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Mediterranean Coasts, Cargoes of Raw Glass

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Preliminary Report

In 1989–2004, chunks of raw glass were discovered in underwater surveys conducted along the Mediterranean coast of Israel (Permit Nos. A-1637, A-3817, A-4076; License Nos. G-32/1990, G-15/1991, G-21/1991, G-26/1992, G-30/1993, G-31/1993, G-21/1994, G-53/1995, G-30/1997, G-13/1999; Fig. 1). The surveys, conducted on behalf of the Israel Antiquities Authority, were directed by E. Galili (underwater archaeology, study of glass cargoes and photography), with the assistance of J. Sharvit (underwater archaeology), D. Moscowitz, H. Sal'i, A. Ya'aqobowitz, and Y. Ayalon (diving), T. Sagiv (photography), Y. Gorin-Rosen (study of glass), B. Rosen (study of glass cargoes) and D.T. Ariel, R. Kool, D. Syon and Y. Meshorer (numismatics). Research on the composition of the glass chunks recovered from the sea was carried out by I. Freestone of the University College London (UCL); the results will be published in the future.

Fifty-two chunks of glass weighing a total of c. 70 kg were discovered and studied. They were classified into three types: (A) glass chunks originating from vessels that sank along the open coast, mainly off of the Carmel coast, between Haifa and 'Atlit, and the coast of Ashqelon)Fig. 1); (B) glass chunks originating from vessels that sank while docking in a natural anchorage, including the northern anchorage at 'Atlit, the Neve Yam anchorage, the southern anchorage at Dor, the southern anchorage at Caesarea and the Apollonia anchorage; and (C) small lumps of glass discovered within the 'Akko harbor. The glass chunks were generally attributed to nearby shipwreck assemblages and were dated according to the finds in these assemblages. All of the chunks were numbered sequentially, save twelve chunks that were retrieved from the 'Akko harbor, which were numbered separately. The glass assemblages are described below in geographical order, from north to south.

'Akko Harbor

During dredging operations in the 'Akko harbor in 1990–1999 (The 'Akko Marina Archaeological Project; map ref. 206894/758291; Galili et al. 2002), 12 chunks of raw glass of various colors and sizes (Fig. 2) were found scattered on the harbor seabed. The glass chunks were dated to the Late Roman, Byzantine and Early Islamic periods based on nearby artifacts. The largest chunk in this group weighs c. 0.5 kg, and the rest range in weight from several dozen grams to 0.25 kg. The chunks of raw glass from the 'Akko harbor are smaller than those found elsewhere along the Israeli coast, all of which originated in shipwrecks. Furthermore, they occur in a wide variety of colors—light blue, light green, bluish-green, yellowish-green and brown—unlike glass chunks in other shipwreck cargoes from the coast of Israel, whose colors are generally uniform. The characteristics of the glass chunks from 'Akko and the distribution of the finds in the harbor indicate that the chunks did not originate in the cargo of a specific vessel that sank there, but probably fell into the sea over the years, as glass cargoes were being handled in the harbor and onboard anchoring vessels.

The Northern Carmel Coast between Haifa and 'Atlit

This section of the coast, which stretches from the beaches south of Haifa to ‘Atlit (length 10 km), is straight, sandy and exposed, and there are no places along it that offer shelter for watercraft. Numerous shipwreck assemblages that included cargoes containing chunks of raw glass were discovered along this section. The finds were usually located c. 100 m from the shore, at a water depth of 3–4 m.

Kefar Samir (North). In 1990, a large concentration of artifacts, including three chunks of raw glass (Nos. 1, 3, 6; Fig. 3), was discovered in the northern part of the site of Kefar Samir (map ref. 196098/745391). The glass chunks were attributed to three assemblages dating to the Roman period, which were identified at the site (Nos. 19–21; Galili and Sharvit 1999a: Fig. 25). Chunk 1 (1940 g) is attributed to Assemblage 19 or 21. Assemblage 19 dates from the third century CE; it includes silver and bronze coins, bronze figurines, bronze items and nails, lead sheathings of hulls and fishing gear (Galili, Rosen and Sharvit 2010). Based on the latest coin in this assemblage, it seems that this vessel sank between 230 and 235 CE (Meshorer 2010:111–112). Assemblage 21 dates from the Late Roman period (fourth century CE); it includes nails, pieces of a lead sheathing and bronze coins, the latest of which dates to 318 CE (Ariel 2010:137). Chunks 3 and 6 (3630 g and 380 g respectively) were found in a concentration c. 100 m south of Chunk 1; they are attributed to Assemblage 20 that was discovered c. 150 m south of Assemblages 19 and 21. An examination of of an additional chunk (7; 18 g) reconvered near by showed that it is not glass, but a blue, opaque stone. Presumably, this stone was shipped as a raw material, just like the chunks of raw glass. The transportation of precious stones and colored stones along maritime trade routes is mentioned in historical sources.

Kefar Samir (South). The site stretches from Dado Beach in the north to the Haifa municipal limits in the south (length c. 2 km; map ref. 195929/743589). Many shipwreck assemblages from various periods were discovered at the site. Ten chunks of raw glass (Nos. 5, 8, 16–18, 27–31; Fig. 4) found in the southern part of the site were classified into three groups according to their color and location: (1) Chunks 27–31 (2390 g, 3000 g, 1400 g, 2850 g, 5000 g respectively); (2) Chunks 16–18 (800 g, 257 g, 66.5 g respectively); (3) Chunks 5 and 8 (396 g and 358 g respectively). It seems that the provenances of the three groups of glass chunks were three assemblages that came from shipwrecks discovered at the site (Nos. 10, 11, 15; Galili and Sharvit 1999a: Fig. 25). Assemblage 10 was dated to the mid-first century BCE (63 BCE) based on the latest silver coin of Ptolemy XII. Assemblage 11 was dated to the second century CE and included a hoard of silver dinars, a wooden anchor with lead fittings and a lead brazier that was used for cooking aboard. Assemblage 15, discovered 20–30 m south of the previous two assemblages, was dated to the Roman period and included several lead pipes, a bronze bowl and a stone mortar. Given the proximity of the three assemblages, it is impossible to ascribe the chunks of glass to any specific assemblage.

Carmel Forge (Hishule Karmel). The site is located south of the Haifa bathing beaches and west of the Carmel Forge plant (map ref. 195792/742669). Two chunks of raw glass were discovered there (Nos. 2, 19; 650 g and 61 g respectively). Assemblages discovered in the area belong to several shipwrecks from various periods. Judging by the artifacts recovered from the seabed, the two chunks of glass were attributed to a vessel that sank in the Roman period. The absence of coins at the site makes it difficult to date this assemblage more accurately.

Tell Hreis. In 1992–1996, two shipwreck assemblages were exposed southwest

of Tell Hreis (map ref. 195484/739058). Nearby concentrations of especially large chunks of green to greenish blue glass (5000–9880 g; Fig. 5) should be attributed to one of these assemblages. One assemblage dates from either the Late Roman or the Byzantine period, and it includes an iron anchor with two arms and several basalt double-cone millstones. The other assemblage dates from the Early Islamic period, and it includes a decorated silver bracelet and several iron ingots.

Megadim. Several shipwreck assemblages from various periods were found at the site (map ref. 195224/737253). Two of them yielded a wealth of artifacts, one from the Hellenistic period and the other from the Mamluk period (Raban and Galili 1985; Syon, Lorber and Galili 2013). In addition, a concentration of several iron anchors from the Byzantine period and a cargo of dozens of loaf-shaped iron ingots was found in this area. The ingots were dated based on a pair of nearby iron anchors that were in use in the tenth–fifteenth centuries CE. Several chunks of raw glass were among the objects discovered in underwater surveys performed in the area (Galili and Sharvit 1999b:98*–99*). It was impossible to attribute the glass chunks to one of the shipwreck assemblages, but judging by the location of the chunks and their characteristics, their provenance was presumably a shipwreck dated to either the Hellenistic or the Byzantine period.

‘Atlit, North Bay Anchorage

Numerous shipwreck assemblages dating from the Early Bronze Age to the modern era were discovered in the northern bay of ‘Atlit (map ref. 194601/734866; Galili and Sharvit 1999b: Fig. 196). In 1989, a large chunk of glass of a unique aquamarine color (No. 15; 2920 g; Fig. 6) was found. Metal artifacts and a small basalt bowl were found at the same place. The ship cargoes closest to where the glass chunk was discovered comprise finds from the Persian (No. 13), Hellenistic (No. 15) and Byzantine periods (No. 17; Galili et al., in press). The chemical composition of the glass is consistent with glass produced in the region during the Byzantine period (I. Freestone, pers. comm.), and therefore the most likely source of the chunk is the Byzantine-period assemblage.

Neve Yam Anchorage

The bay, which extends between the shoreline and the reefs west of Kibbutz Neve Yam, was used as an anchorage during various periods (map ref. 193539/731320). Artifacts originating in shipwrecks from the Hellenistic (No. 3), Roman (No. 4), Byzantine (No. 5) and Mamluk (No. 6) periods were discovered in underwater surveys conducted in the bay (Galili and Sharvit 1999b:100*, Fig. 202). Several chunks of glass that should be attributed to one of the first three assemblages were found scattered in the southern part of the anchorage (Galili and Sharvit 1999b:100*).

Dor, Southern Anchorage

Numerous remains of wrecked ships were discovered in the southern anchorage at Dor, known as ‘the lagoon’ (map ref. 192392/723663). Cargo assemblages originating from vessels that sank while anchoring there dated from the Middle Bronze Age onwards. Several large chunks of glass were discovered within the anchorage (K. Raveh, pers. comm.). Three of them are currently exhibited at the Mizgaga Museum in Kibbutz Nahsholim. The provenance of these chunks is probably one of the shipwrecks whose remains were discovered in the anchorage, most likely a shipwreck assemblage dated to the seventh century CE. That assemblage included a set of fishing gear, a fire basket used for fishing with light to attract fish, and a cluster of eighty bronze coins (Galili, Rosen and Sharvit 2007). The latest coin in the assemblage was minted in 659–663 CE, and dates the approximate time of the wreckage (Syon and Galili 2009). Remains of a glass

industry were exposed at Dor above the remains of the Byzantine church, which was abandoned at the beginning of the Early Islamic period (Gorin-Rosen 2000:61). Raw glass, probably manufactured at Dor or nearby, may have been exported from the southern anchorage.

Caesarea, the Southern Anchorage

Remains of an ancient anchorage that was used from the Middle Bronze Age onward were found southwest of Kibbutz Sedot Yam (map ref. 189695/710592; Galili, Dahari and Sharvit 1993). Three glass chunks (Nos. 9–11; 660 g, 763 g and 585 g respectively; Fig. 7) were recovered in surveys conducted in1989–1991 in the central part of the anchorage, west of the maritime education center and 20–100 m from the shore. The chunks may have been part of a shipwrecked cargo from the first century CE, which was discovered there (Assemblage No. 2; Galili and Artzy 1991: Fig. 32:2; Galili, Dahari and Sharvit 1993: Fig. 6D). The boat's cargo included Roman bronze coins, a bronze statuette of 'Aphrodite removing her sandal', a bronze weight in the form of a bust of a woman, bronze bells, fishing gear and pithoi fragments. Most of the coins were minted in the second half of the first century CE, and in all likelihood the ship was wrecked at about that time. Two of the coins in the assemblage are of Nero and bear the stamp of the city of Caesarea–KAI (Galili and Artzy 1991:42). The bottom of a large glass kiln containing fragments of pale blue raw glass was discovered in a salvage excavation conducted near Caesarea's amphitheater, several hundred meters from the sea (P. Gendelman, pers. comm.). The cargoes of raw glass discovered at Caesarea's southern anchorage suggest that raw glass produced in the region—e.g., near Moshav Bet Eli'ezer and Caesarea—was exported by sea. Evidence for river navigation from the hinterland to the coast was discovered in Nahal Hadera: a dock built of large ashlars, some of which were dressed with grooves for connecting metal clips (Sharvit and Galili 2000; Galili 2009:15). The dock dates to the Roman period and was used as an inland cargo terminal for boats that carried goods downstream to the coast. The dock may also have been used in later times. Such transportation would have allowed to easily transfer heavy cargoes of raw glass that was produced in the kilns at Bet Eli'ezer, as well as agricultural produce, just as watermelons were transported downstream during the Ottoman period.

Apollonia Anchorage

Remains of an anchorage protected by a submerged *kurkar* ridge were found south of Apollonia, near the shore (map ref. 181812/677878); it was used from the Middle Bronze Age onward.

Numerous shipwreck assemblages and objects that fell from anchoring vessels were discovered in the anchorage (Galili, Dahari and Sharvit 1992:164–165, Fig. 181; Galili, Dahari and Sharvit 1993). Two greenish blue chunks of glass were recovered during surveys conducted there (Nos. 20 and 21; 1570 g and 546.5 g respectively; Fig. 8). The upper surface of Chunk 20 was smooth and flat, indicating that it was at the top of the kiln. Chunk 21 was abraded as a result of wave actions. Five small chunks of raw glass (Nos. 22–26) were recovered from the anchorage during a survey performed in February 1991. Two of them (Nos. 22 and 23; 325 g and 262 g respectively) have a greenish blue shade, and three contain kiln debris and a scant amount of raw glass (Nos. 24–26; 258 g, 51 g, 28 g respectively; see Fig. 8). In January 1992, two other chunks of raw glass (Nos. 32, 33; 500 g and 31 g respectively; see Fig. 8) were found in the anchorage. The chunks that contained kiln debris seem to have originated in parts of the ancient city that collapsed as a result of marine erosion. Four glass kilns from the Late Byzantine period were exposed *in situ* at Apollonia, indicating the presence of an extensive glass industry at the site during that period (Roll and Ayalon 1989:217–

221; Freestone, Jackson-Tal and Tal 2008).

Ashqelon

Ashqelon is the most southern site along the seashore in Israel where chunks of raw glass were discovered. In October 1996, a small chunk of green opaque glass (No. 34; 26 g; Fig. 9) was found opposite the Ashqelon National Park (map ref. 158755/622238). This type of glass was used in making *tesserae*; it probably dates from the Roman or Byzantine period, since at the time glass was used extensively in the mosaic industry. A bluish green chunk of glass (No. 35; 500 g; Fig. 9) was discovered on the northern coast of Ashqelon, near the Holiday Inn hotel (map ref. 156752/619310). Mayumas, a suburb of Ashqelon that grew outside the city walls during the Byzantine period, was located in this area (Galili 2009:19). Additional items from the Byzantine period found near the chunk of glass, included iron anchors, lead sounding weights engraved with crosses, dozens of bronze coins from the time of Justin II (565–578 CE), stone composite anchors with carved crosses (Galili et al. 2012), a steelyard bearing Greek inscriptions and engraved crosses, a fragment of a marble chancel screen from a church and a marble grinding bowl. These items confirm the connection between the shipwreck and Byzantine Mayumas. The coins date the shipwreck to the sixth century CE (Galili, Zviely and Rosen 2009:362).

Discussion

Chunks of glass recovered from Mediterranean shipwreck cargoes date from as early as the Hellenistic period. In the first century CE, the production of raw glass expanded in our region; this corresponds to the testimony of written sources, according to which the manufacturing of raw glass in Israel began during that century (Gorin-Rosen 2000). Glass was manufactured by mixing and melting quartz-rich sand, limestone and natron salt or plant ash. Early evidences suggests that raw glass was produced in the vicinity of ‘Akko, and that sand from the Nahal Na‘aman (Belus) and natron from Egypt were used in its production. The natron was mined in Wadi Natron in Egypt and brought by way of the Nile’s Pelusiac distributary to the Mediterranean Sea, and from there shipped along the coast of Israel. In his book, *Geographica* (XVI:758), Strabo mentions the nature and quality of the sand from the mouth of Nahal Na‘aman, which was transported by sea to Tyre and Sidon for use in their glass industry. Pliny (*Natural History*, 36.45) tells of a group of Phoenician seafarers that anchored near the mouth of the Belus River. Molten glass began to flow when they were cooking in a pot that was placed on natron bricks that they brought from their boat. Josephus tells of a place adjacent to ‘Akko where the sand is naturally accumulated in a special basin near the Belus River, and when it is taken away by the ships, the wind brings more sand (*War of the Jews* II:10:2). During the Middle Ages, sand from Nahal Na‘aman was exported to the glass manufacturing centers in Europe (Jacoby 2001).

An unfinished nine ton glass slab was discovered in a cave at Bet She‘arim (Brill 1967). Several kilns were discovered at Apollonia, four of which have been published (Freestone, Jackson-Tal and Tal 2008:67–70). Seventeen kilns were discovered at Bet Eli‘ezer, near Hadera (Gorin-Rosen 2000). The remains of the glass kiln from Caesarea, mentioned above, are similar to those exposed at Bet Eli‘ezer. Other remains of a raw glass industry were identified in surveys performed in the southern Sharon (Roll and Ayalon 1989:217–221), near ‘Akko and elsewhere. Most of the industry’s remains in Israel date from the Byzantine period and the beginning of the Early Islamic period, while some date from the Roman period.

The raw glass cargoes found on the seabed are indicative of the extensive trade that was connected to the raw glass industrial centers on land. Most of the raw

glass production in the region took place along the coastal plains between the Sharon and ‘Akko. The underwater finds show that much of the maritime transport of raw glass also occurred between Apollonia and ‘Akko. In other words, the distribution area of the raw glass manufacturing facilities on land correspond to the area where raw glass cargoes were discovered on the seabed. It seems that the cargoes found at sea were related to the production and marketing system of raw glass along the shores of the Land of Israel.

During the Roman, Byzantine and Early Islamic periods, raw glass was loaded in local anchorages that included Apollonia, Caesarea, Dor, Neve Yam and ‘Atlit and the port of ‘Akko. From there it was shipped to production centers in Europe and Asia Minor. The reason the manufacturing facilities for raw glass were located between ‘Akko and the Sharon is probably due to the availability of the principal raw materials required for this industry. The quartz sand was transported by sea currents along the coast of Israel from the Nile Delta. ‘Akko is considered the northern end of the Nile littoral cell. The Mediterranean vegetation, which was probably used as fuel in the glass industry, was abundant near the shores of the Galilee, the Carmel and the Sharon. South of this area, in the Irano-Turanian and the Saharo-Sindian regions, there is less vegetation (Fig. 10).

The paucity of raw glass finds on the southern coastal strip of Israel, stretching from south of Apollonia down to Ashqelon, indicates the limited extent of glass commerce along the shore. The Yavne-Yam anchorage yielded numerous finds from shipwrecks dating from the Late Bronze Age to the Late Middle Ages (Galili 2009:16) but no raw glass. Yavne-Yam was the only anchorage in southern Israel, between the northern Sinai and Yafo (Jaffa), that could provide shelter for any watercraft, and therefore vessels that sailed along the southern coast between Egypt and Israel must have anchored there. Thus, the absence of raw glass in the Yavne-Yam anchorage truly reflects the ancient circumstances rather than inadequate research. The underwater finds indicate that glass production was an important export industry in Palestine during the Roman, Byzantine and Early Islamic periods, and probably later as well, and that it was mainly destined for European markets.

The chunks of glass from shipwrecks found both along the open coast and in natural anchorages are usually large, and each of these cargo is uniform in color and texture. In contrast, the glass chunks that were discovered in the ‘Akko harbor are smaller and exhibit a variety of shades and textures. The reason for these differences is that while the glass chunks recovered from anchorages and on the open coast originated in complete shipments wrecked along the coast of Israel, those recovered from the ‘Akko harbor are chunks of raw material that accidentally fell into the water during loading and unloading ships in the port over time.

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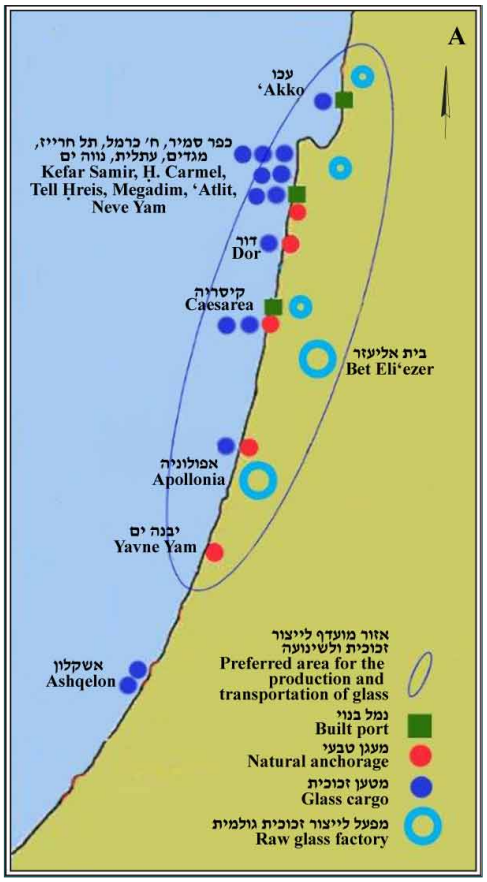


1. Distribution of raw glass discovered off the coast of Israel; anchorages and harbors used to transport the glass; principal production sites of raw glass.

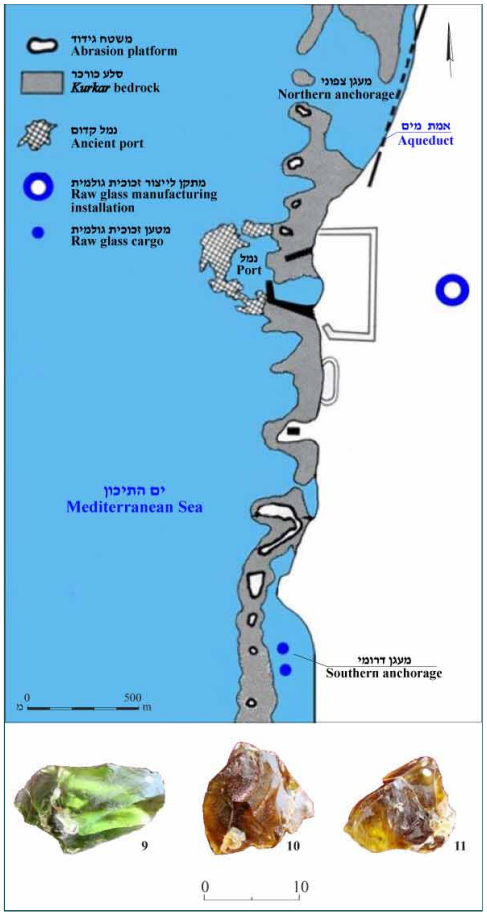
2. Chunks of raw glass from the 'Akko harbor.

3. Chunks of raw glass from Kefar Samir (North and South).

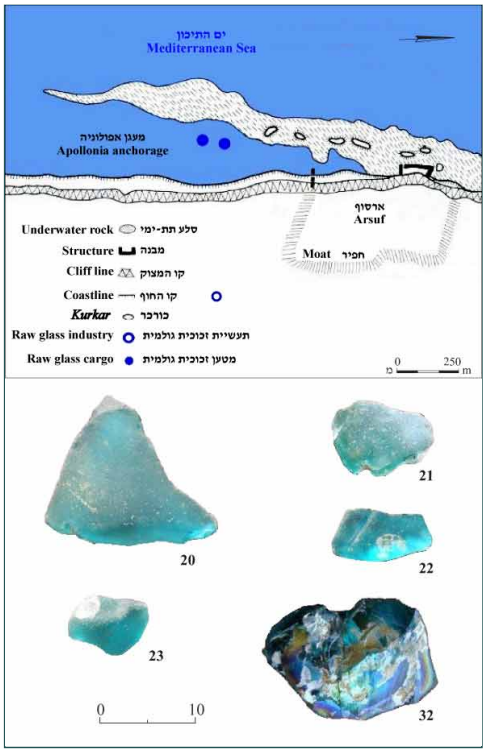
4. Chunks of raw glass from Kefar Samir (South).

5. Chunks of raw glass from Tell Hreis.

6. A chunk of raw glass from the ‘Atlit anchorage.

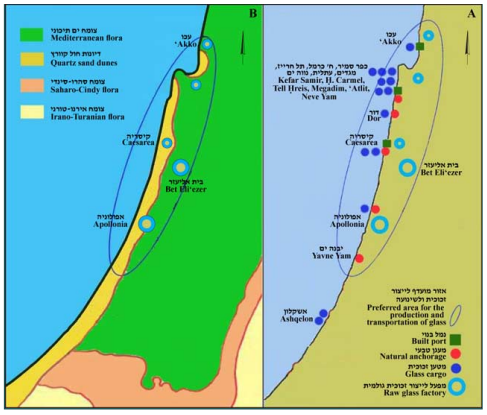


7. Chunks of raw glass from the southern anchorage at Caesarea; a map of the cargoes in the anchorage and the raw glass manufacturing facility in Caesarea.



8. Chunks of raw glass from the anchorage at Apollonia; a map of the cargoes in the anchorage and of the nearby raw glass industry.

9. Two chunks of raw glass discovered in the vicinity of Ashqelon.



10. (A) See Fig. 1; (B) The correlation of Mediterranean flora and the distribution of Nile sand along the coast of Israel; production sites of raw glass; main ports and anchorages.

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