

*Item ex his generibus viatoria pensilia  
uti fierent plures scripta reliquerunt  
Vitruvius, De Architectura IX, 8, 1*

Apollonia-Arsuf, located on the Mediterranean coast of Israel some 17 kilometers north of Jaffa (ancient Joppa, south of Tel Aviv) and 34 kilometers south of Caesarea, has been excavated continuously during the last thirty years.<sup>1</sup> Once a modest coastal settlement,

Apollonia-Arsuf became the urban center of the southern Sharon plain as early as the Persian period (late sixth century BCE) through the Crusader period (until the mid-13<sup>th</sup> century CE).

Apollonia is mentioned in a series of classical sources. Josephus<sup>2</sup> refers to it as one of the *poleis* that belonged to the Jews under Alexander Jannæus. The city is also mentioned in lists of Judæa's coastal towns compiled by Pliny<sup>3</sup> and by Ptolemy.<sup>4</sup>

Apollonia is also noted in some written sources from the Byzantine period. It is recorded twice in the anonymous *Cosmography of Ravenna*: in a list of urban centers of *Iudæa-Palæstina*, where it is listed after Caesarea and before Joppa, and again between Joppa and Caesarea in a long list of the coastal cities of Sinai and Palestine.<sup>5</sup> Apollonia also appears in the detailed list of 25 cities of that name compiled by Stephanus Byzantius under number 13, "near Joppa".<sup>6</sup> On the

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1. The first systematic excavations at Apollonia-Arsuf were carried out in 1950, north of the medieval city wall, by the Israel Department of Antiquities and Museums, directed by Immanuel Ben-Dor and later by Penuel Kahane. The latter published only an abridged preliminary report. See P. KAHANE, "Rishpon (Apollonia); B", *Bulletin of the Department of Antiquities of the State of Israel* 3, 1951, pp. 42-43 (in Hebrew); an English summary is found in A. PERKINS, "Archaeological News: The Near East," *American Journal of Archaeology* 55, 1951, pp. 86-87, fig. 11. A completely new approach, that of exploring the site in a historically and methodologically more coherent way, indicative of a new era of archaeological fieldwork, began in 1977 by Israel Roll. Since then, Roll, who directed seventeen seasons of excavations until 2004, explored large sections of the site, establishing for the first time a chronological and developmental framework for Apollonia-Arsuf. In 2006, an eighteenth season of excavations at Apollonia-Arsuf was carried out, a transition during which the directorship and responsibility over the future excavations at Apollonia-Arsuf were transferred from I. Roll to O. Tal. In 2009 Tal directed a nineteenth season of excavations. For an overview on the site and its history of excavations, see I. ROLL, "Introduction: History of the Site, its Research and Excavations", in I. ROLL and O. TAL, *Apollonia-Arsuf: Final Report of the Excavations, 1. The Persian and Hellenistic Periods (with Appendices on the Chalcolithic and Iron Age II Remains)* (Monograph Series of the Institute of Archaeology 16, Tel Aviv, Tel Aviv University, 1999, pp. 1-62. A more updated overview is to be found in K. GALOR, I. ROLL and O. TAL, "Apollonia-Arsuf between Past and Future", *Near Eastern Archaeology* 72/1 (2009), pp. 4-27.

2. *Ant.* 13.15.4 [395].

3. *NH* 5.69.

4. *Geogr.* 5.15.2. Roman-period remains were discovered during excavations at the site; cf. I. ROLL and O. TAL, "A Villa of the Early Roman Period at Apollonia-Arsuf," *Israel Exploration Journal* 58, 2008, pp. 132-149.

5. *Ravenna Cosmography* 2.14.2 and 5.7.2. See J. SCHNETZ (ed.), *Itineraria Romana*, vol. 2, *Ravennatis anonymi cosmographia et Guidonis geographica*, Leipzig, Friderici Nicolai, 1940, pp. 25, 90, and 133. The *Cosmography of Ravenna* was compiled soon after 700 CE from earlier sources that go back to early Byzantine or even Roman times; see *IDEM*, "Untersuchungen über die Quellen der Cosmographie des anonymen Geographen von Ravenna," *Sitzungsberichte der Bayerischen Akademie der Wissenschaften, Philosophisch-Historische Abteilung* 6, 1942, pp. 1-87; O. A. W. DILKE, *Greek and Roman Maps*, London, Johns Hopkins University Press, 1985, pp. 174-176.

6. *Stephani Byzantii Ethniconum quae supersunt*, ed. A. MEINEKE, Berlin, G. Reimer, 1849, p. 106. It is worth noting that in Stephanus Byzantius' text the name *Sozousa* (s.v., no. 1, p. 596) is also mentioned (for which see below) – most probably because Stephanus used sources from different periods: one from Roman times

other hand, Apollonia does not appear in early ecclesiastical lists. Two nineteenth century scholars, Stark and Clermont-Ganneau, assumed that the reason for its absence derived from the fact that Apollonia's name had been changed to *Sozousa* – a common change for cities named after Apollo Sōter in Byzantine times.<sup>7</sup> Later texts and critical editions of texts, which recount the Persian-Sassanian capture of Jerusalem, record the death of the patriarch Modestus in a city named *Sozos*: *Sozousa* in Georgian texts and Arsuf in Arabic texts.<sup>8</sup> Official documents of the synod of Ephesus held in 449 indicate that in the mid-fifth century CE *Sozousa* was a city in the Byzantine province of *Palæstina Prima* and that its Christian community was headed by a bishop. Bishops of *Sozousa* appear again in the records of two sixth-century ecclesiastical meetings.<sup>9</sup> They may have served in the church with an inscribed mosaic floor that was uncovered in Apollonia in 1962.<sup>10</sup>

The importance of *Sozousa* in Late Byzantine Palestine (sixth to seventh centuries CE in archaeological terms), seems to have been enhanced by the large and affluent Samaritan community that resided in the city until the Islamic conquest, as is evident from the archaeological finds.<sup>11</sup> Arsuf is also mentioned in connection

when listing *Apollonia*, and a source from Byzantine times when mentioning *Sozousa*. For Apollonia, see also *Stephani Byzantii Ethnica*, vol. I, ed. M. BILLERBECK, Berlin/New York, W. de Gruyter, 2006, pp. 228-229.

7. K. B. STARK, *Gaza und die philistäische Küste*, Jena, 1852, p. 452, n. 5; C. CLERMONT-GANNEAU, *Archaeological Researches in Palestine during the Years 1873-1874*, vol. 2, London, Committee of the Palestine Exploration Fund, 1896, pp. 337-339.
8. G. GARITTE (ed.), *La prise de Jérusalem par les Perses en 614* (Corpus Scriptorum Christianorum Orientalium (= CSCO) 203, Louvain, 1960, p. 55; *ibid.*, CSCO 341, 1953, pp. 38-70; *ibid.*, CSCO 348, 1974, p. 131.
9. *Acta Conciliorum Oecumenicorum*, Berlin, W. de Gruyter, vol. 3, ed. E. SCHWARTZ, 1940, pp. 80 and 188, and vol. 4, no. 1, ed. J. STRAUB, 1971, p. 221. For a more detailed discussion on the issue, see I. ROLL, "Introduction: History of the Site" (*supra*, n. 1), p. 9 with relevant bibliography in notes 14-15.
10. R. BRNBAUM and A. OVADIAH, "A Greek Inscription from the Early Byzantine Church at Apollonia," *Israel Exploration Journal* 40, 1990, pp. 182-191; see also I. ROLL, "Introduction: History of the Site" (*supra*, n. 2), pp. 31 and 45.
11. I. ROLL and E. AYALON, *Apollonia and Southern Sharon* Tel Aviv, Hakibbutz Hameuchad, 1989, pp. 51-67 (in Hebrew); I. ROLL, "Introduction: History of the Site" (*supra*, n. 1), pp. 26-53 *passim*. It should be emphasized, however, that Abū l-Fath reports Samaritan synagogues in villages between Zaytā (north of Tūl Karem) and Arsūf, but only a Dosithean (not Samaritan) "meeting place" in Arsuf in the early ninth century long after the Islamic conquest. Cf. M. LEVY-RUBIN, *The Continuatio*

with the Sassanian military campaign in the Holy Land.<sup>12</sup> As there is no evidence of destruction, we may assume that the city surrendered peacefully to its Persian-Sassanian conquerors.<sup>13</sup> The *Acta Anastasii Persæ* relate that the escort conveying the relics of the Christian martyr Anastasius the Persian from Caesarea to Jerusalem in 631 – soon after the Persians evacuated Palestine – marched via *Sozousa*. This indicates that the name *Sozousa* continued to be used for Apollonia-Arsuf until the Islamic conquest.<sup>14</sup>

This article examines a unique clay object that came from the site, which we tend to consider was used as a horizontal (flat) portable sundial (*horologium*). It was retrieved from the 1992 excavation season in Area E, in the southern part of the site. It was found in a Byzantine context with pottery and other finds that are dated to the sixth and seventh centuries CE. The Byzantine remains unearthed during the excavations in Area E belong to several industrial manufacturing installations including a winepress, a drainage shaft, a channel that ends with a small circular pool and a rock-cut vaulted cistern and a four-vat installation, consisting of two pair of pools, one pair with plastered walls and the other built of ashlar (figure 1).<sup>15</sup> Our object came from a fill (Locus 1334) not far from two installations, one being the above-mentioned four-vat installation (Loci 1327, 1331, 1335, 1336) and the other a channel that ends with a small circular pool (Locus 1338).<sup>16</sup>

of the Samaritan Chronicle of Abū l-Fath al-Sāmīrī al-Danaḥī, *Studies in Late Antiquity and Early Islam* 10, Princeton, New Jersey, Darwin Press, 2002, pp. 69-70.

12. P. PEETERS, "La Prise de Jérusalem par les Perses," *Mélanges de l'Université Saint Joseph de Beyrouth* 9, 1923-1924, p. 13. G. GARITTE (ed.), *Expugnatio Hierosolymae A.D. 614* (CSCO 341), Louvain, 1953, pp. 4 and 42; *ibid.*, CSCO 348, 1974, pp. 75, and 104. For discussion, see R. SCHICK, *The Christian Communities of Palestine from Byzantine to Islamic Rule: A Historical and Archaeological Study*, Princeton, New Jersey, Darwin Press, 1995, pp. 20-25.
13. R. SCHICK, *The Christian Communities* (*supra*, n. 12), pp. 20-25, and esp. 250.
14. B. FLUSIN (ed.), *Saint Anastase le Perse et l'histoire de la Palestine au début du VII<sup>e</sup> siècle*, Paris, Éditions du CNRS, 1992, vol. 1, p. 105, and vol. 2, p. 339.
15. The winepress that is not illustrated in fig. 1 was found in Area E right above Locus 1250 of the Roman villa. It was excavated in 1980-1981, and demolished to uncover the earlier, Roman level. It was composed of a plaster floor (Locus 842) slightly inclined to the south, toward a buried *dolium* (Locus 809) serving as collecting vat. For plan and description, cf. I. ROLL and E. AYALON, *Apollonia and Southern Sharon* (*supra*, n. 11), p. 53 and plan with section on p. 40.
16. The object was discovered in the ninth season of excavations in 1992 (license no. G-116/1992). It came from

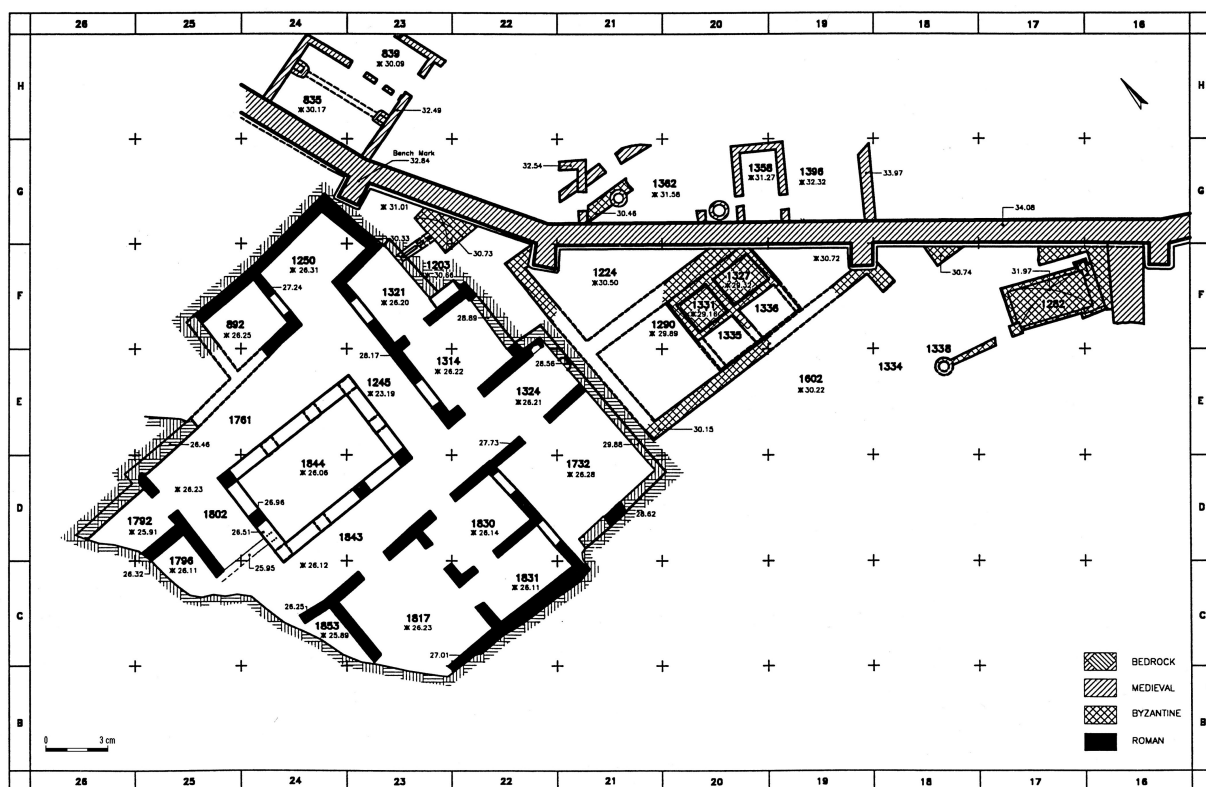


Figure 1 - Apollonia-Arsuf: Plan of Area E.

At a later stage, but still in the Late Byzantine period, the four-vat installation and its surroundings were covered with two much larger basins with white mosaic floors (not illustrated). Apart from the wine-press, the crafts requiring these installations could not be securely determined although the possibility that the four-vat installation was used for *garum et salsamenta*, namely the production of fish sauce and the salting of fish, is appealing. However, the transition from small installations to larger ones seems to suggest a change in ownership – from small artisans to a magnate or an ecclesiastical institution. It should be borne in mind that during the Byzantine period, the city, which was apparently unfortified, reached its greatest prosperity and

largest expansion, up to *circa* 28 000 sqm. It emerged as the chief commercial, industrial and maritime center of the entire southern Sharon Plain.

The object is somewhat pentagonal in shape, *circa* 7.0 cm wide, 9.6 cm long and about 2.0 cm thick; it weighs some 173 gr (figure 2). It is made of high-temperature fired (“stone ware”) clay with many gritty and micaceous inclusions. It is dark orange in color on both the upper and lower surfaces as well as in its core.<sup>17</sup> The upper surface (or disk) depicts a design that was incised (and partially stamped) on it prior to firing and most probably while the object was in a leathery, very

Square E18, Locus 1334, Basket 12934. The locus was located in Square E18, on the upper *kurkar* (fossilized dune sandstone) surface to the southeast of the Roman villa and to the southwest of the four-vat Byzantine-period installation (opened on 01.11.1992). It is currently kept at the storage facilities of the Apollonia-Arsuf Excavations Project at Tel Aviv University. Thanks go to Tel Aviv University, Institute of Archaeology technical staff, namely Rachel Pelta for cleaning and restoring the object, Ada Perry for its drawing and Pavel Shargo for its photographing.

17. Munsell color notations are 5 YR 7/8 = “pale-moderate orange.” Petrographic analysis carried out in the Laboratory for Comparative Microarchaeology and Metal Conservation of Tel Aviv University, Institute of Archaeology, by Yuval Goren, suggests it is Eastern Aegean ware (southwestern Asia Minor). This does not necessarily indicate that it was an Aegean product, as evidence of trade in Samian clay in Palestine is known from the Persian and Hellenistic periods, cf. O. Tal, “On the Identification of the Ships of *kdlry* of the Erased Customs Account from Elephantine”, *Journal of Near Eastern Studies* 68 (2009), p. 7, n. 38, but it seems most likely. The fact that the sundial was Aegean ware suggests it was tuned at a latitude of some 36°-39°.



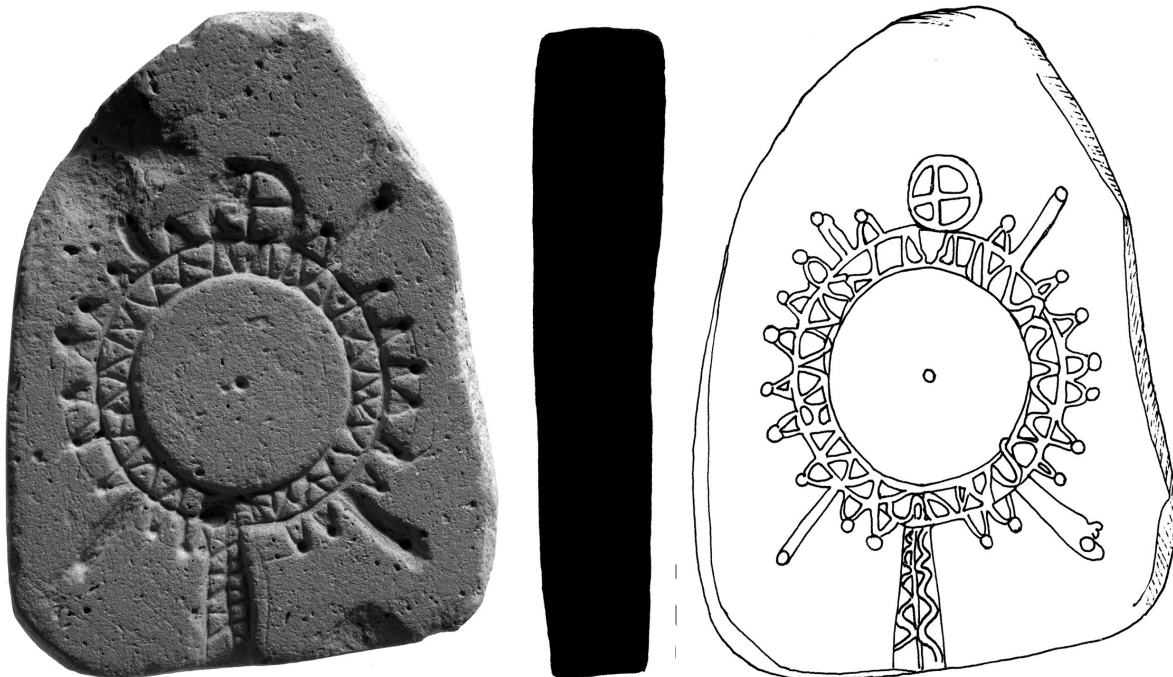


Figure 2 - The portable sundial of Apollonia / Sozousa (photo and drawing).

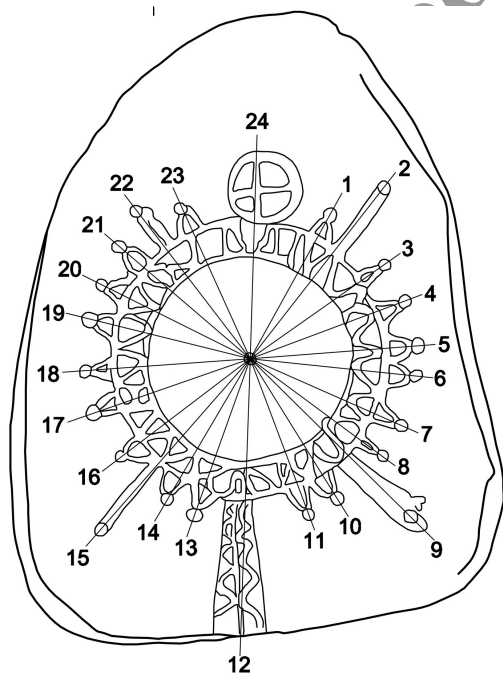
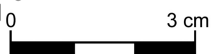


Figure 3 - Division by axes of portable dial.

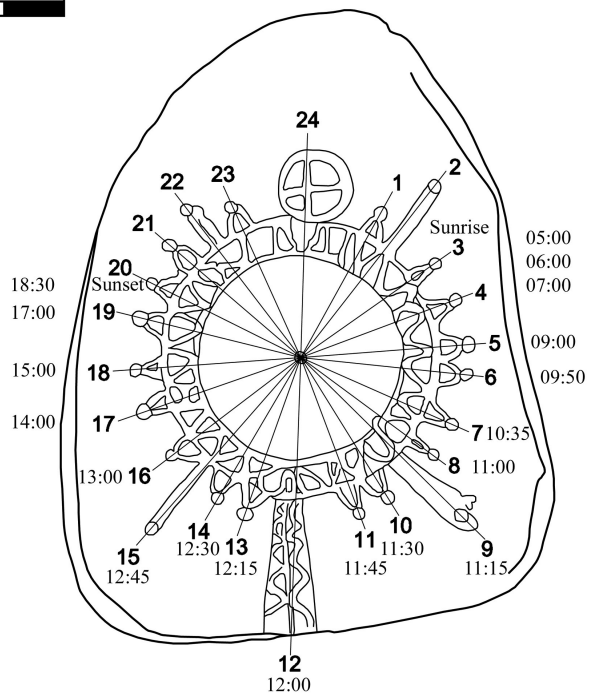


Figure 4 - Division of sun-hour day, with ⊕ south-facing, in the experiment on June 21, 2009, in Tel Aviv (at a latitude of 32°6' north).

hard condition. The design consists of three concentric circles that form two concentric bands around a central puncture in its center. The inner concentric band is roughly incised with a zigzag pattern. The outer concentric band is roughly incised with dotted triangles (17 in total. Its outer line is hardly visible hence it is excluded from the drawing).

The outer band is also adorned with four branches (at axis points 2, 9, 15 and partially preserved 22 respectively) that are almost equidistant. It also has a crossed circle at axis point 24 and an elongated indentation at axis point 12 with a zigzag pattern as if forming an ornamented handle (figure 3).

Assuming it was used as a sundial, for its operation, a portable *gnomon* (i.e., an upright rod, with which it was used, although not discovered) would have been placed on its central puncture, while the object was positioned horizontally on the palm of one's hand or upon a flat surface. At the same time the vertical side of the crossed circle on its 24-point axis (that is, the ⊕), would have been directed southward, and the *gnomon* shadow would have given the time in the day as illustrated in figure 4.

This experiment shows that the four branches on the disk actually divide the sun-hour day into 6¼ hours from sunrise to midday or noon (axis points 2-9, i.e., 05:00-11:15); 1½ hours at midday (axis points 9-15, i.e., 11:15-12:45); and 5¾ hours from after midday ('afternoon') to sunset (axis points 15-20, i.e., 12:45-18:30). All combined give a sun-hour day of 13½ hours on the longest day of the year at the latitude of the experiment. An experiment at a more northern latitude would probably include axis points 21-22 (*supra*, n. 17). The fact that the *gnomon* was in a sense also portable, i.e., not affixed to the sundial body, is important, for it enabled the user to carry the object conveniently. Of course, positioning the disk in accordance with the true south (or the four cardinal points) could have been an obstacle for the user. However, once the position of the sun's orbit was marked, the location of the general south could have been estimated according to the idea that the shortest shade of the *gnomon* represents the true north. Once it is aligned with the vertical side of the ⊕, the south is defined and the *horologium* may then be used to calculate the division of the sun-hour day accurately.

Sundials, especially those of classical antiquity, have long been a subject of study.<sup>18</sup> However, scholars

have paid less attention to portable antique sundials due to their rarity. Only a few studies are known, although none of these published objects are comparable to the one retrieved from Apollonia / Sozousa.<sup>19</sup> The earliest historical reference for such devices, i.e., the first century BCE architect Vitruvius in his *De Architectura*, says, "many also left instructions for making hanging dials (*viatoria pensilia*) for travellers" (IX, 8, 1). This claim may suggest that portable sundials were produced and used first and foremost for travelling (at least in Italy). However, the latitude for which the sundial was produced is of special interest, as a horizontal sundial must be designed for the latitude in which it is to be used, otherwise its accuracy is doubtful. The principle is that the cosmologic reality in which the earth revolves around the sun in its elliptical orbit (i.e., it takes one year for a full revolution of the earth around the sun), is expressed by differences in the movement of the sun's shadow cast by the *gnomon* on the disk in the morning versus the afternoon hours. Sun timekeeping devices thus divided the daylight hours into several units; 12 units seem to be the more frequently recurrent number on Late Antique sundials. On our sundial, the daylight hours were divided into 24 units, but our experiment showed that only 16-17 units were in fact practical, and this may cast doubt on our interpretation.

Given the fact it is made of non-local ware – and the lack of true equivalents, we may also infer that the object could have been used as a sun compass for maritime navigation in the Byzantine period, as sun compasses are essentially sundials used differently.

*Die antiken Sonnenuhren Griechenlands: Festland und Peloponnes*, Frankfurt am Main, Verlag Harri Deutsch, 2006. For modern sundials, see A.E. WAUGH, *Sundials: Their Theory and Construction*, New York, Dover Publications, 1973; R. NEWTON MAYALL and M. W. MAYALL, *Sundials: Their Construction and Use*, New York, Dover Publications, 2000.

18. E.g., P. R. J. ROHR, *Sundials: History, Theory and Practice*, Toronto, University of Toronto Press, 1970; S. L. GIBBS, *Greek and Roman Sundials*, Ann Arbor, UMI, 1973; and more recently K. SCHALDACH, *Römische Sonnenuhren: eine Einführung in die antike Gnomonik*, Frankfurt am Main, Verlag Harri Deutsch, 1997; IDEM,

19. One should mention D. J. DE SOLLA PRICE, "Portable Sundials in Antiquity, Including an Account on a New Example from Aphrodisias," *Centarus* 14, 1969, pp. 242-266; O. A. W. DILKE, *The Roman Land Surveyors: An Introduction to Agrimensores*, Newton Abbot, David & Charles, 1971, pp. 70-73; E. BUCHNER, "Antike Reisen-uhren," *Chiron* 1, 1971, pp. 457-482; IDEM, "Römische Medaillons als Sonnenuhren," *Chiron* 6, 1976, pp. 329-348; J. V. FIELD, "Some Roman and Byzantine Portable Sundials and the London Sundial-Calendar," *History of Technology* 12, 1990, pp. 103-135. Reference should also be given to the "sundial" discovered in Qumran (northwestern shores of the Dead Sea), and the debates around its function, cf. A. LEVY, "Bad Timing: Time to get a New Theory," *Biblical Archaeology Review* 24/4, 1998, pp. 18-23; M. ALBANI and U. GLESSMER, "Un instrument de mesures astronomiques à Qumrân," *Revue Biblique* 104, 1997, pp. 88-115.

When navigation was coastal, keeping a straight course across long distances seems theoretically simple to achieve. However, when navigation was in the open sea, ancient seafarers used astronomical observations, polarization filters or the sun with the help of compasses. In the case of our object, when the sun is out in the cloudless sky the *gnomon* casts a shadow on the disk's upper surface. Different global latitudes will, of course, provide different shadowed lines. By marking the position of the tip of the shadow in equal periods throughout the sun-day, and connecting the points created, an arc (i.e., a parabola) could be generated.

Theoretically, this parabola could illustrate the sun's height during the day, at that time of year, and at that latitude.<sup>20</sup> Once a line is drawn from the center of the disk to the point on the arc closest to the post, the 'true north' of the sun compass is defined. Still, in order to see the 'true north' the object must be on a stabilized surface; to navigate at sea it should be fixed to a ship. However, two basic technical problems prevent its use for maritime navigation: stability and precise timing.<sup>21</sup> Furthermore, even if our 'sun compass' could calculate the correct parabola of its destination and even if we could adjust the end of the shadow of the post precisely on the arc (given the problem of ship stability), constant adjusting the direction of the disk with the line of the keel would be practically impossible. In other words, the disk ('compass') can be fixed to the line of the keel, but keeping it level would be a problem since it is made of clay and would have sunk in a simple floating device (such as a bucket filled with sea water). Thus the helmsman could never have used it to steer the ship accurately.

20. However, in practice land navigation methods could not be easily transposed to sea navigation. On land, such a curve can be incised on a stabilized surface, and suited to the specific day and latitude of recording. At sea, although the change from day to day may not seem very significant – the average change is some 47° in 180 days – one degree of latitude equals 60 nautical miles! See Y. KAHANOV, "Herodotus 4.42, the Sun Direction," *Mariner's Mirror* 86, 2000, pp. 66-72.

21. In order to obtain accurate measurements, stability was a must and could not be achieved in Byzantine ships as we know them. Familiarity with celestial bodies could help, of course, in defining sunrise and sunset, which are easily observed. The question is what can be obtained from so doing; generally sunrise and sunset are used to adjust compass direction, but calculation tables are also needed, as sunrise and sunset are not always precisely set in accordance with the cardinal points. The latitude or meridian passage (noon)-sight would provide a general indication of day timing, and moreover, noontime could point to the general direction of the north (the latter two are similar to the shortest shade of the post), but without total stability of the ship, accurate timing could not be achieved.

tely.<sup>22</sup> Moreover, even if the curve fit the time of year and the latitude of the disk were fixed and stabilized, the result would still pertain only to latitude navigation.

Given the above, we are left with the more logical explanation that this object was probably used as a *viatoria pensilia* (Vitruvius IX, 8, 1), or other kind of timekeeping device, although the fact that it has 24 axis points makes it wholly alien to the Greco-Roman gnomonic tradition.<sup>23</sup> It is thus very tempting to understand this device in the context of the industrial quarter in which it was found. That is, to view it as related to production carried out in one of the industrial manufacturing installations of the Late Byzantine period discovered in Area E, where timekeeping formed part of an industrial process (e.g., the soaking of a certain product for a specific number of daylight hours to gain optimal results). If this was indeed the case, the disk could have been horizontally stabilized against the true south in the installation it served; assuming it was facing the south it could have shown the progress of the daylight hours in a clear manner. Considering it was found in a fill near an industrial manufacturing installation (the four-vat installation) that was fully aligned with the four cardinal points (Loci 1327, 1331, 1335, 1336; figure 1), such an assumption seems logical.<sup>24</sup>

The recent discovery at Apollonia-Arsuf may add to our knowledge of daily time division in Late Byzantine Palestine. It is the only such evidence discovered in Israel (and beyond) so far.

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22. Such a compass can only be used in sea navigation in the north due to the position of the sun, yet we know of it only from later (medieval) contexts, cf. e.g., S. THIRSLUND and C. L. VEBÆK, *The Viking Compass*, Copenhagen, Danish Maritime Museum, 1992; still, we do not really know how it functioned – or even if it was indeed practical. On Mediterranean maritime navigation in general, cf. A. TILLEY, *Seafaring on the Ancient Mediterranean: New Thoughts on Triremes and other Ancient Ships* (British Archaeological Reports, International Series 1268), Oxford, J. and E. Hedges, 2004.

23. We exclude the possibility it could have served as a game board, given its small dimensions.

24. The use of a sundial in an industrial manufacturing installation is known from yet another site in Byzantine Palestine – Deir Sam'an in the region of western Samaria, see Y. TEPPER, "A Sundial from Deir Saman," in S. DAR and Z. SAFRAI (eds.), *Shomron Studies*, Tel Aviv, HaKibbutz HaMeuchad, 1986, pp. 207-217 (in Hebrew).