

A metrological approach to the study of ancient architecture. The cases of the Grotta dell'Arsenale and the villas of Gradola and Damecuta in Capri

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Abstract – The project “Masgaba. An Archaeological Map for the Island of Capri” aims to create the first archaeological GIS of the island of Capri. The main objective is to gain a deeper understanding of the archaeological assets of the island, including their original functions and dimensions, to facilitate their preservation, enhancement, and contribute to territorial planning. The project involves mapping and studying the known sites, conducting field surveys, and utilizing advanced techniques like photogrammetry and laser scanning. This type of survey allows for the application of a metrological approach with a certain level of confidence, which has yielded unexpected results in the Grotta dell'Arsenale and the Gradola and Damecuta villas, especially in terms of planimetry and constructional aspects.

Keywords – Capri Island, Roman architecture, nymphaeum, Roman villa, Roman theatre, Vitruvius.

I. INTRODUCTION

The project “Masgaba. An Archaeological Map for the Island of Capri”, formalized in 2020, is the result of a collaboration between the Soprintendenza Archeologia Belle Arti e Paesaggio for the Metropolitan Area of Naples, the municipalities of Capri and Anacapri, the Institute for Heritage Science of the National Research Council (CNR-ISPC), and the Apragopolis Cultural Association.

The main objective is to acquire knowledge about the actual extent of the archaeological assets on the island, locating their remains and delving into their original functions and dimensions. Creating an archaeological map of the island represents the most suitable tool to address various needs. It will facilitate actions aimed at the protection and enhancement of the cultural heritage, as well as provide a proper understanding of the territorial evolution. This understanding is a fundamental prerequisite for reconstructing the historical events of the area and guiding territorial planning.

The project aims to experiment with innovative methods of monument representation and produce new scientific content, along with detailed graphic documentation to be

incorporated into a dedicated Geographic Information System (GIS). This will be the first modern archaeological map of the island, as well as the first systematic study at the territorial level. In fact, for a long time, the focus had been limited to a few famous monuments. Only in the late 1990s, a study collected information and historical sources on the discoveries of Capri's archaeological assets [1]. Although it serves as an important starting point and reference for future bibliographic or topographic research, the published map is essentially a georeferenced bibliographic repertoire. The known assets, symbolically identified as points, still require further field investigation to verify their actual existence, precise locations, and extent.

However, examining the distribution and quantity of the known assets immediately reveals how extensively the island was built in ancient times. It featured docks and moorings, numerous villas with residential and productive spaces, water systems consisting of cisterns and wells, monumental nymphaea, and much more. All of this confirms Capri's importance in Roman history and its significant role during the Augustan and primarily Tiberian periods. For a certain period, the island was inhabited by the emperor and the entire court, effectively serving as an imperial palace in every respect [2].

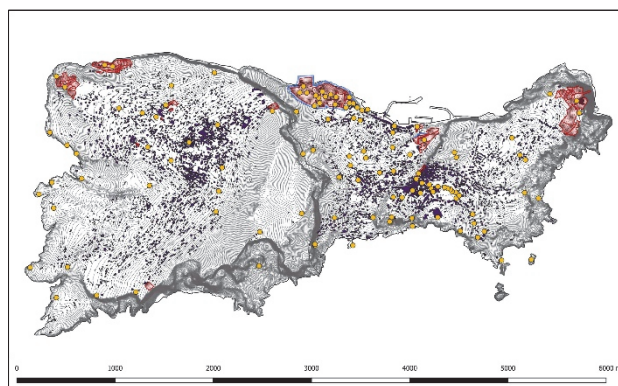


Fig. 1. Capri island, general map with indication of the known archaeological findings (in yellow) and the areas subject to archaeological and landscape bonds (respectively in red and blue).

II. THE PROJECT

Over time, the island has been extensively plundered by antiquity enthusiasts, and modern constructions have often contributed to the destruction of traces of its glorious past. These remnants occupy the few legally protected areas with archaeological and landscape bonds, which account for approximately 3% of the entire island territory. This information was discovered during the project, when cartographic positioning was carried out for areas subject to archaeological restrictions (Fig. 1). All documents and administrative acts containing attached maps or indicating the cadastral numbers of the affected lands and properties were examined. In fact, neither Capri nor the national level has ever produced a unified cartography highlighting all the restricted areas through specific patterns.

The project involves acquiring all existing archaeological documentation, mainly from the Roman era [3]. To accomplish this, a series of sequential activities has been initiated: surveying the known sites through bibliographic and archival research; a review of previous archaeological and historical cartography; construction of a GIS and the subsequent inclusion of basic cartography; creating point and polygonal geometries that respectively define known archaeological findings, protected areas, and surveyed archaeological sites; archaeological reconnaissance aimed at verifying the real consistency of known archaeological assets and discovering new evidence; surface archaeological surveys aimed at documenting, positioning, and studying the findings present on the island.

Regarding the latter, these surveys are carried out using different integrated methodologies and detection techniques, mainly three-dimensional photogrammetry, and laser scanning. They focus on sites or structures lacking recent archaeological graphic documentation, while for others, the metric accuracy of existing surveys will be verified, georeferenced, and included in the overall project. In fact, there are no drawings or plans for most archaeological sites, and even when they exist, they often turn out to be completely incorrect. This is clear in the case of the Arsenale cave and the Gradola villa, recently surveyed by CNR-ISPC, along with the Matermania cave, the Damecuta villa, and the Baths of Tiberius (the villa known as "Palazzo a Mare"). The first two monuments required a revision of the graphic documentation and further exploration in the field of historical-architectural interpretation, as well as extensive extraordinary cleaning work.

Subsequently, an autopsy examination of the walls and coverings was conducted, identifying the stratigraphic units of the walls, their relationships, and the actual surveying. Starting from the assumption that surveying a monument means knowing it, studying it, and analyzing it thoroughly, a "precise to the millimeter" survey allows for the application of a metrological approach with some certainty. This approach has yielded unexpected results in

three sites on the island: the Arsenale Grotto and the Gradola and Damecuta villas. Significant planimetric and constructional novelties have emerged in these sites that were impossible to comprehend from previous documentation.

III. THE GROTTA DELL'ARSENALE

The Grotta dell'Arsenale is a natural cavity of limestone origin, partially modified and constructed during Roman times, along the southeastern slope of the island, between Punta Tragara and Marina Piccola. It falls within the category of caves generically referred to as "*operosa antra*" with purposes of recreation, residence, or areas dedicated to banquets. Being located along a coast characterized by steep rocky walls descending into the sea, it was difficult for the cave to be directly connected to any of the villas on the island of Capri. Instead of being accessible by land, it could only be reached by sea, as is still the case today. However, the historical and topographical context in which it is situated shows that the site occupied a strategic position, with continuous passage due to its location between two piers.

Although the cave has been inspected by scholars over the past decades, it has never been thoroughly studied, surveyed, or described in sources. Instead, it was plundered of its rich decorative coverings, of which only imprints on the rock remain today.

An archaeological report was published by Maiuri during the excavation he directed in 1930 [4]. Instead, the first graphic representation was published only in 1955 when Mingazzini decided to have a plan and perspective section of the western side prepared to accompany his archaeological description of the monument, which he examined during the 1930 excavation [5]. Subsequent researchers who mentioned the cave simply relied on his observations and sometimes published his plan, possibly due to the difficulties associated with accessing the cave itself.

A comparison between the plan published by Mingazzini and the new plan produced as part of the archaeological map project reveals numerous discrepancies [6]. In addition to the evident inaccuracy of the small cave adjacent to the right, the arrangement of the rooms is incorrect with respect to the cardinal points. Even the correlation between the rooms and the access ramp is incorrect. Furthermore, important details about the archaeology structures are missing. All of this has contributed over time to confusing the actual function of the cave, the interior rooms, and the architectural elements present on the vault.

From the analysis of the new planimetry, some noteworthy geometric features have been highlighted, which also allow for hypotheses about the original appearance and purpose of the site. It has emerged that the room at the front is aligned with the access ramp and therefore belongs to the site's initial construction phase,

emphasizing its particularly significant role due to its centrality. Furthermore, a precise compositional scheme is recognized, with a second room positioned radially behind the circular masonry structure, symbolically uniting all the spaces. The southeastern room stands out, with its center precisely 120 degrees from the room at the front. It is still unclear whether there was another corresponding space to it. However, the third room, constructed in a later phase using *opus latericium*, falls outside of this scheme (Fig. 2).

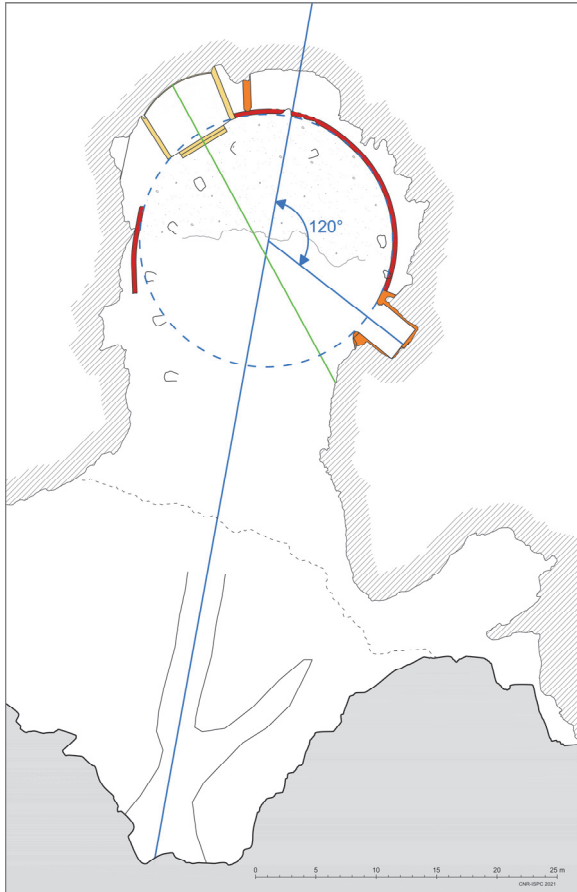


Fig. 2. New planimetry of the Arsenal Grotto in Capri, indicating the archaeological structures (red is *opus incertum*, orange is *opus reticulatum*, yellow is *opus latericium*) and the compositional scheme.

Its direct predecessor is the Tiberius cave in Sperlonga, with which it shares dimensions, access methods, and a planimetry scheme. However, unlike the Tiberius cave, there are no traces of hydraulic systems in the Arsenale cave that would suggest the presence of water elements inside the cavern. The aquatic element in this case appears to be more of a scenic inclusion, as it could be observed from inside the cave, which opens towards the sea.

A very rare feature found in the Capri cave is the presence of nine recesses distributed along the perimeter of the circular space, at the height of the natural vault's springing line. Various hypotheses have been proposed

over time regarding their function, such as housing for beams, or cavities for coffers or decorative niches. However, the recent survey has refuted these hypotheses and highlighted their inclination towards the floor level and the irregularity of their distribution and shape. Instead, a possible function related to the artificial lighting of the interior space is suggested, considering their downward inclination of about 20-30 degrees from the vault's plane, and the directions of each recess that seem to aim at diffusely distributing light within the circular space.

Unfortunately, it seems difficult to find comparisons with possible lighting setups in ancient caves, mainly due to the poor preservation of the vaults. However, it is remarkable to recall a recess of quadrangular shape in the Sperlonga cave, possibly related to the lighting system composed of marble theatrical masks, from which light emitted from the hidden oil lamps would emerge through the mouths and eyes [8]. The cave, although it has received various interpretations over the decades, can be considered, based on its planimetry and construction type, as one of those natural spaces that the Romans knew how to exploit as a place of freshness and rest, while also enjoying a panoramic view of the sea.

C. G.

IV. THE VILLA OF GRADOLA

Arranged along the northwestern slope of the island, the remains of Villa Gradola occupy an area located directly above the famous Blue Grotto (Fig. 3).

Their first mention dates to 1830 [9], but they were initially interpreted as road substructures. It was not until the summer of 1883 that American Colonel John Clay Mac Kowen initiated a series of excavations and was the first to recognize the ruins of an imperial palace [10]. In the 1930s, Paolo Mingazzini confirmed the colonel's insights, suggesting it was a Roman villa with at least three levels, constructed with *opus incertum* and *opus reticulatum* [11]. A few years later, Amedeo Maiuri, who also deserves credit for initiating the first preservation efforts in 1951, developed a new historical and topographical framework for this area of the island, linking Gradola and the underlying Blue Grotto to the orbit of the Villa of Damecuta, certainly imperial in terms of its location, size, and complexity. Thus, the grotto would have served as a maritime nymphaeum associated with the Villa of Damecuta, while the "small villa" of Gradola would have been built to support imperial visits to the nymphaeum [12].

In the summer of 1964, the exceptional discovery of two marble statues on the sandy bottom of the Blue Grotto, representing Tritons, seemed to confirm Maiuri's hypothesis, and plans for future excavations in the area of Villa Gradola were announced. However, a new season of research and excavations only began in the 1980s, when illegal construction posed a significant threat to the island's rich archaeological heritage. In 1998, Gradola's area finally became the focus of a planned excavation,

investigating the easternmost part of the villa (now completely overgrown), revealing a series of previously unseen structures, possibly related to a long walkway (*ambulatio*) open towards the sea, a type known in other Capri villas (Villa of Palazzo a Mare, Villa Jovis, and Villa of Damecuta) [13].

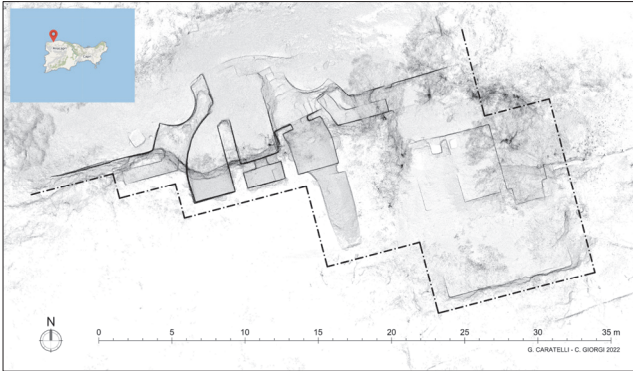


Fig. 3. Capri, Villa of Gradola, plan.

As we have already noted elsewhere [14] and reiterate here, the new surveying activities carried out by CNR-ISPC have significantly advanced our understanding of the Roman villa at Gradola. Indeed, the laser scanner survey of the visible remains has highlighted the limitations and errors in the old graphic documentation.

For example, compare, in the figure published by Ciardiello [13, p. 35], the misalignment of the two supporting walls with an intervening gap, the lack of alignment between the back walls of the supporting rooms in the forepart, or the semicircular niches of varying sizes. Furthermore, the analysis of the survey has suggested the idea of a substruction system (*basis villae*) based on traditional criteria of axiality, symmetry, and modularity (Fig. 4).

Indeed, all the structural elements can reasonably be fit within a modular grid, based on a minimum interval of 3 Roman feet, exactly coinciding with the thickness of the *opera incerta* walls of the forepart or with the width of the two cavities inside it. The geometric construction of the forepart itself finds interesting correspondences within the same compositional framework: the radius of the outermost circle is 27 feet, while that of the inner circle is 18 feet; the center (P) of the angle determining the opening (E-F) and the inclination of the side walls of the central niche fits perfectly within the modular grid; furthermore, the same geometric construction also divides the hemicycle into three spaces (E-F = e-f); finally, the width and position of the side niches (A-B = C-D) are determined by the intersection of the outer circle and the same modular grid, following an interval of 9 feet (a-b = 9 feet = 3 modules), which also recurs elsewhere (overall width of the semicircular wall of the forepart and the width of room 13 in Fig. 4).

Furthermore, based on some known measurements, it is

possible to attempt a planimetric reconstruction of the as-yet unexplored areas. For example, regarding the series of rooms behind the hemicycle, we have exact dimensions for at least a couple of them (rooms 10 and 14 in Fig. 4). These rooms have the same depth but a different width, which can sometimes be reasonably hypothesized. If we assume that the dividing walls had a similar thickness to those of the forepart (i.e., 3 Roman feet), the space between rooms 7 and 10 could be filled with two more rooms of identical size (rooms 8 and 9). Alternatively, it could also accommodate a single room with an exactly square floor plan, with one side measuring 18 Roman feet (equal, therefore, to the minor radius of the semicircle). Rooms 1 and 6, like their mirror counterparts (rooms 5 and 11), are entirely hypothetical but could have had a width equal to that of the side rooms of the hemicycle (rooms 2 and 4).

Furthermore, regarding the subterranean rooms 12 and 13, currently inaccessible because they are still being used as cisterns, given the width of the room with reticulated masonry above room 13, the available space can be filled in various ways. However, hypothetically, it is preferable to imagine room 12 having a width similar to that of rooms 7 and 10 or slightly wider. Finally, for the rooms in the southernmost sector, directly founded on the rock ledge, only a few traces remain, particularly in the area of room 15, but it is advisable to refrain from attempting any reconstruction due to the scarcity of available data.

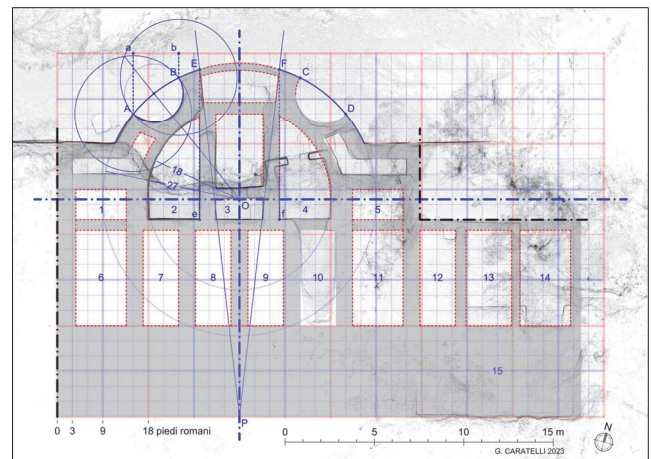


Fig. 4. Capri, Villa of Gradola, modular grid and planimetric reconstruction hypothesis.

V. THE VILLA OF DAMECUTA

Perched at a commanding position (150 meters above sea level) overlooking the Gulf of Naples, the Villa of Damecuta occupies a vast limestone plateau (possibly partially artificially leveled) on the Punta dell'Arcera (Fig. 5). Already known to scholars in the 19th century, it was excavated by Maiuri in the 1930s and 1940s [12], and due to the abundance and extent of the exposed ruins, it has always been considered, after Villa Jovis [15], one of the most important imperial residences on Capri [16].

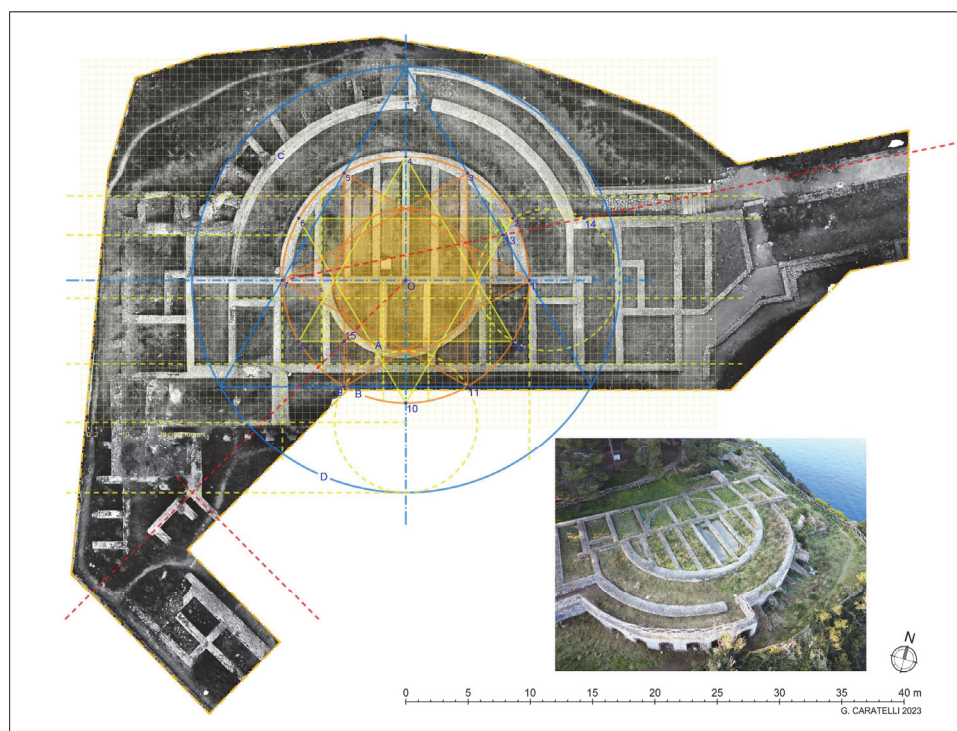


Fig. 5. Capri, Villa Damecuta, plan and comparison with the Vitruvian scheme for the Latin theatre designing.

The visible remains, constructed with *opus incertum* and *opus reticulatum* with limestone, are divided into at least three sections: a main one (the western one), characterized by the presence of a large hemicycle, and two others (the central and eastern ones), arranged “in festoons” along the northern edge of the plateau, featuring a panoramic walkway (*ambulatio*) with portico and exedra. There is also a small group of rooms (currently inaccessible for safety reasons) that were occupied by a tower in the medieval period.

During the latest survey campaign in 2022, the western and central sections were surveyed using laser scanning and terrestrial and drone photogrammetry. Like other sites and monuments on Capri, it awaited a planimetric verification and update since the 1940s [12]. The availability of this data finally allows for a new analysis of the monument. The problem has been addressed on several occasions by Clemens Krause, who has been involved in the survey and study of Villa Jovis [15, 17], a residential complex of unquestionable imperial ownership, characterized, like the villas of Damecuta and Gradola, by a semicircular element [18].

Now, from a strictly metrological point of view, almost all the structural elements of the Villa of Damecuta can be framed within a modular grid based on a minimum interval of 2 Roman feet, which also corresponds to the thickness of most of the walls (Fig. 5). This circumstance leads to the fact that many of the rooms have dimensions (expressed in Roman feet of 29.6 cm) divisible by the number 2. However, the observation of the presence of four concentric circles is the basis for an unexpected

discovery. In fact, it appears that the western sector of the Villa of Damecuta was designed based on the planimetric scheme suggested by Vitruvius in *De Architectura* for sizing the Latin theater (see *Vitr.* 5, 6, 1-6). Overlooking some inaccuracies due to the lack of perfect symmetry (as well as the interpretative problems that afflict the Vitruvian text, for which reference is made to [19]), and overlaying this geometric scheme onto the villa’s plan, numerous coincidences are noticed that can hardly be considered a result of chance (Fig. 5). For example, most of the walls with a north-south orientation contained within circle B can be traced using the intersection points between the sides of triangles inscribed within the same circle (see the sides passing through points 3-11, 4-10, 5-9). Furthermore, starting from the same points or utilizing other easily identifiable ones, it is possible to determine the dimensions of many of the rooms or, finally, the orientation of entire sectors. This is the case for the southwestern sector (see the line passing through the center O and point 15) or the long ambulatory with a portico and exedra on the eastern side (the direction is that passing through points 7 and 13 or 7 and 14). Finally, even if the largest circle (D) was used as a starting point for tracing the Vitruvian scheme, the coincidences between the scheme and the walls would in any case remain extremely convincing.

VI. CONCLUSIONS

In conclusion, a methodological approach based on the availability of accurate measurements and a well-surveyed

planimetric base, achievable only through instrumental surveying, offers the possibility to investigate, and sometimes understand, archaeological remains with a certain degree of reliability. In this regard, the three Capri archaeological sites examined in this study represent enlightening examples.

For instance, the Grotta dell'Arsenale was likely designed based on a tripartition of the available space, suggested by the 120-degree angle between the rear chamber and the small southeastern room. On the other hand, despite the limited visibility of its remains (few and poorly preserved, concealed by lush island vegetation), the Villa of Gradola has revealed a rigorous design plan based on traditional principles of axiality and symmetry. This allowed for hypotheses regarding the layout of currently inaccessible areas. Moreover, any doubts about the presence of a hemicycle on the front side of the villa (sometimes questioned but based on an overly cautious approach [16]) have been dispelled. This semicircular element, perhaps the most characteristic and defining feature of the entire architectural complex, has recently been referred to as a "hemicycle with a view" in very similar contexts [18]. The Villa of Gradola can now be included in the small list of residences (mostly presumed to be imperial property) characterized by the presence of a hemicycle, although the nature of whether it was a covered or open space (and thus its exact function) is still a subject of discussion [14].

Finally, regarding the Villa of Damecuta, which still awaits a comprehensive survey and a detailed analysis of its remains, the initial results arising from the application of a renewed metrological approach, based on the systematic and extensive use of laser scanning, are highly encouraging. Indeed, the possibility of applying Vitruvius's suggested scheme for sizing the Latin theater to the visible remains may suggest new possibilities for reading and interpreting a site that, based on our current knowledge (limited, and conditioned by a state of mediocre preservation or significant alterations from modern restorations), remains elusive and difficult to comprehend.

G. C.

REFERENCES

- [1] E. Federico, E. Miranda (eds.), "Capri antica. Dalla preistoria alla fine dell'età romana", Capri, 1998.
- [2] L. Di Franco, "Da Augusto a Tiberio, da *otium* a *secessus*. L'evoluzione del ruolo dell'isola di Capri quale residenza imperiale attraverso la documentazione archeologica", *Mélanges de l'École Française de Rome - Antiquité*, 134, 1, 2022, pp. 211-258.
- [3] C. Giorgi, G. Caratelli, "Verso una nuova carta archeologica per l'isola di Capri. Il contributo del CNR al progetto Masgaba", in R. Bosso, L. Di Franco, G. Di Martino, S. Foresta, and R. Perrella (eds.), "Archeologie borboniche, la ricerca sull'antico a Capri e nelle province di Napoli e Terra di Lavoro (Capri-Anacapri, 11-12 ottobre 2019)", Roma, 2020, pp. 21-41.
- [4] A. Maiuri, "Grotte-ninfei imperiali dell'Isola di Capri", *Bollettino d'Arte*, 25, 1931, pp. 149-160.
- [5] P. Mingazzini, "Le Grotte di Matermania e dell'Arsenale a Capri", *Archeologia Classica*, 7, 1955, pp. 139-163.
- [6] C. Giorgi, "La Grotta dell'Arsenale a Capri: analisi del contesto, delle murature e degli apparati decorativi", in [7], pp. 69-88.
- [7] L. Di Franco, and R. Perrella (eds.), "Le grotte tra Preistoria, età classica e Medioevo. Capri, la Campania, il Mediterraneo. Atti del Convegno Internazionale di Studi (Capri-Anacapri, 7-9 ottobre 2021)", Roma, 2022.
- [8] A. Viscogliosi, "*Antra cyclopi*: osservazioni su una tipologia di *coenatio*", in B. Andrae, and C. Parisi Presicce (eds.), "Ulisse. Il mito e la memoria" (Catalogo della mostra. Roma, 22 febbraio-2 settembre 1996), Roma, 1996, pp. 252-269.
- [9] G. Feola, "Rapporto sullo stato attuale dei ruderi augusto-tiberiani nella isola di Capri. Manoscritto inedito del 1830, pubblicato ed annotato dal nipote Dott. Ignazio Cerio di Capri", Napoli, 1894.
- [10] J. C. Mac Kowen, "Capri", [Napoli, 1884].
- [11] P. Mingazzini, "Edizione archeologica della carta d'Italia al 100.000. Foglio 196. Vico Equense (Penisola Sorrentina ed Isola di Capri)", Firenze, 1931.
- [12] A. Maiuri, "Capri. Storia e monumenti", Roma, 1956.
- [13] R. Ciardiello, "Abitare a Capri in età romana: il complesso residenziale di Gradola", in M. Amitrano, E. Federico, and C. Fiorentino (eds.), "Conoscere Capri. Studi e materiali per la storia di Capri", 5, Capri, 2007, pp. 29-45.
- [14] G. Caratelli, "La villa romana di Gradola a Capri. Nuove indagini e prospettive di ricerca", in [7], pp. 89-108.
- [15] C. Krause, "Villa Jovis. L'edificio residenziale", Napoli, 2005 (part. pp. 231-250).
- [16] A. Esposito, "La Villa di Damecuta a Capri. Analisi dei resti e ricostruzione dei livelli dell'edificio", *Oebalus. Studi sulla Campania nell'Antichità*, 4, 2009, pp. 323-339.
- [17] C. Krause, "Hemizyklien im frühkaiserzeitlichen Villenbau", *Mitteilungen des Deutschen Archäologischen Instituts*, 107, 2000, pp. 37-78.
- [18] B. Burrell, "A hemicycle with a view", *Memoirs of the American Academy in Rome*, 63-64, 2018-19, pp. 137-167.
- [19] M. Salvatore, "Le geometrie del teatro latino di Vitruvio. Interpretazioni e sviluppi nella trattatistica rinascimentale", in E. Mandelli (ed.), "Dalla didattica alla ricerca. Esperienze di studio nell'ambito del dottorato", Firenze, 2007, pp. 63-74.