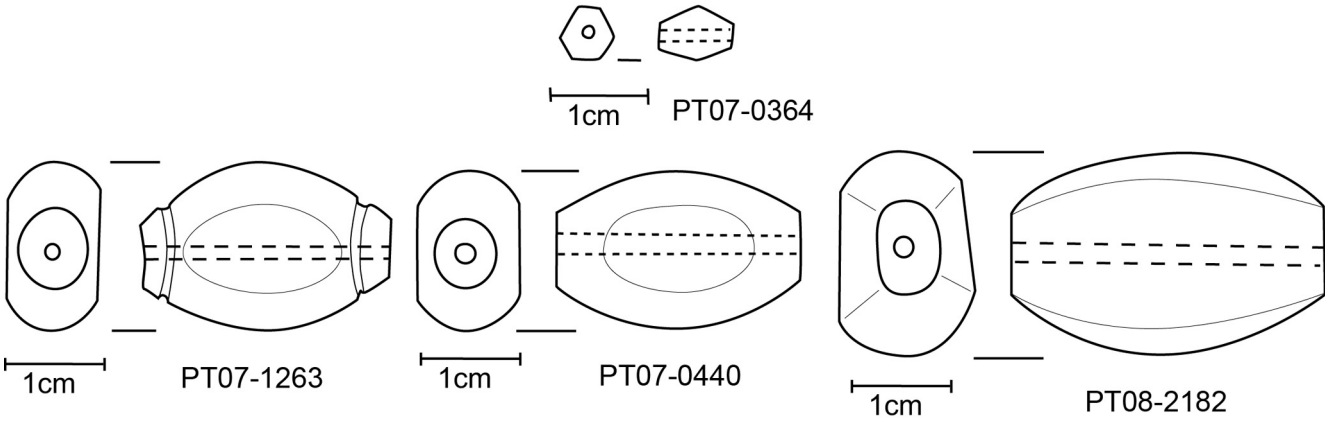

Figure 5. Quartz beads showing transverse section from 2007-'08 excavations at Pattanam.

Figure 6. Serpentine and other green stone beads from 2007-'08 excavations at Pattanam.

as having a barrel shape longitudinally and being roughly triangular in transverse section. This type of bead appears similar to those reported by Francis at Arikamedu, which he identified as a type of steatite. According to Francis, beads of this type, which he also describes as triangular in section and decorated with incisions over the surface, have been found at Kaveripattinam and Kodumanal in Tamil Nadu, Óc Eo in Vietnam, and Khlong Thom, Thailand (Francis 2004:506).

CONCLUSIONS

Francis argued that there were two technological traditions of stone bead production in South India that were associated with two different cultural/ethnic groups. However, I argue that the overlap of pecking and grinding, the variability in the *chaîne opératoire*, and the distribution of these techniques within areas of Kodumanal, Arikamedu and Pattanam suggests that pecking and grinding were not exclusively associated with particular raw materials, and were not the intellectual property, or exclusive cultural practices of different ethnic groups. As Francis argued, some bead makers may have migrated from other regions of India to take advantage of economic opportunities within these southern ports. However, there is currently not sufficient evidence in the bead making techniques, or the presence of ceramics or other material culture from Gujarat or other regions outside South India, to suggest a large-scale migration.

Although the absence of evidence should not always be taken as evidence of absence, it seems most likely that bead makers, regardless of regional affiliations, were using both pecking and grinding techniques. I do, however, agree with Francis' claim that the difference between pecking and grinding cannot simply be explained by function or application, such as the difference between rounded bead forms and faceted ones. Pecked faceted forms have been found, as well as rounded forms that have been ground. Without going back to re-analyze all the Arikamedu material first-hand, I cannot evaluate Francis' claims about the differential ordering or sequence of the *chaînes opératoires*. However, if his observations were true at Arikamedu, that may be an exception, as the same pattern does not hold at either Kodumanal or Pattanam.

Some material and ornament types are lacking from these two excavation seasons. There is neither lapis nor steatite stone beads and apparently no shell or glass, rings, or ear-spool ornaments. Small numbers of glass bangles and ornaments made from gold and terracotta have been identified (Cherian et al. 2016). Some of these idiosyncrasies may be the result of a small sample size. On the other hand, another explanation may lie in the chronology of the site, and the particular trenches and layers excavated in the 2007-'08 season.

As an important port of trade, it is difficult to establish whether the finished and unfinished products were loaded onto the boats mentioned in Pliny's text and the Sangam poem (Puranāṉūṟū 343) for trade. Or they may have also been used and worn by the inhabitants of Muziris. Bangles and anklets are the ornaments mentioned most frequently in the Sangam corpus, and yet only 51 bangle fragments were identified in excavations from 2007-2015 (Cherian et al. 2016). Does this sample and assemblage therefore represent purely trading activities, and not the ornaments of daily wear? Further excavation and analysis of these materials will help answer these and other questions, about the production and trade of stone beads in South India.

Considering the question of migrants from Gujarat or other parts of India, there is currently a lack of evidence for other forms of material culture distinctive to those regions of India found at Pattanam. The more likely interpretation is that the two regionally affiliated technical traditions and *chaînes opératoires* ultimately came to be transmitted not through the migration of people, but through the transmission of knowledge and training in those techniques. Since both Arikamedu and Pattanam were important ports of trade, it is also possible that the materials, including both finished and unfinished products that may have originated elsewhere, and that partially finished beads and ornaments may have themselves been traded. This would result in a much more muddled view. According to Cherian et al. (2010, 2011), a local lapidary workshop has been discovered. Analysis of the remains to look for micro-debitage and reconstruct the reduction sequence from that area may help to clarify these issues.

Furthermore, analyses such as LA-ICP-MS (Laser Ablation-Inductively Coupled-Mass Spectrometry) or INAA (Instrumental Neutron Activation Analysis) of some of the finished and unfinished stone beads and materials from Pattanam would be extremely useful to compare to the increasingly large database of sources of carnelian and agate in Gujarat and elsewhere (e.g., Carter and Dussubieux 2016; Law et al. 2013; Theunissen et al. 2000). By examining the Pattanam material using these methods, we may find that the material can be positively identified with sources in Gujarat, but it is also possible that these beads and raw materials might match other sources in Iran and Southeast Asia, or perhaps even belong to an as yet undiscovered South Indian agate source. The combination of information about the geologic sources, the beads, and their techniques of manufacture may also contribute to our understanding of the regional association of different techniques, such as pecking and grinding, and the different *chaînes opératoires* and order of drilling and polishing. Much more research remains to be done to improve our understanding of the locations and organization of bead production, and the nature of the trade in raw materials, unfinished and finished beads in South India, and the wider Indian Ocean, and Mediterranean spheres.

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ENDNOTES

1. The *Periplus Maris Erythræi* is a navigational guide to the Indian Ocean, written in Greek, by an anonymous Roman-Egyptian, in approximately the 1st century CE (Casson 1984).

2. The terms in these documents are *damirike* and *limurike*. The term *damirike* appears to be the Greek rendering of *Tamilakam* (meaning Tamil country), and *limurike* the result of a transcription error in Greek where Δ (i.e. D/delta) seems to have been mis-transcribed as Λ (i.e. L/lambda) (Caldwell 1856[1875:14]). The "ri" probably results from a misinterpretation of the retroflex L of Tamil, heard by foreigners unused to the sound of retroflex consonants.

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