Early Roman military fortifications and the origin of Trieste, Italy

Federico Bernardini[a,b,1], Giacomo Vinci[c], Jana Horvat[d], Angelo De Min[e], Emanuele Forte[e], Stefano Furlani[e], Davide Lenaz[e], Michele Pipan[e], Wenke Zhao[e], Alessandro Sgambati[f], Michele Potleca[g], Roberto Micheli[h], Andrea Fragiacomo[i], and Claudio Tuniz[a,b,j]

[a]Multidisciplinary Laboratory, The "Abdus Salam" International Centre for Theoretical Physics, 34014 Trieste, Italy; [b]Centro Fermi, Museo Storico della Fisica e Centro di Studi e Ricerche "Enrico Fermi," 00184 Rome, Italy; [c]Department of History and Protection of Cultural Heritage, University of Udine, 33100 Udine, Italy; [d]Institute of Archaeology, Research Centre of the Slovenian Academy of Sciences and Arts, 1000 Ljubljana, Slovenia; [e]Department of Mathematics and Geosciences, University of Trieste, 34127 Trieste, Italy; [f]Agriculture and Forests Inspectorate of Trieste and Gorizia, 34134 Trieste, Italy; [g]Civil Protection of Friuli Venezia Giulia, 33057 Palmanova, Italy; [h]Soprintendenza per i Beni Archeologici del Friuli Venezia Giulia, Trieste, 34132 Trieste, Italy; [i]Society for the Prehistory and Protohistory of Friuli Venezia Giulia, 34100 Trieste, Italy; and [j]Centre for Archaeological Science, University of Wollongong, Wollongong, NSW 2522, Australia

An interdisciplinary study of the archaeological landscape of the Trieste area (northeastern Italy), mainly based on airborne light detection and ranging (LiDAR), ground penetrating radar (GPR), and archaeological surveys, has led to the discovery of an early Roman fortification system, composed of a big central camp (San Rocco) flanked by two minor forts. The most ancient archaeological findings, including a Greco–Italic amphora rim produced in Latium or Campania, provide a relative chronology for the first installation of the structures between the end of the third century B.C. and the first decades of the second century B.C. whereas other materials, such as Lamboglia 2 amphorae and a military footwear hobnail (type D of Alesia), indicate that they maintained a strategic role at least up to the mid first century B.C. According to archaeological data and literary sources, the sites were probably established in connection with the Roman conquest of the Istria peninsula in 178–177 B.C. They were in use, perhaps not continuously, at least until the foundation of Tergeste, the ancestor of Trieste, in the mid first century B.C. The San Rocco site, with its exceptional size and imposing fortifications, is the main known Roman evidence of the Trieste area during this phase and could correspond to the location of the first settlement of Tergeste preceding the colony foundation. This hypothesis would also be supported by literary sources that describe it as a *phrourion* (Strabo, V, 1, 9, C 215), a term used by ancient writers to designate the fortifications of the Roman army.

airborne light detection and ranging | ground penetrating radar | archaeological surveys | early Roman military fortifications | Trieste (Italy) origin

The art of camp building is probably a key element behind the strength of the Roman army (1) and its gradual expansion in most Mediterranean regions and Western Europe, where numerous modern cities have developed from a Roman military fortress (2). Its origin, however, is not clear. The earliest archaeological traces of military camps are so far provided by Spanish sites dating back to the last two decades of the third century B.C. and the beginning of second century B.C. (3–5). They mainly consist of relatively large concentrations of archaeological material, apparently not associated with any structure, that have been interpreted as remains of temporary camps (6, 7). The existence of coeval military permanent fortifications at *Tarraco* (Tarragona) and *Emporion* (Girona), reported by literary sources, has been recently confirmed by archaeological investigations (3–5).

However, the most ancient secure and complete examples of military camps date back to the mid to late second century B.C. (1, 3–5). Among them there are the sites from Numantia and its area, related to the Numantine War (154–133 B.C.) (8, 9) and the Roman military complex of Pedrosillo, dated to the Lusitanian Wars (155–138 B.C.) (10, 11).

Surprisingly enough, not a single Roman military fortification had been discovered in Italy until the recent identification of the Mt. Grociana piccola fort in the northeastern part of the peninsula close to Trieste (12). Further research, mainly based on LiDAR (light detection and ranging) remote sensing, ground penetrating radar (GPR), and archaeological surveys, has shown that the Mt. Grociana structures are just part of a Republican fortification system, which includes two additional sites. Here, we present the plan of emerging and buried identified structures, their spatial relationship, and the associated archaeological materials to define their chronology and historical significance.

According to ancient sources, the Latin words used to define the fortifications of the Roman army are *castra* (in Greek, *stratopedon*) and its diminutive *castellum* (in Greek, *phrourion*), which have been generally translated by British archaeologists as "fortress/camp" and "fort," respectively (1, 13). Following this conventional terminology, we use here the terms "camp" or "fortress" to designate sites larger than 10 ha, and the term "fort" to indicate the smaller fortifications, independently of the building techniques and possible permanent or temporary functions.

Geographical and Geomorphological Background

The archaeological sites presented here are located in northeastern Italy, in the innermost part of the gulf of Trieste, called the Bay of Muggia (Fig. 1*C*, sites 1–3), one of the most protected natural harbors of the northern Adriatic coast. In the study area, part of the External Dinarides (14), a Mesozoic carbonate

Significance

Archaeological evidence from the Trieste area (Italy), revealed by airborne remote sensing and geophysical surveys, provides one of the earliest examples of Roman military fortifications. They are the only ones identified in Italy so far. Their origin is most likely related to the first year of the second Roman war against the Histri in 178 B.C., reported by Livy, but the sites were in use, perhaps not continuously, at least until the mid first century B.C. The main identified San Rocco military camp is the best candidate for the site of the first Trieste.

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[1]To whom correspondence should be addressed. Email: fbernard@ictp.it.

platform, overlays an Eocene turbiditic succession (Flysch of Trieste) (Fig. 1*C*) (15).

Two of the Roman fortifications, San Rocco and Montedoro, are located at the top of marly-arenaceous hills divided by the Quaternary alluvial deposits of the Rosandra River (Fig. 1*C*). This area is part of a fertile semicircular territory delimited on the north and the east by the steep slope karstic plateau and, on the south, toward the Istrian peninsula, by the Montedoro ridge, gradually declining from its highest point, the Socerb village, to the Stramare landing place (16). The San Rocco site is located in a central strategic position, 2 km away from the innermost present-day shore of Muggia Bay, and its southeast slope is surrounded by the Rosandra River. The Montedoro fort stands on a large terrace of the Montedoro ridge, looking at the Zaule plain just in front of San Rocco hill (Fig. 1*C*). The Bay of Muggia was affected by a tectonic down lift of about 1.6 m over the last two millennia (17, 18) and has suffered considerable silting up since the Roman Age, due to natural sedimentary alluvial processes and historic human-made landfills (19). Another Roman fortification, preliminarily described by Bernardini et al. (12), stands on Mt. Grociana piccola, located in the Karst plateau (Fig. 1*C*), and overlooks both Muggia Bay and the routes leading from the Trieste gulf to today's Slovenia and Quarnero gulf (Croatia).

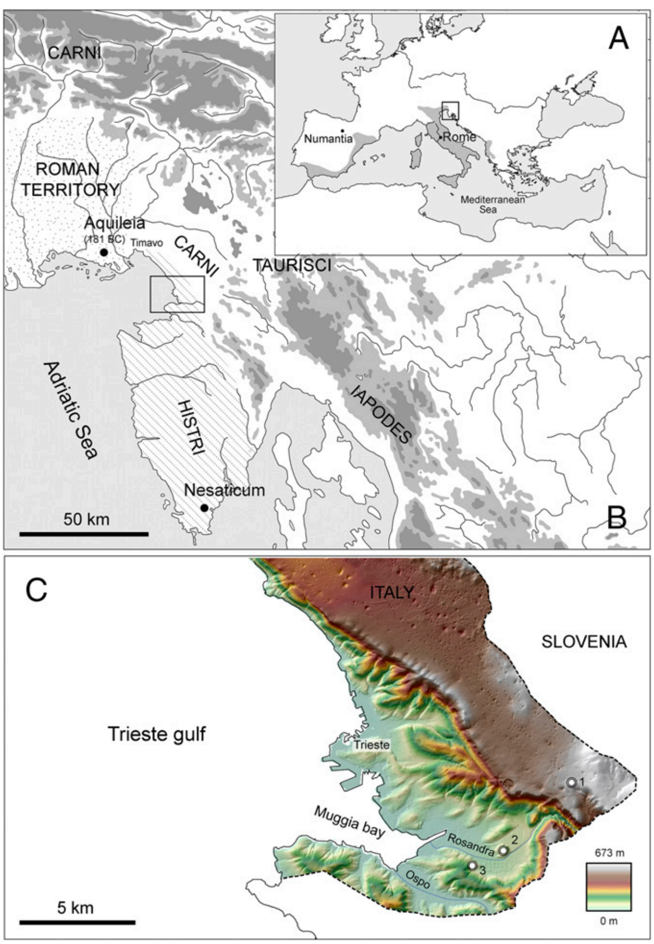

Fig. 1. Location of the study area. (*A*) Schematic extension of Roman territory at the beginning of second century B.C. in light gray. (*B*) Northeast Adriatic regions before the second Istrian war (178–177 B.C.), showing the Roman territory (dotted area) with the location of Aquileia (founded in 181 B.C.), the territory of Histri (striped area), and the areas occupied by other tribes. (*C*) LiDAR-derived elevation model of the study area with the location of the Roman fortifications discussed in the paper. Site 1, Mt. Grociana piccola; site 2, Mt. San Rocco; site 3, Montedoro.

Historical Background

The archaeological and literary sources available for the northern Adriatic territory during the second century B.C., corresponding to La Tène C2 and La Tène D1a of central European chronology (20–22), do not allow a precise reconstruction of its complex cultural features but indicate that it was subject to several cultural influences. On the one hand, today's Western Slovenia, including part of the Karst, was occupied by Celtic tribes (defined as Carni by literary sources) (22–24) belonging to the Inner Carniolan (Notranjska)/Karst cultural group (25–27). From an archaeological viewpoint, the only remarkable evidence of Celtic presence in the study area, starting at least from the third century B.C., has been identified in the necropolis of Socerb, Slovenia, in use, apparently without interruptions, between the sixth century B.C. and the first century A.D. On the other hand, literary sources report that, at the beginning of the second century B.C., the area previously under the Venetic cultural influence (26) was controlled by the Histri (23), whose central territory included the entire Istrian peninsula delimited on the east by the Raša River, Mt. Učka, and the Ciceria plateau, with the main capital town (Nesactium) located in the southeastern coast of the peninsula (Fig. 1*B*).

After a first conflict between Rome and the inhabitants of Istria in 221 B.C., the area became subject to the direct Roman influence in the first half of the second century B.C. (24, 27–29). Literary sources report that, in 183 B.C., the Romans forced a Celtic tribe, perhaps the Taurisci (30), settled in 186 B.C. not far from the future colony of Aquileia, to abandon their *oppidum* and come back to their territory beyond the Alps (31, 32). Other clashes are reported between the Romans and the Histri during the foundation of Aquileia in 181 B.C. (24, 33), but it was only a few years later, during 178–177 B.C., that Istria was conquered and its people definitely subjected. The Roman military activities carried out during the first year of the conflict took place in the area approximately corresponding to today's province of Trieste, between the Timavo River and the first landing place in Istrian territory, which could be identified somewhere in Muggia Bay (12, 34, 35). A few years later, in 176 B.C., a garrison of *socii nominis Latini* was stationed in the Istrian territory to control the indigenous population and prevent possible attacks against Aquileia (23). The area, in fact, continued to be politically unstable until at least the mid first century. In 171 B.C., the consul G. Cassius Longinus mistreated the Histri, Carni, and Iapodes (24, 31, 32, 36). In 129 B.C., further military expeditions were undertaken against the Taurisci, Histri, Carni, and Liburni (24, 32, 36, 37) and, in 115 B.C., against the Carni (24).

The colony of Tergeste was probably founded by Gaius Julius Caesar during his proconsulship in Gaul (58–50 B.C.), a chronology accepted by most authors, or less likely during his dictatorship (49–44 B.C.) (26). An incursion of Iapodes to Tergeste in 52 B.C. (36, 38) might have caused Roman military reactions.

Results

Mt. Grociana Piccola.

Structures. LiDAR-derived images of Mt. Grociana piccola (Fig. 2*A*) clearly show a trapezoidal structure with blunt angles (161 × 96 × 173 × 122 m) oriented east–west, housing a smaller rectangular one (100 × 43 m) with a different orientation (Fig. 2*A*, structures 2 and 1, respectively) (12). This inner structure is tilted 18 degrees from the horizontal east–west direction. The areas enclosed in the big and in the small structures are about 2 ha and 0.4 ha, respectively. On site, the remains of the external wall are recognizable as a small bump (3–4 m wide and less than 1 m high) (Fig. 2*A* and Fig. S1, graph b-b1), which interrupts the slope of the hill and produces, especially on the northeast side,

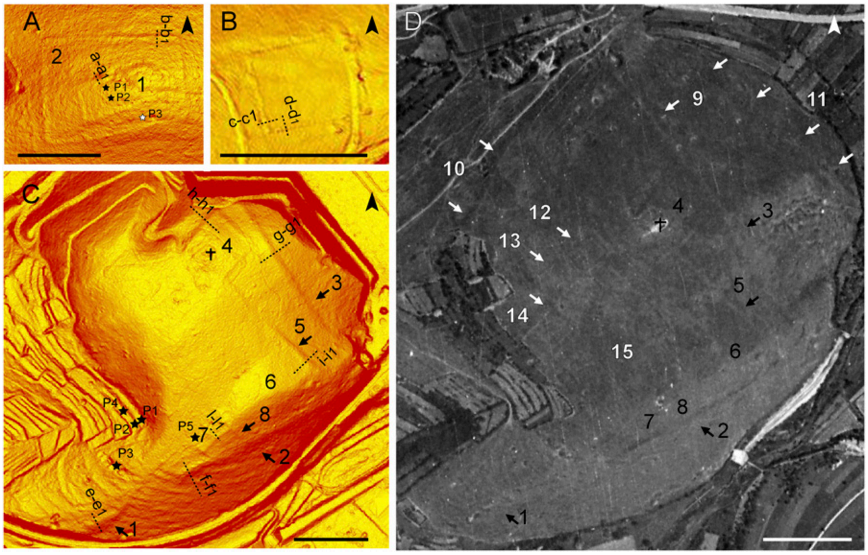

Fig. 2. The archeological sites. LiDAR-derived slope maps of Grociana piccola (*A*), Montedoro (*B*), and San Rocco (*C*) sites, showing the identified structures (structures 1–8) and the position of related orthogonal topographic profiles shown in Fig. S1 (from a-a_1 to l-l_1). Black and white stars, positions of pottery and metal findings, respectively; black cross, position of ruins of San Rocco church. (*D*) A 1957 aerial photograph of the San Rocco site before the destruction of its northern slope, showing the position of additional destroyed structures (structures 9–15). (Scale bars: 100 m.)

a small and narrow terrace. In correspondence to the eastern side, where the wall is crossed by a modern path, its basal part is exposed, showing a simple dry stone structure composed of medium size blocks, made of local limestone. The ruins of the inner rectangular fortification, definitely more imposing than the external one, are detectable as a bump about 6 m wide and 1–2 m high enclosing a relatively flat hill top and supporting artificial large terraces (Fig. 2*A* and Fig. S1, graph a-a1).

Archaeological findings. Archaeological surveys inside the inner wall have allowed the discovery of two rims of Lamboglia 2 amphorae (Figs. 2*A*, sites P1 and P 2 and 3 *A*, *1* and *A*, *2*). One of them shows a triangular section, suggesting a chronology between the end of the second century B.C. and the beginning of the first century B.C., whereas the morphology of the other one indicates a relative dating within the first century B.C. (12). Relatively abundant amphorae and pottery fragments are spread on the hill top inside the rectangular upper fortification whereas they are apparently absent in the area between the internal wall and the external fortification. However, in the southwest sector of this area (Fig. 2*A*, site P3) an iron military footwear hobnail has been found (Figs. 3 *A*, *3* and 4*A*). Its underside shows distinct workshop marks, a sort of cross with four little protuberances. It corresponds to the type D of Alesia (39), which is generally dated to the late Republican period and in particular between Caesar's Gallic Wars and the fourth decade B.C. (40–47). Geographically close to the Trieste area, artifacts of the same type have been found in eastern Friuli (48) and western Slovenia (45–47). If the maximum diameter of the Grociana piccola hobnail is compared with artifacts from Caesarean–Augustan sites, hobnails of similar size are reported from Alesia, Hermeskeil, Boviolles, and Ribemont sur Ancre (Fig. 4*A*).

Evidence of such types of hobnail from archeological sites dated before the Gallic Wars is not available so far. Numerous footwear hobnails have been recently discovered in the putative battlefield of *Baecula* (208 B.C.) (7), but, unfortunately, a complete description of these artifacts has not been published yet (49).

Mt. San Rocco.

Structures. The archaeological relevance of the area was only partially recognized by Vattovani (50), Lettich (51), and Flego and Župančič (52), who also reported the presence of archaeological materials, mainly amphorae fragments, in the area. However, no archaeological materials were collected and published. Unfortunately, since the first identification of the archaeological structures, the morphology of the central part of the hill has been altered.

The LiDAR-derived images have allowed us to visualize effectively the plan of the surviving emerging structures, showing additional parts and many significant differences with respect to the schematic topographic map produced in the 1990s (52). The emerging archaeological features are mainly detectable as small topographic vertical anomalies (Fig. 2*C*).

A southeast external rampart, tilted about 30 degrees from the east—west direction, is easily identifiable across the slope of the hill (Fig. 2*C*, structures 1 and 2). As it runs from the southwest end toward its middle part, its altitude increases and then gradually decreases as it approaches the level of the surrounding plain. Starting from the southwest, a segment of this rampart is preserved for about 60 m in length and shows a maximum width of about 25 m (Fig. 2*C*, structure 1 and Fig. S1, graph e-e_1). After an interruption of about 90 m, the straight structure 2, lower than 1 m, appears with an extension of about 255 m and a maximum width of 20–25 m (Fig. 2*C*, structure 2 and Fig. S1, graph f-f_1).

A northeast external rampart goes for about 260 m northwestwards to where the hill has been destroyed with a maximum width of about 20 m (Fig. 2*C*, structure 3 and Fig. S1, graph g-g_1).

Inside these external walls (structures 1–3), a smaller square fortification (structure 4 of Fig. 2*C*), with a slightly different orientation and lacking the southwest side, protects the highest point of the hill where, in the central area, the remains of San Rocco church are still visible. It is tilted about 50 degrees from the east–west direction. The northwest side of structure 4 is about 70 m long, 15 m wide, and 1 m high (Fig. S1, graph h-h_1). The northeast and southeast preserved sides have about the same length and width. A transversal rampart, about 180 m long, 10 m wide, and 1 m high (Fig. 2*C*, structure 5 and Fig. S1, graph i-i_1), starts from the southeast side of structure 4 and ends in correspondence to the eastern edge of the hill. A large terrace has been recognized to the southwest of structure 5 (Fig. 2*C*, area 6). Other smaller structures have been identified in the southern part of the archaeological site: A wall with a southwest–northeast orientation, about 50 m long and 2 m wide, runs in

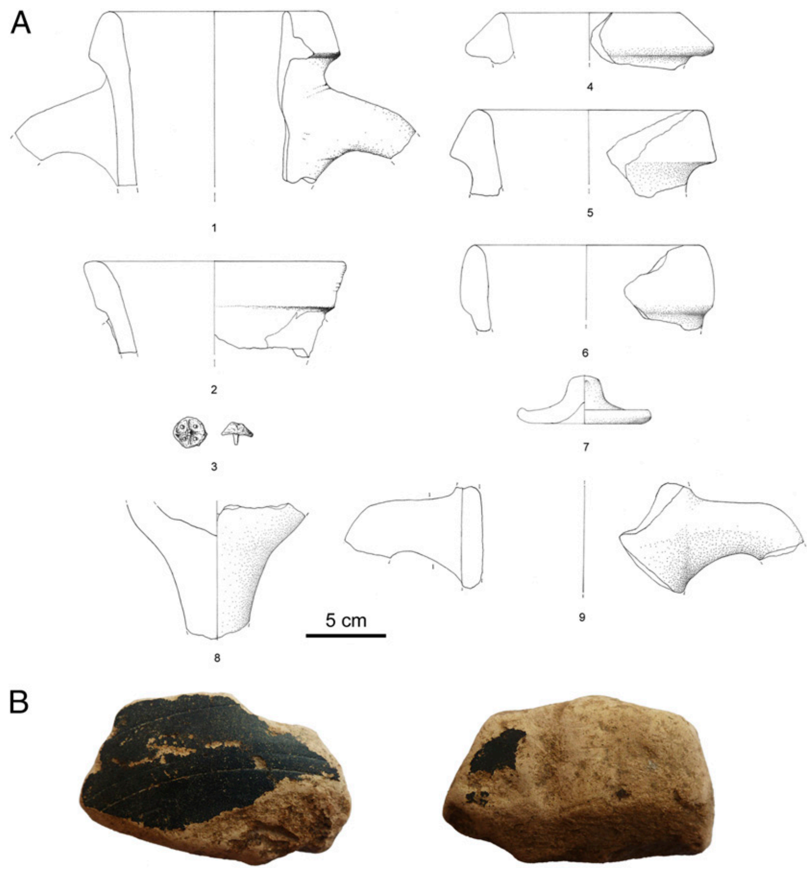

Fig. 3. Archaeological materials from the Roman fortifications. (*A*) Archaeological materials from Grociana piccola (*1*–*3*) and San Rocco (*4*–*9*) Roman fortifications. Drawings by S. Privitera (*1*, *2*), G. Zanettini (*3*), and A.F. (*4*–*9*). (*B*) Fragment of black slip pottery open vase from the San Rocco camp (maximum length, 4 cm).

correspondence to the margins of the hill, producing a small terrace (Fig. 2*C*, structure 7 and Fig. S1, graph l-l$_1$); a perpendicular wall (structure 8 of Fig. 2*C*), about 30 m long and 2 m wide, crosses structure 7 toward the big southern external rampart 2. On site, these structures are identifiable as collapsed dry stone walls. Moreover, south of external structure 2, additional features are visible only looking at the 2D hillshade of the LiDAR digital elevation model (DEM) produced with specific light conditions (azimuth, 225; declination, 45°): From the external wall, four hardly visible perpendicular features about 60–70 m long run toward the Rosandra River, following the line of maximum slope (Fig. S2).

The photo-aerial documentation has revealed that the site was much bigger than earlier believed, occupying most of the destroyed northwestern part of the hill (Fig. 2*D*). It emerged clearly that the northeast external rampart 3, today interrupted in the area close to the inner upper rectangular fortification 4 due to the destruction of the hill, ran northwards for about 180 m (Fig. 2*D*, structure 9) and then turned southwards, surrounding the northwest side of the hill with a semicircular fortification (Fig. 2*D*, structure 10). It can be calculated that the area delimited by such external fortifications was about 13 ha. Another possible rectilinear defensive structure has been identified further to the north (Fig. 2*D*, structure 11).

Other structures have been recognized inside the external fortifications: (*i*) southwest of structure 4, a rectangular structure with a similar orientation (about 40 m long and 35 m wide) (Fig. 2*D*, structure 12); (*ii*) a wall, about 55 m long, starting from the southwest corner of structure 12 and running southwestwards (Fig. 2*D*, structure 13); and (*iii*) a wall, about 155 m long, starting parallel and very close to the southeast side of structure 12 and running toward the southwest (Fig. 2*D*, structure 14). Even more interesting are the not clearly identifiable features recognizable in the large area (about 170 × 160 m) between the 155-m wall and the southern external fortification. A series of parallel long rectilinear features oriented northwest–southeast are intersected, mainly in the southern part (Fig. 2*D*, structure 15), by other perpendicular structures, creating a regular subdivision of the space in square/rectangular entities of about 10–15 m × 10–15 m.

GPR investigations carried out mainly in the well-preserved southeast sector of the site have given information about the nature of the emerging archaeological features and revealed the presence of additional buried structures (Fig. S3, grids 1 and 2 and 2D profiles X_1–X_2 and Y_1–Y_2).

Several possible walls have been detected, and most of them match the results of the integrated LiDAR and aerial photograph analysis (Figs. S3–S5).

The 2D X_1–X_2 profile (Fig. S5) through the northwest rampart of structure 4 (Fig. 2*C*) shows several possible walls both to the north of the remains of the San Rocco church and exactly in correspondence to the rampart, which is made of stone blocks and soil. Within grid 1, the remains of stone wall 8 (Fig. 2*C*) start at about 60 cm below the topographic surface whereas, to the north, an accumulation of big stones has been identified a few meters from this structure (Fig. S4). It reaches the depth of about 1 m from the surface, where large and flat sandstone blocks are visible, and could be a strip of pavement or could derive from the collapse of a structure. Part of structure 7 (Fig. 2*C* and Fig. S4) has also been detected. Within grid 2, GPR data have imaged wall 5 (Fig. 2*C*), which is made of mixed stones and soil and has, to the east, a wide (up to more than 5 m) area of

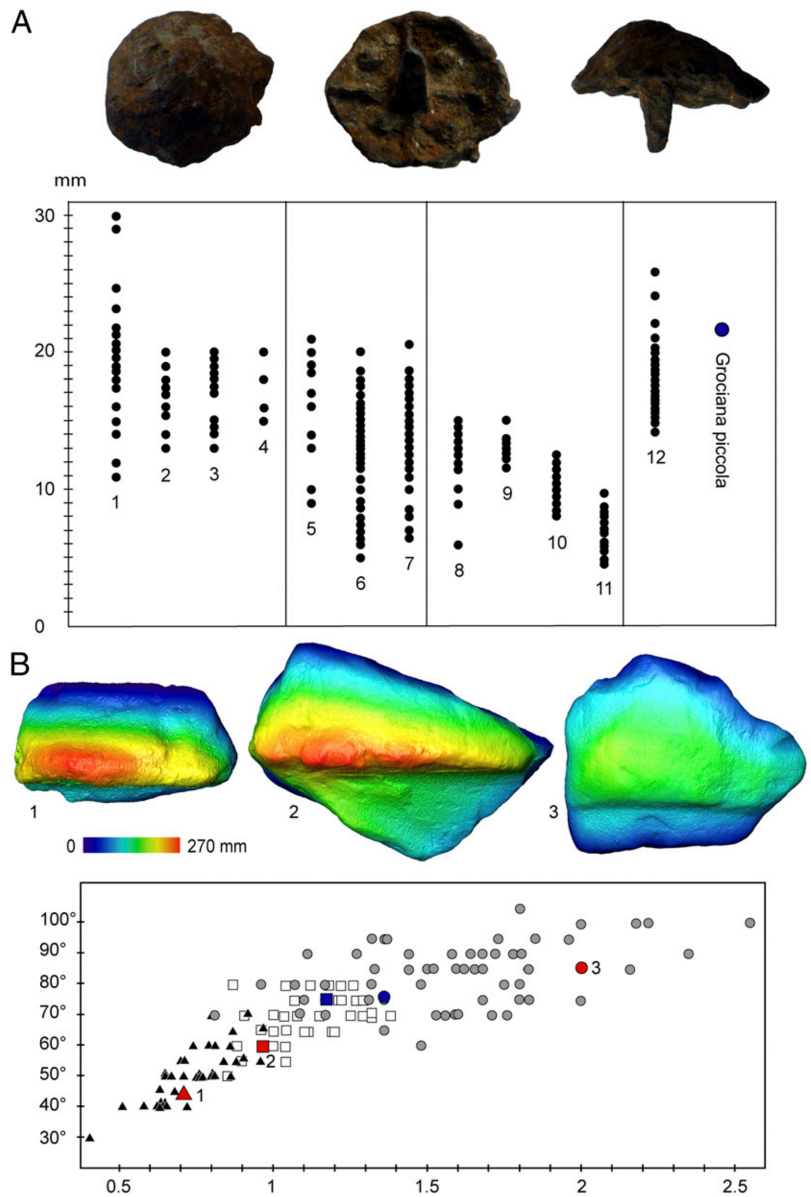

Fig. 4. Morphometric diagrams of selected artifacts. (*A*) Military footwear hobnail from Grociana piccola and its diameter in comparison with hobnails sizes from Caesarean–Augustan sites (modified from refs. 42 and 43). No. 1, Alesia; no. 2, Gergovia; no. 3, Uxellodunum; no. 4, Vernon; no. 5, Boviolles; no. 6, Corent (sanctuary); no. 7, Ribemont sur Ancre; no. 8, Dangstetten; no. 9, Rödgen; no. 10, Haltern; no. 11, Augsburg-Oberhausen; no. 12, Hermeskeil. (*B*) MicroCT-derived thickness maps of amphora rims from the San Rocco camp rendered by a false-color scale and amphora rims morphometric diagram [*x* axis, ratio between the height of the rim, measured from the top to the point of maximum width, and its maximum width; *y* axis, angle between the horizontal and the exterior sloping wall of the edge of the rim (modified from ref. 63)], including Greco–Italic (black triangles), archaic Lamboglia 2 (white squares), and Lamboglia 2 amphorae (gray circles) from Sermin (Slovenia). No. 1, late Greco–Italic amphora from San Rocco; no. 2, archaic Lamboglia 2 amphora from San Rocco; no. 3, Lamboglia 2 amphora from San Rocco. Blue symbols refer to the amphora rims from the Grociana piccola fort.

collapse (Figs. S4 and S5). In the southwest part of grid 2, in correspondence to terrace 6, two probable main structures have been detected. A rectilinear noncontinuous stone structure, labeled 6a, follows the southern limit of the Mt. San Rocco plateau. It could be a continuation of wall 7. The other structure, labeled 6b, is semicircular and contains, to the west, several shallow structures difficult to interpret due to the large collapses. The structures 6a and 6b could also be recognizable in the photoaerial documentation (Figs. 2*D* and 5*B*, area 6).

Archaeological findings. Amphorae and pottery fragments have been discovered mainly in the southeastern sector of the hill. They are useful to evaluate the chronology of the site.

A rim belonging to a late Greco–Italic amphora (Fig. 3 *A*, *4*) (53–57) has been discovered in a small field (Figs. 2*C*, site P1 and 2*D*, area 15). Its profile can be well-compared with type VIa (dating about 210–190 B.C.) or to type VIb (dating to the first decades of the second century B.C.) of the classification proposed by Cibecchini and Capelli (57), partially corresponding to MGS/RMR VI (55, 56) and Lyding Will 1c (53) types (Fig. 3 *A*, *4*). Macroscopic external observation and X-ray computed microtomography (microCT) of the sample have shown the presence of abundant very dense inclusions (Fig. S6 *A*, *1*) that have been later recognized as igneous silicate phases. Microscope observations and microprobe analyses have shown that their heavy mineral assemblages are different from

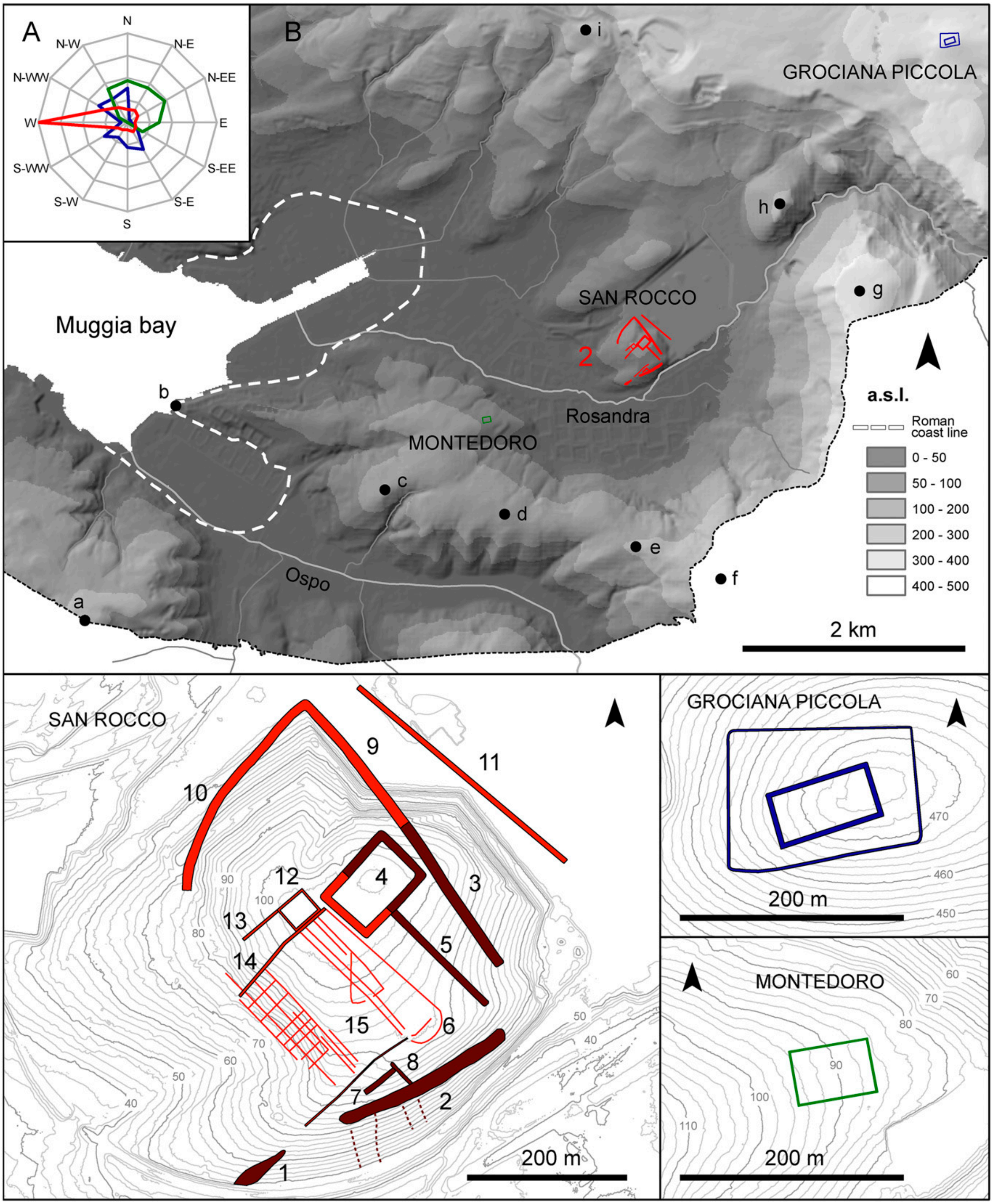

Fig. 5. (*A*) Diagram showing the directional visibility from the Roman fortifications within an 8-km radius. Blue, Grociana piccola; red, San Rocco; green, Montedoro. (*B*) LiDAR-derived digital terrain model with the location and plan of Grociana piccola, Montedoro, and San Rocco fortifications. Orange, features reconstructed from photo aerial documentation; red, surviving emerging features. The black circles indicate the main pre-Roman sites: a, Elleri; b, Stramare; c, Montedoro; d, Trmun; e, Prebenico; f, Socerb; g, Mt. Carso; h, San Michele; i, Cattinara.

those of local pottery productions, being characteristics of the Roman Magmatic Province, including both Latium and Campania, which are among the main original production centers of these transport vessels (57–60).

Late Greco–Italic amphorae are rather rare in the site of the Trieste gulf (61). Greco–Italic amphorae or later archaic Lamboglia 2 have been reported from Terzo Ramo del Timavo and Villaggio del Pescatore/Casa Pahor sites (19); a single rim of a possible late Greco–Italic amphora has been discovered in the indigenous Cattinara hill fort (62) near the Roman fortifications presented in this paper. On the other hand, abundant remains of late Greco–Italic amphorae have been found in Sermin, a site located along the Istrian coast north of Koper in Slovenia (63). However, most of the Sermin late Greco–Italic amphorae (64, 65) and probably all of the few dubious other specimens from the Trieste province (according to the macroscopic fabric descriptions) are made from clay that was formed from carbonate marl rocks, indicating an Adriatic production. Only one rim and a few fragments from Sermin (63) are macroscopically similar to the San Rocco sample, showing an orange color, rough fabric, and mainly shiny black inclusions probably corresponding to volcanic minerals.

From a typological viewpoint, the late Greco–Italic amphora rim from San Rocco fits well the morphological features of the oldest amphorae from Sermin (Fig. 4*B*), which have been dated between the end of the third century B.C. and the first three quarters of the second century B.C. (63).

In addition to the late Greco–Italic rim, six fragments of vessel walls with a similar fabric, although richer in black sand, have been found close to positions P1 and P2 of Fig. 2*C*. They could be fragments of Greco–Italic amphorae, as suggested by their considerable thickness, ranging from 100 to 150 mm, as well as remains of central Italian kitchenware. This high-quality pottery production, particularly suitable for cooking, given its resistance to high temperature, was spread across the Mediterranean mainly during the second and first centuries B.C., after the Roman expansionism and emigration of the Italic population (66). Close to the San Rocco site, central Italian kitchenware has been reported from the Mandrga and Preval sites in the strategic Razdrto pass area, dated between the end of the second century B.C. and the beginning of the first century B.C. (22), as well as in Aquileia (67).

An amphora rim, attributable to the archaic Lamboglia 2 type (Fig. 3 *A*, *5*) and very similar to one of those recovered from the Mt. Grociana piccola inner structure (Fig. 3 *A*, *1*), has been discovered close to the late Greco–Italic one (Fig. 2*C*, site P1). It is typologically comparable with Lamboglia 2 amphorae, with a triangular section from Sermin (63), probably datable between the end of the second century B.C. and the beginning of the first century B.C. (Fig. 4*B*). Such amphora types are reported from relatively numerous sites of northern Adriatic regions (12, 22, 61). A last amphora rim, coming from position P2 (Fig. 2*C*), belongs to a late banded Lamboglia 2 type (Fig. 3 *A*, *6*) and can be therefore dated within the first century B.C. Lamboglia 2 types, in fact, were produced along the Adriatic coast until approximately the third decade B.C. (22).

A fragmented amphora lid made on a potter's wheel, found near the other amphorae remains (Fig. 2*C*, site P3), shows an upper bottom with finger impressions, a deep concave underside, and turned-up edges (Fig. 3 *A*, *7*). It is well comparable with type PA 2 from Sermin (63), a shape reported from many sites of northern Italy (67, 68) and also from the Mandrga and Preval sites near Razdrto Pass in Slovenia (22). It was used to close both late Greco–Italic and Lamboglia 2 amphorae types (22, 63, 68). In the same area where the late Greco–Italic and archaic Lamboglia 2 rims have been discovered, a handle, likely belonging to the Lamboglia 2 type, also has been found (Fig. 3 *A*, *9*). A base of a probable Lamboglia 2 amphora (Fig. 3 *A*, *8*) has been discovered in correspondence to position P5 of Fig. 2*C*.

Finally, a very small fragment of a black slip pottery vessel, belonging to an open shape (Fig. 3*B*), has been collected from area P4 of Fig. 2*C*. Unfortunately, its bad state of preservation hinders a precise typological and chronological attribution within the Republican period.

Montedoro. A 54 × 74-m rectangular structure with a southwest–northeast orientation has been identified on the northern side of the Montedoro ridge (Fig. 2*B*). The structure orientation is very similar to that of the inner rectangular fortification of Mt. Grociana piccola although their building techniques are different. Montedoro fort is formed by a ditch and a contiguous internal rampart according to the Roman building technique often used for military camps (Fig. 2*B* and Fig. S1, graphs c-c_1 and d-d_1). Unfortunately, LiDAR data of the area acquired in 2006 and 2009 show the partial destruction of the site, whose northeastern part has been leveled. The entire preserved sector of the site is covered by grassland, which makes it very difficult to identify surface findings. Nevertheless, the rectangular shape of the structure testifies it was built after the prehistoric period.

Viewshed Analysis and Directional Visibility. Single viewsheds results show intervisibility between the three fortifications. In addition, the analysis of directional visibility within a circular area with an 8-km radius shows that all of them overlook only a limited percentage of territory. In fact, the nonvisible area corresponds to 80.3% for Grociana piccola, 86.9% for San Rocco, and 90.8% for Montedoro. Nevertheless, the sites are visually interconnected, thus strongly suggesting that their position in front of northern Istria was accurately chosen. Grociana piccola mainly overlooks part of the Karst plateau north and south of the site, the southern sector of Muggia Bay up to the Stramare landing place and the Socerb plateau; the main San Rocco camp controls the Muggia bay; and the small Montedoro fort dominates Muggia Bay and, in particular, the valley of the Rosandra River at the foot of San Rocco hill (Fig. 5*A* and Fig. S7).

Discussion

According to the imported late Greco–Italic amphorae remains (53–57), the first Roman settlement of the San Rocco site can be dated between the end of the third century B.C. and the first decades of the second century B.C. It was probably in use, perhaps not continuously, until the mid to late first century B.C., as suggested by archaic and late Lamboglia 2 amphora types.

When comparing the general shape of the San Rocco site and the building technique of its external ramparts with Spanish military camps dated to the mid to late second century B.C. (3–5), common features can be recognized. Both Spanish camps and San Rocco do not show a regular plan, they lack any ditch, and their defensive structures are built directly on the ground surface without foundations and show a relatively low height. However, the emerging remains of the external ramparts of San Rocco have an exceptional width, between 20 and 25 m. They derive from the gradual collapse of the defensive walls, probably made of turf, soil, and stones, which could be reinforced by wooden elements (69).

Only archaeological excavations could give precise information about the building technique of the ramparts, but it is possible that the stones detected by GPR investigations were used to build the outer faces of the wall, with the intervening space filled with small stones and soil, using a technique very similar to that recognized in the Spanish military camps (5).

At Grociana piccola, the few Lamboglia 2 amphora findings from the inner fortification are comparable with those found in San Rocco. In addition, the hobnail of type D from Alesia confirms the military function played by the site also during the mid first century B.C. Although no archaeological artifacts have been discovered so far in the Montedoro fort, the spatial interdependence of the three sites shown by visibility studies and the similar orientation of the Montedoro site, the San Rocco structures, and the Grociana piccola inner fortification supports the hypothesis that at least parts of them were simultaneously built during the first half of the second century B.C. On the other hand, the external fortification of Grociana piccola, showing a trapezoidal shape with a playing-card layout oriented north to south, could belong to a later building phase. This hypothesis is supported by some similarities with the close Roman stronghold at Nadleški hrib in western Slovenia, where some hobnails of the same type have been recently discovered. This site is dated to the middle or second half of the first century B.C. (70).

Although the archaeological materials found so far in the Trieste sites, exclusively through surface investigations, are not abundant, they give reliable chronological information. The historical context, the relative and absolute position of the sites, their plan and the building techniques, their similarity with coeval Roman camps, and the presence of a military footwear hobnail leave little doubt of the military origin of the Trieste fortifications. Future archaeological excavations and magnetic surveys may be able to more precisely define the first settlement phase of the sites and their development through time, perhaps revealing a nonmilitary reutilization of the main San Rocco camp.

The origin of the fortifications is most likely related to the first year of the second Roman war against the Histri in 178 B.C., which, according to literary sources, is the only significant military episode of the first half of the second century B.C., having taken place in the area approximately corresponding to today's province of Trieste (24). According to Livy (XLI, 1, 1–6), the Roman fleet moved to the first landing place at the border of the Istrian territory whereas the two consular legions camped at slightly less than five Roman miles from it. Toward Istria, between the camp and the sea, a military unit was stationed also to protect the soldiers involved in water supply. Moreover, about 3,000 Celtic allies camped at about one Roman mile from the main camp, along the way to Aquileia. The landing place described by Livy could be identified in Muggia Bay (12, 34, 35). Grociana piccola stands at about five Roman miles from the shore of Muggia Bay, but its size is not consistent with a double legionary camp. On the contrary, the San Rocco site fits well the dimension of a large fortification, and its inner regular space subdivision recalls the plan of military barracks (Fig. 5) (1, 8, 9). If the San Rocco hill is identified with the main camp reported by Livy (XLI, 1, 1–6), the location of the Montedoro site, overlooking the access to the Rosandra River at the foot of the San Rocco hill, could correspond well to the position of the small military unit described by Livy (XLI, 1, 1) as stationed toward Istria, between the main camp and the sea.

The first chronological phase proposed for San Rocco and, more cautiously, for Grociana piccola and Montedoro predates by some decades the military camps of the Pedrosillo and Numantia areas (3–5).

Considering that, after the second Roman Istrian war, the northern Adriatic regions were an unstable border area for more than 100 y, it is not surprising that the fortifications of Trieste area were in use, perhaps not continuously, at least until the mid first century B.C. The San Rocco camp is certainly the most significant archaeological site in the Trieste area in this historic phase. It includes an area wider than 13 ha, which was defended by wide ramparts and strategically located very close to the most protected natural harbor of the northern Adriatic (Fig. 5). Secure archaeological evidence earlier than the first century B.C. has never been discovered in the historical center of Trieste, which corresponds to the site of the colony of Tergeste (26, 71). Also, for this reason, some scholars have hypothesized that the colony was founded in a previously uninhabited location whereas the original site of the first Tergeste would have been located somewhere else, probably in the area in front of Muggia Bay (26). The San Rocco site, built in this area probably in connection with the second Istrian war, is the most probable place where, in 176 B.C., a garrison of Latin allies was stationed by the Romans to control the indigenous population and prevent possible attacks against Aquileia (Livy, XLI, 14, 6). Considering its strategic position, exceptional size, inner regular planning, and imposing fortifications, it is very unlikely that it coexisted with another site of similar importance. Therefore, the San Rocco hill is the most likely candidate for the site of the first Tergeste in accordance with literary sources, which designate it as *phrourion* (Strabo, V, 1, 9, C 215), a term used by ancient writers to designate the fortifications of the Roman Army (13).

Materials and Methods

LiDAR Data Acquisition and Elaboration. The LiDAR data covering Friuli Venezia Giulia were acquired by the Helica Company for the Civil Protection of Friuli Venezia Giulia in 2009, using a airborne laser terrain mapper (ALTM) Optech 3100 mounted onto an AS350 helicopter. This system allows the acquisition of data from a maximum height of 3,000 m above ground level with a frequency of 33.000 kHz and a density of 4–5 laser shots per square meter. The resulting point-cloud data in LAS format were classified in nonground (class 1) and ground points (class 2) through a filtering procedure. The ground data covering the entire study area were processed using free open-source software (SAGA, GRASS, and QGIS). The LAS files were imported into Saga GIS as point clouds, from which the points belonging to the ground (class 2) were extracted. To merge different grids, a new grid system, covering the entire study area, was created, and the cell set at 50 cm. Then, the data were rasterized and interpolated through the module available in SAGA software "grid tools, close gaps." This operation produces a continuous raster, which is called the digital terrain model (DTM). The DTMs created were then processed through the alternative use of the open-source software mentioned above to maximize the quality of resulting maps. These images mainly consist of multiple shaded reliefs at different light conditions, slope, and contour maps. Then, all of the raster maps deriving from the DTMs previously created were digitized and integrated into a single geographic information system (GIS) platform created in QGIS.

Viewshed Analysis and Directional Visibility. GIS-based visibility analysis was carried out by calculating multiple viewsheds with the module *r.viewshed* in Grass GIS from the highest locations of each fortified site, adding 3 m height for the observer and 2 m for the target. Each viewshed was performed within an 8-km radius to cover the distance between the coast and the Grociana piccola fort, by considering a DEM additional buffer zone of 8 km to limit the so-called "edge effect" (72, 73). For this purpose, the NASA Aster GDEM2m (1 arc-second grid resolution and an ~20- to 30-m accuracy) was used to cover the entire area considered. Additional viewsheds were calculated by using the LiDAR-derived grids to compare results produced by different grids. To represent the theoretical visible area from each site according to different directions, directional visibility was then calculated by dividing the whole visible area into 30-degree sectors according to 12 different directions, following the method proposed by Wheatley and Gillings (74).

Historical Aerial Photography. Historical aerial photographs of the study area, taken by the Italian Military Geographical Institute in 1957, were used to check the visibility of the emerging archaeological structure and their possible continuation in a destroyed sector of the San Rocco hill (aerial photograph IV, 2019). The aerial pictures were georeferenced to precisely overlap them with the LiDAR-derived images.

GPR Data Acquisition and Processing. The GPR is a high-resolution geophysical technique based on the propagation of electromagnetic (EM) waves within a frequency range usually between 1 MHz and 3 GHz. This method uses the reflections of an EM pulse, which are in turn related to variations in the dielectric properties of the investigated materials. GPR is increasingly used to image shallow subsurfaces because it allows obtaining precise, high-resolution information. The GPR data, after appropriate processing, which usually includes several algorithms, can be adopted for both 2D and 3D subsurface imaging. Application of such technique for archaeological prospecting ranges from preliminary detection of subsurface structures to detailed mapping of archaeological levels and high-resolution characterization of buried remains in several different environments.

GPR data were acquired on November 26 and 27, 2013 with a ProEx Malå Geoscience GPR, equipped with 250-MHz shielded antennas, having a constant 0.7-m offset. Such antennas gave the best tradeoff between resolution and penetration depth in the investigated site. A differential global positioning system (DGPS) device was used for measurement (trace) positioning whereas the GPR triggering was done by an odometer connected to the antennas; the mean trace interval was 0.1 m. Fifty-six GPR profiles were acquired (22 within grid-1 and 34 within grid-2), with a nominal spacing of 1 m and a trace interval of 0.1 m. The total profile length was more than 3,250 m, with the length of each profile being different due to logistic constraints (bushes, trees). The entire dataset was processed using ProMAX software (Landmark), originally developed for reflection seismic, and Prism modules, with a processing flow that included the following: DC removal, drift removal (zero time correction), geometrical-spreading correction, exponential-amplitude correction, bandpass filtering, and 2D migration (Kirchhoff). All of the available data were combined into a single pseudo 3D dataset by using the OpendTect software, giving to each trace its actual spatial location. To better highlight, correlate, and characterize the subsurface structures, we calculated GPR attributes. The concept of GPR attributes stems from seismic-attribute analysis, a research topic originated in the early 1970s for hydrocarbon exploration. Actually, seismic-attribute analysis is routinely adopted, especially in the oil and gas industry (75). Similarities between the kinematic properties of seismic and GPR data have been well-demonstrated, and the main difference regards the scale of applicability and the physical parameters, such as velocity, frequency, and perturbing field. This formal equivalence suggests that processing and interpretation techniques developed for seismic data may be applied to GPR data, usually with minor adjustments. In the last years the application of attribute analysis for different GPR data interpretation has increased, with a continuous implementation of new or optimized algorithms (76–78). Examples of applications related to archaeology have also been reported (79–82).

X-Ray Computed Microtomography. Most of the archaeological pottery materials discovered during the archaeological surveys in the considered sites were analyzed by X-ray computed microtomography (microCT) to produce 3D models and virtual sections, useful for the typological attribution, and a preliminary microtextural characterization (Fig. S6). The analyses were carried out at the Multidisciplinary Laboratory (MLAB) of the Abdus Salam International Centre of Theoretical Physics (ICTP), where a cone beam microCT system has been specifically built to study paleontological and archaeological material (83). It is based on a microfocus X-ray source (minimum focal spot size 5 mm, voltage up to 150 kV) and a large area flat-panel sensor. Exploiting the cone-beam geometry, a complete reconstruction of several artifacts with variable isotropic voxel sizes was obtained. The microCT scans were carried out with a source voltage of 145 kV and a current of 200 μA, recording 2,400 projections of the sample over 360°.

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Supporting Information

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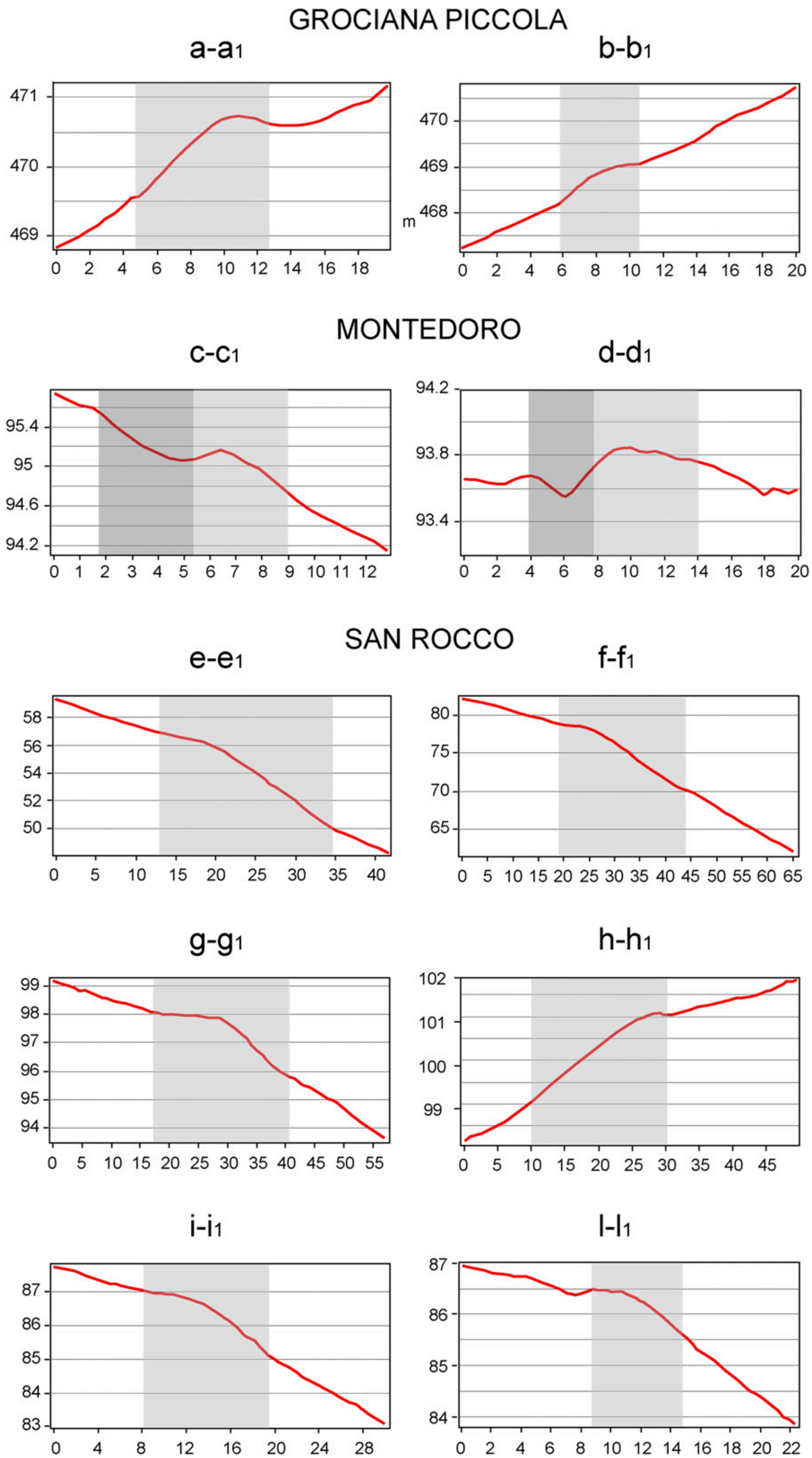

Fig. S1. LiDAR-derived orthogonal topographic profiles of the emerging structures of Grociana Piccola, Montedoro, and San Rocco. For the position of the profiles (from a-a_1 to l-l_1) see Fig. 2 *A–C*; the *y* axis shows the altitude above sea level in meters whereas the *x* axis shows the distance in meters. The light gray areas show the extension of the ramparts remains, and the dark gray ones show the extension of the Montedoro ditch.

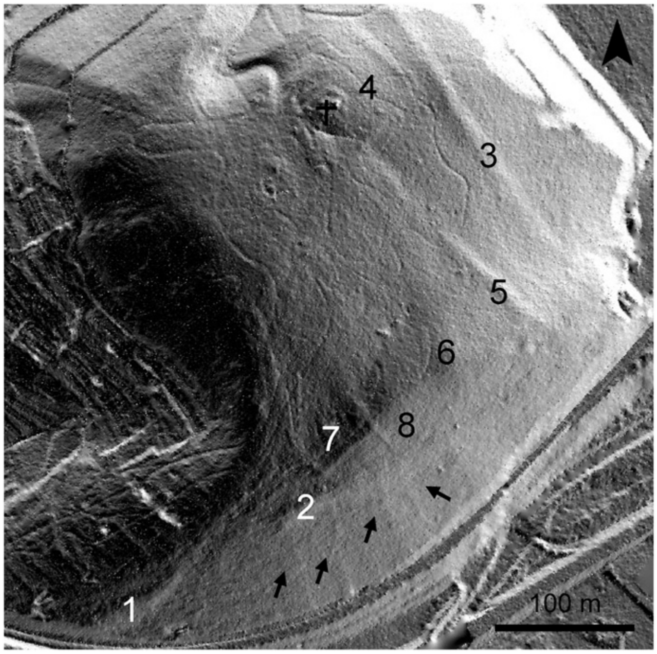

Fig. S2. A 2D hillshade of the LiDAR DEM of the San Rocco hill (azimuth, 225; declination, 45°), showing the emerging structures already identified in Fig. 2*C* (from site 1 to site 8) and, by the black arrows, the position of hardly identifiable parallel features in the southern sector of the site. Black cross, position of the ruins of the San Rocco church.

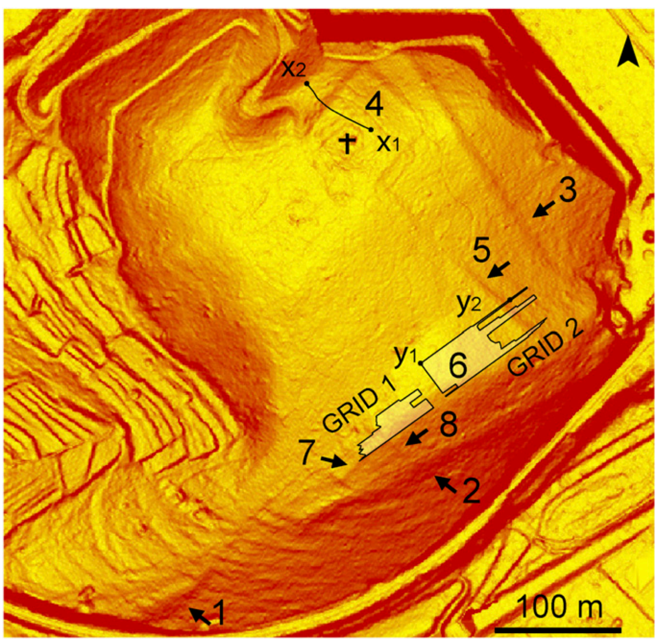

Fig. S3. LiDAR-derived slope map of Mt. San Rocco showing the identified structures of Fig. 2*C* (sites 1–8) and the location of the GPR survey (grid 1, grid 2, profiles X_1-X_2 and Y_1-Y_2).

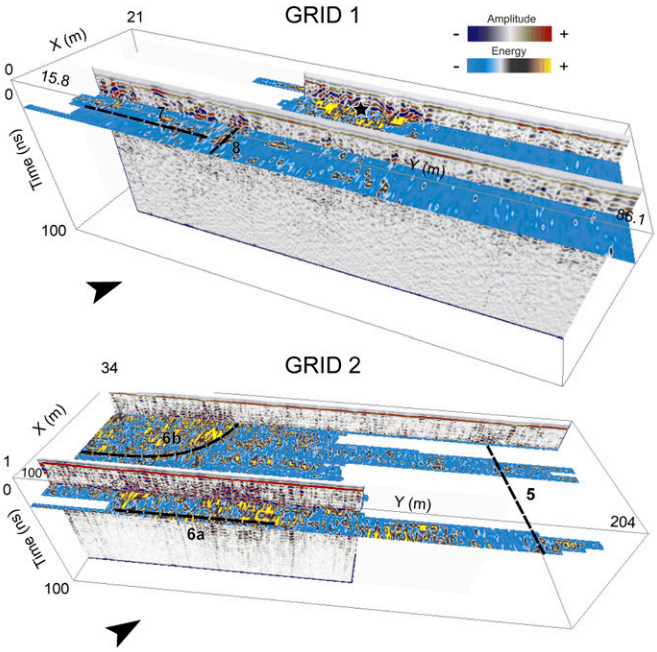

Fig. S4. The 3D volumes of grid 1 and grid 2. In the vertical sections, reflection amplitude is shown whereas, in the time slices (horizontal planes), the energy attribute is plotted. Bold numbers refer to the structure classification of Fig. 2C. In correspondence to terrace 6 of Fig. 2C, at least the remains of two structures, labeled 6a and 6b, are recognized. The black star identifies an accumulation of big stones not detected by LiDAR.

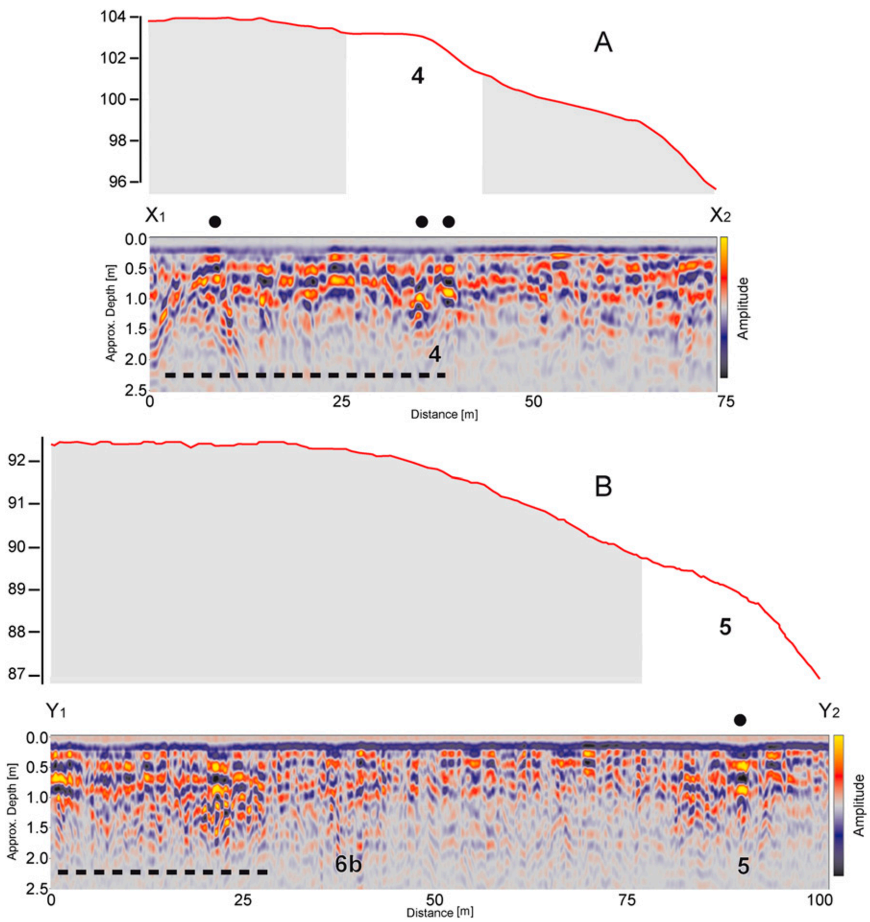

Fig. S5. LiDAR-derived topographic profiles and GPR 2D profiles X_1-X_2 (*A*) and Y_1-Y_2 (*B*) acquired on the top and southeast sector (grid 2) of Mt. San Rocco, respectively (for the location, see Fig. S3). Black dots mark possible walls; dotted lines show the areas where archeological structures are more apparent; bold numbers highlight the position of archaeological structures shown in Figs. S3 and S4.

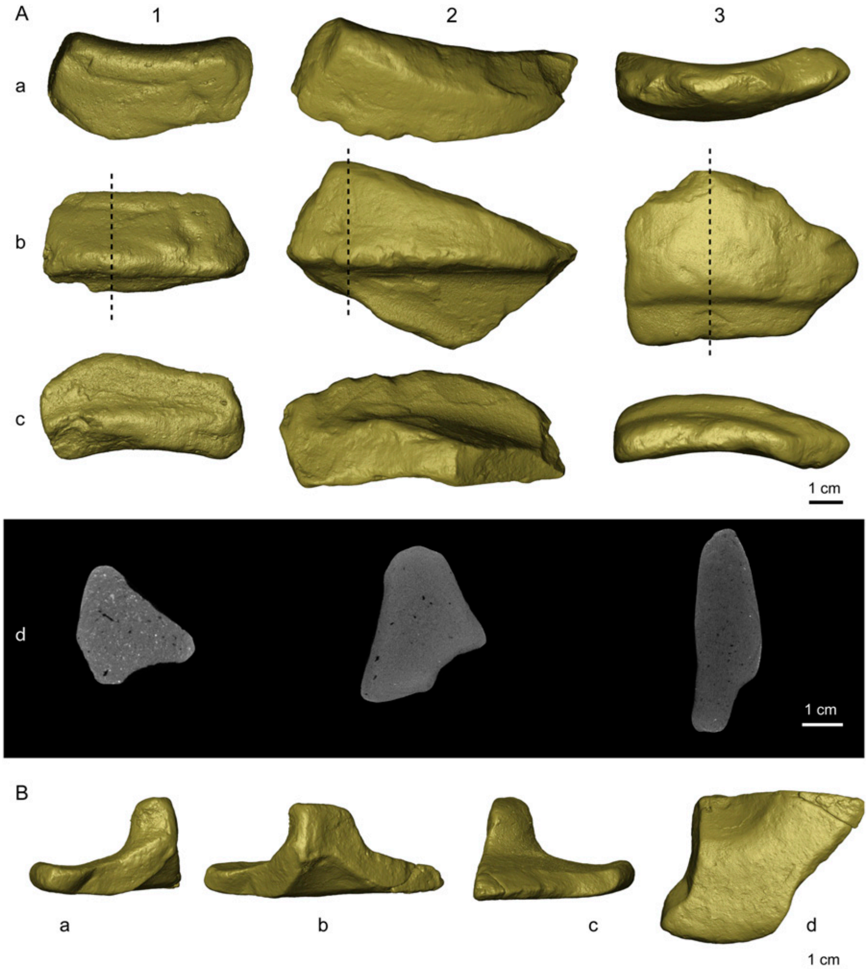

Fig. S6. (*A*) X-ray microCT-based virtual renderings and sections of the amphora rims from the San Rocco camp. Shown are (*1*) a late Greco–Italic amphora, (*2*) an archaic Lamboglia 2 amphora, (*3*) a banded Lamboglia 2 amphora. Shown are (*a*) upper view, (*b*) frontal view with the position of the transversal section, (*c*) lower view, and (*d*) transversal sections. (*B*) X-ray microCT-based virtual renderings of the amphora lid from San Rocco.

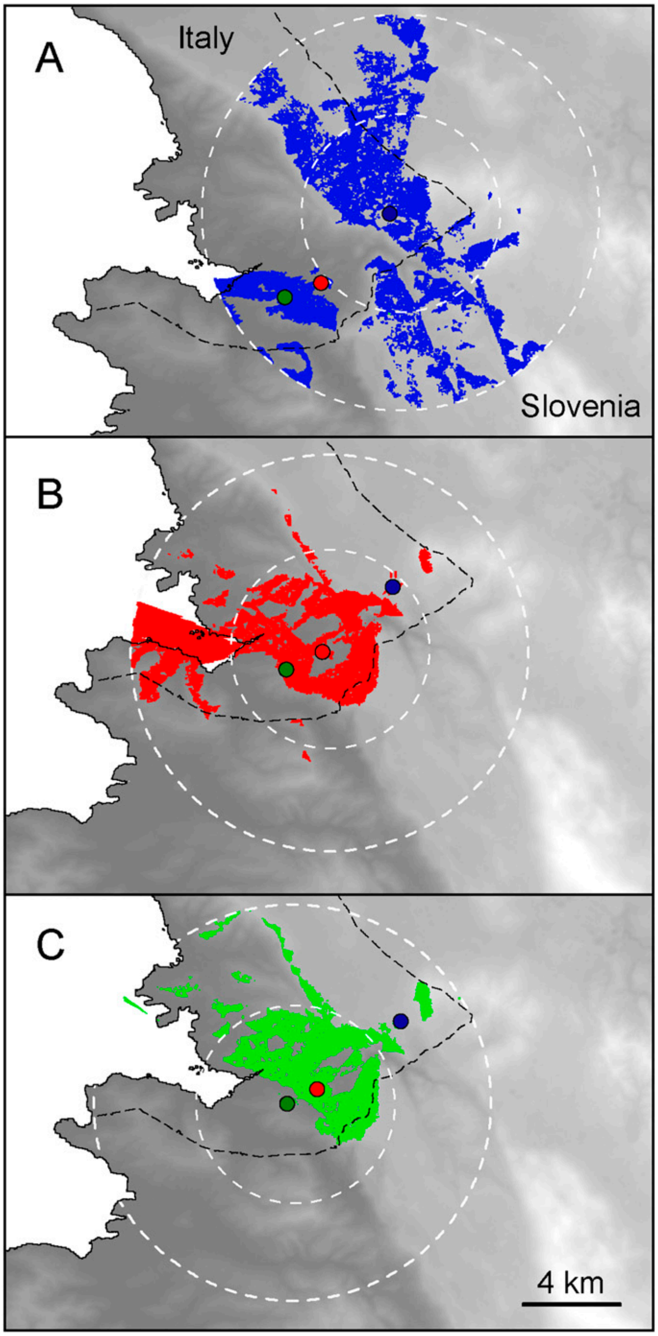

Fig. S7. Visible areas from Grociana piccola (*A*), San Rocco (*B*), and Montedoro (*C*) fortifications within a radius of 4 and 8 km (white dotted circles). Blue dot, location of Grociana piccola; red dot, location of San Rocco; green dot, location of Montedoro.