Where is the Phoenician harbour of Tyre?

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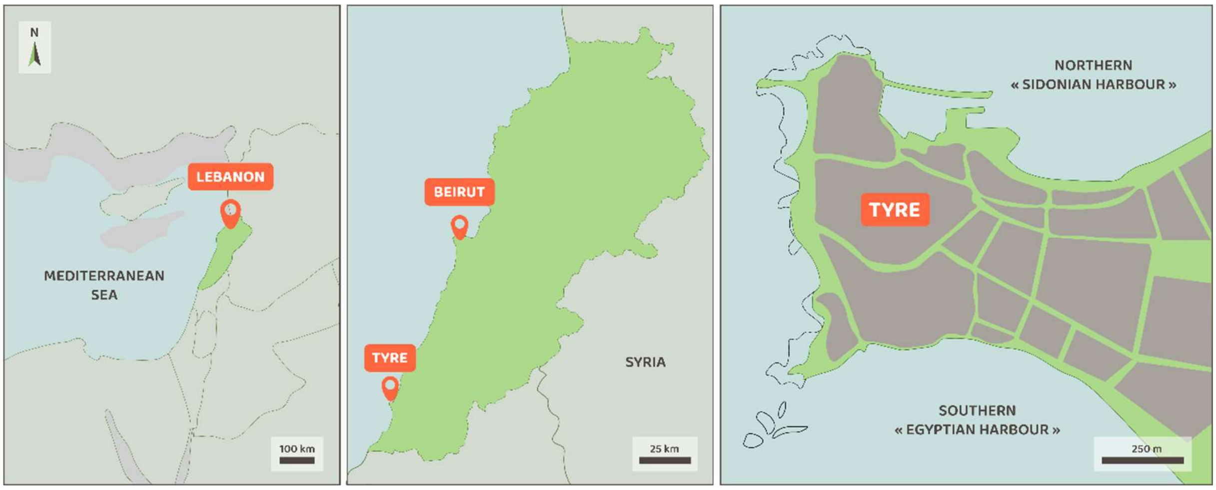
Published online 26 January 2024: https://archeorient.hypotheses.org/26907

Introduction

The renowned Phoenician city of Tyre (Lebanon) is one of the finest examples of major changes triggered by the construction of a causeway affecting the development of its harbours. Building sustainable ports along coastlines is a difficult endeavour because coastlines are among the most rapidly changing landscapes on Earth. This challenge is faced worldwide today. Besides, the erection of coastal structures alters coastal dynamics in such a way that new structures tend to affect earlier constructions. The study of ancient harbours shows that it has been a nagging problem in coastal management since Antiquity. Investigating ancient cases is interesting because it provides more time depth into these changes than the modern cases, owing to the centuries of coastal changes that have elapsed since the structures started to alter their environment.

Tyre city was founded on a small coastal island from which it resisted invasions and sieges for many centuries. In 332 BCE, Alexander-the-Great eventually succeeded in seizing the city after building a causeway 4 stades long[1] and 2 plethra wide[2], which was laid in water depths reaching 3 fathoms[3]. The causeway interrupted longshore sand transport, forcing sand to pile-up against and on top of the causeway, thus creating a sandy isthmus that has connected Tyre to the mainland ever since.



Location of Tyre in Lebanon (Figure by Sylvia Vinai).

Where was the “Egyptian harbour”?

The isthmus profoundly altered the layout of Tyre and its harbours. Ancient authors Strabo (16, 2) and Arrian (2, 7), living in the first and second centuries CE, report that the Phoenician city had two harbours, one opening towards the north (the so-called “Sidonian Harbour”, or “Port of Astronoe”), and the other opening to the south (the so-called “Egyptian Harbour”). The ancient northern harbour is filled with Hellenistic to Byzantine sediments and is clearly documented below the modern harbour of Tyre (Marriner et al., 2005). The

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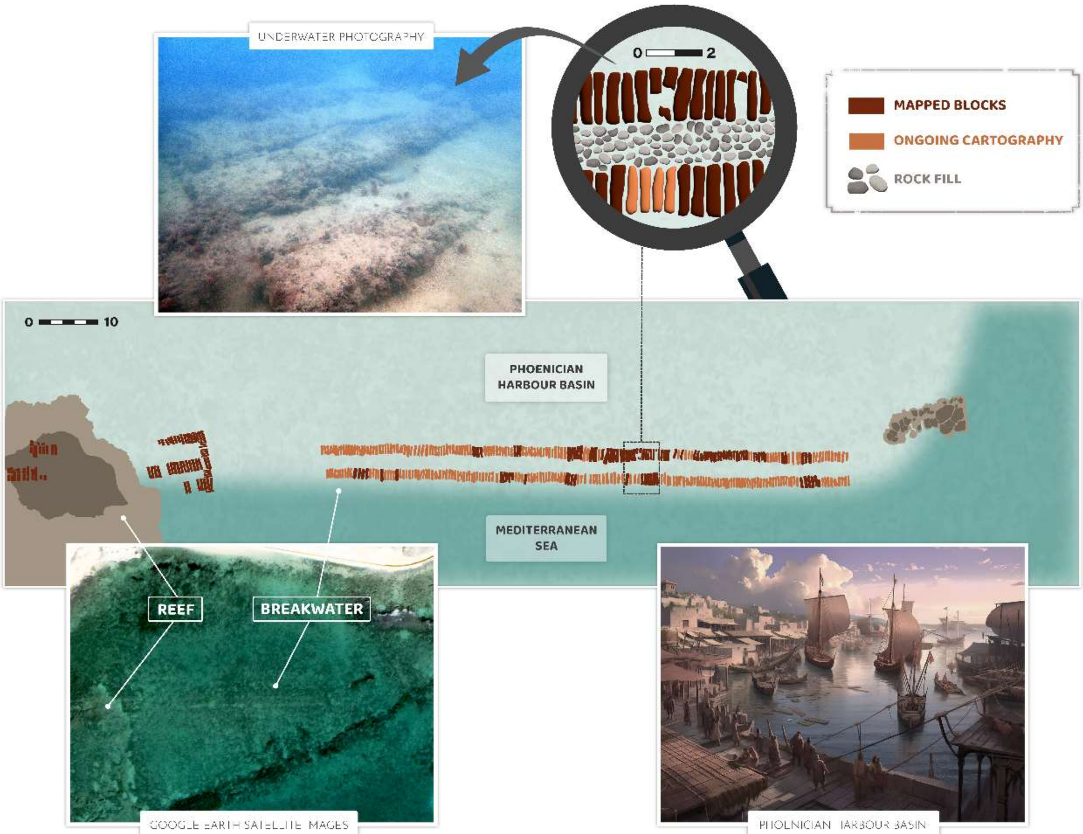
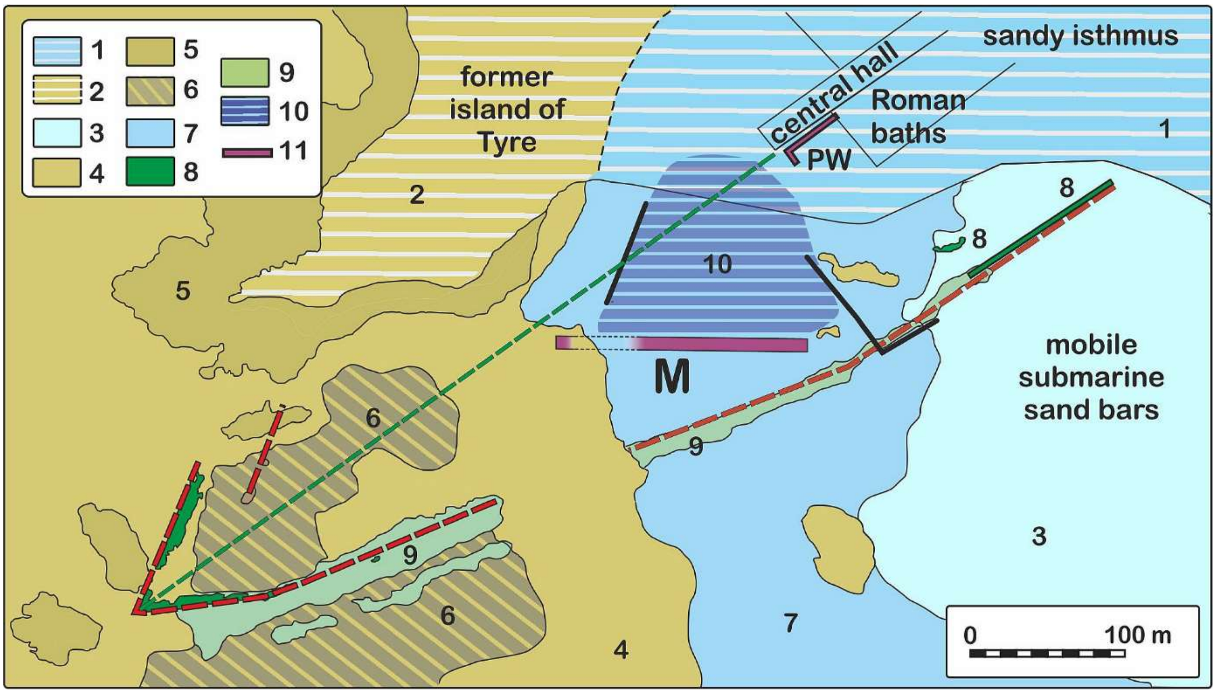
[1] ca. 750 m, acc. to Quintus Curtius, 4, 2 & Diodorus Siculus, 17, 7, however, Pliny, 5, 17 mentions 700 paces, i.e., nearly 1 km.
[2] ca. 60 m, acc. to Diodorus Siculus, 17, 7.
[3] 5.4 m, acc. to Arrian, Anabasis, 2, 18.

southern harbour no longer exists and several hypotheses for its location have been put forward over the past two centuries.



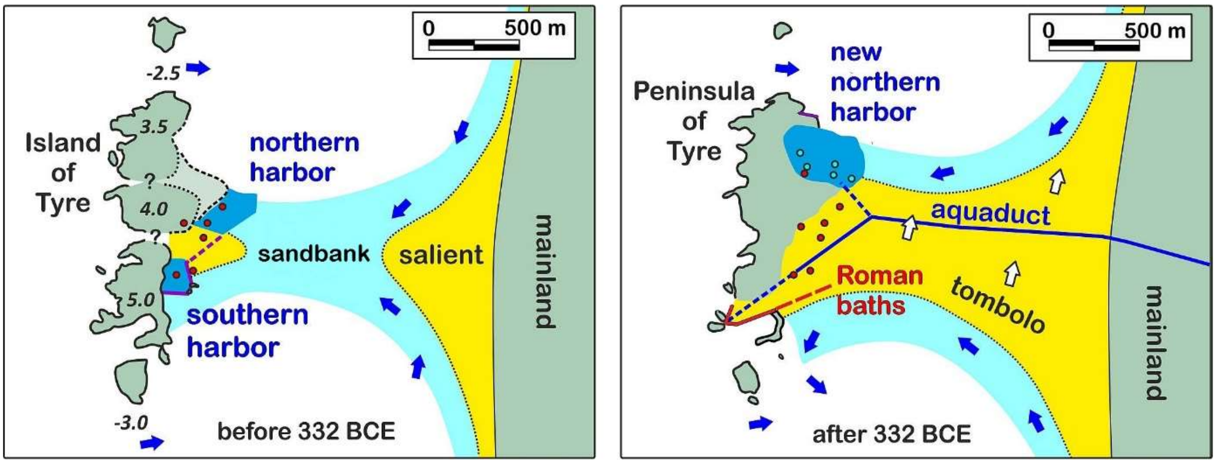
The east-west aligned, Phoenician-style breakwater discovered in 2019 extends over some 130 m. It displays a double alignment of oblong blocks (Figure by Sylvia Vinai, adapted from Goiran et al., 2021).

A breakwater, similar in style to the Phoenician breakwater built in the 6th-4th centuries BCE along the north coast (Nourredine, 2019), was identified in 2019 along the south coast by a team of researchers led by the Archéorient Laboratory, Maison de l'Orient et de la Méditerrannée, at the University of Lyon 2, France, by reinterpreting previously identified structures and improving the mapping (Goiran et al., 2021). Cores collected onshore by the team revealed the presence of sediments typically deposited inside a harbour basin, behind the offshore structure (Brocard et al., 2024). The newly identified breakwater is therefore regarded as protecting the Egyptian Harbour of Tyre ("M" on the figure below). Its basin ("10" on the figure below) would have covered an area of up to one hectare (100 x 100 m), south of the Roman baths complex. The port structures of the southern Phoenician harbour of Tyre appear to have been buried during the Hellenistic and Roman periods, allowing the south-east corner of the island to be used by the Romans for the development of monumental baths. The team suggests that the southern harbour had to be abandoned owing to the rapid growth of a massive sandy isthmus during the centuries which followed the erection of Alexander's causeway. The area of this southern harbour was then repurposed, with the building of monumental baths, and the development of an urban district protected by Roman-style seawalls.



Distribution of man-made structures, bedrock, and sediments around the southern harbour of Tyre.
Red dashed line: Poidebard (1939)'s southern harbour enclosure. Green dashed line: axis of the monumental Roman baths. Geology: 1: emerged part of the sandy isthmus, 2: emerged land over calcarenite bedrock (wherever bedrock is above -2.5 m), 3: submarine part of the sandy isthmus, 4: submerged outcrops of calcarenite, 5: shore platform cut into calcarenite (mostly man-made), 6: natural block pavement over calcarenite, 7: natural block pavement over marine sediments, 8: roman concrete (*opus caementicium*), 9: rubble mound dyke, 10: proposed southern harbour-basin, 11 (M): east-west Phoenician-like breakwater.

In addition, coring also revealed the presence of harbour sediments likely deposited in another basin, at an earlier location of the northern harbour of Tyre. This northern harbour would have been also abandoned to give way to the growing sandy isthmus, and relocated to its Hellenistic-Byzantine location, under the modern harbour of Tyre.



Schematic paleogeographic maps of Tyre highlighting the effect of the formation of the sandy isthmus on its two Phoenician harbours, the displacement of the northern harbour further north, and the repurposing of the southern harbour into a Roman baths area. Red & blue dots: corings. Arrows: net sand flux (blue: marine, white: terrestrial). Numbers on left panel refer to the minimum, currently constrained elevation of the calcarenitic bedrock relative to the ancient sea level at -2.5 m.

Earlier interactions between port development and sediment deposition

The evolution of the marine landscape of Tyre was influenced by the development of the city well before Alexander's conquest. Tyre started as a small offshore outpost of the city of Ushu, or Palaeotyre (Old Tyre), which was founded on the stretch of coast facing the island. Urban and port development really started on the island after 1 500 BCE (Bikai, 1987). Various archives indicate that some islets were then probably interconnected, enlarging the original island, and improving shelter from sea waves to such an extent that by 1 350 BCE, the Tyrian king Abimilky reportedly stationed battleships in a proto harbour in the lee of Tyre Island (Amarna Letter EA 153). As sedimentation in the lee of Tyre Island further progressed, a submarine sand bank formed, built by the refraction and diffraction of waves around the island. A large harbour was still present in the lee of the island by around 1 200 BCE (Anastasi 1 papyrus) but the accumulation of sand over the sand bank had led to its partial emergence, creating a coastal "salient" attached to the lee of the island. Around 950 BCE, famous Tyrian king Hiram I, friend of King David and King Solomon, connected one more islet to the main island, and reclaimed the area in between, which was called "Eurychoros" (wide space, agora) by Menander, according to Josephus Flavius (Apion, 1, 17-18). Hiram I obviously used the naturally formed salient and extended it through additional land reclamation. By then, the initial single harbour in the lee of the island had probably been largely occupied by the sand bank, and a new layout with two harbours had to be implemented, with a northern Sidonian Harbour and a southern Egyptian Harbour, set astride the growing sandbank. We do not know who might have carried out the work, possibly Hiram I himself, or one of his successors, possibly Ethbaal I around 875 BCE (Katzenstein, 1973). At that time, the southern harbour could have been the main one, as a north-south reef aligned with Tyre Island better protected the whole southern bay, which therefore could have been used as a summer anchorage area.

Both harbours were probably used for several centuries, while the city remained an island, as documented by the bronze bands of Balawat (858 BCE) and by Esarhaddon's Annals (671 BCE). During that time the city prospered and resisted several important sieges (Salmanazar V, from 726 to 722 BCE, Nebuchadnezzar II, from 585 to 573 BCE), weathering also earthquakes and tsunamis (760-750 BCE, 590 BCE, 525 BCE, 199-198 BCE, 148-130 BCE, 92 BCE, 19 CE, 303 CE, 502 CE, 551 CE and many more after that) (Gatier, 2011a).

After Alexander-the-Great built his causeway, the tombolo formed, and the harbours were once again threatened by sand accumulation. The northern harbour was moved away from the tombolo, at its current location, below the modern harbour. The southern harbour, on the other hand, was abandoned, possibly even before the Romans arrived in the area in 64 BCE (Gatier, 2011b). They probably used sand removed during the levelling of the tombolo for further land reclamation and built the monumental Roman baths and an urban district starting in the 1st century CE. The research team suggested that the structures described by Poidebard (1939) are the Roman seawalls that protected this urban area from sea waves.

An estimated 2.5 m relative sea level rise affected the site, submerging the southern harbour structures. The age of this submergence is still poorly constrained, but it most likely occurred quite late during Antiquity, possibly in Hellenistic and/or Roman-Byzantine times (between say 500 BCE and 500 CE). The sea then overtook the seawalls of the southern district, gutted the Roman landfill, and unearthed the Phoenician quay- and breakwater-structures that were beneath it, exposing them on the seafloor.

How long did it take for the sand to pile up between Tyre Island and the mainland?

The research team conducted sand flux and sand volume calculations to provide a rough estimate of the time required for coastal processes to accumulate the sand volume currently contained in the peninsula that connects the former island of Tyre to the mainland.

The influence of tidal currents is negligible because the tidal range oscillates between 30 cm (neap tides) and 50 cm (spring tides). Longshore sediment transport is therefore determined by winds and waves (Nir, 1996). The sandy isthmus of Tyre started to form during the Roman Climatic Optimum (200 BCE-100 CE), the climate of which is regarded as similar to the present-day (Murray, 1987). The team therefore used the present-day wind and wave climate at Tyre (fr.wisuki.com) to assess sand fluxes at Tyre. The strongest winds (> 50 km/h) come from the southwest, with weaker winds (0-20 km/h) tracking from northwest. Waves come from a narrow western sector, with some northwest storms.

Littoral drift is quantified by several more or less complex formulae. The simplest and most widely used one was proposed by CERC (US Army Corps of Engineers) in 1984:

$Q = K.\ H^{2.5}.\ \sin(2\theta)$

where Q is the littoral drift (in m^3/year), K is a coefficient determined by wave steepness and sand grain size, H is the wave height at breaking (in m), and θ is the angle (in °) of incidence of waves on the coastline at the breaker line. Littoral drift is nil for wave crests parallel to the coastline (θ = 0°), increases to a wave incidence up to 45° and diminishes at higher values.

At Haifa, to the south of Tyre, modern longshore drift moves 50 000-80 000 m^3/yr of sand northwards (Zviely, 2007) for a mean incidence angle of waves of θ = 10°. Assuming this sand transport capacity at Haifa, the decrease in the incidence angle to θ = 6° at Tyre implies that longshore transport capacity at Tyre is reduced by a factor 0.6 to 30-50 000 m^3/yr.

The total volume of sand accumulated behind Tyre Island was calculated as the difference between the elevation of the modern onshore and offshore surface of the sandy isthmus and the elevation of the substrate over which the sands were deposited. The resulting volume of sand accumulated behind Tyre Island before 332 BCE was estimated to 10 million m^3, and the volume accumulated after 332 BCE, to 30 million m^3 (Brocard et al. 2024).

This volume required 6 to 10 centuries to accumulate at a rate of 30 000 to 50 000 m^3/yr, which means that the isthmus would have been able to reach its current size between the 3rd and the 7th century CE.

Conclusion

The harbour history of Tyre, spanning a period of 3 500 years, is one of abandonment and relocation of infrastructures, resulting in a complex pattern of structures, often superimposed one on top of the other. The development of many ancient ports was hampered at some point by a geological process of some sort, such as tectonic uplift or subsidence, soil settlement in deltas and estuaries, and, most commonly, by coastal progradation, either by direct ingress of fluvial sediments in estuaries and deltas, or by coastal accretion down drift of river mouths. There, man-made structures affect longshore sediment transport. For example, sand accumulated updrift (south) of the Roman port of Caesarea Maritima, but Tyre, in southern Lebanon, constitutes a remarkable case by the large amplitude of changes imparted by man-built structures. The only other case of such an amplitude is Alexandria (Egypt), and in both cases, the most important changes have been caused by… Alexander-the-Great.

Acknowledgements

Directorate General of Antiquities (DGA) of Lebanon. Mission Française Archéologique de Tyr supported by the French Ministry of European and Foreign Affairs (MEAE) and the IFPO (Institut Français du Proche Orient). Agence Nationale pour la Recherche ANR [AquaTyr, 2022]. Honor Frost Foundation. Geoarchaeologia society. INSH-Institut National des Sciences Humaines et Sociales (International mobility grant SMI). Thanks to Sylvia Vinai for the nice pictures.

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