Geoscience rediscovers Phoenicia’s buried harbors

Nick Marnier*, Christophe Morhange*, Claude Doumet-Serhal*; Centre National de la Recherche Scientifique (CNRS) CEREGE UJF UMR 6635, Europé de l’Arbois, 13545 Aix-en-Provence, France; British Museum, LBPNM, 11 Canning Place, London W8 5AD, UK; Centre National de la Recherche Scientifique (CNRS) UMR 5805 EPOC, Université de Bordeaux I, Avenue des Facultés, 33405 Talence, France.

ABSTRACT

After centuries of archaeological debate, the harbors of Phoenicia’s two most important city states, Tyre and Sidon, have been re-discovered, and including new geochronological results reveal how, where, and when they evolved after their Bronze Age foundations. The early ports lie beneath their present urban centers, and we have indentified four harbor phases. (1) During the Bronze Age, Tyre and Sidon were characterized by semi-open marine coves that served as protoharbors. (2) Biostratigraphic and lithostratigraphic data indicate the presence of early artificial basins after the first millennium B.C. (3) The harbors reached their apogee during the Greco-Roman and Byzantine periods. (4) Silting up and coastal progradation led to burial of the medieval basins, lost until now.

Keywords: geochronology, coastal geomorphology, ancient harbor, Mediterranean.

INTRODUCTION

Since 1998, a multidisciplinary team under the auspices of the British Museum and the United Nations Educational, Scientific, and Cultural Organization’s World Heritage Centre has been investigating the environmental history of Phoenicia’s two most famous city states, Tyre and Sidon, located on the present-day Lebanese coast (Figs. 1 and 2). The sites have long histories of human occupation extending back to the Middle Bronze Age (Katz- enstein, 1997), and both cities were important trade centers during the Phoenician, Persian, Greco-Roman, and Byzantine periods. Paradoxically, in spite of their celebrity and former splendor, very little can be gleaned from the ancient sources vis-à-vis their coastal paleoenvironments, and our knowledge of the cities’ ancient harbors is meager at best. Since the seventeenth century, the locations of Phoenicia’s ancient harbors have been the subject of continuous archaeological speculation (Renan, 1864; Poidebard, 1939; Poidebard and Lauf- fray, 1951; Frost, 1971, 1973). Unfortunately, research during the past 30 yr has been hindered by political unrest in the region, and until our investigation the scientific community has known nothing of the evolution of these harbors over the past 6000 yr.

Geological Context

The Tyre-Saida block is bounded to the east by the Roum fault and to the south by the Rosh Haniza–Ras Nakoura fault. The internal fan-shaped fault pattern of this panel is characterized by dominantly NW-trending dextral faults to the south and NW-trending sinistral faults to the north (Dubertret, 1975; Ron et al., 1984; Ron and Eyal, 1985). Subsidence in the Tyre area since antiquity is corroborated by submerged urban quarters and quarries on the island’s southern coast, currently 2.5 m below mean sea level (MSL) (El Amouri et al., 2005); the northern harbor’s ancient breakwater also lies 2.5 m below MSL. The breakwater, 3 m high and composed of at least 5 thick stone layers, has recorded a relative sea-level rise of at least 3.5 m since antiquity. In contrast to Tyre, relative sea level in Sidon has been more stable during the late Holocene. Raised geomorphological shoreline markers are scattered and their elevations are low. On the offshore harbor island of Zire, 500 m from mainland Sidon (Fig. 2), the bottom of an ancient quarry is sealed by beach rock at +0.5 m. It contains quarried blocks mixed with well-preserved shells of Pirenella concava. The radiocarbon age of these shells constrains the submergence of the quarry to 2210 ± 50 B.P. The margins of the quarry also show an uplifted notch at +0.5 m concomitant with this underwater phase. Close examination of beach-rock thin sections shows that this sediment has experienced at least two different diagenetic environments, meteoric followed by marine. Zire Island has therefore undergone a minor movement, with the onset of the downwarping tendency being dated.

METHODS

Our discovery of the two Phoenician harbors was made possible using high-resolution geoscience techniques, the robustness of which has been demonstrated at other ancient harbor sites around the Mediterranean (e.g., Reinhardt and Raban, 1999; Kraft et al., 2003; Gislen and Morhange, 2003).

Coring was used to elucidate the Holocene coastal stratigraphy of both Tyre (25 cores) and Sidon (15 cores). We used a network of cores to retrace Holocene shoreline evolution and harbor infilling. High-resolution lithostratigraphic and biostratigraphic analyses were undertaken under standardized laboratory conditions (see GSA Data Repository*).

New 14C dates (n = 42) precisely constrain the chronology of the various sedimentary environments observed (Table DR1; see footnote 1). All dates were calibrated using the OxCal program and are quoted to 2σ. Material dated included seeds, wood, charcoal remains, and in situ molluscan marine shells. Marine shells have been corrected for a reservoir effect of 400 yr (Stuiver et al., 1998; Reimer and McCormac, 2002).

RESULTS AND DISCUSSION

Our geological data have identified the following four harbor phases (Fig. 3).

Bronze Age Protoharbors (ca. 3000–1200 B.C.)

During the Bronze Age, natural downwind embayments and coves north of the Tyrian and Sidonian promontories were attractive sites for anchorage havens. Since sea level attained broad stability ca. 6000 B.P. (Laborel et al., 1994; Bard et al., 1996; Fleming et al., 1998), the northern coast of Tyre has been naturally semiprotected by a small Quaternary ridge complex (Fig. 1). Up until the first millennium B.C., biostratigraphical and lithostratigraphical signatures from the Tyrian Bronze Age basin were typical of a semi-open marine cove. Medium to fine sands characterize the stratigraphic unit, which is dominated by breckish-lagoidal and coastal oolitic assemblages, with infaunal sand and upper muddy sand macrofauna assemblages (Fig. 3; see Data Repository* for detailed data sets). Shallow draft boats would have been hauled onto the beach face, and more sizable merchant vessels anchored in the bay, their...
cargoes ferried to and from the proximal shoreline by smaller vessels.

In the northern harbor of Sidon, a similar protohabor phase has been dated to the Middle Bronze Age, ca. 3600 B.P. (1700–1450 B.C.). Compared with Tyre, Sidon’s northern basin afforded better shelter because it has been naturally protected by a long, 600 m offshore Quaternary ridge for the past 6000 yr. Deposition of fine-grained sand records early sheltering of the bay. This facies is dominated by brackish-lagoonal (Cyprideis torosa, Loxoconcha elliptica) and marine-lagoonal (Loxoconcha spp., Xestoleberis spp.) ostracod assemblages, in addition to infraunal sand and upper clean sand macrofauna assemblages. In Sidon, the Middle Bronze Age was a period of rapid urbanization with extensive economic activity (Doumet-Serhal, 2003), and this semi-protected harbor phase appears concomitant with the beginnings of early port infrastructure. The existence of artificial harbor works during the Middle Bronze Age is debated. Frost (1995) attributed the early maritime infrastructure of Arrados, Syria, on the Levantine coast, to the Bronze Age, and a harbor quay in Dor, Israel, has been dated to the 1200–1300 B.C. (Raban, 1995). The Middle Bronze Age site of Yavne-Yam, Israel, also shows the presence of submerged boulder piles, which were used to improve the quality of the ancient anchorage.

Semi-artificial Phoenician and Persian Harbors (ca. 1200–332 B.C.)

During the first millennium B.C., rising sea levels and expanding international trade (i.e., the need for greater docking capacities) forced the Phoenicians to build artificial harbor works. The widespread use of metal, notably iron, in naval construction meant that larger and stronger boats could be built, capable of sailing much greater distances. The semi-protected harbors built by the Phoenicians were characterized by accelerated sedimentation rates and a significant rise in silts (Fig. 3). Fine-grained tolerant biocenoses dominated assemblages of marine fauna.

Scouring and dredging practices during the Roman and Byzantine periods explain why early first millennium B.C. strata are often absent (see following). In Caesarea, dredging of muds has also been invoked to explain sediment gaps observed in the ancient harbor stratigraphy (Reinhardt et al., 1998).

Slight differences in molluscan assemblages between Tyre and Sidon are linked to the regional geomorphological context. The island of Tyre is located downwind of the Litani delta, a competent watercourse transporting mainly sands. Acting as a base-level sediment sink, Tyre’s northern harbor preferentially trapped fine sands, creating biotopic conditions favorable to the development of upper clean sand assemblage taxa. By contrast, Sidon’s northern harbor was much better pro-
Figure 3. Synthesis of Holocene facies from Tyre and Sidon’s ancient harbor basins.

Figure 4. Maximum extension of Tyre’s Middle Bronze Age northern harbor. Our work reveals that the ancient harbor was ~40% larger than present, with the heart of the ancient basin beneath the medieval and modern city center. Alexander the Great’s causeway was constructed to breach the island city’s defenses in 332 B.C. Core locations are denoted by black dots. Maximum harbor extent is represented by black and white line. Dotted line marks approximate island limit by Greco-Roman time.

increase in sedimentation rates (0.5–1 mm/yr to 10 mm/yr) is measured during the Roman and Byzantine periods. Such rapid accretion is related to changing modes of land occupation during antiquity, and it is well documented that sifting up of harbers was problematic at that time (Blackman, 1982). Our chronostratigraphic data demonstrate that, to share this, the Romans and Byzantines dredged the shallow bottoms, maintaining a workable harbor depth and large docking capacity (Marriner and Morhange, 2005). Inside the caves, this human-induced shortening of the sediment column did not result in biofacies and lithofacies modifications; i.e., the composition of the biocenose of the sedimentary assemblages is identical from the Iron Age up to the Roman period. This phenomenon has been observed in sections at a number of harbor excavation sites; e.g., there is extensive evidence for dredging in the Roman harbor at Marseilles, and in Naples from the fourth century B.C. onward. Rapid siltting up persisted in the harbor basins of Tyre and Sidon until ca. A.D. 500–900.

Medieval Destruction Phase

After the Byzantine period, the economic demise of Tyre and Sidon as important trade centers is clearly recorded by exposed beach units, a classic feature of all semi-abandoned harbors (Golran and Morhange, 2003). At both sites, an increase in coastal (Avulia woodwardii and Avulia convexa) and marine ostracod taxa is to the detriment of formerly abundant brackish-lagoonal species (Cyprides toretos). A plethora of extra-sites macrofauna assemblages indicates a reopening of the environment to offshore marine processes,
ACKNOWLEDGMENTS

We thank the Directorate General of Antiquities of Lebanon, CEDRE. UNESCO World Heritage, the Lebanon British Friends of the National Museum, and the Association Internationale de recherche pour la Sauvegarde de Tyr, particularly M. Chalas, for technical and financial support. Murrer has benefited from an Emirite Cordiale scholarship (2004-2005) and a Leverhulme Study Abroad Studentship (SAS2005/400032). We also thank D.E. Fosovsky, R. Hetherington, A. Long, E. Marcus, P. Pirazzoli, and two anonymous referees for their helpful comments on earlier versions of this paper.

REFERENCES CITED


Manuscript received 18 May 2005
Revised manuscript received 22 August 2005
Manuscript accepted 27 August 2005
Printed in USA

Figure 5. Maximum extension of Sidon’s Middle Bronze Age harbors. Lithostratigraphic studies of cores from southern cove reveal no fine-grained harbor facies. This is consistent with a natural, fair-weather open harbor, where small vessels would have been hauled onto beach face. During storms, largest vessels sought shelter in better-protected northern harbor or on lee-ward side of Ziro outer harbor. Core locations are denoted by black dots. Maximum harbor extent is represented by black and white line.

whereby deteriorating infrastructure no longer sheltered the ancient harbor confines.

CONCLUSIONS

We have demonstrated that a multiproxy geoscience methodology is a powerful archaeological tool, overcoming many of the financial and technical difficulties faced by field archaeologists today (Stanley et al., 2004). These nondestructive techniques have clear scope for use at other sensitive coastal sites, and the use of soft sediment geological records is an insightful means of deciphering ancient history. Our results allow us to accurately retrace the maximum limit of Tyre and Sidon’s Middle Bronze Age basins, and to show that large portions of these have since silted up and are now buried beneath the city centers (Figs. 4 and 5). This evolution has been induced by sediment trapping, a phenomenon that has preserved these historical archives and offers exceptional prospects for future archaeological research. The locations of Tyre and Sidon at the distal margins of small deltas explain why these two harbors are still in use today and why they have not, as is the case of Troy’s harbors (Kraft et al., 2003) and the Mazarnd delta (Brückner et al., 2002), undergone kilometers-scale coastal progradation to become landlocked sites. This work has far-reaching implications for our understanding of Phoenician maritime history and provides a unique opportunity to conserve Phoenician cultural heritage.

GEOLGY, January 2006