Our threatened archaeological heritage: A case study from the Tamil Nadu coast

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From the beginning of the Christian era, a number of sites having contact with the Roman world were in existence on the coastal belt of India. There are several indirect references in the literature which suggest that the shifting of shoreline was one of the major threats to habitation.

The present paper deals with the archaeological evidences for the shifting shorelines on the east coast of India. The basic data were collected during underwater archaeological exploration of Poompuhar during the last five years. A reference to the ancient map of Tranquebar prepared by Danish rulers in mid 17th century has been made to establish the shoreline shift. We present here information about archaeological structures on the Tamil Nadu coast which have withstood the test of time but are nevertheless in danger of being destroyed during the present time. The reason for this is discussed and we are of the opinion that they are due to the combination of man made and natural causes.

EMERGENCE of any human settlement or civilization along the coast is dependent on the stability of the coastline with time. It is believed that the shifting of coastline was one of the causes for decline of the Indus Valley civilization[1]. From the beginning of the Christian era, a number of sites having contact with the Roman world were in existence on the coastal belts of India. The Roman colonies settled mostly along the east coast. Several indirect references exist in the literature which suggest that the shifting of shoreline was one of the major threats to habitation. The *Mahabharata* mentions that Dwarka was destroyed by the sea[2]. The *Mani- mekhalai* of the Tamil Sangam literature mentions the destruction of *Puhar* (present Poompuhar) by the sea during the reign of Chola king Ilangkilli[3]. These references clearly indicate that migration of the shoreline and associated effects had an impact on the human settlement.

We present here archaeological evidences for shifting shoreline on the east coast of India. These include the data collected during underwater archaeological exploration of Poompuhar and a reference to the ancient map of Tranquebar prepared by Danish rulers .

Methodology

Onshore and intertidal areas

Onshore intertidal explorations were conducted in Poompuhar and surrounding sites, Tranquebar, Vanagiri, Chinnavanagiri and Nayakankuppam (Figure 1). A number of archaeological remains exist all along the Tamil Nadu coast, particularly between Nayakankuppam to Tranquebar. These remains include terracotta ring-wells, pottery, brick structures, etc. Offshore explorations in Poompuhar and Tranquebar were conducted with the help of echo-sounder, side scan sonar and sub-bottom profiler. The diving operations were extended from initial prime sites to the adjoining areas. Each diving campaign covered an area of about 15,000 m^2 in a circular search pattern. Subsequently, airlifting work was undertaken to expose the objects buried in the sediments.

Results

Poompuhar and around

A brick structure of 1.2 m height, 1.2 m width and 4 m length exposed in intertidal zone of Poompuhar and in all 11 courses of bricks were recorded[4] (Figure 2). Based on the brick size ($36 \times 18 \times 6$ cm) this structure dates to approximately early century of the Christian era. The present location (intertidal zone) clearly indicates a human habitation followed by a landward migration of the shoreline.

Four brick structures with a width of 3.4 m are visible in low tide zone off Kaveri mouth located at 60 m seaward and at 1 m water depth[4]. These structures stand in north–south direction in a line with a total length of 25 m. The brick size is $22 \times 13 \times 6$ cm, suggesting the Danish period (17th century AD).

The ring-wells at Poompuhar (Figure 3) and at Vanagiri were noticed during low tide[5]. These ring-wells were generally used for fresh water.

Temple at Vanagiri

The Masalamani temple at Vanagiri, dated approximately to 11th century, is presently under threat of destruction (Figure 4). About 50% of the structure has already been destroyed (Figure 5) and submerged in the sea. The temple is constructed with brick walls, stone lintels and pillars. This is a clear evidence to show the advance of the shoreline in the last 900 years.

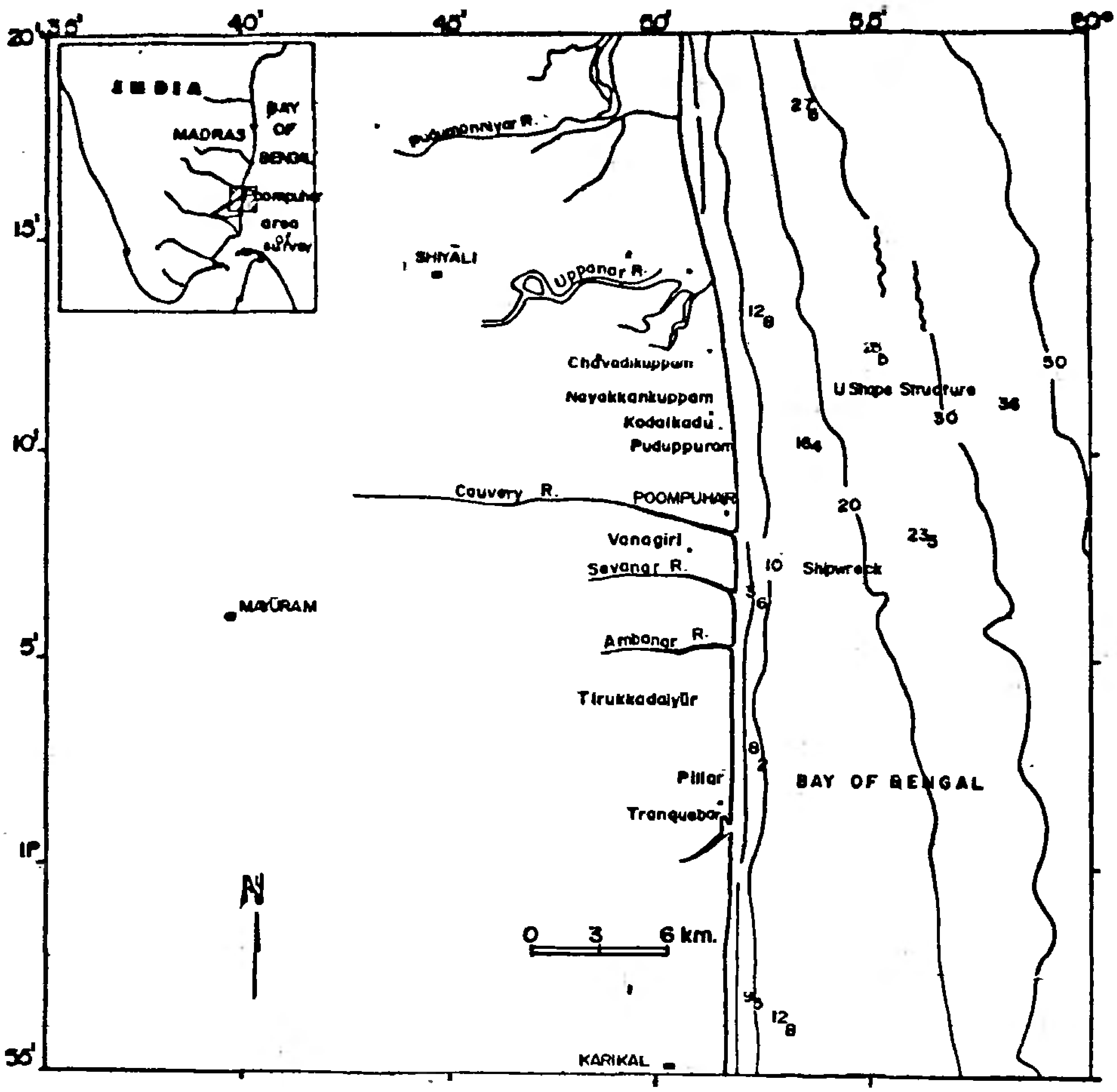

Figure 1. Map showing the location of archaeological sites in and around Poompuhar/Tranquebar.

Figure 2. A 4th century AD brick structure exposed in intertidal zone of Poompuhar.

Figure 3. An ancient terracotta ring-well in intertidal zone of Poompuhar, used for obtaining fresh water.

Tranquebar

The earliest habitation in Tranquebar goes back to later Chola period (9th century AD) and continued till today. Local people collect the Chola/Dutch and Danish coins during low tides and sell them. Probably these coins are being extracted by the wave action on the coastal section.

A Siva temple of the Chola period is presently the potential target of Tranquebar sea (Figure 6). The sea has already destroyed more than 50% and is likely to engulf the entire temple in the near future. This temple is also built with bricks and stones. Even during low tide, about 25% of the temple remains in the sea and this is yet another instance of an advancing shoreline.

Evidence exists on the remains of a Dutch Fort have been submerged in the sea. They are located 100 m away from the present-day shoreline. This is partly exposed during low tide (Figure 7). Two brick wells of the Danish period can be seen at the intertidal zone. In addition, several other structures can be seen during low tide. There are also evidences in Tranquebar about the destruction of modern houses due to encroachment of the sea in the recent past.

A mid 17th century map of Tranquebar has been displayed in the Dansborg Museum at Tranquebar. It shows a complete plan of the town along with the then shoreline (Figure 8). A careful study of the map suggests that: i) the Tranquebar town was well-protected by a seaward fort wall, and ii) the Siva temple was sufficiently landward within the fort wall. It is estimated that during the 17th century AD, the shoreline was at least 50 m away from the fort wall and the temple located around 250–300 m from the shoreline. This observation suggests that the shoreline has transgressed about 300 m in the last 300 years infringing at an average rate of one metre per year.

Figure 4. An 11th century Masalamani Temple at Vanagiri (photographed in March 1991).

Figure 6. An 11th century Siva Temple at Tranquebar under destruction.

Figure 5. Closer view of the Temple at Vanagiri and shore features (photographed in February, 1997). Note the great destruction of the temple in the last 6 years.

Figure 7. Remains of a 17th century Dutch Fort in the sea of Tranquebar.

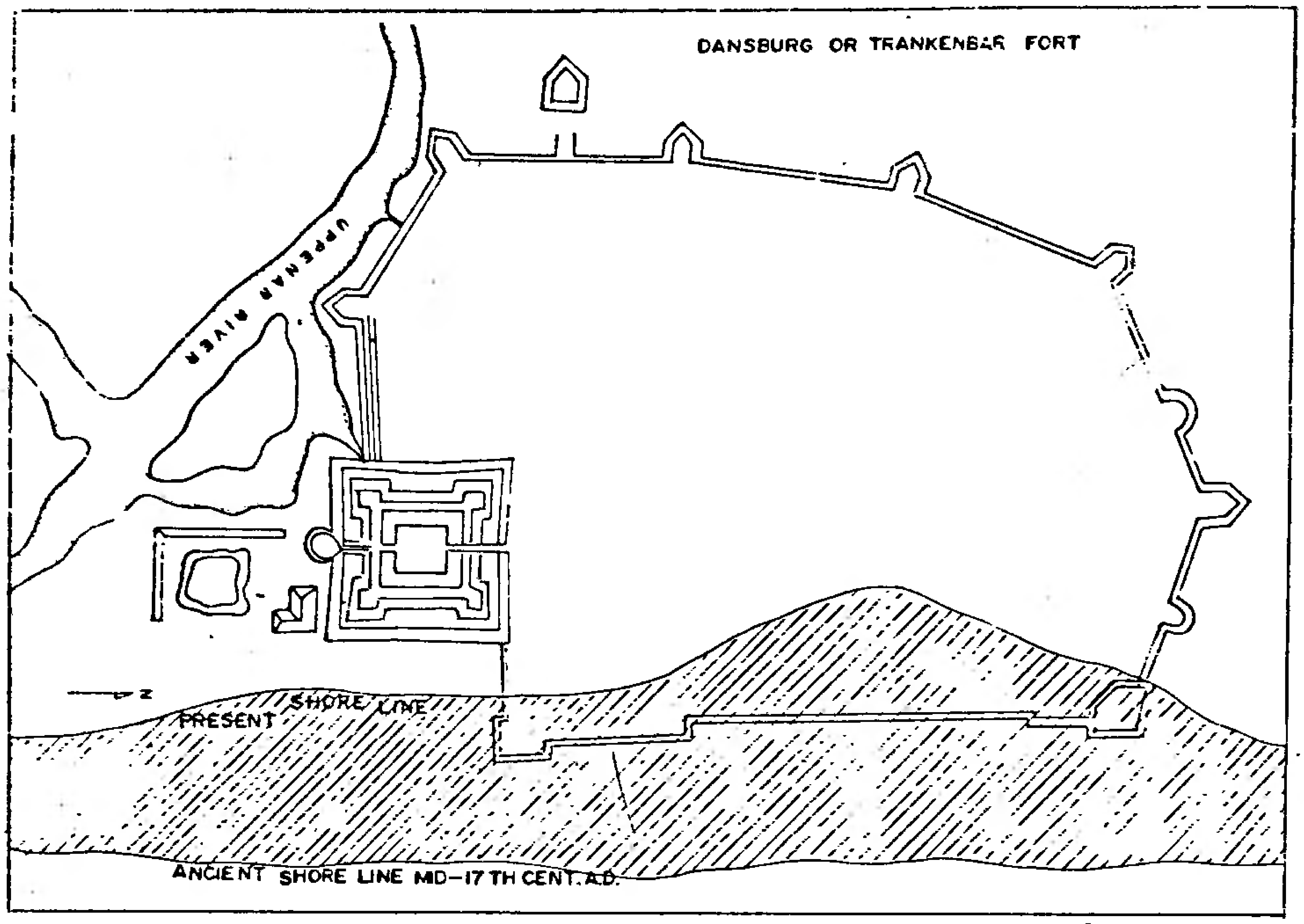

Figure 8. Map of Tranquebar fort of mid-17th century AD (copied from Densborg Museum Tranquebar, Tamil Nadu).

Offshore explorations at Poompuhar

There are two large areas in the sea at 5 to 8 m water depth where habitational remains were located: a) south of Poompuhar consisting of a number of stone blocks, rolled bricks and pottery. The airlifting operation at these places indicates that the remains have been buried in the sediment. Similarly, at a second site towards north of Poompuhar a few dressed stone blocks were noticed. These stone blocks occur in three general dimensions (30 × 20 × 5 cm, 65 × 40 × 10 cm and 60 × 35 × 10 cm). Grey ware pottery, consisting of a part of a bowl and another potsherd of a huge storage jar were also found at 1 m depth below the seabed. These were buried below compact clay and loose sand. On the basis of size and shape of the pottery, the remains date back to early centuries of the Christian era[6].

Figure 9. Fallen pedestal of Kannagi statue installed in 1973 at Poompuhar.

Discussion

The explorations at Poompuhar and Tranquebar demonstrate that the sea has gradually encroached the land to a greater extent since the last 2000 years.

It is worth mentioning here that, in 1973 the Kannagi statue was installed at the shore of Poompuhar about 200 m away from the high water line (Figure 9), and in 1994 it was shifted about 150 m landward because the structure was destroyed by the sea (Figure 10). Similarly, other monuments at Poompuhar were also destroyed by the sea (Figure 11).

Factors responsible for the land erosion may include the construction of several dams along the course of river Kaveri since 1900 AD for irrigation and hydro-electricity. The rivers discharge significant amount of land-derived detritus to the sea, thus maintaining a dynamic balance between the coast line and the sea. The influx of sediment to the sea by Kaveri has been

Figure 10. The same Kannagi statue reinstalled in 1995 about 150 m landward at Poompuhar.

Figure 11. Monument at Poompuhar built in 1973, destroyed by the sea.

reduced to negligible amount due to the construction of several dams, resulting in a disturbed natural balance. This human-induced disturbance appears to have withdrawn the natural resistance to the waves. Subsequently, the sea began to erode the coast line, leading to submergence of several ancient coastal structures of the Poompuhar.

At Tranquebar, which is situated 15 km south of Poompuhar, there is a clear indication of coastal erosion from the last 300 years. From the Figure 8 it can be suggested that the southern bastion of the fort was protecting the present Dansborg museum, but there is no barrier against the temple, causing the great destruction. Thus, ancient habitational sites are being damaged badly by the wave action because there is no proper protection for them.

While the immediate cause of coastal erosion is the removal of sand from the beaches that results in destabilization and destruction of coastal structures, the ultimate causes need to be addressed.

The Bay of Bengal, whose western boundary is formed by the east coast of India, is a rather unusual sea. The Bay of Bengal is subjected to a large number of high-intensity cyclones compared to the Arabian Sea. Cyclones are short-lived phenomena, capable of causing immense amounts of destruction when they cross the sea and hit the coastline. The destructive power of cyclones at present and in the past along the coast of Madras, Andhra, Orissa and Bangladesh is sufficiently well-documented.

The next geological peculiarity that can contribute to the coastal erosion is the narrowness of the eastern continental shelf. This shelf is less than 50 km in width, in contrast to the western shelf which is a few hundred kilometres wide. Wave propagation over a narrow shelf results in low frictional loss of energy and thus expends much energy on the coastline, causing a great degree of coastal erosion.

Superimposed on these factors is the net rise in global sea level. Recent evidences from the west coast of India[7,8] and from widely scattered regions such as Florida[9] in the Atlantic indicate episodic and rapid rise and fall of the sea level. The rates reported are about a metre per century over a time period of 500 to 1000 years. These findings have now dispelled the notion that sea level is a stable and unchanging datum. The inference drawn from the above is that during a period of rising sea level the zone of erosion shifts landward (submergence), and during a fall in sea level, the zone of erosion shifts seaward, resulting in seaward progradation of land. An example of this is the location of ancient ports at Korkai and Algankulam in south Tamil Nadu coast far inland but which were patently designed and located to be on the shoreline.

Conclusion

The coastal erosion in Poompuhar and Tranquebar region has been occurring for 2000 years. The archaeological records suggest that, the erosion has become more vigorous in the last 100 years. If this rate of erosion continues, then in the next 50 years temple of Vanagiri and the fort and temple at Tranquebar will be submerged. It is time for scientists, archaeologists, bureaucrats and policy makers to address the severe problems of erosion and evolve a proper strategy for the protection of coastal archaeological sites.

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RESEARCH COMMUNICATIONS

Interaction of porphyrins with concanavalin A and pea lectin

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Currently porphyrins are used as photosensitizers in photodynamic therapy for the treatment of cancer. However, this approach suffers due to the inability of many porphyrin-based drugs to accumulate preferentially in tumours. In view of this, we considered if the carbohydrate-binding proteins, lectins, which preferentially recognize malignant cells, could be used for the targeting of porphyrins to tumour cells. In the present study, we have investigated the interaction of a free base porphyrin, *meso*-tetrasulphonatophenylporphyrin and the corresponding metal derivative, *meso*-zinc-tetrasulphonatophenylporphyrin with two legume lectins, concanavalin A and pea (*Pisum sativum*) lectin. Each lectin subunit was found to bind one porphyrin molecule and the association constant, K_a, estimated from absorption and fluorescence titrations at room temperature (28 ± 1°C) was in the range of 1.2×10^4 M^{-1} to $6.3 \times 10^{4}4$ M^{-1}. Both free lectin and lectin saturated with the specific saccharide were found to bind the porphyrin with comparable binding strength, indicating that porphyrin binding takes place at a site different from the sugar-binding site. These results indicate that lectins may potentially serve as drug-delivery agents for porphyrin sensitizers in photodynamic therapy.

LECTINS are ubiquitous carbohydrate-binding proteins of non-immune origin, which agglutinate cells or precipitate polysaccharides or glycoconjugates[1]. In recent years lectins have become increasingly important as tools for the study of carbohydrates, both in solution and on cell surfaces[2]. The sugar-binding and haemagglutinating properties of lectins are used for preparative and analytical purposes in biochemistry, cell biology and immunology. Some lectins have the ability to interact preferentially with transformed cells and hence they have been suggested for use as carriers for targeted delivery of chemotherapeutic agents. For example, conjugates of concanavalin A (Con A) and the α-chain of diphtheria toxin[3] or ricin[4] have been prepared and tested for targeting the toxin to tumour cells. In addition to binding of carbohydrates, lectins are also known to bind other small molecules such as 1,8-anilinonaphthalenesulfonate (ANS), 2,6-toluidinylnaphthalenesulfonate (TNS), adenine and cytokinin[5–7].

Photodynamic therapy (PDT), a new modality for cancer treatment that utilizes porphyrins and metalloporphyrins as sensitizers[8], has attracted a great deal of attention in recent years. When irradiated with light of the appropriate wavelength, these sensitizers go into the excited state and interact with molecular oxygen, converting it into the singlet state, ultimately resulting in tumour necrosis[9]. However, the selectivity of these sensitizers towards tumour cells is not always sufficient for PDT to be specific for the tumour tissue alone[10]. One possible way to improve the ability of the photosensitizers to target tumour tissues specifically is to couple them with another agent which can preferentially interact with the malignant cells.

The above considerations prompted us to investigate if lectins could be used as carriers for the targeted delivery of porphyrins to tumour cells so as to increase their therapeutic potential. We have, therefore, undertaken