

The secret of Papanaidupet¹⁾

E. Marianne Stern

The Toledo Museum of Art, Toledo, OH (USA)

Nearly the entire population of the village of Papanaidupet is engaged in the production of glass beads. There is a strict division of labour between men and women. It is not known when bead-making in Papanaidupet began, let alone whether a tradition reaching back into Roman times can be proved. The beads are made from tubes that are not blown but drawn with the aid of a curious instrument called a *ladha*. This technique is of particular interest to archaeologists because telltale pieces of waste from archaeological excavations in Arikamedu betray the use of a *ladha* or *ladha*-like instrument two thousand years ago when Arikamedu was in close contact with the Roman world.

Das Geheimnis von Papanaidupet

Fast die gesamte Bevölkerung des Dorfes Papanaidupet ist in der Glasperlenproduktion beschäftigt. Es herrscht eine strenge Arbeitsteilung zwischen Männern und Frauen. Wann die Glasperlenherstellung in Papanaidupet begann, ist nicht bekannt, geschweige denn, daß man eine durchgehende Tradition seit der Antike nachweisen könnte. Die Perlen werden aus Rohren hergestellt, die nicht geblasen, sondern gezogen werden. Dies geschieht mit Hilfe eines eigentümlichen Instrumentes, das *Ladha* genannt wird. Für Archäologen ist diese Technik von besonderem Interesse, weil aussagekräftige Abfallstücke aus Ausgrabungen in Arikamedu darauf hinweisen, daß die *Ladha* oder ein *ladha*-ähnliches Instrument bereits vor 2000 Jahren benutzt wurde, als Arikamedu in engem Kontakt mit der römischen Welt stand.

1. Historical background

In spring 1986 the author had the opportunity to visit the village of Papanaidupet in the South Indian state of Andhra Pradesh (figure 1), where glass beads are made from tubes which are not blown, but drawn. How hollow tubes could have been made without the aid of a blowpipe is a question that has puzzled archaeologists for many years. Glass tubes have been discovered in archaeological contexts which date from long before the invention of the blowpipe. The earliest ones were found in Egypt, in a glass workshop belonging to the royal palace in Amarna, and can be dated to the 14th century B.C. Their discovery originally led to the assumption that the Egyptians must have been the inventors of the blowpipe. Although it is now generally agreed that the invention of glass blowing took place some time during the first century B.C., presumably somewhere along the Syro-Palestinian coast, no explanation has been offered for the early glass tubes. The technique used in Papanaidupet is particularly interesting because there is evidence that glass tubes were made in India by the same method two thousand years ago,

when extensive trade contacts existed between South India and the civilizations bordering the Mediterranean Sea.

One of the most intriguing discoveries of ancient glass tubes was made in Arikamedu, in the former French territory of Pondicherry (figure 1). Ancient Greek and Roman authors knew the site by the name

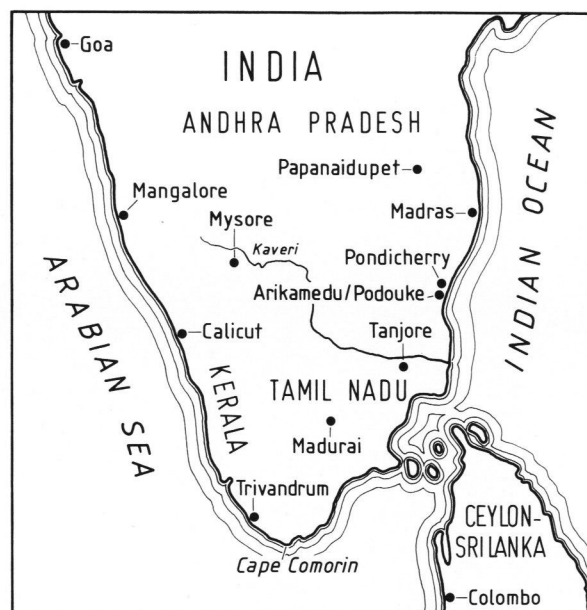


Figure 1. Map of India. Redrawn after E. M. Stern: *Indias Mozaiek*.

Received 7 November 1986, revised manuscript 26 May 1987. Eine deutsche Fassung dieser Arbeit liegt in der Bibliothek der Deutschen Glastechnischen Gesellschaft, Mendelssohnstraße 75-77, D-6000 Frankfurt 1, vor.

¹⁾ Presented in German on 17 October 1986 at the meeting of the Fachausschuß V of the German Society of Glass Technology (DGG) in Düsseldorf.

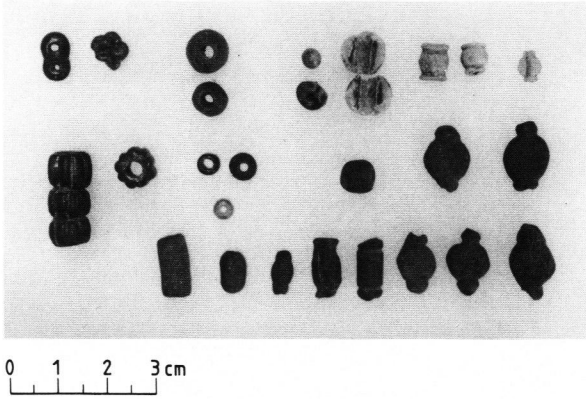


Figure 2. Coloured glass beads from old French excavations in Arikamedu. The Pondicherry Museum.

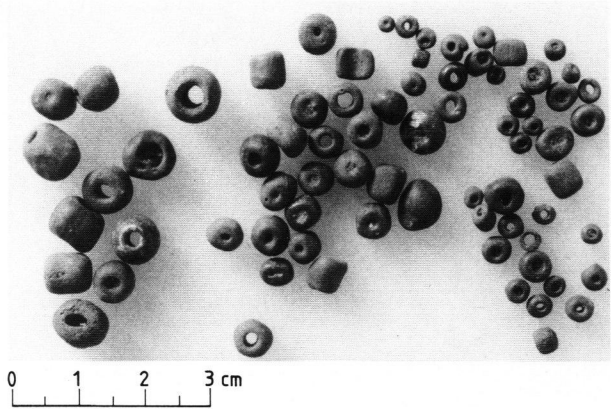


Figure 3. Opaque red glass beads from Arikamedu. The Pondicherry Museum.

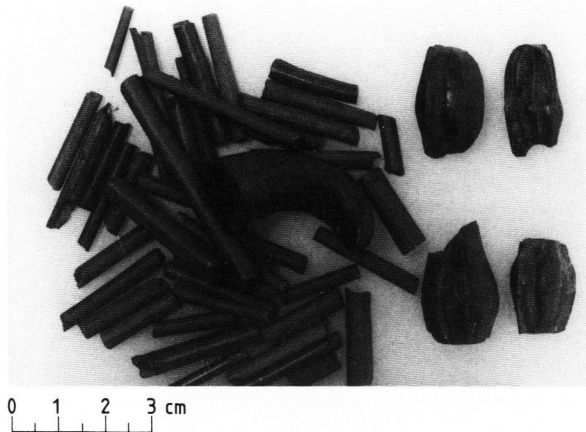


Figure 4. Broken tubes and "knots" of opaque red glass from Arikamedu. The Pondicherry Museum.

of Podouke; according to them, the city was one of the main trading partners of the Romans during the first century A.C. The discovery of imported wine amphoras, terra sigillata ceramics, and glass is evidence of the contacts between Podouke and the Mediterranean. The Pondicherry Museum has an enormous quantity of glass beads, chips of raw glass, and waste from bead-making from Arikamedu. The material comes from a stratum dated to the first century B.C. Since an anonymous Greek author wrote that raw, or unworked glass, *hyelos arge*, was an important export product in the early Roman India trade (*Periplus Maris Erythraei* Chs. 54.55.56), the author assumes that part, if not all, of the raw glass used in Arikamedu came from Egypt.

The beads show a large variety of types (figure 2), but most of them are simple, more or less spherical or cylindrical shapes (figure 3). There is evidence that, as in Papanaidupet, the glass tubes excavated in Arikamedu were used for the bead industry. Short pieces of tubes, cut to the size of a bead, are evidence of the cutting process, while clumps of beads melted together testify to the finishing of the beads by means

of fire-tumbling (figure 2, top left). The most interesting pieces, however, are fragments of glass tubes with swellings resembling a knot in a tree trunk (figure 4). The swellings are produced by bits of foreign material which block the interior of the tube so that it can not be made into a bead. It is these discarded glass knots that reveal that the ancient glassworkers of Arikamedu produced the tubes for their beads in a similar way as the modern glassworkers in Papanaidupet.

2. Bead manufacture in Papanaidupet

Papanaidupet (= Old Naidupet) is a small village about 140 km northwest of Madras, with about 5000 inhabitants who nearly all depend on the bead industry for their living; 1000 are actively engaged in the production of glass beads. The existence of the bead industry in Papanaidupet was recorded by D. Narayan Rao in his Reports to the Madras Government in 1929 (Preliminary Report of the Survey of Cottage Industries) but nobody knows how old it is. The work is traditionally done in the families; the women learned the craft from their mothers, the men from their fathers. According to Mr. Gaur of Moti & Co. which handles all aspects of the organization of the production and marketing, "the parents of their grandparents already made glass beads; they have done so for more than a century. His use of the term "more than a century" seems to imply "since anyone can remember" and may designate a considerably longer period of time than a hundred years.

In India, where modern technology has not yet taken over all aspects of production and labour is still incredibly cheap, Moti & Co. can compete on the economic/commercial market and make a profit in spite of the laborious techniques to be described below. Customers come to them from all over India and from foreign countries as well. Nevertheless, the company's dream is to buy modern machines that will enable them to make regularly shaped beads that are all the same size; in that way the bead makers of

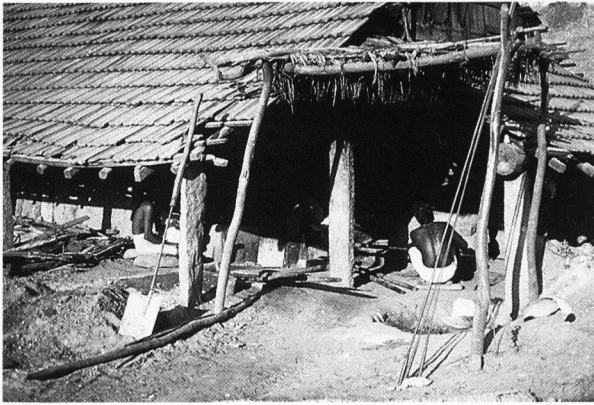


Figure 5. Furnace for drawing glass tubes: man feeding fire (on the left) and man working with the "ladha" (on the right), Papanaidupet.

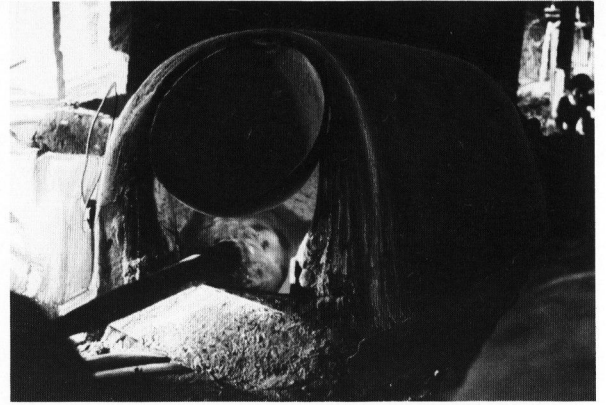


Figure 6. Mouth of the furnace for drawing glass tubes. The glass cone on the "ladha" can be seen below the potsherd, Papanaidupet.



Figure 7. "Ladha" in the foreground with pounding instruments in the background, Papanaidupet.

Papanaidupet might even be able to compete with Japan.

Until recently the glassworkers of Papanaidupet imported their raw glass from the glassworks in Firozabad in North India. In 1968 the government of Andhra Pradesh built a new factory on the outskirts of the village for the melting of glass. Glassmakers and chemicals are imported from Firozabad, the sand from nearby Gudur. The government glass factory produces only for the local bead industry; no bangles or other objects of glass are made in Papanaidupet. The overall production is about 30 to 32 t glass per month and includes all colours needed by the bead makers. Colourless (decoloured) glass is the cheapest and opaque white the most expensive.

Chemicals and sand are mixed dry and heated for 4 or 5 h before broken glass is added and the actual melting begins. This takes about 24 to 26 h in a furnace heated with coal to a temperature of 1440 °C. There are two furnaces: a larger one with four crucibles at a time and a smaller one with one crucible. The crucibles are made of clay, on the spot, from wooden moulds; their capacity is 450 kg (di-

schematic presentation:

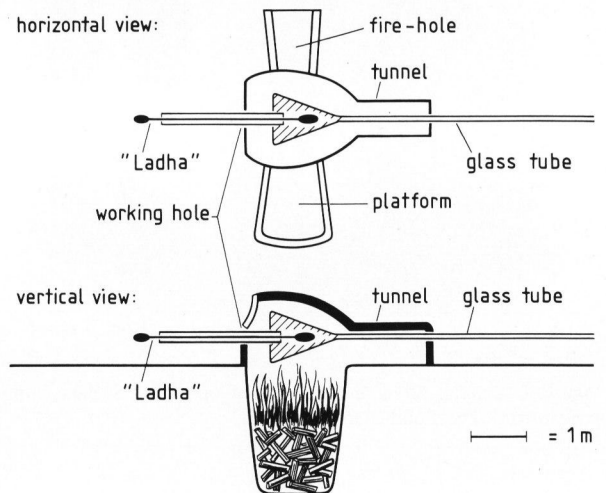


Figure 8. Plan of the furnace for drawing glass tubes; horizontal projection and longitudinal section, Papanaidupet.

ameter 91 cm, external height 71 cm, internal height 61 cm).

The furnaces for glassworking are at the other end of the village. There are two types of furnaces, one for the drawing of glass tubes, the other for tumbling the beads which will be described later.

The furnace for tube-drawing is protected from the sun by a shed of about 15 m length (figure 5). On the left sits a man who feeds the fire with wood, while the man on the right rotates a huge cone of glass in the furnace. A large potsherd hanging in front of the working hole prevents the heat from escaping (figure 6). Another man supports the glass cone with a flat shovel to keep it from sagging. The cone turns on a curious instrument, called a "ladha" (figure 7). The ladha consists of a thick metal pipe with a diameter of about 10 cm and a mobile inner rod; the wide end of the pipe is inserted into the glass cone. From time to time, the glassworker turning the ladha

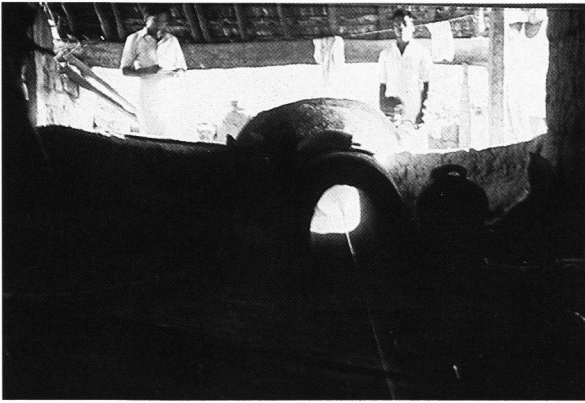


Figure 9. The back of the furnace for drawing glass tubes. The glass tube is drawn from the pointed end of the glass cone, Papanaidupet.



Figure 10. Drawing the glass tube. One man pulls continuously, while the other cuts off lengths of about 1.00 to 1.20 m, Papanaidupet.

pushes the inner rod forward in order to prevent the hollow space within the cone from collapsing. In this way, he pushes the pointed end of the glass cone open so that the thread drawn out of the glowing mass at the back of the furnace remains hollow.

The furnace is made of clay; it is an ingenious, tripartite construction combining oven, marver, and "annealing" tunnel in one (figure 8, above). The working hole is at the front, while the tunnel through which the glass tube is drawn is at the back. On either side are two short structures: a platform for heating and marvering the raw glass, and a fire-hole. Figure 8 (below) shows a longitudinal section of the furnace, from the working hole to the mouth of the tunnel, with the glass cone mounted on the ladha, and the hollow glass thread being drawn out of the end of the cone. The oven is about 1.80 m long, and the tunnel at the back 1.20 m. The fire-pit is about 2.10 m deep; the bottom with a diameter of 1.20 m is covered with wood ash. The distance between the working hole and the end of the shed at this side is nearly 3.00 m.

The preparation of the glass cone and mounting it on the ladha takes place at midnight when it is coolest outside. First a quantity of about 50 kg of raw glass is heated on the platform adjoining the furnace (figure 8, above). After about 3 h the glass is soft enough to force a rod with a diameter of about five times a "normal" punty into it and heat it in the furnace until it is hot enough to be marvered into a globular shape. Then one of the workers pulls the giant punty out of the glass and inserts the hollow pipe of the ladha in its stead. He pours a handful of crushed brick down the ladha and pushes the bits with the mobile inner rod through the glass until he has made a hole through its entire length. If the hole is not large enough, he has to repeat the procedure until he can finally go to the working hole and put the ladha with the hollowed glass in the furnace.

At the mouth of the tunnel, another glassworker enters a long metal rod with a round iron hook into

the tunnel and tries to catch the hot glass cone from the back where the hole has been made with the inner rod. Simultaneously the worker with the ladha pushes the rod forward through the pipe and the cone to keep the hole open. As soon as the man at the other end catches the glass with the hook, he starts to pull and the drawing of the tube begins. The entire mass of glass in the cone is drawn out in one continuous tube. During this process, which takes about 4 h, experienced workers are able to control the thickness of the tube.

The man who draws the tube sits about 5 m away from the mouth of the tunnel. Through the tunnel he can see the pointed end at the back of the hot cone (figure 9). While he pulls the tube hand over hand, a second man, to the left, cuts it at regular intervals into lengths of about 1 to 1.2 m and lays them on the ground behind him (figure 10). Because of the distance from the furnace the tube has become stiff and no longer changes its shape. However, it is still so hot that the man pulling the glass has to protect his hands with a piece of wet jute material.

Before discussing the tube-drawing described above, the description of the processes involved in making the beads is to be finished first, since they seem to be similar to those practised in Arikamedu in the first century B.C.

The cutting of the tubes is men's work, like all operations at the furnace. The instruments used are so primitive that there is no reason to assume they could not have existed two thousand years ago: a toothed iron anvil of about 1 cm thickness and about 15 to 20 cm wide and a thin iron hand axe. The tube cutters work at home. They assemble lengths of glass tubes of similar diameter side by side on the anvil and cut them to slices of 1 mm or more with the axe (figure 11). A sheet stretched out below and behind the anvil catches the slices of glass flying through the air.

After the tubes are cut to the size of a bead, the sharp edges of the slices have to be rounded in fire.



Figure 11. Cutting glass tubes of opaque white glass to bead-size slices. The slices are caught in a sheet.



Figure 13. Together with rice dust the tumbled beads are pounded to shape with a wooden pestle in a wooden mortar, Papanaidupet.

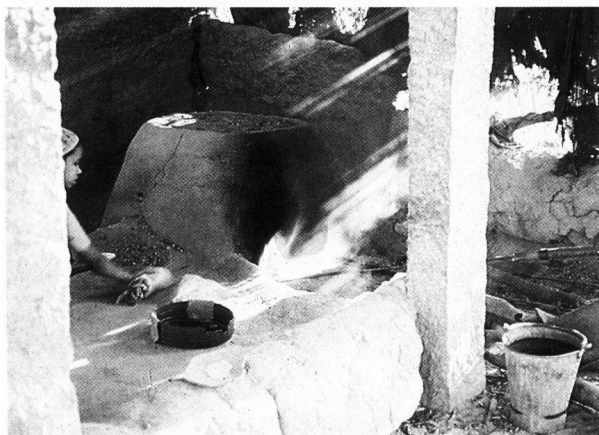


Figure 12. Furnace for fire tumbling. Within the ridge on the top cow dung is smouldering, Papanaidupet.

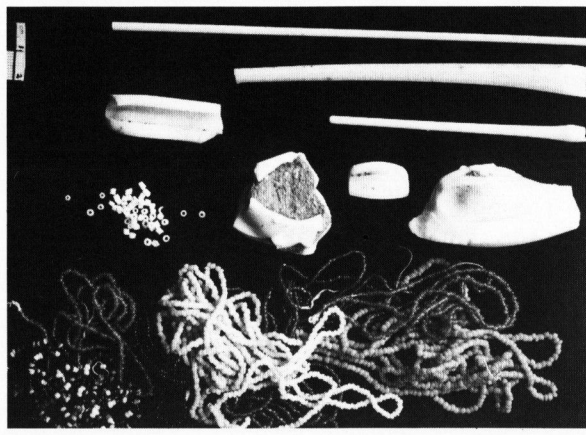


Figure 14. Tubes, "knots", bead-size slices and finished beads, Papanaidupet.

This is done in a smaller furnace (figure 12), below a second shed, near to the tube-drawing furnace. The tumbling furnace is shallower than the former, the height of the interior about 1.20 m, including the fire-pit. The slices are in a large metal bowl, just inside the glory hole. They are mixed with ash of cow dung in order to prevent them from melting together, but nevertheless the glassworker responsible for the tumbling has to keep stirring them with a large metal hook; if he stops for one moment, the beads may melt together. A slight depression, surrounded by a low ridge, on the top of the furnace is filled with smouldering cow pat.

The polishing of the beads takes place in the same shed. This is women's work. One woman sieves the beads to remove the cow dung ash, and another mixes them with rice dust and pounds them in a tall wooden mortar (figure 13). By this treatment the beads receive a polished surface. The difference between the polished surface of the finished beads and the sharp edges of the unfinished ones is clearly visible in figure 14.

The stringing is done at home. In one hand a woman holds a bin full of beads in her lap, and in the other a bundle of fifteen long metal needles spread out like a fan (figure 15). She pricks the needles into the beads with regular, rhythmic movements. It does not take long before the needles are filled with beads. Then she inserts a thin thread through the eye of each needle, pushes the beads off the needles and onto the threads, and the next bundle of fifteen threads is ready (figure 15). Each bundle weighs about 454 g, the British standard, which is still the sales unit for the beads made by Moti & Co.

3. The ladha

The instrument for drawing the glass tubes, called ladha, has already been referred to in section 2. This instrument with its mobile inner rod for pushing open the beginning of the glass tube at the pointed end of the glass cone is an ingenious invention. But the secret of its success appears to depend on the addition of foreign material before the actual tube-drawing

can begin. The crushed brick not only facilitates the piercing of a hole through the glass before this is caught by the worker at the tunnel mouth, it also creates a void between the butted end of the inner mobile rod and the beginning of the glass thread as it is drawn out at the back of the cone. By pulling back the inner rod, the air in the ladha is automatically sucked through the glass cone and into this void so that the thread stays hollow. In other words: the function of the ladha is the opposite to that of a blowpipe, it is a device not for blowing but for sucking air.

To judge from the waste from the tube-drawing in Papanaidupet, not all the crushed brick is drawn out of the glass when the beginning of the tube is made. Although the workers are careful to pour in only the small amount needed, there are always bits that remain swirling in the hot glass, occasionally blocking the tube as it is gradually drawn out. These parts of the tube can not be used for bead-making. After the tube-drawing is completed, the workers check all the lengths of tubing for areas that are blocked in order to cut them out. They recognize the irregularities in the tubes by a peculiar form of swelling. These swellings, or knots (figure 14, left), look exactly like those in the tubes discovered during the excavations at Arikamedu (figure 4) and are, in fact, identical. The only difference is that the knots in Papanaidupet contain crushed brick, while those in Arikamedu contain grains of light coloured sand.

4. Conclusion

The secret of Papanaidupet is the addition of crushed brick to create a void in the glass cone when the hole is made through it before tube-drawing begins. The study of the tube-drawing process shows that the foreign material blocking the tube every now and then is that part of the crushed brick that was not pushed out of the glass but remained swirling in the hot mass; it betrays the use of the ladha or a ladha-like instrument. If glass tubes with knots containing bits of foreign material are diagnostic for recognizing the use of the ladha, one may conclude to that the glassworkers of Arikamedu already used a ladha or ladha-like instrument 2000 years ago. As mentioned in section 1., the knots in the glass tubes from Arikamedu are the most informative pieces of waste from the bead industry. There are hundreds of them in the material from the French excavations. The sand contained in the knots is evidence that the tubes were made with a ladha; it must have been added for the same purpose as the crushed brick in



Figure 15. Threading finished beads, Papanaidupet.

Papanaidupet, that is in order to create the necessary void so that the air in the ladha could be sucked through the hot glass into the tube as it was being drawn out. The secret of Papanaidupet was therefore the secret of the glassworkers of Arikamedu 2000 years ago.

✱

The author wishes to thank Mr. Rada Kissan Gaur of Moti & Co., Papanaidupet, for explaining the methods of production. Thanks are also due to the Museum of Pondicherry and the Ecole Française d'Extrême Orient for supporting the author's investigations. For reviewing the German original text the author thanks Dela von Boeselager.

5. References

- Begley, V.: Arikamedu reconsidered. *Am. J. Archaeology* **87** (1983) p. 461–481.
- Casal, J. M.: *Fouilles de Virampatnam Arikamedu*. 1949.
- Francis, P. jr.: *Guide to the beads in the Pondicherry Museum*. (In prep.)
- Pattabiramin, P. Z.: *Les fouilles d'Arikamedu (Podoukè)*. 1946.
- Raschke, M. G.: New studies in Roman commerce with the East. In: *Aufstieg und Niedergang der Römischen Welt*. II, 9. 2. 1978. p. 604–1361.
- Schmitthenner, W.: Rome and India//Aspects of universal history during the principate. *J. Roman Stud.* **69** (1979) p. 90–106.
- Stern, E. M.: *Indiaas Mozaiek*. 1986. (Distributed by Bergensche Boekhandel, 1861 CS Bergen (The Netherlands).)
- Stern, E. M.: The role of glass in the early Roman India trade. *Pap. Hist. Soc. Pondicherry*. (In prep.) (Also in: Stern, E. M.: *Indiaas Mozaiek*. 1986. p. 20–23.)
- Stern, E. M.: On the glass industry of Arikamedu. In: *XIV International Congress on Glass, New Delhi (India) 1986*. (In prep.)
- Stern, E. M.: Arikamedu en de Vroeg-Romeinse India handel. *Spiegel Hist* (1987) p. 106–112.
- Wheeler, R. E. M.: Arikamedu//An Indo-Roman trading station on the east coast of India. *Anc. India* **2** (1946) p. 17–101.

87R0633