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Geoarchaeology of Beirut's ancient harbour, Phoenicia

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ABSTRACT

This paper presents geoarchaeological results from the ancient harbour of Beirut (Lebanon). As at Sidon, knowledge of Beirut's ancient tell has advanced significantly over the past decade, thanks namely to redevelopment of the city centre and excavations centred on the modern port. In spite of this research, understanding of the city's coastal palaeoenvironments during antiquity is poor. Buried Iron Age harbourworks presently 300 m from the sea attest to pronounced coastal changes during the past 3000 years. These processes have been significantly accentuated during the last two centuries by redevelopment of the port, which remains in use some 5000 years after its foundation. Here we elucidate the coastal stratigraphy east and west of the Bronze Age tell to yield new insights into the evolution of the Beirut seaboard, in addition to the complex history of human–environment interactions. These chronostratigraphic data are subsequently used to (1) precisely locate the main anchorage haven during antiquity; and (2) propose a chronology for its evolution.

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1. Introduction

Whilst archaeological discovery in Lebanon has a long and productive history, research in the nation's capital has been hampered by enduring demographic, geographic and geopolitical factors (Renan, 1864; Chéhab, 1939; Mouterde, 1942–1943; Lauffray, 1944–1945, 1946–1948; Elayi and Sayegh, 2000; Curvers and Stuart, 2004; Doumet-Serhal, 2004). Although it is known from written accounts that Beirut played an important role in world affairs, especially during the Roman and Byzantine periods (Mouterde and Lauffray, 1952; Hall, 2004), precise archaeological and topographical data regarding the city have long been missing. Despite the fact that the identification of ancient Bêruta/Berytos/Berytus with modern Beirut had never been called into question, the exact location of the ancient city and tell within the modern agglomeration was open to fervent debate (de Vaumas, 1946; Davie, 1987). Sporadic surveys by 20th century scholars tended to suggest the ancient city lay in an area between the present port, delimited by rue Foch to the east, rue Allenby to the west, and the place de l'Etoile to the south (Fig. 1). Beirut has, however, been built up progressively on ancient habitation layers rendering extensive archaeological excavations in such a dense urban fabric politically and logistically difficult (Forest and Forest, 1977).

Against this backcloth of data paucity, plans to reconstruct and modernise Beirut's city centre during the early 1990s offered exciting opportunities to explore the evolution of this important site on an unprecedented scale (Lauffray, 1995; Lefèvre, 1995a,b). The area surrounding the present seaport is rich in buried archaeological monuments and relics, bearing witness to a complex history of human occupation spanning some 5000 years (Gavin and Maluf, 1996; Elayi and Sayegh, 2000; Curvers and Stuart, 2004; Doumet-Serhal, 2004). Since 1993, national and international institutions have supported a project involving hundreds of archaeologists covering the quasi-totality of ancient Beirut, and notably the ancient centre demarcated by the medieval walls.

For *Solidere*, the reconstruction agency, one of the early concerns was to marry urban development with archaeology so that the rich heritage of the city centre could be integrated into the rebuilding process. Unfortunately, as wealthy developers and politicians vied with archaeologists, the project received criticism from some quarters for falling short of many of these initial goals, this in spite of rigid government legislation designed to avoid bygone errors (e.g. the Lebanese Antiquity Law; Lauffray, 1995; Karam, 1996; Naccache, 1996, 1998; Seeden, 1999; Raschka, 2006). Nonetheless, the unique urban excavation has produced a great mass of data since its inception in 1993 (Perring et al., 1996; Saghieh, 1996; Butcher and Thorpe, 1997; Cumberpatch, 1997; Curvers and Stuart, 1997, in press; Finkbeiner and Sader, 1997; Heinze and Bartl, 1997; Thorpe, 1998–1999; Thorpe et al., 1998–1999; Elayi and Sayegh, 2000; Faraldo Victorica and Curvers, 2002; Doumet-Serhal, 2004).

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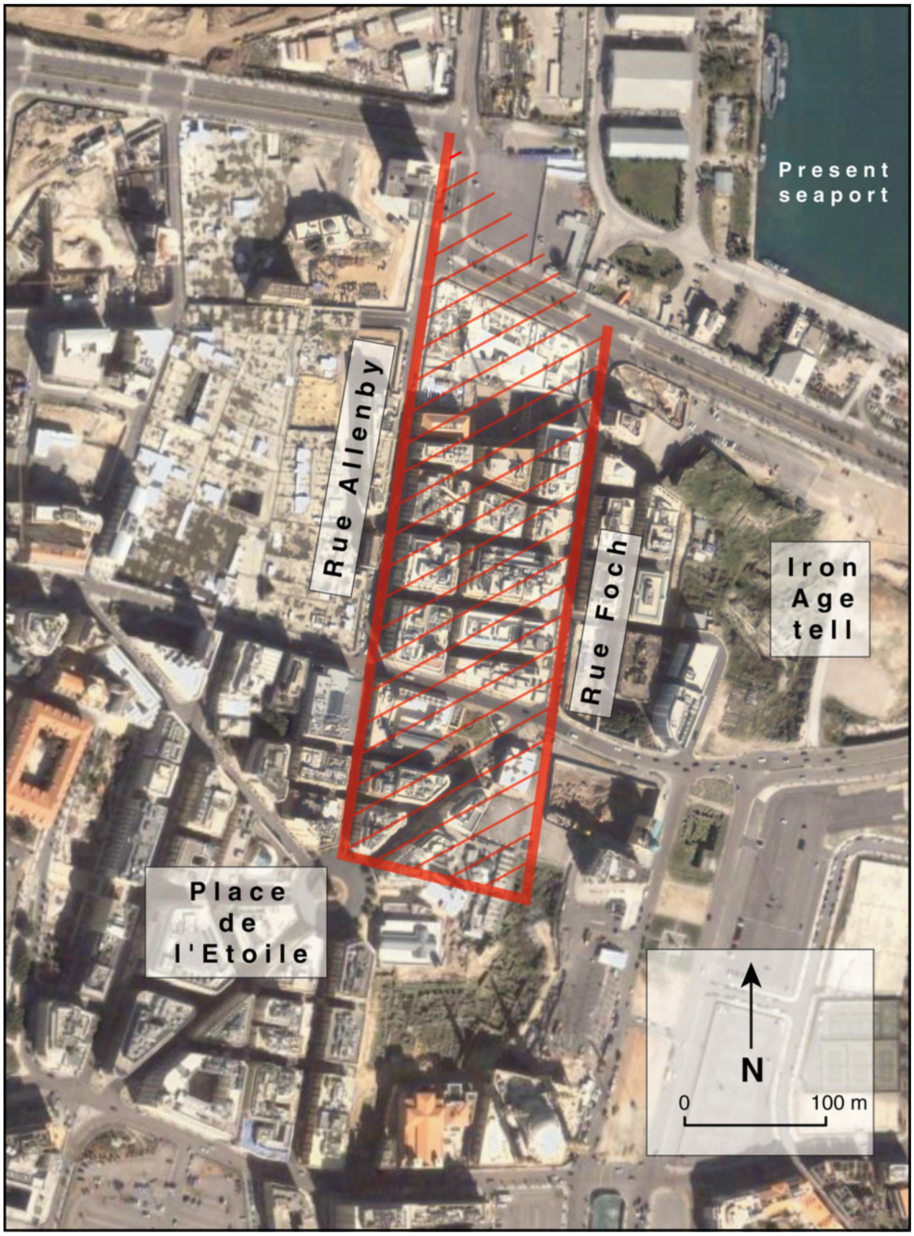


Fig. 1. Early archaeological surveys tended to suggest that the ancient city lay in an area between the present port seaboard, delimited by rue Foch to the east, rue Allenby to the west and the place de l'Etoile to the south (Renan, 1864; Chéhab, 1939; Mouterde, 1942–1943; Lauffray, 1944–1945, 1946–48; de Vaumas, 1946; Mouterde and Lauffray, 1952; Davie, 1987).

Without doubt, the main positive outcome of the project has been the spatial coverage of archaeological and topographical data obtained for both the ancient and historical periods (Elayi and Sayegh, 2000; Curvers and Stuart, 2004). From a geoarchaeologist's standpoint, therefore, coupling this data with a study of the coastal stratigraphy offered unprecedented opportunities to (1) accurately relocate the city's ancient harbour(s); (2) precisely reconstruct 5000 years of coastal deformation; and (3) better comprehend human–environment interactions at both the local and regional scales, through a comparison with Sidon and Tyre (Marriner et al., 2005; Marriner and Morhange, 2006a,b).

2. Archaeological and geomorphological contexts

Beirut's rocky promontory, 6 km long by 2 km wide, is one of the most defining geomorphological traits of the otherwise rectilinear Lebanese coast (Dubertret, 1940). Wedged between the Mount Lebanon range to the east and the Mediterranean to the west, the promontory is surrounded by the sea on two of its three sides; it is intersected by a network of transverse faults which cut across the Lebanon chain (Figs. 2 and 3; Dubertret, 1955).

The peninsula attests to a long history of human occupation beginning in the middle Palaeolithic (Fleisch, 1946; Copeland and Wescombe, 1965, 1966). Twenty sites are known from the Neolithic, the oldest of which was discovered in 1930 at Tell Arslan, 8.5 km south of Beirut, underneath a Roman habitation layer (Bergy, 1932). For later periods, Beirut's tell and city centre bear out 5000 years of continuous human occupation spanning the Bronze Age and Iron Age, in addition to the traces left by the Persian, Seleucid, Roman and Byzantine empires (Mouterde, 1966; Hall, 2004). At its greatest extent, archaeological evidence suggests that ancient Beirut covered an area of at least 1.2 km by 0.8 km (Mikati and Perring, 2006).

The ancient city was founded on the northern part of the peninsula, in a depression between two hills, Ashrafieh to the east

Fig. 2. Oblique aerial photograph of the Beirut agglomeration in 2006. The city occupies a peninsula sandwiched between the Mount Lebanon range to the east and the Mediterranean sea to the west. The ancient city lies on the northern flank of the peninsula, where its ancient anchorage was protected from the dominant south-westerly wind and swell.

(102 m above MSL) and Ras Beirut (95 m) to the west (de Vaumas, 1946; Figs. 2 and 3). Ashrafieh and the eastern portion of the Beirut promontory comprise Neogene marls, while Ras Beirut has been fashioned in Cenomanian limestones (Dubertret, 1955, 1975). Three periods of Quaternary sea level still-stand have cut abrasion platforms into the northern façades of Ashrafieh and Ras Beirut, at 85–100 m, 40–65 m and 6–20 m (de Vaumas, 1944; Sanlaville, 1977). The vast majority of the archaeology is concentrated upon the lower, northward facing terrace which reaches 800–1000 m width in the Nahr Beirut area (Sanlaville, 1977). The Ashrafieh–Ras

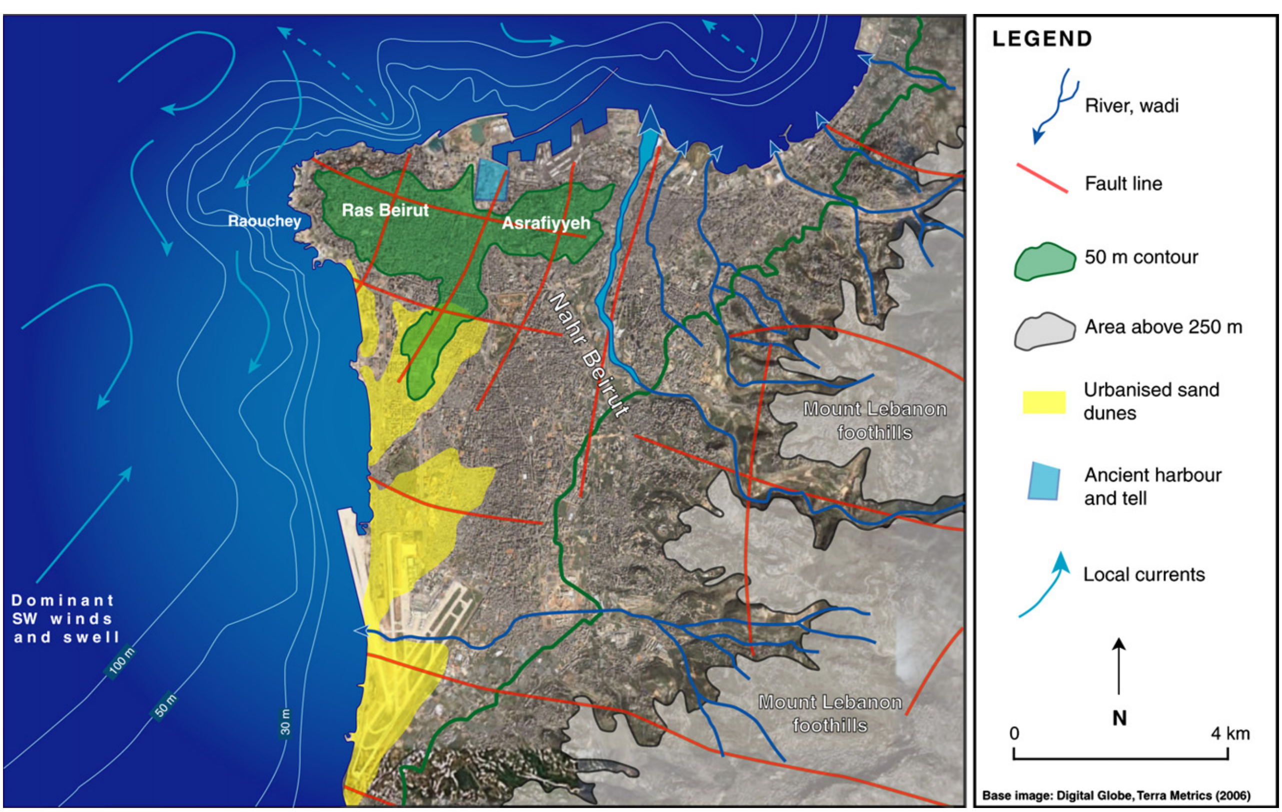


Fig. 3. Geography of the Beirut peninsula (base image: DigitalGlobe, 2006).

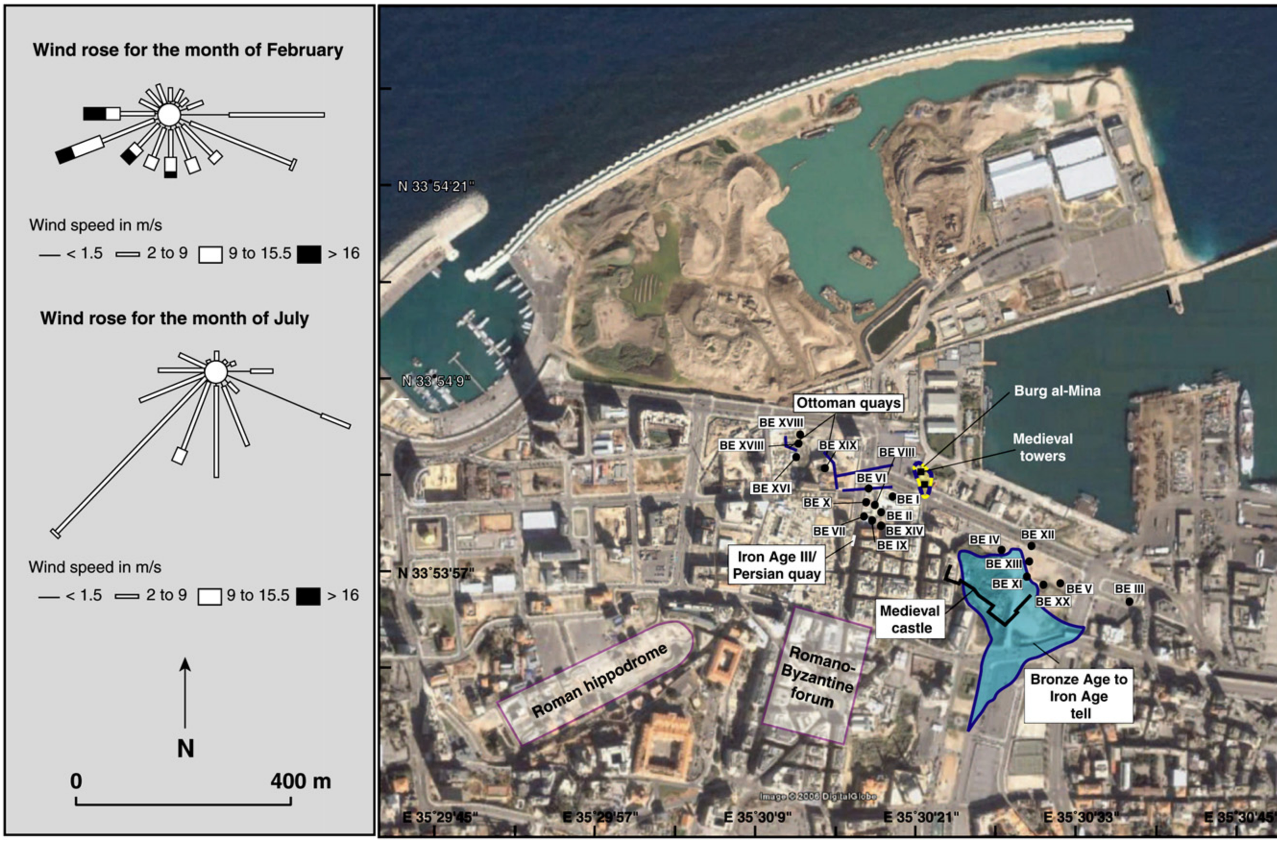
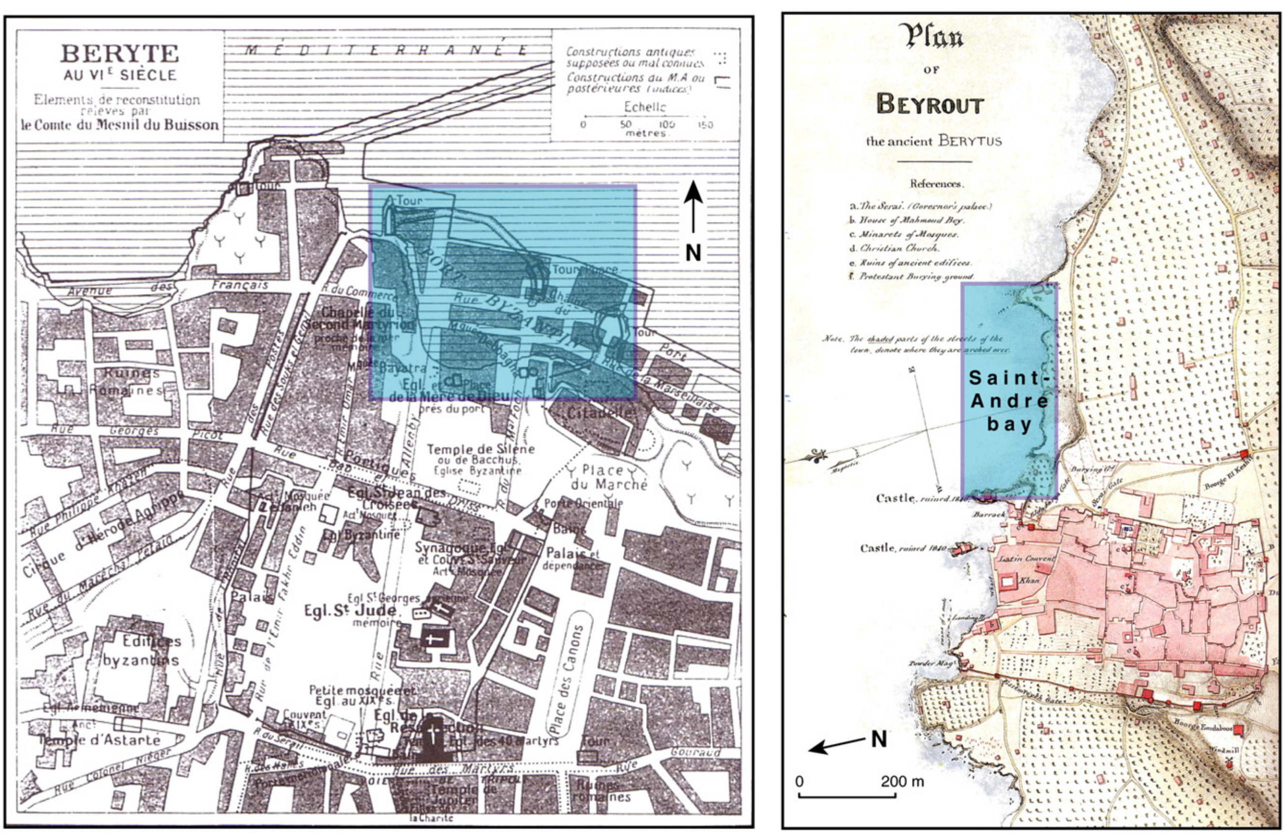


Fig. 4. Location of core sites at Beirut. Archaeological data from Elayi and Sayegh (2000) and Marquis (2004).



Mesnil du Buisson (1921)

Vaumas (1946) on Royal Engineers map of Beirut (1841)

Fig. 5. du Mesnil de Buisson (1921) and de Vaumas' (1946) hypotheses for the location of Beirut's ancient harbour (blue shading).

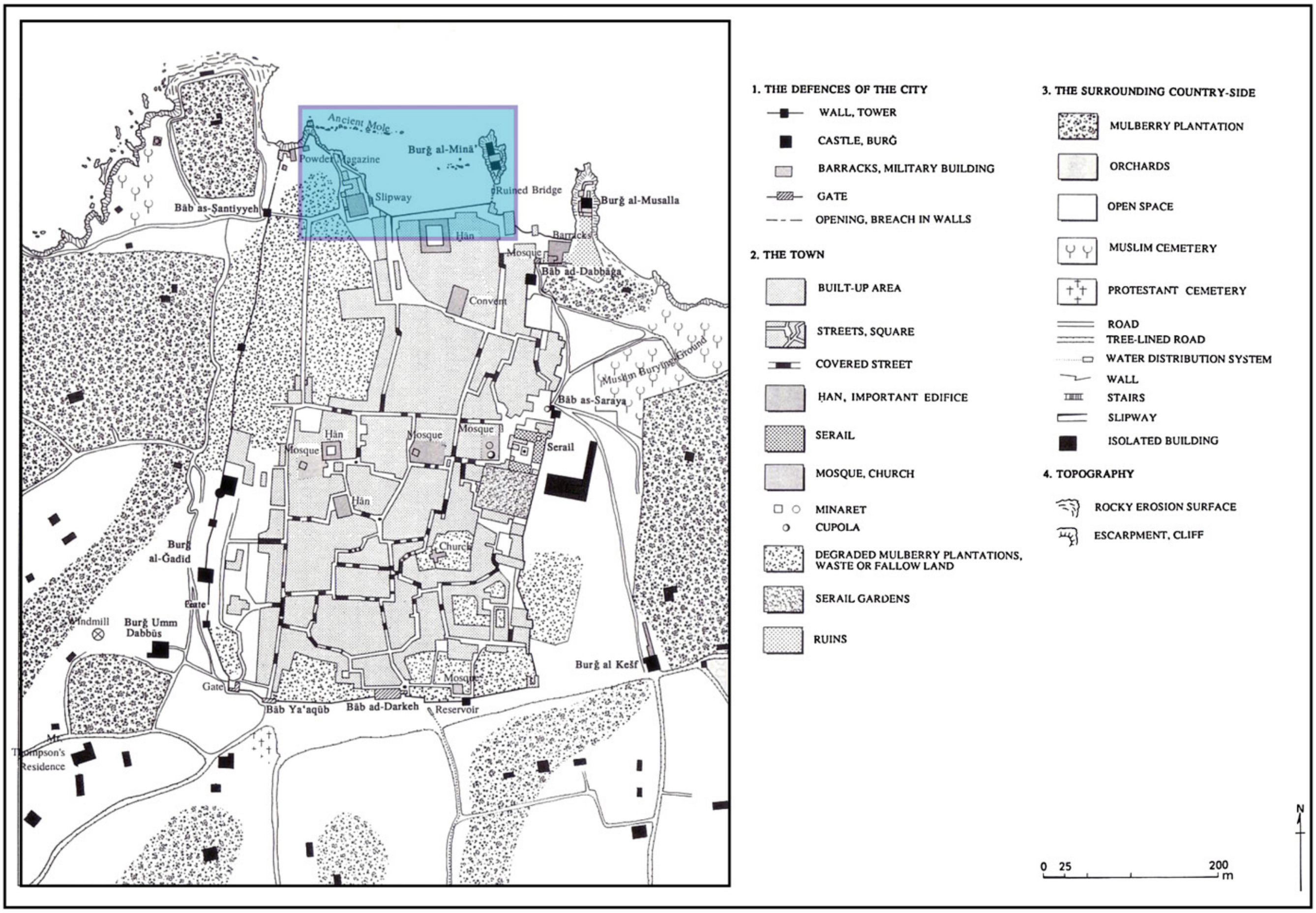


Fig. 6. Davie's (1987) proposed location for Beirut's ancient harbour.

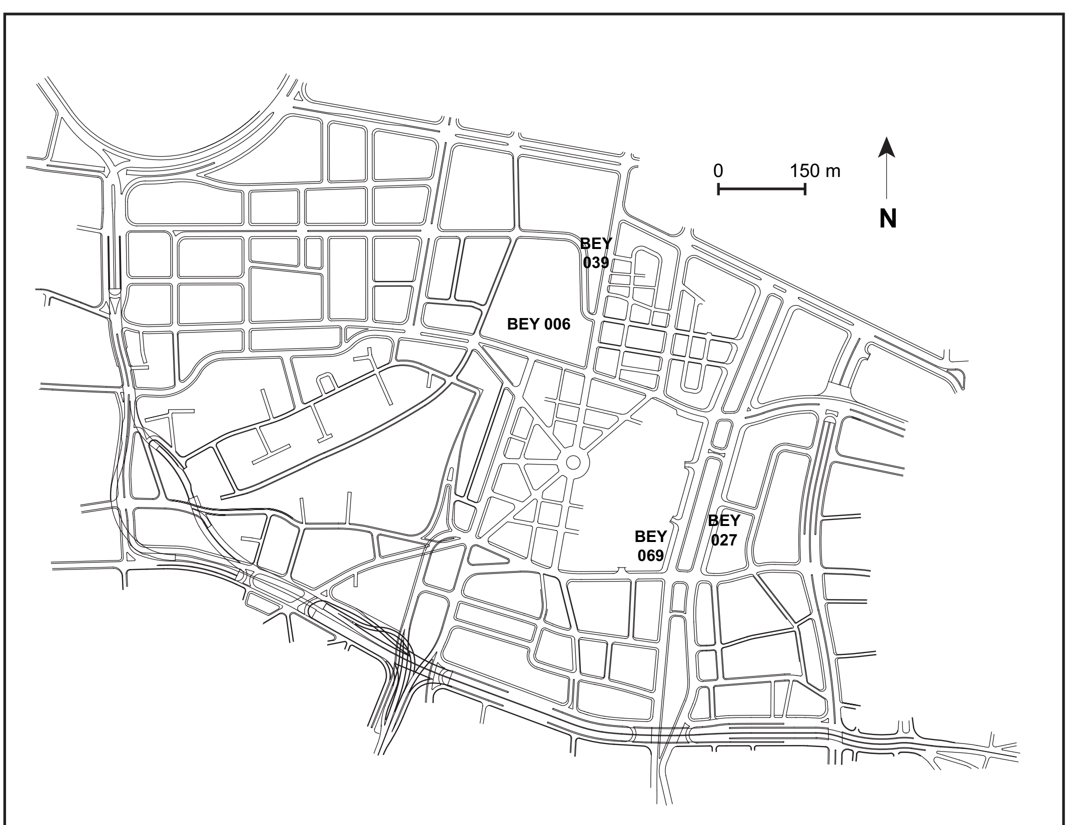


Fig. 7. Location of BEY archaeological sites discussed in the text (base map from Curvers and Stuart, 2004).

Beirut depression included a shallow bay open to the north, formed by the drowning of a talweg system after 6000 BP. It is this natural cove that later became the ancient seaport. In the centre was a small island, Burg al-Mina, while to the east and west two elevated land spurs closed the basin (Fig. 3, see Fig. 10 for the coastal map of Beirut in 1876). A SSW-NNE trending fault cuts from the port to Basta et-Tahta, and puts into contact the Neogene and Cenomanian formations (Dubertret, 1955, 1975).

This ancient city was very easy to defend: to the west access was blocked by the abrupt cliffs of Raouchey whilst the river Nahr Beirut prevented access from the east (Fig. 3). The Nahr Beirut, fed by its two tributaries Wadi Hammana and Wadi Salima, is 23 km long and

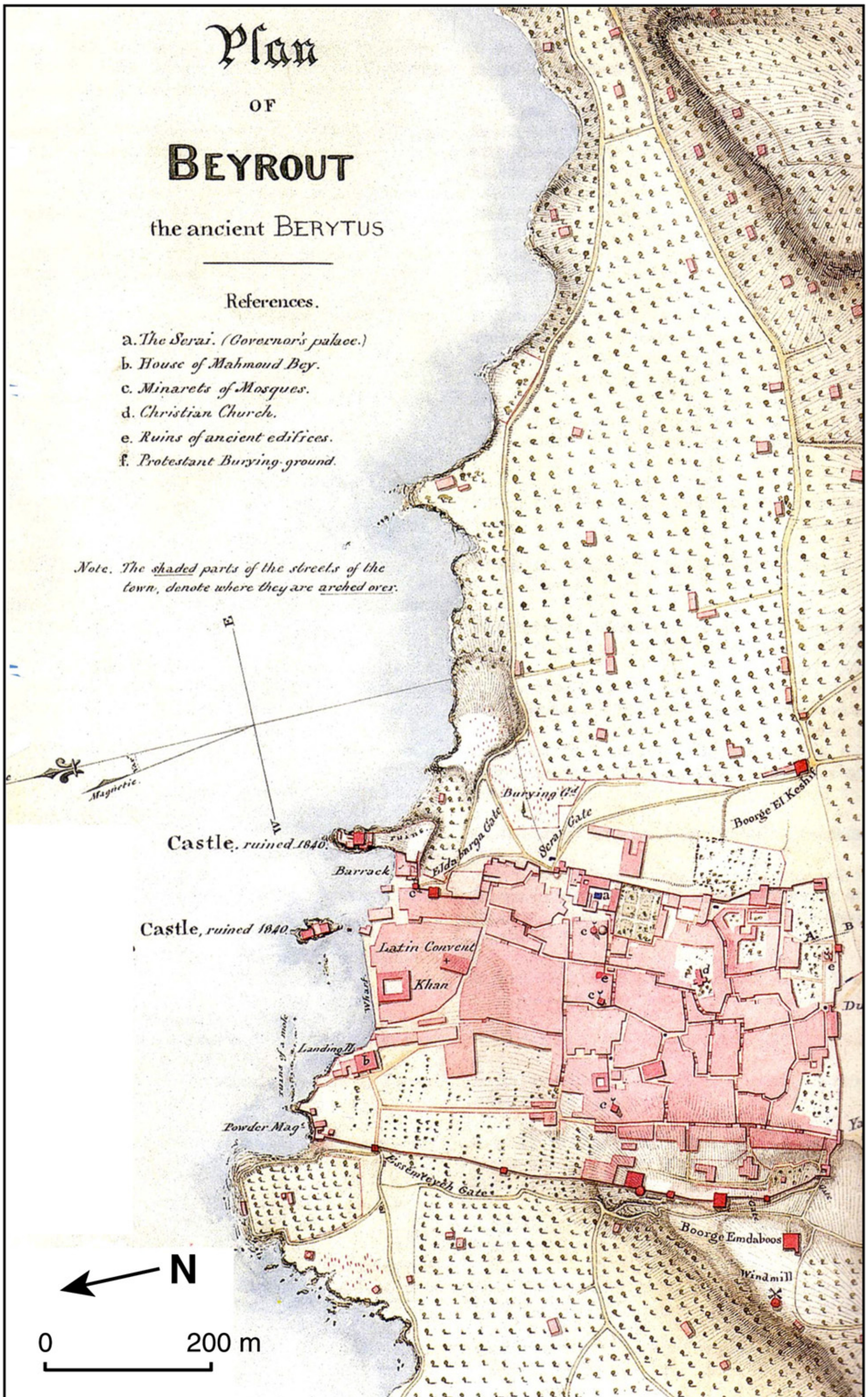


Fig. 8. Map of Beirut as it appeared in 1841 (Royal Engineers, 1841) before the significant construction works undertaken to modernise the ancient harbour. The port coastline has been significantly artificialised since this time (see figures overleaf).

flows in a narrow, deeply incised valley which diminishes as it approaches the sea (Fig. 3). To the south, defence was afforded by the hills of Ashrafieh. In ancient times, the only means to enter the ancient city was either by sea, via the port, or through a narrow talweg corridor between the hills of Ashrafieh and Ras Beirut (which presently runs between the roads of Damas and Basta).

During the Bronze and Iron Ages it appears probable that, as at Sidon, two urban nuclei existed, an ‘‘upper city’’ centred on the tell and a ‘‘lower city’’ on the banks of the ancient harbour (Elayi and Sayegh, 2000; Curvers, 2002). The Hellenistic and Romano-Byzantine cities were founded south, southwest and west of the ancient tell. Much of the city centre has preserved this rigid grid-like morphology, and features such as the Roman hippodrome and forum are still clearly discernible in the urban fabric (Fig. 4). Beside brief mentions in (1) second millennium Egyptian sources (Papyrus Anastasi I from Memphis, dated to the 13th century BC [Sayegh and Elayi, 2000]); (2) Late Bronze Age Ugaritic texts (RS 11.730, RS 34.137, RS 86.2212, RS 17.341 and letter CK 7 from the 13th–12th centuries BC [Arnaud, 1992]); (3) the El Amarna letters from Egypt, dated to the 14th century BC (Goren et al., 2004); and (4) the Periplus of Pseudo-Scylax (Periplus 104), dated to the 4th–3rd centuries BC, the port of Beirut remains curiously absent from the classical sources until the late Roman period. It is later abundantly cited in numerous Byzantine, Arab and medieval chronicles (Sayegh and Elayi, 2000).

Despite its former glory, Beirut was little more than a small fishing harbour by the 17th century. During the 19th century, Laorty-Hadji (1855) laments the demise of the harbour ‘‘Cà et là des débris et des fûts de colonnes, misérables restes de l’antique Béryte, servent dans le port à amarrer les bateaux. Formé par une jetée, ce port autrefois profond et commode, les habitants l’avaient laissé encombrer de ruines et de sables.’’ Jessup (1910) compounds his predecessor’s words ‘‘[…] there was no harbour, only an open roadstead, and boats landing from ships anchored outside would strike bottom before reaching the beach […]’’.

3. Methods and data acquisition

A total of 20 cores was drilled at sites around Beirut’s ancient tell (Fig. 4). We refer the reader to earlier papers on Sidon and Tyre for a detailed review of the equipment and methods used (Marriner et al., 2005; Marriner and Morhange, 2006a,b; Marriner et al., 2007). These include numerous sedimentological, biostratigraphical and chronostratigraphical proxies. Old city maps and engravings of Beirut have been studied to precisely reconstruct changes in the port coastline since the 19th century (Ormsby, 1839; Wyld, 1840; Löytved, 1876; Baedeker, 1912; Royal Engineers, 1841; Scott, 1841; Skyring, 1841; CERMOC, 1995, 2000). All maps were georeferenced before being superimposed to form a single chart. This composite map was subsequently married with the archaeological and stratigraphic data to yield insights into coastal deformations during the ancient and historic periods (Francou, 2002).

4. Where was Beirut’s ancient harbour located?

Before the recent excavations of the city centre, the exact location of Beirut’s ancient harbour had been open to ardent speculation. In the absence of solid archaeological evidence, four main hypotheses dominated the literature: (1) for du Mesnil du Buisson (1921), the harbour lay between Bab es-Santiye, Burg al-Mina island and the rue de la Marseillaise, just north of the present silted up basin (Fig. 5); (2) like his counterpart, Dussaud (1927) constrained the ancient port to the northern façade of the Beirut peninsula but is very vague in attributing a precise geographical location: ‘‘[…] la population de marins dût demeurer le long des anses, aujourd’hui en partie comblées, qui ouvrent vers le nord, disposition qui signale les meilleurs abris de la côte syrienne’’; (3) for de Vaumas (1946) the ancient harbour lay in the bay of Saint-Andre, the cove east of the Iron Age tell (Fig. 5); (4) finally, it was not until the 1980s that Davie (1987) proposed a plausible and well-argued hypothesis for an ancient seaport in the area between

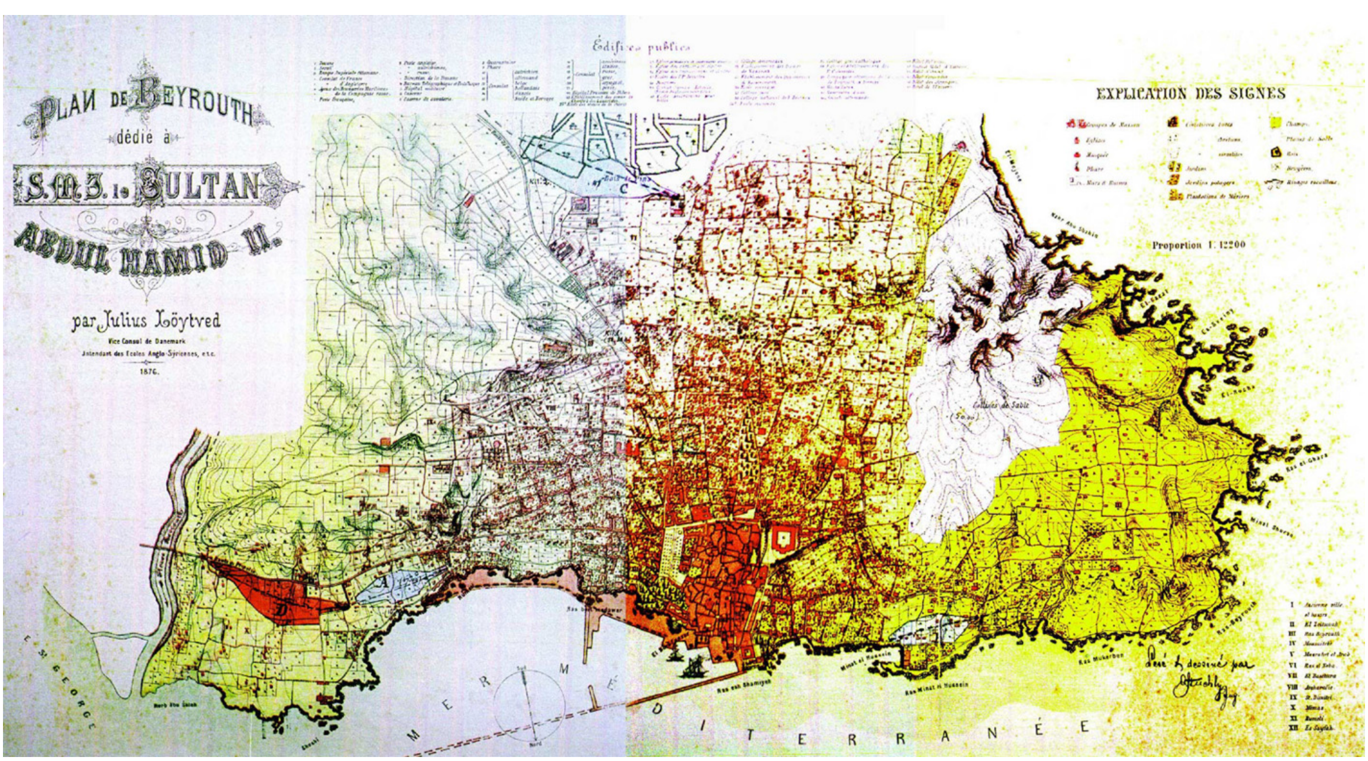


Fig. 9. Löytved’s (1876) map of Beirut in which the first phase of coastal redevelopment is clearly manifest.

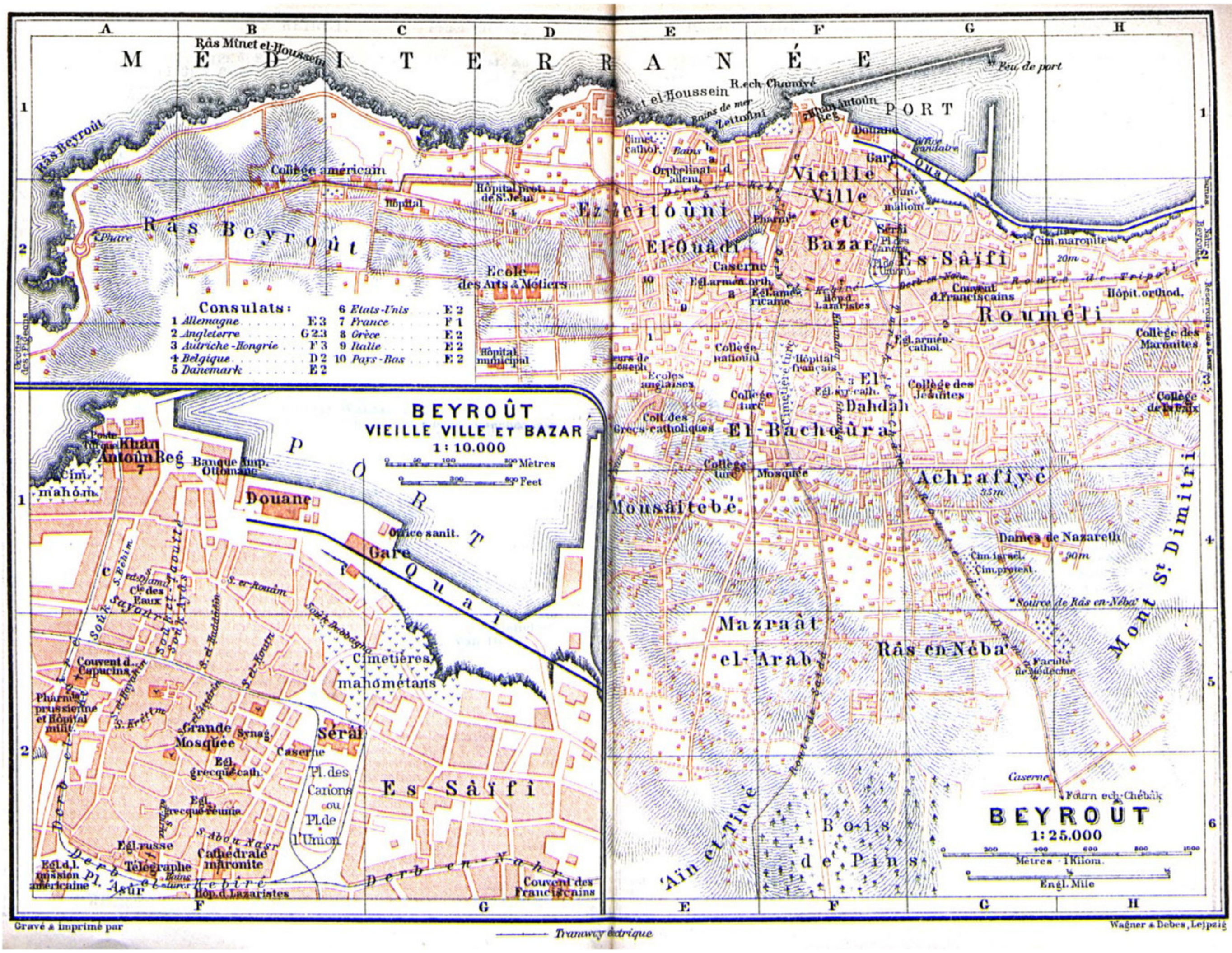


Fig. 10. Beirut [Beyrout] city centre and coastline in 1912 (from Baedeker, 1912).

Fig. 11. 5000 years of coastal deformation in Beirut's ancient harbour. Note the progressive regularisation of the coastline from a natural indented morphology to an increasingly rectilinear disposition during later periods (base image: DigitalGlobe, 2006). Archaeological data from Elayi and Sayegh (2000) and Marquis (2004).

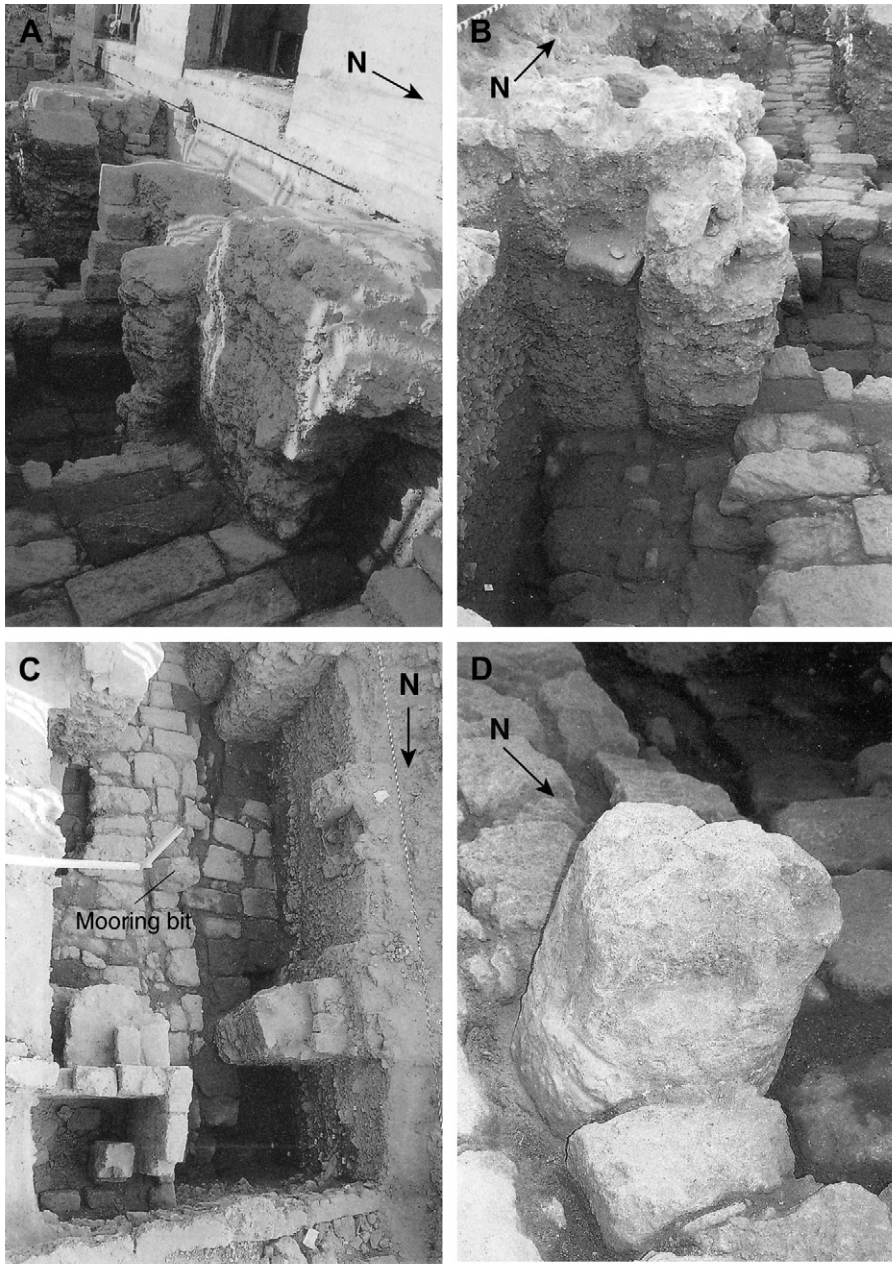


Fig. 12. A–C: Iron Age III/Persian harbour quay at excavation plot 039. The excavations at this plot covered ~3000 m^2. This quay presently lies ~300 m from the coastline. It shows the western bank of the harbour at this time, and also the south–north trending façade of the seaport in this area. The quay comprises ramleh sandstone blocks, measuring ~60 cm by 30 cm, and fixed together by a grey mortar. The two underlying strata constitute larger blocks (60 by 100 cm) stacked without the use of a mortar. This type of construction is typical of the Phoenician period. D. Quay mooring bit 140 cm from the quayside, 45 cm in diameter and fashioned in a ramleh sandstone block (all photographs from Elayi and Sayegh, 2000).

Table 1
Radiocarbon dates and calibrations

Sample name	Code	Nature of sample	Radiocarbon date (BP)	Cal. BP	Cal. BC/AD
Beirut BVIII 5	Poz-17616	Seed	1550 ± 30	1530–1370	420–580 AD
Beiut BVIII 7	Poz-20498	Pine cone fragment	1265 ± 30	1290–1090	660–860 AD
Beirut BVIII 9	Poz-20422	*Chamelea striatula*	5990 ± 40	6500–6290	4550–4340 BC
Beirut BVIII 14	Poz-17617	*Loripes lacteus*	8250 ± 50	8970–8610	7020–6660 BC
Beirut BIX 1	Poz-20499	Seeds	1235 ± 30	1270–1070	680–880 AD
Beirut BIX 3	Poz-20423	Seeds	1145 ± 30	1170–970	780–980 AD
Beirut BIX 6	Poz-20424	Seeds	1515 ± 30	1520–1330	430–620 AD
Beirut BX 5	Poz-20426	Wood fragment	1215 ± 30	1260–2320	690–890 AD
Beirut BX 7	Poz-20421	*Cerithium vulgatum*	2160 ± 30	1860–1660	90–290 AD
Beirut BX 11	Poz-17615	*L. lacteus*	6160 ± 40	6710–6480	4760–4530 BC

Zaytuneh and the Rivoli cinema, at the foot of the tell's southwestern flank (Fig. 6). In order to test these early hypotheses, 20 cores were drilled to the east and west of the ancient tell (Fig. 4).

Ancient Beirut lies in an area that was fertile, well-drained, flat and wide, and where the sea could be exploited for food and transportation. Whilst the internal structure of the city has remained relatively stable since antiquity, the biggest topographical changes have occurred along the southern coastal flank of the settlement. Iron Age harbourworks at excavation plot BEY 039 (rue Allenby; Fig. 7), more than 300 m from the present artificialised coastline, attest to significant coastal deformation during the past 3000 years. A study of 19th and 20th century maps, coupled with the elucidated coastal stratigraphy and harbour infrastructure, has yielded a precise reconstruction of port coastal changes since the Bronze Age (Figs. 8–11).

Unlike Sidon and Tyre, the entirety of the former basin at Beirut today lies landlocked beneath the city centre. This is due not only to silting up since antiquity, but also the considerable construction works undertaken since the 19th century. Only the western cove has yielded fine-grained sediments diagnostic of a sheltered environment, although it is suggested that sandy beaches to the east of the tell could have been used as a fair-weather anchorage for shallow draught vessels from the Bronze Age onwards. Like the southern bay at Sidon, cores Be III, Be V, Be XII and Be XX only manifest medium grain marine sands. Due to the nature of the urban context, the majority of the cores in the western harbour are concentrated in the northwest portion of the basin between Burg al-Mina and the Ottoman quays (Fig. 11). Archaeological surveys south of this core network indicate that the maximum extension of the ancient harbour during the Bronze Age lay some 300 m from the present coastline (Elayi and Sayegh, 2000).

We present and discuss the sedimentological datasets in Section 5. The coastal changes are characterised by two periods.

4.1. Bronze Age to medieval period coastal changes

The basin was formed by the drowning of an active talweg ~6000 BP; our calculations suggest that the ancient cove had an approximate surface area of ~50,000 m^2 at this time (Fig. 11). Archaeological data from Elayi and Sayegh (2000) and Marquis (2004) support a ~70 m progradation of the coastline between the Early Bronze and the Roman periods. A Middle to Late Bronze Age shoreline has been unearthed at BEY 069 (Bouzek, 1996). This find suggests that the lower reaches of the drowned wadi formed a creek at the base of the tell, which was exploited as an anchorage haven at this time. Such a scenario is consistent with data from southern Levant, where wadis were widely exploited as natural anchorages during the Bronze Age (Raban, 1987; Morhange et al., 2005). Data from BEY 027 infer that by the Late Bronze Age, the creek had silted up to become inactive, before complete urbanisation during the Hellenistic period (Arnaud et al., 1996; Mendleson, 1996).

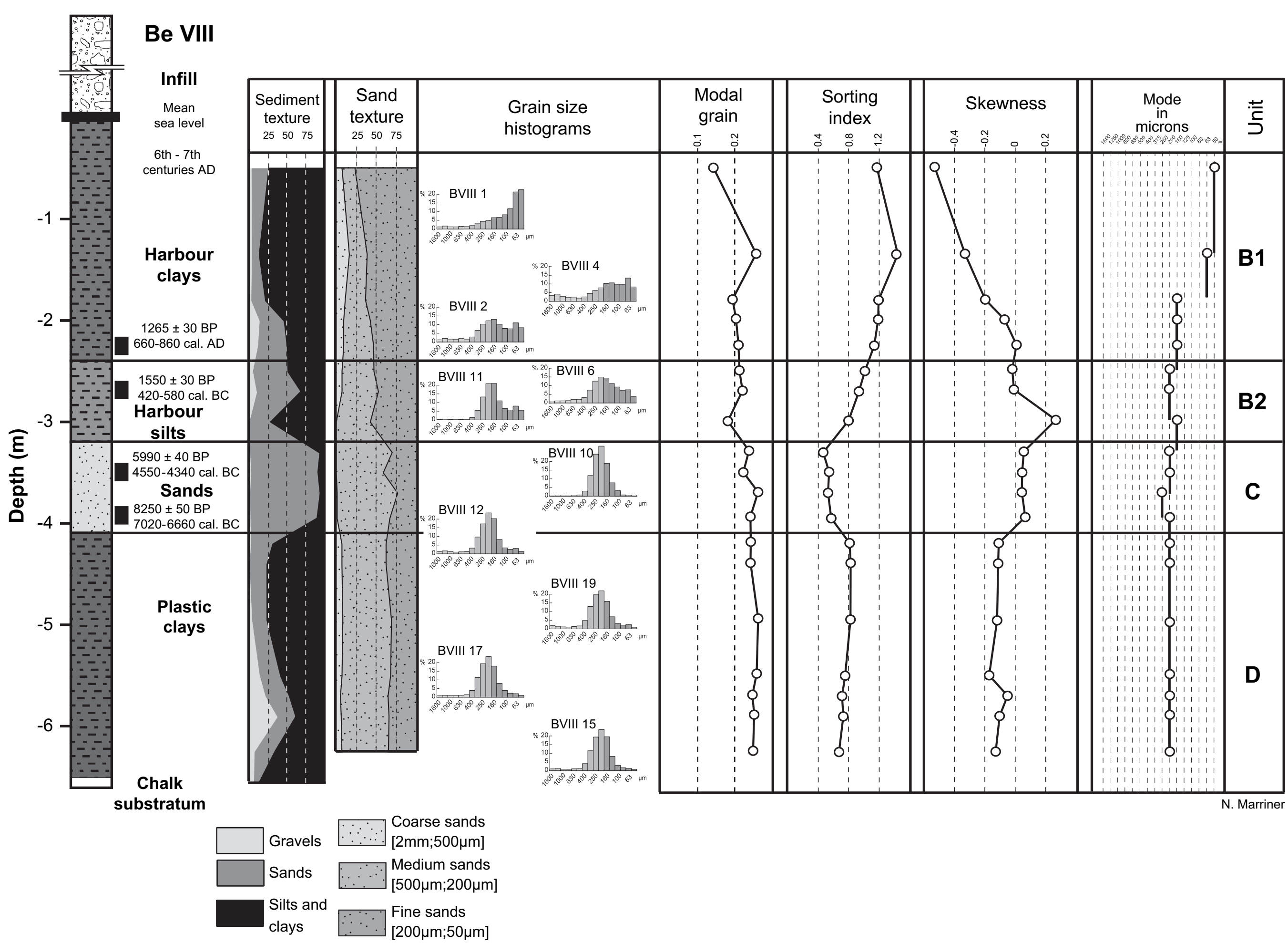


Fig. 13. Sedimentology of core Be VIII.

For later periods, an Iron Age III/Persian quay was unearthed at excavation site BEY 039 (Fig. 12). Located in rue Allenby, the quays indicate the contemporary extension and north–south orientation of the port. Although the exact location of the southern Iron Age coastline is not known, the pattern of Iron Age archaeological finds shows that it lies just north of rue Weygand (Elayi and Sayegh, 2000).

As at Sidon and Tyre, it is hypothesised that repeated dredging during the Roman and Byzantine periods reduced the natural progradation tendency by removing sediment from silted up portions of the basin. Although this premise is corroborated by the chronostratigraphic data more widespread work is clearly required on the dredging question. From the onset of the Byzantine crisis and the beginning of the 19th century, settlement demise accounts for rapid silting up; the medieval archaeology attests to a 30 m coastal progradation between 660 AD and 1600 AD (Marquis, 2004).

4.2. Modern period coastal changes

Between the Renaissance period and today, five sets of maps have been used to document the evolution of the coastline. This work builds upon earlier research by Davie (1987). The maps exploited include those of Ormsby (drawn in 1831 and published in 1839), Wyld (1840), Royal Engineers (1841), Scott (1841), Skyring (1841), Löytved (1876) and Baedeker (1912).

At the end of the 18th century, Beirut was a small fishing settlement of 4000 inhabitants, playing a very minor role in the transport of goods to Syria (Monicault, 1936; Babikian, 1996). The rise of the city as a major commercial port goes back to the coastal revival initiated by steamship navigation, which triggered a shift in economic activity from inland caravan cities like Damascus (Hastaoglou-Martinidis, 1998; Davie, 2000). In 1832, Beirut was established as the capital of Vilayet Sidon, a measure that attracted consular representation and foreign traders. After this time, the seaport expanded in four major phases, clearly documented by the coastal artificialisation. (1) *Between 1867 and 1876*, Beirut underwent a significant phase of seaport redevelopment. Low import duties, the building of the wharf, and the construction of the Beirut–Damascus cross-mountain road opened Beirut to the Syrian/Arabian interior and made it the region's principal entrepot, supplanting Acre and Sidon as the Levant's primary maritime hub. (2) *Between 1920 and 1943*, Beirut fell under French colonial rule and underwent a renewed phase of seaport redevelopment (Monicault, 1936). (3) *Post-World War II*, Beirut also saw a series of new port constructions, notably with an expansion of the docking capacities. (4) Finally, *since the early 1990s*, following a number of decades of geopolitical turmoil, the Lebanese government has set about rebuilding and modernising central Beirut and its port infrastructure. These ongoing works notably include a large artificial port to the northwest of the present basin (Fig. 11).

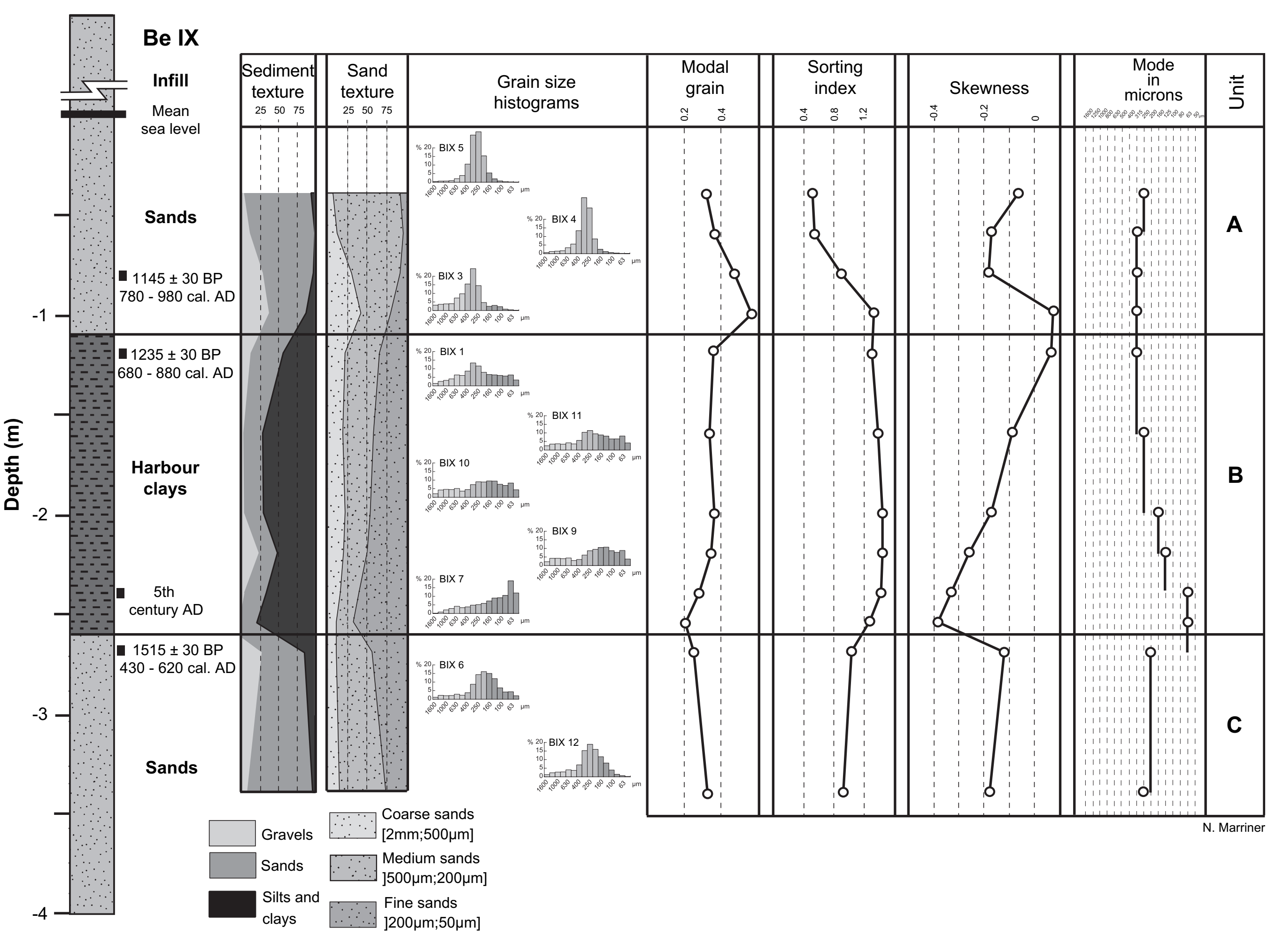


Fig. 14. Sedimentology of core Be IX.

In total, Beirut's port area bears witness to over 5000 years of human modification and artificialisation, characterised by a ~1 km dislocation of the coastline. Research shows increasing levels of coastal regularisation since the Neolithic, with the most profound changes taking place after the 18th century.

5. When and how did Beirut's ancient harbour evolve?

Only the cores between Burg al-Mina and the western land spur yielded facies analogous with a well-protected ancient harbour (Fig. 11). Litho and biostratigraphical studies from three of these cores, Be VIII, Be IX and Be X have established five phases in the evolution of Beirut's seaport. It is important to stress that the chronological interpretations are based upon ceramic and radiocarbon chronologies (Table 1) and cross-correlation with the well-dated sequences at Sidon and Tyre.

5.1. Early to mid-Holocene low-energy lagoon

5.1.1. Description

The limestone substratum in core Be VIII is overlain by a dark plastic clays unit (3/2 5Y olive black) comprising over 75% silts and clays. Medium sorting indices of ~0.8 and skewness values of −0.11 to −0.17 are consistent with the predominance of medium to fine sands (Figs. 13–15). The molluscan suite is relatively poor, with very few tests being represented. Those present comprise species from the upper muddy-sand assemblage in sheltered areas (*Loripes lacteus*, *Cerithium vulgatum*), lagoonal (*Cerastoderma glaucum*) and the upper clean-sand assemblage (*Nassarius mutabilis*; Figs. 16–18). The ostracod fauna has a relatively low faunal density of between 20 and 40 tests per 10 g of sand. The suite is dominated by the brackish lagoonal species *Cyprideis torosa* (Figs. 19–21). Tests of marine lagoonal and coastal taxa are concomitant with proximity to the coastline.

5.1.2. Interpretation

We interpret this plastic clays unit as a naturally sheltered coastal environment that began accreting as transgressing Holocene sea levels reached the basin vicinity. Analogous facies have been observed at both Sidon and Tyre and support data from the northern coast of Israel (Galili and Weinstein-Evron, 1985; Cohen-Seffer et al., 2005). This lagoon environment would have been protected by a series of proximal beach ridges, breached during periods of storm and high swell. Full marine conditions are only recorded in the cove by a sublittoral sands unit at ~6000 BP (see Section 5.2).

5.2. Pocket beach/Bronze Age proto-harbour

5.2.1. Description

Unit C comprises a shelly sands unit with medium sorting indices of between 0.5 and 1. Medium sands dominate the unit and

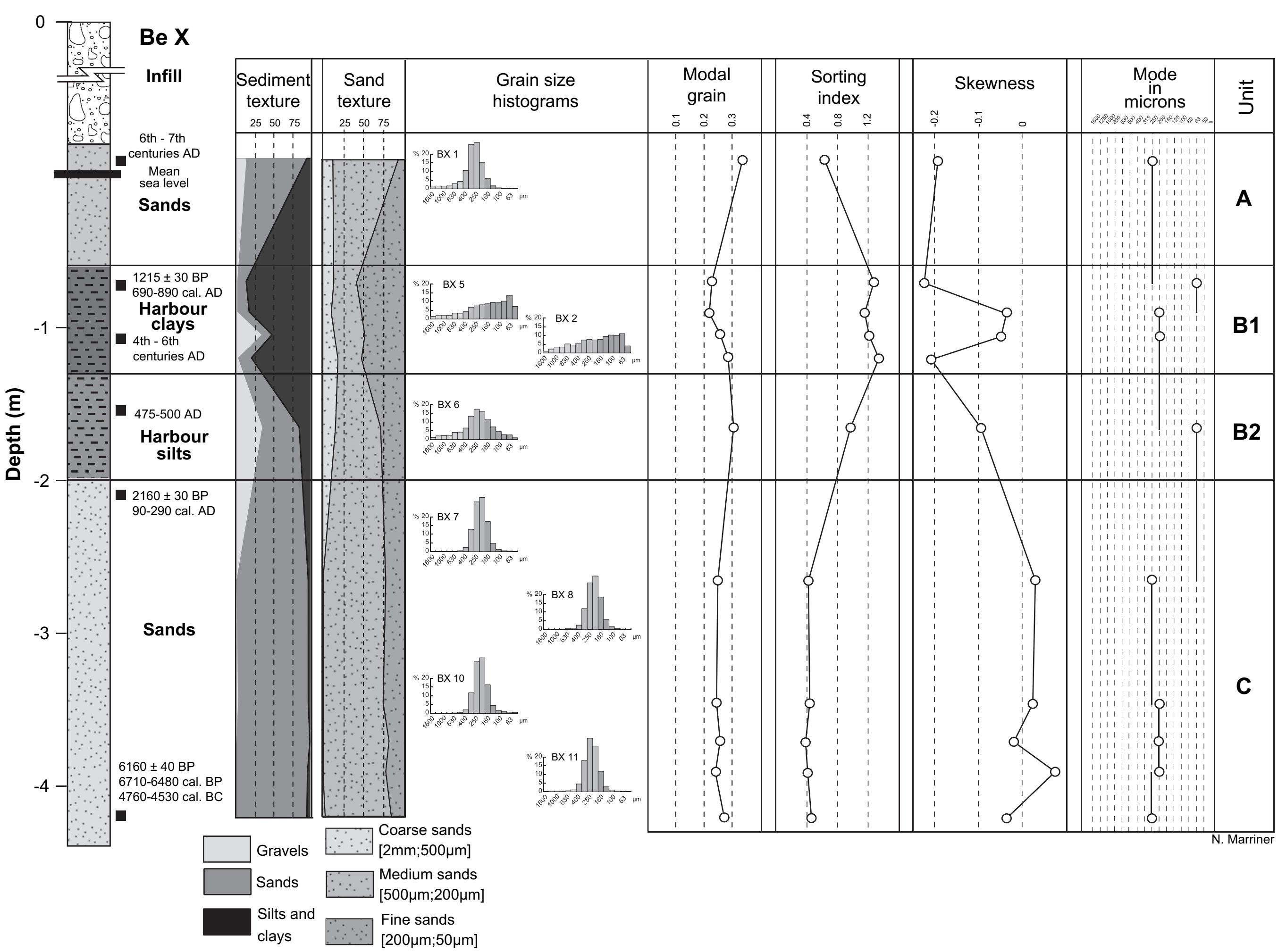


Fig. 15. Sedimentology of core Be X.

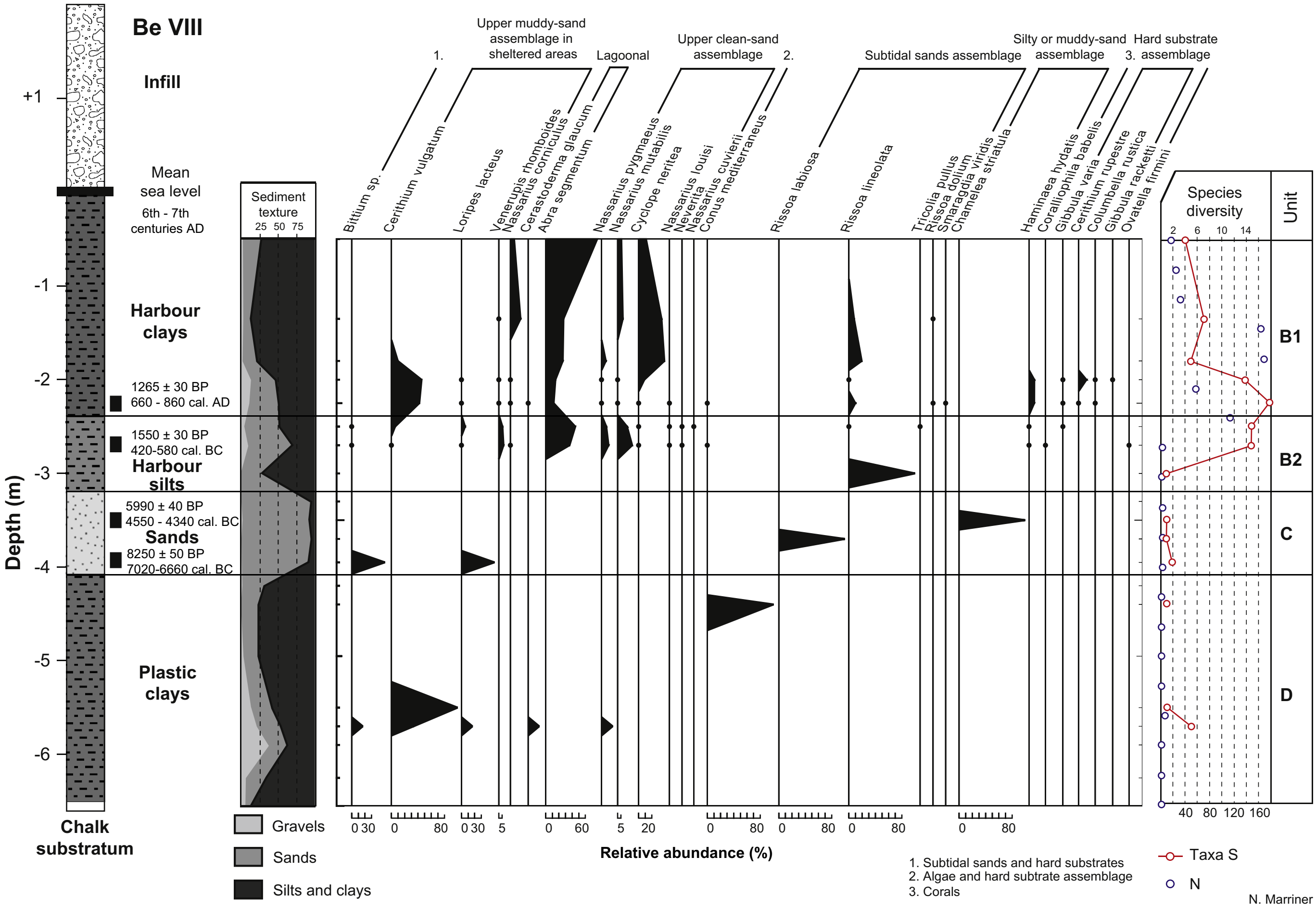


Fig. 16. Molluscan macrofauna of core Be VIII.

constitute 50–80% of the total sands fraction. The sedimentological proxies all point to a medium to low-energy marine environment. The molluscan faunas are dominated by taxa from four assemblages, the upper clean-sand assemblage (*C. vulgatum*), the subtidal sands assemblage (*Rissoa* spp.), the upper muddy-sand assemblage in sheltered areas and the subtidal sands and hard substrates assemblage (*Bittium reticulatum*). Medium to low-energy marine dynamics are further corroborated by the marine lagoonal (*Loxoconcha* spp., *Xestoleberis aurantia*) and coastal (*Pontocythere elongata*, *Hiltermannicythere* sp., *Aurila convexa*) ostracod species.

5.2.2. Interpretation

The proxy data evoke the accretion of a sublittoral sand facies within a naturally protected marine cove, which began accumulating after ~6000 BP. This stratigraphy is reminiscent of the pocket beach units observed at both Sidon and Tyre (Marriner et al., 2005; Marriner and Morhange, 2006a,b). Such a sheltered environment, looking north and protected from the dominant winds and swell by the south-western flank of the peninsula, explains the decision by human societies to settle on the tell overlooking this marine embayment. The settlement's topography would have been known to sea-faring crews who hopped between natural anchorages during the early days of maritime trade (Marcus, 2002a,b). Bronze Age settlers used the fertile land on this wide terrace for food. Interaction with the sea, through this natural cove, permitted trade and the exploitation of marine food resources.

Beirut, although not a prominent Bronze Age town, benefited from its geographical position halfway between Sidon and Byblos to serve as a stop-over for traders *en route* to and from Egypt, southern Levant, Syria and Anatolia. It followed the general model of urban development, namely the construction of palaces, temples and city walls designed to protect and consolidate this maritime-derived wealth (Curvers and Stuart, 2004). Although overshadowed by its sister city-states Byblos, Sidon and Tyre, mentions of Beirut in Ugaritic texts and the El Amarna letters are a reflection of its involvement in the eastern Mediterranean world during the Late Bronze Age (Arnaud and Salvini, 2000; Goren et al., 2004).

Unlike Sidon, there is no sedimentological evidence in support of primitive Bronze Age harbourworks. This could be for two reasons: (1) the absence of such infrastructure during the Bronze Age at the site; and/or (2) the failure to pick up a diagnostic signature due to the proximal position of the cores to the cove entrance. The heart of the Bronze Age basin appears to have been located ~120–150 m to the south (Fig. 11), although archaeological investigations have thus far not unearthed any artificial infrastructures dating to this period.

5.3. Closed Iron Age (?) to Roman/Byzantine harbours

5.3.1. Description

In unit B1, the onset of artificial harbourworks is characterised by a sharp rise in the silts and clays unit (25–75% of the total sediment). Sorting indices of 0.8–1 attest to a medium sorted sand fraction. The sediment juxtaposes fine-grained sands and silts with

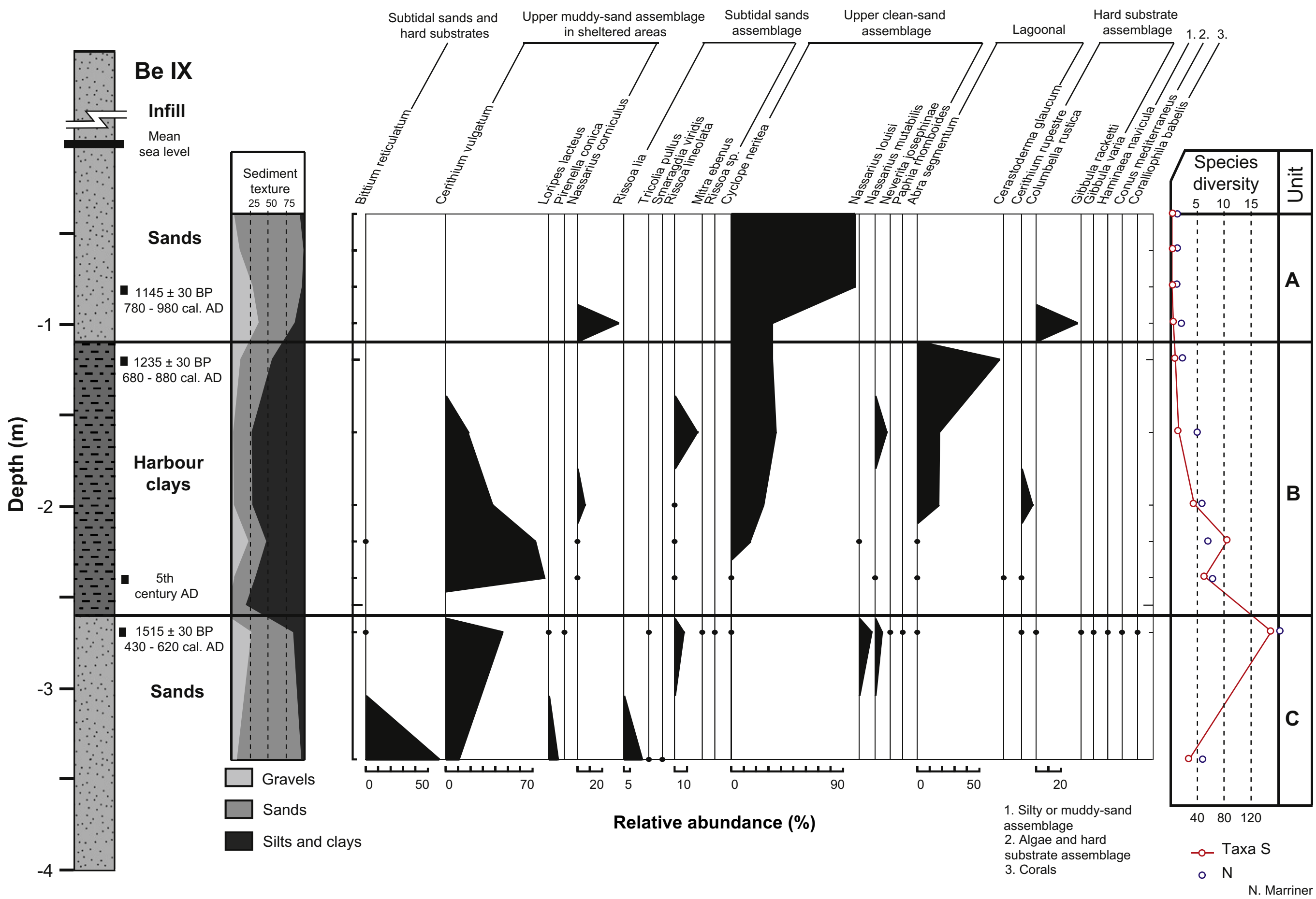


Fig. 17. Molluscan macrofauna of core Be IX.

a rich coarse-grained debris constituting wood fragments, glass, seeds and ceramics. Sample BVIII 5 has been dated 1550 ± 30 BP (420–580 cal. AD), consistent with the Late Roman/Byzantine period. Such a juxtaposition of coarse-grained versus fine-grained material is a classic feature of artificial harbours in proximity to an urban settlement. The macrofauna is dominated by four assemblages, the upper muddy-sand assemblage in sheltered areas (*C. vulgatum*, *L. lacteus*, *Venerupis rhomboides*), the upper clean-sand assemblage (*Cyclope neritea*, *Nassarius louisi*, *N. mutabilis*, *Nassarius pygmaeus*), the lagoonal assemblage (*Abra segmentum*) and the subtidal sands assemblage (*Rissoa lineolata*). Species from the lagoonal (*C. torosa*), marine lagoonal (*Loxoconcha* spp., *X. aurantia*) and coastal (*A. convexa*, *P. elongata*) domains constitute the ostracod suite. This is accompanied by a rise in faunal densities to between 100 and 300 tests per 10 g of sand.

5.3.2. Interpretation

The presence of artificial harbourworks is clearly manifest in the basin stratigraphy. Unequivocally attributing these changes to the Iron Age is problematic given repeated dredging phases during the Roman and Byzantine periods. Roman and Byzantine dredging has culminated in an archiveless harbour for the Iron Age period. For example, core Be VIII presents a chronostratigraphic hiatus of ~4000 years around 3 m below present mean sea level between ~1500 BP and ~6000 BP (Fig. 13). Only at Sidon have we been able to localise and date pockets of fine-grained Iron Age sediments (Marriner and Morhange, 2006b). Research has shown that the Roman period marks a technological watershed in many ancient harbours of the Mediterranean (Oleson, 1988; Rickman, 1988). At Marseilles and Naples, for example, wide-reaching infrastructure enterprises were undertaken not only to overdeepen the rapidly silting up port, but also to completely refashion harbour layouts (Hesnard, 2004a,b).

Although a gradual progradation of the harbour coastline is recorded between the Bronze Age and Roman period, there is very little information on the nature of harbourworks employed (Fig. 11). Thus far, only an Iron Age III/Persian quay has been unearthed (Elayi and Sayegh, 2000; Sayegh and Elayi, 2000; Fig. 12), buried ~60–70 m south of the core network. Just north of two 19th century Ottoman quays, no fine-grained harbour sediments have been unearthed indicating the harbour was not more extensive in this northerly direction (Figs. 22 and 23). It seems likely that the 19th century quay reemployed foundation courses from a more ancient harbour structure. However, in the absence of strong archaeological data, we can only tentatively hypothesise that this edifice was adapted and recycled from the Iron Age onwards. Unlike the southern prograding harbour coastline, the northern limits of the port basin have probably varied very little over the past 6000 years.

During the Phoenician period archaeological finds in and around the basin suggest that the harbour was used as a commercial and fishing hub (Curvers and Stuart, 1996). By the second half of the 8th century BC, the Phoenician city-states were providing Assyria with much of its maritime resources (Elayi, 1984, 1990). Abundant

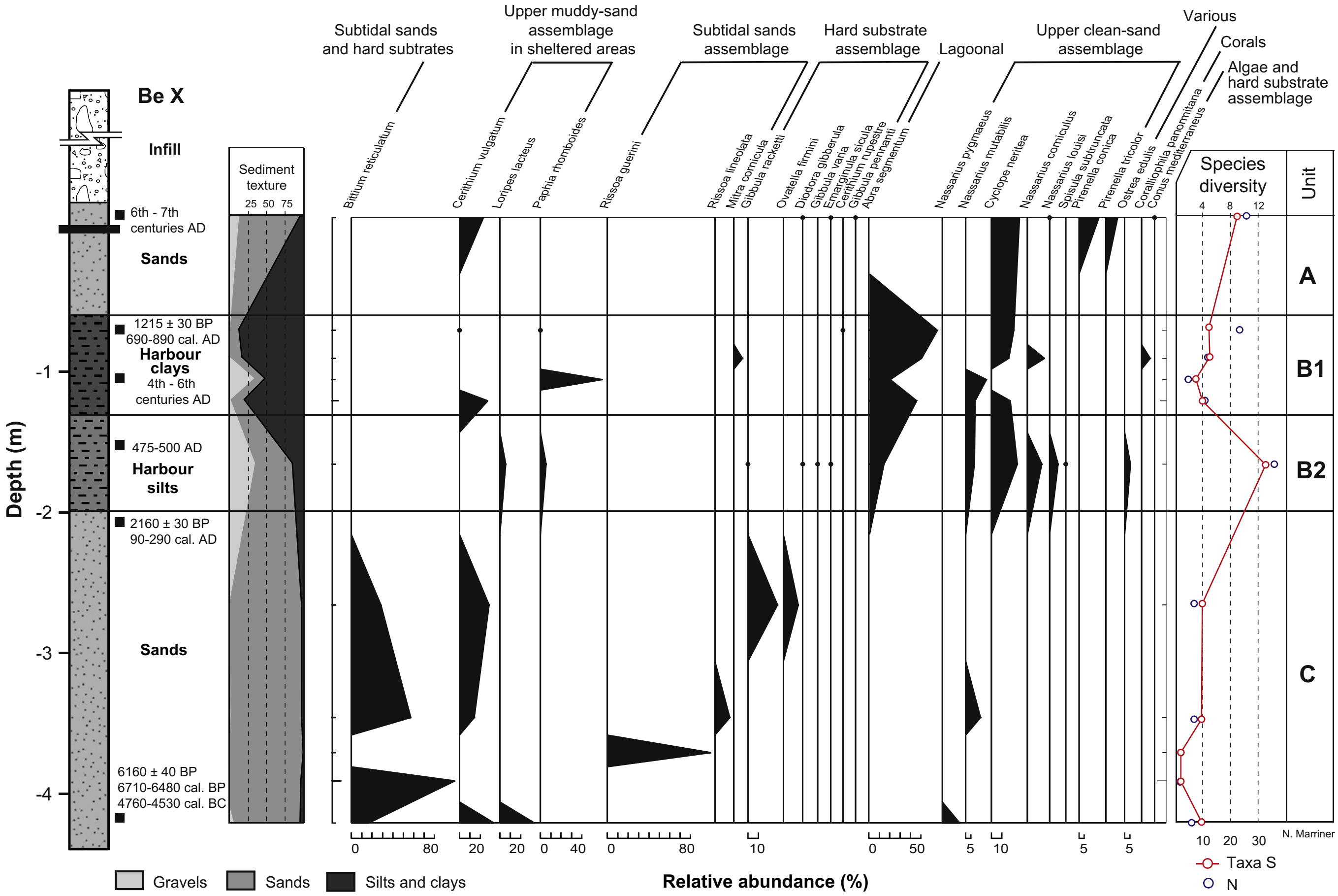


Fig. 18. Molluscan macrofauna of core Be X.

imported ceramics and transport containers are consistent with a rich Mediterranean trade (Curvers and Stuart, 2004). Archaeological research on Phoenician and Persian urban quarters bordering the harbour shows the importance of murex finds (*Bolinus brandaris* and *Hexaplex trunculus*), which can be put into relation with purple-dye production (Doumet, 1980, 2004; Marquis, 2004). Finds of nets and fish bones on a large scale also indicate the importance of the fishing industry (Elayi and Sayegh, 2000). Fish would have been dried and exported to local and regional markets in the hinterland, and possibly further afield. A harbour of this size was also capable of assuring the transportation of cedar wood, prized in construction throughout the Levantine basin (Elayi, 1984, 1990). The relative absence of military finds appears to suggest that the city did not support a large military float as was the case at Sidon and Tyre during the same period (Elayi and Sayegh, 2000).

The existence of smaller secondary and/or outer harbours must not be excluded. Two coves appear conducive to the accommodation of shallow draught boats. (1) The ~400 m by ~150 m palaeo-embayment immediately east of the tell (Fig. 11) has yielded medium to fine-grained sand facies at the base. Although it is difficult to make precise interpretations on the geomorphology of this cove, because the upper parts of the coastal stratigraphy have been reworked by the 19th century redevelopment, the archaeological remains and topographic data in this area do allow the morphology of the cove to be reconstructed (Ormsby, 1839; Wyld, 1840; Royal Engineers, 1841; Scott, 1841; Skyring, 1841; Löytved, 1876; Baedeker, 1912; Davie, 1987, 2001). (2) ~350 m west of Beirut's ancient harbour a second marine cove, still manifest in 19th century maps, might have served as a fair-weather harbour (Fig. 11). Clearly further work is required to corroborate these working hypotheses.

The archaeological data demonstrate that the 6th–5th centuries BC were a period of urban expansion of the lower city, which spread out and beyond the two overlooking promontories (Sader, 1999; Curvers, 2002; Curvers and Stuart, 1998–1999). The pottery found in Beirut from the earliest Hellenistic contexts includes amphorae originating from Sidon, Tyre, Cyprus and the Aegean. The presence of these imported wares indicates the importance of Beirut and its harbour in Mediterranean trade at this time. On the basis of trends in pottery finds, it has been hypothesised that Beirut was a dependency of Sidon during the Hellenistic period (Reynolds, 1999), becoming independent after the 2nd century BC. At this time, there was a shift from Ptolemaic dependence to the new imperial policy of the Seleucid rulers. During the Romano-Byzantine period, the monumental centre of the city shifted from the Iron Age tell and harbour area, to a zone outside the borders of the Iron Age city (Lauffray, 1944–1945; Davie, 1987; Faraldo Victorica and Curvers, 2002).

5.4. Closed Late Roman and early Byzantine harbours

5.4.1. Description

Transition to plastic harbour clays is concurrent with the technological apogee of Beirut's ancient harbour during the Late Roman and Byzantine periods. The unit is constrained by numerous ceramic finds dating to the 5th–7th centuries AD. Sorting indices of between 1.2 and 1.5 are concomitant with a poorly sorted sediment (Figs. 13–15). Fine sands comprise over 50% of the total sand

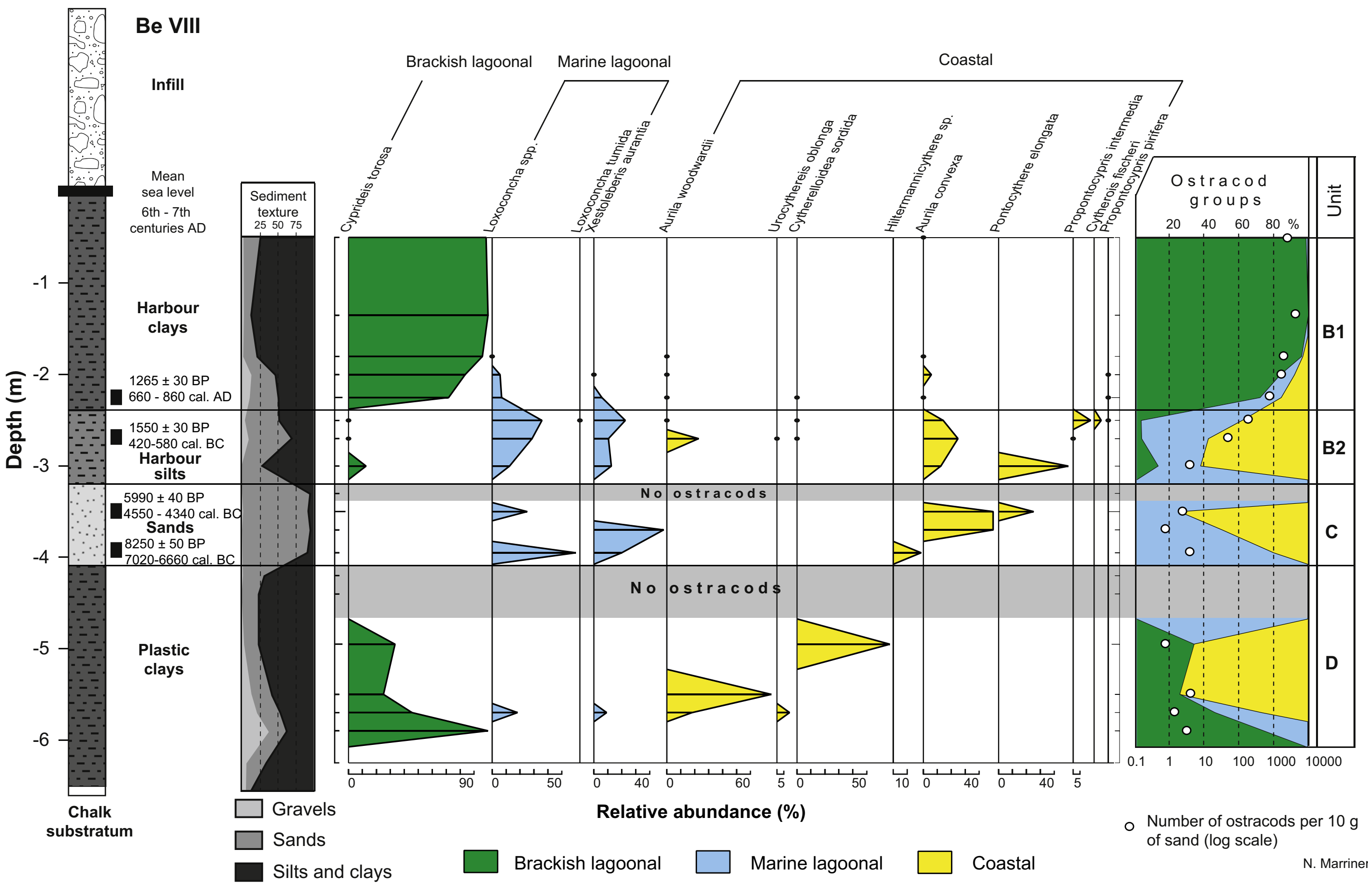


Fig. 19. Ostracod microfauna of core Be VIII.

fraction. Poorly developed histograms are consistent with the juxtaposition of fine-grained deposits trapped in the basin by a fall in water competence and coarse-grained material deriving from slope wash and urban waste. Five groups dominate the molluscan fauna, namely the upper muddy-sand assemblage in sheltered areas, the upper clean-sand assemblage, the silty or muddy-sand assemblage, the lagoonal assemblage and the subtidal sands assemblage (Figs. 16–18). A sharp rise in the lagoonal species *A. segmentum* indicates a heavily artificialised basin. This tendency is corroborated by the ostracod data, characterised by the monospecific domination of *C. torosa* and accompanied by a sharp rise in faunal densities (>1000 tests per 10 g of sand; Figs. 19–21).

5.4.2. Interpretation

Urban development which started in the Roman period continued under Byzantine rule. The hinterland also witnessed an era of prosperity with the development of agriculture, mainly oil and wine production, and of the silk, glass and purple industries (Hall, 2004). Archaeological data suggest that the early Roman city grew up on the tracks of the previous Hellenistic city wall (Saghieh-Beydoun et al., 1998–1999). Between the 2nd and 4th centuries AD, major changes in the urban fabric and layout are recorded, consistent with the foundation of the new imperial capital at Constantinople in 330 AD (Sader, 1999). Against this backcloth of economic and cultural opulence Beirut's harbour was developed to accommodate increased mercantile traffic. Archaeological data from the port area record a significant overhaul in the basin topography (Curvers, personal communication). Production of Beirut amphorae was expanded to collect and export goods from the hinterland, in response to the city's economic growth (Reynolds, 1999). This concentration of wealth was associated with a number of new public and monumental constructions, including a hippodrome, two large bath complexes and new forums (Curvers and Stuart, 2004; Doumet-Serhal, 2004).

Consolidation of Roman engineering techniques and infrastructure is translated in the ancient harbour by the B1 plastic clays unit. Although there is very little archaeological data pertaining to the nature of harbourworks during the Late Roman and Byzantine periods, research at sites such as Caesarea, Ostia and Cosa shed light on the technology and techniques employed at Beirut (Oleson, 1988; Oleson and Branton, 1992; Brandon, 1996, 1997; Hohlfelder, 1997; Humphrey et al., 1998; Oleson et al., 2004a,b).

We attribute the relative absence of seaport infrastructure unearthed from this and earlier periods to three factors: (1) repeated destruction of port edifices during catastrophic earthquakes and tsunamis (Guidoboni et al., 1994; Reinhardt et al., 2006; Salamon et al., 2007; Curvers, personal communication). Beirut's peninsula is located in a highly seismic area (Dubertret, 1955, 1975); the ancient city lies upon three fault lines, one of which intersects the harbour basin (Darawcheh et al., 2000; Fig. 3). Calculations indicate that +7 earthquakes (Mercalli scale) have an average return period of 50 years in this area (Plassard and Kogol, 1981). Iron Age, Roman and Byzantine habitation layers show evidence of anomalies and structural fracture lines, degradation that has been linked to seismic activity (Saghieh Beidoun, 1997). The most devastating historical earthquake to have struck Berytus occurred in 551 AD, and was associated with massive urban destruction (see Section 5.5); (2) the recycling of port infrastructures throughout

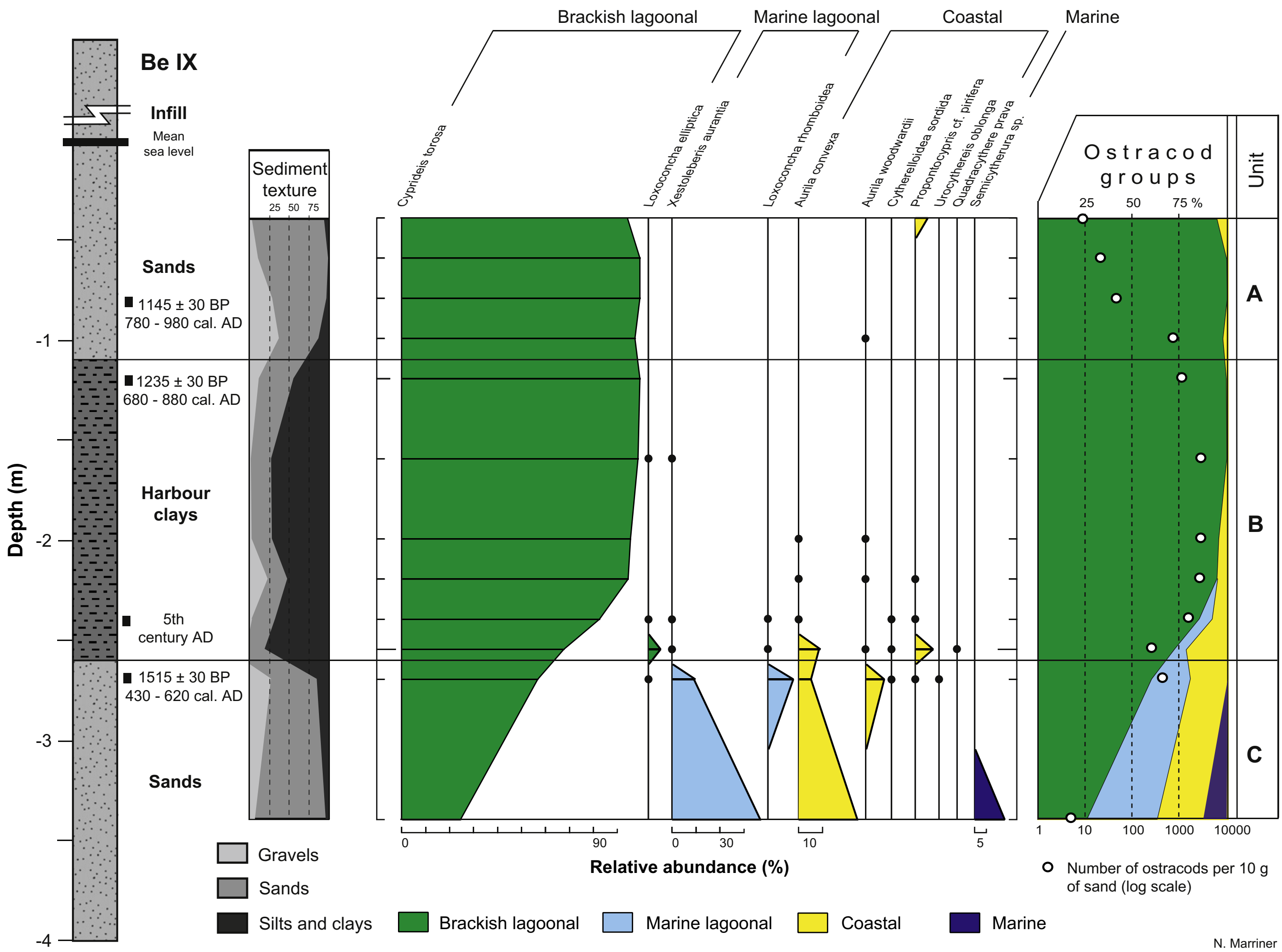


Fig. 20. Ostracod microfauna of core Be IX.

history; and (3) finally, the absence of archaeological excavations in these areas. Until the harbour has been satisfactorily surveyed, it is impossible to assign more weight to one factor over another.

5.5. Islamic and medieval harbours

5.5.1. Description

Transition to a well-sorted medium-grained sand after the 6th–7th centuries AD is consistent with an opening up of the harbour basin to coastal dynamics (Figs. 13–15). A rapid fall in the silts and clays fraction from +75% in unit B1 to <20% in unit A suggests that this change was relatively rapid. The transformation is accompanied by an increase in molluscan species from the upper clean-sand assemblage (*C. neritea*) and the hard substrate assemblage (*Columbella rustica*; Figs. 16–18). *C. torosa* continues into this unit, although a pronounced decline in faunal densities is observed from 1000/10 g sand to <100/10 g sand (Figs. 19, 20 and 22).

5.5.2. Interpretation

The transition from fine-grained to coarser-grained sedimentation is a classic stratigraphic feature of ancient harbours. It is usually linked to a partial/total abandonment of the basin and/or the economic and political decline of a site (Goiran and Morhange, 2003; Marriner and Morhange, 2007). Unlike Sidon and Tyre, the widespread archaeological excavations undertaken since 1993 mean that there is no shortage of evidence to explain the sudden demise of Beirut's seaport, centred on the 6th–7th centuries AD (Curvers and Stuart, 2004). As we have outlined in earlier papers (Marriner et al., 2005; Marriner and Morhange, 2006b), there appear to be four complementary dynamics at work: (1) historical; (2) tectonic; (3) tsunamogenic; and (4) climatic. It is important to insist upon two points.

5.5.2.1. Archaeological. The 7th century AD marks a decline in Byzantine hegemony on the circum Levant and an expansion of Islamic influence (Bonner, 2005). At Beirut, two lines of archaeological evidence document economic decline after the 6th–7th centuries AD. (i) *Urban*: excavations suggest that great tracts of the city were left in ruin after the 551 AD earthquake, with patchy evidence for urban rebuilding (Seeden and Thorpe, 1997–1998; Curvers and Stuart, 2004; Mikati and Perring, 2006). Many parts of the city show a mixed pattern of abandonment and continued occupation. (ii) *Ceramic ware*: the pottery recovered from the forum of this period manifests a significant change in the range and character of goods being imported into the city, consistent with a decline in Mediterranean traffic (Perring et al., 1996; Perring, 1999).

5.5.2.2. Lithostratigraphical. Excavations undertaken in Beirut's harbour by Curvers et al. have revealed the presence of tree branches and considerable amounts of unabraded Roman pottery

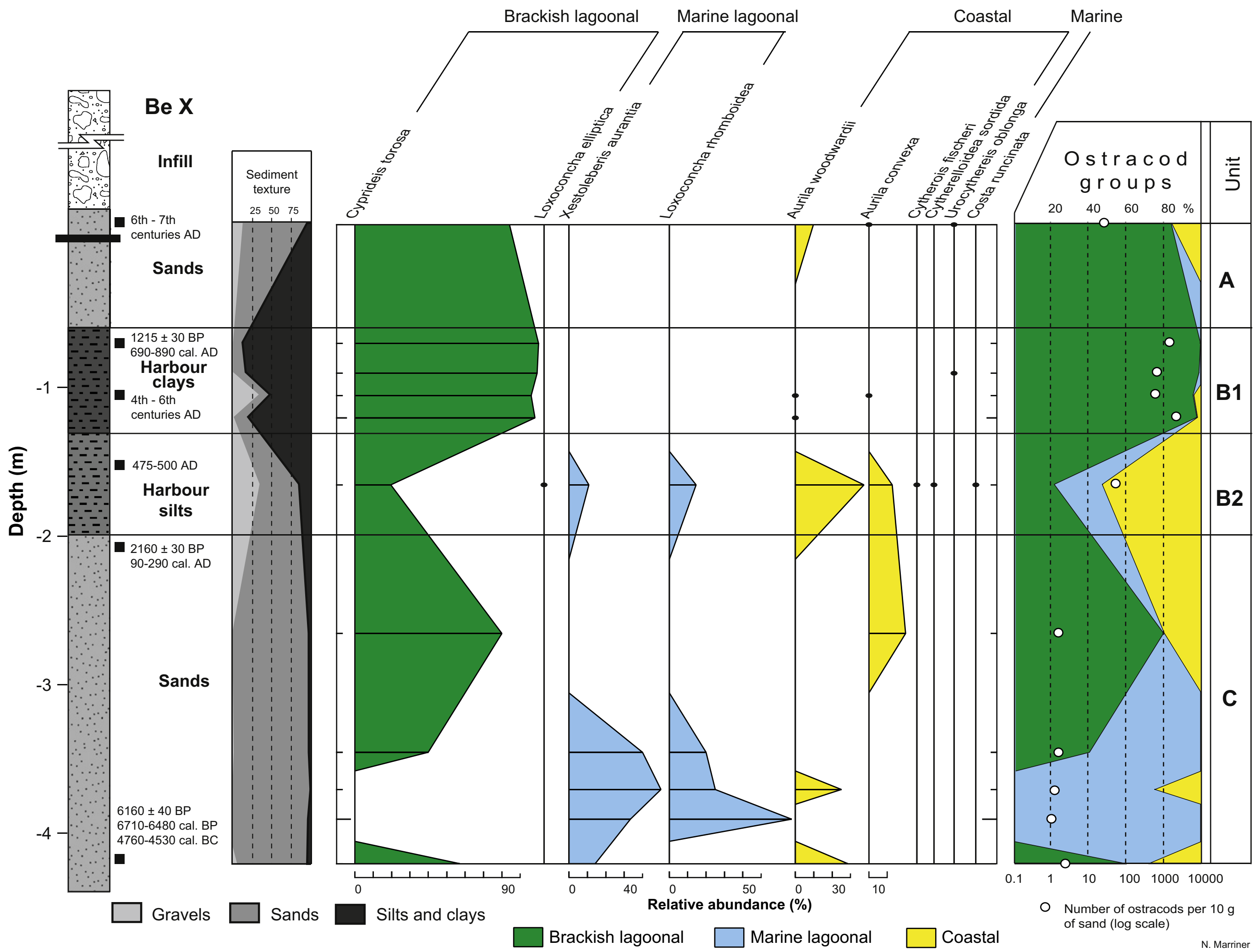


Fig. 21. Ostracod microfauna of core Be X.

and rubble in 6–7th century AD layers (Curvers, personal communication). Surveys in the Ottoman harbour have unearthed harbour muds and silts which lie unconformably above sea-scoured bedrock (Curvers and Stuart, 2004). These have been attributed to tsunami action and indirectly infer considerable damage to the city's seaport infrastructure. This archaeological evidence, coupled with the stratigraphic data, support major changes in the port's configuration at this time. At no point during the Islamic and medieval periods do we record such a well-protected harbour. In light of this, there appears to be a clear link between the retraction of the Byzantine Empire to its Anatolian core and the catastrophic destruction of many parts of Beirut, including its harbour area, during the 551 AD earthquake and tsunami.

The 551 AD earthquake is the best documented earthquake to have struck ancient Beirut in antiquity (Brown, 1969; Guidoboni et al., 1994; Soloviev et al., 2000). Described as the highest magnitude event to have affected the eastern Mediterranean (Darawcheh et al., 2000), its seismic repercussions were felt as far afield as Mesopotamia. At a more general level, the period is characterised by significant and catastrophic coastal deformations throughout the region (Goiran, 2001; Pirazzoli, 1986, 2005; Morhange et al., 2006).

The 551 AD earthquake is mentioned by several pre-1900 AD catalogues including those of Bonito (1691) and Perrey (1850). Recent research has postulated two hypotheses for the event's epicentre: (1) Guidoboni et al. (1994) have presented three ancient texts which they believe attest to an epicentre off the coast of Beirut; and (2) Ambraseys et al. (1994), on the other hand, have suggested that the earthquake's epicentre lay in the Jordan rift valley. Tsunami destruction along the Lebanese coast from Tripoli to Tyre would tend to favour the former.

The accounts of a number of chroniclers who lived at the time of the event have survived to present, including Malalas (491–578 AD), Agathias (532–580 AD) and John of Ephesus (507–586 AD), and an itinerary dated 560–570 AD written by a traveller named Antoninus Placentinus. According to Antoninus Placentinus, the Bishop of Beirut – an eyewitness of the earthquake – estimates that there were 30,000 deaths (Darawcheh et al., 2000). Although this figure is difficult to corroborate, it seems plausible as Beirut was considered to be the pearl of the Phoenician coast at this time. In the aftermath of the event, fires and disease probably also contributed to this number.

The accompanying tsunami is documented by John of Ephesus' account: "before the earthquake happened, the sea retired roughly two miles, then the people were rushed in the seabed to find wealth at the sunken ships, then an immense wave returned, flooding the shore and drowning ships as well as the people who were in the seabed and along the coast" (in Guidoboni et al., 1994).

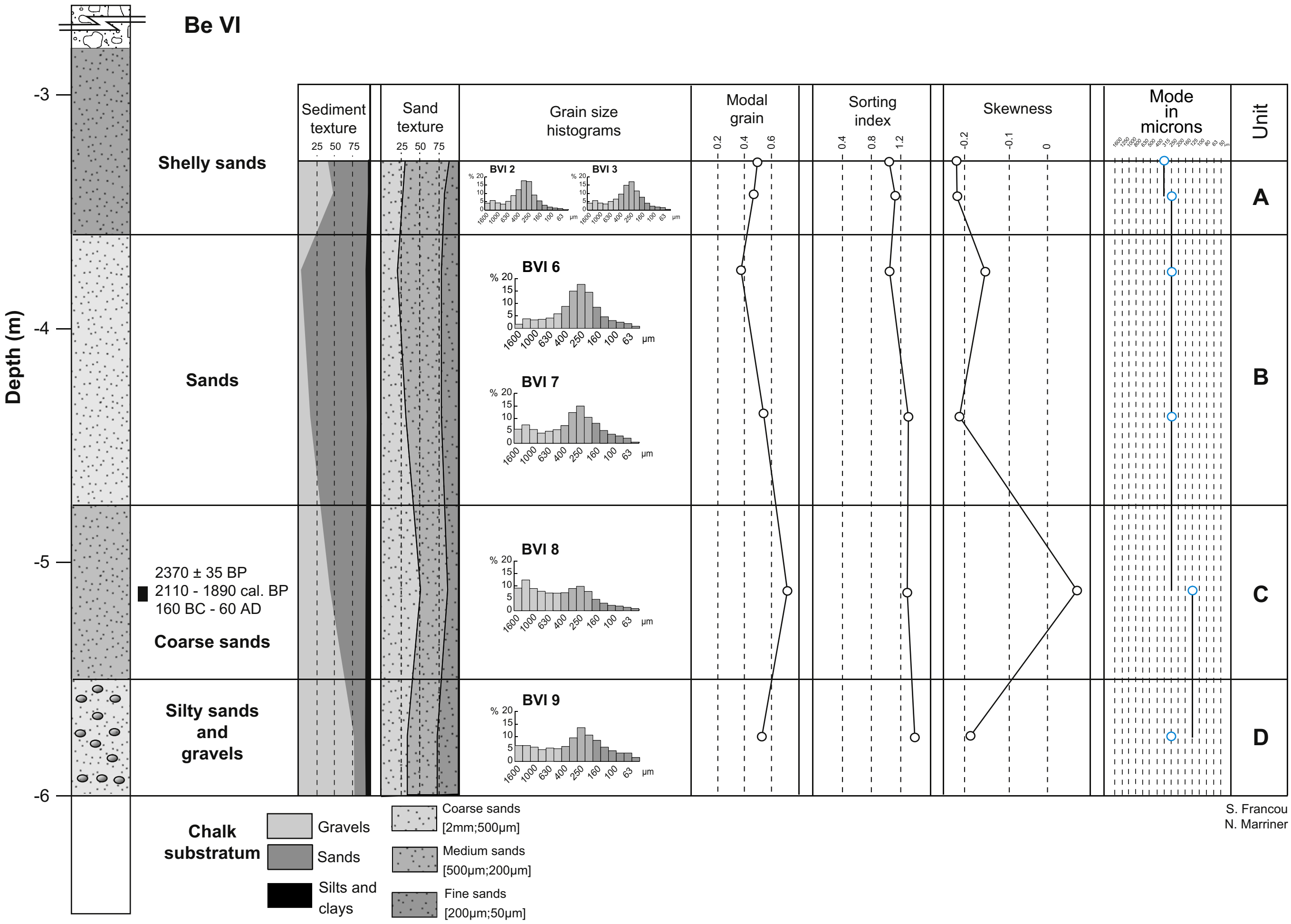


Fig. 22. Sedimentology of core Be VI. Poorly sorted sands and the dominance of coarse and medium sands confer an exposed marine environment in this area since 6000 BP. There are no stratigraphic units diagnostic of a harbour environment.

Although sedimentary traces of the tsunami impacts are not observed in the cores, recent excavations suggest that the ancient sources did not exaggerate in their description of the archaeological destruction caused by the event (Curvers and Stuart, 2004). New research has yielded closely dated stratigraphic sequences at a number of dig sites that unequivocally corroborate the widespread earthquake damage (Elayi and Sayegh, 2000; Curvers and Stuart, in press). In the aftermath, Beirut underwent altering patterns of trade, production and consumption. The archaeology also shows that many parts of the city were left in partial ruin or even abandoned, with limited evidence for reconstruction. Mikati and Perring (2006) present a model of ‘continuity’ but degradation of urban infrastructure at post-earthquake Beirut. Dating of raised shorelines north of Beirut confirms uplift of 50–80 cm (Morhange et al., 2006).

6. Conclusion

Coastal artificialisation during the past 200 years means that Beirut’s ancient harbour is completely landlocked beneath the city centre. The ancient harbour lies in a talweg depression between the Iron Age tell to the east and a land promontory to the west (Fig. 11). The anchorage took full advantage of these natural endowments, which were gradually reinforced from the Iron Age onwards. The harbour comprised a deep bay looking north and sheltered from the dominant south-westerly winds. It appears that the basin was closed by a belt of partially drowned reefs, gradually reinforced to form an artificial mole (although it should be noted that no traces of this mole have been uncovered during the recent excavations). It is hypothesised that Borj al-Mina served as an outer harbour during the Bronze and Iron Ages (see Fig. 11), in the same way as Zire island at Sidon.

According to Raban (1995), Levantine harbours were preferentially located in three areas: (1) on coastal peninsulas (Akko, Athlit, Sidon); (2) on offshore islands in proximity to the coastline (Tyre, Arwad); and (3) in coastal lagoons and wadis (Dor). The Beirut model appears to be a unique composite of these, comprising a drowned wadi – whose creek was manifestly used as an anchorage during the Bronze Age – and a small drowned island sandwiched between two enveloping land promontories.

The coastal stratigraphy elucidates five phases in the evolution of the basin spanning the last 6000 years. The core network lies in the northern portion of the ancient basin; clearly complementary stratigraphic data are needed further south, where the heart of the Bronze Age and Iron Age anchorages is to be found. Within this context, an interesting area for future research is the rue Allenby, where Iron Age III/Persian quays have been uncovered (Elayi and Sayegh, 2000). Sediments in the immediate vicinity of this cove have the potential to reveal more precise data on the Bronze Age and Iron Age histories. Despite the significant areas excavated, the opportunity to survey the ancient harbour using classical dig techniques, *sensu* Marseilles (Hesnard, 1995; Morhange et al., 2003)

Fig. 23. Ottoman quays unearthed during the EDRAFOR construction works and studied by Seeden and Thorpe (1997–1998; photographs courtesy of EDRAFOR). These quays lie just outside the ancient basin and attest to a gradual dislocation of the harbour coastline since the Bronze Age.

and Naples, could be rued in years to come (Lauffray, 1995; Karam, 1996; Naccache, 1996, 1998; Seeden, 1999; Raschka, 2006).

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