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# Coordinates and chronology of the ancient port city of Poompuhar, South India

As the southern part of the Indian Peninsula including the state of Tamil Nadu (TN) (Figure 1 *a* and *b*) is a low easterly gradient plain, the rivers that originate from the Western Ghats and the uplands in the west seem to have flowed towards the east with stable dynamics as evidenced from their well-evolved life histories with youthful, mature and old stages. So, the mouths of these river systems provided favourable avenues for ports and the related flourishing maritime activities since historical times[1]. The port city of Poompuhar located at the mouth of River Cauvery in TN was one such a city of glory and had a prominent maritime history attracting traders from several countries (Figure 1).

Poompuhar was established by the Chola Empire during the Sangam period (300 BC–AD 300) of the Tamils and its glory was maintained even after the Chola dynasty during the Kalabras' rule (AD 300–600) and its legacy continued further during the rule of the Pallavas as well (AD 600–850). When the Chola dynasty re-emerged during AD 850, the later Chola kings added further fortification to Poompuhar, which seems to have later submerged in the Bay of Bengal[2]. Several mentions have been made about Poompuhar in the Sangam and post-Sangam literature, *Silapathikaram*, *Manimekalai*, *Purananuru*, *Agananuru*, *Natrinai* and *Pattinappalai*[1–4]. Owing to its maritime importance, researchers from archaeology, epigraphy, history, Tamil literature, geology and other related fields have attempted to unravel the history of the submerged port city.

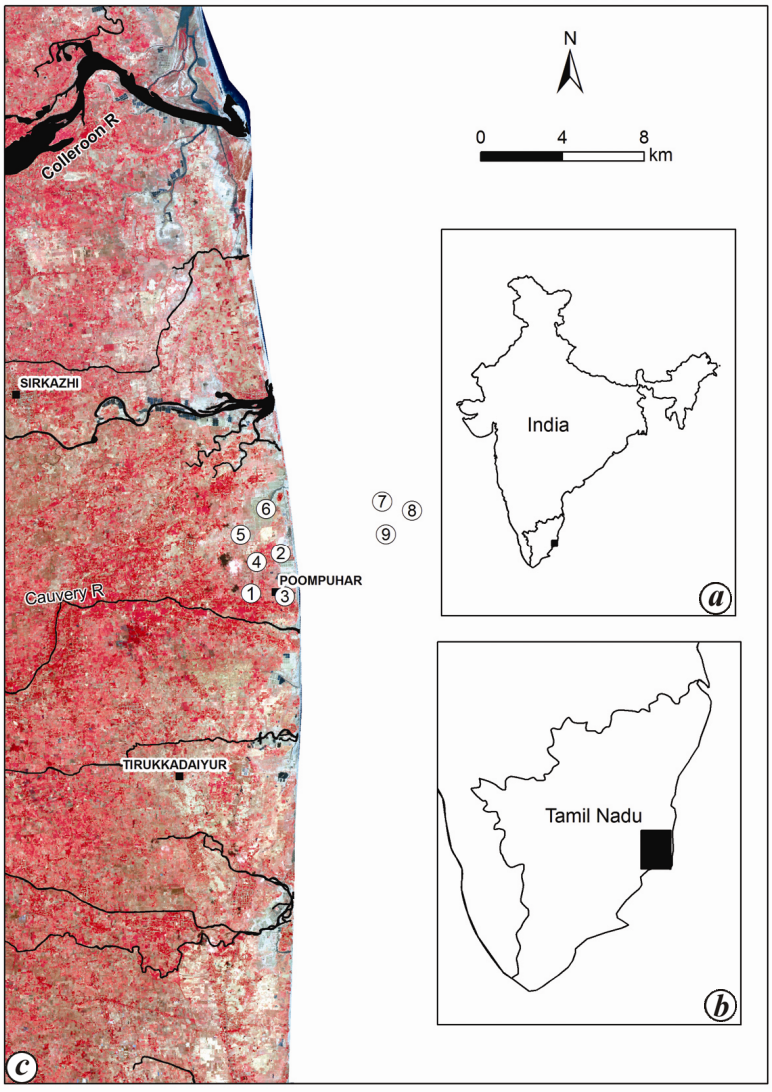


**Figure 1.** ***a***, ***b***, Key maps. ***c***, IRS satellite false colour composite image showing archaeological remains (1–9) of Poompuhar.

Among many studies, the on-land and underwater archaeological explorations carried out using modern tools and technologies have brought out several scattered remains of Poompuhar, viz. Buddha Vihara (1), Yavanar Irukkai (2), wharf (3), settlements of business community (4), urn burials from Venkadu (5) and Kadaikadu (6) in the present day land portions, and Soma Kundam (7), Surya Kundam (8) and Vellidai Mandram (9) at about 8 km northeast of present-day Poompuhar in the offshore region at a depth of 20–25 m in the sea (Figure 1). Other archaeological remains like brick structures, cairn circles, ring wells, ship wreck, wharves, Buddha Vihara, etc. were found both onshore and offshore[5–11]. So the exact coordinates (location) and the spread of Poompuhar are not clear – whether the scattered remains found in the land portion at present and those found up to 8 km inside the sea are the spread of the same city, or the underwater archaeological remains are part of earlier Poompuhar city and those found in present-day land portion are the later settlements re-established when the sea level rose.

Similarly, as far as the chronology (age) of Poompuhar is concerned, different observations have been made by the earlier workers, including citations made in the Tamil literature. Some studies have assigned an age of 11,000 years to this port city[12], whereas the $^{14}C$ dating carried out by NIO indicated a range of 2320 yrs BP to some of the remains of the present Poompuhar city[13]. Various Sangam and post-Sangam Tamil literature mentioned that Poompuhar might be of Sangam period (300 BC–AD 300 or 2000 yrs BP). Again, the world atlas prepared by Ptolemy[14] during AD 140 mentioned 15 port cities in southern India, including Poompuhar, which indicates its existence during 1870 yrs BP. Hence the exact age and lifespan of Poompuhar city remains an enigma. The present study was carried out to analyse (i) the exact geoposition/geo-coordinates of Poompuhar and (ii) its period of establishment and time-span.

The near-shore topographic data of GEBCO (General Bathymetry Chart of the Ocean) was analysed and digital elevation model (DEM) was generated using the ArcGIS software for the near-shore topography of Poompuhar region. Analysis of the post-glacial sea-level curve[15] showed that the sea level has risen from a depth of 125 m below the present mean sea level (PMSL) to the present level in between the Last Glacial Maxima (LGM) of 20,000 yrs BP and the present day (Figure 2). The sea-level rise was found to be steady as well as exponential, with two standstill periods (static sea-level periods) during 14,000–13,000 and 12,000–11,000 yrs BP (1 and 2, Figure 2). From the above sea-level curve of LGM to the present day, the sea levels of six different periods, viz. (i) 20,000, 15,000, 11,000, 9,000, 8,000 and 7,000 yrs BP were filtered out, with values at 125, 110, 50, 25, 18 and 5 m below PMSL respectively (Figure 2).

The sea levels of these six periods were wrapped over the above GEBCO-based DEM of near-shore topography and the past land–ocean distribution and coastlines were found for the above periods (1–6, Figure 3).

Such past coastlines with land in the west and ocean in the east show that the coast was located (1 and 2, Figure 3) 30 km east-southeast of present-day Poompuhar/Kaveripoompattinam, with prominent easterly convexity during 20,000–15,000 yrs BP. The coast located 15 km east of present-day Poompuhar during 11,000 yrs BP was also convex (3, Figure 3). In both cases, the DEM shows

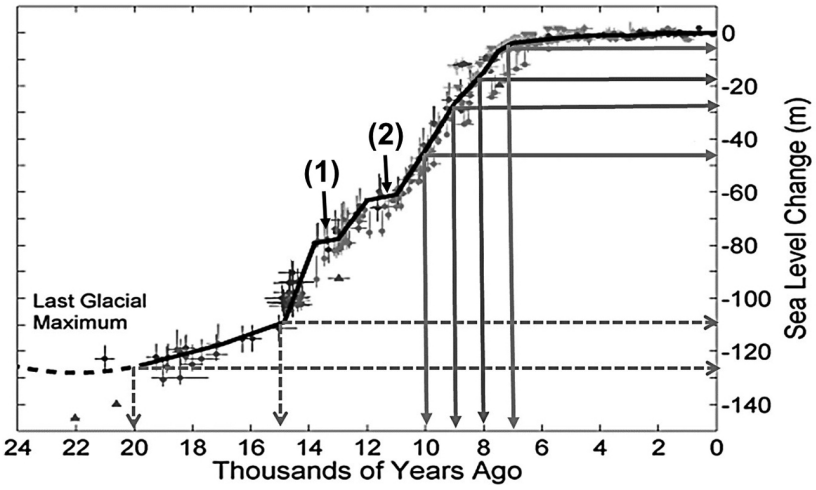


**Figure 2.** Global sea level curve since Last Glacial Maxima.

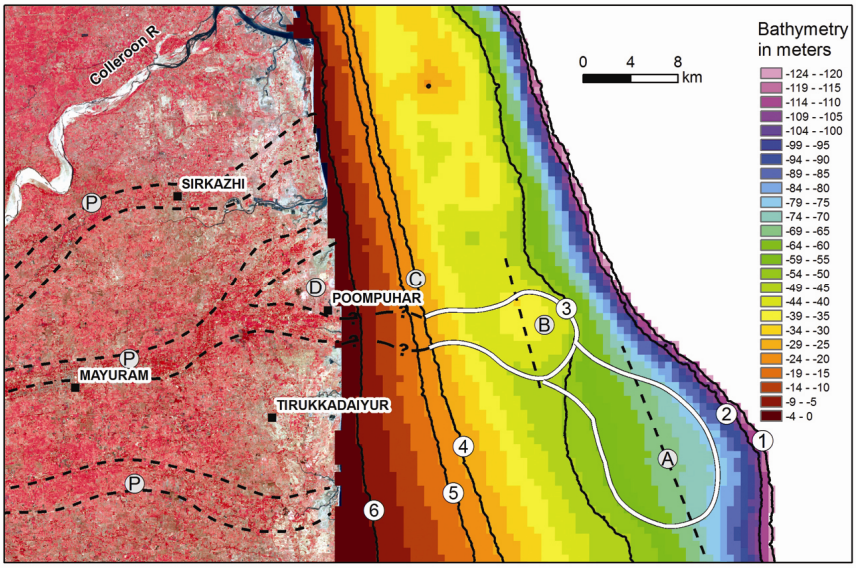


**Figure 3.** Old courses of river Cauvery (P); Past coastlines during 20,000 yrs BP (1), 15,000 yrs BP (2), 11,000 yrs BP (3), 9,000 yrs BP (4), 8,000 yrs BP (5) and 7,000 yrs BP (6); drowned lobate deltas (A&B).

well-defined topographic highs in the convex land portion. An earlier study[16] has shown that the present-day east and west coasts of the Indian Peninsula have alternate convexities and concavities and the former have been explained to be the structural culminations of the east–west trending cymatogentic arches, while the latter to the complementary deeps related to the post-collision buckling of the Indian Plate. The studies[16] further observed lobate and arcuate deltas along the convex coasts caused due to tectonic emergence and withdrawal of the sea, and digitate and estuarine deltas along the concave coasts representing cymatogenic deepening and tectonic subsidence. The Vaigai lobate delta in the southern Ramanathapuram area, the Cauvery arcuate delta in the central Vedaranniyam region and the proto Cauvery lobate delta in the northern Chennai region of TN have thus been explained to be due to tectonic arching, block faulting and uplifts; whereas the estuarine and digitate Pudukkottai Vellar and Ponnaiyar delta fronts of TN have been attributed to the intervening cymatogenic deep/tectonic subsidence[16,17]. The study[16] also inferred that in zones of cymatogenic arching, there is extensive soil erosion and the sediments are dumped into the ocean along the convex coasts forming promontories and protruding deltas.

Under these geodynamic settings of the Indian coasts in general and the east coast of TN and the Cauvery delta in particular, such convexities found in the east and east-southeast of present-day Poompuhar along with topo highs (2 and 3, Figure 3) are significant. Hence NNW–SSE topographic cross-sections were drawn over the DEM along the topo highs of 15,000–11,000 yrs BP (A, Figure 3) and of 11,000–9,000 yrs BP (B, Figure 3) using 3D analyst module of ArcGIS. They showed that these topo highs have elevations ranging from 7 to 10 m (Figures 4 and 5). Thus it was surmised that these convex coasts with elevated land masses must be the arcuate/lobate deltas of River Cauvery, viz. Delta-A and Delta-B (Figure 3). Delta-A might have been formed by the Cauvery around 20,000 yrs BP during which the tectonically induced convex coastline was around 30 km east-southeast of present-day Kaveripoompattinam and the sea level was more than 110 m below PMSL. When the sea level rose from 110 to 50 m below PMSL during 15,000–11,000 yrs BP, Delta-A might have been submerged and the Cauvery may have truncated in length due to obstruction by the sea and hence might have formed Delta-B around 15 km east of present-day Kaveripoompattinam (B, Figure 3). When the sea level further rose from 50 to 25 m below PMSL during 11,000–9,000 yrs BP, Delta-B might have also submerged.

Under the scenario of such land–ocean interactive dynamics, when the coast was located nearly 30 km east-southeast of the present-day Poompuhar between 20,000 and 11,000 yrs BP, that too with river mouth and a lobate/arcuate delta, there are obvious reasons to postulate that the first settlement of Poompuhar (Poompuhar-A) might have been established at Delta-A (Figure 3). When the sea level rose from 125 to 50 m during 20,000–11,000 yrs BP, Poompuhar-A might have been submerged and people would have shifted to Delta-B and established Poompuhar-B around 11,000 yrs BP. When Poompuhar-B also submerged due to further sea-level rise between 11,000 and 9,000 yrs BP, people would have again shifted towards the west on the landward side and established Poompuhar-C, where only Soma Kundam, Surya Kundam and Vellidai Mandram (7–9, Figure 1) are found. When the sea level further rose and Poompuhar-C may have also submerged, people would have established the present-day Poompuhar/Kaveripoompattinam (Poompuhar-D). Such constant shifting of the port city appears to be logical under the proven phenomenon of sea-level rise. Further, the age of Poompuhar has been estimated as more than 11,000 yrs BP (ref. 12), which coincides with the location of Poompuhar-A only. Further, such an age cannot be assigned to present Poompuhar (Kaveripoompattinam) because during 11,000 yrs BP, the coastline was located 15–20 km east of Kaveripoompattinam. So, the age of Poompuhar-A must be around 15,000–11,000 yrs BP, Poompuhar-B around 11,000–9000 yrs BP, and Poompuhar-C around 9000–7000 yrs BP as revealed by the coastlines (Figure 3). The present Poompuhar-D may be around 2000–2500 yrs BP only (Sangam period), because the marine transgression

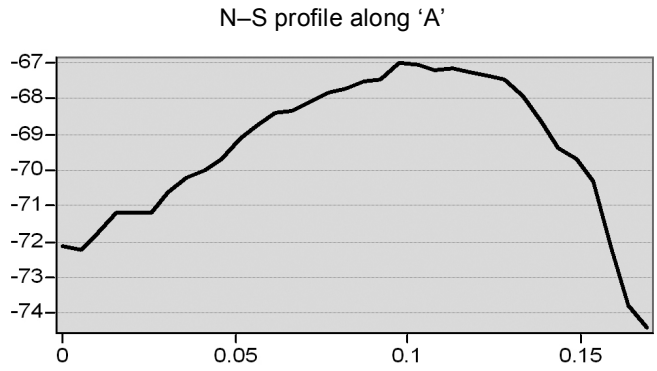


**Figure 4.** N–S profile along drowned arcuate/lobate delta A.

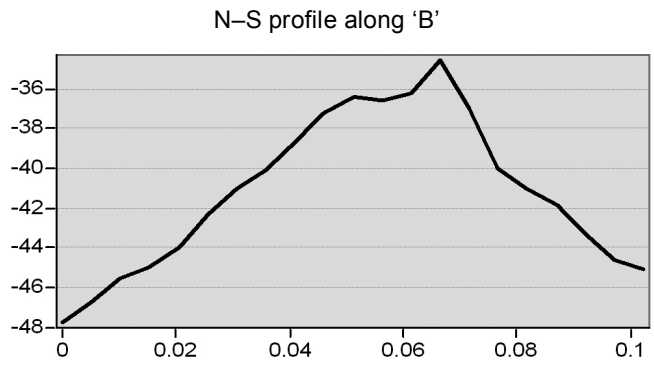


**Figure 5.** N–S profile along drowned arcuate/lobate delta B.

that occurred in the area during 7000–6000 yrs BP, engulfed the land up to 8 km west of present Poompuhar-D and the sea had withdrawn to present Poompuhar-D region only around 2500–2000 yrs BP according to the $^{14}C$ dating of beach ridges of Vedaranniyam area[18]. Probably, Poompuhar-D (Kaveripoompattinam) might have flourished more during the Sangam period and hence glorified the Sangam literature. So what is mentioned in the Sangam literature about Poompuhar is only about Kaveripoompattinam. No tools and technologies were available in the past for 3D mapping of sea-bed topography, visualization of different scenarios of sea-level rise and the mapping of past coastlines. Hence, the earlier workers could not visualize the possibility of Poompuhar inside the sea and obviously the question of archaeological remains/$^{14}C$ dating in Deltas A and B did not arise.

Thus existence of arcuate/lobate deltas of the Cauvery inside the sea in the above-mentioned locations and the obvious postulations of earlier Poompuhar cities in those deltas cannot be ignored. However, these new scientific postulations on the possibility of Poompuhar city in Delta-A and Delta-B regions (Figure 3) warrant detailed studies.


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# Incidence of gold associated with copper mineralization in Garhwal Lesser Himalaya, Rudraprayag district, Uttarakhand, India

Base-metal mineralization occurs widely in the rocks of the Garhwal Group of Proterozoic Lesser Himalayan Sequence, viz. Dhanpur, Pokhri and Mohankhal prospects, but gold (Au) associated with such mineralization is rarely recorded from Garhwal Himalaya. Here we report significant incidences of gold associated with sulphide mineralization in dolomite-hosted quartz–carbonate veins of Pithoragarh (=Lameri) Formation from Lameri–Koteshwar area, in parts of Rudraprayag district, Uttarakhand, India. The Au values recorded from bedrock and stream sediment samples from the area are 475 ppb and 1.42 ppm respectively. Scanning Electron Microscope – Energy Dispersive X-ray (SEM-EDX) studies have indicated the presence of gold along with chalcopyrite, pyrite, sphalerite and galena in various samples. The identification of native gold in quartz vein, under SEM, is the first record of *in situ* gold incidence from Rudraprayag area. Sporadic occurrences and small deposits of metallic minerals in the Garhwal belt are mainly restricted to Mesoproterozoic to Early Palaeozoic.

The studied area falls under Survey of India toposheet nos 53 J/15 and 53 N/3 in parts of Rudraprayag district. The regional geology comprises volcano-sedimentary sequence of Meso–Proterozoic Garhwal Group, which is subdivided into four formations in stratigraphic sequence in ascending order namely Agastmuni, Rautgara, Pithoragarh (=Lameri) and Berinag (=Nagnithank)[1] (Figure 1). This part of the Lesser Himalayan sequences is sandwiched by the Main Central Thrust in the north and North Almora Thrust in the south. The study area comprises rocks of Rautgara, Pithoragarh and Berinag formations intruded by mafic dykes (meta-gabbro). Dolomite of Pithoragarh/Lameri Formation is dominantly exposed in Lameri–Koteshwar area with occasional bands of carbonaceous slate. The dolomite is stromatolitic, light grey in colour and is intruded by thin quartz–carbonate veins. These quartz–carbonate veins are usually diffused within dolomite and such zones of dolomite-hosted veins vary in their width from a few centimetres to as much as 8 m. Chlorite schist associated with quartzite of Berinag Formation occurs dominantly to the west of the area and is best exposed around Rudraprayag town in the Mandakini River valley (P. S.