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Imported Building Materials of Sebastos Harbour, Israel

Gregory F. Votruba
Santa Rosa CA 95404 USA. sgvotruba@yahoo.com

Archaeological research of the remains of Herod the Great's Sebastos Harbour has identified foreign building materials, corroborating Josephus' description of its construction. The three materials are 17,000 m^3 of volcanic ash (pozzolana) from Puteoli, 11–14,000 m^3 of timber from Seleucia Pieria, and cobblestones of unidentified origin. These materials and their importation are discussed, using past provenance analysis, new data, and historical and logistical considerations. The pozzolana and timber importation demanded dozens of transport ships, and is evidence of the sophistication of the construction of Sebastos Harbour and the efficient organization of the Mediterranean under Augustus' control.

Key words: Caesarea Maritima, Roman harbour, provenance analysis, Puteoli, Antioch, Seleucia Pieria.

The excellent preservation of Herod the Great's 1st-century-BC Sebastos Harbour at Caesarea Maritima, combined with Josephus' unique descriptions (BJ 1.408–414 and AJ 15.331–41), has enabled archaeologists and historians to reconstruct its form and much of its architecture (Figs 1 and 2). This paper focuses on one aspect, that of the provenance, quantity and logistics of shipping the imported construction materials used in its two artificial moles. It is inspired by the discovery of three types of foreign construction materials identified during fieldwork: volcanic ash, timber and cobblestones, which may have been among the materials alluded to by Josephus:

> The remarkable thing about the construction of the harbour was that Herod did not have any local supplies suitable for so great a project, but it was brought to completion with materials imported at enormous expense. AJ XV.332 (trans. Oleson, 1989a).

The architecture of the moles

Sebastos Harbour's two moles, built between 22 and 15 BC (Roller, 1998: 134–5), enclosed an area of about 100,000 m^2 (Fig. 1). The approximately 500-m-long southern mole projects from a natural peninsula with a northward semicircular curve, and the straight northern mole reaches about 275 m west from a slightly-projecting coastline, both ending at the north-facing entrance. The width of the moles, determined through geophysical survey to be *c.*60 m (Boyce *et al.*, 2004: 131, 133), was suitable for the wave-spray protection wall, towers, storage areas and promenade which were built on them. Because the site lacked offshore rock outcrops beyond its two small natural promontories, the moles were founded on the sandy sea-floor as deep as 5 m. A submerged or nearly-submerged subsidiary rubble breakwater running along the course of the southern mole, which Josephus identifies as the *prokumatia*, protected the harbour from one of the Mediterranean's highest-energy wave environments (Raban, 1988: 197). Individual concrete *pilae*, upon which statues were displayed, were placed just outside the harbour entrance.

Fieldwork has identified that the structural integrity of the moles derived from marine concrete-block spinal walls. This skeleton was reinforced with concrete and kurkar (the local calcareous-cemented aeolianite sandstone) ashlar-walled compartments, which were allowed to fill naturally with sand, and subsequently paved (Raban, 1988: 189–93). Various concrete mole substructure walls, 4–5 m high and 14–15 m wide, have been distinguished from the mass of harbour rubble on a recently produced residual-magnetic-field map (Boyce *et al.*, 2004: fig. 6B). Within the better-preserved northern mole, these walls defined three compartments with void space approximately 20 × 30 m (Boyce *et al.*,

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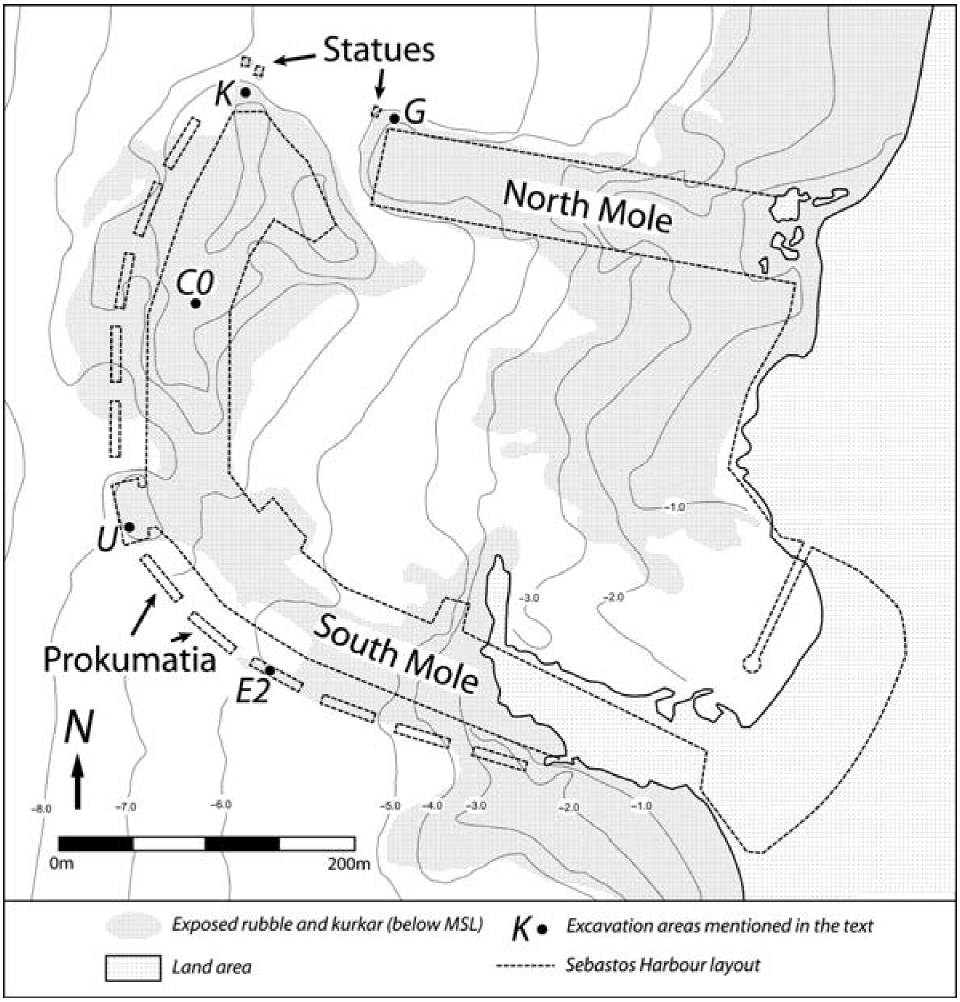

Figure 1. Bathymetry, ruins, excavation areas and configuration of Sebastos Harbour. (Modified from Reinhardt and Raban, in press, and Boyce *et al.*, 2004)

2004: 133–4). The dimensions of the concrete walls match the width and height dimensions of the well-studied Area K series of five concrete blocks (each about 14 × 7 × 4 m), which were laid in a loose header-pattern, and are assumed to have been constructed by the same method (Boyce *et al.*, 2004: 133) (Fig. 1). The inner edge of the main breakwater was lined with kurkar ashlars also laid in header orientation. Before placing many of the structural elements the sandy sea-floor was paved with stones and rubble to protect the sand below from being undermined by currents (Raban, 1988: 186–7; Reinhardt and Raban, in press). The construction of the moles was a massive effort demanding placement of about 140,000 m^3 of building material in the sea (the volume of two moles whose combined length is 775 m, 60 m wide, and an average of 3 m deep).

Pozzolana importation

Sebastos Harbour is not only remarkable for its size and engineering sophistication, but also for its apparent use of building materials imported from great distances. Oleson and Branton (1992) have determined that the volcanic ash component which produced the hydraulic properties of the concrete was Italian in origin.[1] Using trace-element analysis they determined that this material was identical to that present in the area of the Roman town Puteoli near Naples, and distinct from those found in closer sites, including sources in the Carmel Ridge near Caesarea. It is presumed that Puteoli ash (pozzolana) was either the only known material which when added to mortar enabled its solidification underwater (Oleson and Branton, 1992: 57–8), or at least Puteoli was the most accessible source.

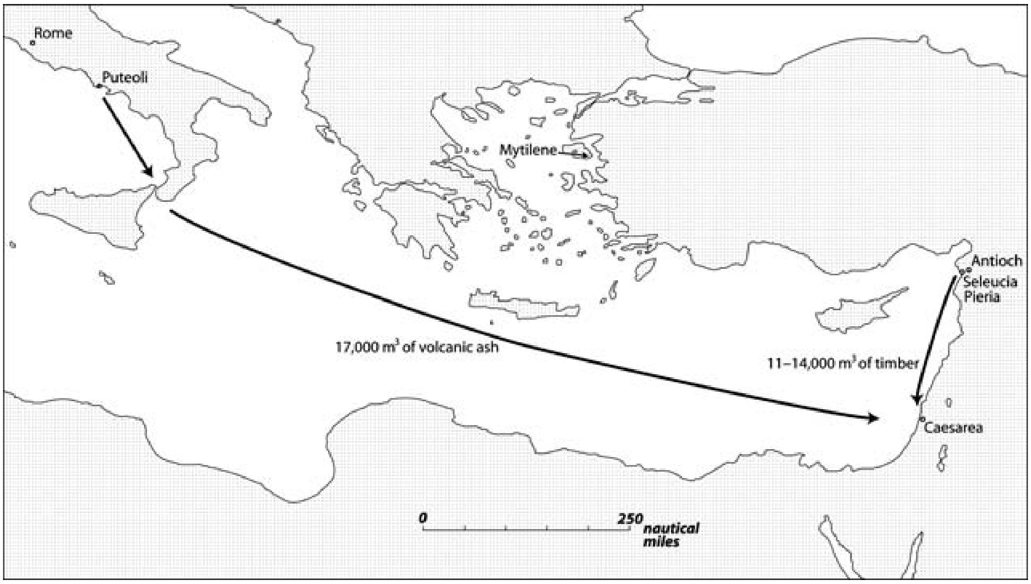

Figure 2. Map showing the proposed locations from which Sebastos Harbour mole building materials were acquired, estimated quantities, and the routes of the sailing vessels. Mytilene is the likely location of the harbour's planning by Herod and Agrippa in 23 BC. (G. Votruba)

The quantity of this imported pozzolana may be roughly calculated from the original volume of concrete in the breakwaters to be 78,000 m^3,[2] over half of the total volume of the moles. In addition to the mortar the builders incorporated large (10–25 cm diameter) aggregate, primarily angular kurkar. Based on observation of various blocks, a reasonable estimate of aggregate in the concrete is 80% (62,400 m^3). Thus 20% solid mortar, or 15,600 m^3, is implied. However, as stated by DeLaine (1997: 123), this quantity actually represents two-thirds of the original dry constituents, allowing for the roughly one-third loss of volume when the materials are mixed with water. Therefore the volume of ingredients to make 15,600 m^3 of mortar would have been about 23,400 m^3.

The amount of pozzolana necessary can be determined from this figure, based on the ratio of lime to pozzolana in the mortar. Analysis of mortar from two concrete blocks (from Areas E2 and G) indicates a ratio of lime to fine volcanic aggregate of 1:2, which is the proportion specified by Vitruvius (5.12.5) for hydraulic mortar (Oleson, 1989b: 201–02) (Fig. 1). Using this ratio, 23,400 m^3 of unlithified mortar gives 15,600 m^3 for pozzolana and 7800 m^3 for slaked lime. Considering a further 10% loss due to wastage of materials the quantities would be 17,300 m^3 and 8700 m^3 respectively.

The great distance from Puteoli to Caesarea, over 1000 nautical miles demanding a roughly 2-month round-trip sail (Casson, 1971: 298) (Fig. 2), and the large quantity of pozzolana used[3], indicate that this was a large enterprise for the Ancient World. Puteoli may have been an advantageous quarry location, since the large Alexandrian grain ships, which unloaded at its port, would have had space available to take the pozzolana to Caesarea on their return to Alexandria (Hohlfelder, 1999: 158–9). To transport the estimated quantity of volcanic ash at least 44 shiploads of 400 tons would have been necessary. The wreck of a bulk carrier of this capacity, believed to be one of those transporting pozzolana, discovered in the Northern Harbour of Caesarea's precursor Straton's Tower, may testify to the size of ships used in the enterprise, as well as use of that facility for unloading (Raban, in press). Considering the extra weight of the containers, and that a ship would carry somewhat less than its capacity, five or six dozen such ship-loads may be a more realistic quantity.

Marcus Agrippa

The massive scale of the harbour, pozzolana importation, and marine concrete architecture with its closest parallels in Italy, have led researchers to suspect that the connection with Italy is more than simply one of pozzolana supply, and that Herod would have needed both political and logistical backing from the ruling power in Rome

(Hohlfelder, 2000: 251). The construction of Sebastos Harbour would have been very much in Rome's interest. Rome would have appreciated the naval infrastructure to preserve its eastern Mediterranean hegemony (Beebe, 1983: 202; Roller, 1998: 69; Hohlfelder, 2000: 243). Others have claimed that Sebastos offered a valuable berth for the Rome-Alexandria grain fleets, securing Rome's lifeline (Beebe, 1983: 205; Oleson and Branton, 1992: 51; Raban, in press). Rome would certainly also have been interested in the salt, bitumen and exotic eastern goods which could have been exported from Judea. Most profoundly, as Gianfrotta writes, 'Caesarea was part of the trend toward increasing trade, which was of critical importance for Rome and for the political world system of the new Augustan order' (1996: 74–5).

Rome is therefore assumed to have found value in the construction of Sebastos, and in particular Augustus' military commander and confidant Marcus Agrippa is credited as being an active protagonist (Hohlfelder, 2000). Having worked on and commissioned naval building in the Bay of Naples, Agrippa would certainly have been aware of the properties of its volcanic ash for hydraulic concrete, properties known in Italy since at least the mid-1st century (Hohlfelder, 2000: 250; Oleson *et al.*, 2004: 202). It has therefore been proposed that at a meeting between Herod and Agrippa in Mytilene in 23 BC (AJ 15.349), Herod's conjectural mention of his Sebastos Harbour ambition, combined with Agrippa's recognition of the importance of the sea and knowledge of harbour engineering, catalyzed the construction of Sebastos which was begun the following year (Hohlfelder, 2000: 250) (Fig. 2).

Agrippa's role may have been a leading one in organizing the shipment of pozzolana, and even dispatching Italian manpower experienced in construction with marine concrete to Judea (Hohlfelder, 2000: 252). Considering that the practice of building with concrete in the open sea had been previously experimented with only in Italy, Italian builders are assumed to have been active in the construction of Sebastos (Hohlfelder, 1996: 78–9). It would not have been the only project of Herod's to use Italian expertise. At Herod's Palace in Jericho there are characteristically Roman *opus reticulatum* and *opus incertum*, floral and geometric pattern frescos, and indiscriminate use of the Ionic and Corinthian orders which are attributed to Italian builders also proposed to have been sent by Agrippa (Roller, 1998: 173). Uniquely Roman architecture and decorative aspects are also known from Masada and Herodion (Roller, 1998: 166, 188–9).

However, Sebastos Harbour should not be considered solely as an Italian project, as the Italians would have been working side-by-side with master-builders of the Phoenician harbour tradition. The feature in front of, and surrounding the main mole to absorb the waves, called the *prokumatia* by Josephus, has its best parallels with the wave-catchers of Dor and the offshore island harbour of Sidon (Raban, 1988: 195–7) (Fig. 1). The practice of building marine architectural elements on foundation cobbles has been observed also at Iron Age Athlit and Akko (Raban, 1988: 186–7). The technique of 'header' ashlar construction, minimizing the potential damage to the structure by wave suction, was used for marine architecture in the Phoenician ports at Tabat el-Hamam, Athlit, Akko, Tyre and Sidon (Raban, 1988: 193–5), and also appears at Straton's Tower's northern harbour (Raban, 1995: 168). The technique of floating concrete forms may not have been developed in the West, but in the East, with the earliest preserved example being from Alexandria, filled with non-hydraulic concrete dated to the 3rd century BC (Goddio and Dawish, 1998: 35–6).

It is therefore apparent that Italian and eastern technologies were combined for the construction of Sebastos Harbour, and it is likely that Italian and local master-builders participated and cooperated. Neither would have had experience in constructing such large breakwaters in the open sea, and would have been working from their combined marine architectural knowledge, experience, and by trial and error.

Timber importation

A second important building material that was necessarily imported was timber for the concrete formwork. Fortunately, well-preserved examples have been uncovered in the harbour's north-western corner, in excavation areas located on opposite sides of the harbour entrance.[4] Light is shed on the location of original procurement of the timber by determination of the preserved wood's genus and species.

The earliest such analysis was made on wood sampled from the formwork to the east of the harbour entrance (Area G), which produced the following genus identifications: *Abies* sp., *Picea* sp., *Pinus* sp., *Populus* sp., *Quercus* sp. and unidentified conifers (Liphschitz *et al*., 1989: Table 2). The fact that these types are not native to the region[5] and generally grow in Europe (Liphschitz *et al*., 1989: 194) led researchers to suggest that the timber was imported from beyond the Eastern Mediterranean (Hohlfelder, 1996: 79), even particularly from Italy (Raban, 1989: 287; Raban, 1992: 4). Since then three other samples of wood from Caesarea Harbour's formwork have been identified to the species level and published in a provenance study. One sample from Area G was identified as *Pinus silvestris* or *Pinus nigra* (Hohlfelder, 1999: 160). Two other samples, one from a formwork west of the harbour entrance, the northernmost of the series of five of Area K, and another of uncertain provenance, were identified as *Pinus brutia* (Hohlfelder, 1999: 160). Hohlfelder offers a circumstantial case that these samples came from Cyprus, based on the following evidence. *Pinus brutia* and *Pinus nigra* represent tree species plentiful in Cyprus;[6] Ammianus Marcellinus (4th century AD) wrote that Cyprus had all the resources fully to outfit a ship (XIV.8.14); there was a political connection between Herod and the government of Cyprus, citing Josephus' mention that in 12 BC Herod secured an important concession from Augustus for ownership of half of the copper mines on Cyprus and permission to manage the rest (AJ XVI.128); and that, based on the likely shipping route, Cyprus would have been a convenient stopping place for the Caesarea-bound Italian pozzolana vessels intending to acquire an extra cargo of timber (Hohlfelder, 1999: 160–61). Hohlfelder further suggests that a harbour on the southern or western coast, such as Paphos, may have been the port where the timber was loaded for Caesarea.

In an attempt to test these Cypriot and Italian provenance hypotheses, the formwork of Areas G and K was re-excavated in 2002 to allow collection of more wood samples for botanical analysis.[7] Eleven samples from different components were collected, six from the southern block of Area G, and five from the inner cell of the northernmost caisson of Area K, designated K2. The botanical analysis of the samples from K2 show that two plank tenons and a wooden nail were made of *Quercus coccifera*; a corner post was made of *Cedrus libani*; and a plank was made of *Pinus brutia*. From Area G a tenon and a treenail were identified as *Quercus cerris*, and an upright, a plank, and two beams were made of *Pinus nigra*. Also to be added to the corpus of the formwork wood species are those identified over recent years during submission for 14C analysis, and not as yet used in provenance analysis (all were collected from formwork K2 and identified by Dr Liphschitz). One sample, collected from a stringer, was identified as *Fagus sylvatica* (Segal and Carmi, 1996: 87). Of four other samples whose parts from which they were collected were not recorded, two were *Cupressus sempervirens* (Segal and Carmi, 1996: 87; pers. comm. A. Raban, June 2002) and two were *Pinus* sp. (European) (Segal and Carmi, 1996: 86–7).

Identification of timber genus and species, such as *Abies* sp., *Cedrus libani*, *Cupressus sempervirens*, *Fagus sylvatica*, *Picea* sp., *Pinus brutia*, *Pinus nigra*, *Quercus cerris* and *Quercus coccifera*, are evidence of provenance because their Mediterranean distributions are limited.[8] However, *Pinus* sp., *Populus* sp. and *Quercus* sp. are represented throughout the fertile regions of the Mediterranean basin, and therefore do not provide particular geographical definition. The timber is assumed to have been felled at coastal locations, as water transport was considerably more economical than land transport. Meijer and Nijf, using ancient economic data, such as Diocletian's Price Edict, assume a general ratio of prices of 1 (sea): 5 (river) and 28 (land) (1992: 133–5). It may therefore have been more economical for Herod's Caesarea construction, being located on the coast, to ship wood from across the Mediterranean than bring it from a nearby inland location. Large quantities of *Juniperus phoenica*, which is presumed to have been brought from Edom (Liphschitz and Biger, 1995: 123–4), were found in Hellenistic-Early Roman levels at Masada, 'En Rachel, and Moa, but it is not found amongst the species identified from Sebastos. The timber identifications and modern distribution literature do not indicate the hinterland of any particular port where all of these trees are found, and could be exported together. It is therefore assumed that the timber was derived from two or more separate locations. Nevertheless it is useful to compare the Sebastos group of trees with economically valuable tree populations of various Mediterranean regions.

The Italian hypothesis is weakened by the absence of three of the Sebastos tree species during the Early Roman period. *Cedrus libani*, which grows as far west as the eastern Aegean region, is not native to, and has not been naturalized in, Italy (Tutin, 1993: 32). The existence of *Cupressus sempervirens* in Italy, native as far west as Greece, is a result of naturalization in ancient times, and the historical evidence suggests that it was scarce in Italy during the construction period of Sebastos Harbour. During the Early Roman Empire cypress was conspicuously missing from any building in Rome, and writers associate it primarily with planted contexts, such as parks, cemeteries, and boundary-marking (Meiggs, 1982: 46, 48, 243). The isolated stands of *Pinus brutia* growing in Calabria are also believed to have been naturalized (LeMaitre, 1998: 413). Therefore the Early Roman Italian peninsula may have been unable to produce, much less export, three of the 11 types of wood identified in the harbour. It may also be relevant that five of the most important woods used in the west, *Pinus halepensis*, *Pinus pinaster*, *Quercus ilex*, *Quercus robur* and *Quercus sessiflora*, are not identified in the Caesarea formwork (Meiggs, 1982: 44–6). Therefore, although certain tree-types could have been exported from Italy, the species identified from Sebastos Harbour do not match well with the economically-valuable tree regime of the Italian regions.

Apart from the lack of congruity of the timber species between Sebastos Harbour and Italy, acquisition of timber from central Europe would have been a significant diversion from earlier Eastern Mediterranean timber-importation history. Neither is there a parallel in the ancient world for long-range timber importation such as from Italy to Judea, nor had a Levantine ruler ever had to look beyond the timber-endowed north-eastern Mediterranean. The earliest sources of supply for southern regions starved of long and straight timber appear to be the Lebanese mountains. According to Josephus, Lebanon was a major source of timber until at least the time of Antiochus II for the rebuilding of Ptolemais (AJ XII.141). If Lebanese access became difficult, the forests of Cyprus were used. Such was the situation for the Egyptians when the Hittites began to compete, and later, when the Seleucids came into conflict with the Ptolemies (Meiggs, 1982: 398; Burnet, 1997: 64–5). However, when access to timber from either source became restricted the parties had to look further north, as may have been the case for Anthony and Cleopatra in developing an interest in Cilician forests for their fleet (Strabo XIV.5.3).

Similarly, Herod appears to have looked beyond the Levant and Cyprus for his timber. Regarding Syrian and Lebanese coastal regions, three of the types of trees Herod used in his harbour do not grow there (*Fagus sylvatica*, *Picea* sp., and *Quercus coccifera*). Cyprus lacks *Abies* sp., *Fagus sylvatica*, *Picea* sp., *Quercus cerris*, and *Quercus coccifera*.[9] The state of the Lebanese and Cypriot forests in the Early-Roman Period is unclear, but it is understood that they experienced extensive felling during the Hellenistic period, not least for the construction of the Syrian and Egyptian fleets. Lebanon, in addition, had to support its own thriving iron-smelting and glass-making industries, and Cyprus its large copper and silver industries (Meiggs, 1982: 395, 397). Strabo's reference to the destruction of Cypriot forests is relevant textual evidence on the subject; however, he places most of the blame on extensive clearing for arable farming (XIV.6.5 quoting Eratosthenes). It may not be coincidental that the earliest record of forest management is a mention by Theophrastus (HP 8.8.1) of decrees by Cypriot kings to protect trees and to prevent cutting (Burnet, 1997: 67). The previously-mentioned passage by Ammianus Marcellinus is not necessarily evidence that Cypriot forests were productive throughout ancient periods, but rather of their recovery by the 4th century AD (Meiggs, 1982: 381). Perhaps recent exhaustion of the accessible Lebanon and Cypriot forests caused the south Levantine and Egyptian rulers of the Early-Roman Period to look further north for their timber.

The Sebastos trees best match the tree populations of the southern coast of Turkey, which has dense populations of *Abies* sp., *Cupressus sempervirens*, *Cedrus libani*, *Pinus nigra*, *Pinus brutia*, *Quercus cerris*, *Quercus coccifera*, and smaller numbers of *Picea* sp. and *Fagus sylvatica*, which are at the southern extreme of their range. Of this area the Amanos Mountain region is conspicuous, being documented with eight of the nine diagnostic tree types,[10] and may be most suitable as the source of Herod's timber for a number of other reasons. The Amanos region is well endowed with forests, as well as being the location of the mouth of the Orontes, one of the eastern Mediterranean's two large navigable rivers, upon which timber was floated, easing its transport from the mountains to the sea. The virtues of the region's trees and river are briefly poeticized by Libanius in the 4th century AD:

> Most important of all, its [Orontes] course below the city [Antioch] is navigable. It is not impassable because of rocks, as much even of the Nile is, hence it is of great advantage to us and deserves the praise which Pindar bestowed upon the river Hipparis in Camarina, that it 'swiftly weldeth together a soaring forest of steadfast dwellings' by providing carriage for timbers from all quarters (11.262, trans. Norman, 2000).

The situation was probably similar during Herod's reign. Immediately to the north of the mouth of the Orontes was situated the port-city of Seleucia Pieria (Fig. 2). Founded by Seleucis I Nikator, the city operated as Antioch's Mediterranean port throughout the Roman period. Its oval harbour-basin, 600 × 400 m, now completely silted up, is defined by slopes to the north and east, and has sea/fortification walls to the south and west roughly dated to the Roman-Hellenistic periods (Pamir, 2001: 102, 116). The post-Actium era proved to be fruitful for Antioch, due in large part to its position on some of the most important trade routes of the Roman Empire, and it was upgraded from Senatorial to Imperial Province by Augustus (Downey, 1961: 163–5). This could have been an active period for Seleucia Pieria as well, and Starr goes as far as to suggest that Augustus established the *Classis Syriaca* there (1960: 114–15).

Such a major port would have the necessary infrastructure for exporting the large quantities of construction timber needed for the Sebastos mole formwork. This again can be roughly calculated based on the estimate of 200 concrete harbour forms, that about 12,800 m^3 of timber would be required for the formwork, considering that each form consisted of about 64 m^3 of wood (Brandon *et al.*, 1999: n. 5). Assuming wastage of 10%, the amount of timber required might have been 14,200 m^3 (about 7100 tons, assuming a bulk density of 500 kg per m^3). However, a small percentage of the forms may have been pulled free for re-use. Only about 20% of the Area K forms would have been available for re-use, as its floor, inner cell, and internal bracing would have been inaccessible after placement of the concrete, leaving only the side planking available. If this wood had been re-used the amount necessary to be imported would have been somewhat less, about 11,400 m^3. Without considering stowage limitations, such a volume of timber would have required 15 shiploads of 400 tons. Seleucia Pieria and Caesarea being some 200 nautical miles distant, using the local offshore breezes the round trip voyage may have taken two weeks (Fig. 2).

Perhaps it was fortunate that Herod had strong connections with Antioch. As a young politician Herod was often in Antioch (AJ XIV.440, 451; BJ I.328, 512), and it was there that he made political contacts, such as that with Marcus Antonius (Roller, 1998: 214). Later at Daphne he was defended by Messala against the complaints of Jewish leaders (BJ I.243). Herod also escorted Octavian to Antioch on the latter's return to Rome from Alexandria (BJ XV.218; Roller, 1998: 214). However, Herod's warm relationship with Antioch can be best viewed in his contribution to refurbish 20 stadia of a poor street and build a stoa along it (AJ XVI.148; BJ I.425; Roller, 1998: 214). Its proposed date of 20 BC (Roller, 1998: 214–15), during Augustus' second tenure in the East, places its building a couple of years after starting the construction of Sebastos. A 6th-century-AD writer, John Malalas, using official city building records, noted that Herod's building in Antioch was in honour of Augustus (223). Perhaps Augustus assisted Herod with the purchase of timber in bulk from the Antioch region for the project.

Foundation cobbles

During the excavation in 2001 a third foreign construction material, cobblestones, was exposed under a particularly large concrete block (CO), originally one of the southern breakwater's foundation elements, standing about 4.5 m tall, 8 m at its greatest width and 5 m at its greatest breadth in its eroded state (Figs 1, 3 and 4). The cobblestones acted as a foundation layer for the concrete block, presumably to inhibit differential settling and prevent wave surge from undermining the sand below the block, while also raising the level of the construction area (Raban, 1988: 186–7; Reinhardt and Raban, in press). Because the block has shifted 30° to 64° northwards from its originally horizontal position, as determined from the existing beam-impressions (Reinhardt *et al.*, 2001: 6–7), the southern underside of the block had been scoured by currents which occasionally

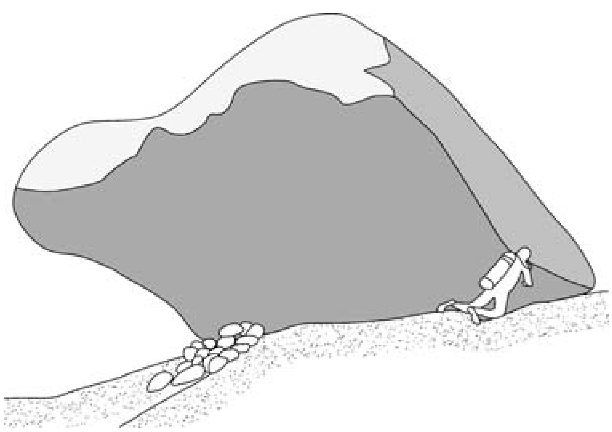

Figure 3. The Area CO element looking towards the west. Cobbles of the foundation exposed during the excavation are seen to the left. (Tracing from a photograph by B. Goodman.)

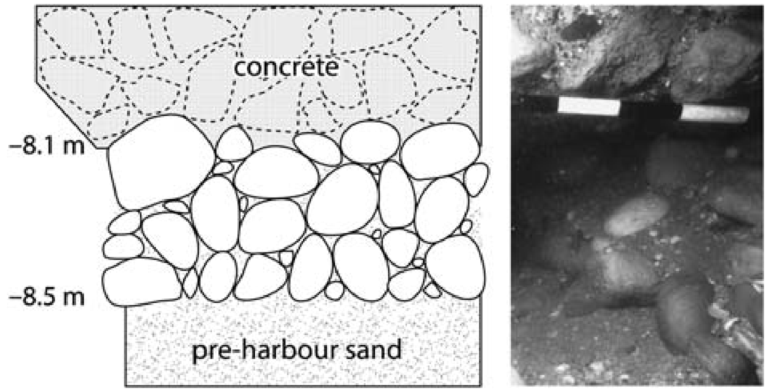

Figure 4. The cobble foundation beneath the concrete element of Area CO. The photograph is of one side of the tunnel excavated beneath the concrete element, illustrating the foundation in situ. The scale-bar divisions are 10 cm. (Photograph by B. Goodman)

exposed the cobble layer to bioerosion. Excavation beneath the northern part, however, displayed a protected stone layer about 0.4 m thick, upon which liquid concrete had been poured and moulded to it (Reinhardt *et al*., 2001: 8) (Fig. 4).

Generally the cobblestones of the foundation may be characterized as hard (6–7 Mohs hardness rating),[11] up to 35 cm in diameter, well-rounded, highly spherical, and with smooth and polished exteriors. These are characteristics of erosion by sustained high-energy streams. Petrographic analysis of 11 stones identified cherts, silicified limestones, and dolomites. The cobblestone layer, distinct from the large crushed kurkar aggregate in the concrete, and found in a localized area beneath the block, is evidence of discrimination in the use of materials by the builders. They may have chosen such hard stones to ensure that the concrete block's foundation was sound, perhaps a concern particular to this block, which appears to have been one of the harbour's largest.

Although the petrographic analysis did not identify any diagnostic stone-types or fossils which could have provided definitive provenance, the overall characteristics of the cobbles strongly suggest that they are of foreign origin. At least the larger of the Area CO cobble stones are not found in the Carmel Coast region, due to lack of the high-energy sustained-flow streams necessary. Rather, the local variety exhibits poorer roundness, greater angularity, and a rougher exterior. Additionally the brecciated and striated patterns and marble-like colours of many of the Area CO cobblestones are not found in the region (Fig. 5). Only uniform white to beige stones, primarily softer limestones, are observed in the stream-beds

Figure 5. Two Area CO foundation cobbles illustrating the stones' well-rounded characteristics, and displaying brecciation unique to the Carmel Coast region. (G. Votruba)

of the coastal plain around Caesarea, consistent with the Carmel Range bedrock.

The same stones have not been found in an archaeological context elsewhere in Caesarea. Although similar foundations have been observed beneath other concrete blocks in the harbour, the individual stones have been recorded primarily as kurkar and do not exhibit similar high-energy riverine-formation characteristics. The quantity of cobbles of the original Area CO block foundation may have amounted to 40 m^3 (about 90 tons). This small number of stones may not have been a special shipment of imported stones, but rather the use of a ship's ballast. Alternatively, if they had been incorporated under other harbour elements, they would represent a small fraction of the total of such stones.

Exotic stone importation

Josephus's references to white/bright stone construction at Caesarea (λευκῆς πέτρας (AJ

15.331), λευκῷ λίθῳ (BJ 1.408), also see BJ 1.414), occasionally translated as marble, have raised the question of whether Herod imported such exotic stone together with his construction materials. However, it is apparent from archaeological research that Herod incorporated marble only rarely in minor decorative contexts, and that he preferred to construct with building stone close at hand (Fischer and Stein, 1994). Herod's Temple at Caesarea, for instance, mentioned by Josephus as having been constructed of white, high-quality stone and workmanship, visible from far out at sea (AJ 13.339), is now known to have been constructed with the local yellowish-orange kurkar and covered with stucco to imitate marble (Kahn, 1996: 131–2, Holum, 1999: 19). The same stucco-covering technique has also been recognized in other Herodian constructions, such as the casemate wall of Masada (Roller, 1998: 188) and for pillars at Herod's palace in Jericho (Netzer, 1981: 58).

No marble or other exotic building-stone elements have been recorded amongst the kurkar and concrete harbour rubble. However, several kurkar blocks buried in the outer harbour sand (Area U) with smoothly-laid stucco on one of their sides (Raban *et al.*, 1999: 168), may indicate that the technique was employed in decorating Sebastos Harbour (Fig. 1). It proves an interesting paradox that bulk quantities of construction materials were imported, but exotic stone apparently was not.

Conclusions

A pan-Mediterranean cosmopolitan enterprise in pozzolana, timber, and perhaps foundation-stones, may be envisaged, in which at least two distinct regions of the Mediterranean world; Puteoli over 1000 nautical miles north-west of Caesarea, and Seleucia Pieria 200 nautical miles to the north, provided materials for the construction of Herod's Sebastos harbour (Fig. 2). Marcus Agrippa may have both organized the shipment of some 17,000 m^3 of pozzolana, and commissioned Italian master-builders experienced in marine concrete construction to co-operate with the local builders of Levantine tradition to construct two magnificent and completely-artificial breakwaters, perhaps the world's first on a modern scale. The shipment of some 11–14,000 m^3 of timber may have been organized by King Herod in concert with Augustus, at Antioch, and exported from the Seleucia Pieria harbour.

The enterprise of importing building materials for Sebastos Harbour was on an imperial scale, considering the quantities and distances involved, but this should not be overemphasized with regards to the construction of the harbour. Contrary to Josephus' writing, Sebastos harbour was not built completely of imported construction material, but perhaps only 20%, the bulk being Carmel coastal sand, kurkar, and limestone quarried from the nearby mountains. Furthermore, the imported materials used were functional, not decorative, as the use of marble would have been, suggesting a measure of practicality to King Herod's megalomania. Considering the enterprise as a whole, starting from a meeting in Mytilene, in which a major harbour construction was organized for Judean Caesarea, requiring shipments of pozzolana from Puteoli and timber from Antioch, and culminating in its construction, it serves as a testament of the unified and organized nature of the Mediterranean in the Early-Roman Period.

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Notes

1. Samples of pozzolana collected in 2005 during ROMACONS research were also determined to have come from Puteoli (pers. comm. J. P. Oleson, 29 July 2006).
2. A figure proposed by Boyce *et al.* (2004: 135) based on a conceptual model of the mole structures, in which the harbour is built primarily of Area K type concrete walls. This figure equates to some 200 forms, each containing a volume of about 390 m^3 of concrete.
3. About 17,300 tons, considering a pozzolana bulk density of 1000 kg/m^3. This density figure is an estimate derived from the specific gravity of 1.58 for the pozzolana isolated from a concrete sample from Area E2 (Oleson, 1989b: 202), which does not account for the interstitial pore space and the fact that there is considerable variability of pozzolana even within a single quarry.

4. See Oleson (1985) and Brandon (1997) for analysis of the architecture of Areas G and K formworks respectively (Fig. 1).
5. These samples were placed in deionized water rather than sea-water during their transport to the botanical laboratory, causing deformation, limiting analysis to the genus level (Liphschitz *et al*., 1989: 191). Nevertheless the researchers were able to determine that the *Pinus*, *Populus* and *Quercus* sp. samples were distinct from the local varieties (Liphschitz *et al*., 1989: 194). A report of *Picea europea* (Oleson, 1985: 168) is not accurate as the species does not exist.
6. *Pinus silvestris*, if indeed it was the species (rather than *Pinus nigra*), does not grow as far south as Cyprus. *Pinus brutia* and *Pinus nigra* are also found in large numbers elsewhere such as Turkey.
7. The sampling was performed with the guidance of Chris Brandon and Avner Hillman, and the species identification was performed by Nili Liphschitz of the Institute of Archaeology at Tel Aviv University, to all of whom I am grateful. In Dr Liphschitz's report it is mentioned that the only country in which these species grow together is Turkey.
8. Determinations of the tree-growing regions are based on their positive reference for particular locations in one or more of these texts: G. E. Post and J. E. Dinsmore (1932); P. H. Davis, M. J. E. Coode, and J. Cullen (1965); M. Zohary (1973); R. D. Meikle (1977); K. Browicz and J. Zieliânski (1982); G. Krüssmann (1991); M. Rival (1991); M. Vidakovic (1991); T. G. Tutin (1993); K. Browicz (1996); T. Skroppa (2003). The sample identified as *Pinus silvestris* or *Pinus nigra* mentioned above is not considered further as both are only possibilities.
9. *Quercus coccifera* ssp. *calliprinos*, such as that documented by Meikle (1977: 1484–1486), is distinguished by Dr Nili Liphschitz and this author differently, rather as *Quercus calliprinos*. For the same reason *Quercus coccifera* ssp. *coccifera*, not identified on Cyprus, is considered here as *Quercus coccifera*.
10. *Quercus coccifera* is the only species not keyed to the Amanus mountains, specifically growing only west of the Taurus mountains (Zohary, 1973: 356). Anatolia's coast west of the Amanos is however deficient in *Picea orientalis* and *Fagus sylvatica*. The *Quercus coccifera* was unlikely to have been found in the region, and may be considered to have been trans-shipped from a location further west. The *Abies* sp. found in the Amanos region, is of the genus *cilicica*, and that of the *Picea* sp., *orientalis.*
11. In contrast, the six river-stones collected from Carmel coastal streams displayed Mohs ratings of 3–3.5. Thanks are due to the General Directorate of Highways, Technical Research Department, Geological Services Branch in Ankara, Turkey for performing these Mohs hardness tests. For the stone-type identification of the samples I thank the petrographic analysis of Dr Eşref Atabey of the Mineral Research and Exploration General Directorate, Department of Geology, Balgat-Ankara, Turkey.

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