Title: **Ceramic building material from the Roman forts on the Colchis coast: archaeology and archaeoceramological analysis**

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ABSTRACT: The article collects the modest information on the use (and possible production) of ceramic building material by the Roman army in Colchis, using it as a backdrop for presenting the exceptional richness, in quantity as much as diversity, of finds from Gonio/Apsaros. They are made even more exceptional by the signatures found on these products. The article presents documented examples of stamps on bricks, roof tiles and ceramic pipes from the fort and links them with construction project of specific Roman army units in the Cappadocia province. The results of laboratory tests conducted on samples of ceramic products and raw clay from Gonio, presented in Part 2, are an important element of the presented analysis. Based on these results, it has been possible to distinguish two reference groups for the production of which clay from near the fort was used. However, it has not been possible to indicate the specific deposits of such raw material used by the Roman army.

KEYWORDS: Roman army/fortifications/military architecture, military brick stamps, Roman ceramic building material

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Abstract: The article collects the modest evidence available on the use (and possible production) of ceramic building material by the Roman army in Colchis, using it as a backdrop for presenting the exceptional richness, in quantity as much as diversity, of the finds from Gonio/Apsaros. The signatures on these products add to the value of this assemblage. Part 1 of the article presents documented examples of stamps on bricks, roof tiles and ceramic pipes from the Gonio/Apsaros fort and links them to the construction projects of specific Roman army units in the Cappadocia province. The results of laboratory tests conducted on samples of ceramic products and raw clay from Gonio, presented in Part 2, distinguish between two reference groups for the production of which clay from near the fort was used. However, it has not been possible to indicate the specific deposits of such raw material used by the Roman army.

Keywords: Roman army/fortifications/military architecture, army brick stamps, ceramic building material

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PART 1. CERAMIC BUILDING MATERIAL FROM THE ROMAN FORTS IN COLCHIS: ARCHAEOLOGICAL DATA

The Roman military presence on the Colchis coast is attested among others by finds of stamped ceramic building materials. Bricks, tiles and pipes from five archaeological sites bear stamps referring to Roman army garrisons. A review of this material is presented in the context of the recent discoveries from Gonio/Apsaros down to the end of 2017.

Not much is known about the Roman army's use (and possible production) of ceramic building material in Colchis. *Opus mixtum* brickwork has been registered in the defensive walls of the forts in Pitsunda/Pityus and Sukhumi/Sebastopolis, but crucial data on sizes and signatures are missing. A brick with an incomplete legionary stamp is known from the latter site, but the find comes from a secondary context. The Roman fort in Poti/Phasis was supposedly made entirely of brick—Arrian's historical source was confirmed by the account of a 19th-century traveler, Frédèric Dubois de Montpéreux, who even described the plan of the fort and provided brick dimensions—but archaeologists have not found any trace of Roman fortifications near the Rioni River mouth. The Tsikhisdziri/Petra Justiniana site is located further south and is dated substantially to the reign of the emperor Justinian or later. Nevertheless, it has yielded a fragment of a stamped brick produced in an army brickyard during the Principate.

Against this backdrop, the ceramic building material finds, including bricks, roof tiles and ceramic pipes, from Gonio/Apsaros (modern Georgia) are exceptional, in terms of both quantity and variety, but also due to the signatures on the products. The stamped finds are instrumental in linking construction activities to specific Roman army units present in the province of Cappadocia. The finds from Gonio/Apsaros have been sampled for archaeoceramological laboratory tests, which have also included samples of raw clay from Gonio. Małgorzata Daszkiewicz's work on this material, the results of which are presented in detail in Part 2 of this article, is an important element of the presented analysis. The distinguishing of two reference groups for the production of which clay from near the fort was used has demonstrated beyond doubt the production of ceramic building material (as well as pottery) near the site, without specifying however the potential deposits of raw material used for this purpose by the Roman army.

ROMAN FORTS IN COLCHIS DURING THE PRINCIPATE PERIOD

The distribution of Roman and early Byzantine forts on the coast of Colchis has been the subject of a number of studies, frequently mapping the location of particular fortifications (Lekvinadze 1969: Fig. 1; Zuckerman 1991: 539; M.P. Speidel 1992a: Fig. 1; 1992b: Fig. 1; M.A. Speidel 2009: 627) and differing slightly in the details. This is due to the differences already present in the surviving ancient sources dealing with the Roman military presence on the eastern Black Sea coast. *Tabula Peutingeriana* presents two settlements with possible forts: Apsaros (Gonio) and Sebastopolis (Sukhumi). These two are labeled with an icon signifying a legionary base, like Novae (in Moesia) and Satala (in Cappadocia). Pliny the Elder's description of this part of the Black Sea coast mentions both names (Plin. *Nat.* 6.4), describing a fort (*castellum*) next to each. Pliny also listed Phasis, but only as the name of a river and town located at its mouth. The Heniochs (Heniochi) are also said to live in the neighborhood of Apsaros (Apsarrum) and Sebastopolis. The tribe is listed (as the first alongside the Colchians) in Agrippa's speech cited in Josephus's text (Jos. *Bell.* 2. 366–367). Ἡνιόχους appear there in the context of dependence on Rome and the control maintained by Roman garrisons over the eastern and northern coasts of Pontus. However, no specific fortifications are mentioned as being located in their country. All the quoted sources appear to refer to the same period, that is, in all probability, prior to AD 69 (see also

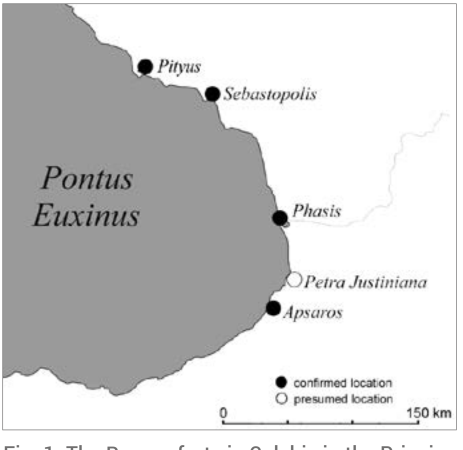

Fig. 1. The Roman forts in Colchis in the Principate period (Gonio/Apsaros Expedition/ drawing O. Kubrak)

Mitford 2018: 37) [*Fig. 1*]. Almost 60 years later, in his *Periplus*, Arrian described another garrison apart from the forts in the aforementioned settlements (Arr. *Peripl.* 6, 10, 17), namely *Phasis* (Arr. *Peripl.* 9), situating it between the two bases. Arrian's account is accurately dated to the time of his governorship in Cappadocia, that is, the 130s.

Keeping in mind the significance of the quoted sources, it can be assumed that in the second half of the 1st century the Romans established only two forts (Apsaros and Sebastopolis) on the coast of Colchis. The one in Phasis was built slightly later, most probably at the beginning of the 2nd century AD (Mitford 2018: 55, 412, 419). Investigations in Gonio have increasingly supplied evidence for a very early date for the fort there, even as far back as Nero's reign (Dąbrowa 1980: 385; Braund 1994: 178; Karasiewicz-Szczypiorski 2016: 62; Mitford 2018: 37–40, 55, 71). No comparable research results are known from Sukhumi. As for Phasis, Arrian's account of earthen fortifications and wooden towers being replaced by brick fortifications indicates the freshness of memories of this undertaking in people's minds at the time of his inspection. The *Periplus* suggests that Sebastopolis was the most distant garrison (Arr. *Peripl.* 17, 18). Therefore, the fort in Pityus (Pitsunda) must have been constructed later than the three forts discussed above (M.A. Speidel 2009: 604), which may be the reason for its absence from the quoted sources. The general assumption on these grounds is the much younger age of the remaining fortifications linked to Roman military presence on the Colchis coast.

ROMAN CERAMIC BUILDING MATERIAL IN FORT CONSTRUCTION IN COLCHIS

Roman ceramic building materials, including stamped fragments, have been recorded at four Roman fortification sites beside Gonio in Colchis. The following overview presents this assemblage and its limitations.

Pitsunda/Pityus and Sukhumi/Sebastopolis. Based on published information, excavation in the two forts uncovered remains of fortifications built in the *opus mixtum* technique with brick separators present in the stone walls. At Pitsunda these consisted of four brick courses, at Sukhumi only two (Lekvinadze 1969: 83–86). A mixed brickwork wall at Pitsunda was dated to the 4th–5th century AD, while a similar wall at Sukhumi was claimed to be of an earlier date, although the supporting evidence is questionable despite the location within the walls of an older "Roman" fort. This is due to the later construction within the ruins of a smaller fortification, referred to as Justinianic in date. The sites cannot be seen and there is no new research to clarify these doubts. Observations by Karasiewicz-Szczypiorski at Gonio/Apsaros, for example, indicate that walls considered earlier as being of Roman date were in fact Byzantine in their entirety, although perhaps Justinianic also in their lower parts. The same may be suggested for ancient Sebastopolis. The proposed dating of the fortifications using the *opus mixtum* technique in ancient Pityus seems highly probable however. Karasiewicz-Szczypiorski's research into the fortifications of the Tauric Chersonesos places the first examples of walls with brick separators in Justinian's reign. The situation in the northern part of Colchis may have been similar.

Finding a fragment of a brick with the stamp **LEG** [---] (Lekvinadze 1969: 87) and two fragments of a "ceramic plaque" (probably a roof tile) with the stamp **[LE] G XV** in Pitsunda (Kiguradze, Lordkipanidze, and Todua 1987: 88; see Mitford 2018: 419, 551) is worth mentioning. The stamps, which all look very similar, have a rectangular frame and originated probably from the same matrix. The clay appears to be very much the same in all three cases. The brick fragment was discovered in a layer from the 2nd–3rd century AD within the ruins of an observation tower situated some 3–4 km northwest of the Pityus fort, near Lake Inkiti (Kiguradze, Lordkipanidze, and Todua 1987: 88; see Lekvinadze 1969: 87). The watchtower may have been part of a still unstudied system of observation posts in advance of the fort, presumably protecting the local port (see M.A. Speidel 2009: 604; see Karasiewicz-Szczypiorski 2015: 61–63, 69). The other two stamp fragments come from excavations within the fort, from layers dated to the end of the 2nd or beginning of the 3rd century AD. No other examples of legionary stamps from the Colchis area are known.

The nearest legionary fortress from the time of the Principate was Satala in the Cappadocia province. All the forts on the Colchis coast were under the authority of the same provincial governor of Cappadocia, as attested by Arrian's *Periplus*, for example. Ceramic building material from Satala was stamped by the legio XV Apollinaris (Mitford 1997: No. 6; Hartmann 2004: 9–10), hence the proposed reconstruction of the stamp from Pitsunda as **LEG [XV]** or perhaps **LEG [XV APOL]** (see Lekvinadze 1969: 87; M.A. Speidel 2009: 604; Mitford 2018: 551). It does not follow from this that building material was delivered to Pitsunda from the mother province. A more probable scenario is that the unit (*vexillatio*) responsible for construction works in Colchis consisted of soldiers and officers from the said legion, in which case the building material made near the construction site could have been marked using the legionary stamp. Physical and chemical analyses of the ceramic building material and raw clay have attested to a similar situation in the case of the use of the Claudian Ninth legion stamp in Crimea (Sarnowski 2005: 130; 2006: 100).

Poti/Phasis. Even the approximate location of the Roman fort in the Poti area is vague due to the accumulation of sediments carried by the Rioni River at its mouth, forming new stretches of land where it flows into the Black Sea. The remains of the fort are thus at some distance from the present riverbank and may have been covered with layers of silt that had accumulated later. In addition, the river tended to change its course as a result of being periodically "clogged up" with sediments at its mouth, making the whereabouts of the main channel in the Roman period unknown. Neither the dynamics of sediment accumulation nor details of the changes in the course of the Rioni River have been established in full to date. Moreover, with the modern town of Poti occupying much of the flat terrain at the former river mouth, it is possible that the remains of the fort are concealed under the present town or that they were destroyed during its expansion.

The Swiss traveler Frédéric Dubois de Montpéreux (1839: 67–70) could still see the ruins of the fort in the 1830s. He described a square fort with four square watchtowers and a gate facing the sea. The walls surrounded a public square with one side measuring 140 steps (180 m by 175 m; see Mitford 2018: 415). The fort, located five viorsts (5385 m) from the sea at the time, was allegedly built of brick bonded in pink mortar. Lekvinadze cited the Swiss traveler's account, focusing on the plan from the atlas that supplements the description (Dubois de Montpéreux 1839: Atlas, XVIII; Lekvinadze 1969: Fig. 5). He reproduced a sketch outline of the fortifications on a square plan with four round(!) corner towers. The scale in steps ("pas") indicates that the fortifications were slightly larger than could have been concluded based on the cited description.

Dubois de Montpéreux knew the text in Arrian's *Periplus* and believed that the ruins he had seen should be linked to the described brick fortifications. However, both the description and the plan made by the Swiss traveler point to a later date for the remains. The fort was almost certainly a late Roman *quadriburgium*. In this particular form it could not have been constructed at the beginning of the 2nd century. However, it might have been built using bricks from older fortifications.

From the point of view of the subject undertaken in this article, the most significant piece of information is that of Arrian (Arr. *Peripl.* 9) that the walls and fort towers were in their entirety made of fired brick, a fact which he fails to note in his description of the other forts (Apsaros, Sabastopolis). This fragment of the *Periplus* is significant for another reason, namely, that he makes it a point to say that the fort was previously an earth-and-timber construction with the towers built of wood. To be discussed thus in a report from an inspection tour by the governor, the reconstruction of the fort had to have been a relatively recent event. Otherwise, the text would not have mentioned the previous fortifications. Indeed, the brick building appears to have been an exception among the forts in the governor's charge for reasons connected to the availability of building material in the nearest surroundings. There were no stone deposits near the mouth of the Rioni River, as was the case of both Sebastopolis and Apsaros, hence the original earth-and-timber structure and the later introduction of brick.

In his description Dubois de Montpéreux recorded the dimensions of the brick used in the construction. His "le pouce" or inches, we get 28.4 × 16.2 × 2.7, upon conversion into centimeters give 27 × 15 × 2.5 cm (see Mitford 2018: 415). No actual bricks survive for comparison, but it must have been a rectangular brick of Roman brick size and proportions, closest to the larger bricks known from Tauric Chersonesos (Sarnowski 2005: 127).

Tsikhisdziri/Petra Justiniana. The name as well as the discovered architectural remains point to the age of Justinian as the period of construction. Curiously, there are no apparent earlier fortifications in this spot. Some researchers, including Karasiewicz-Szczypiorski, admit the possibility of an earlier (perhaps short-lived) presence of the Roman army at the discussed site (see also Lekvinadze 1969: 87–88). Thus far, the only find confirming possible construction activity during the Principate period is a fragment of a brick with an intact **VEX FA** stamp (Lekvinadze 1969: 87; Braund 1994: 189; Todua 2003: 6). This inscription is read as an abbreviation originating from the name of a separate unit: *vex(illatio) fa(siana)* (M.P. Speidel 1992a: 206; see Lekvinadze 1969: 87; Braund 1994: 189; Mitford 2018: 412, 549–550). Looking at the better-identified Roman presence in Taurica (M.P. Speidel 1992a: 206), one is entitled to assume that a detachment consisting of soldiers delegated from various units of the Cappadocian army was stationed at Phasis. In all probability, they were under the command of an officer (or officers) of the legio XV Apollinaris (see *AÉ* 1996: 1358 = *AÉ* 1999: 1349; Vinogradov, Zubar', and Antonova 1999). The discussed stamp almost certainly confirms that a *vexillatio* from Phasis was producing ceramic building material (M.P. Speidel 1992a: 206), presumably for the fort that Arrian had seen there recently built entirely of brick (see above). Arrian's term for the soldiers garrisonned at the mouth of the Rioni river, ἐπίλεκτοι, quite probably signified a *vexillatio fasiana* (M.P. Speidel 1992a: 206). Therefore, it could be possible that bricks with the **VEX FA** stamp were produced near the fort of Phasis during the reign of Hadrian (see Braund 1994: 189).

The question is how the brick found its way to Petra and the circumstances under which it was found there (M.A. Speidel 2009: 603). Petra lies very conveniently on a lofty cape, affording excellent conditions for the observation of sailing routes and signaling passing ships in order to facilitate navigation.

It can be assumed that a fort or observation point was constructed there already in the first half of the 2nd century. The locality is also situated next to the most convenient route leading from the north (from central Colchis) in the direction of Cappadocia. From this perspective, having in mind control over this route, a fort in Petra would be a perfect substitute for Apsaros. In addition, the location rises above the plains that extend farther to the north and has a fairly convenient anchorage. In terms of the surrounding landscape, Petra resembles the Aj-Todor Cape in Taurica, where a Roman fort was constructed under the Antonines (Karasiewicz-Szczypiorski forthcoming).

The stamped brick in question is the sole find of its kind. One should keep in mind that building material (possibly from the demolition of other structures) for the construction of Justinian's fortifications at Petra must have been delivered by sea. However, at this time, the late Roman *quadriburgium* at Phasis may have still been in use and indeed, as indicated above, it cannot be excluded that it was built on the ruins and/or using construction material from (some) older fortifications. All in all, it cannot be said with any certainty that an additional fort existed at the site of the later Petra between Phasis and Apsaros during the time of the Principate. Also we do not know when the brick with the **VEX FA** stamp was used at this site.

Gonio/Apsaros. In the case of this fort, Arrian's account does not provide many details of the fortification or building structures in place at the time of his inspection. The only information included regards the existence of walls and a moat (Arr. *Peripl.* 6). Research to date indicates that the fort from the time of the Principate, built on a "playing-card" plan, that is, a rectangle with rounded corners, was moved slightly to the north and arranged with its longer axis running N–S [*Fig. 2*].

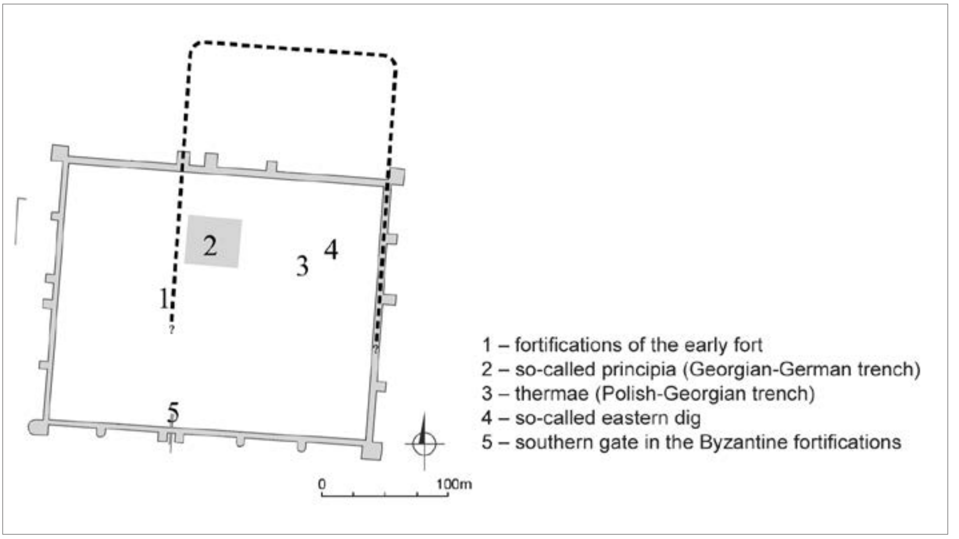

Fig. 2. Plan of the Gonio/Apsaros fort (Gonio/Apsaros Expedition/after Geyer 2003; adaptation R. Karasiewicz-Szczypiorski; drawing J. Kaniszewski and O. Kubrak)

As a result, parts of the fortifications from the first centuries AD can be observed in the form of earth ramparts outside the walls of the later fort (Geyer 2003: Pl. 2). Nothing can be said of building material and techniques until these remains have been studied, but based on observations made at sites

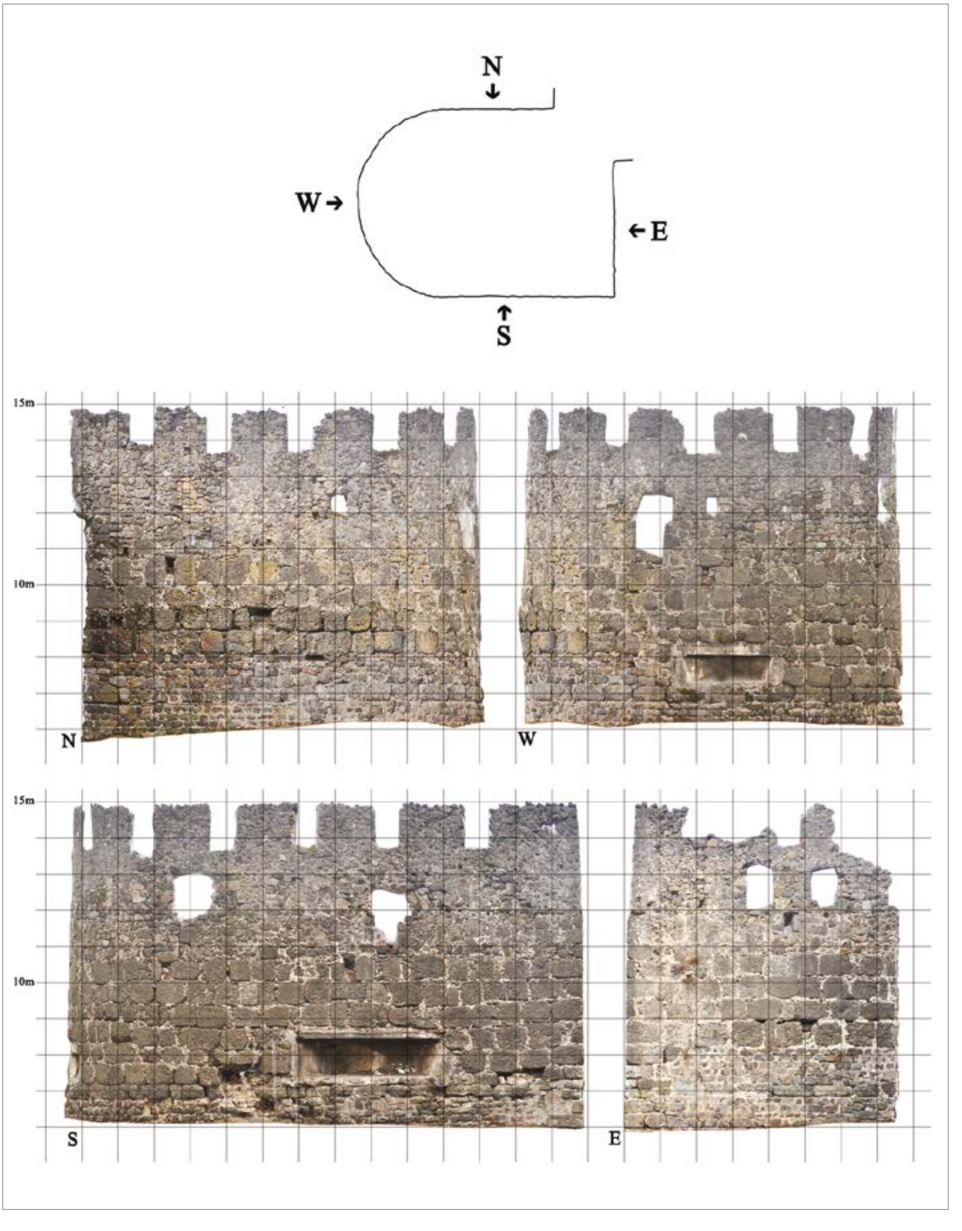

Fig. 3. Tracing successive stonework phases in the walls of the southwestern tower of the Apsaros fort (pre-renovation state) (Gonio/Apsaros Expedition/orthophotography and processing J. Kaniszewski)

studied in greater depth and linked to the presence of Roman garrisons in Crimea, it can be assumed that the earliest fortifications used to be made of partly worked blocks of local stone bonded with raw clay (see Sarnowski, Savelja, and Karasiewicz-Szczypiorski 2007: 61; Karasiewicz-Szczypiorski 2015: 57, Fig. 5: 2,3; see also Kakhidze 2008: 304–305; Kakhidze and Mamuladze 2004: 4–16). Research by the Polish–Georgian expedition has shown that some early buildings inside the fort of the time of the Principate were constructed in a similar way (e.g., the ruins of a granary discovered in 2017; see Karasiewicz-Szczypiorski and Mamuladze 2018). Walls of raw clay were raised on top of foundations made of broken stone bonded in clay mortar. They might have been reinforced using a wooden framework. The use of clay (without adding any stone) for wall construction is attested by clay backfills over 0.50 m thick observed in many places, the baths excavated in 2014–2017 being one example (Karasiewicz-Szczypiorski et al. 2016: 526–528). No wooden frameworks have been evidenced anywhere thus far.

Defensive walls observed on the surface (probably exclusively Justinian or later) were built using stone bonded in lime mortar. None of the observed phases of construction show the use of brick [*Fig. 3*].

Neither are there any examples of *opus mixtum* walls with an alternating stone–brick arrangement. Interestingly, mixed-work walls were constructed in the early Byzantine fortifications raised at Pitsunda and Sukhumi.

Despite the obvious superiority of stone structures and those made of raw clay, ceramic building material has been noted in different contexts at Gonio in the fort from the time of the Principate. In the latrine, which was part of the Phase 1 bathhouse, the floor and the bottom of the drainage channel were made of square bricks [*Fig. 4:2* and bottom]. Rectangular bricks were also found in the ruins of the furnace (*praefurnium*) used in Phase 2 of the building in question [*Fig. 4:6*]. In addition, individual pipes preserved *in situ* were the vestiges of draining systems from the *frigidarium* basins of Phases 1 and 2 [*Figs 4:3; 5* bottom left]. A fragment of a ceramic pipe aqueduct was also uncovered in the street adjacent to the bathhouse on the north [*Fig. 5* top]. In all probability, it should be linked to the renovation of the bathhouse building (Phase 2) and its later usage. In some of the bath chambers, primarily in the room with the mosaic floor, the remains of a collapsed roof from Phase 2 were preserved on the floor [*Fig. 5* bottom right]. The destruction layer was full of broken roof tiles, both flat roof tiles (*tegulae*) and semi-circular ones (*imbrices*).

Other examples of secondary use of ceramic building material in the bathhouse include a wall (W2), reconstructed in Phase 2, in which concentrations of broken brick and ceramic tiles mixed with pure clay were observed in two places [see *Fig. 4:5*]. At the present stage of research it is unclear what the purpose was of these ceramic fillers in the structure of a wall made of stone mortared with raw clay. It might be some trace of unpreserved framework, e.g., a ceramic foundation placed beneath a vertical wooden post. Finely crushed ceramic material also constituted a significant admixture to the mortars used to seal

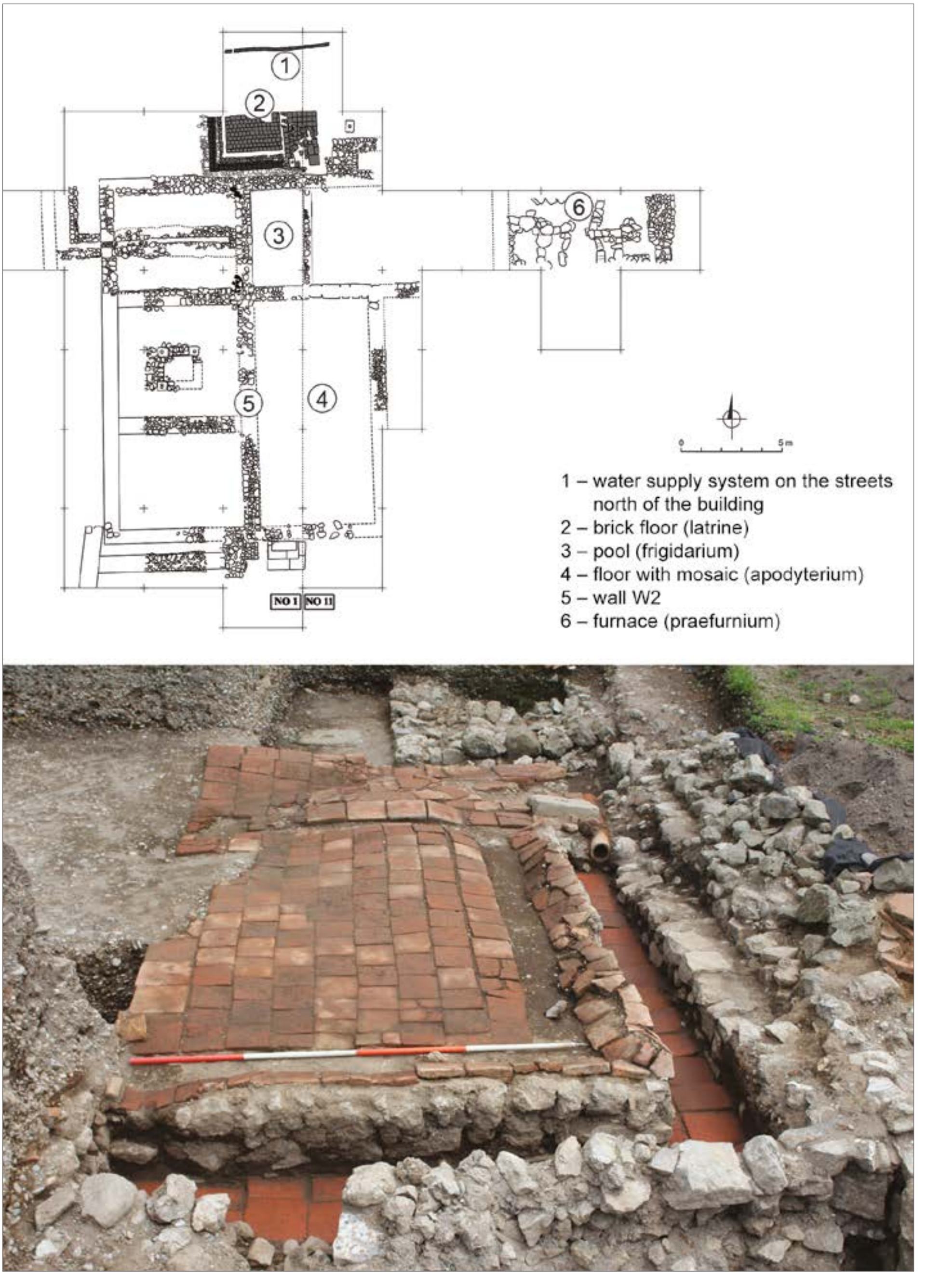

Fig. 4. Baths at Gonio. Polish–Georgian trench: top, plan; bottom, view from the west; note the floor and canal in the latrine made of square bricks (Gonio/Apsaros Expedition/drawing and digitizing M. Marciniak; photo A. Trzop-Szczypiorska)

Fig. 5. Baths at Gonio: top, latrine floor (Phase 1) from east and water supply system consisting of ceramic pipes on the street north of the building (Phase 2); bottom left, northern edge of wall W2 viewed from the west, showing ceramic pipe for draining water from the *frigidarium* pool (Phase 1); bottom right, layer of broken roof tiles covering the mosaic floor from Phase 2, during exploration (Gonio/Apsaros Expedition/photos O. Kubrak, A. Trzop-Szczypiorska)

the *frigidarium* basins and floors in both Phases 1 and 2 [see *Fig. 4:3*].

Most of the excavated fragments of the water supply systems were made of ceramic pipes of varying diameters and lengths. Most examples of this type of installation come from the excavation inside the southern gate in the late fortifications [see *Fig. 2:5*]. The clearly observable connection between this water supply system and the gap in the gate indicates their late (Byzantine) origins. Smaller aqueduct fragments were also found during the excavation of the so-called command headquarters (*principia*) [see *Fig. 2:2*], as well as in the Polish–Georgian "eastern trench" (sector NO 11, Sqs 90 and 99) in 2014 [see *Fig. 2:4*]. The course of the pipelines uncovered so far indicates that during the time of the Principate water was supplied from an unknown source situated east of the fort. It was not until the Byzantine period that water came from

Fig. 6. Backfill of a bathhouse furnace (*praefurnium*) during exploration with a rectangular brick stuck in the layer (Gonio/Apsaros Expedition/ photo A. Trzop-Szczypiorska)

a source located south of the stronghold (Geyer 2003: Pls 2, 3).

To sum up, the ceramic building material originating from the excavations conducted at the Gonio/Apsaros fort represents the following categories:

◗ Square bricks. Bricks in three different sizes were used in the thermae: *bessales* (18.5–19 × 19 × 4 cm), *pedales* (26 × 26 × 4 cm) and *bipedales* (52.5 × 53 × 5.5 cm). Examples of all three types have been identified in the floor of the latrine from the Phase 1 bathhouse [see *Figs 2:3; 4:2*].

◗ Rectangular bricks. Only a few specimens have been found fully intact, excavated in the thermae. Their dimensions amount to 13–13.8 × 20–21 × 2.5–3 cm, and they come from Phase 2 bathhouse destruction layers (NO 11, Sq. 8). The dimensions of many fragmentary bricks, recognized by their proportions as rectangular, could not be reconstructed. A few broken specimens were found in the ruins of the furnace (*praefurnium*) and in the neighboring hypocaust basement (NO 11, Sqs 36–37). Based on the context, it can be concluded that they had been used to build the hypocaust system in Phase 2 [*Fig. 6*].

◗ Flat roof tiles with upturned ledges (*tegulae*). No complete specimen has been recovered so far, making an estimate of the original size impossible. Some examples bear the impressions of fingers running along the still wet clay surface [*Fig. 7* top left]. On a few of the sherds, straight prominent "ribs" have been preserved, arranged perpendicularly to the upraised tile edges [*Fig. 7* top right]. Holes made before firing can sometimes be observed on the roof tile fragments from Byzantine layers (see Karasiewicz-Szczypiorski et al. 2016:

530). Both solutions must have had some practical function, but in the case of the openings we can be certain that they served to attach the tiles to the roof structure using iron nails.

◗ Semicircular roof tiles (*imbrices*). One specimen, preserved intact, came from the ruins of the bathhouse; it was 46 cm long [*Fig. 7* center left]. Its surface was decorated with elongated depressions

Fig. 7. Examples of fragmentary roof tiles from the bathhouse in Gonio/Apsaros: top row, flat roof tiles (*tegulae*), prominent "ribbing" on the surface of the tile on the right; center left, semicircular roof tile (*imbrex*); center right, round ceramic tile; bottom row, ornamental ceramic tiles (Gonio/Apsaros Expedition/photos O. Kubrak)

made by running fingers along the still wet clay surface. Similar traces could be observed on fragments of other specimens of this type.

◗ Flat tiles (*parietales*). Fragments of such ceramic tiles were excavated from the structure of one of the walls in the thermae reconstructed in Phase 2 [see *Fig. 4:5*]. An almost intact tile from this set measured 22 × 22 × 3.5 cm, but some of the other fragments must have come from larger tiles (a fully preserved edge of one tile amounted to 32.5 cm), although they could well be part of a square tile. A series of zigzagged and wavy grooves made with a pointed tool was noted on the surface of tiles of this kind [*Fig. 7* bottom row]. A single groove running around the tile near its edge was also observed on some of the specimens [*Fig. 7* bottom right]. These may be assumed to be the broken floor tiles from the thermae before it was reconstructed, that is, from Phase 1. In all probability, the described incised ornament served a practical purpose as well (that is, preventing slipping on a wet floor).

◗ Tiles with protuberances (*tegulae mammatae*). This type of building material was found only in fragmentary form in the thermae area. Individual stubs were found in secondary contexts with fragments of the flat tiles of which they had originally been a part. The tiles were 1.4 cm thick.

◗ Round tiles. Recorded examples were about 27 cm in diameter and 4.5–4.9 cm thick [*Fig. 7* center right]. They came from secondary contexts inside the bathhouse and in one case, from a layer preceding the reconstruction of the thermae. In the latter case, it may have been part of a pillar (pilae) in the hypocaust cellar of Phase 1. However, the only hypocaust examined so far, situat-

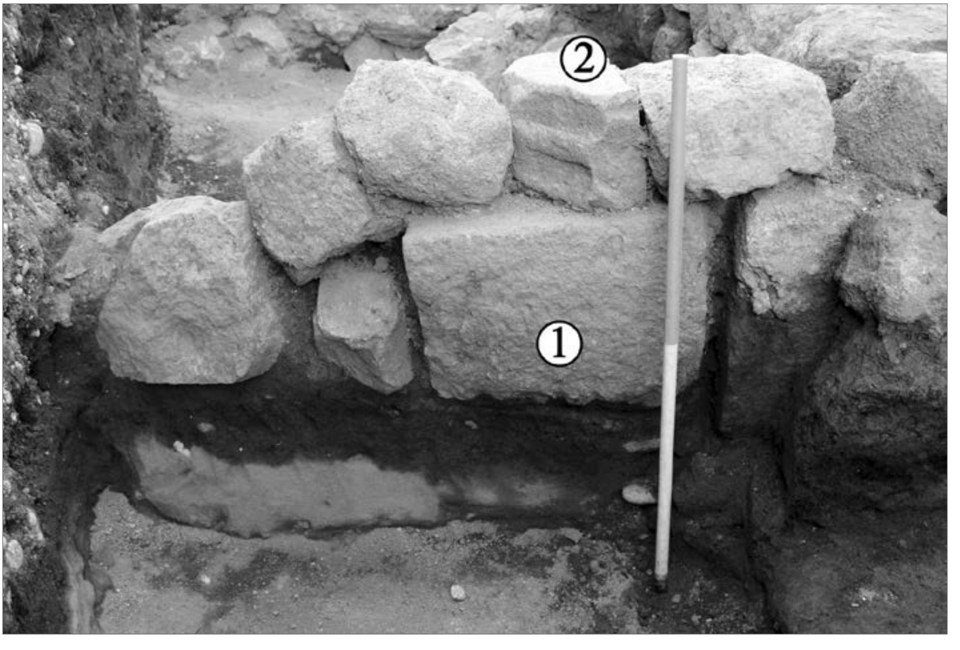

Fig. 8. Stone pillar from the hypocaust basement by the furnace (*praefurnium*). 1, 2 – secondarily used architectural elements (Gonio/Apsaros Expedition/photo A. Trzop-Szczypiorska)

ed next to the furnace in the northern part of the bathhouse (NO 11, Sq. 36), had stone pillars. Among other things, architectural elements from unidentified earlier buildings were used to make these pillars [*Fig. 8*].

◗ Ceramic pipes, round in section. Sections of aqueducts made of ceramic pipes were found in several places in the area occupied by the Byzantine fort. Most of these are therefore of Byzantine date, but in some cases the context is uncertain. A few can be assumed to be from the first centuries AD, but none so far have been recovered intact and hence could not be measured. In the so-called "eastern dig" (Sector NO 11; Sqs 89–90, 99–100), the situation was similar with damaged pipes being found from two different pipelines of various diameters. A section of a water supply system, consisting of cracked but usually fully preserved pipes, was found in the street north of the bathhouse [see *Figs 4:1; 5* top]. This is almost certainly a later part of the pipeline (consisting of larger-diameter pipes) discovered in the "eastern trench" in question [see *Fig. 2:4*]. The two sections are aligned with one another and the pipes are laid sloping downwards from east to west. This indicates that water must have been supplied from the hills to the east of the fort. So far, one sample has been taken from this pipeline for physico-chemical analyses and one complete pipe was removed for measurement and photographic and drawing documentation [*Fig. 9*]. This pipe proved to be 38 cm long and had an external diameter of 14.8 cm.

◗ No examples of pipes of quadrangular section (*tubuli*) have been found so far, although they were frequently used to lay vertical heating ducts in baths, for example. Their absence may be explained by the presence of tiles with protuberances which could have formed hollow spaces in the walls for the circulation of hot air.

This exhausts the list of types of ceramic building material found during the excavations at the Gonio/Apsaros fort, especially the bathhouse, but without discussing specific variations in full, since the main objective of this presentation is provide an introduction to the physicochemical analyses of

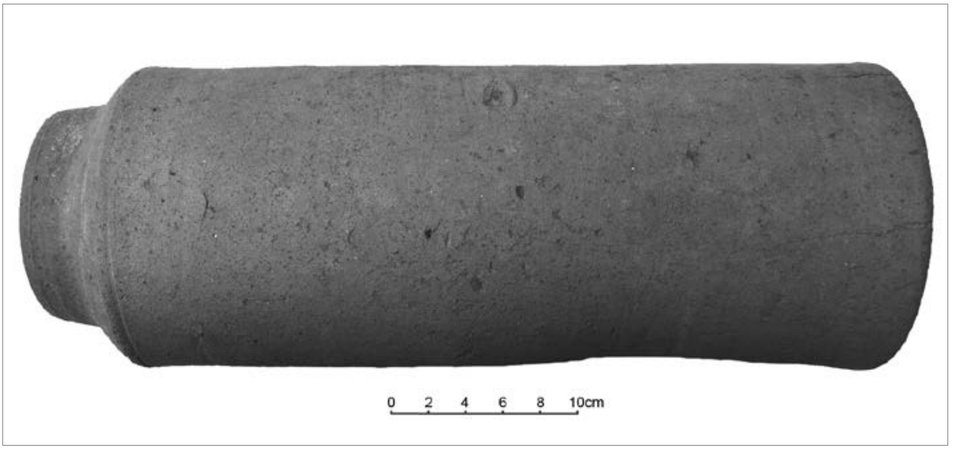

Fig. 9. Pipe from the water supply system discovered north of the bathhouse in Gonio/Apsaros (Gonio/Apsaros Project/photo O. Kubrak)

this category of material (see below). This topic, as well as that of the frequency with which various products were encountered among the finds from Gonio, and other statistical comparisons involving the ceramic building material, will be dealt with in a separate study.

STAMPS ON CERAMIC BUILDING MATERIAL FROM GONIO/APSAROS

The small size of the assemblage of stamped building material from Gonio/Apsaros is surprising, especially when compared with the number of such finds from other collections, such as the Roman forts and posts in Taurica (Sarnowski 2005; 2006). For example, more than a dozen roof tile fragments with stamps were found in a small watchtower on the Kazackaya Hill near Inkerman, where—one should keep it in mind—only the roof was covered with ceramic tiles (Sarnowski, Savelja, and Karasiewicz-Szczypiorski 2007: 62). The other architectural features there were built of broken stone and raw clay.

Fig. 10. Example of a stamp from the bathhouse excavation: fragment of a rectangular field with an almost illegible inscription C[---] (Gonio/Apsaros Project/photo K. Żywicki)

Only a little more than a dozen stamped bricks and tiles were found within the entire Gonio/Apsaros fort. Almost all of them were found in fragments. In most cases, this makes a reconstruction of the inscriptions and, in consequence, the identification of the military unit that produced the building material impossible. The high soil acidity levels in Gonio constitute another destructive factor, leaving ceramic surfaces eroded and soft. Without the usual calcium carbonate patina encountered at most other archaeological sites, even gentle washing of the specimens leads to further damage and abrasion. However, the original percentage of stamped brick and roof tile specimens may be assumed to have been comparable to the production of other military brickyards. The unfavorable circumstances of deposition must have contributed to traces of weakly impressed stamps, especially letters, being rubbed off [*Fig. 10*]. It is also possible that many impressions could have gone unnoticed during routine documenting of large amounts of material.

Stamp types

COH II [---]

Inscription placed within a rectangular field [*Fig. 11:a,a'*]. At least four such stamp fragments have been found on roof tiles and two on bricks. None of these is complete. The stamped bricks come from the so-called "principia" [see *Fig. 2:2*], one of these from backfill consisting mainly of broken roof tiles. This layer is dated broadly to the 1st–3rd centuries AD. A stamped roof tile fragment was also found in the thermae, but in a layer connected to the destruction of the roof from the Byzantine period; it is perhaps evidence of secondary use of older material following the dismantling of the previous building.

The most probable reconstruction of the inscription is COH II [CLA], read as *Coh*(*ors*) II *Cla*(*udia*) or *Cla*(*udiana*) (M.P. Speidel 1984: 106; Mamuladze, Khalvashi, and Aslanishvili 2002: 34, Figs 1 and 2; Kakhidze 2008: Fig. 19; M.A. Speidel 2009: 613; Mitford 2018: 412, 550).

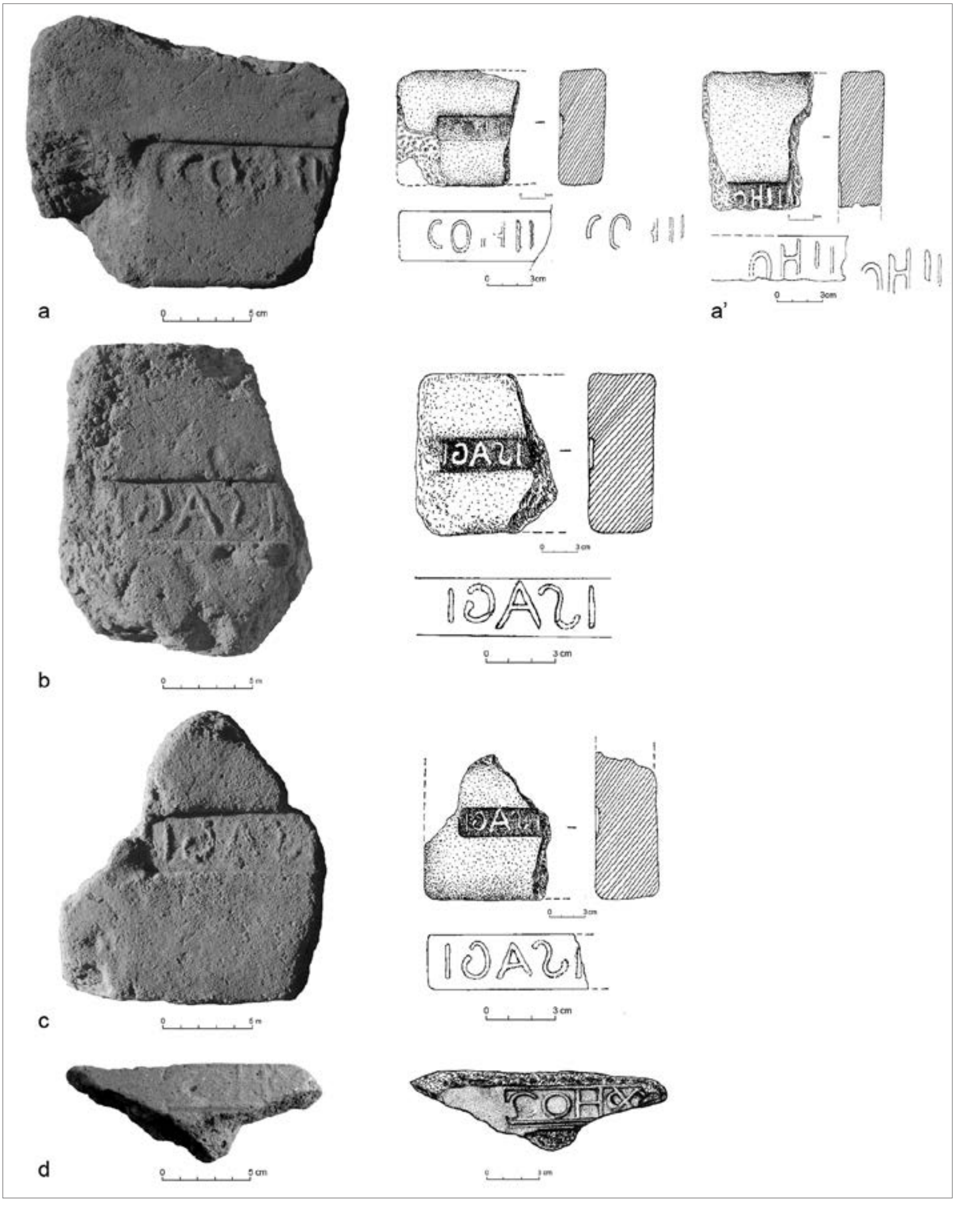

Fig. 11. Stamped brick and roof tile fragments: a – COH II [---]; b – I SAGI; c – [II]I SAGI; d – COH ∞ [-] (Gonio/Apsaros Project/photos G. Dumbadze, drawing A. Javelidze)

I SAGI or [II]I SAGI

Inscription placed in a rectangular field, incised as a mirror image [*Fig. 11:b,c*]. Two examples, one fully preserved, were found on bricks. One of the bricks was found in a humus layer.

The most probable reconstruction of the inscription is (*Cohors*) I *sagi*(*ttaria*) or (*Cohors*) [II]I *sagi*(*ttaria*) (see Mamuladze, Khalvashi, and Aslanishvili 2002: 35, Fig. 3; Kakhidze 2008: Fig. 20; M.A. Speidel 2009: 620; Mitford 2018: 550).

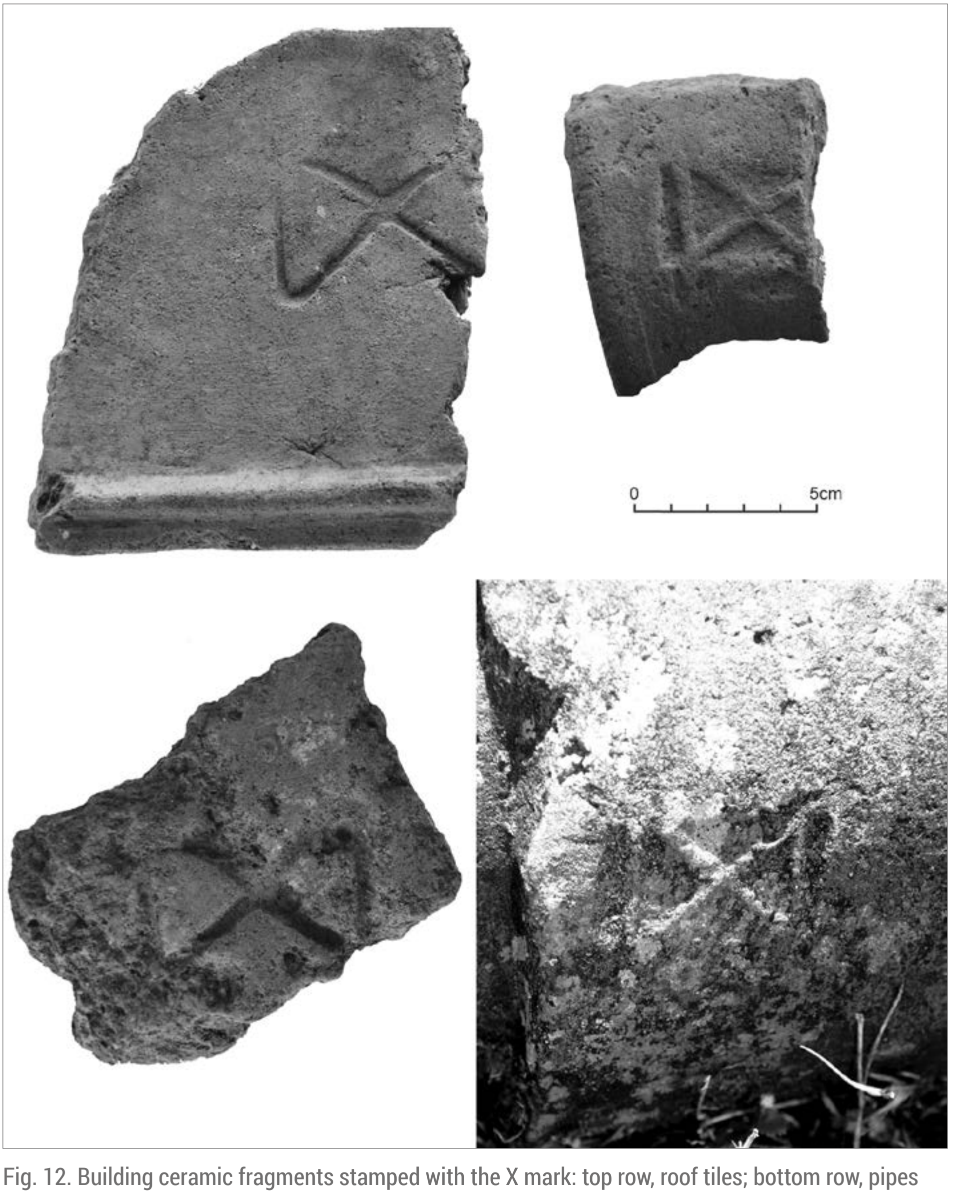

Fig. 12. Building ceramic fragments stamped with the X mark: top row, roof tiles; bottom row, pipes (Gonio/Apsaros Project/photos G. Dumbadze)

In light of the information gathered to date on the auxiliary forces that composed part of the army of the Cappadocia province, this might be a signature left behind by the *Cohors* III *Syrorum sagittariorum* (M.A. Speidel 2009: 619–620). However, three other archer cohorts should also be taken into consideration: *Cohors* I *Bosporanorum milliaria equitata sagittaria* (M.A. Speidel 2009: 612) or *Cohors* I *Ituraeorum milliaria equitata sagittaria* (M.A. Speidel 2009: 616), and also perhaps *Cohors* I *Numidarum* (*equitata*?) *sagittaria* (M.A. Speidel 2009: 618).

COH ∞ [-]

Inscription in a rectangular field. Only one fragment of such a stamp on a roof tile was recorded from Gonio, in a layer of rubbish along with other bricks and roof tiles from the Roman period (Khalvashi and Aslanishvili 2014: 336) [*Fig. 11:d*]. The stamp may have been produced in a brickyard serviced by soldiers of the *Cohors milliaria equitata civium Romanorum* (M.A. Speidel 2009: 617). If this assumption is correct, the following reconstruction of the inscription can be proposed: **COH ∞ CR** – *Coh*(*ors*) *milliaria c*(*ivium*) *R*(*omanorum*). The **∞** mark pertains to finds from the Gonio/Apsaros fort. This indicates that signatures from this group represent production by the same military unit, which was in all probability the said *Cohors milliaria equitata civium Romanorum*.

X

The mark is said to be present on ceramic pipes from the 2nd century AD (Mamuladze, Khalvashi, and Aslanishvili 2002: 38). It was also encountered on fragments of ceramic building material collected during a fieldwalking survey of the Satala site in 2004 (Hartmann 2004: 9, Nos S 04/8 and S 04/9), which also yielded from the same area legio XV Apollinaris stamps on ceramic building material. At Gonio, several examples of **X** stamps were collected from the humus layer or from contexts that were in one way or another unprovenanced. Roof tiles were also marked in this way. These are undoubtedly complete stamps, consisting of a single graphic symbol. At least four variants can be distinguished [*Fig. 12*]. Based on an analysis of a larger number of specimens, it can be said that the symbol used in Satala was not identical to that used in Gonio. At Apsaros there are no tiles with an X mark, only **∞** marks.

CERAMIC BUILDING MATERIAL AT APSAROS: PRODUCTION OR DELIVERY?

The results of physicochemical analyses, presented below in Part 2, of a number of specimens from different ceramic products (including roof tiles, bricks and pipes), as well as raw clay from various deposits, have provided some crucial information. Primarily, most of the specimens taken from ceramic building material, including all of the stamped specimens, belong to two reference groups distinguished as a result of the analyses [see below, *Table 1*]. However, it should be noted that only products signed with the stamp **COH II [---]** were categorized in the Apsaros 2 group, while the Apsaros 1 group contained examples with this stamp and with the **I SAGI** stamp. In addition, it can be said that Apsaros 1 clay was used to produce bricks, roof tiles and pipes, while Apsaros 2 clay has been confirmed as having been used only for roof tile production. However, at the current state of research, it is difficult to formulate more far-reaching conclusions as in the case of the majority of the stamped bricks and roof tiles the context and circumstances in which they were found remain unknown. Information available about the dig, the sector and square from which they originate is insufficient.

The relatively high number of samples allocated to each of the two listed groups allows for the assumption that the products from these clay types were locally made (in bulk and over a longer period). This remains a hypothesis since the currently analyzed raw clay samples from the vicinity of the fort did not show any similarity to the above-mentioned reference groups [see below, *Table 1*]. It is interesting to note that raw clay also used as a substructure layer under the frigidarium floor (MD5784) in Phase 2 was not present in the production of items belonging to the Apsaros 1 and Apsaros 2 groups. Acquiring the clay necessary for the construction works somewhere nearby seems almost certain. This same clay might have also been supplied to the brickyard.

In turn, in light of the analysis results, it should be assumed that other producers may have provided smaller consignments of building material, probably by sea. This might have been the case especially at the onset of Roman presence in Apsaros, before local facilities, indispensable for fort construction, were organized. Confirmation of this hypothesis is provided by the analysis results of a sample taken from one of the bricks from the latrine floor, functioning in Phase 1 of the bathhouse (MD5782). The result in this case is not concordant with the results of any of the other analyses. The outcome of an analysis of a roof tile fragment originating from the backfill formed following the collapse of the bathhouse roof is the most surprising (MD5779). This roof functioned in Phase 2, that is, in the first half of the 2nd century. In that period, local building material must have been in use; nonetheless, the discussed roof tile differs from the remaining ones.

To summarize, it is proposed that the products made from clay classified as belonging to the Apsaros 1 group may have been manufactured at the time of Arrian's inspection of the fort or, more broadly, during Hadrian's reign. The reconstruction of the garrison bathhouse took place then, at the latest (Karasiewicz-Szczypiorski 2016: 54). This is the farthest-reaching conclusion that can be drawn from an examination of the contexts from which some of the samples originated. Phase 2, that is, the reconstruction of the thermae (and perhaps also of other buildings in the fort), would refer at the latest to the first half of the 2nd century AD. Intensified construction activities required large amounts of different material. In the case of the bathhouse, this signifies the necessity of producing diverse building ceramics that would be water- and fire-proof. Two samples originate from contexts obviously linked to the Phase 2 building: a pipe fragment (MD5783) and a brick sherd (MD5780). One other such sample, probably linked to the reconstruction of the thermae (Phase 2), is a roof tile fragment (MD6144).

These observations refer indirectly to Arrian's comment about the presence of a garrison composed of as many as five cohorts in Apsaros during his inspection. It can be assumed that two of them signed their ceramic production using stamps: **COH II** [---] and **I SAGI**. Does it mean that the Apsaros 2 group represented earlier production? This currently seems to be the most probable interpretation. It can be assumed that the limited selection of produced items (only roof tiles?) comes from a period preceding the concentration of the army and Arrian's visit. The reinforcement of the garrison in Apsaros (most probably only temporary) seems to have led to intensified construction activities. The increased demand for brickyard production may explain the opening of an additional, perhaps more efficient clay deposit (Apsaros 1). Simultaneously, extraction of raw material that had been in use previously (Apsaros 2) may have been terminated, but this remains uncertain. Simultaneous use of two different clay deposits (for a period of time) may have been caused by the different properties of the raw material. Technological and functional analyses should resolve this issue.

Although clay deposits corresponding to the reference groups Apsaros 1 and Apsaros 2 could not be determined, the general ceramic production at the site in the Roman period has been confirmed archaeologically. A kiln for firing amphorae was found in the southwestern part of the late fort (Mamuladze, Khalvashi, and Aslanishvili 2002: 38). Under the Principate, this area was located outside the defensive walls [see *Fig. 2:1*]. This, most probably, pertains to civilian production carried out in a settlement next to the garrison.

In the case of Apsaros, continued research into the sources of the construction material (including clay) is most certainly required, hopefully determining the deposits used by the Roman army. Further analyses should give more in-depth knowledge into two reference groups possibly applicable to the study results from Gonio. So far, there are only a few amphora and cooking ware sherds that have been found to belong to these groups [see below, *Table 1*]. The group including two amphorae from chemical groups 1 and 13 (MD214 and MD6141) may attest to production involving the use of clay from the vicinity of the fort [see below, *Fig. 17*].

Research into the ceramic production in Apsaros from the Roman period is in its initial stage. Undoubtedly, continued excavations will lead to acquisition of more stamped bricks and roof tiles, including specimens with fully preserved stamps.

PART 2. CERAMICS AND RAW MATERIALS: RESULTS OF ARCHAEOCERAMOLOGICAL ANALYSIS OF CERAMIC SAMPLES FROM GONIO/APSAROS

An archaeoceramological analysis was carried out on five pottery sherds (Colchian amphorae and common wares), 16 fragments of ceramic building materials (bricks, roof tiles, one pipe and one floor tile fragment) and one sample of daub clay (MD5784) from the excavations at the Gonio/Apsaros fortress. Ten samples of clay raw materials collected by Shota Mamuladze from the vicinity of the site were also analyzed. The analysis was undertaken in order to determine whether the ceramic finds from Apsaros are homogeneous or non-homogeneous in terms of the raw materials used to make them (both clay and non-plastic components), and to assess the chemical composition of clay available in the region and its suitability for making pottery.

To this end the analyzed ceramics from Apsaros were classified using a provenance classification system, taking into account matrix type (the matrix being the plastic part of the ceramic body which hardens during firing, commonly referred to as 'clay') and the chemical composition of the ceramic material (known as the fingerprint of the ceramic body from which a particular ceramic artifact was made) as well as non-plastic inclusions (clastic material = natural or intentional temper). A firing test was used to classify the raw material samples according to their suitability for making ceramic building materials (CBM) and/or pottery. Subsequently, the matrix type and chemical composition of selected raw material samples was determined, as was the case with pottery.

The analytical methods used were as follows: MGR-analysis (Matrix Group by Refiring) for pottery; plasticity test (determining water of plasticity values), and firing test for raw material samples; chemical analysis by wavelength-dispersive X-ray fluorescence (WD-XRF) for both artifacts and raw materials.

The MGR-analysis was applied in order to determine the composition of the ceramic matrix. Matrix types can be identified using this technique because the thermal behavior of plastic components during firing is governed by their chemical and phase composition (Daszkiewicz 2014; Daszkiewicz and Maritan 2017; Daszkiewicz and Schneider 2001). After the sherds are refired, at a temperature higher than their original firing temperature, i.e., once the effects caused by the original firing temperature and conditions are 'removed', the color, shade and appearance of the matrix relate to the chemical and phase composition of the plastic part of the body. The MGR-analysis allowed the pottery to be classified into groups of sherds made of the same plastic raw material.

The chemical analysis of sherds was used to establish the chemical composition of both the plastic and non-plastic ingredients of the pottery fabric. This analysis enabled the quantity of major and trace elements in the body to be established, revealing the geochemical characteristics of the raw materials used, although the phases in which individual elements occur could not be determined[1] (giving the major elements as oxides[2] is standard procedure in geochemistry when presenting the results of chemical analysis).

When using these two analytical methods in provenance studies, ceramic groups are determined independently using MGR-analysis and chemical analysis. Each of these methods yields a different type of classification (matrix groups and geochemical groups respectively). Collectively, this type of classification allows provenance groups to be established, highlighting differences in chemical composition but also demonstrating what these differences are associated with (e.g., ceramic artifacts belonging to two different groups may be locally produced using the same clay with the addition of different tempers depending on the intended function of the product).

ANALYSIS RESULTS

CERAMICS

All ceramic building material fragments (CBM) and pottery sherds were made of non-calcareous clays colored by iron compounds. These samples have a sintered matrix type (SN).[3] Ten MGR-groups[4] were identified based on the thermal behavior of the matrix. Group sizes vary. The most numerously represented is MGR-group 1 (seven samples). Eight MGR-groups are each represented by a solitary sample[5] [*Table 1*].

The CBM was made of plastic raw materials that fired to various shades of red-brown at 1200°C [*Figs 13–14: MGR 1–5*]. In contrast, pottery sherds fired to shades of red, brownish-red and reddish-brown at 1200°C [*Fig. 14: MGR 6–10*].

Non-plastic temper was noted in all of the samples. This was readily visible macroscopically (particularly after refiring) in the form of black particles characterized by a melting point of below 1200°C. Particles with a melting point of below 1150°C were also observed. Clastic material groups (groups of samples with similar quantities, composition and particle size of non-plastic ingredients) are consistent with plastic raw material groups (i.e., MGR-groups). Two rim sherds (samples MD6140 and MD6142 representing MGR-groups 7

1 Ca content, identified by chemical analysis, may be attributable to, for example, inclusions of calcite or dolomite or anorthite, or may occur exclusively in the clay fraction in the matrix.

2 Si = silicon, calculated as SiO_2; Al = aluminium, calculated as Al_2O_3; Ti = titanium, calculated as TiO_2; Fe = iron, total iron calculated as Fe_2O_3; Mn = manganese, calculated as MnO; Mg = magnesium, calculated as MgO; Ca = calcium, calculated as CaO; Na = sodium, calculated as Na_2O; K = potassium, calculated as K_2O; P = phosphorus, calculated as P_2O_5.

3 Sintered matrix type (SN) = the sherd is well-compacted; it may or may not become smaller in size in comparison to the original sample, whilst its edges remain sharp.

4 MGR-groups represent groups of greatest similarity. Samples attributed to the same MGR-group and to the same clastic material group were made of the same ceramic body.

5 It is highly unlikely that only a single vessel would have been made from one ceramic body, thus it is assumed that the sample submitted for analysis represents a group of vessels made of the same raw material. This is why the term 'group' is used even in relation to so-called groups that are represented by only one sample.

and 9 respectively) were very distinctive because of the size and composition of their inclusions, which were macroscopically observed almost exclusively in the form of black particles characterized by a melting point of below 1200°C [see *Fig. 14*]. A much greater diversity in temper composition was macroscopically visible

Table 1. List of analysed samples: laboratory number in Daszkiewicz & Schneider database, water of plasticity, MGR-groups, chemical groups and reference groups (Digitizing M. Daszkiewicz)

Type of sample	Stamp or inventory number	Laboratory number	Plasticity water H_2O/100g [%]	MGR group	Chemical group	
brick	I SAGI	MD204	-	1	G2	reference group Aps 1
roof tile	[CO]H [II ---]	MD205	-	1		
brick	I SAGI	MD208	-	1		
brick	[C]OH II [---]	MD209	-	1		
tegula		MD5781	-	1		
pipe		MD5783	-	1		
roof tile	C[OH II ---]	MD6144	-	1		
brick		MD5780	-	5		
roof tile	C[OH II ---]	MD206	-	4	G3	reference group Aps 2
roof tile	CO[H II ---]	MD207	-	4		
roof tile		MD210	-	4		
roof tile		MD211	-	4		
roof tile		MD212	-	4		
roof tile		MD213	-	4		
Colchian amphorae		MD6141	-	8	G1	?
amphorae		MD214	-	6	G13	
rim fragment		MD6140	-	7	G10	?
rim fragment		MD6142	-	9		
Colchian amphorae		MD6143	-	10	G11	
clay daub		MD215	-	11	G4	various local and regional clays and products
clay	clay 2015	MD5784	37	12	G5	
clay	No. 1	MD5939	40	13		
clay	No. 4	MD5941	56	15		
tegula		MD5779	-	2	G6	
floor tile		MD5782	-	3	G7	
clay	No. 5	MD5942	36	16		
clay	No. 6	MD5943	43	17		
clay	No. 7	MD5944	52	18	G8	
clay	No. 2	MD5940	50	14	G9	
clay from mountain	No. 9/2016	MD6176		19	G12	
clay	No. 3	-	41	not analysed		
clay	No. 8	-	66			

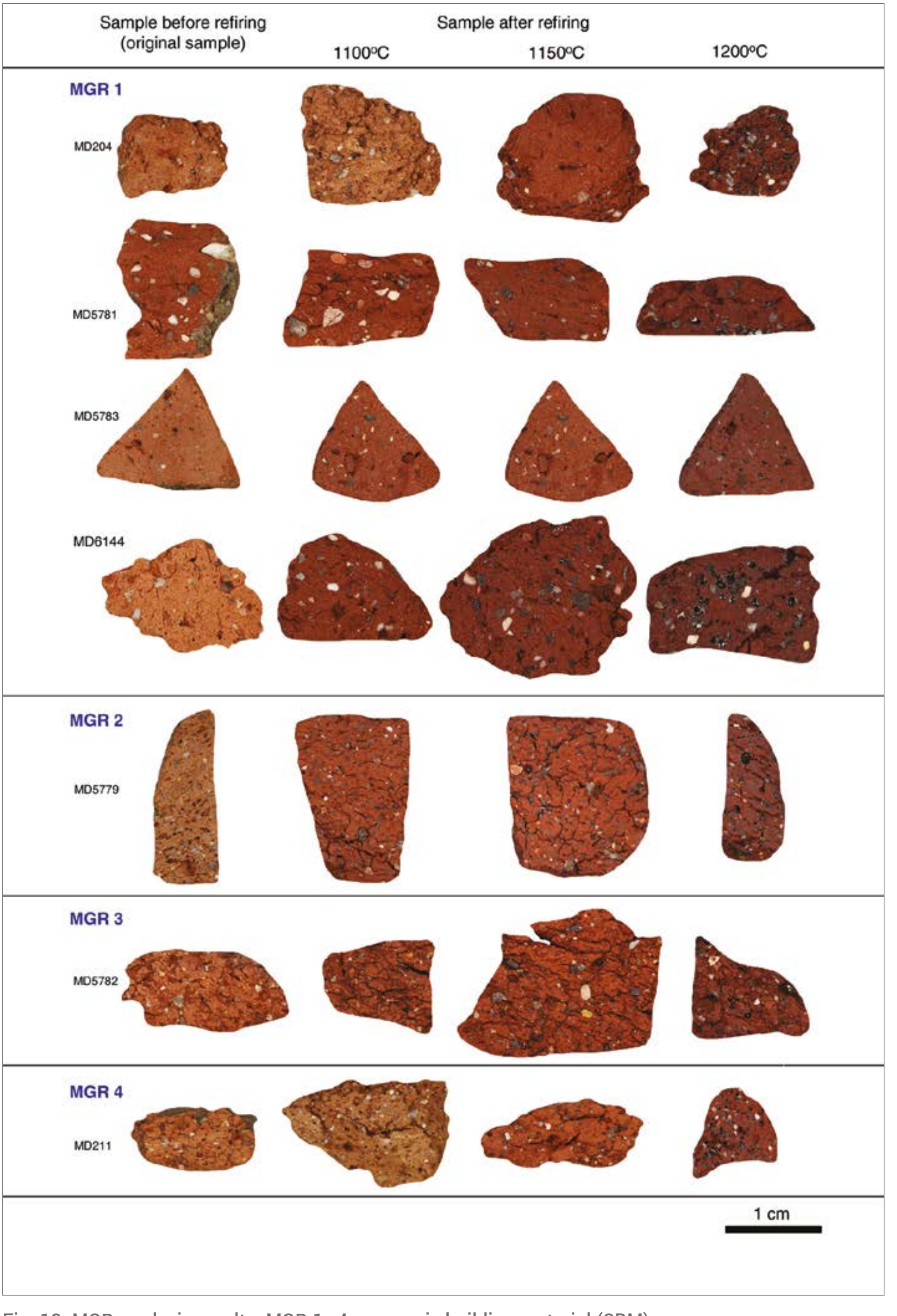

Fig. 13. MGR-analysis results: MGR 1–4 – ceramic building material (CBM)
(Digitizing M. Daszkiewicz, macrophotos M. Baranowski)

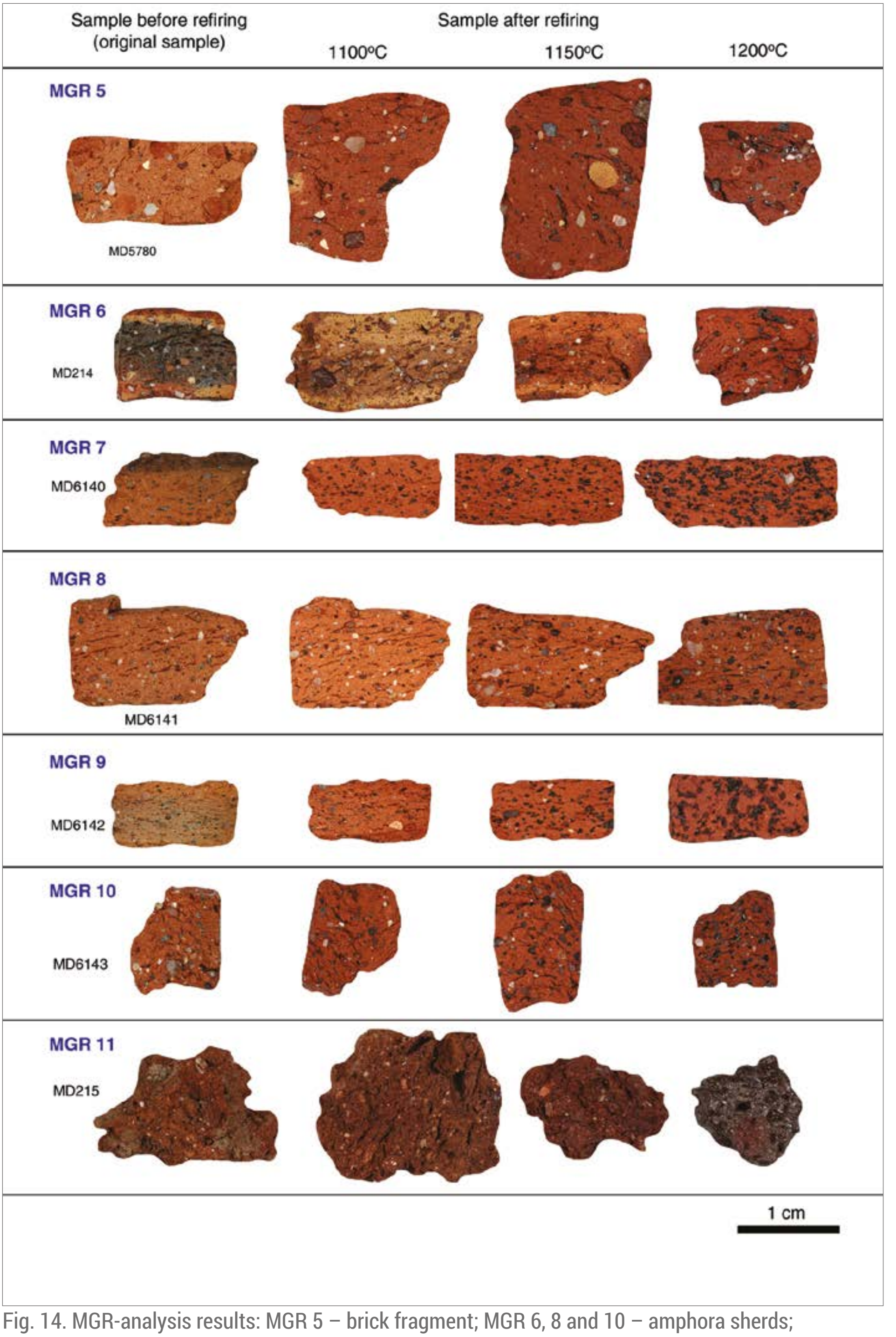

Fig. 14. MGR-analysis results: MGR 5 – brick fragment; MGR 6, 8 and 10 – amphora sherds; MGR 7 and 9 – pottery rim sherds; MGR 11 – daub (Digitizing M. Daszkiewicz, macrophotos M. Baranowski)

in all the other samples of amphorae and CBM [see *Figs 13–14*]. Furthermore, larger particles of temper were visible in some CBM samples (brick MD5780, tegula MD5781), as were clay aggregates or clay lumps, indicating that the preparation of the plastic part of the ceramic body did not produce homogeneous material (brick MD5780, pipe MD5783, roof tile MD6144).

The recipes (the proportion of the plastic to the non-plastic part of the ceramic body) used in making the two vessels represented by the rim sherds were not the same. The percentage of non-plastic ingredients used was estimated at 30% for sample MD6140 and 20% for sample MD6142. The ceramic bodies from which the amphorae were made (MD214, MD6141 and MD6143) were prepared using a different recipe. They contain 15% non-plastic ingredients. Fewer non-plastic particles are visible in the CBM samples (10-15%).[6]

Table 2. Chemical analysis results for ceramic building material (Aps 1 and Aps 2), pottery (chemical groups 1, 13[1], 10, 11) and locally/regionally occurring clays
Results of chemical analysis by WD-XRF (Preparation M. Daszkiewicz, measurements G. Schneider and A. Schleicher in GFZ Potsdam). Analysis on ignited samples, major elements normalized to a constant sum of 100%, loss on ignition stated in column 'l.o.i.', elements in brackets are determined with lower precision (Digitizing M. Daszkiewicz)

MGR group	Chem. clus.	Lab. No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	V	Cr	Ni	(Cu)	Zn	Rb	Sr	Y	Zr	(Nb)	Ba	(La	Ce	Pb)	l.o.i.
			per cent by weight										ppm														%
		?																									
8	1	MD6141	68.14	1.27	19.24	7.59	0.045	0.78	1.06	0.44	0.96	0.48	165	178	34	34	79	49	97	21	258	31	363	20	51	42	5.84
		?																									
6	13 (1)	MD214	66.22	0.96	19.22	9.22	0.028	1.63	1.26	0.57	0.84	0.05	193	125	36	32	48	45	74	16	164	11	421	12	23	23	0.20
		Aps1 reference group																									
1	2	MD209	67.30	1.11	18.53	6.87	0.088	1.35	1.17	1.58	1.82	0.17	163	203	47	54	84	63	168	23	215	12	409	26	53	22	0.96
1	2	MD204	65.10	1.04	18.66	8.04	0.100	1.23	1.78	1.92	1.68	0.44	143	210	50	65	80	53	176	21	194	12	402	17	50	19	4.24
1	2	MD208	64.85	1.15	19.43	7.04	0.065	0.90	1.26	1.78	1.65	1.89	162	210	49	79	114	59	163	22	223	12	450	17	43	30	5.60
1	2	MD205	65.31	1.11	18.83	7.44	0.088	1.83	1.52	1.79	1.83	0.27	166	249	60	80	109	56	208	27	191	10	444	29	60	30	1.64
1	2	MD6144	64.98	1.06	19.26	7.77	0.096	1.50	1.44	1.38	1.78	0.75	140	188	59	67	90	58	194	28	192	14	449	15	45	23	1.51
1	2	MD5783	64.56	1.22	19.85	8.48	0.095	0.84	0.95	0.97	1.87	1.16	140	228	51	81	72	68	150	22	234	18	458	17	24	21	4.46
1	2	MD5781	64.56	1.12	19.73	9.04	0.086	1.47	0.93	1.01	1.83	0.23	197	202	56	73	89	62	164	23	197	16	436	21	47	22	1.00
5	2	MD5780	66.01	1.02	19.55	7.75	0.048	1.23	1.25	1.22	1.60	0.33	121	157	49	90	78	53	151	18	182	17	380	20	30	130	1.34
		Aps2 reference group																									
4	3	MD211	54.89	1.23	25.10	10.71	0.098	2.77	2.42	1.27	1.16	0.36	268	203	46	114	94	36	175	22	141	7	419	6	40	16	1.55
4	3	MD210	54.10	1.24	24.63	11.45	0.096	2.91	2.87	1.29	1.06	0.36	267	208	41	100	99	32	182	22	128	7	421	<5	38	15	1.52
4	3	MD206	54.34	1.23	24.97	11.28	0.098	2.76	2.63	1.29	1.04	0.36	259	155	53	112	96	33	176	22	126	6	430	<5	33	112	1.50
4	3	MD207	54.33	1.24	24.90	10.83	0.096	2.92	2.78	1.32	1.04	0.55	234	244	62	114	109	35	181	20	139	6	397	8	41	16	2.16
4	3	MD213	54.67	1.26	24.88	10.77	0.077	2.19	2.90	1.39	0.95	0.93	222	256	43	89	82	29	188	21	129	8	390	7	26	18	5.15
4	3	MD212	52.93	1.31	24.83	11.25	0.129	2.32	3.27	1.43	0.99	1.54	249	269	46	93	95	31	200	22	141	8	393	12	38	74	6.85
		various local/region clays and products (* = tegula; ** = floor tile)																									
11	4	MD215	53.40	1.10	21.43	11.48	0.178	4.42	4.15	1.47	1.83	0.55	313	192	67	158	107	52	385	23	107	<5	433	15	36	16	1.07
12	5	MD5784	58.75	1.49	23.73	12.28	0.109	1.28	0.64	0.14	1.15	0.43	380	220	79	118	83	90	90	20	234	21	228	40	47	22	9.03
13	5	MD5939	56.80	1.59	26.04	12.96	0.222	1.03	0.08	0.06	1.04	0.18	348	263	143	154	105	81	67	23	247	24	262	41	85	30	10.06
15	5	MD5941	55.07	1.56	28.50	13.09	0.038	0.79	0.08	0.00	0.76	0.11	330	163	73	192	88	64	64	29	229	20	179	38	66	21	11.20
2	6*	MD5779	53.02	1.21	25.36	12.46	0.162	1.87	1.92	0.89	1.45	1.65	242	147	73	241	93	46	213	29	125	10	468	14	58	15	7.52
3	7**	MD5782	52.48	1.45	26.41	13.81	0.122	2.51	1.30	0.49	1.06	0.37	339	193	96	203	98	51	144	26	133	14	349	17	64	17	1.15
16	7	MD5942	50.10	1.77	28.02	15.65	0.144	2.10	0.50	0.15	1.39	0.19	504	169	85	199	132	61	143	22	141	12	426	33	39	13	12.08
17	7	MD5943	47.96	1.63	28.21	16.50	0.128	2.76	0.85	0.22	1.44	0.30	486	128	77	206	128	50	137	29	121	9	468	30	44	15	10.64
18	8	MD5944	47.41	1.51	32.07	16.44	0.097	1.58	0.00	0.01	0.64	0.25	426	150	54	264	92	39	39	55	108	<5	188	31	56	8	12.23
14	9	MD5940	51.02	1.47	24.74	16.68	0.154	1.89	0.41	0.09	3.31	0.24	438	392	83	186	116	99	309	20	123	10	758	38	25	14	9.16
19	12	MD6176	44.44	1.73	32.02	19.00	0.228	1.73	0.09	0.01	0.46	0.29	546	333	470	491	111	26	56	37	101	6	249	49	57	15	12.87
		?																									
9	10	MD6142	66.72	1.29	15.04	8.14	0.039	3.12	4.00	0.28	0.40	0.96	180	454	56	25	47	31	98	25	232	25	194	26	53	31	3.12
7	10	MD6140	61.82	1.52	16.13	9.11	0.058	4.22	5.55	0.37	0.42	0.82	143	646	83	31	70	26	123	29	251	31	161	29	71	32	3.06
		?																									
10	11	MD6143	60.98	1.61	16.87	13.76	0.079	1.74	2.69	0.52	0.40	1.36	266	499	67	47	110	32	158	27	259	24	180	34	37	32	5.34

The chemical analysis results indicate that the analyzed pottery and CBM were made from raw materials of very diverse chemical composition [*Table 2*].

RAW MATERIALS

The plasticity test, which included estimating the water of plasticity (make-up water) content, was the first analytical procedure to be performed. The amount of make-up water was determined in all of the clay samples discussed in this paper. The resultant values (in g H_2O per 100 g of dry matter) are listed in *Table 1*. Water of plasticity is the amount of water needed to bring 100 grams of clay to a workable plasticity (see *Appendix* below). This test revealed that the water of plasticity content in the analyzed raw material samples ranges from 36 g to 66 g H_2O/100 g clay. Two of these samples did not exhibit the characteristics of plastic raw materials (clay Nos 3 and 8); however, the first firing test was also performed on these samples. In order to determine water of plasticity, the prepared clays were pressed into plaster moulds of a Gorgon's mask. These masks were fired at 900°C [*Fig. 15*].[7]

Clay Nos 3 and 8 did not produce suitably workable plastic masses. They could be formed into briquettes, but because of their high content of silt- and sand-sized particles, the objects made of these raw materials had very little mechanical resistance (grains crumbled away from their surfaces when lightly rubbed with a finger). Thus, these raw materials could not have been used either for making pottery or CBM (it is unlikely that these types of raw materials would have been levigated). One sample (MD5941) is characterized by severe shrinkage, resulting in cracks. This clay would have had to be tempered. The remaining raw materials would have been suitable for making ceramics without the need for any additional processing (such as levigation or tempering).

The next stage of the raw material analysis (two non-plastic samples were excluded from further analysis) was to carry out a firing test to assess whether the raw materials could have been used for making the pottery and CBM discovered at Apsaros. Briquettes for this test were formed using a plastic mass and non-porous porcelain moulds to create dome-shaped (plano-convex) samples; these were then dried and fired in the same conditions used for pottery subjected to the MGR-analysis. The fired briquettes were subsequently classified into the MGR-groups using the same procedure as for refired ceramic specimens.

All of the raw materials are non-carbonate clays colored by iron compounds, and they all have a sintered (SN) matrix [*Fig. 16*].

This is the same matrix type as that of the analyzed ceramic artifacts. Similar non-plastic ingredients were also

6 Macroscopic assessments were carried out using the AGI Data Sheets for Geology in the field, laboratory, and office, compiled by R.V. Dietrich, J.T. Dutro, Jr. and R.M. Foose, American Geological Institute 1982.

7 Taking into account loss on ignition, it can be assumed that the original firing temperature of pottery and CBM falls within a range of 800–900°C.

observed in the form of black particles with a melting point of below 1200°C. When fired at 1200°C, the clays take on various colors, from beige-brown (MD6176) to reddish-brown (MD5784) and brown (MD5942). Extensive cracks were observed in the briquette made of clay characterized by severe shrinkage (MD5941). Each of the raw material samples was attributed to a different MGR-group (MGR-groups 12–19).

The daub clay sample stood out among the tested samples. It represented a combination of two raw materials

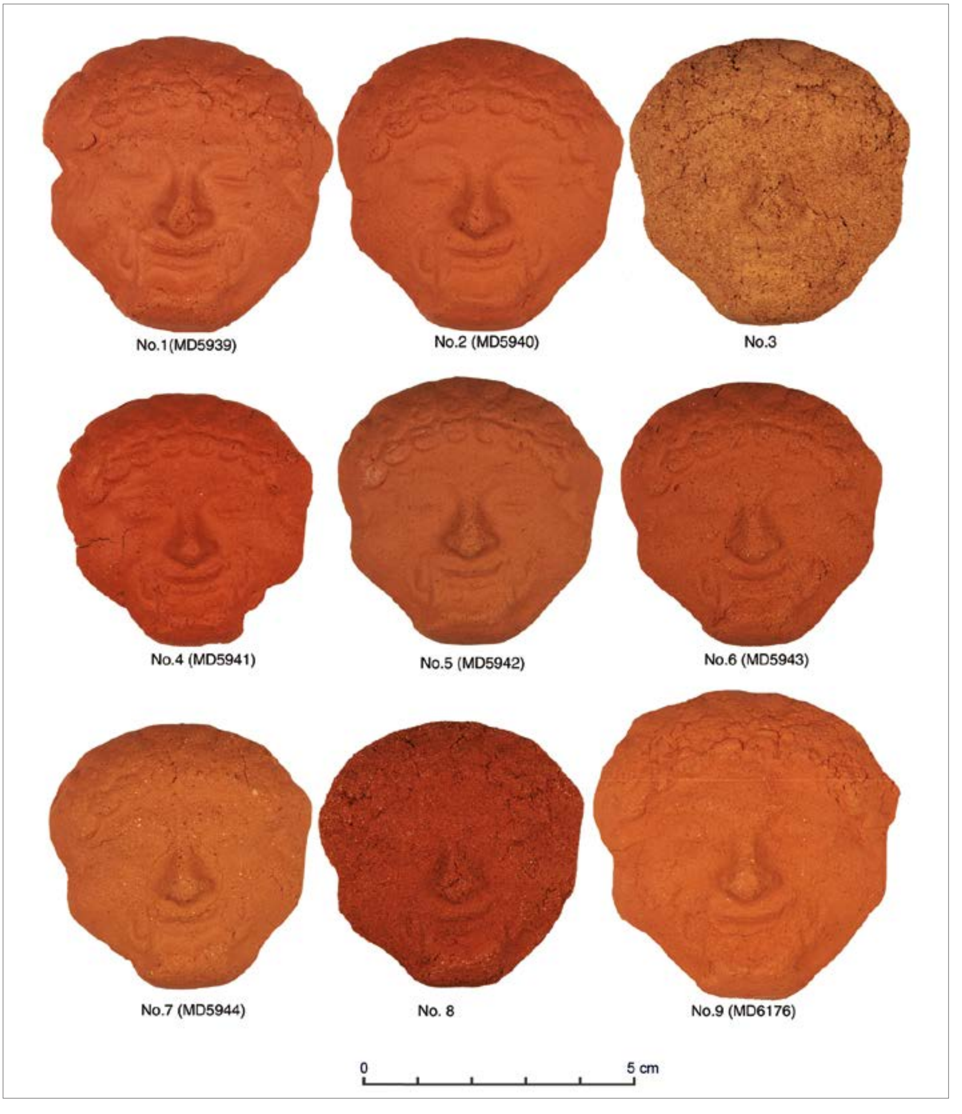

Fig. 15. Plasticity test: samples formed in plaster moulds and fired at 900°C in an oxidising atmosphere in a laboratory kiln (Digitizing M. Daszkiewicz, photos M. Baranowski)

Fig. 16. Firing test results: briquettes made in porcelain moulds (Digitizing M. Daszkiewicz, macrophotos M. Baranowski)

characterized by very different thermal behaviors. One of the raw materials has a sintered matrix (SN), while the second, which is the predominant of the two, has an over-melted matrix (ovM).[8] The daub was exposed to a temperature that was high enough to cause the thermal decomposition of clay minerals, resulting in a loss of plasticity (it is in fact a ceramic fabric).

The chemical analysis was performed on all of the raw materials and on the daub sample [see *Table 2*]. The results are discussed in the following section together with the results of the chemical analysis carried out on the ceramic finds.

PROVENANCE GROUPS

In provenance studies it is important to remember that there are two principal means of determining the provenance of a sample. Samples can be attributed to:
– reference groups with a known production place,
– reference groups without a known production place.

In the first instance, comparative studies are required to establish whether a particular compositional group represents kiln wasters, potter's tools or raw materials (the fact that a ceramic find belongs to a group representing the majority of samples from a given site does not always mean that the majority represents local products native to that site). In the second instance, the compositional group does not correspond to any group of known provenance (at the current stage of research).

The local provenance of the pottery and CBM found at Apsaros could potentially be confirmed by comparing their analysis results with those of the raw materials.

The MGR-analysis and firing tests demonstrate that none of the analyzed ceramic samples belong to the same MGR-group as the raw material samples [see *Table 1*]. However, they do share certain traits: an SN matrix type and macroscopically visible black particles characterized by a melting point of below 1200°C. They differ in color when fired at 1200°C; only the tegula fragment (MD5779) fires to the same color (albeit of a different shade) as raw material MD5784.

Once the results of the MGR-analysis are known, this will enable the correct interpretation of chemical clusters deriving from multivariate statistics. This means that after the MGR-analysis and firing tests, it is evident that none of the analyzed clays were used directly as raw materials for making the analyzed fragments of pottery and CBM. However, given the fact that there are certain similarities between them, this does not rule out the possibility that they may belong to the same chemical group.

The results of chemical composition analysis of ceramic finds and raw materials enabled various chemical groups to be identified and some of these could be combined into larger provenance groups. The results of multivariate cluster analysis[9]

8 Overmelted matrix type (ovM) = the surface of the sample becomes overmelted and its edges slightly rounded.

9 Both the multivariate cluster analysis and principal components analysis were carried out using a licensed copy of the SYSTEM Package obtained from the Weierstrass Institute for Applied Analysis and Stochastics, Leibniz Institute in Forschungsverbund Berlin e.V.

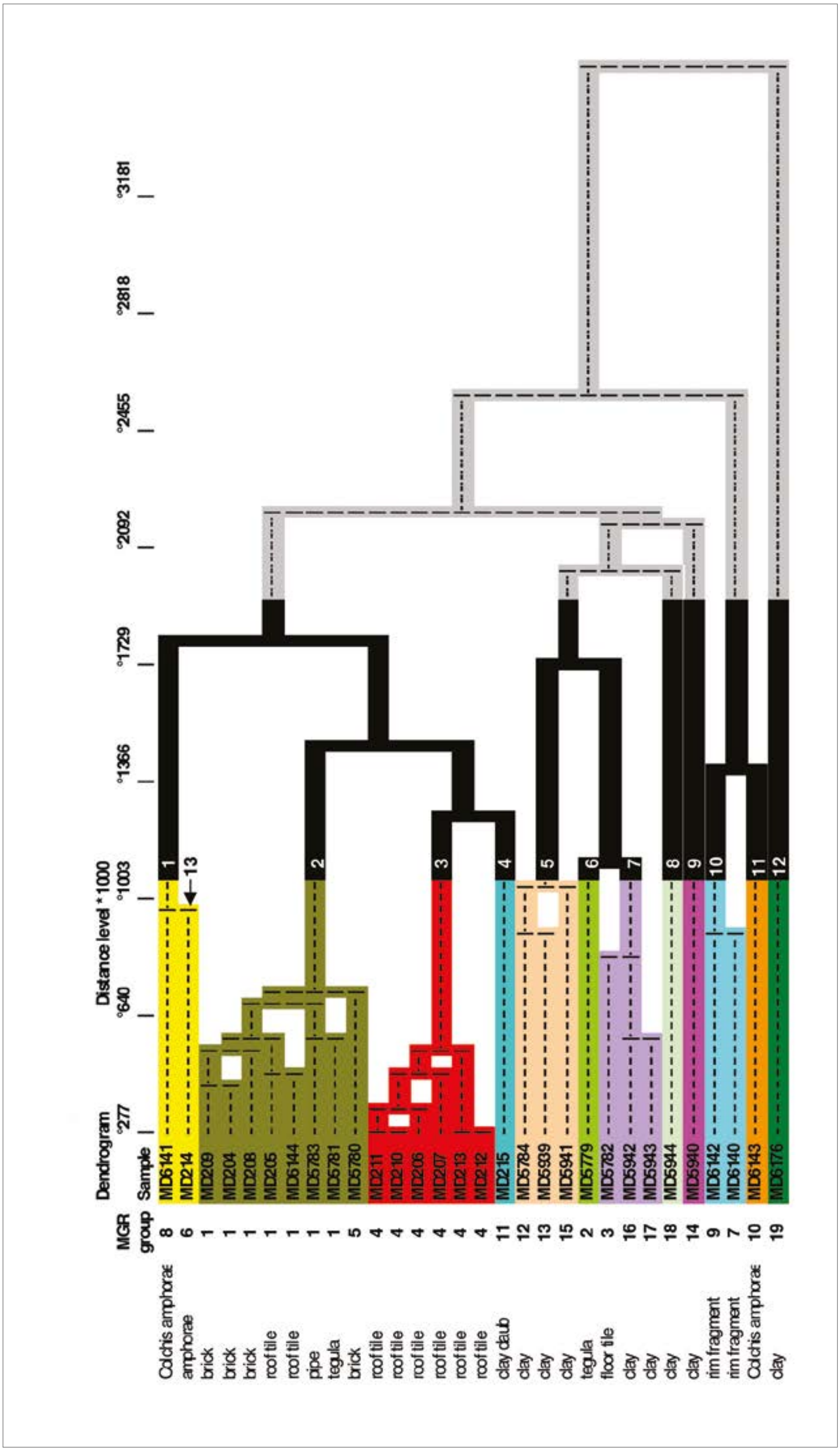

Fig. 17. Dendrogram of the results of multivariate cluster analysis (Digitizing M. Daszkiewicz)

are presented as a dendrogram [*Fig. 17*].

This analysis[10] takes into account the chemical composition of all 30 analyzed samples. Twelve clusters were singled out. The first of these encompasses two fragments of amphorae made from different clays, as determined by the MGR-analysis (MGR groups 6 and 8). The differences in chemical composition between these two samples (e.g., in their Ti, Mg, Cr and Zr levels) are significant enough for this cluster to be divided into two chemical groups, each represented by a single sample: group 1 by sample MD6141 and group 13 by sample MD214 [see *Fig. 17* and *Table 2*]. The remaining clusters produced by multivariate cluster analysis are consistent with the chemical groups (denoted as G1–G13 in *Table 1*). Cluster 2 in the dendrogram (chemical group G2) consists of eight samples, including all of those attributed to MGR-group 1 (seven samples) and one sample representing MGR-group 5. These are fragments of four bricks, two roof tiles, one tegula fragment and the sole fragment of pipe analyzed. These chemical groups are characterized by SiO_2 levels of 64.56–67.30wt.%, Fe_2O_3 levels ranging from 6.87 to 9wt.%, and by relatively high levels of Na_2O [see *Table 2*]. Although the amphorae representing chemical groups G1 and G13 have similar levels of SiO_2, Al_2O_3 and Fe_2O_3, Group G2 differs from them in having higher levels of Na_2O, K_2O and Cr and much higher levels of Sr despite having a similar CaO content (strontium is a geochemical correlate of calcium). The third cluster (equating to chemical group G3) is represented by six samples, all of which belong to the same MGR-group (4) and all of which are roof tile fragments. All samples belonging to MGR 4 and G3 have a very similar chemical composition, which differs markedly from the samples attributed to G2. SiO_2 levels are much lower (52.93–54.89wt.%), Al_2O_3 levels are much higher (24.63–25.10wt.%) and Fe_2O_3 levels range from 10.71 to 11.45wt.%. MgO and CaO levels are also higher, whilst the Sr/Ca ratio is twice as low. The average Al/Si ratio is 0.29 for G2 and 0.46 for G3. The results of the MGR-analysis show that the increased silica content in the samples attributed to G2 is not related to larger numbers of coarse grains of quartz temper, but to grains measuring less than 100μm (macroscopically visible at 40× magnification), hence to the type of clay.

The fourth cluster comprises only one sample: a piece of daub representing MGR-group 11. It differs from the samples ascribed to G3 in having higher levels of MgO and CaO, though, unusually for a daub sample, it does not have elevated levels of phosphorus or barium.

The next cluster consists of three clay samples attributed to MGR-groups 12, 13 and 15. These clay samples also fall into cluster 7 (encompassing two clay samples and a floor tile fragment) and clusters 8 and 9 (each containing one clay sample). The three clusters comprising clay samples and a floor tile, together with cluster 6, comprising a tegula (MD5779), can be classified as one large group. The characteristic feature of all these clays is

10 Analysis using Euclidean distance and average linkage aggregative clustering of a distance, Z-scores transformation, elements used: Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, V, Cr, Ni, Cu, Zn, Rb, Sr, Y, Zr and Ba.

their very low CaO and NaO levels, their high Al_2O_3 content (up to 32.07wt.% in sample MD5944) as well as their very high Fe_2O_3 content (12.28–16.67wt.%) and associated high vanadium content. This group does not include cluster 9, comprising clay MD5940, which was the only clay sample characterized by high levels of potassium (3.31wt.% K_2O) and had the highest Sr content (309 ppm) noted in any of the analyzed samples, whilst also having a very low CaO content (0.41wt.%).

The group of clusters containing clays include neither the daub sample nor the clay sampled from the hills overlooking the site (R. Karasiewicz-Szczypiorski, personal communication) (sample MD6176, cluster 12, see *Fig. 17*), which is characterized by a very high Fe_2O_3 content (19.00wt.%) and, rarely noted, very high levels of Ni, Cu and Zn (according to the person who collected this clay sample, there is no possibility of contamination resulting from the sampling method). High Cu levels (though not as high as those of clay MD6176) are characteristic of all the clay samples and of the tegula and floor tile samples included in the clay clusters [see *Table 2*].

Two pottery sherds (MD6140 and MD6142) representing two different MGR-groups have a similar chemical composition characterized by MgO and CaO levels higher than noted in other ceramic finds and a high Cr content, much bigger than that of the remaining ceramics and clays. Cluster 11 comprises a single sample, that is, a Colchian amphora sherd

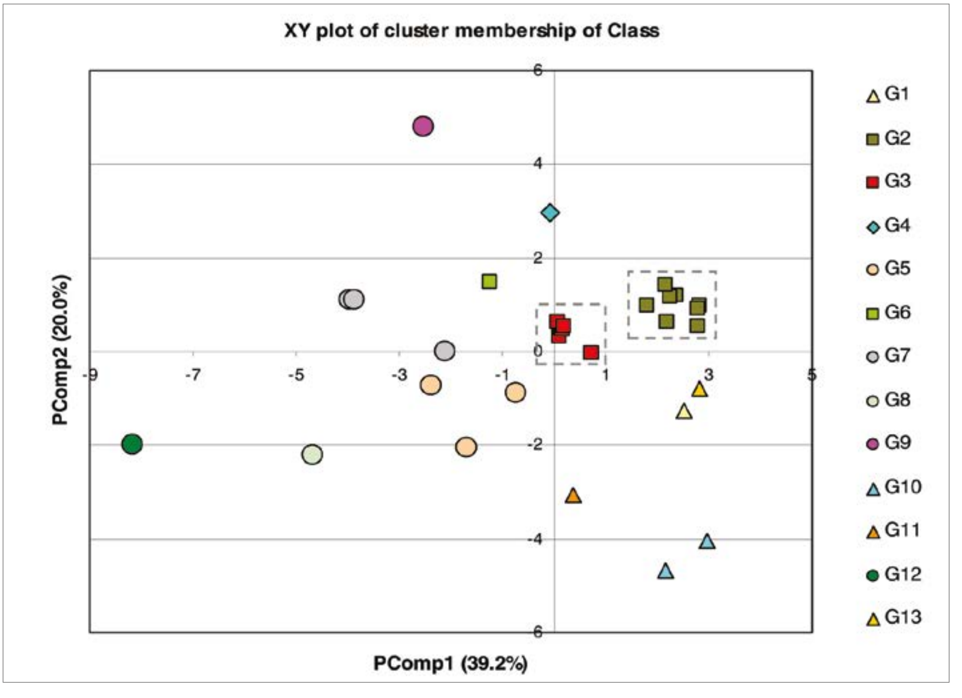

Fig. 18. PCA scores plot. Elements used: Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, V, Cr, Ni, Cu, Zn, Rb, Sr, Y, Zr and Ba. G1– G13 = chemical groups (Digitizing M. Daszkiewicz)

(MD6143) with high levels of SiO_2, TiO_2 and Fe_2O_3, and a high P_2O_5 content as well as low Ba concentration.

Defining groups based on chemical composition led to the identification of 13 chemical groups [*Fig. 18*]: G1–G13, nine of which are associated with one MGR-group. Four of the chemical groups encompass various MGR-groups [see *Table 1*]. Discrimination between groups G1–G13 was carried out by means of a principal components analysis (PCA).[11] Here, component 1 explains 39.2% of the variation, while component 2 20.0%.

As can be seen from the loadings plot, Si, Ti, Al, Fe, Ca, V, Ni, Cu and Zr have a high correlation with PC1; Na, Y and Zr with PC1 as well as with PC2; and K, Rb, Sr and Ba with PC2. Three samples grouped into one cluster by the multivariate cluster analysis (chemical group G7, three different MGR-groups) fall into two groups in PCA: two clay samples and a separate group comprising a floor tile fragment. This is attributable to the higher levels of silica and calcium and lower concentrations of iron, vanadium, zinc and barium in this sample. Given that this sample also belongs to an MGR-group different than either of the two clays, it is probable that an analysis of a larger number of floor tiles

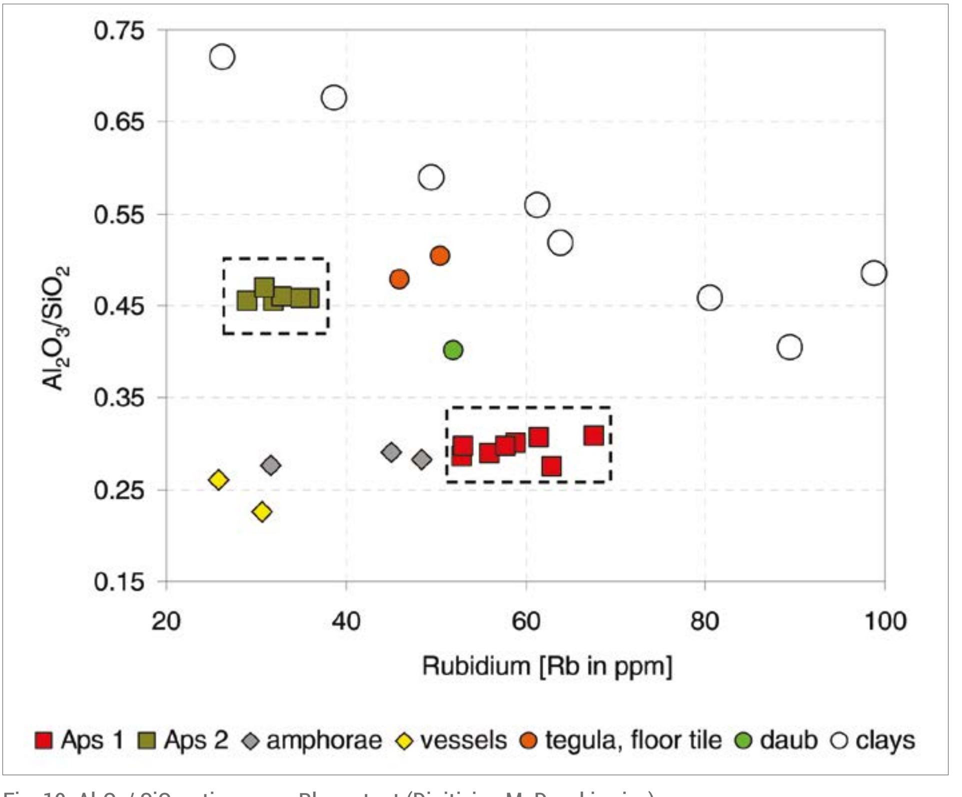

Fig. 19. Al_2O_3 / SiO_2 ratio versus Rb content (Digitizing M. Daszkiewicz)

11 Using the same elements as for the multivariate cluster analysis.

would lead to the identification of a distinct chemical subgroup. Both the PCA and a bi-plot of rubidium content versus Al_2O_3/SiO_2 ratio show good discrimination of chemical and MGR groups. Two homogeneous groups consisting of CBM fragments are clearly distinguishable (chemical group G2 = MGR 1 and 5; and chemical group G3 = MGR 4). If the archaeological evidence supports the idea that bricks with stamps: **I SAGI** and **[C]OH II [---]** and roof tiles with stamps: **[CO]H [II ---]** and **C[OH II ---]** were locally made, then group G2 (MGR1 and 5) can be recognized as an Apsaros reference group 1 (Aps 1). Similarly, if roof tiles bearing the stamps: **C[OH II ---]** and **CO[H II ---]** can also be deemed to be local products, then group G3 (MGR 4) can be recognized as a second Apsaros reference group (Aps 2) [*Fig. 19*].

Courtesy of A. Rogava we could compare the results of chemical analysis of pottery vessels and clay raw materials done by him (unpublished master's thesis) with the results of our analysis. One of the chemical groups includes two ceramic fragments analyzed as part of Radosław Karasiewicz-Szczypiorski's project (sample MD6140 and MD6142). Interestingly, the clay raw materials collected by Rogava and those analyzed within the framework of this project, differ in chemical composition from the chemical composition of ceramic vessels and CBM (and this is not related to the effect of temper).

CONCLUSIONS

1. Three principal CBM groups can be identified: a group of samples (mostly brick fragments) attributable to the Aps 1 reference group; a group of samples (exclusively roof tiles) attributable to the Aps 2 reference group; and a *tegula* and a floor tile associated with the analyzed raw materials [see *Table 1*].

2. The analyzed pottery was not made of the same raw materials as the CBM. Each of the sherds was made of a different plastic raw material (different MGR-groups). No Colchian amphorae with a similar chemical composition have been noted in the literature. The provenance of these vessels remains unknown.

3. The analyzed local/regional raw materials were not used for making the analyzed pottery and CBM (the tegula and floor tile mentioned in the first point are similar in chemical composition, but belong to different MGR-groups than the raw materials).

APPENDIX
DESCRIPTION OF METHODS USED

PLASTICITY TEST AND ESTIMATION OF WATER OF PLASTICITY

Water of plasticity values were estimated for eight samples. These values are given in *Table 1* in g H_2O per 100 g of dry clay (water of plasticity is the amount of water required to bring 100 g of clay to a plastic state; in practical terms, this means that the clay can be rolled into a ball which will not feature any cracks, and when a certain amount of pressure is subsequently applied to it—the amount depending on the type of clay—the clay ball will merely become misshapen but will not crack). Gorgon's masks were made from the prepared clays using a plaster mould (the mould was made from a replica of a Gorgon's head from Taranto) and the behavior of the ceramic body was assessed after firing at 900°C.

FIRING TEST

After adding water of plasticity (distilled water) to the raw materials, the resultant plastic masses were formed in a non-porous porcelain mould. Four briquettes were made from each raw material. These dome-shaped (plano-convex) briquettes were then dried and three of them were fired at the following temperatures: 1100°C, 1150°C and 1200°C. They were fired in a Carbolite laboratory resistance furnace in static air, at a heating rate of 200°C/h and a soaking time of 1 h at the peak temperature and cooled at a cooling rate of 5°C/min to 500°C, followed by cooling in the kiln for one hour. They were subsequently removed from the kiln and left cooling until they reached room temperature. Having been cooled, each of the briquettes was glued onto card and photographed in standardized conditions using a digital SLR camera with a fixed macro lens.

One unfired briquette of each raw material was kept as a reference of the original sample, and another unfired briquette was processed for chemical analysis by WD-XRF.

MGR-ANALYSIS

Four thin slices were cut from each sample in a plane at right angles to the vessel's main axis. One of these sections was left as an indicator of the sample's original appearance, whilst the remaining three were refired, each one at a different temperature, in a Carbolite electric laboratory resistance furnace using a standard procedure. Firing was carried out at the following temperatures: 1100°C, 1150°C and 1200°C in static air (i.e., without airflow), at a heating rate of 200°C/h and a soaking time of 1 h at the peak temperature, and cooled at a cooling rate of 5°C/min to 500°C, followed by cooling in the kiln for one hour. They were subsequently removed from the kiln and left to continue cooling until they reached room temperature. The fragments were then glued onto paper and a photograph was taken with a macro lens for each slice.

CHEMICAL ANALYSIS

Chemical analysis by WD-XRF (wavelength-dispersive X-ray fluorescence) was

12 In the case of raw material samples, the cast discs cracked during cooling. It was only after three attempts using different cooling rates that a disc suitable for measurement was obtained.

used to determine the content of major elements, including phosphorus and a rough estimation of sulphur and chlorine. Total iron was calculated as Fe_2O_3. Samples were prepared by pulverising fragments weighing approximately 2 g, having first removed their surfaces and cleaned the remaining fragments with distilled water in an ultrasonic device. The resulting powders were ignited at 900°C (heating rate 200°C/h, soaking time 1 h), melted with a lithium-borate mixture (Merck Spectromelt A12) and cast into small discs for measurement.[12] This data is, therefore, valid for ignited samples but, with the ignition losses given, may be recalculated to a dry basis. For easier comparison the major elements are normalized to a constant sum of 100%. Major elements are calculated as oxides (see above note 2) and are given in per cent by weight; trace elements are given in ppm. Analysis precision for the major elements is below 2%, rising to a maximum of 6% for sodium and trace elements (for very low contents, it rises to 20%). Accuracy was tested by analyzing international reference samples and by exchange of samples with other laboratories. For major elements in standard reference samples, the maximum deviation is mostly below 5% and for sodium and trace elements (except La, Ce, Nb, Pb, Th) it is below 10%.

Preparation of the samples for analysis was carried out by Małgorzata Dasz-kiewicz at ARCHEA. Measurement using a PANanalytical AXIOS XRF-spectrometer and the calibration of Arbeitsgruppe Archaeometrie was performed by Gerwulf Schneider (Freie Universität Berlin) and Anja Schleicher (Helmholtz-Zentrum Potsdam, Deutsches Geo-ForschungsZentrum GFZ, Sektion 4.2, Anorganische und Isotopengeochemie).

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Abbreviations

▫*AÉ* *L'Année épigraphique*

▫Arr. *Peripl.* Arrian, *Periplus Ponti Euxini*

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▫*Tab. Peut.* *Tabula Peutingeriana*

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ABBREVIATIONS

AAE	*Arabian Archaeology and Epigraphy*
ANM	*Archéologie du Nil Moyen*
AV	*Archäologische Veröffentlichungen, Deutsches Archäologisches Institut, Abteilung Kairo*
BASOR	*Bulletin of the American Schools of Oriental Research*
BCH	*Bulletin de correspondance héllenique*
BIFAO	*Bulletin de l'Institut français d'archéologie orientale*
BSFE	*Bulletin de la Société française d'égyptologie*
CRIPEL	*Cahiers de recherches de l'Institut de papyrologie et égyptologie de Lille*
EtTrav	*Études et travaux. Travaux du Centre d'archéologie méditerranéenne de l'Académie des sciences polonaise*
FIFAO	*Fouilles de l'Institut français d'archéologie orientale*
GAMAR	*Gdańsk Archaeological Museum African Reports*
GM	*Göttinger Miszellen*
JEA	*Journal of Egyptian Archaeology*
JJP	*Journal of Juristic Papyrology*
MDAIK	*Mitteilungen des Deutschen Archäologischen Instituts, Abteilung Kairo*
OIP	*Oriental Institute Publications*
OLA	*Orientalia lovaniensia analecta*
PAM	*Polish Archaeology in the Mediterranean*
PSAS	*Proceedings of the Seminar for Arabian Studies*
SAAC	*Studies in Ancient Art and Civilisation*
ZÄS	*Zeitschrift für ägyptische Sprache und Altertumskunde*

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